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The Influence of Trip Purpose on the Mode Choice Between High-Speed Train and Airplane: Leisure Vs. Non-Leisure Trip

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Abstract

Jakarta – Surabaya Corridor plays an important role in connecting two major metropolitan cities in Java Island on each end and other cities in between the corridors. The corridor is currently served by highway, conventional rail network, and air transport mode. However, due to high trip demand, this corridor almost reaches its capacity. Developing a high-speed train network between Jakarta – Surabaya is one of the priority programs stated in the National Railway Masterplan (RIPNAS). The Jakarta – Surabaya high-speed train will be a competitor to the existing air transportation services, as both modes have competitive travel time and pricing. Previous studies have shown that operation HSR could have an adverse effect on the demand for airplane passengers. Passenger mode choice can be influenced by several factors, including the trip's purpose. This study aims to understand the differences between leisure and non-leisure trip maker in choosing their mode. Specifically, this study focuses on the competition between a high-speed train and existing air transport service on Jakarta – Surabaya Corridor. A stated preference survey was used to collect data on passenger mode choice. The logit binomial model was used to model the mode choice, with time and cost differences as the quantitative independent variables and trip purpose as the qualitative variable. This study used a dummy variable to represent the different trip purposes, leisure and non-leisure. The result found that the odds ratio is 0.646, which indicated that passengers on leisure trips are less likely to move to HST from the airplane. This result is useful for the planner as it can indicate the potential passenger demographic and come up with services that suit their needs.

Keywords: *mode choice, logit model, trip purpose, dummy variable, high speed train*

INTRODUCTION

Jakarta and Surabaya hold a very important role as two major cities in Indonesia. Those two cities have the biggest economic activities in the countries. The economic potential of these regions reached 55.62% of the GRDP of Java, while Java Island contributed 47.27% of the national GDP. Jakarta and Surabaya are also home to about 9.59 million and 2.94 million residences, respectively. They are also part of metropolitan agglomeration. Jakarta is part of the Jabodetabek (Jakarta, Bogor, Depok Tangerang, and Bekasi) Agglomeration area, with a population of 27.9 million. At the same time, Surabaya is part of Gerbangkertosusila (Gresik, Bangkalan, Mojokerto, Surabaya, Sidoarjo, and Lamongan) Agglomeration Area with a population of 9,1 million. The population, economy, and business activities in those two cities cause the travel demand between Jakarta and Surabaya quite high. The demand for executive train passengers between Jakarta - Surabaya in 2016 was approximately 1.1 million passengers/year and projected to increase and reach be 3.1 million passengers/year in 2030. The number of aircraft passengers is about 8.04 million/year and is

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projected to be 30.5 million passengers/year in 2030 (Nurhidayat, Utomo, Fajar, & Widyastuti, 2018). The demand for airplanes is higher than the executive train. It indicates that an airplane is still a more preferable choice to an executive train to travel from Jakarta-Surabaya. It is because the travel time of Jakarta – Surabaya aircraft is shorter than the executive trains or other transportation modes. Passenger using an aircraft takes approximately 5 hours to travel door-to-door between these two cities, while it takes 9 to 12 hours using the executive train. The increasing number of Jakarta Surabaya airplane passengers each year will soon saturate the corridor due to limited capacity.

The government plan to develop a high-speed train (HST) corridor between Jakarta and Surabaya as an alternative mode to accommodate the increasing demand between the two cities. The plan is stated in the National Railway Masterplan (RIPNAS)(Kementerian Perhubungan, 2011). The HST line is expected to be able to connect Jakarta and Surabaya with a maximum travel time of about 5 hours. It will help to increase the capacity of transportation links between Jakarta – Surabaya, which is currently served by highways, conventional railway systems, and airplanes.

