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Airline and railway disintegration in China: the case of Shanghai Hongqiao Integrated Transport Hub

Givoni, Moshe

Chen, Xueming

Transport Research Unit, Tel Aviv University, Israel[1]
Virginia Commonwealth University, Richmond, VA, USA[2]

Abstract

In China, the need to integrate the air and rail networks has been identified and dozens of transport hubs that include air and HSR links have been built or are planned. In this research, which is complementary to Chen and Lin, the level and potential for air-rail integration at Shanghai Hongqiao Integrated Transport Hub is examined and analyzed. The results show that despite the excellent infrastructure the actual level of integration is low, while the potential benefits from such integration could be very large. It seems that in China the main barrier for air-rail integration is institutional and stems from the institutional (and cultural) division between air and rail transport and from the importance placed on promoting competition almost at any cost – both of these barriers can be said to be 'imported' to China from (especially) the U.S. and Europe. But with the infrastructure for air-rail integration in place, the potential to realize such an integration is far greater. A move away from the uni-modal governance and planning of transport can open the door not only to air-rail integration but to the creation of a truly integrated transport system in China.

Keywords: air-rail integration; Highspeed rail; Hub and spoke; airlines; integrated Transport Hub; shanghai Hongqiao; railway station; rail planning

1 *Givoni, Moshe.Transport research Unit, Department of Geography and the Human environment, Tel aviv University, Tel aviv, Israel. Email: givonim@post.tau.ac.il*

2 *Chen, Xueming. L. Douglas Wilder school of Government and public affairs, Virginia Commonwealth University, Richmond Va, Usa*

1. Introduction

Despite its potential benefits, the idea of air-rail integration (**Givoni 2007a**; **Givoni and Banister 2006**) is not gaining ground, even at times when congestion at airports increases. It is not that policy makers are blind to the idea. The EU, in its 2011 Transport White Paper, declares 10 goals one of which (Target 6) is 'By 2050, connect all core network airports to the rail network, preferably high-speed' (**EC 2011, 9**). Calls for integration are heard elsewhere as well. Yet, despite integrated transport in general, and air- rail integration more specifically, being a formal policy objective there is not much evidence of it. More common is for the disintegration of modes to prevail, especially between air and rail transport with London Heathrow airport being a prime example. **Givoni and Rietveld (2008)** and later **Givoni (2015)** try to provide some explanations for this lack of air–rail integration. While the roots of the problem are traced back to the institutional division between the air and rail industries and between air and rail policy making, the practical and most tangible obstacle for air and rail integration is a lack of infrastructure to support it – i.e. high-quality rail station at the airport.

This obstacle has been realized in China and led to the construction of many Integrated Transport Hubs, primarily as part of the construction of the high-speed rail (HSR) network and stations (**Hickman *et al.* 2015**). Many of these integrated hubs include an airport adjacent to HSR station, offering the infrastructure for air-rail integration. A prime example of the newly built integrated hubs is 'Shanghai Hongqiao Integrated Transport Hub' that includes Shanghai Hongqiao Airport (one of two major airports in the city) and Shanghai Hongqiao Railway Station (one of three major stations in the city) alongside a large metro and bus stations (see more details below and in **Chen and Lin 2016**). At least from an infrastructural perspective, Hongqiao hub provides the conditions to become a blueprint for air–rail integration. Examining to what extent this is the case in practice is the main objective of this paper. Overall, and unlike **Chen and Lin (2016)** who see the Hongqiao hub as a case of air–rail integration and through their analysis suggests way to further improve it, the analysis here shows that Shanghai Hongqiao Integrated Transport Hub is more a case of airline and railway disintegration and in this context aims to provide an analysis of the potential for such integration and what might stands in its way.

To achieve its aim and objective, the paper first reintroduces the model of airline and railway integration and briefly discusses the emergence of the Integrated Hub concept in China (The Integrated hub model) before providing a detailed description of Hongqiao hub from supply and demand perspectives (Shanghai Hongqiao Integrated Transport Hub). Current and future air–rail integration at the hub are then examined (current and future air–rail integration) followed by the assessment of the potential for air and rail integration (assessing the potential for airrail integration). The paper ends by providing key policy conclusions for the promotion of air-rail integration and the challenges in overcoming current air–rail disintegration (Conclusions and discussion). The analysis relies on a range of sources and primarily Hongqiao Hub plans alongside airline and railways schedules.

2. The Integrated hub model

2.1 The concept of the Integrated hub

As illustrated in Figure 1, in an airline's Hub and Spoke (H&S) network, which was adopted by many of the major airlines after the deregulation of the U.S. air passenger market in 1978, two types of network models can be distinguished: (1) the Hinterland model: short-haul flights feed traffic into long-haul flights; and (2) the Hourglass model: short-haul services are replaced by the more profitable long-haul flights (**Doganis and Dennis 1989** in **Button and Stough 2000**).

A third model that is offered is the Integrated hub model: short-haul services are provided by the airlines using the railways (rather than aircraft) to feed traffic into the airlines' long-haul services (**Givoni and Banister 2006; Givoni 2007a, 2007b**).

In the Integrated hub model, rail services may be provided to those destinations which are currently served by aircraft, and in this case, mode substitution takes place. Rail services may also be to destinations that are not currently served by aircraft and by that expand the airline's network, creating a win–win situation for both railway and airline industries. Mode substitution can potentially also provide significant environmental benefits, especially air and noise pollution around airports, although the environmental impacts of air transport could worsen if runway capacity freed through mode substitution is taken up by new (longer routes) air services (**Givoni 2007b**). Albalate, Bel, and Fageda (2015) demonstrate for three European countries that the introduction of HSR services on routes where air services were in operation, does not necessarily lead to reduction in flight frequency, even if the number of seat supplied is lower.

The success of airline and railway integration requires a close cooperation and collaboration between the airline and railway operator. According to **Givoni and Banister (2006)**, the commercial agreement between the airline and railway operator can take different forms, similar to cooperation agreements airlines sign between them (e.g. code-share agreements). There is no reason for code-share agreements, whereby one airline operates the flight, but many can offer it to their passengers, to not include rail service providers (**Chiambaretto and Decker 2012**). In Europe, Lufthansa operates rail services as part of its network on several routes, such as Frankfurt–Stuttgart and Frankfurt–Cologne. The rail service is actually operated by Deutsche Bahn (DB) but carries a Lufthansa code. Another example of commercial agreements between airlines is the formation of airline alliances. Unfortunately, the railways have largely remained outside of these agreements (**Givoni 2015**).

