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# A Study on Transport Mode Choice Behavior of Aircraft and High Speed Train Using the Logit Model: A Case Study of The Jakarta-Surabaya Route

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***Abstract*— This research was conducted to analyze the model of transportation mode selection between aircraft and high speed train of Jakarta-Surabaya route as an empirical case study, assuming the construction of high speed train infrastructure has been completed and ready to operate connecting Jakarta-Surabaya. In this research we offer two independent variables i.e. travel time and fare incurred. The collected data is obtained by spreading the questionnaire to respondents as the user plane destination Jakarta-Surabaya using stated preference and binomial logit model. We found that with the operation of Jakarta-Surabaya high speed train has a negative impact on air transport demand especially for passengers' aircraft. In addition, indicates the level income of the person, the higher also the use of the modes with the fastest travel time without taking into account the cost of the trip must be issued.**

***Index Terms*— high speed train, travel time, fare, stated preference, binomial logit model**

## I. Introduction

Jakarta and Surabaya are 2 (two) largest cities in Indonesia with population of 9.59 million and 2.94 million, as well as a magnet of surrounding cities. The population of Jabodetabek is 27.9 million, Kedungsepur 5,8 million and Gerbangkertosusila 9,1 million, so overall the total population reaches 31,25% of Java population. The economic potential of these three regions reached 55.62% of the GRDP of Java (Java GDP is 47.27% of national GDP).

The travel demand of Jakarta - Surabaya is increasing. The number of executive rail passengers in 2016 are approximately 1.1 million passengers / year and projected to be 3.1 million passenger / year in 2030. The number of aircraft passengers is approximately 8.04 million / year and projected to be 30.5 million passengers / year in 2030. The travel demand of Jakarta - Semarang executive rail in 2016 is approximately 472 thousand passengers / year and projected to be 1.45 million passenger / year in 2030. The number of aircraft passengers in 2016 are approximately 2.3 million passenger / year and projected to be 4.6 million passengers / year in 2030. The potential of Jakarta - Semarang railway passengers compared to Jakarta - Surabaya only 46.5%, while the comparison of aircraft passengers on the same route only 15.2%.

From the data above, it is known that the use of an airplane from Jakarta-Surabaya is still dominant because the travel time of Jakarta – Surabaya aircraft is shorter than the Executive trains or compared to the other transportation modes. Passenger using an aircraft takes 5 hours, while using the executive train takes 9 to 12 hours. the increasing number of Jakarta Surabaya airplane passenger each year will have a direct impact on the capacity of the airport in flight traffic serve the request because it is directly related to the frequency of flights, runway capacity, capacity building terminals and so on. This is the reason why the government plans to build high speed train on Jakarta to Surabaya corridor to improve transportation services which include transport quantity, travel speed, safety and comfort.

TABLE I
JAKARTA-SURABAYA ROUTE PASSENGERS AIRCRAFT

| | 2012 | 2013 | 2014 | 2015 | 2016 | Growth (%) |
|---|---|---|---|---|---|---|
| Jakarta - Surabaya | 5.035.216 | 5.613.642 | 5.371.110 | 5.228.922 | 5.860.098 | 3,86 |
| Jakarta - Semarang | 2.288.825 | 2.056.839 | 2.038.181 | 2.140.339 | 2.425.269 | 1,46 |
| Semarang - Surabaya | 227.481 | 305.389 | 285.555 | 302.816 | 341.948 | 10,73 |

Source: PT. Angkasa Pura II, 2017

The government plans to build a Jakarta-Surabaya high speed train to cut the recent travel time which spent 10 hours using an executive class train and 5 hours by aircraft (including time to airport, check in, waiting time, boarding, on-board and waiting for luggage). In order to attract the passengers of the aircraft to the train, the Jakarta-Surabaya high speed train should be designed with a maximum duration of 5 hours and the ticket price is below the aircraft price. Thus, can be estimated that by 12.43% of the aircraft passenger shifting to the high speed train. To make it happened, high

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speed train should be designed to operate at an average speed of 166 km / hour and a minimum speed of 180 km / hour.