The entrance of a new mode in a corridor usually will lead to a mode shift from the existing mode to the new one. Previous studies have shown that the introduction of high-speed railways affects airplane demand negatively (Castillo-Manzano, Pozo-Barajas, & Trapero, 2015; Li, Strauss, & Lu, 2018; Strauss, Li, & Cui, 2021; Yang, Burghouwt, Wang, Boonekamp, & Dijst, 2018). The operation of HST is expected to affect airplane passenger demand. Many factors can influence mode shift, both qualitative and quantitative variables. The influence of quantitative variables on mode choice behavior has been explored in many studies. Travel time, travel cost, distance to airport/station, population, and GDP are quantitative variables that have been proven to influence mode choice (Cascetta, Papola, & Pagliara, 2010; Li et al., 2018; Park & Ha, 2006). Meanwhile, few studies explored the influence of qualitative variables in the mode choice model due to its characteristics. As the name suggested, the qualitative variable has no tangible measurement that can easily be quantified and included in the model.

The traditional discrete choice models can only accommodate quantitative attributes of alternatives and socio-economic characteristics of the individuals as the explanatory variables. Qualitative attributes are rarely included in the mode choice model. In the last decade, "hybrid choice" models have been explored to include qualitative factors in the mode choice model. Tangible attributes and intangible elements associated with users' perceptions and attitudes can be included through latent or dummy variables (Outwater, Castleberry, Shiftan, Ben-Akiva, Shuang Zhou, & Kuppam, 2003). Previous studies have shown that including latent variables (LV) in the mode choice model helps improve choice model goodness of fit (Ashok, Dillon, & Yuan, 2002).

Latent variables (LV) are usually used to represent subjective elements in mode choice behavior. These variables try to represent factors that cannot be quantified directly, although it influences the mode choice behavior. A standard revealed preference (RP) or stated preference (SP) survey is required for the data collection process to capture users' perceptions regarding some aspects of the alternatives that cannot be measured based on observation only. Before commencing a survey, the LV needs to be defined in advance based on factors assumed to be relevant for each case study. It means that ex-ante identification of appropriate factors that may influence the perception should be made during the survey design process. This procedure should be followed in any application context(Skrondal & Rabe-Hesketh, 2004).

The inclusion of attitudes and perceptions in choice modeling has been a topic of interest for a long time as a way of better understanding individual behavior and decisions processes. Previous studies have shown the advantages of including attitudinal and perception variables, as they can significantly improve the explanatory power of traditional models (Kuppam, Pendyala, & Rahman, 1999; Mokhtarian & Salomon, 1997). This paper focuses on the inclusion of trip purpose in the mode choice between high-speed train and airplane. As trip purpose is an intangible variable, a dummy variable was used to represent the gender in modelling process. The results will give understanding on how female and male can have either same or difference preference in choosing their transport mode.

LITERATURE REVIEW

The introduction of a new mode in a corridor will create competition with the existing mode, leading to the possibility of a mode shift. Various studies have shown that introducing high-speed trains caused a decline in airplane passenger demand due to shifting from airplanes to high-speed trains (Castillo-Manzano et al., 2015; Li et al., 2018; Strauss et al., 2021; Yang et al., 2018). This competitiveness between high-speed railways and airplanes is more apparent, especially on routes with almost similar travel times. Therefore, the competitiveness of HSR depends on the travel distance. Study shows that HSR causes more impact on airplane passenger for a route with travel distance between 500 km to 800 km (Chen, 2017). It is the range where the trip distance between Jakarta and Surabaya falls into (±713 km). Therefore, the introduction of HSR on the Jakarta – Surabaya corridor can potentially affect airplane passenger demand for this route.

Many factors can influence the mode choice of passengers. Previous studies have identified several factors that can affect one mode choice. Factors related to trip characteristics include cost difference, trip frequency, travel time, trip length, and seat availability (Albalate, Bel, & Fageda, 2015; Behrens & Pels, 2012; Castillo-Manzano et al., 2015; Yang et al., 2018; A. Zhang, Wan, & Yang, 2019; Q. Zhang, Yang, & Wang, 2017). Meanwhile, demographic and economic profile factors include GDP, fuel price, hub status, population, and population density (Albalate et al., 2015; Castillo-Manzano et al., 2015). The trip purpose is one of the qualitative factors that can influence passenger mode choice (Chantruthai, Taneerananon, & Taneerananon, 2014). However, not many studies have included this factor due to the difficulty to include such qualitative into the mode choice model.