A prerequisite for airline and railway integration is the colocation of a railway station at the airport. The most favorable situation is to directly integrate railway stations into the main passenger terminal(s) of airports, which will create a seamless intermodal transfer. Amsterdam Schiphol airport is such a good example. In addition, the railway station needs to be a through station (providing a high-frequency service to many destinations) rather than an end of the line station. For more discussion on airline and railway integration see Givoni and **Banister (2006), Givoni (2007a, 2007b)** and **Givoni and Rietveld (2008)**.

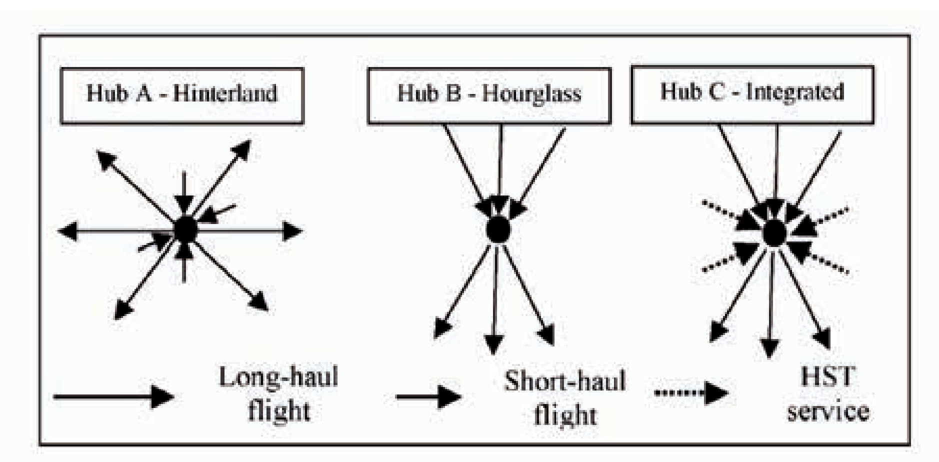

Figure 1. The Integrated Hub model of H&S operation (Source: Givoni 2015).

Note: HST – High-Speed Train.

2.2 The emergence of the Integrated hub in China

China is experiencing rapid economic growth and fast expansion of transport infrastructure in recent years. For example, in China, the number of civil airports increased from 94 in 1990 to 175 in 2010 and is expected to reach 244 in 2020 (**Fu, Anming, and Zheng 2012**). At the same time, China is fast developing its HSR network largely to accommodate the increase in demand for rail transport, i.e., for capacity reasons (ibid.; **Chen 2012**), similar to what was the case in Japan and France, albeit at a much larger scale. The intermediate and long-term plans for the HSR network were first published in 2004 and later updated in 2008 by the then Ministry of Railways, subject to approval by the State Council (**Chen 2012**). By the end of 2015, the total operating length of China's HSR network had reached 190000 km[1]. The network model of HSR in China is that of a 'comprehensive national' and its backbone consists of four east-west and four north-south lines (ibid.). By 2020, the Chinese HSR network is expected to link all provincial cities and cities with a population of over half a million (**Chen 2012**). These figures have already made China the largest HSR network in the world and an almost ideal case for airline and railway integration, considering also the regulatory environment that might be more open for cooperation between the modes (see below).

Moreover, in the development of HSR in China, strategic consideration was given to the location of the stations, with respect to which cities are served (which is obvious) and the function of each station as a hub in the HSR network. As **Hickman et al. (2015)** illustrate (Figure 2, 180), the network consists of several tiers of 'hub' stations, or 'multimodal interchange hubs,' which range from superlarge to large and medium hubs – those which offer interchange with multiple transport modes, and more modest small and basic hubs. The position of a station in the hub hierarchy is determined by the operational volume of the station. Hickman et al. (2015) note that the Chinese rail hubs often have very large, airport-style, multilevel buildings (see also Chen, Hickman, and Saxena 2014). In this context, the need to integrate the air and rail networks has been identified and more than 32 Chinese airports are planning HSR links and turning the airports into transport hubs (**Fu, Anming, and Zheng 2012**). According to **Givoni and Banister (2007)**, for an airport to be suitable for air-rail integration, it would be better to have the railway station situated at the airport and the station should offer a high-frequency service (not necessarily HSR service) to many destinations, as noted above.

Rail services in China are categorized according to the types of service offered (**see Appendix A**). This categorization lends itself for the consideration of air–rail relationship. Train services of types G and D – the fastest services – are those where HSR is most likely to successfully compete with aircraft services. On train services of types C, Z, T, K and S – where routes tend to be relatively short (and speed varies but, with the exception of C trains, is lower than 200 km/h) – rail is more suitable to complement aircraft services. Considering the Integrated Hub model (Figure 1), rail services G and D can substitute current aircraft services, while rail services C, Z, T and K can complement current aircraft services.

3. Shanghai Hongqiao Integrated Transport Hub

Shanghai Hongqiao Integrated Transport Hub best illustrates the concept of the Integrated Hub in China and it can be used as a case study to analyze air–rail integration as in **Chen and Lin (2016)**, or as a case study of air-rail disintegration as done in this paper. This section first describes the physical characteristics of the hub and the supply of services, it then examines the demand for services at the hub before describing the regulatory framework within which the hub is operated. The data used and described below are similar to that used by **Chen and Lin (2016)** in their analysis.

3.1 The supply side

Following the development of Puxi (traditional city centre) and Pudong (east to the traditional city centre) areas, the next logical step for Shanghai's development was to create a new growth pole and a subcentre to the west. At the heart of this development is the Shanghai Hongqiao Integrated Transport Hub ('Hongqiao Hub' for short) which is expected to support and facilitate the economic development in the Hongqiao Business District (see **Chen and Lin (2016)**).

