https://doi.org/10.3311/PPtr.38792 | 1

Periodica Polytechnica Transportation Engineering

Assessing the Impact of High-Speed Rail Development on Conventional Passenger Trains and Sustainability of Transportation in Indonesia

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Received: 12 November 2024, Accepted: 27 August 2025, Published online: 05 December 2025

Abstract

There are many studies on the impact of high-speed rail (HSR) on airplane travel demand, economic growth, connectivity, accessibility, and regional development. However, the degrees to which HSR affects the demand for conventional passenger trains and operation of conventional rail are rarely discussed. This study attempted to fill this gap by identifying and investigating the potential impact of introducing a high-speed rail network in Indonesia, focusing on its implications for conventional passenger trains and the overall sustainability of the transportation system, utilizing an origin-destination matrix, a stated preference survey and choice analysis. The results show that fare is an influential attribute compared to travel time. High-speed trains are substitutes for medium to long distance and complementary for short distance travel. The study provides valuable insights for transport operators, policymakers, and planners. Key findings include a nuanced understanding of potential demands, travel attributes, strategic considerations for optimizing HSR operational plans and sustainable transport.

Keywords

high-speed rail, demand, impact, stated preference, policy maker, sustainable

1 Introduction

To date, Indonesia has made significant progress in high-speed rail (HSR) development, particularly with the operational Jakarta to Bandung route covering 89.4 miles (143 kms). The Indonesia National Railway Masterplan further emphasizes the nation's commitment to HSR advancements, envisioning a comprehensive 446 miles (713 km) network connecting Jakarta to Surabaya, intending to reduce the travel time between these major cities to 150–180 min, facilitated by trains reaching speeds up to 170 mph (Coordinating Ministry for The Economic, 2023). It's essential to note that the current travel time between Jakarta and Surabaya is approximately 10 hours by executive train and 4 hours by plane, accounting for various pre-flight and post-flight activities (Nurhidayat et al., 2018). The last few decades have witnessed rapid growth in Chinese railway sectors in terms of travel demand and technological development (Chen and Haynes, 2017). This development included the introduction of high-speed rails (HSR) that affect conventional passenger train and cargo train services (Cheng and Chen, 2021). HSR has been the most significant technological breakthrough in the rolling stock industry since 1964 (Jiao et al., 2017). Chinese HSR network in 2020 reached 37,900 km (Cheng and Chen, 2021), and it carried seven billion passengers in 1.7 billion trips a year. Meanwhile, HSR carried 143 million and 130 million passengers in Japan and France, respectively (Li et al., 2019).

Studies on the effect of HSR have been conducted on various aspects, including its effect on regional economic growth (Chen et al., 2016), travel demands and competition between HSR and plane (Chen et al., 2019; Gu and Wan, 2020; Nurhidayat et al., 2018, 2023; Ren et al., 2020; Wang et al., 2020b; Wang et al., 2020a; Yang et al., 2018a),

Cite this article as: Nurhidayat, A. Y., Widyastuti, H., Sutikno, Upahita, D. P. (2025) "Assessing the Impact of High-Speed Rail Development on Conventional Passenger Trains and Sustainability of Transportation in Indonesia", Periodica Polytechnica Transportation Engineering, https://doi.org/10.3311/PPtr.38792

competition with conventional rail (Cheng and Chen, 2021), and the aviation industry (Bukovac and Douglas, 2019; Fu et al., 2012; Su et al., 2020; Wong et al., 2002; Zhang et al., 2019a; Zhang et al., 2017). However, the effect of HSR on conventional passenger and cargo trains remains unclear. The study by Wang et al. (2020a) reported that the HSR network has a substitution effect on intercity bus services. A shift toward high-speed trains has been increasingly supported due to environmental reasons, as the effect of air transport on environmental pollution has increased to an alarming level (D'Alfonso et al., 2016; Strauss et al., 2021; Yu et al., 2021). The study by Li et al. (2020) examined the effect of HSR on the conventional trains and found that HSR could reduce the conventional train travel frequency. Cheng and Chen (2021) reported a decrease in conventional train operational capacity due to the presence of HSR service. Although the effect of HSR on conventional trains has been examined, further investigation into the attributes that affect HSR passengers' preferences, such as price, frequency, travel time, and the degree of their effect on each corridor, is necessary.

HSR expansion may cause economic loss and high market risk due to substantial construction costs (Zhao et al., 2015); hence, it is suggested to improve the conventional train services to address the increasing demands instead of establishing a new HSR network (Wu et al., 2014). However, such an argument is still unclear as other cost components, travel time, and other variables should be taken into account in developing HSR (Ren et al., 2019). One of the factors responsible for a city's economic, environmental, and social development is the provision of proper public transportation with good service (Gwilliam, 2008). The development of the HSR network could improve the property value along the corridor (Chen and Haynes, 2015) and improve social welfare (Wang et al., 2020c). Therefore, the government needs to apply proper regulations to improve the benefits of both modes of transport (Tsunoda, 2018) and consider the potential of intermodal integration (Socorro and Viecens, 2013) as it may enhance travel frequency and reduce emissions (Jiang et al., 2021). The considerable investment cost for HSR development has become a particular concern, especially when compared to investment for the conventional rail transport. Albalate and Bel (2012) state that HSR development may cost between $22.5 to 50 million per mile, which is 1.45 – 3 times higher than conventional railway development cost (Cheng and Chen, 2021; Li et al., 2020). The line between Jakarta, Cirebon, Semarang, and Surabaya carries 3.3 million people annually on executive trains. It implies that there is great potential for development along the corridor. On the other hand, HSR could pose a great challenge for the conventional railway and aviation industry as HSR may serve as a complementary or even substituting mode for the same route, thus affecting the demands on the particular route.

Table 1 shows the distance, travel time by existing train and high-speed rail for the three main corridors of the Jakarta-Cirebon, Jakarta-Semarang and Jakarta-Surabaya railway lines.

This study addresses several critical points to contribute to existing literature. Firstly, it assesses the current and potential demand for conventional passenger trains and operational capacity, utilizing the corridor capacity as a limitation for each studied corridor. Secondly, it investigates travel attributes such as travel time and fare, which significantly influence user preferences, along with assessing HSR's contribution to the passenger rail system's capacity. A stated preference survey is conducted to discern passenger preferences and the potential impact of HSR services on conventional trains in each corridor. Lastly, the study provides a scientific basis for transportation planners to optimize HSR operational plans, serving as a strategic foundation for policymakers to guide investments in HSR development and sustainable transportation.

This paper is organized as follows: Section 2 presents relevant studies, material and methods in detail. In Section 3, the analysis result of potential demands, travel attributes, and HSR effect are described. Lastly, the conclusion and limitations of this study, as well as potential recommendations for future studies, are discussed in Section 4.

2 Materials and methods

Relevant literature on the effect of HSR on the conventional train services was reviewed, including literature related to travel attributes, stated preference survey, modal split, and discrete choice model to analyze the transportation impacts. Research gaps were identified based on the analysis of the literature. The literature review aimed to (a) describe the main attributes used in the HSR preference model and (b) understand the effect of HSR in the Indonesian context in terms of social, economic, and route characteristics.

Table 1 Travel time and distance by existing rail services

Route	Distance (km)	Travel Time using Existing Rail	Travel Time using HSR
Jakarta - Cirebon	210	2 h 31 min	46 min
Jakarta - Semarang	435	5 h 7 min	1 h 36 min
Jakarta - Surabaya	713	8 h 30 min	2 h 36 min

2.1 Research gaps

Although a number of studies have evaluated the effect of HSR operation on regional economic growth, accessibility, connectivity changes, transit-oriented development (TOD) development around HSR stations, airplane travel and aviation industry demand, limited attention is given to its effect on conventional train services, particularly the passenger train services. Previous studies examined HSR using available data panels, including travel data, service frequency, and departure schedule, and only a few studies investigated travel characteristics, travel variables, and service capacity. As a result, the impacts on conventional train services when HSR is in operation remain unclear. The present study attempts to contribute to the body literature by first analyzing the demands of the conventional train services on HSR's potential route. The route demands were presented in the form of an origin-destination matrix to illustrate the potentials and the effect of HSR on each corridor. Second, identifying the extent of the impact of high-speed rail operations on service distances. Third, examining the effect of HSR on conventional passenger trains to find out the role of HSR, whether it serves as a substitution or a complementary mode.

