International Journal of Technology 10(2): 405-416
ISSN 2086-9614

DEMAND FORECAST OF JAKARTA-SURABAYA HIGH SPEED RAIL BASED ON STATED PREFERENCE METHOD

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(Received: October 2018 / Revised: November 2018 / Accepted: March 2019)

ABSTRACT

Intercity roads, rail networks and air transport in Java, Indonesia, have suffered greatly due to the congestion of goods and passenger transport. The plan to build a 730 kilometer high-speed rail (HSR) route from Jakarta, the state capital, to Surabaya, the capital of East Java Province, has been discussed in the public sphere for years. The Government of Indonesia (GOI) plans to connect these two cities by HSR to supplement the alternatives, such as conventional rail, air and toll roads. The HSR service is expected to reduce the existing average intercity train travel time from nine hours to five hours, or even to three depending on the maximum design speed. Currently, door-to-door air travel may take five hours. Another goal of the Jakarta-Surabaya HSR is to improve accessibility between major cities in Java, reduce congestion between them, and reduce air pollution, accidents and energy consumption along the transport corridor. The purpose of this study is to estimate the number of passengers from existing modes of transportation (e.g. road, rail and air) who would be willing to change their choice of mode to the planned high-speed trains. The data for the study are based on stated choice questions posed to respondents, in which the differences in attributes such as travel time and cost; service frequency or headway; and accessibility, such as the distance and cost to reach the stations, are the main factors influencing switching behavior to the new HSR services. The chosen model is the MNL III model, with 45.36% accuracy and 0.128 pseudo R-square. By using the Multinomial Logit model (MNL), the study reveals that the most important variable is travel time, followed by frequency and cost. The MNL model is also used to estimate the initial HSR ridership to produce the demand forecast along the planning horizon.

Keywords: Demand forecast; High-speed rail; Multinomial logit; Stated preference

1. INTRODUCTION

Java Island is the busiest island in Indonesia, with Jakarta and Surabaya being the most populated cities, located at either end of the island. As economic center hubs, both Jakarta and Surabaya have very high populations, namely 10.17 million (Jakarta City Statistics Agency, 2016) and 2.85 million (Surabaya City Statistics Agency, 2016) respectively. Movement or trips between the two cities are mainly motivated by business and are currently facilitated by train, plane and road transport, including toll roads. According to the Indonesia National Railway Master Plan, the government is planning to develop a Jakarta-Surabaya high-speed train, with a length of

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Permalink/DOI: https://doi.org/10.14716/ijtech.v10i2.2442

approximately 730 km. This train will connect several cities between Jakarta and Surabaya, such as Cirebon and Semarang along the north corridor, as well as Bandung and Yogyakarta in the south. It is expected to deliver benefits in terms of energy and shorter travel times. However, in order to achieve the optimum benefits, there should be a significant modal shift, from private vehicles, planes and existing trains to the proposed high-speed train.

The development of a high-speed train as an alternative to air travel is an urgent matter. According to flightradar24 (2018), there are 591 flights weekly from Surabaya to Jakarta alone. If this figure is added to other flights along the Jakarta-Surabaya-Bali route, there are 4,000 flights monthly, or 1,000 flights weekly. This is the busiest air traffic route in Indonesia, on which airlines and users of air transportation often experience excessive delays during departure and landing. Furthermore, most airports on Java Island are over capacity by a factor of 5–7; some runways and terminals are now undergoing expansion, and a few new airports are also being built. The Southern Java air traffic navigation service is now also being considered for development, linking Jakarta, Bandung, Tasikmalaya, Purbalingga, New Yogyakarta International Airport in Kulonprogo, and Surabaya. The provision of HSR services will ultimately change the pattern of intercity travel in the corridor, as HSR will absorb some of the long-distance travelers.

The main objective of this study is to review the previous Jakarta –Surabaya HSR demand forecast, develop a new choice of mode model, and update the forecast. In this study, access and egress to and from HSR stations are represented explicitly by distance and cost parameters, which complement previous studies such as Barus et al. (2016), who found that access to stations was very important to improve the competitiveness of inter-city transportation, although it was still qualitative.

2. LITERATURE REVIEW

In 2013, Acharya and Morichi (2013) conducted a study on the importance of high-speed rail for Asian development. The HSR transport mode was deemed necessary to support economic growth and high population levels, which result in high travel demand. In addition, HSR development, or the rail mode of transport in general, result in lower emissions compared to road or air. This claim is supported by Shukuri (2014), who compared energy consumption per seat between high-speed rail and air, with results of 90MJ/passenger and 746MJ/passenger respectively. The experience of Japan also shows the successful implementation of HSR (Kyushu Shinkansen), which is marked by its increasing modal share against air. The modal share of HSR against air for the Osaka-Kumamoto line increased from 32% in 2009 to 59% in 2012, while for the Osaka-Kagoshima Line, the share increased from 10% in 2009 to 28% in 2012 (Shukuri, 2014). This shows the potential of HSR to shift a significant number of passengers from air travel if it is developed and managed properly.