The Hongqiao hub includes an airport, railway station, metro station, coach/bus station all under one roof and including good access to the motorway network. At present, it is the only such hub in China that has both an airport and a railway at the same place (500 m apart) and where transfer by walking is possible (in about 10 min.[2]) While the airport, railway and coach stations support intercity travel, the metro and bus stations focus on urban, intracity transport and serve largely as access/egress routes to the integrated hub.

Figure 2. Destinations with direct air service to Hongqiao hub.

Before the opening of Pudong International Airport (which is serving mainly international flights and is now the third-largest airport in China) in 1999, Hongqiao Airport used to be the principal airport in Shanghai. Since 1999, however, Hongqiao airport has primarily served domestic flights. As part of the development of the hub, a second runway and a new terminal (Terminal 2) opened in 2010 to allow maximum capacity to reach 40 million passengers per year. In 2010, the airport served over 31.2 million passengers (on average 85,000 passengers per day), primarily through Terminal 2 (about 90%), making it the fourth-busiest airport in terms of total passenger traffic in China[3]. By 2013, the airport handled over 35.5 million passengers (5.3% growth) and was ranked 36th in the world by passengers, behind Pudong airport that was ranked 21st in the world (total demand over 47 million passengers[4]). The airport served 64 Chinese cities in 344 daily flights in 2013. The main destinations served were Beijing (41 daily departures), Shenzhen (32), Guangzhou (30), and Xiamen (23). Another 36 destinations in China were served with over five daily flights (Kunming, Qingdao, Nanjing, Changsha and Tianjin all had between 13 and 11 daily departures) and 19 destinations in China were served by less than four daily flights. The airport also serves international and regional services, from Terminal 1, but they are relatively limited and include Tokyo, Seoul, Hong Kong, Taipei (4 daily departures to each destination) and Macau (3 daily departures). Connection between Terminal 1 on one side of the airport and Terminal 2 and the adjacent rail station on the other side of the airport is through the Metro and a shuttle bus. The two dominant airlines at Hongqiao Airport are China Eastern Airlines, for which the airport is a hub (offering 105 departing flights) and Shanghai Airlines (65), followed by Juneyao Airlines (35), Spring Airlines (34), China Southern Airlines (28), Air China Limited (22) and Xiamen Airlines (17). Sixteen more airlines offer service from the airport with as many as 12 airlines offering only one departure per day.

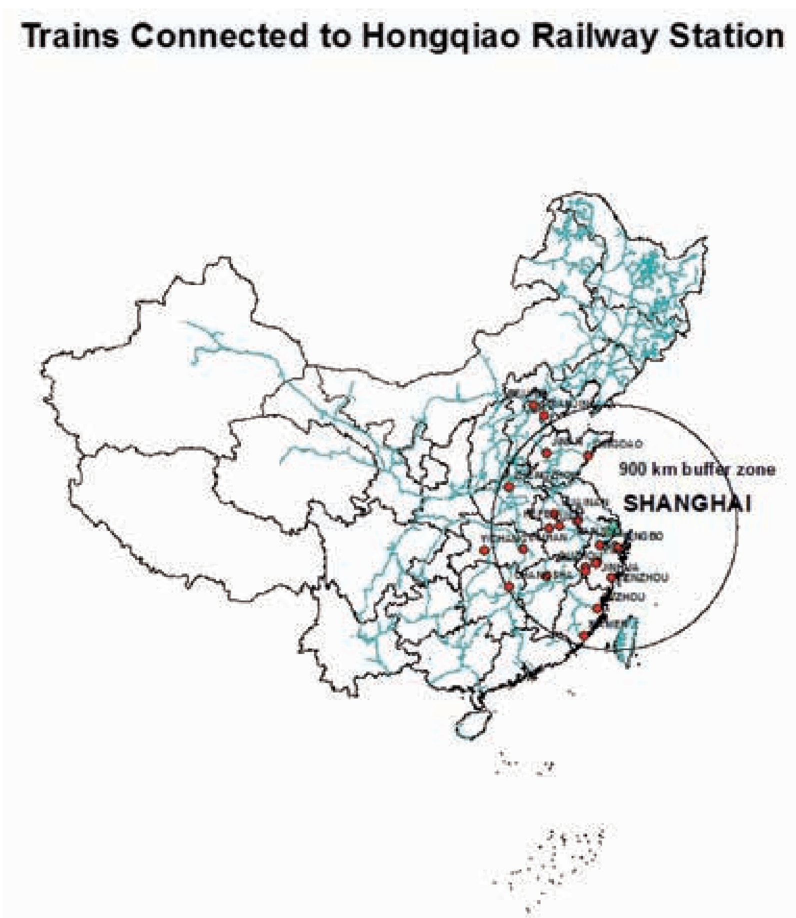

Figure 3. Destinations with direct rail service to Hongqiao hub.

Opened in 2010 as well, and located 500 m west to Terminal 2, Hongqiao Railway Station has a design capacity of 52.72 million passengers per year planned for 2020. It is one of the largest rail terminals in China and is one of the three main railway stations in Shanghai – the others being Shanghai and Shanghai South Railway Stations. The station includes a floor area of about 1.3

million m², 16 platforms, and 30 tracks. It is planned to cater in the future for Maglev services but these are yet to be finally decided on. The station only provides HSR services (train types G – 65% of the services and D – 35% of the services – see Appendix A) on the Beijing–Shanghai Passenger Dedicated Line (PDL), Shanghai–Hangzhou Intercity HSR Line and Shanghai–Nanjing Intercity HSR Line, all three opened in 2010–2011. The 143 services departing from the station (in 2013) served 28 cities the main ones being: Beijing (South) served by 32 daily services; Nanjing, Ningbo (East) and Hangzhou by about 16 daily services and Hankou by 12 daily services. Twenty-three destinations were served by less than 10 daily trains, many by one or two only.

The Coach station at the hub provides inter-city bus services from/to Shanghai, mainly to Jiangsu Province – located at the core of the Yangtze River Delta (YRD) Megaregion (204 coach services per day) and Zhejiang Province (74 coach services per day). Hongqiao hub is also well connected with the Motorway network.