2.2 Travel attributes

Literature on travel attributes shows that some characteristics, such as population density, land availability, recreational facility, city size, and accessibility, may affect passengers' preference for transportation modes, especially for stations located in urban areas (Beckerich et al., 2019; Hall, 2013; Kim et al., 2018; Mohino et al., 2014; Yin et al., 2015). Some travel attributes, including cost, travel time, frequency, population, and GDP, are considered to significantly affect mode preference. Travel time was found to be an important factor in mode choice in China (Yang et al., 2018a; Yang and Zhang, 2012) and Europe (Dobruszkes, 2011). Various attributes such as travel frequency (Dobruszkes, 2011; Dobruszkes et al., 2014; Inoue et al., 2015; Lee et al., 2016; Park and Ha, 2006), income (Castillo-Manzano et al., 2015; Li and Sheng, 2016; Nurhidayat et al., 2018), and ticket price (Albalate et al., 2015; Behrens and Pels, 2012; Brueckner et al., 2013; Cascetta et al., 2011; Hofer et al., 2008; Zhang et al., 2017) were also found to significantly influence mode preference. A recent study conducted by Li et al. (2020) included frequencies, time, and seat availability as factors affecting mode preference in the mode choice model. Different demographic, social, economic, and geographic conditions of the route location may influence the characteristics of the trip maker and their travel attributes. Hence, it is important to evaluate the travel attributes and the trains' operational capacity in different routes and see how their performance affects each corridor.

2.3 The impact of introducing HSR on air travel demand and conventional rail transport

The effect of HSR on the aviation industry has drawn significant attention, and many studies have reported that HSR exhibited a substitution effect on air transportation as it decreases demands on air transportation (Albalate et al., 2015; Chen and Haynes, 2017; Wan et al., 2016; Wang, et al., 2020b; Wang et al., 2018; Yang et al., 2018a), especially passengers of LCC or FSC classes (Clewlow et al., 2014; Lee et al., 2016; Su et al., 2020; Wang et al., 2020d). The competition between HSR and air travel appears to be influenced by several attributes such as cost/tariffs, travel time, and frequency (Delaplace and Dobruszkes, 2015; Inoue et al., 2015; Martín and Nombela, 2007; Yang et al., 2018a; Zeng and Wang, 2020; Zhang et al., 2017), distance, population, and GDP (Albalate et al., 2015; Bilotkach et al., 2010; Castillo-Manzano et al., 2015; Chen et al., 2016; Li et al., 2020; Zhang et al., 2018; Zhang et al., 2020). The development of the HSR network is reported to significantly affect accessibility and connectivity (Jiao et al., 2017) as well as the improvement of the economy (Li et al., 2018).

Meanwhile, a study by Li et al. (2020) applied a difference in difference (DID) approach and found that HSR operation affects conventional trains' frequency, even without significant changes in tariffs and travel time. The study by Cheng and Chen (2021) also found that HSR operation decreased the conventional train route capacity. The study focused on the relationship between HSR and conventional train operations and partially depicted the effect of HSR on cargo train capacity. On the other hand, the study by Wu et al. (2014), who examined the HSR network expansion to resolve issues on rail capacity, found that improving conventional trains is more feasible than establishing a new HSR network due to high investment costs.

2.4 The stated preference (SP) and choice modelling

Stated preference survey has been widely used in transportation and market research to determine the preferences of users towards new transport modes or products compared to existing ones (Nurhidayat et al., 2018). SP refers to a survey method that is used to assess user preference towards an alternative mode that does not yet exist. The survey framework consists of several scenarios of attribute combinations that are perceived to affect one's travel preference (Lee et al., 2016).

This survey is conducted to see the response regarding one's preference over several travel alternatives.

The mode selection model aims to determine the proportion of people who will use each mode (McFadden, 1981). This process is carried out to calibrate the mode selection model in the base year by knowing the independent variables that affect the mode selection. After the calibration process has been carried out, the model can be used to predict the mode selection by using the value of the independent variable for the future. Most studies employed a network analysis model, econometric model, and gravity model to investigate the mode preference and mode choice model (Cheng and Chen, 2021). A study conducted by Yang et al. (2018a) used regression panels from 2007 to 2013 and an econometric model to demonstrate the negative effect of HSR operation on three major airlines in China (Zhang et al., 2017). Meanwhile, Wan et al. (2016) used the DID approach to depict the HSR operation in China, Japan, and South Korea. Lee et al. (2016) used a mixed logit model to identify the preference between HSR and airplanes for the Seoul-Jeju route. Cheng and Chen (2021) applied SEM to evaluate factors affecting travel behaviors and modal preference between HSR and conventional trains. A linear regression-based econometric model has also been applied to analyze the demands for HSR and air passenger traffic in Europe and forecasting practices (Clewlow et al., 2014). Table 2 shows various studies on the impact of HSR on conventional train and air transport services, including the type of model and research method.

2.5 Data collection

The stated preference survey and logit binomial model were used to model and predict conventional train passengers' preferences on the HSR. Both techniques are commonly used for identifying travel attributes and passengers' behaviors with regard to alternative modal preferences (Danapour et al., 2018; Hess and Polak, 2005; Park and Ha, 2006;Román et al., 2007). Data were collected by distributing questionnaires and conducting interviews directly in the predetermined locations, i.e., train stations along the proposed HSR corridor (Gambir Station, Cirebon Station, Semarang Tawang Station, and Surabaya Pasarturi Station). The total number of respondents for the Jakarta-Cirebon corridor was 250 respondents, 410 respondents for the Jakarta-Semarang corridor, and 378 respondents for the Jakarta-Surabaya corridor. Specifically, as illustrated in Fig. 1, the following corridors were included: Jakarta-Cirebon (JKT-CN), Jakarta-Semarang (JKT-SMT), and Jakarta-Surabaya (JKT-SBI). The total track length of these corridors is 713 km (446 mil).

2.6 Design questionnaire

The SP survey compared two modes of transportation, including HSR and conventional trains, for each corridor mentioned previously. HSR was considered as the alternative mode of transport, while the conventional train was the existing mode. Travel attributes were also included in the questionnaire to describe the characteristics of these two modes. The variable was chosen based on analysis from previous studies. Fare and travel time were chosen as the main attributes based on the analysis and review of previous studies about mode choice and user preference.

The questionnaire comprised four main sections. The first section is about the respondents' profiles, including age, gender, education level, occupation, and monthly income. The second section describes the passengers' travel characteristics, including travel origin, origin base, travel purpose, total travel time, and total travel distance. In the third section, the respondents were asked to rank the importance of factors affecting their preference: speed, comfort, safety, weather sensitivity, fare, punctuality, access, and security. The respondents were asked to rank the factors from the most important (1) to the least important (8). The fourth section measured the passengers' preference toward the offered modes (HSR and conventional train) when both modes were in operation (see Table 3). The participants were asked to complete a set of stated preference statements to indicate their preference towards the two modes in different hypothetical scenarios of tariff and travel time. The participants needed to respond with their preference on each statement in a 5-scale Likert option, ranging from 1 (stay using current mode) to 5 (move to new mode).