## II. LITERATURE REVIEW

Lee et al. (2016) classified passengers into two distinctive groups as business passengers and leisure passengers in order to analyze each group's choice of the mode transportation when air transportation is in competition with high speed rail Seoul-Jeju route. Flight fare, travel time, frequency, safety and duty free shopping availability were considered as explanatory variables.

Park and Ha (2006) carried out SP research on Seoul-Daegu route air passengers supposing that KTX is introduced on the Seoul-Daegu route. After KTX was introduced, it was proven that there were actual changes in air transportation demand and passengers' preference compared to periods prior to the launch. To carry out the preference survey, access time, fare and the frequency of operation were set as variables.

Fourie and Lubbe (2006) analyzed choice attributes of FSC and LCC business air passengers in South Africa. The choice attributes included eleven variables of degree of seat comfort, schedule/frequency, fare, authority of seat choice, cancellation charge, airport lounge facility, frequent flyer program, business seat choice, inflight food and drinks, method of payment and in-flight entertainment.

Hees et al. (2005) classified passengers into two distinctive groups as business/travellers and residents/visitors in order to analyze each group's choice of airports among San Francisco International (SFO), San Jose Municipal (SJC) and Oakland International (OAK) airports, all located in vicinity of San Francisco Bay area. Flight fare, frequency and access time were considered as explanatory variables. As a result, preference towards air transportation in the SP research turned out to be 14% which increased to 28% after the KTX entry, slightly higher than the supposed value.

Inoue et al. (2015) using a stated-preference survey, examine changes in air transport demand by the entry of low cost carriers into domestic service, and with the beginning of operation of the Linear Chuo Shinkansen. Total fares, total travel time and frequency were considered as explanatory variables.

## III. METHOD

### *A. Design of stated preference technique*

SP technique is an approach to respondents to know their response to different situations. In this technique the researcher can fully control the factors that exist in the hypothesized situation. Each respondent was asked about the response if they were faced with the situation given in the actual conditions (how are their preference to the options offered).

In this study, stated preference (SP) techniques utilized transport mode choice on the specific route based on statement of their preferences. Actually SP techniques have been successfully applied to the transport choice problems. For air transport, researchers have also tried to apply SP techniques for demand analysis.

### *B. Selecting Choice Independent Variable*

#### *1 Travel time attribute*

Travel time is the travel time of the vehicle in minutes or hours, which is the time required to start the journey from the starting point to the airport until arriving at the destination including the time of reporting the departure (check in, boarding pass), waiting at the terminal (waiting time), transit / stop time and baggage handling to the end of destination. The average travel time of air transport from major cities in the Jakarta-Surabaya was 300 min (90 min travel time to airport and airport to destination, 60 min check in and waiting time, 30 min boarding time, 90 min on board and 30 min baggage handling/time to out in airport).

#### *2 Fare attribute*

Lee et al. (2016) fare is the costs incurred for the payment of the transportation fee in rupiah per person, which is the cost of the Jakarta - Surabaya route. This variable is given three levels of value. The highest level is set at average air fare of 2016. The medium and low levels are set at values respectively 10% and 20% lower than the highest level's value. This was due to the assumption that if high speed train, a new mode of transportation, is introduced to the market, air carriers would set lower air fares to maintain their market share and competitiveness.

In this research, the travel cost is the price of the trip ticket issued by the respondent to buy the aircraft ticket route Jakarta-Surabaya.

### *C. Structure of the questionnaire*

Park and Ha (2006), As described in previous sections, two factors which influence transport modal choice behaviour were determined as attributes for the SP experiment: fare and travel time. Three levels were assigned for each attribute. Table I shows the fractional factorial plan of combinations of attribute levels. This fractional factorial plan is based on the catalogue of fractional factorial designs found in the Orthogonal Experimental Design Table (Hahn and Shapiro, 1966). Following the design Table II, the test plan code corresponds, and then by applying the master plan number, which can be designated as questions can be created by the Hahn's table. The alternative experimental design is shown in Table II.