Previous studies have attempted to estimate the demand for high-speed rail in Indonesia. Two estimated the demand for the Jakarta-Bandung section, while another estimated it for the Semarang-Surabaya section. In 2012, the Japan International Corporation Agency (JICA, 2012) conducted a study of high-speed rail focusing on a demand forecast based on a binary logit model. All these studies were based on stated choice and used the binary logit model to estimate the proportion of modal shift to new rail services from automobiles, conventional trains and coaches. In its study, JICA (2012) defines three options for high-speed rail routes: route 1 (Jakarta-Bandung); route 2 (Jakarta-Bandung-Cirebon); and route 3 (Jakarta-Cirebon, through the northern corridor). The study reveals that the most influential factors for both conventional and high-speed rail are travel time inside the mode, travel time outside the mode (waiting time, transfer time), and tariffs. With the assumption that high-speed trains from Jakarta to Bandung will operate in 2020 on the Jakarta-Surabaya route, the daily number of passengers after 30 years of operation was predicted to reach 149,000 on the Jakarta-Bandung route, 193,000 on the Jakarta-Cirebon route (through Bandung), but only 40,000 on the Jakarta-Cirebon (northern coast) route. It is worth noting that if the HSR line passed through Bandung, it would increase ridership fairly significantly. The study by JICA (2012) also estimated that the conversion ratio of existing mode to HSR in 2020 would be 30%–35% for rail, 26%–34% for long-distance buses and 6%–21% for passenger cars.

In 2015, the Indonesia-China High-Speed Rail Company appointed PT. LAPI ITB (2015) to conduct another study of demand forecast for the Jakarta-Bandung section of the high-speed rail from 2020 to 2070. The study used a binary logit model to predict the modal shift to the new high-speed train from various transport modes operating along the Jakarta-Bandung corridor, namely shuttle buses, coaches, private cars and conventional trains. The data were collected using the stated preference method and considered several attributes such as tariffs, travel time, waiting time, access time and delays. In addition, the survey also collected other types of data, such as socioeconomic aspects, and the ability and willingness to pay. The study forecast demand based on three scenarios (optimistic, moderate and pessimistic) and three kinds of HSR service (standard, semi and express), with differences in the value of tariffs and travel time. The daily passenger forecast for the express high-speed train in 2070 was expected to reach 103,211 for the optimistic scenario, 80,152 for moderate scenario and 65,404 for pessimistic scenario. According to LAPI (2015), the conversion ratio of existing modes to HSR in 2020 is 49.47% for conventional rail, 52.12% for Primajasa buses, 50.09% for passenger cars, and 51.21% for shuttle buses.

The following year, PT LAPI ITB (2016) was once again appointed to conduct a study, but for the Semarang-Surabaya section. Similar to the previous studies on high-speed rail, this study used the binary-logit model and data obtained from a stated preference survey. The mode choice attributes that are considered in this study are travel time, tariffs, frequency and punctuality. The study also forecast the demand for high-speed trains based on optimistic, moderate and pessimistic scenarios from 2020 to 2070. The difference between the scenarios is in mode attributes and the growth factor. The results regarding demand forecast for 2020 were markedly low, with the number of daily passengers ranging from 11,974 to 16,217 for the moderate scenario. Demand is expected to increase from 119,518 to 189,945 by 2070. According to the study, the conversion ratio from existing modes are 60.92% for air, 44.74% for existing trains, 43.65% for buses, 51.31% for cars and 42.58% for shuttle buses.

Recently, the Government of Indonesia, through the Agency for the Assessment and Application of Technology (BPPT), also undertook a study on rail track revitalization along the northern Java rail network, from Jakarta to Surabaya. The options of an HSR with an average speed of above 200 kph and with a standard gauge of 1034 mm were also considered. A comparative study is also being conducted in parallel by JICA. Both parties seem to be pursuing the so-called medium maximum speed of 160 kph with a narrow gauge 1067mm, resulting in a 5 to 6 hour average travel time between Jakarta and Surabaya. At the time of writing of this paper, the financial and business models of the rail revitalization are yet to be finalized.