2.7 Analysis method: the model of user preference and model calibration

In this study, we used a stated preference approach to build a mode selection model based on the answers that have been chosen by the respondents. We then built a mode selection model to analyze the high-speed rail travel demand, and we used travel attributes, i.e., fares and total travel time. We set these two variables at different levels to obtain a combination of respondents' answers so that the best mode selection model could be obtained (Ben-Akiva and Lerman, 1985). In the rating technique, respondents expressed the degree of their best choice by using semantic and numeric scales. The scale was defined with sentences such as "Definitely choose A", "Maybe choose B", "Do not choose either". Respondents can be asked to express their preference for each choice by showing a certain score or by choosing between a pair of choices. If the respondents state their preference

Table 2 Studies of the impact of HSR operation on conventional rail and air transport services

Author	Type of model	Research method	Results
Cheng and Chen (2021)	SEM	Panel data	Although the impacts vary spatially in different corridors, HSR has been demonstrated to have a substitutional effect on conventional passenger trains.
Albalate et al. (2015)	Multivariate econometric regression	Level year panel data (route)	With considerable competition between HSR and airplanes, HSR can feed airports for long-haul flights.
Behrens and Pels (2012)	Multinomial and mixed logit models	SP	HSR is a worthy substitute for airline travel
Zhang et al. (2020)	Herfindahl– Hirschman Index (HHI) and Lerner index	Paned data	HSR wants to reduce demand for the airplane market
Wang et al. (2020d)	Regression models	Panel data	Low-cost high-speed rail operations have an impact on air traffic and full-service high-speed rail (FSR's)
Su et al. (2020)	Econometric models	Panel data	The HSR contributes to lowering profitability and airfares
Mizutani and Sakai (2021)	DID (Difference in Differences)	Survey	The HSR has an impact on airfare and medium distances
(Wu et al., 2014)	-	Panel data	The operations of HSR led to a considerable reduction in travel demand as well as high investment costs.
Chai et al. (2018)	Regression models	Panel data	The HSR travel time has a shock effect on aviation transportation
Chen et al. (2019)	Regression models	Panel data	HSR entry reduced air passenger volume by 17.88% and flight frequency by 15.80%
Jiménez and Betancor (2012)	Regression models	Route-level data	HSR service entry reduces air travel by 17%
Li et al. (2020)	Nested logit, DID	Panel data	HSR service entry reduces the frequency of conventional rail services

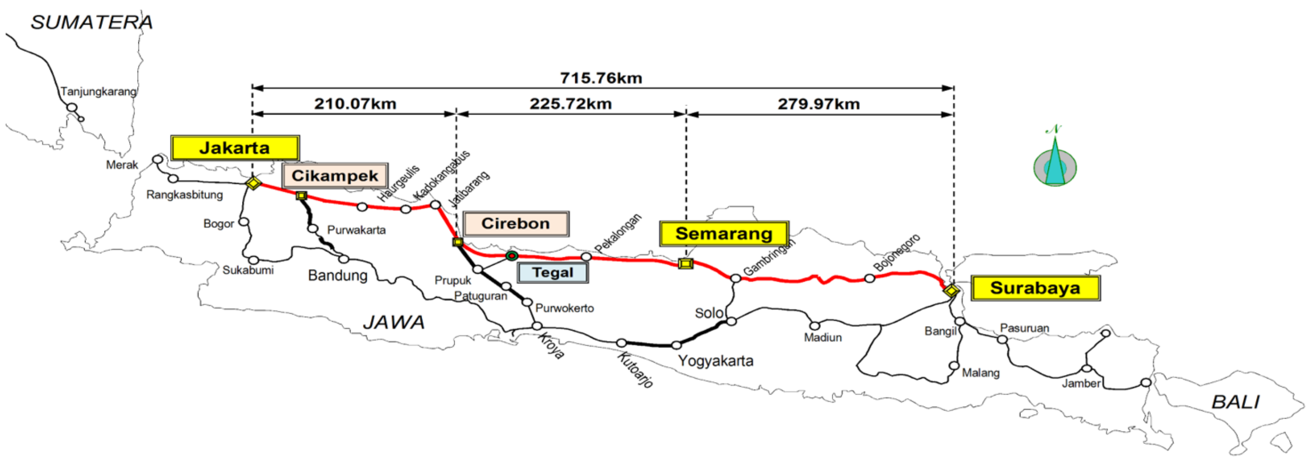

Fig. 1 The three rail corridors utilized in the analysis

among the chosen pairs, a scale of 1 to 5 is usually used to indicate the possible choices. Several practitioners have used the following symmetric scale: $C_1 = 2.197$, $C_2 = 0.847$, $C_3 = 0.000$, $C_4 = -0.847$, $C_5 = -2.197$, which corresponds to the Berkson-Theil transformation of the following choice probabilities: 0.1, 0.3, 0.5, 0.7, 0.9 (Ortúzar andWillumsen, 2011). The utility function was built using the linear regression method.

According to the concept of random utility (Ben-Akiva and Lerman, 1985), the probability that a choice tends to alternative i is the same as the probability that the utility of alternative i is greater than or equal to the utility of other alternatives from a set of alternatives. So the probability of alternative i being chosen by n individuals who are faced with some alternatives C_n is as follows:

Table 3 The scenarios for the stated preference survey

Attributes	Conventional	HST	Choice
Travel time (minute)	540	420	
Travel cost/fare ($)	40	45	
Travel time (minute)	540	420	
Travel cost/fare ($)	40	60	
Travel time (minute)	540	300	
Travel cost/fare ($)	40	45	
Travel time (minute)	540	300	
Travel cost/fare ($)	40	65	
Travel time (minute)	540	180	
Travel cost/fare ($)	40	50	
Travel time (minute)	540	180	
Travel cost/fare ($)	40	70	
Travel time (minute)	540	120	
Travel cost/fare ($)	40	50	
Travel time (minute)	540	120	
Travel cost/fare ($)	40	75	

$$P_n\left(i|C_n\right) = Prob\left(U_{in} \geq U_{jn}, \forall j \in C_n\right) \tag{1}$$

In the binomial logit model, C_n consists of two alternatives (for example, alternatives i and j), so the probability of individual n choosing alternative i is:

$$P_n\left(i|C_n\right) = Prob\left(U_{in} \geq U_{jn}\right) \tag{2}$$

While the probability of choosing alternative j is:

$$P_{jn} = 1 - P_{in} \tag{3}$$

The binomial logit model is built on the assumption that $\varepsilon_n = \varepsilon_{jn} - \varepsilon_{in}$ will be independent and identically distributed according to the logistics distribution function, as follows:

$$F\left(\varepsilon_n\right) = \frac{1}{1+e^{-\alpha\varepsilon}}, \alpha > 0, -\infty < \varepsilon_n < \infty \tag{4}$$

Where α is a parameter with a positive scale beside the approach with the normal distribution being quite good, the logistic distribution is easier to analyze. Assuming that ε_n is logistically distributed, the probability of choice for alternative i is given by:

$$P_n\left(i\right) = Prob\left(U_{in} \geq U_{jn}\right) \tag{5}$$

Data from field interviews were used to calibrate the utility function for the new mode (HSR). A regression analysis produced the constant value and coefficient for the utility function (u (TD, CD)) that is used in the logit binomial function (Janić, 1993; Liu and Li, 2012).

$$U_i = \beta_0 + \beta_1\left(\text{travel time}\right) + \beta_2\left(\text{travel cost}\right) \tag{6}$$

Eq. (6) shows the constant and coefficient values of the utility function. Based on the result of regression analysis with a 95% confidence level, we found that the ordinary least square value for the utility model is 0.50. It means that the utility model has good closeness to represent the real condition. The ordinary least square of 0.50 means that the influence of all attributes on the utility of this model is 50%, and the rest is influenced by other attributes that are not included in this model. A study on mode choice between HSR and economy and business class airplanes in Japan used a discrete choice model with linear regression and an ordinary least square method (Mizutani and Sakai, 2021).

3 Results and discussion

3.1 Conventional rail potential demand

Demands for conventional trains and HSR in countries with both modes of transport tend to increase. The total conventional train passenger demand in the next fifty years was predicted using the observed years (2012–2019) as the baseline, and we used demand elasticity with income growth, annual average (Nurhidayat et al., 2018) and average growth of 2.4% and 4.3% per year (Kroes and Savelberg, 2019). Population growth averaged 1.31% (2012–2019), economic growth averaged 5.71% (2012–2019), and regional development based on the regulation and predictive steps agreed upon by the transportation planners and policymakers in Indonesia were also considered as factors that influence passenger demand growth. The data from Indonesia Railway Company (PT. KAI) demonstrates the increase in conventional train demands in the last few years. Fig. 2 shows the potential demands for the conventional train services in Indonesia, based on the average annual passenger increase and the travel origin-destination.

The potential demand for rail passenger travel based on origin and destination is depicted in Fig. 2 above for the years 2019 through 2040. It is clear that the growth in each corridor varies. It should be pointed out that the COVID-19 epidemic caused a significant decline in demand for conventional train travel of about 70%, which was assisted by Indonesia's economic development, which only reached 2.97%, starting in 2020. Many nations have reacted to the COVID-19 outbreak by implementing economic strategies to mitigate its effects. Beginning in 2023, due to improved Indonesia's economic situation and lifting the pandemic status, passenger growth will resume its typical pattern. The growth environment will revert to normal starting in 2028 (Gagnon et al., 2023; Takyi et al., 2023).