Mode choices have been developed for decades to estimate the possibility of a traveler choosing one mode over the others. Mode choice models usually include factors that are assumed to significantly influence passenger mode choice. The logit model has been used for decades to model the possibility of choosing a mode. However, the logit binomial model can only accommodate quantitative factors. Therefore, the influence of qualitative factors is relatively unknown. For the last decade, researchers have explored the idea of using a hybrid logit model with dummy/latent variables to include qualitative factors in mode choice models. The inclusion of qualitative factors is important to understand the influence of such variables in mode choice. A latent variable is found to be able to accommodate qualitative variables into the model (Outwater et al., 2003). The inclusion of qualitative variables through latent or dummy variables has been found to improve the goodness-of-fit and explanatory power of the mode choice model (Ashok et al., 2002; Kuppam et al., 1999; Mokhtarian & Salomon, 1997).

RESEARCH METHOD

Data Collection

Stated Preference Survey

A stated preference survey has been widely used in transportation and market research to determine users' preferences towards new transport modes or products compared to existing ones. The other type of survey used in market research is Revealed Preference (RP). RP is conducted based on the actual market observation that compares user preferences towards existing products. Meanwhile, SP is developed based on hypothetical scenarios of several choices, including not-yet-implemented options. SP has been used in the transportation field to predict the preferences for different modes, especially the newly introduced mode of transport.

SP has several advantages and disadvantages compared to RP. The survey design of SP is more controllable compared to RP since the variable that will be included in the experiment design can be decided based on the research requirement. Another advantage of SP is that, as mentioned before, it can consist of future products or plans that are not yet being implemented in the marketplace (Jones & Bradley, 2016; Sanko, 2001). This advantage makes SP a popular option to study new products before it is launched to the market, including new modes. Since the researcher has more extensive control over the survey design, the variability of the attributes can be set to give a more significant contrast between different products. The other advantage of SP compared to RP is that the research can control the collinearity between variables.

A stated preference survey was done to collect data on the passenger preference between high-speed trains (future mode) and existing airplanes. The survey was conducted at the Soekarno-Hatta International Airport, Jakarta, and Juanda International Airport, specifically targeting airplane passengers traveling between Jakarta and Surabaya. The participants were asked to rate their preference toward the two modes under various scenarios containing a combination of travel time and cost differences.

Questionnaire Design

The questionnaire was designed based on several scenarios of a combination between possible travel time and cost differences. The travel time represents the whole time the passenger spends on the journey, from the beginning of the trip until the passenger reaches the destination, including access time, waiting time, boarding time, egress time, etc. The cost represents all the costs passengers spend, including ticket fare, tax, access, and egress costs. The calculation of the travel time differences was based on the estimated travel time of HST (fastest scenario – slowest scenario) compared with the average travel time by existing airplane. The travel time differences were defined into four levels: same as existing mode, 30 minutes slower, 60 minutes slower, 30 minutes faster, and 60 minutes faster. Meanwhile, the travel cost differences were calculated based on the estimated cheapest and most expensive travel cost by HST and the range of travel costs by airplane. Table 1 shows the experimental design of this study.