Hongqiao hub is planned to be well integrated with the city's transport network. Five different metro lines are planned to pass through the airport, with Metro Line 2 (connects Hongqiao and Pudong airports) and Metro Line 10 (has a stop at the railway station, Terminal 2 and Terminal 1) already in operation. Metro Lines 5, 17 and the Qingpu Express are under construction. The hub also serves a wide range of local bus routes.

Overall, Shanghai Hongqiao Integrated Transport Hub offers excellent air, rail and road infrastructure and is well connected. It is a major node on all of these respective networks. It thus certainly has the conditions to be a truly Integrated Hub.

3.2 The demand side

According to Shanghai Hongqiao's Central Business District Governing Board, on average 684,300 passengers used the various transport facilities at the Hub every day in 2013[5] (see Table 1 for details). This daily demand split was 50.6% for urban transport and 56.5% for intercity long-distance travel. The majority of long-distance passengers used the rail station (28.7%), while only 13.9% passengers used the airport. The daily demand is forecast to grow to 693,600 in 2020, with most of the increase expected in the demand for rail travel (the railway station is expected to cater for 45.5% of the demand[6]). The demand for Coach services will increase almost threefold but will continue to serve a relatively minor share of the hub's passengers. The airport is also expected to grow, but by only 15% and in 2020 is expected to serve 109,400 passengers per day, equivalent to about 40 million passengers per year, just over 11% of the Hub's daily demand. By 2020, most of the passengers using the hub, almost 60%, will be intercity long-distance travelers. With respect to intracity travel, the metro is the main access/egress mode to the hub. Shanghai Hongqiao Integrated Transport Hub is still a relatively new transport facility that is rapidly growing, the demand for its services is focused around the long distance travel modes, rail and air, with the rest of the demand for various modes is mainly to access/egress the railway and airport services[7].

Table 1. Demand and mode Share at Hongqiao Hub, 2013 and 2020.

Mode	2013*		2020**	
	Average daily passengers	%	Average daily passengers	%
Railway station (external)	196,100	28.7	438,200	45.5
Airport (external)	95,000	13.9	109,400	11.4
Coach bus (external)	6,200	0.9	23,000	2.4
Metro, bus, taxi, and other vehicles (internal)	386,800	56.5	393,000	40.8
Total	684,300	100	963,600	100

*Shanghai Hongqiao Central Business District Governing Board's Website, http://www.shhqcbd.gov.cn/html/shhq/shhq_2013/2014-01-13/Detail_6403.htm;
**Shanghai Comprehensive Transportation Institute.

A survey of the airport's passengers conducted by Huang, Yang, and Gu (2011) found that 30% were local residents in Shanghai, while 70% were from outside the city, most of them are residents in the YRD region. In terms of trip purpose, 48% of passengers were tourists, 19% travel for private business purposes, 12% for public business purposes and 10% travelled to visit relatives (11% travelled for other purposes). A different and not comparable, unpublished survey of railway station users conducted in February 2012 by Tongji University planning graduate students among 1834 passengers shows that 70% of rail passengers were from Shanghai and 30% from other cities. The main trip purpose among rail passengers was business travel (45%). The most popular mode of transport to get the railway station was the Metro (61%) followed by taxi (15%), bus (8%) and private car (8%). Less than 5% of the rail passengers surveyed were transfer passengers from the airport.

Although the surveys of the airport and railway station passengers are not comparable, they nevertheless shed some light on the different characteristics of passengers using each of the modes. In general, it appears that the rail station primarily serves Shanghai, while the airport has a much wider catchment area than Shanghai only. In both facilities, it appears that business travel makes up close to half of the demand. Although not the largest rail or airport in Shanghai, the combined demand for transport services in the Hongqiao integrated hub makes it the largest transport facility in the city.

3.3 The regulatory framework of China's transportation system

At the central government level, the Ministry of Transport (MOT) of China is an agency responsible for railway, road, air and water transportation regulations and is a member of the State Council of China. Until March 2013, the Ministry of Railways was in charge of the railways, not the MOT, and its duties were taken up by the MOT (safety and regulation), State Railways Administration (inspection and monitoring) and China Railway Corporation (construction, operation, and management). The State Railways Administration has several main functions including the formulation of laws, regulations and provisions for the supervision and administration of the railways. As the owner of China's railroad tracks, stations, and rolling stocks, China Railway Corporation is the national railway operator that operates both passenger (including HSR) and freight rail services. Within China Railway Corporation, the Transport Bureau is specifically responsible for developing the HSR network and determining the station locations, subject to approval from the State Railways Administration.

The Civil Aviation Administration of China (CAAC) is the regulatory agency under the MOT that oversees civil aviation and responsible for air transport safety. In 1987, the CAAC's airline operations were split into six separate airlines each named after the geographic region where their headquarters and main operation were located. These airlines (Tier-1) were: Air China; China Southwest Airlines; China Eastern Airlines; China Northwest Airlines;China Southern Airlines; and China Northern Airlines[8]. In addition to the above largest state-owned airlines, there are also other medium-sized airlines (Tier-2) subsidized by local governments and other funding partners including: Shenzhen Airlines (Major Parent Company: Air China), Xiamen Airlines (Major Parent Company: China Southern Airlines), Shanghai Airlines (Major Parent Company: China Eastern Airlines), Shangdong Airlines (Major Parent Company: Air China). Examples of fully privately owned airlines (Tier-3) include Hainan Airlines, Spring Airlines, Juneyao Airlines, Okay Airlines, and others.

In China, airports are typically owned and operated by the airport authorities of local governments. Local planning departments and transportation departments will determine the ground access to the airports, in conjunction with the airport authorities.

From a regulatory perspective, Shanghai Hongqiao Integrated Transport Hub consists largely of two components: the railway station and the 'international airport' (although most of the flights are domestic). The railway station is under the direct jurisdiction of Shanghai Railway Bureau, which is one of 18 railway bureaus administered by China Railway Corporation, while the airport is currently administered by Shanghai Airport Authority (SAA), which is the state-owned enterprise directly under the jurisdiction of Shanghai Municipal Government. SAA is the regulatory body that is also responsible for Shanghai Pudong International Airport. The regulatory link between the SAA (operating the airports) and the CAAC (regulating air transport) is through the airlines using Shanghai's airports. The main operators within Hongqiao hub are all profit maximization entities. In summary, while the railways are the only mode of transport in China that is centrally planned, the airports are usually locally planned.