Fig. 2 Visualization based on network keywords from Author keywords: (a) Jakarta–Cirebon; (b) Jakarta–Semarang; (c) Jakarta–Surabaya; (d) Semarang–Surabaya

3.2 Travel attribute priority

The survey also covers the factors that influence the respondent mode choice, as shown in Fig. 3. The result shows that most of the respondents choose safety and comfort as the most important factors that influence their mode choice, while the resistance to weather and fare are the lowest priority. Meanwhile, speed and punctuality have only medium priority in the mode choice. The speed of the vehicle will affect the travel time; from this, one can say most of the respondents put travel time on a higher priority than cost.

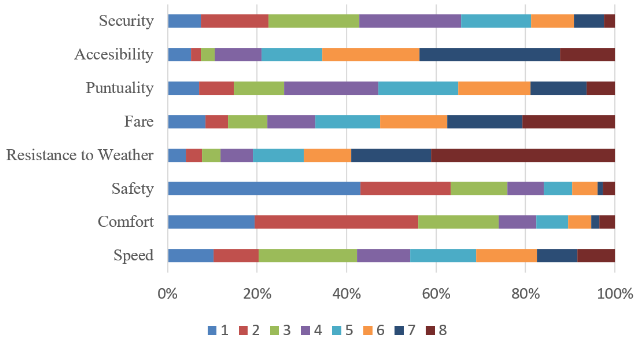

Fig. 3 Priority of travel attributes in transport mode selection

Gundelfinger-Casar and Coto-Millán (2017) found that fare and travel time are important attributes that determine the modal preference in Spain. Similarly, Ma et al. (2019) also reported that fare and travel time are the most influential attributes of HSR modal preference for the Beijing-Shanghai route. Fare and travel time are consistently reported to be the main factors affecting one's preference (Capozza, 2016; Martín and Nombela, 2007; Ortúzar and Simonetti, 2008; Zeng and Wang, 2020). Li and Sheng (2016) found that HSR travel time is the most important factor in affecting HSR market share.

As has been discussed in Section 2, travel time and ticket fare are the two most dominant attributes that influence the travelers' mode preference (Yang, et al., 2018b). The analysis results indicate that travel time is the main attribute ($p < 0.05$) that influences mode preference in the Jakarta – Surabaya Corridor. The results also show that ticket fare has a smaller coefficient and does not significantly influence the mode choice for the Jakarta – Surabaya Corridor. In other words, the travelers on the Jakarta – Surabaya Corridor tend to choose their mode of travel based on the travel speed since they are more concerned about the travel time. The result is different from previous studies in China that found that both travel time (Yang, et al., 2018b) and ticket fare (Xia and Zhang, 2017; Yang, et al., 2018a) significantly influenced mode choice. Meanwhile, studies in Europe found that travel time and trip frequency significantly influence the mode choice (Dobruszkes, 2011) and (Behrens and Pels, 2012).

3.3 Modal competition HSR

We used the discrete choice model to find attributes (e.g., traveling time and fare) that influence travelers' choice of transport mode (HSR or conventional rail) and the impact of introducing HSR on the conventional rail route between Jakarta and Surabaya. Table 4 summarizes respondents' characteristics, including gender, age, level of education,

Table 4 Respondents' characteristics

Demographic and socioeconomic	Categories	Jakarta-Cirebon		Jakarta-Semarang		Jakarta-Surabaya	
		Tot.	Perc.	Tot.	Perc.	Tot.	Perc.
Age	Below 18 years	12	4.8	12	2.9	5	1.3
	18–29 years old	80	32.1	133	32.5	77	20.4
	30–39 years old	60	24.1	95	23.2	92	24.4
	40–49 years old	58	23.3	71	17.4	115	30.5
	50–60 years old	21	8.4	61	14.9	50	13.3
	61 and above	18	7.2	37	9.0	38	10.1
Gender	Male	175	66.3	250	61.1	244	64.7
	Female	74	29.7	149	36.4	125	33.2
Lev. of Education	Junior high school	16	6.4	21	5.1	24	6.4
	Senior high school	89	35.7	119	29.1	123	32.6
	Diploma	21	8.4	27	6.6	25	6.6
	Undergraduate	100	40.2	185	45.2	176	46.7
	Postgraduate	18	7.2	50	12.2	18	4.8
Occupation	Civil servant	12	4.8	50	12.2	42	11.1
	Private employee	106	42.6	173	42.3	122	32.4
	Businessman/entrepreneur	56	22.5	49	12.0	86	22.8
	Professional	6	2.4	10	2.4	5	1.3
	Students	37	14.9	51	12.5	35	9.3
	Housewife	19	7.6	39	9.5	50	13.3
	Others	11	4.4	29	7.1	32	8.5
Monthly income	< IDR 3 million	49	19.7	75	18.3	74	19.6
	IDR 3–6 million	79	31.7	113	27.6	94	24.9
	IDR 6–9 million	40	16.1	69	16.9	85	22.5
	IDR 9–12 million	22	8.8	38	9.3	49	13.0
	IDR 12–15 million	8	3.2	17	4.2	22	5.8
	IDR 15–18 million	5	2.0	20	4.9	9	2.4
	IDR 18–21 million	1	0.4	6	1.5	3	.8
	> IDR 21 million	13	5.2	14	3.4	10	2.7
Trip Purpose	Work	161	64.7	278	68.0	208	55.2
	Social purposes	39	15.7	59	14.4	95	25.2
	Vacation	19	7.6	23	5.6	22	5.8
	Business	9	3.6	16	3.9	25	6.6
	School/college	11	4.4	13	3.2	13	3.4
	Others	1	0.4	155	12	3	.8

Source: Authors' calculation.

occupation, and their traveling purposes. These data are useful for further comparing the characteristics of passengers of different traveling modes for each corridor. Most of the respondents were between 18–49 years old, i.e. in the productive age range. Most of them worked as private employees or businessmen/entrepreneurs, which explains their need to travel between cities. It is in line with the trip purpose of the respondent. More than half of the trip purposes were related to working trips.

The binomial model was used for the proposed mode preference model to explain the attributes affecting the HSR modal preference and their effect on conventional train services. Each respondent's answer was examined to find out its consistency with traveling time and cost as the main factor. The answer was also further categorized based on explanatory factors, including travel frequency, mode of transport, travel purpose, and socioeconomic conditions. The survey's results also indicated that most conventional train users have two primary characteristics: they tended to be under 49 years old and came from average middle-class workers. Most respondents (75.4%) were under 49 years old, and 80% had less than \$800 income for the Jakarta-Surabaya route. It suits big cities' income characteristics, as Moss and Qing (2012) asserted.

This study focused on the difference in both train fare and travel time, which are considered to significantly affect passenger's preferences (Mizutani and Sakai, 2021). The effect of the fare and travel time differences was captured using the responses of the respondents for different scenarios based on the combination of fare and travel time differences. The analysis results were used to evaluate the effect of HSR operation on the conventional train. The results were defined as the log-linear equation presented in Eq. (1). A 5% estimation error was applied to minimize bias during the data collection. The results of the discrete model with simulation data are shown in Table 5.