3. STUDY AREA

The high-speed rail network will start from Jakarta, connecting large cities such as Bandung, Cirebon and Semarang, and ending in Surabaya. Trains and planes currently serve this corridor. The study focuses on the Jakarta-Surabaya Section; Jakarta and Surabaya are the most populous cities in Indonesia and are core metropolitan areas. The population of Jakarta Metropolitan Area is approximately 29 million, while that of the Surabaya Metropolitan area is 9,115,485 (National Statistics Agency, 2010). Moreover, Bandung City and Semarang City are also key metropolitan areas along the corridor. The land transport corridor has suffered greatly from passenger and freight congestion, both within cities and intercity, as well as air transport congestion at Java airports, which are operating in the range of 2 to 5.5 times their design capacities. Our moderate estimate of total social costs, including unproductive travel times, externalities, energy waste, healthcare and accident costs, may reach 250 trillion IDR (USD 17.25 billion) annually. Therefore, the development of a high-speed railway is necessary. According to Latief et al. (2016), an increased share of rail transport will support the economy by alleviating road congestion.

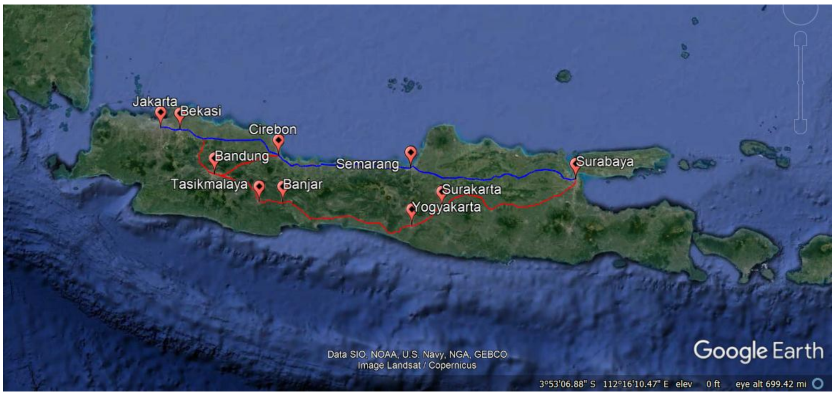

Figure 1 High-speed train alternative routes

There are three alternative routes for connecting the two hubs, as shown in Figure 1. The first is the northern coast route, while the second is the southern coastal route. Both of these alternative routes pass through large cities such as Jakarta, Bandung, Yogyakarta, Semarang and Surabaya. An alternative route combines parts of the previous routes; that is, going from Jakarta to Bandung and further north to Cirebon, Semarang and Surabaya, following the northern coast route. The lengths of the northern and southern coastlines connecting Jakarta and Surabaya are approximately 682 km and 843 km, respectively. The most suitable route for the high-speed railway depends on the level of demand in decades to come. This puts emphasis on the importance of this study, which focuses on the northern coast route plan. As mentioned by Berawi et al. (2015), the northern route from Jakarta to Surabaya involves the lowest cost compared to the other route options, which highlights its potential. However, it should be noted that the most appropriate route for a high-speed railway is not necessarily along the northern coast; potential also exists for an HSR line along the southern coast.

4. METHODOLOGY

The workflow of the study is divided into four phases: (1) questionnaire design; (2) data collection; (3) data analysis and modeling; and (4) model implementation. The questionnaire included questions on the socioeconomic characteristics of the respondents and stated preference (SP) choice cards.

4.1. Questionnaire Design

The questionnaire is divided into three parts. The first part explores the respondent's socioeconomic characteristics; the second is related to mode choice preference (stated preference); and the third is related to accessibility to train stations or airports. The questionnaire design incorporates a method proposed by TEMS (2008) and Sanko (2001). Respondents are asked several questions to capture their socioeconomic characteristics and the passengers interviewed are those who travel between Jakarta and Surabaya for business purposes. The data related to socioeconomic characteristics include age, gender, occupation, monthly income (salary and another income sources), monthly transport expenditure, and trip frequency between Jakarta and Surabaya per month.

The stated preference (SP) survey is designed to capture respondents' preferences accurately. As this study focuses on passengers making business trip between Jakarta and Surabaya, attributes for the SP survey are based on business trip characteristics. These attributes include travel time, tariffs and frequency. Before determining the level of each attribute, the existing mode attribute value is first identified to ease the process of determining the high-speed train attribute values. The attribute value is then divided into different levels.

The high-speed railway is planned to operate at a speed at 200–320 km/hour and will run on a 700 km track. Therefore, the travel time between Jakarta and Surabaya will be approximately 2.5 to 3.5 hours. A 4.5-hour attribute level is also added to anticipate slower operational speeds. The three values are then used as attribute levels for the "travel time" attribute. For the "tariff" attribute, the level is based on existing rail and air tariffs, at IDR 385,000 and IDR 450,000 to 1,000,000, respectively. To be competitive with the existing modes, the attribute levels for high speed railway are therefore determined at values of between IDR 385,000 and IDR 1,000,000, namely at IDR 600,000, IDR 750,000 and IDR 900,000. The frequency of existing Jakarta-Surabaya trains is 3 times/day, while flight frequency is 8 times/day. For the high-speed railway, the value for the "frequency" attribute is determined at 5 times/day, 8 times/day and 10 times/day in order to be competitive with and similar to other transport modes.