Table 1. Experimental Design

New Mode (HST)	
Travel Time Differences	Travel Cost Differences
30 minutes slower	• Same as Airplane • Rp 30,000 cheaper • Rp 40,000 cheaper • Rp 110,000 cheaper
60 minutes slower	• Same as Airplane • Rp 40,000 cheaper • Rp 90,000 cheaper • Rp 150,000 cheaper
30 minutes faster	• Same as Airplane • Rp 50,000 more expensive • Rp 100,000 more expensive • Rp 150,000 more expensive
60 minutes slower	• Same as Airplane • Rp 50,000 more expensive • Rp 100,000 more expensive • Rp 200,000 more expensive

New Mode (HST)	
Travel Time Differences	Travel Cost Differences
Same as Airplane	• Same as Airplane • Rp 30,000 more expensive • Rp 40,000 more expensive • Rp 110,000 more expensive • Rp 30,000 cheaper • Rp 40,000 cheaper • Rp 110,000 cheaper

The questionnaire also included questions regarding the participants' characteristics and their current trip information. The participant characteristics included data such as age, gender, education, occupation, and income. The information regarding the current trip characteristics had trip purpose, origin, destination, travel time, and travel cost. Those data will be used to analyze the respondent's characteristics as well as their travel behavior or trend. Table 2 shows the list of the supporting data included in the questionnaire.

Table 2. List of Supporting Data

Category	**Data**
Demographic Data	• Age • Gender • Education • Occupation • Income
Travel Data	• Origin and Destination • Trip Purpose • Existing Mode • Travel Time • Travel Distance • Travel Cost

Modelling

The mode choice behavior between existing airplane services and the high-speed train was modeled based on the logit binomial model. The logit mode choice model is based on the cumulative logistic probability function. It follows the formulation shown in equation (1).

$$P_i = \frac{1}{1+e^{-U(x_i)}} \quad (1)$$

Where

P_i = probability of choosing mode i
$U(x_i)$= utility function of mode i

When equation (1) is multiplied by $1 + e^{U(x_i)}$ on both sides, it will produce the utility function as shown in equation (2) below. The utility function represents the characteristics of the alternatives i.

$$\text{Ln}\left(\frac{P_i}{1-P_i}\right) = U(x_i) = \alpha + \beta x_i \quad (2)$$

The utility function between high-speed trains (new mode A) and airplane (existing mode B) shows the tendency of an individual to choose their mode of transport based on the travel time difference and travel cost difference. α in equation (2) indicates that other influencing variables have not been represented by the independent variables in the equations. This study will add trip purpose as the qualitative independent variable. A dummy variable was used to represent the trip's purpose. The trip purpose was categorized into two groups: Leisure Trip and Non-Leisure Trip. The utility function of the high-speed train with a dummy variable can be written as shown in Equations (3) and (4).

$$\text{Ln}\left(\frac{\text{P}_\text{A}}{1-\text{P}_\text{A}}\right) = U(x_A) = a_0 + a_1\Delta cost + a_2\Delta time + a_3 D_i \quad \text{.......... (3)}$$

or

$$\text{Ln}\left(\frac{\text{P}_\text{A}}{1-\text{P}_\text{A}}\right) = U(x_A) = a_0 + a_1(cA - cB) + a_2(tA - tB) + a_3 D_i \quad \text{.......... (4)}$$

Where:

P_A = Probability to choose high-speed train
$U(x_A)$ = Utility function of high-speed train
$\Delta cost$ = total travel cost difference between high-speed train and airplane
$\Delta time$ = total travel time difference between high-speed train and airplane
D_i = dummy variabel for gender
a_0 = intercept
a_1, a_2 = constant
a_3 = defferential intercept coeffisien

The two groups of trip purpose were represented by value: D_i = 1 for leisure trip and D_i = 0 for non-leisure trip. Equation (5) and (6) shows the utility function of high-speed train under each category.

$$U(x_A|D_i = 1) = (a_0 + a_3) + a_1(cA - cB) + a_2(tA - tB) \quad \text{.......... (5)}$$
$$U(x_A|D_i = 0) = a_0 + a_1(cA - cB) + a_2(tA - tB) \quad \text{.......... (6)}$$

Equation (5) and (6) can be subtituted into Equation (4) to form Equation (7) and (8)

$$\text{Ln}\left(\frac{\text{P}_1}{1-\text{P}_1}\right) = (a_0 + a_3) + a_1(cA - cB) + a_2(tA - tB) \quad \text{.......... (7)}$$
$$\text{Ln}\left(\frac{\text{P}_0}{1-\text{P}_0}\right) = a_0 + a_1(cA - cB) + a_2(tA - tB) \quad \text{.......... (8)}$$