Table 5 Results of the model parameters

Variable	Origin - Destination		
	JKT-CN	JKT-SMT	JKT-SBI
Constants			
Constants (β_0)	5.063532073	2.939257497	5.437937077
Independent variable:			
Time different (β_1)	2.903825192	3.790528391	1.616524694
Cost different (β_2)	−0.000107262	−8.46769E-05	−6.31098E-05
Observations	1525	2507	2124
R^2	0.598867278	0.557924266	0.61072996
Multiple R	0.773865155	0.746943282	0.78149213
p-value	0.004**	0.002**	0.001**

** Significant at $\alpha = 0.05$.

3.4 Effect on travel time and fare to market competition

Competition in the HSR market has a direct impact on the fares and services offered especially to existing rail passengers. Existing rail transport currently offers different classes (luxury, executive, business and economy). The fare structure offered and the travel time given to existing rail users provide many alternative options to choose from. Different fares and travel times will show different flexibilities which will be shown in the sensitivity model and modal share. A model using two travel attributes, travel time and fare, was developed to explain the mode preference without inclusion of the traveling frequency (Behrens and Pels, 2012; Dobruszkes, 2009; Dobruszkes et al., 2014). A p-value of less than 0.05 was applied for each corridor. The result showed that in each corridor the p-value is less than 0.05, implying that travel time may significantly affect the Jakarta-Surabaya route. In other words, respondents in this study tended to choose a mode of transport based on their socioeconomic level and traveling purposes between the two cities. This study is consistent with the findings in the Chinese context, where travel time (Dobruszkes et al., 2014; Yang, et al., 2018a) and fare are more important (Yang, et al., 2018a; Yang and Zhang, 2012; Zhang et al., 2019b), whereas in Europe, travel time and frequency emerged as the most important factors in mode choice model (Behrens and Pels, 2012; Dobruszkes, 2009, 2011).

Model elasticity is used to determine the sensitivity of attribute changes to the probability of mode selection by measuring the percentage change in the probability of mode selection due to a change in the percentage of a particular attribute in the utility function of each model. For example, using the utility difference of the existing travel attributes, the utility value and probability of selecting high-speed rail and conventional rail can be calculated based on the obtained model equation (see Table 5). Changes in existing trip attribute values are used to test the elasticity of the model and not the differences in attribute values between the two modes. For example, the Jakarta-Cirebon corridor. By referring to Eq. (5), the probability is obtained as:

$$P = \frac{\exp^{U_{jkt-cn}}}{1+\exp^{U_{jkt-cn}}} \tag{7}$$

Where U = utility function, a_1 = time difference, and a_2 = cost difference. The average probability obtained from the time different and cost different attributes is used as a potential passenger transfer from conventional trains to fast trains during current real operating conditions and can also be used in the coming year when the fast train services start operating. The amount of passenger displacement is obtained between the average probability and the potential demand at this time of the year the high-speed rail plan operates. For market elasticities (see Table 6), a time difference of 180 min and a cost difference of 25 US$ will make 99.97% of conventional rail passengers switch to using HSR, so the effect of HSR is a substitute for conventional trains.

The competition between price and travel time offered by HSR services will have a significant impact on the conventional rail market (see Table 6 – Table 8), most conventional rail passengers will switch to HSR services. In particular, medium-distance passengers will switch to HSR and have a substitution effect for current services. The magnitude of potential demand HSR is shown in Fig. 4.

3.5 HSR impact on conventional rail

Given that the Jakarta and Surabaya corridor is a potential corridor due to the high passenger travel demand, with rail crossing capacity soon to peak in 2037, it is possible that the introduction of HSR could divert some of the conventional rail travel demand and thus the existing capacity will again change. Further analysis describes the effect size of HSR operation on conventional trains in each corridor, as shown in models in Table 6 – Table 8. The effect varied, depending on each corridor. For the Jakarta-Cirebon corridor, only 16.0% of respondents would likely move to HSR (travel time 60 min and fare 34$). In contrast, for the Jakarta-Semarang corridor, HSR operation could close the conventional train service as

Table 6 Modal share JKT-CN route

Time (min)	Cost (US$)	Modal share HSR	Time (min)	Cost (US$)	Modal share HSR	Time (min)	Cost (US$)	Modal share HSR
180	25	99.97%	120	25	100%	60	25	100%
180	26	99.69%	120	26	99.98%	60	26	100%
180	28	97.25%	120	28	99.85%	60	28	99.99%
180	29	79.69%	120	29	98.62%	60	29	99.92%
180	30	30.31%	120	30	88.81%	60	30	99.31%
180	32	4.60%	120	32	46.78%	60	32	94.13%
180	33	0.53%	120	33	08.88%	60	33	63.99%
180	34	0.0006%	120	34	1.07%	60	34	16.45%

Note: US$ 1 = 15.000 IDR

Table 7 Modal share JKT-SMT route

Time (min)	Cost (US$)	Modal share HSR	Time (min)	Cost (US$)	Modal share HSR	Time (min)	Cost (US$)	Modal share HSR
240	33	99.81%	180	33	100%	120	33	100%
240	35	98.44%	180	35	99.96%	120	35	100%
240	37	88.25%	180	37	99.70%	120	37	99.99%
240	38	47.36%	180	38	97.55%	120	38	99.94%
240	40	9.70%	180	40	82.62%	120	40	99.53%
240	42	1.27%	180	42	36.22%	120	42	96.17%
240	43	0.15%	180	43	6.35%	120	43	75.01%
240	45	0.02%	180	45	0.80%	120	45	26.39%

Note: US$ 1 = 15.000 IDR

Table 8 Modal share JKT-SBI route

Time (min)	Cost (US$)	Modal share HSR	Time (min)	Cost (US$)	Modal share HSR	Time (min)	Cost (US$)	Modal share HSR
300	43	99.92%	180	43	100%	120	43	100%
300	45	99.62%	180	45	99.98%	120	45	100%
300	47	98.18%	180	47	99.93%	120	47	100%
300	48	91.78%	180	48	99.65%	120	48	99.99%
300	50	69.79%	180	50	98.32%	120	50	99.93%
300	52	32.35%	180	52	92.38%	120	52	99.68%
300	53	9.01%	180	53	71.51%	120	53	98.45%
300	55	2.01%	180	55	34.20%	120	55	92.95%

Note: US$ 1 = 15.000 IDR

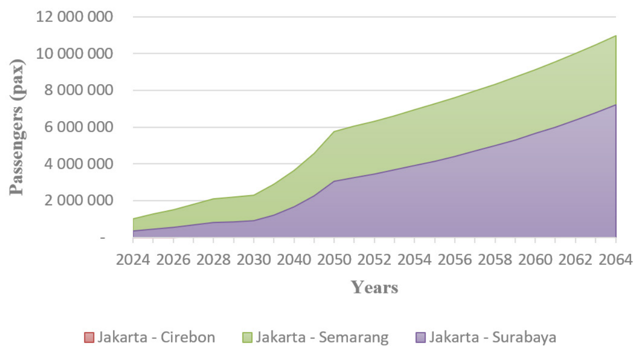

Fig. 4 Segmentation demand HSR

the model showed that 96.2% of passengers would likely move to HSR (travel time 120 min and fare 42$). HSR operation would also potentially close the conventional train service for the Jakarta-Surabaya corridor, as the model indicated that 98.3% of passengers would move to HSR (travel time 180 min and fare 50$). HSR operation in Jakarta-Surabaya and Jakarta-Semarang would likely create a substitution effect on the conventional train services, while its operation in the Jakarta-Cirebon corridor may serve as the complementary mode. The results of the analysis show that for routes with a distance of < 400 miles fast trains will only be a complement, while for routes with a distance of more than 400 miles fast trains will reduce travel demand and result in a substitution effect; this also applies to air travel. HSR market share with respect to air transportation decreases with distance. Its share becomes modest for routes beyond 400 miles (Behrens and Pels, 2012).

It has been widely acknowledged that the HSR operation significantly affected the air travel and demands for the conventional train services. Considering the high investment needed in the HSR project, primarily related to the infrastructure (Wu et al., 2014), policymakers need to ensure the competitiveness of HSR (Danapour et al., 2018). It may also adversely affect the conventional train operations due to its substitution effect. It is important for policymakers to consider the long-term effect of HSR competitiveness when deciding to make plans and regulations (Jiang and Zhang, 2016).