According to the existing mode attribute value identification, the high-speed train attributes are shown in Table 1.

Table 1 Attributes and attribute values (3 levels)

Travel Time (minutes)	Tariff		Frequency
2 hours 30 minutes	IDR	600,000	5 times/day
3 hours 30 minutes	IDR	750,000	8 times/day
4 hours 30 minutes	IDR	900,000	10 times/day

These attribute values are then combined with a fractional factorial design, resulting in nine combinations (scenarios), as shown in Table 2. These nine scenarios are compared with the attribute values of the existing modes and the respondents' choice or preference regarding the nine scenarios is then recorded. The accessibility attribute is valued by comparing Gambir Station for executive trains, Soekarno Hatta airport for planes, and Halim Station for high-speed trains. Respondents were also asked about the location of their origin (administrative area). The distance from the respondent's origin to the station was then measured accordingly. The sample size was determined using the Slovin method. Based on data from Angkasa Pura II (Indonesia Airport Corp.) and PT KAI (Indonesia Railway Corp.), the number of passengers making business trips between Jakarta and Surabaya using air and the existing railway is 8024 passengers/day and 691 passengers/day, respectively. Therefore, the population is determined at 8,715 passengers/day. With a confidence level of 95%, the sample size for the survey was calculated as follows:

$$n = \frac{N}{1 + N \, x \, e^2} \tag{1}$$

Hence, the sample size $n = \frac{8715}{1+8715 \, x \, 0.05^2}$ = 382 respondents

402 people were interviewed at four different locations, namely Jakarta Gambir Station, Pasar Turi Station (Surabaya), Soekarno Hatta Airport (Jakarta), and Djuanda Airport (Surabaya). The survey took place between 19th April and 26th May 2016. The reason the sampling was carried out evenly was due to the fact that inbound and outbound air passengers on the Jakarta-Surabaya

route, who represented the majority of inter-city travel modes, were found to be almost equal from the statistical data collected from the airport operator PT Angkasa Pura Corporation.

Table 2 High speed rail attributes and levels

Attribute	Scenario								
	1	2	3	4	5	6	7	8	9
Travel Time (Hours)	4.5	4.5	4.5	3.5	3.5	3.5	2.5	2.5	2.5
Tariff (IDR)	900,000	750,000	600,000	900,000	750,000	600,000	900,000	750,000	600,000
Frequency (Times/Day)	5	8	10	10	5	8	8	10	5

4.2. Data Collection

The data in this study comprise primary and secondary data. The primary data were collected from the stated preference survey, while the secondary were obtained from the related institution, namely the Indonesian Railway Corporation (2015), Angkasa Pura II Corporation (2016), an Indonesia airport operator, and the Jakarta Central Statistics Agency (2016).

The discrete choice method is used to determine the probability of the choice of mode between the high-speed train and existing modes, such as plane and current trains. This method rates elements, namely decision makers, alternatives, alternative attributes and decision rules (Koppelman & Bhat, 2006). The discrete choice model used for this study is the multinomial logit model (MNL), using the choice probability formula of Domencich and McFadden, cited in Ortuzar and Willumsen (2011). The formula is as shown in Equation 2.

$$\mathrm{P_{iq}} = \frac{\exp(\beta\, V_{iq})}{\sum_{Aj\varepsilon A(q)} \exp(\beta\, V_{jq})} \tag{2}$$

The data were modeled using NLOGIT, software for discrete choice analysis which provides several model specifications, such as linear and non-linear ones (Greene, 2011). The inputs for the software are the choice set consisting of mode attributes, which were presented to the respondents in the stated preference survey. The modes considered included existing trains, air and the new high-speed train. The attributes included travel time, tariffs and mode frequency. In this study, four MNL model specifications are tested: MNL I, MNL II, MNL III and MNL IIIa, the attributes of which are listed below.

MNL I : Travel time, tariffs and frequency.
MNL II : Travel time, tariffs, frequency and accessibility.
MNL III : Travel time, tariffs, frequency, accessibility and socioeconomic factors (income, expenditure on transport, and trip frequency)
MNL IIIa : Similar to MNL III, but excluding income and expenditure on transport with regard to existing trains.

The four specifications were tested in order to find the best-fit model, which was measured by the highest *R-square* value and the percentage (%) of accuracy.