Equation (7) represent the behavior of passenger on leisure trip in choosing their mode of transport between high-speed train and airplane with intercept (($a_0 + a_3$), while Equation (8) indicates the non-leisure passenger behaviour with intercept a_0. The odds ratio can be calculate using formula as shown in Equation (9). Odds ratio indicates how likely passenger in a leisure trip to choose high speed train compare to non-leisure trip.

$$Odds\ Ratio = \text{Ln}\left(\frac{\text{P}_1}{1-\text{P}_1}\right) \Big/ \text{Ln}\left(\frac{\text{P}_0}{1-\text{P}_0}\right) \quad \text{.......... (9)}$$

FINDINGS AND DISCUSSION

Respondents' General Characteristics

A total of 229 responses were collected from the stated preference survey. The respondents' demographic, as well as their travel characteristics, were obtained through the survey. The respondents aged between 14 and 69 years old, with an average age of 36.5. The age group represents the productive and working age groups. The dominant occupation of the respondent is an employee of either a private company or state company, followed by an entrepreneur/businessman and civil servant. It can be understood as those occupations requiring high mobility, including traveling from one city to another for business or work trips. Table 3 shows the general information of the respondents.

Table 3. General Information of the Respondents

Variable	**Percentage**
Gender	Male: 64%, Female: 36%
Age	Average: 36.5
	Min: 14; Max: 69
Occupation	Civil servant: 11.7%
	Employee: 46.7%
	Businessman: 15.3%
	Student: 8,7%
	Other: 17.5%
Education	Elementary/Middle School: 4%
	High School: 27%
	Diploma: 8%
	Bachelor: 48%
	Postgraduate: 12%

In addition to the general information of the respondent, trip characteristics data is also collected during the survey. Table 4 shows the trip characteristics data of the respondents. The trips mostly begin and end around the agglomeration area of Jabodetabek and Gerbangkertasusila, as both areas are within the hinterland of the airport. Only a few trips went beyond those areas. The trip is mostly business and work trips. It is in line with the respondents' dominant occupations: employee, businessman, and civil servant. Those three groups are most likely to make business or work trips. The average travel time of the current trip using an airplane is about 343 minutes. The longest travel time can reach 960 minutes, while the shortest is about 120 minutes. The variation in travel time depends on the distance from the origin to the airport and the airport to the destination, access mode, as well as waiting time at the airport.

Table 4. Trip Characteristics

Variable	**Characteristic**
Purpose of The Trip	Work: 29.1%
	Social: 13%
	Recreation: 6.7%
	Business: 42.6%
	Study: 2.7%
Travel Time	Average: 343 minutes
	Min:120 minutes
	Max: 960 minutes

Variable	Characteristic
Travel Cost	Average: IDR 793,952
	Min: IDR 400,000
	Max: IDR 3,000,000

Influence of Trip Purpose: Leisure Vs. Non-Leisure

Data collected from the survey were tabulated into a database. Every respondent was given 23 scenarios. Therefore, every respondent will have 23 responses. The time differences and cost differences were included in the model as the independent quantitative variables. As the qualitative variable, the trip purpose was represented by a dummy variable. The Dummy variable is generated by coding the trip purpose categories into two values: 1 for a leisure trip and 0 for a non-leisure trip. *R Studio* was used as a modeling and statistical tool. Table 5 shows the results and statistic indicator of the logit binomial logit model.