4 Conclusion

This study proposed an empirical model to estimate the demands for conventional rail services, influencing attributes, and the effect of HSR operation in the same corridor using a logit binomial model. The stated preference survey was used to capture the passengers' preferences. Several important and interesting findings were found from the literature review and data analysis. First, potential demands for conventional rail transport were very high, whereas the current line capacity is limited, and the demand is expected to reach capacity in 2037. However, increasing the line capacity through train speed improvement is difficult due to the limitations of the infrastructure conditions. The current maximum speed using a narrow gauge is 90 km/h for the existing route along the corridor with a rail length of 446 miles (713 km). Second, the impact of the Jakarta and Surabaya railroad passenger travel demand will be reached in 2037, meaning that the operating capacity will be met. Third, the effect of HSR operation on conventional rail service may vary, depending on the intercity distance. Modal share of HSR: from conventional rail for the Jakarta-Cirebon corridor 16%, for the Jakarta-Semarang corridor 96.2%, and for the Jakarta-Surabaya corridor 98.3% of passengers would move to HSR. This study confirmed that HSR operation likely creates a substitution effect on the conventional train services, which would affect the corridor with > 400 km distance, and it was not suitable for short distances like Jakarta-Cirebon (<400 km). The medium and long-distance corridors were found to be significantly affected by HSR operation, as the effect on travel time will be bigger than in the case of short distance travel. The shortened travel time may come with higher fares to support the HSR operation. Thus, HSR would naturally make the trade-off between the travel time and the cost.

Indonesian conventional rail would likely lose the competition when HSR is in operation (substitution), leading to conventional rail closures. The next challenge is to optimize the existing line capacity when the conventional passenger train service is closed. As an alternative, the line could be used for freight transport to minimize the logistic cost. Government intervention, as the policy maker and regulator, is necessary to support this scheme. HSR infrastructure development cost was found to be very high, and the government's policy plays a pivotal role in determining sustainable transportation policy. The balance between HSR price and travel is also important in determining the market of HSR. Although this research has its limitations, it can serve as a firm foundation for predicting the repercussions of the new HSR network on existing services operating along this route. To establish a collaborative rather than adversarial relationship with the new HSR, existing rail operators must take into account the interdependent factors of ticket prices, waiting times, frequency, convenience and location of HSR stations.

Acknowledgment
Thank you to the survey team for collecting data in the field.

References

Albalate, D., Bel, G. (2012) "High-Speed Rail: Lessons for Policy Makers from Experiences Abroad", Public Administration Review, 72(3), pp. 336–349. https://doi.org/10.1111/j.1540-6210.2011.02492.x

Albalate, D., Bel, G., Fageda, X. (2015) "Competition and cooperation between high-speed rail and air transportation services in Europe", Journal of Transport Geography, 42, pp. 166–174. https://doi.org/10.1016/j.jtrangeo.2014.07.003

Beckerich, C., Benoit, S., Delaplace, M. (2019) "Are the reasons for companies to locate around central versus peripheral high-speed rail stations different? The cases of Reims central station and Champagne-Ardenne station", European Planning Studies, 27(3), pp. 574–594. https://doi.org/10.1080/09654313.2019.1567111

Behrens, C., Pels, E. (2012) "Intermodal competition in the London-Paris passenger market: High-Speed Rail and air transport", Journal of Urban Economics, 71(3), pp. 278–288. https://doi.org/10.1016/j.jue.2011.12.005

Ben-Akiva, M., Lerman, S. R. (1985) "Discrete Choice Analysis: Theory and Application to Travel Demand", The Journal of the Operational Research Society 38(4), pp. 370–371. https://doi.org/10.2307/2582065

Bilotkach, V., Fageda, X., Flores-Fillol, R. (2010) "Scheduled service versus personal transportation: The role of distance", Regional Science and Urban Economics, 40(1), pp. 60–72. https://doi.org/10.1016/j.regsciurbeco.2009.09.003

Brueckner, J. K., Lee, D., Singer, E. S. (2013) "Airline competition and domestic US airfares: A comprehensivereappraisal", Economics of Transportation, 2(1), pp. 1–17. https://doi.org/10.1016/j.ecotra.2012.06.001

Bukovac, S., Douglas, I. (2019) "The potential impact of High Speed Rail development on Australian aviation", Journal of Air Transport Management, 78, pp. 164–174. https://doi.org/10.1016/j.jairtraman.2019.01.003

Capozza, C. (2016) "The effect of rail travel time on airline fares: First evidence from the Italian passenger market", Economics of Transportation, 6, pp. 18–24. https://doi.org/10.1016/j.ecotra.2016.06.002

Cascetta, E., Papola, A., Pagliara, F., Marzano, V. (2011) "Analysis of mobility impacts of the high speed Rome-Naples rail link using withinday dynamic mode service choice models", Journal of Transport Geography, 19(4), pp. 635–643. https://doi.org/10.1016/j.jtrangeo.2010.07.001

Castillo-Manzano, J. I., Pozo-Barajas, R., Trapero, J. R. (2015) "Measuring the substitution effects between High Speed Rail and air transport in Spain", Journal of Transport Geography, 43, pp. 59–65. https://doi.org/10.1016/j.jtrangeo.2015.01.008

Chai, J., Zhou, Y., Zhou, X., Wang, S., Zhang, Z. G., Liu, Z. (2018) "Analysis on shock effect of China's high-speed railway on aviation transport", Transportation Research Part A: Policy and Practice, 108, pp. 35–44. https://doi.org/10.1016/j.tra.2017.12.001

Chen, Z., Haynes, K. E. (2015) "Impact of high speed rail on housing values: An observation from the Beijing-Shanghai line", Journal of Transport Geography, 43, pp. 91–100. https://doi.org/10.1016/j.jtrangeo.2015.01.012

Chen, Z., Haynes, K. E. (2017) "Impact of high-speed rail on regional economic disparity in China", Journal of Transport Geography, 65, pp. 80–91. https://doi.org/10.1016/j.jtrangeo.2017.08.003

Chen, Z., Xue, J., Rose, A. Z., Haynes, K. E. (2016) "The impact of high-speed rail investment on economic and environmental change in China: A dynamic CGE analysis", Transportation Research Part A: Policy and Practice, 92, pp. 232–245. https://doi.org/10.1016/j.tra.2016.08.006

Chen, Z., Wang, Z., Jiang, H. (2019) "Analyzing the heterogeneous impacts of high-speed rail entry on air travel in China: A hierarchical panel regression approach", Transportation Research Part A: Policy and Practice, 127, pp. 86–98. https://doi.org/10.1016/j.tra.2019.07.004

Cheng, J., Chen, Z. (2021) "Impact of high-speed rail on the operational capacity of conventional rail in China", Transport Policy, 110, pp. 354–367. https://doi.org/10.1016/j.tranpol.2021.06.016

Clewlow, R. R., Sussman, J. M., Balakrishnan, H. (2014) "The impact of high-speed rail and low-cost carriers on European air passenger traffic", Transport Policy, 33, pp. 136–143. https://doi.org/10.1016/j.tranpol.2014.01.015

Coordinating Ministry for The Economic (2023) "Perubahan Ketiga Atas Peraturan Menteri Koordinator Bidang Perekonomian Nomor 7 Tahun 2021 Tentang Perubahan Daftar Proyek Strategis Nasional" (Third Amendment to the Regulation of the Coordinating Minister for Economic Affairs Number 7 of 2021 Concerning Changes to the List of National Strategic Projects), Jakarta, Indonesia. [online] Available at: https://peraturan.bpk.go.id/Details/267134/permen-ko-perekonomian-no-7-tahun-2023 [Accessed: 04 March 2024] (in Indonesian)

D'Alfonso, T., Jiang, C., Bracaglia, V. (2016) "Air transport and high-speed rail competition: Environmental implications and mitigation strategies", Transportation Research Part A: Policy and Practice, 92, pp. 261–276. https://doi.org/10.1016/j.tra.2016.06.009

Danapour, M., Nickkar, A., Jeihani, M., Khaksar, H. (2018) "Competition between high-speed rail and air transport in Iran: The case of Tehran–Isfahan", Case Studies on Transport Policy, 6(4), pp. 456–461. https://doi.org/10.1016/j.cstp.2018.05.006

Delaplace, M., Dobruszkes, F. (2015) "From low-cost airlines to low-cost high-speed rail? The French case", Transport Policy, 38, pp. 73–85. https://doi.org/10.1016/j.tranpol.2014.12.006

Dobruszkes, F. (2009) "New Europe, new low-cost air services", Journal of Transport Geography, 17(6), pp. 423–432. https://doi.org/10.1016/j.jtrangeo.2009.05.005

Dobruszkes, F. (2011) "High-speed rail and air transport competition in Western Europe: A supply-oriented perspective", Transport Policy, 18(6), pp. 870–879. https://doi.org/10.1016/j.tranpol.2011.06.002