The developed multinomial logit model was then implemented to estimate the ridership of the high-speed train using the MNL model. The estimate was categorized into three scenarios: optimistic, moderate and pessimistic.

5. DATA SET AND PROCESSING

The survey successfully engaged 402 respondents, with their proportion equally spread across the four locations. To ensure that only good quality data were employed during the analysis, several criteria were used to validate the data or eliminate inconsistent data. Only fully completed questionnaires with rational responses were included in the study. For instance, the amount of monthly income and transport expenditure must be proportional. The trip origin of respondents must also be either in the Jabodetabek Area (Jakarta, Bogor, Depok, Tangerang and Bekasi) or Gerbangkertosusila (Gresik, Bangkalan, Mojokerto, Surabaya, Sidoarjo and Lamongan). The respondents whose trips originated in these areas were deemed appropriate to give their views on the Jakarta-Surabaya High-Speed Train. After this process, 13 data points out of the 402 were eliminated. This was due to invalid responses; i.e., incomplete answers, irrational answers or trip origins outside the research study area. After clearing 13 invalid samples, there were 389 remaining samples from 382 samples needed, so this was enough with the sample size requirements.

5.1. Socioeconomic Data

The majority of respondents, namely 40%, were 31 to 41 years old, followed by those within the age range of between 19 to 30 years, at 32%. 20% of the respondents were between 41 and 50 years old, while the ages of the remaining 8% ranged from 51 to 65 years old. Among the respondents, males dominated, with a proportion of 77% while the remaining 23% were female. With respect to occupation, 48% of the respondents worked in state/privately-owned enterprises, followed by 28% who were entrepreneurs. The proportion of civil servants, students and others were 17%, 4% and 3%, respectively. The monthly income range of the highest proportion of respondents was IDR 5,000,000 to IDR 10,000,000 (44%), followed by IDR 3,000,000 to IDR 5,000,000 (19%). 18% of respondents had a relatively high income, ranging from IDR 10,000,000 to 15,000,000. Only 2% of respondents had an income greater than IDR 15,000,000.

According to the data collected, 42% of respondents spent from IDR 1,000,000 to IDR 2,000,000 on monthly transport expenditure, followed by those who spent from IDR 2,000,000 to IDR 3,000,000 and from IDR 3,000,000 to IDR 4,000,000, at 27% and 21%, respectively. Regarding trip frequency, the majority of respondents (51%), only travelled once a month, followed by 2 or 3 times a month (41%). Respondents who travelled 6 to 7 times a month, or more than 7 times a month, only constituted 1% of the total number. It is interesting to note that 64% of the respondents stated that they would be likely to use the high-speed train, and 16% said that they would do so on a regular basis. 10% said that they were still unsure and only a few stated that they would be unlikely to use the high-speed train (9%). Finally, only 1% of respondents stated that they would not use the HST.

5.2. Stated Preference Data

The stated preference data are derived from the respondents’ choice of mode. They were offered nine scenarios, consisting of three alternatives for each mode (train, plane or high-speed train). The respondents’ choices for each of these can be seen in Figure 1.

According to Figure 1, HST is preferred most in scenario 9, in which the travel time is 2 hours 30 minutes, the tariff is Rp.600,000, and the frequency (departures) is 5 times a day.

5.3. Accessibility to Station and Airport

Out of a total of 199 respondents from Jakarta City, 48, or 24%, started their trip from Central Jakarta. From the 190 respondents from Surabaya City, 53, or 28%, started their journey from South Surabaya. The respondents were also asked about how they reached the station or airport. Out of the 389 respondents, 49% used taxi to reach the airport or train station, while 34% travelled by car. Those who used the bus are 7% of all respondents and the same is for “ojek” (motorcycle taxi) at 7%. The remaining 3% of all respondents use other modes. Respondents’ travel cost data were obtained directly from them. The access cost for car usage was based on the vehicle's operational cost, which is 1,238 IDR per km. The access cost for taxi, bus and ojek was also obtained directly from the respondents. For those who chose "other mode," additional information was required to clarify which mode was used. These included using "hotel shuttle bus or hotel vehicles" and "walking." The travel cost of these "other modes" can be regarded as 0, as the respondents did not incur any costs to reach the station.