TABLE II
VALUE OF EACH ATTRIBUTE LEVEL

| | Travel Time (Minute) | Fare (IDR) | Aircraft |
|---|---|---|---|
| Level of Attribute | -30 | 0 | Travel time 300 min |
| High speed train | -30 | -50.000 | Fare (IDR) 720.000 |
| | -30 | -100.000 | |
| | -30 | -150.000 | |
| | -60 | 0 | |
| | -60 | -50.000 | |
| | -60 | -100.000 | |
| | -60 | -150.000 | |
| | 30 | 50.000 | |
| | 30 | 100.000 | |
| | 30 | 150.000 | |
| | 60 | 0 | |
| | 60 | 100.000 | |
| | 60 | 200.000 | |
| | 60 | 300.000 | |
| | 0 | 0 | |

Note: May 2017

### *D. Stated preference survey*

The Stated Preference technique bases the demand estimate on an analysis of responses to the choice of modes offered and is still in the planning stage. The implementation of the stated preference survey is done to see the respondent's preference to the level of the travel attribute offered. Respondents were asked to choose alternative options as they wanted.

The survey was conducted to respondents who travelled from Jakarta to Surabaya using an aircraft with the aim to see the preferences of the attributes offered. From the survey that has been done then the data recorded include the age, gender, job, education, trip purpose, and the mode used to the airport, in addition to other measurements asked for in general documentary records and the documentation of the stated preference test.

### *E. Model Calibration*

The stated preference data analysis is to decompile all preference into utility sections contained in each attribute being surveyed. The utility function is used to measure the attractiveness of each option (hypothetical scenario) given to the respondent.

The logit model is simply a log ratio of the probability of choosing a mode to the probability of not choosing a mode.

$$log\left(\frac{Pi}{1-Pi}\right) = v(xi) \quad (1)$$

where

$Pi$ = Probability of choosing mode i.
$v(xi)$ = Utility of mode $i$

A mode is chosen if its utility increases for several reasons, among others, the first, utility itself is a function of the network effect, the more users, the more valuable the service, the higher the utility. Second, the utilization increases along with the decrease in user costs. Third, the technological advances that occur over time and as the number of users increases will lower the relative cost.

An equation of a utility is given:

$$log\left(\frac{PA}{1-PA}\right) = \beta o + \beta 1(cA - CT) + \beta 2(tA - tT) = vA \quad (2)$$

Where:

$PA$ = Probability of taking new mode.
$cA,cT$ = cost of new mode, existing mode
$tA,tT$ = travel time of new mode, existing mode
$v$A = Utility of new mode

The model can be translated using algebra become as follow:

$$\frac{P_A}{1-P_A} = e^{vA} \quad (3)$$

$$P_A = e^{vA} - P_A e^{vA} \quad (4)$$

$$P_A(1 + e^{vA}) = e^{vA} \quad (5)$$

$$P_A = \frac{e^{vA}}{1+e^{vA}} \quad (6)$$

An object such as a vehicle does not have utility, it is characteristics of a vehicle that have utility. The introduction of e lets us do some aggregation. As noted above, we think of observable utility as being a function:

$$v_A = \beta o + \beta 1(cA - CT) + \beta 2(tA - tT) \quad (7)$$

where each variable represents a characteristic of the auto trip. The value β0 is termed an alternative specific constant. Most models say it represents characteristics left out of the equation.

## IV. RESULT AND ANALYSIS

The questionnaire was prepared and issued by the surveyors directly to the respondents and collected immediately. The questionnaire was organized to collect data on gender, age, income level, job, education level, trip purpose and the modes used to the airport, in addition to other measurements asked for in general documentary records and the documentation of the stated preference test.