Dobruszkes, F., Dehon, C., Givoni, M. (2014) "Does European high-speed rail affect the current level of air services? An EU-wide analysis", Transportation Research Part A: Policy and Practice, 69, pp. 461–475. https://doi.org/10.1016/j.tra.2014.09.004

Fu, X., Zhang, A., Lei, Z. (2012) "Will China's airline industry survive the entry of high-speed rail?", Research in Transportation Economics, 35(1), pp. 13–25.
https://doi.org/10.1016/j.retrec.2011.11.006

Gagnon, J. E., Kamin, S. B., Kearns, J. (2023) "The impact of the COVID-19 pandemic on global GDP growth", Journal of the Japanese and International Economies, 68, 101258.
https://doi.org/10.1016/j.jjie.2023.101258

Gu, H., Wan, Y. (2020) "Can entry of high-speed rail increase air traffic? Price competition, travel time difference and catchment expansion", Transport Policy, 97, pp. 55–72.
https://doi.org/10.1016/j.tranpol.2020.07.011

Gundelfinger-Casar, J., Coto-Millán, P. (2017) "Intermodal competition between high-speed rail and air transport in Spain", Utilities Policy, 47, pp. 12–17.
https://doi.org/10.1016/j.jup.2017.06.001

Gwilliam, K. (2008) "A review of issues in transit economics", Research in Transportation Economics, 23(1), pp. 4–22.
https://doi.org/10.1016/j.retrec.2008.10.002

Hall, P. (2013) "High Speed Two: The Great Divide", Built Environment, 39(3), pp. 339–354.
https://doi.org/10.2148/benv.39.3.339

Hess, S., Polak, J. W. (2005) "Mixed logit modelling of airport choice in multi-airport regions", Journal of Air Transport Management, 11(2), pp. 59–68.
https://doi.org/10.1016/j.jairtraman.2004.09.001

Hofer, C., Windle, R. J., Dresner, M. E. (2008) "Price premiums and low cost carrier competition", Transportation Research Part E: Logistics and Transportation Review, 44(5), pp. 864–882.
https://doi.org/10.1016/j.tre.2007.03.004

Inoue, G., Ono, M., Uehara, K., Isono, F. (2015) "Stated-preference analysis to estimate the domestic transport demand following the future entry of LCCs and the inauguration of the Linear Chuo Shinkansen in Japan", Journal of Air Transport Management, 47, pp. 199–217.
https://doi.org/10.1016/j.jairtraman.2015.06.004

Janić, M. (1993). "A model of competition between high speed rail and air transport", Transportation Planning and Technology, 17(1), pp. 1–23.
https://doi.org/10.1080/03081069308717496

Jiang, C., Zhang, A. (2016) "Airline network choice and market coverage under high-speed rail competition", Transportation Research Part A: Policy and Practice, 92, pp. 248–260.
https://doi.org/10.1016/j.tra.2016.06.008

Jiang, M., Jiang, C., Xiao, Y. B., Wang, C. (2021) "Air-HSR cooperation: Impacts on service frequency and environment", Transportation Research Part E: Logistics and Transportation Review, 150, 102336.
https://doi.org/10.1016/j.tre.2021.102336

Jiao, J., Wang, J., Jin, F. (2017), "Impacts of high-speed rail lines on the city network in China", Journal of Transport Geography, 60, pp. 257–266.
https://doi.org/10.1016/j.jtrangeo.2017.03.010

Jiménez, J. L., Betancor, O. (2012) "When trains go faster than planes: The strategic reaction of airlines in Spain", Transport Policy, 23, pp. 34–41.
https://doi.org/10.1016/j.tranpol.2012.06.003

Kim, H., Sultana, S., Weber, J. (2018) "A geographic assessment of the economic development impact of Korean high-speed rail stations", Transport Policy, 66, pp. 127–137.
https://doi.org/10.1016/j.tranpol.2018.02.008

Kroes, E., Savelberg, F. (2019) "Substitution from Air to High-Speed Rail: The Case of Amsterdam Airport", Transportation Research Record: Journal of the Transportation Research Board, 2673(5), pp. 166–174.
https://doi.org/10.1177/0361198119839952

Lee, J. K., Yoo, K. E., Song, K. H. (2016) "A study on travelers' transport mode choice behavior using the mixed logit model: A case study of the Seoul-Jeju route", Journal of Air Transport Management, 56(Part B), pp. 131–137.
https://doi.org/10.1016/j.jairtraman.2016.04.020

Li, H., Strauss, J., Shunxiang, H., Lui, L. (2018) "Do high-speed railways lead to urban economic growth in China? A panel data study of China's cities", The Quarterly Review of Economics and Finance, 69, pp. 70–89.
https://doi.org/10.1016/j.qref.2018.04.002

Li, H., Strauss, J., Lu, L. (2019) "The impact of high-speed rail on civil aviation in China", Transport Policy, 74, pp. 187–200.
https://doi.org/10.1016/j.tranpol.2018.11.015

Li, H., Wang, K., Yu, K., Zhang, A. (2020) "Are conventional train passengers underserved after entry of high-speed rail?-Evidence from Chinese intercity markets", Transport Policy, 95, pp. 1–9.
https://doi.org/10.1016/j.tranpol.2020.05.017

Li, Z. C., Sheng, D. (2016) "Forecasting passenger travel demand for air and high-speed rail integration service: A case study of Beijing-Guangzhou corridor, China", Transportation Research Part A: Policy and Practice, 94, pp. 397–410.
https://doi.org/10.1016/j.tra.2016.10.002

Liu, R., Li, A. (2012) "Forecasting high-speed rail ridership using a simultaneous modeling approach", Transportation Planning and Technology, 35(5), pp. 577–590.
https://doi.org/10.1080/03081060.2012.701816

Ma, W., Wang, Q., Yang, H., Zhang, A., Zhang, Y. (2019) "Effects of Beijing-Shanghai high-speed rail on air travel: Passenger types, airline groups and tacit collusion", Research in Transportation Economics, 74, pp. 64–76.
https://doi.org/10.1016/j.retrec.2018.12.002

Martín, J. C., Nombela, G. (2007) "Microeconomic impacts of investments in high speed trains in Spain", Annals of Regional Science, 41(3), pp. 715–733.
https://doi.org/10.1007/s00168-007-0116-8

McFadden, D. (1981). "Econometric models of Probabilistic choice", In: Structural Analysis of Discrete Data with Econometric Applications, The MIT Press, pp. 198-272. ISBN 0-262-13159-5

Mizutani, J., Sakai, H. (2021) "Which is a stronger competitor, High Speed Rail, or Low Cost Carrier, to Full Service Carrier? – Effects of HSR network extension and LCC entry on FSC's airfare in Japan", Journal of Air Transport Management, 90, 101965.
https://doi.org/10.1016/j.jairtraman.2020.101965

Mohino, I., Loukaitou-Sideris, A., Urena, J. M. (2014) "Impacts of High-Speed Rail on Metropolitan Integration: An Examination of London, Madrid and Paris", International Planning Studies, 19(3–4), pp. 306–334.
https://doi.org/10.1080/13563475.2014.950638

Moss, M. L., Qing, C. (2012) "The Emerge of the "Super-commuter"",[pdf] Ruding Center for Transportation, New York University Wagner School of Public Service, New York. Available at: https://wagner.nyu.edu/files/rudincenter/supercommuter_report.pdf [Accessed: 01 September 2025]

Nurhidayat, A. Y., Widyastuti, H., Utomo, D. P. (2018) "Model of transportation mode choice between aircraft and high speed train of Jakarta-Surabaya route", IOP Conference Series: Earth and Environmental Science, 202, 012002. https://doi.org/10.1088/1755-1315/202/1/012002

Nurhidayat, A. Y., Widyastuti, H., Sutikno,Upahita, D. P. (2023) "Research on Passengers' Preferences and Impact of High-Speed Rail on Air Transport Demand", Sustainability, 15(4), 3060. https://doi.org/10.3390/su15043060

Ortúzar, J. D. D., Simonetti, C. (2008) "Modelling the demand for medium distance air travel with the mixed data estimation method", Journal of Air Transport Management, 14(6), pp. 297–303. https://doi.org/10.1016/j.jairtraman.2008.08.002