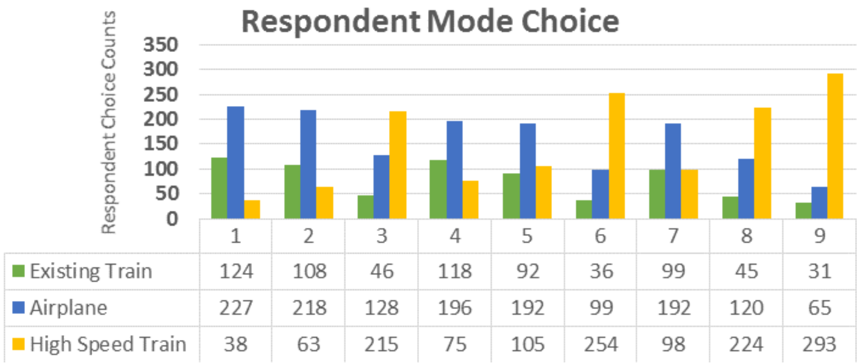

Figure 1 Respondents' choice of mode based on stated preference

6. ANALYSIS

6.1. Model Calibration Results

According to the statistical test in the NLOGIT software, the model chosen for the analysis was the MNL IIIa. This is because according to the results generated by the software, MNL IIIa has the greatest level of % accuracy and pseudo R square, as shown in Table 3.

Table 3 Pseudo R-square and % accuracy

Parameter	MNL I	MNL II	MNL III	MNL IIIa
Pseudo R-square	0.107	0.121	0.127	0.128
% Accuracy	43.84%	44.82%	45.33%	45.36%

This can be regarded as a good model, since the value of -2 [LLc - LLβ] = 943.284 is higher than the chi-square value (16.919), which was generated at a 5% significance level with df = 8, as this study uses nine attributes and therefore the df value is at 9–1 = 8. This means that the β_i coefficient has a very strong relationship with the developed model. In other words, β_i is statistically significant. The variables that have a significant influence are those with a p-value lower than α (0.05).

According to the parameter obtained from the analysis using the NLOGIT software, the utility functions for the probability choice are written as follows:

$$U\ (Train) = 1.808 + (-0.717\times\text{Travel Time}) + (-0.00808\times\text{Tariff}) + (0.098\times\text{Frequency}) + (-0.026\times\text{Access Distance}) + (-0.00377\times\text{Access Cost}) + (-0.286\times\text{Trip Frequency}) \quad (3)$$

$$U\ (Airplane) = -1.050 + (-0.717\times\text{Travel Time}) + (-0.00808\times\text{Tariff}) + (0.098\times\text{Frequency}) + (-0.026\times\text{Access Distance}) + (-0.00377\times\text{Access Cost}) + (0.324\times\text{Income}) + (-0.470\times\text{Transport Expenditure}) + (-0.3579\times\text{trip Frequency}) \quad (4)$$

$$U\ (HST) = (-0.717\times\text{Travel Time}) + (-0.00808\times\text{Tariff}) + (0.098\times\text{Frequency}) + (-0.026\times\text{Access Distance}) + (-0.00377\times\text{Access Cost}) \quad (5)$$

6.2. Demand Forecast

As mentioned earlier, in the 2016 base year passenger travel data for Jakarta- Surabaya was obtained from Angkasa Pura II (Indonesia Airport Corp) and PT KAI (Indonesia Railway Corp). This data consists of regular travelers and businesses that choose planes and trains as a mode of travel. Table 4 lists the potential number of long-distance passenger travel markets that might switch to high-speed trains, once HSR starts operating. This study only focuses on passengers traveling on business trips from Jakarta to Surabaya or vice versa. As can be seen in Table 4, in 2016 there were 8,024 passenger planes and 691 passenger trains on business trips along Jakarta-Surabaya, both directions.

Table 4 Passengers travelling for business purposes on executive trains and planes in 2016

Passengers	Plane	Executive Train
Number of passengers in 2016 (pax) total	4,680,391	604,800
Business trips (pax/year) in 2016	2,808,234$^{*)}$	241,920$^{**)}$
Business trips (pax/day) in 2016 $^{\#)}$	8,024	691

Note: $^{*)}$ Plane business trips 60%, $^{**)}$ Train business trips 40%, $^{\#)}$ 1 year = 350 operating days

It is assumed that the Jakarta-Surabaya high-speed train will be in operation in 2025. The number of passengers, therefore, is projected from 2016 to 2025. The growth rates for executive train and flight modes is 2.9% and 6.7%, respectively. Therefore, the number of passengers in 2025 is forecasted to be 14,383 per day for planes and 894 per day for executive train.

The high-speed train demand forecast in this study is divided into three scenarios: optimistic, moderate and pessimistic. The indicators used for all of these are growth rate and attribute value adjustment, as shown in Table 5.

Table 5 Attribute adjustment for each scenario

Scenario	Attribute					
	Travel Time (hours)	Tariff (IDR)	Frequency (trips/day)	Access Distance (km)	Access Time (minutes)	Access Cost (IDR)
Pessimistic	4.5	750,000	8	11	50	75,000
Moderate	3.5	750,000	8	11	36	50,000
Optimistic	3.5	600,000	10	11	20	20,000

By using the attribute values for the three different scenarios, and also the choice probabilities based on multinomial logit Equation 2 and utility functions Equations 3, 4 and 5, the modal split for existing train, plane and high-speed railway in 2025 is shown in Table 6. The modal split values are then used as the basis for the high-speed railway passenger forecast up to 2050.