4. Current and future air-rail integration

The close proximity of a major airport and a railway station provides for an almost ideal starting point for air-rail integration. At present, however, this integration is relatively limited as appears from the survey of railway passengers reported above. Nevertheless, some form of integration does exist. Three airlines have signed agreements with Shanghai Railway Bureau to provide integrated air–rail services in the YRD area: China Eastern (largest airline at the hub by daily departures), Spring Airlines (4th largest) and Air China (6th largest) and the profile of destinations they serve by rail is shown in Table 2. The rail services offered by airlines are designated a flight number but otherwise are not different from nonairline rail services. The frequency of air–rail services varies and in somecases considered to be in a trial period. Overall, the existing frequency of air–rail integration services is relatively limited in scope and is confined to nearby cities in the YRD region. A round of interviews[9] suggested that also in the eyes of local experts and policy makers, the level of air–rail integration, despite the progress being made, is low (compared by the interviewees to that at Frankfurt airport for example). At Hongqiao hub, luggage cannot be seamlessly transferred from the rail station to airport, it must be checked in twice. Another form of integration that currently exists allows passengers to check in for their flight at Kunshan bus station, about 45 kms from the airport and then be transported by bus to either Hongqiao or Pudong airports, a form of road–air integration.

Given that the Integrated Hub concept in China is still relatively new, a long-term view of air-rail integration is required. Such a view is provided by a forecast of the daily number of passengers transferring between the different modes at the hub in 2020 (Table 3). Considering an average estimate of the range provided in each cell of Table 3, it is clear that in 2020 the transfer of passengers within the integrated hub is expected to be between the long (air and rail) and the short distance (urban) modes of transport. The transfer of passengers from aircraft torail (HSR and Intercity) is expected to be 6000 daily passengers, about 11% of the airport passengers. Another 3100 daily passengers are expecting to transfer from the aircraft to the Maglev rail services (if they will be built), the majority (2500 passengers) to the planned interairport Maglev service, thus transfer from air to air using a Maglev ground transportation service.

Table 2. profile of rail services provided by airlines at Hongqiao hub.

Airline	China eastern	Spring airlines	Air China	Distance from Shanghai (km)
Daily flights	105	34	22	
Rail destinations	8	13	9	
Cities served by the airline 'rail' service	suzhou Wuxi Changzhou	suzhou Wuxi Changzhou	suzhou Wuxi Changzhou	84 126 165
	ningbo	ningbo	ningbo	314
	Jiaxing	Jiaxing	Jiaxing	84
	Zhenjiang	Zhenjiang		237
		Hangzhou	Hangzhou	159
	Kunshan		Kunshan	50
		Yiwu	Yiwu	304
	Tongxiang	Tongxiang		112
		Hefei		468
		shaoxing		202
		nanjing		311
		Danyang		210
			Taizhou	466

The main onwards mode for airport passengers other than to the local, urban public transport services (63%) is the private car (road network, 14%). Seventy-six percent of daily HSR passengers in 2020 are forecast to transfer to the local public transport services, while only 2% are expected to transfer from the 'HSR' to the 'Intercity rail' services, from long to short distance HSR routes[10]. Although the expected level of air-rail integration at the hub in 2020 will not be small, the picture that emerges from the forecast is that the hub is largely serving to connect Shanghai's local transport network with the long-distance, intercity transport network. Air-rail integration as a strategically planned interface between the two of the main long-distance transport networks in China is not really considered. The rapid development of the Chinese transport network as well as fast changes in other sectors means the forecast in Table 3 is likely not up to date anymore. However, it still shows the level of air-rail integration expected at the time which illustrates the planning 'mind set' of those responsible for the hub's future development.

Table 3. Year 2020 projected daily intermodal transfers at the Hongqiao Hub.

Mode or service	HSR	Intercity rail	Aircraft	Inter-airport (Maglev)	Shanghai- Hangzhou (Maglev)	Express bus	Car	Urban public transport
Hsr		1000-2000	2000-3000	7000-8000	1000-2000	500-1000	6000-7000	65,000-66,000
intercity rail	1000-2000		3000-4000	7000-8000	400-1000	500-1000	1000-2000	68,000-69,000
aircraft	2000-3000	3000-4000		2000-3000	400-1000	3000-4000	7000-8000	34,000-35,000
interairport (Maglev)	7000-8000	7000-8000	2000-3000		0	1000-2000	0	0
shanghai-Hangzhou (Maglev)	1000-2000	400-1000	400-1000	0		1000-2000	1000-2000	24,000-25,000
express bus	500-1000	500-1000	3000-4000	1000-2000	1000-2000		0	3000-4000
express highway	6000-7000	1000-2000	7000-8000	0	1000-2000	0		0
Urban public transport	65,000-66,000	68,000-69,000	34,000-35,000	0	24,000-25,000	3000-4000	0	

note: The total forecast demand by node (summing a row or a column) is not equal to that shown in Table 1 since the two represents different forecasts done at different times.

Source: Li and Zhu 2008.

Table 4. Comparison of routes on which the modes compete.

Origin	Airline frequency	Rail frequency	Air linehaul time (min)	Train linehaul time (min)	Air fare in CNY	Train fare in CNY
Beijing	41	34	150	336	336	553
Changsha	11	2	105	402	220	468.5
Fuzhou	8	7	80	377	188	261.5
Jinan	2	1	85	236	200	398.5
Longyan	1	1	85	570	250	373.5
nanchang	4	3	85	376	260	237
Qingdao	13	4	80	398	227	518
Tianjin	11	2	115	303	300	513.5
Wenzhou	3	7	65	212	230	226
Wuhan	7	15	90	301	336	302.5
Xiamen	23	7	80	513	200	328
Yichang	1	2	90	496	540	348.5
Zhengzhou	8	3	80	410	227	236.5

Note: For door-to-door travel time it is assumed that access and waiting time is 100 min for a flight and 60 min for an Hsr travel.