Table 5. Result of Statistical Analysis

	Estimate	Standard Error	Pr(>|z|)
Intercept	1,055e-01	9,377e-02	< 2e-16
Time Difference	4,236e-01	4,452e-02	< 2e-16
Cost Difference	-1,411e-05	6,3620e-07	< 2e-16
Dummy Variable (Leisure Trip)	-4,356e-01	-5.611	2,01e-08

The result of the statistical analysis shows that travel time and cost differences significantly influence the mode choice behavior, with a p-value less than 0.10. Previous studies have shown that travel time and cost influence mode choice (Behrens & Pels, 2012; Danapour, Nickkar, Jeihani, & Khaksar, 2018; Ren, Chen, Wang, Wang, Wang, Dan, et al., 2019). The result indicates that cost difference negatively impacts mode shift. It means that if the ticket fare for HST is set at a more expensive price, it the less likely that people will shift from airplane to HST. The statistical analysis also shows that travel time has a more significant influence than travel cost, indicated by the more considerable coefficient value. Most of the respondents are traveling for business or work and returning after a business trip. For this kind of trip, travel costs should be less of a concern since the company will pay it. Travel time becomes a more important factor, as they need to spend their time more efficiently.

The result also shows that trip purpose has a quite significant influence on the mode choice. It is in line with the previous study that indicates trip purpose as one factor that influences HST travel demand. Given the differences in trip purpose, they may have a different concerns when deciding the mode of transport. Passengers on leisure trips will be less concerned about the travel time than a non-leisure trips, such as business and work trips. On the other hand, non-leisure passengers, such as passengers who travel for business or work trips, will be less concerned about the pricing since mostly the company will cover the ticket fare for the journey. Trip purpose even has a bigger influence than the travel cost difference, as indicated by the bigger estimated coefficient for the dummy variable. Based on the result statistical analysis shown in Table 5, the Equation (7) and (8) can be re-written as:

$$\mathrm{Ln}\left(\frac{P_1}{1-P_1}\right) = 0.25 - 0.000014(cA - cB) + 0.424(tA - tB) \quad (10)$$

$$\mathrm{Ln}\left(\frac{P_0}{1-P_0}\right) = 0.105 - 0.000014(cA - cB) + 0.424(tA - tB) \quad (11)$$

The result also shows that the odds ratio is 0.646, or less than 1. This indicates that leisure passengers are less likely to shift from airplanes to high-speed trains than non-leisure passengers. The possibility of the higher ticket price for HST may hinder leisure passengers from shifting from airplanes to HST. HST is less sensitive to weather conditions than airplanes. Bad weather conditions may affect or even delay the flight. On the other hand, HST, with faster travel time and dedicated corridor, give sense of reliability for people that concern about the time. Therefore, non-leisure passenger (business or work trip) may see HST as more reliable choice for them to travel.

CONCLUSION

Various factors can influence passengers in choosing their preferred transport mode, which includes quantitative and qualitative variables. Many studies have been done to understand the influence of quantitative variables on mode choice and include quantitative variables in the mode choice model, e.g., income, distance, population, etc. However, only a few studies have included qualitative variables. The discrete choice model traditionally can only accommodate the measurable variable. Understanding qualitative variables' influence on mode choice will help to understand the behavior of the passengers and attract more passengers.

This paper tried to explore the potential influence of trip purpose on mode choice. Specifically, the trip purpose was divided into two categories: leisure versus non-leisure trips. This paper focuses on the influence of trip purpose on the mode choice behavior between high-speed trains and airplanes in the Jakarta – Surabaya Corridor. A dummy variable was used to represent the trip purpose in the analysis process. The results showed that the odds ratio is 0.646, which mean that leisure trip maker is less likely to choose high-speed train than non-leisure one. Non-leisure passengers, such as people who travel for business or work trips, are more attracted to move high-speed trains than airplanes. It might be due to the fact that non-leisure passenger tends to put more importance on travel time and punctuality. This result is useful for the planner as it can indicate the demographic of the potential passenger. Based on this result, the service provider and government can also consider strategies to make high-speed trains more attractive for leisure passengers.

LIMITATION & FURTHER RESEARCH

Future study may consider including more variable into the mode choice model to get a better understanding of factors that influence mode choice behavior and how it affects each other.

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