TABLE III
GENERAL SURVEY RESULT DATA

| Variable | Percentage |
|---|---|
| Gender | Male : 77.19%, Female : 22.81% |
| Educattion level | Junior high school : 1.99% |
| | Senior high school : 20.15% |
| | Diploma : 9.20% |
| | Bachelor : 50.25% |
| | Postgraduate : 18.16% |
| Job | Government employee : 17.62% |
| | Employee : 46.90% |
| | Businessman : 14.14% |
| | Student : 9.43% |
| | Other :8.93% |
| Income level | IDR < 6.000.000 : 40.94%<br>IDR 6.000.000 - 12.000.000 : 27.05%<br>IDR 12.000.000 - 18.000.000 : 14.39% |
| | IDR > 18.000.000 : 14.64% |
| Trip purpose | Work : 78.81% |
| | Social : 11.41% |
| | Recreation : 4.22% |
| | Business : 2.23% |
| | Study : 0.50% |
| | Other : 1.74% |

The access transport modes to the airport were private car, airport taxi, online taxi, airport bus and motorcycle. Table IV shown the modal share of access to both Airport based on the survey respondents.

TABLE IV
THE MODAL SHARE OF ACCESS TO AIRPORT

| Classifications | Respondents | |
|---|---|---|
| | No. of respondents | Share rate (%) |
| Private car | 138 | 35,8% |
| Airport taxi | 74 | 19,2% |
| Online taxi | 71 | 18,4% |
| Airport bus | 15 | 3,9% |
| Official car | 41 | 10,6% |
| City bus | 18 | 4,7% |
| Motorcycle | 19 | 4,9% |
| No response | 9 | 2,3% |
| Total | 385 | 100% |

The fare of passenger aircraft for Jakarta-Surabaya and executive class trains is based on the results of a survey conducted in the Table V.

TABLE V
FARE AIRCRAFT AND EXECUTIVE TRAIN JAKARTA-SURABAYA FROM SURVEY RESULT

| Mode & Route | Level Income (IDR) | | | | |
|---|---|---|---|---|---|
| | <6 million | 6-12 million | 12-18 million | >18 million | Avarage |
| Aircraft Jakarta-Surabaya | Rp694,500 | Rp711,260 | Rp753,000 | Rp761,320 | Rp720,820 |
| Executive Train Jakarta-Surabaya | Rp438,080 | Rp436,310 | Rp417,000 | Rp439,820 | Rp433,400 |

From the results of the total travel time survey required from Jakarta-Surabaya using an aircraft with details of the time to the airport, the time needed to check, boarding, on-board, waiting for baggage and heading to the final destination as presented in the Table VI:

TABLE VI
TOTAL TRAVEL TIME JAKARTA-SURABAYA USE AIRCRAFT FROM SOEKARNO HATTA INT. AIRPORT AND JUANDA INT. AIRPORT

| Variable | Surabaya-Jakarta | Jakarta-Surabaya |
|---|---|---|
| Accsess time to airport | 50,42 | 83,22 |
| Waiting time | 71,79 | 78,66 |
| On board time | 90,5 | 94,78 |
| Transfer mode | 27,99 | 36,34 |
| Agress time to destination | 80,53 | 46,24 |
| Total (minute) | 321,23 | 339,24 |

Calibration is the process of estimation of the parameter value in an equation that gives the best results or closest to the observations in the field. Calibration of a regression equation will produce numerical values of the constants and the regression coefficients of the equation. The results of the calculation of the calibration can be seen in the following Table VII:

TABLE VII
THE RESULT OF MODEL CALIBRATION

| Variable | Level Income (IDR) | | | |
|---|---|---|---|---|
| | <6 million | 6-12 million | 12-18 million | >18 million |
| Constants | | | | |
| $a_0$ | 1,274862593 | -0,18720133 | -0,46808054 | -1,625498249 |
| t-stat | 14,89249284 | -1,39490732 | -2,13028511 | -8,456539071 |
| Independent Variable: Time Different ($a_1$) | 0,090483491 | 0,119062379 | 0,178805615 | 0,18885228 |
| t-stat | 30,85173173 | 26,26141697 | 25,78292603 | 29,37266856 |
| Cost Different ($a_2$) | -6,81871E-05 | -6,73752E-05 | -3,10398E-05 | -3,40293E-05 |
| t-stat | -69,30454024 | -45,10258357 | -11,78575050 | -15,05716019 |
| $R^2$ | 0,700196376 | 0,624764532 | 0,503864384 | 0,535659391 |

Interpretation of the signs on the coefficients can be used to indicate whether the equation makes sense or not, the interpretation of the value of $R^2$ to see how far these equations can explain the influence of an attribute in the selection mode, then interpretation of the value of f-stat and t-stat to figure out the significance of the influence of an attribute both individually and simultaneously in the equation.

The constant value of the regression is the value that stating the influence of the characteristics individuals that are not considered in the utility function in the selection mode. The smaller regression constants (close to zero) are the better. On binomial logit difference models, of all the alternative equations that have the smallest constants are (-1.6254), followed by (-0.4680) and (-0.1872).

The regression coefficient is a value that indicates the magnitude of the contribution of each attribute against a utility function equation. On binomial logit difference model of all the attributes that have the smallest coefficient value is the attribute of travel expenses (travel cost) (rupiah) of -0.000068 followed by attributes of time travel (minutes) of 0.0904, travel time (journey time) (minutes) of 0.00886.

The model that resulted has a value of the determination coefficient ($R^2$) the largest i.e. 0.700. This means that the influence of all attributes to changes the utilities on this model is 70% and the remaining 30% are influenced by other attributes that are not considered in this model.

On binomial logit difference model, attributes in time travel (travel time) has a positive sign (+) on all alternative equations. This means that if there is an increase in the ratio between the aircraft travel time trip and high speed train (aircraft travel time trip increased or high speed train decreased) then it will result in a probability of selection modes an aircraft decreases, and probability of high speed train increases.

On binomial logit difference model, attributes the in travel costs (travel cost) has a negative sign (-) on all alternative equations. This means that if there is a decrease in the ratio between the aircraft travel cost and high speed train (the cost of aircraft increases or the cost of high speed train decreases) then it will result the probability of selection modes an aircraft decreased and high speed train increased.