5. Assessing the potential for air-rail integration

Figures 2 and 3 show the cities from which there is a direct air service and rail service to Hongqiao airport and rail station, respectively. The maps also include a 900 km radius line around Hongqiao hub to depict the distance where the two modes are considered to still be in direct competition. Somewhat surprisingly, there are many more direct flights than rail service to the hub (not necessarily to Shanghai, since many rail services terminate at the other main railway stations). There is a clear duplication of air and rail services to the hub from several cities (see below) and, given rail connectivity to cities that offer HSR service to the hub, large potential for substitution by rail of some of the flight services, especially given the low frequency of service by some airlines (see below). Altogether, there are 61 destinations within 900 km radius that are served directly form the hub by air services and 26 such destinations served by rail.

A more detailed analysis of the routes served by air and rail to Hongqiao hub reveals 13 routes in which services are offered by both modes (competition routes – see Table 4) and additional 56 routes where the service is only offered by one of the modes (complementary routes, excluding international destinations).

With respect to fares, and in general, on the routes where the modes compete flights services are cheaper (Table 4)[11].Out of 13 routes, on eight routes the flights were considerably cheaper (more than 50 Yuan and up to about 300 Yuan), on four routes the fares were comparable and only on the route from Yichang using HSR was considerably cheaper, by almost 200 Yuan from flying. In terms of service frequency, the differences between the modes are relatively small and the choice between high (over 10) medium (between 5 and 10) and low (under 5) daily service frequency is very similar for aircraft and rail services. With the exception of one route, the airlines in general offer higher level of services. With respect to time, and restricting the comparison to in-vehicle time (as opposed to door-to-door travel time) aircraft services are of course considerably faster, with only on two routes (Jinan and Wenzhou) the difference is less than 3 h. Assuming a check-in time of two hours for flights and only 30 min for rail in China, flights are still faster by a margin on all routes (Table 4). Thus, travelling by HSR might be competitive to the flight in terms of travel time only if the railway station is located in the city centre while the airport considerably far from the centre. In addition to travel time, comfort factors should also be considered in the comparison between air and rail and the advantage here is clearly with travelling by HSR, which provides the conditions to use travel time for work, rest, etc.

Table 5. potential runway capacity to be released at Hongqiao airport following mode substitution.

Runway utilization at Hongqiao Airport (Average daily in 2013) Total daily: ATM: 332; Seats: 48767					Runway utilization			
					Route level		Cumulative	
Destination	Distance	ATM	Seats	Aircraft	ATM (%)	Seats (%)	ATM (%)	Seats (%)
nanjing	273	12	444	37	3.6	0.9	3.6	0.9
Tunxi	374	1	162	162	0.3	0.3	3.9	1.2
Wenzhou*	418	3	474	158	0.9	1.0	4.8	2.2
Chizhou	447	1	158	158	0.3	0.3	5.1	2.5
Huai'an	450	1	37	37	0.3	0.1	5.4	2.6
Lianyungang	468	2	324	162	0.6	0.7	6.0	3.3
Wuyishan	532	1	158	158	0.3	0.3	6.3	3.6
Linyi	541	2	324	162	0.6	0.7	6.9	4.3
Xuzhou	554	1	158	158	0.3	0.3	7.2	4.6
anqing	555	1	21	21	0.3	0.0	7.5	4.6
Jingdezhen	589	1	158	158	0.3	0.3	7.8	4.9
Fuyang	606	1	162	162	0.3	0.3	8.1	5.3
nanchang*	632	4	632	158	1.2	1.3	9.3	6.6
Wuhan*	676	6	894	149	1.8	1.8	11.1	8.4
Fuzhou*	678	9	1458	162	2.7	3.0	13.8	11.4
Qingdao	693	13	2054	158	3.9	4.2	17.8	15.6
Jining	715	1	162	162	0.3	0.3	18.1	15.9
Jinjiang	763	5	810	162	1.5	1.7	19.6	17.6
Longyan*	784	1	158	158	0.3	0.3	19.9	17.9
Yichun	805	1	162	162	0.3	0.3	20.2	18.2
Xiamen*	827	22	3564	162	6.6	7.3	26.8	25.5
Ji'an	833	1	162	162	0.3	0.3	27.1	25.9
Yantai	846	7	1134	162	2.1	2.3	29.2	28.2
Jinan*	852	3	486	162	0.9	1.0	30.1	29.2
Ganzhou	854	1	158	158	0.3	0.3	30.4	29.5
Zhengzhou*	858	9	1458	162	2.7	3.0	33.1	32.5
Jinggangshan	860	1	180	180	0.3	0.4	33.4	32.9
Total/ave.		111	16052	145	33.4	32.9		

*Note: Distance in km; aTM = air Traffic Movements (take-off only); aircraft = average aircraft size. ave. = average, Bold cities – destinations within the YrD area. *– routes where there is currently a Hsr service.*

From destinations where there is either a HSR or a flight service to the hub (56 in total), the level of service is relatively low with often only one or two daily services. On only three routes, where a HSR service is offered but not a flight service, the frequency of service is very high[12] and stands at between 19 and 25 services per day. In terms of air service frequency, out of 43 routes where there is a flight service but no HSR, on only 12 routes the frequency of service can be considered high, and very high (over 10 per day) on two routes. It appears that the majority of destinations on which the two modes do not compete there is a relatively low demand for services to Hongqiao hub (this does not necessarily mean low demand for services to Shanghai). Such routes, however, might offer more potential for integration between the modes (see below).

Another way to consider air–rail integration or the lack of it at Hongqiao hub, is to consider the potential to free runway capacity (as in **Givoni and Banister 2006**) through mode substitution. There are 27 destinations within 900 km radius of Hongqiao Airport that are served by flights but could potentially be served by rail only (Table 5). These destinations currently take up about third of the runway capacity (in terms of Air Traffic Movements (ATM) and seat capacity). Looking only at those routes where currently there is already a HSR service, eight routes (marked by * in Table 5) they take up 17 and 19% of the airport's ATM and seat capacity, respectively, and, with the exception of Xiamen, Fuzhou and Zhengzhou, offer relatively low or modest frequency. The remaining 19 routes, where there is currently no HSR service, take up 16 and 14% of the airport's ATM and seat capacity, respectively, and in general offer low level of service (on 15 routes there are only one or two daily services). It is clear from Table 5 that the aircraft operated by the airlines from Hongqiao airport are single-aisle (narrow body) aircraft, many of them small aircraft within this category. This has implications of the use of runway capacity.