Table 6 Mode split based on the three scenarios (year 2025)

Scenario	Mode	Choice Probability	Passengers/day (without HST)	Passengers per day (with HST)
Pessimistic Scenario	Existing Train	0.201	894	3067
	Plane	0.618	14383	9444
	High-Speed Train	0.181	0	2765
	Total	1	15277	15277
Moderate Scenario	Existing Train	0.164	894	2499
	Plane	0.504	14383	7693
	High-Speed Train	0.333	0	5085
	Total	1	15277	15277
Optimistic Scenario	Existing Train	0.075	894	1143
	Plane	0.23	14383	3521
	High-Speed Train	0.695	0	10613
	Total	1	15277	15277

Table 7 shows that the growth rate for each scenario declines from 2040 onwards. This is based on the assumption that the number of passengers towards the end of the planning horizon will be constrained by train capacity.

Table 7 Growth rate for each scenario

Scenario	Year					
	2025	2030	2035	2040	2045	2050
Pessimistic	-	2.5%	3.0%	4.0%	3.0%	1.0%
Moderate	-	3.5%	4.0%	5.0%	4.0%	2.0%
Optimistic	-	4.5%	5.0%	6.0%	5.0%	3.0%

The growth rate is then used as the basis for high-speed train demand forecast up to 2050. By using the modal split value in Table 6 and passenger growth rate in Table 7, the demand forecast for the high-speed railway is shown in Figure 2.

According to the results of the demand forecast, in 2050 the number of passengers served by the high-speed train in the moderate scenario is 12,596 per day, while in the optimistic and pessimistic scenarios, the high-speed train is estimated to serve 33,421 and 5,376 passengers per day, respectively.

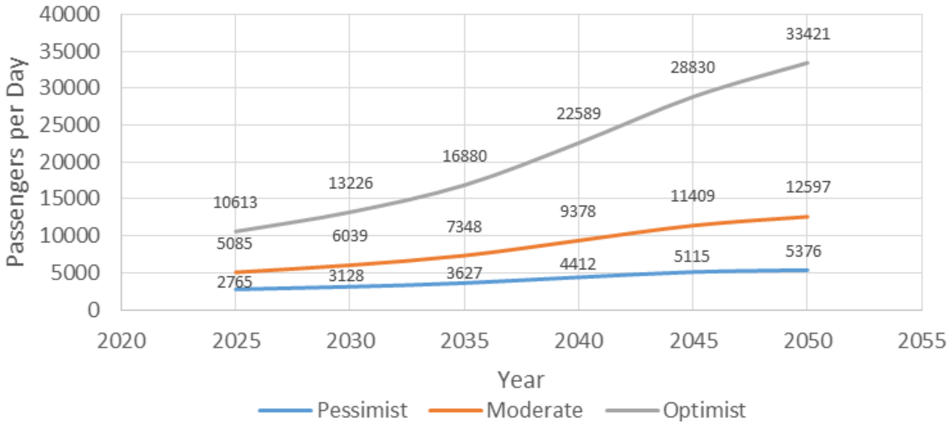

Figure 2 High-speed rail demand forecast (optimist, moderate and pessimist scenario)

7. CONCLUSION

The results of the analysis of the high-speed train mode choice give insights into important attributes, which may be useful for the development of the service. Based on the MNL III model, the variable with the greatest influence is travel time, with the coefficient of -0.717, followed by mode frequency and tariff, with coefficients of -0.098 and -0.00808, respectively. Among the accessibility variables, distance has the greatest influence, with a coefficient value of (minus) 0.026, while cost has a coefficient value of (minus) 0.00377. These results show that in order for the high-speed train to attract more passengers, emphasis should be placed on travel time. In addition, HST stations must be highly accessible. This can be implemented by locating the HST stations around the city center, and by providing connecting feeder transport to and from them.

From the respondent characteristics, those that have a monthly income above IDR 5,000,000 are more likely to choose planes over high-speed trains. This is also the case for passengers with a monthly income above IDR 3,000,000. However, passengers that travel more than once a month would tend to prefer high-speed trains over planes.

Based on the MNL IIIa model, the choice probabilities for high-speed train, plane and executive train for the moderate attribute value are 33.28%, 50.36% and 16.36%, respectively. In addition, by using the MNL IIIa model, the number of passengers per day for the high-speed trains by 2050 is estimated to be 12,597 (4,597,905 passengers per year) in the moderate scenario. In the optimistic and pessimistic scenarios, the number of passengers per day is estimated to be 33,421 (12,198,665 passengers per year) and 5,376 (1,962,240 passengers per year), respectively.