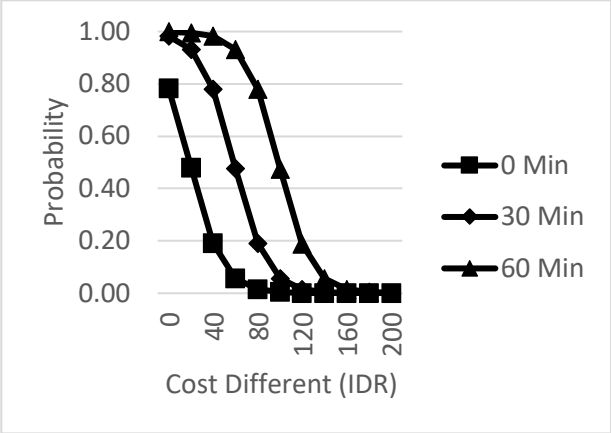


**Fig. 1.** Probability Mode Choice for Level Income < 6 Million (IDR)

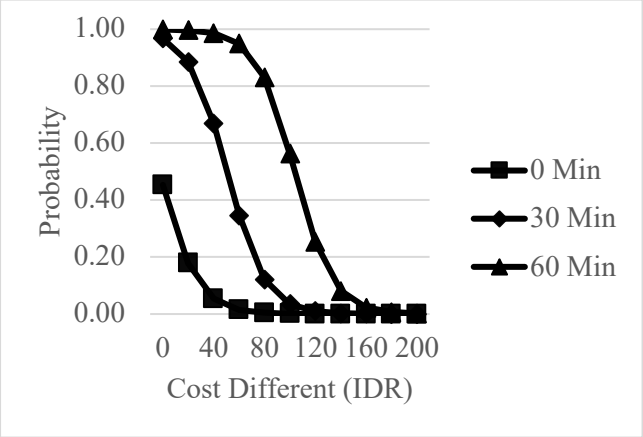


**Fig. 2.** Probability Mode Choice for Level Income 6 - 12 Million (IDR)

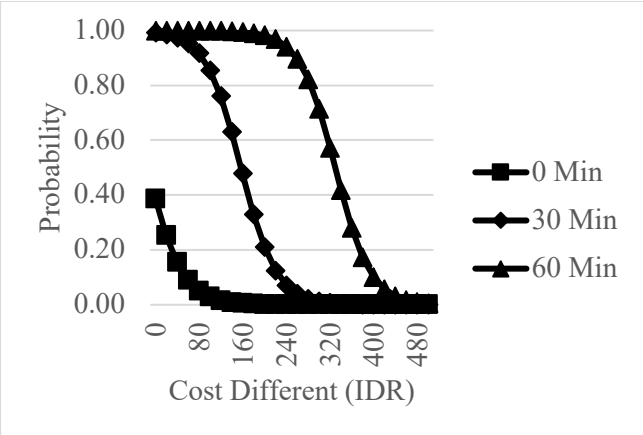


**Fig. 3.** Probability Mode Choice for Level Income 12 - 18 Million (IDR)

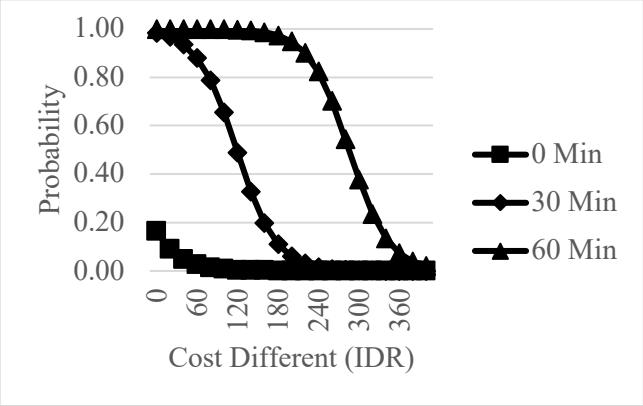


**Fig. 4.** Probability Mode Choice for Level Income > 18 Million (IDR)

From the picture above appear distinction probability selection mode of an aircraft with a high speed train from Jakarta-Surabaya for each income level. For the same travel time between aircraft with the high speed train about 5 hours, then the probability of the passengers of the aircraft choose the high speed train the lower on the income levels > 18 million and otherwise. Means the tendency of people who have a high level of income very sensitive against standard service provided by high speed train mode including travel time mode offered can compete with aircraft (fast and on time).

## V. Conclusion

The purpose of this study is to find conducted to analyze the model of transportation mode selection between aircraft and high speed train of Jakarta-Surabaya route by simply pasting a variable travel time and fare must be issued.

From the resulting model, passengers with high income levels will still tend to use aircraft compared to high speed trains if the travel time and fareare the same because they believe the aircraft travel time is certain so that time is the top priority in determining the mode selection to be used (fast and on time).

By using the technique of stated preference survey, we find the probability of the use of modes between aircraft with a high speed train Jakarta-Surabaya for each respective income level that determined. The higher socio-economic status of someone, the higher probability also the use of the modes with the fastest travel time without taking into account the cost of the trip must be issued. In addition the study also aims to seek out other variables that affects the respondent in determining the option mode that will be used besides travel time and travel costs, include frequency, facilities provided, distance towards the station, the mode that used to the airport/station.

This study can be used as fundamental data to build customized strategies for airlines when new participants participate in existing routes or when high speed train competitors on the existing route. In addition, this study can be used in determining alternative mode selection strategies between Jakarta and Surabaya which can balance the travel time using aircraft.

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