6. Conclusions and discussion

The need to and benefits from integrating the different elements of the transport system are well recognized (**Givoni and Banister 2010**) but nevertheless are seldom fully internalized by policy makers. This is often apparent in the disintegrated planning of the air and rail networks, even at the age of the HSR, which is recognized on many routes as a potential substitute to the aircraft. Current HSR plans in the US as in California's HSR13 and the UK as in HS214 are two very illustrative examples. China is very different in this respect. China seems to be the first country to internalize the need for integrated infrastructure, including the infrastructure for air-rail integration, when planning and developing its HSR network. The evidence from Shanghai Hongqiao Integrated Transport Hub suggests, however, that this is not sufficient for airline and railway integration at the operational level, to materialize.

What seem then to stand in the way for a full, beneficial airline and railway integration are institutional barriers. At the national level, the airline and railway industries are regulated by different government entities with distinct regulations, revenue sources, cost expenditures, and operating procedures. The airline industry is more decentralized, operating more like an oligopoly, with several airlines competing against each other, while the airports are locally owned and managed. In contrast, the railway industry is a full monopoly. Along several medium-range corridors (e.g. 300–500 km, and in some cases, up to 900 km as indicated in Table 5), the two industries directly compete for the same customers. Each industry has its own self-interests, lacking a revenue/cost sharing mechanism.

Despite the concept of the 'integrated hub' being an important element in the development of the Chinese HSR, it is still a 'railway' (State Railways Administration) and not a multimode (Ministry of Transport) planning initiative. Furthermore, with the operators of rail and aircraft services in China being profit maximizers, the focus on competition might make them blind for the full potential of integration. This 'blindness' seems to be present also within the regulatory bodies governing transport in China and air transport especially. The limited evidence for air– rail integration that does exist (Table 2 and see Chen and Lin 2016) reinforces that potential for such integration exists. When China 'discovered' and adopted the idea of HSR around 2004, it also imported the idea of HSR as a competitor to the aircraft and thus the airlines. By that, China locked itself into an inefficient use of these, largely complementary, long-distance modes of transport, even to the point of destructive competition between the modes (more so for the airlines – Fu, Anming, and Zheng 2012) and inefficient use of airports' and stations' capacity.

From a technological perspective, the difference between the modes should be apparent and assessed from the distance and demand perspectives. In terms of distance, aircraft is a long-range long-haul mode of transport, while HSR is short-range long-haul mode of transport. There is an overlap in this respect between the modes on routes of about 400–1000 km. Within this range, aircraft are suited to cater for relatively low demand routes while rail, HSR in particular, for high-demand (dense) routes. This functional consideration of air and rail transport advocates for a geographical division (of routes) between the modes. In turn, it lends itself for a very different organization of China's air and rail services, domestically and internationally, where routes of over 1000 km are mainly served by aircraft and shorter routes predominantly by rail. Under 1000 km, dense routes should be operated by HSR, while very thin routes by aircraft[15]. In that range, conventional rail services should serve routes with 'medium' demand.

In a hypothetical reorganization of air and rail transport in Shanghai, with a focus on air-rail integration, the role of Hongqiao and Pudong airports will change. Hongqiao, since it has excellent HSR connectivity, will become the international gateway to Shanghai and the YRD region and will offer a seamless transfer between a range of international (air) destinations and domestic (rail) destinations – becoming the first truly 'integrated hub' as depicted in Figure 1. For the same reason, Hongqiao airport should become a transfer point between domestic long-haul (aircraft) and short-haul (HSR) routes. Pudong airport, under this new organization of services will become a pure origin-destination airport for those wishing to travel to/from Shanghai and not beyond. The relatively high demand for travel foreseen between the airports (Table 3), currently served by a metro[16], and the consideration of an expensive Maglev line for that is evident for the inefficiency of the current functional roles of the airports. If HSR is supposed to accelerate the regional economic integration in China (**Zhang and Nie 2010** in **Chen 2012**) organizing in this way the functions of the two airports should be conductive. Furthermore, it will allow Shanghai to develop a true hub airport, using the Integrated Hub model (Figure 1). **Fu, Anming, and Zheng (2012)** argue that for the Chinese aviation industry there are multiple benefits from transforming the airlines' network to hub and spoke networks.

Extending further the hypothetical re-organization of Shanghai's Hongqiao hub and adhering to the Integrated (air-rail) Hub model, suggests that Hongqiao railway station should also serve conventional railway services to further maximize the inland reach, or catchment area, of the airport/hub. As **Givoni and Dobruszkes (2013)** show, most of the demand for HSR seems to originate from the slower, conventional railway. A truly Integrated Transport Hub should connect all transport networks and offer a seamless transfer between all these respective networks. It is such an integrated transport hub that should be the backbone of China's transportation network with such a hub in each of the mega-city regions, and where rail and HSR services mainly complement and not compete with the aircraft.

The above suggestion does not mean the end to competition in the Chinese airline industry. Rather, it suggests, as alluded to by **Perl and Goetz (2015)** and **Fu, Anming, and Zheng (2012)**, a reorientation of China's airlines away from domestic services and more towards international services. In the competition with foreign airlines, an adoption of the air-rail integration model should give Chinese carriers a significant competitive advantage, largely by substantially increasing the number of domestic destinations served by Chinese airlines (using rail services).

Even if the wheel cannot be turned back, the potential for air and rail integration at Shanghai's Hongqiao hub can still be realized, at least partly. Considering future demand for services to/from Hongqiao, the potential for air-rail integration is still large and thus the potential for much more efficient utilization of Hongqiao's facilities in the face of future growth in demand. This will require a move away from the uni-modal nature of governing and planning transport, which is currently the dominant approach worldwide. Given China's political nature, it is expected that a move away from such unimodal approach will be easier to adopt. With the infrastructure for air–rail integration in China very much in place, especially in Shanghai, the potential for air–rail integration can be more easily realized and in turn can act as a catalyst for the creation of a truly integrated transport system.