Ortúzar, J. D. D., Willumsen, L. G. (2011) "Modelling Transport", John Wiley & Sons, Ltd. ISBN 9780470760390. https://doi.org/10.1002/9781119993308

Park, Y., Ha, H. K. (2006) "Analysis of the impact of high-speed railroad service on air transport demand", Transportation Research Part E: Logistics and Transportation Review, 42(2), pp. 95–104. https://doi.org/10.1016/j.tre.2005.09.003

Ren, X., Chen, Z., Wang, F., Wang, J., Wang, C., Dan, T., Du, Z. (2019) "Impact of high-speed rail on intercity travel behavior change: The evidence from the Chengdu-Chongqing Passenger Dedicated Line", Journal of Transport and Land Use, 12(1), pp. 265–285. https://doi.org/10.5198/jtlu.2019.1302

Ren, X., Chen, Z., Wang, F., Dan, T., Wang, W., Guo, X., Liu, C. (2020) "Impact of high-speed rail on social equity in China: Evidence from a mode choice survey", Transportation Research Part A: Policy and Practice, 138, pp. 422–441. https://doi.org/10.1016/j.tra.2020.05.018

Román, C., Espino, R., Martín, J. C. (2007) "Competition of high-speed train with air transport: The case of Madrid-Barcelona", Journal of Air Transport Management, 13(5), pp. 277–284. https://doi.org/10.1016/j.jairtraman.2007.04.009

Socorro, M. P., Viecens, M. F. (2013) "The effects of airline and high speed train integration", Transportation Research Part A: Policy and Practice, 49, pp. 160–177. https://doi.org/10.1016/j.tra.2013.01.014

Strauss, J., Li, H., Cui, J. (2021) "High-speed Rail's impact on airline demand and air carbon emissions in China", Transport Policy, 109, pp. 85–97. https://doi.org/10.1016/j.tranpol.2021.05.019

Su, M., Luan, W., Fu, X., Yang, Z., Zhang, R. (2020) "The competition effects of low-cost carriers and high-speed rail on the Chinese aviation market", Transport Policy, 95, pp. 37–46. https://doi.org/10.1016/j.tranpol.2020.05.025

Takyi, P. O., Dramani, J. B., Akosah, N. K., Aawaar, G. (2023) "Economic activities' response to the COVID-19 pandemic in developing countries", Scientific African, 20, e01642. https://doi.org/10.1016/j.sciaf.2023.e01642

Tsunoda, Y. (2018) "Transportation policy for high-speed rail competing with airlines", Transportation Research Part A: Policy and Practice, 116, pp. 350–360. https://doi.org/10.1016/j.tra.2018.06.030

Wan, Y., Ha, H. K., Yoshida, Y., Zhang, A. (2016) "Airlines' reaction to high-speed rail entries: Empirical study of the Northeast Asian market", Transportation Research Part A: Policy and Practice, 94, pp. 532–557. https://doi.org/10.1016/j.tra.2016.10.014

Wang, J., Du, D., Huang, J. (2020a) "Inter-city connections in China: High-speed train vs. inter-city coach", Journal of Transport Geography, 82, 102619. https://doi.org/10.1016/j.jtrangeo.2019.102619

Wang, J., Huang, J., Jing, Y. (2020b) "Competition between high-speed trains and air travel in China: From a spatial to spatiotemporal perspective", Transportation Research Part A: Policy and Practice, 133, pp. 62–78. https://doi.org/10.1016/j.tra.2019.12.030

Wang, K., Xia, W., Zhang, A., Zhang, Q. (2018) "Effects of train speed on airline demand and price: Theory and empirical evidence from a natural experiment", Transportation Research Part B: Methodological, 114, pp. 99–130. https://doi.org/10.1016/j.trb.2018.05.017

Wang, W., Sun, H., Wu, J. (2020c) "How does the decision of high-speed rail operator affect social welfare? Considering competition between high-speed rail and air transport", Transport Policy, 88, pp. 1–15. https://doi.org/10.1016/j.tranpol.2020.01.008

Wang, Y., Sun, L., Teunter, R. H., Wu, J., Hua, G. (2020d) "Effects of introducing low-cost high-speed rail on air-rail competition: Modelling and numerical analysis for Paris-Marseille", Transport Policy, 99, pp. 145–162. https://doi.org/10.1016/j.tranpol.2020.08.006

Wong, W. G., Han, B. M., Ferreira, L., Zhu, X. N. (2002) "High-Speed Rail Operations on an Existing Network: An Assessment Model for China", Transportation Planning and Technology, 25(3), pp. 239–254. https://doi.org/10.1080/0308106022000019008

Wu, J., Nash, C., Wang, D. (2014) "Is high speed rail an appropriate solution to China's rail capacity problems?", Journal of Transport Geography, 40, pp. 100–111. https://doi.org/10.1016/j.jtrangeo.2014.05.004

Xia, W., Zhang, A. (2017) "Air and high-speed rail transport integration on profits and welfare: Effects of air-rail connecting time", Journal of Air Transport Management, 65, pp. 181–190. https://doi.org/10.1016/j.jairtraman.2017.06.008

Yang, H., Burghouwt, G., Wang, J., Boonekamp, T., Dijst, M. (2018a) "The implications of high-speed railways on air passenger flows in China", Applied Geography, 97, pp. 1–9. https://doi.org/10.1016/j.apgeog.2018.05.006

Yang, H., Dobruszkes, F., Wang, J., Dijst, M., Witte, P. (2018b) "Comparing China's urban systems in high-speed railway and airline networks", Journal of Transport Geography, 68, pp. 233–244. https://doi.org/10.1016/j.jtrangeo.2018.03.015

Yang, H., Zhang, A. (2012) "Effects of high-speed rail and air transport competition on prices, profits and welfare", Transportation Research Part B: Methodological, 46(10), pp. 1322–1333. https://doi.org/10.1016/j.trb.2012.09.001

Yin, M., Bertolini, L., Duan, J. (2015) "The effects of the high-speed railway on urban development: International experience and potential implications for China", Progress in Planning, 98, pp. 1–52. https://doi.org/10.1016/j.progress.2013.11.001

Yu, K., Strauss, J., Liu, S., Li, H., Kuang, X., Wu, J. (2021) "Effects of railway speed on aviation demand and CO2 emissions in China", Transportation Research Part D: Transport and Environment, 94, 102772. https://doi.org/10.1016/j.trd.2021.102772

Zeng, N., Wang, Z. (2020) "Analysis of Beijing-Guangzhou High-Speed Railway Competitiveness Based on Generalized Travel Cost Model", IOP Conference Series: Earth and Environmental Science, 587(1), 012099. https://doi.org/10.1088/1755-1315/587/1/012099

Zhang, A., Wan, Y., Yang, H. (2019a) "Impacts of high-speed rail on airlines, airports and regional economies: A survey of recent research", Transport Policy, 81, pp. A1–A19. https://doi.org/10.1016/j.tranpol.2019.06.010

Zhang, F., Graham, D. J., Wong, M. S. C. (2018) "Quantifying the substitutability and complementarity between high-speed rail and air transport", Transportation Research Part A: Policy and Practice, 118, pp. 191–215. https://doi.org/10.1016/j.tra.2018.08.004

Zhang, Q., Yang, H., Wang, Q. (2017) "Impact of high-speed rail on China's Big Three airlines", Transportation Research Part A: Policy and Practice, 98, pp. 77–85. https://doi.org/10.1016/j.tra.2017.02.005

Zhang, Q., Yang, H., Wang, Q., Zhang, A., Zhang, Y. (2020) "Impact of high-speed rail on market concentration and Lerner index in China's airline market", Journal of Air Transport Management, 83, 101755. https://doi.org/10.1016/j.jairtraman.2019.101755

Zhang, R., Johnson, D., Zhao, W., Nash, C. (2019b) "Competition of airline and high-speed rail in terms of price and frequency: Empirical study from China", Transport Policy, 78, pp. 8–18. https://doi.org/10.1016/j.tranpol.2019.03.008

Zhao, J., Zhao, Y., Li, Y. (2015) "The variation in the value of travel time savings and the dilemma of high-speed rail in China", Transportation Research Part A: Policy and Practice, 82, pp. 130–140. https://doi.org/10.1016/j.tra.2015.09.012