Future studies should consider the transit network assignment model to reproduce ridership estimates throughout the HSR lines and nodes (stations) to verify the importance of various combination station locations in improving HSR ridership. In addition, there is a potential to develop an HSR line on the southern coast. Further studies could develop a network model for alternative HSR routes, one of which could be the combination of the southern and northern routes, starting from Jakarta to Bandung, then traversing to Cirebon on the southern coast to reach Surabaya along the northern cost corridor. Depending on the network and additional data availability, the demand for these alternative routes could be estimated in the future.

8. ACKNOWLEDGEMENT

This study was made possible with the help of Angkasa Pura Corp. and Indonesia Railway Corp. as data providers. The grant from the Ministry of Research, Technology and Higher Education through "Hibah Berbasis Kompetensi (HIKOM)", Grant Number: 127/SP2H/ PTNBH/ DRPM/ 2018 is also acknowledged in supporting this study.

9. REFERENCES

Acharya, S., Morichi, S.J., 2013. Introducing High Speed Train (HSR) System in Developing Asia - Issues and Prospects. *In:* Proceedings of the Eastern Asia Society for Transportation Studies, Volume 9

Barus, L.S., Martell-Flores, H., Hadiwardoyo, S.P., Batoz, J., 2016. Intercity Mode Choice Modelling: Considering the Intracity Transport Systems with Application to the Jakarta-Bandung Corridor. *International Journal of Technology,* Volume 7(4), pp. 581–591

Berawi, M.A., Berawi, A.R.B, Prajitno, I.S., Nahry, N., Miraj, P., Abdurachman, Y., Tobing, E., Ivan, A., 2015. Developing Conceptual Design of High Speed Railways using Value Engineering Method: Creating Optimum Project Benefits. *International Journal of Technology,* Volume 6(4), pp. 670–679

Flightradar24., 2018. *Surabaya Juanda International Airport*. Available Online at https://www.flightradar24.com/data/airports/sub, Accessed on June 27, 2018

Greene, W.H., 2011. *LIMDEP Student References Guide - Econometric Software*. Version 9. New York: Econometric Software, Inc

Indonesia Railway Corp (PT. KAI), 2015. *Annual Report*. Bandung. PT. KAI

Jakarta City Statistics Agency., 2016. *Jakarta City in Figures*. Jakarta: Jakarta City Statistics Agency

JICA, 2012. *Study on High Speed Railway Project (Jakarta – Bandung Section) Final Report*. Jakarta: Japan International Consultants for Transportation

Koppelman, F.S., Bhat, C., 2006. *A Self Instructing Course in Mode Choice Modeling: Multinomial Logit and Nested Logit Models*. U.S Department of Transportation

Latief, Y., Berawi, M.A, Rarasati, A.D, Supriadi, L.S., Berawi, A.R.B., Hayuningtiyas, I.S., 2016. Mapping Priorities for the Development of the Transportation Infrastructure in the Provincial Capitals of Indonesia. *International Journal of Technology,* Volume 7(4), pp. 544–552

PT LAPI ITB, 2015. *Data Renewal and Demand Forecast Update – High Speed Railway (Jakarta – Bandung Section) Final Report*. Bandung: LAPI ITB

PT LAPI ITB, 2016. *Surabaya - Semarang High Speed Rail (Demand Forecast) Final Report*. Bandung: LAPI ITB

National Statistics Agency (BPS), 2010. *Population Census 2010*. Available Online at: https://sp2010.bps.go.id/index.php/navigation/wilayah, Accessed on November 16, 2016

National Statistics Agency (BPS), 2016. *Number of Railway Passenger*. Available Online at https://www.bps.go.id/linkTabelStatis/view/id/1417, Accessed on 16 November 2016

Ortuzar, J.D., Willumsen, L.G., 2011. *Modelling Transport*. 4th Edition. Chichester, United Kingdom: John Wiley & Sons Ltd

Sanko, N., 2001. Guidelines for Stated Preference Experiment Design. *Master Theses*, Graduate Program, Ecole Nationale des Ponts et Chaussees, Paris

Shukuri, M., 2014. *Exploring the Successful Stories of Shinkansen – High Speed Rail based on Crash Avoidance Principles*. International High Speed Rail Association

Surabaya City Statistics Agency, 2016. *Surabaya City in Figures* (Surabaya Dalam Angka). Surabaya: Surabaya City Statistics Agency

TEMS (Transportation Economics & Management Systems), 2008. *High Speed Rail Feasibility Study Methodology Technical Report.* United States: TEMS, Inc/Quandel Consultants, LLC