Latest planning announcements in China suggest the idea of air–rail integration as part of the future development of HSR still has merit and that it might have been recognized. According to the medium- and long-term railway network plan, which was approved during the State Council executive meeting on June, 2016, the HSR network should be extended to include eight vertical and eight horizontal lines that will link many large- and medium-sized cities of 1–4 h apart[17]. This can substantially increase the scope for HSR services to complement air services at air-rail hubs. In the Shanghai area, according to the Shanghai-Nantong Intercity Railway Phase II Plan, the Pudong Airport will be directly connected to the HSR network via a new HSR station at the airport. The plans also include a direct rail line connecting Pudong and Hongqiao Airports[18]. This suggests the importance of connecting the main international airport to the rail network has been recognized, but not yet the benefits of fully adopting the integrated hub model at Hongqiao.

7. Notes

1. See http://baike.baidu.com/view/3119844.htm (last accessed on 6/7/2016).
2. A random test by one of the authors revealed that it is possible to walk from the airport to the railway station without using any other modes of transportation, in about 10 min.
3. https://en.wikipedia.org/wiki/List_of_the_busiest_ airports_in_China#cite_note-1.
4. Based on ACI data, published on Wikipedia (https:// en.wikipedia.org/wiki/List_of_the_world%27s_ busiest_airports_by_passenger_traffic – accessed 18 October 2015).
5. Passengers who, for example, used the metro to get to the airport are counted twice: first arrival from Metro, followed by second departure from airport.
6. The forecast assumes the construction of interairport (Hongqiao–Pudong) and Shanghai-Hangzhou Maglev project, which to date has not been approved.
7. See Li 2014 and Qian et al. 2014 for the mode split on access journey to other large airports in China.
8. China Northern Airlines, China Southwest Airlines and China Northwest Airlines were integrated into China Southern Airlines, Air China, and China Eastern Airlines, respectively, in 2002 as part of the CAAC reorganization strategy.
9. The interviewees included: An Urban Planning Professor of Tongji University; the Deputy Director of Shanghai Comprehensive Transportation Planning Institute; and the Planning Manager of Hongqiao Airport. The interviews were conducted in the Summer of 2014.

10. In Table 3, the term ‘HSR’ refers to the so-called passenger dedicated HSR long lines passing through the study area (e.g. Beijing–Shanghai high-speed railway). The term ‘Intercity Rail’ refers to those HSR short lines running between cities within the study area (e.g. Shanghai–Nanjing intercity high-speed railway, Shanghai–Hangzhou intercity high-speed railway). Technologically, they are both HSR lines carrying train types G and D.
11. For air services, the cheapest economy fare and, for rail, the fare for the fastest service were assumed. While rail schedules and fares are relatively constant across days (as there is only one service supplier), air flight schedules and fares fluctuate over time due to the existence of competition between multiple airlines and travel agencies. This means that rail fares might be more attractive, especially closer to the day of departure. Data used here represent the average.
12. For air transport, five daily services or higher is considered to be high-frequency service.
13. The new line is planned with a station at San Francisco International airport at one end of the line, but without connection to Los Angeles International airport on the other end.
14. HS2, or high-speed 2, is the HSR line planned from London to the North, Birmingham in stage 1 and later Manchester and Leeds in Stage 2. Heathrow airport is not planned as a station on the line, but a branch line connection is planned as part of Stage 2. The connection of HS2 with HS1, will allow HSR services from Britain to Europe, Paris and Brussels especially.
15. It is evident in Tables 4 and 5 that currently there are many ‘thin’ (with very low frequency of service) routes served by both air and HSR services, often in competition between the modes.
16. At present, the interairport link between Hongqiao and Pudong Airports (separated by Huangpu River) is very poor, taking one hour or longer. Metro Line 2 that connects the airports is very crowded since it serves and traverses the urban CBD area. At present, the planned Maglev service between the airports has been suspended.
17. Source: http://english.gov.cn/policies/policy_watch/2016/06/30/content_281475383269632.htm. (last accessed on 2/8/16).
18. Source: http://news.takungpao.com/mainland/focus/ 2016-02/3282727.html. (last accessed on 2/8/16).

8. Disclosure statement

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11. Appendix A.Types of trains services operating in China

Train type and specifications	Main characteristics
G – High-speed electric multiple units (eMU) train	The fastest, long distance train in China, with top speed of up to 300 km/h. [since the Wenzhou collision accident on July 23 2011, the government has ordered the maximum operating speed to be cut to 300 km/h, from 350 km/h. This speed policy is being reevaluated by China railway Corporation (source: http://www.singpao.com/xw/nd/201510/ t20151016_575726.html)].
– electric multiple units (eMU)	Called Hexiehao (Harmony) or bullet trains in Chinese. Designed for top speed of 250 km/h. Have been widely used for serving fast and frequent services between the main cities, such as Beijing–shanghai, shanghai–suzhou and shenzhen–Guangzhou.
– intercity eMU	same as train G with top speed of up to 300 km/h, but runs on shorter distance routes, largely between two nearby cities. For example, the 120-km Beijing–Tianjin intercity railway.
Z – Direct express	With top speed of 160 km/h, this train is also used for long-distance travel. in general, run directly to the destination city or with limited number of stops on the way.
T – express	This train type has limited number of stops on routes mainly in the major cities. The highest speed is 140 km/h.
K – Fast	This train type has a top speed of 120 km/h and has more stops than the T type.
s – suburban	This train type has a top speed of 100 km/h, it travels on relatively short routes, and is largely used for travel (commuting) between the city center and the suburbs.
– Temporary	This series is in operation only during the peak travel time, such as in the Chinese spring Festival and the national Holiday. These services will not be listed in the official schedule. These trains are often subject to delays. its top speed is 100 km/h.
Y – Tourist	This train type largely serves tourist destinations such as popular tourist cities. For example, there are Y-trains departing between Beijing and Qinhuangdao. its top speed is 120 km/h.

Source:

China railway Corporation. 2014. The notice on printing and issuing new Train services, no. 308. accessed December 4, 2015 from: http://bbs.railcn.net/ thread-1499931-1-1.html.