A Study on Intercity Transportation Mode Choice on Two Corridors in Java Island

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Abstract: As the most dense-populated island, intercity transportation on Java Island plays an important role to address regional disparity. It is hoped that by improving intercity connection will stimulate economic growth in the vicinity areas as well as reduced urbanization rate. This paper discusses study on intercity modal share in two corridors on Java Island: Jakarta-Bandung corridor and Jakarta-Surabaya corridor. This study analyzes some factors that influence diverted trend in transportation mode. The methodology used in the analysis comprises the following steps: identified the problem, collecting secondary data, developing model for the problem and conducting a survey. Sequence of analysis was performed, using descriptive statistics and linear regression analysis. By figuring out those factors, it is expected that it can be implemented as a consideration in improving balanced modal shared to support economic development.

Key Words: intercity travel mode, unbalanced modal share, load factor

1. BACKGROUND
Java is the most dense-populated island in Indonesia, with almost 60% country population live in it (Indonesia Statistic Bureau; 2010). Since the distribution of population and natural resources are uneven, better transportation facilities are required, in order to support a compatible and compromise development in all sectors spatially. Improvement of intercity transportation system is needed in order to stimulate the economic growth as well as to reduce the urbanization rate.

However, improvement in only one sector of transportation, for example, highway only, does not seem to be an ideal solution, since some adverse impact might occur. Some of the impacts are encourage of the use of private car, this will lead to inefficiency of fuel consumption and
road congestion that will restrain the productivity of the society. Furthermore, the development that focused on only one sector of transportation will result in cutback for other modes, which can be a burden for other development sectors.

There are 3 big cities in Java Island: Jakarta as the capital city of Indonesia, Bandung and Surabaya. This paper discusses intercity connections between Jakarta-Bandung corridor as a medium distance case, and Jakarta-Surabaya corridor as a long distance case. Those corridors showed that the development on highway transport or the liberalization on air transport fares made railways mode, intercity bus, and sea transport face a serious problem on decreasing their services and number of passengers. Furthermore, this unbalanced modal share situation might give negative impact on regional development. From the existing condition, this research will analyze factors that influence diverted trend in transportation mode. It is expected that the result of the study can be used as a recommendation for a better transportation system.

2. EXISTING CONDITION
2.1. Jakarta-Bandung Corridor
Bandung, the capital city of West Java province, is well known as the tourism city. Located relatively near to Jakarta, make lots of people from Jakarta spend their holiday in Bandung. On the other hand, number of people from Bandung that earn their living in Jakarta is quite high. These facts imply that Jakarta - Bandung transportation is potential for the economic activities in both cities.

There are several mode choices to reach Bandung from Jakarta or vice versa. The choices are using highways, railways and also airways. Since the travel frequency is high for Jakarta-Bandung corridor, the government did improvement in this corridor by developing the Cipularang toll. It is expected that this development will reduce travel time and will result in more trips.

The development of Cipularang toll gave impact not only for travel time and trip numbers for highway mode of transport, but also the trend for other transportation modes. Those trends will be divided into three time intervals: before year 2005, between year 2005 – year 2010, and after 2010, as shown by the following table.

Table 1 Frequency & Load Factor by Mode for OD: Jakarta – Bandung

<table>
<thead>
<tr>
<th>Mode</th>
<th>Class</th>
<th>Capacity</th>
<th>Before 2005</th>
<th>Load factor</th>
<th>2005-2010</th>
<th>Load factor</th>
<th>2010--present</th>
<th>Load factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>AC/Luxury</td>
<td>40</td>
<td>60</td>
<td>0.7 - 1</td>
<td>60</td>
<td>&lt; 0.7</td>
<td>77</td>
<td>&lt; 0.6</td>
</tr>
<tr>
<td></td>
<td>Ordinary</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Speed Rail</td>
<td>400</td>
<td>7</td>
<td>0.7-1.7</td>
<td>7</td>
<td>&lt; 0.5</td>
<td>8</td>
<td>&lt; 0.7</td>
<td></td>
</tr>
<tr>
<td>Conv. Rail</td>
<td>1st Class</td>
<td>102</td>
<td>7</td>
<td>0.7-1.7</td>
<td>7</td>
<td>&lt; 0.5</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>2nd Class</td>
<td>256-384</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air</td>
<td>&lt; 100</td>
<td>3</td>
<td>&lt; 0.7</td>
<td>3</td>
<td>&lt; 0.5</td>
<td>1</td>
<td>&lt; 0.7</td>
<td></td>
</tr>
<tr>
<td>Travel (shuttle bus)</td>
<td>10—14</td>
<td>--</td>
<td>--</td>
<td>800</td>
<td>&gt; 0.7</td>
<td>&gt; 800</td>
<td>&gt; 0.7</td>
<td></td>
</tr>
</tbody>
</table>

Source: Ministry of Transportation
The Cipularang toll began to operate in mid 2005. Before it was operated, from the table 1, it can be seen that railways is the most favorite transportation mode in Jakarta-Bandung corridor, followed by highways modes and the last is airways mode. With the total level of services 14 times a day for high speed rail and conventional rail, the load factor can attain 0.7 to 1.7.

Since the Cipularang toll was operated, between years 2005-2010, the trend in modal share was changed. Travel (shuttle bus), the new highway mode, came up as the new competitor in this corridor. It became a new favorite transportation mode with load factor of more than 0.7 and frequency per day about 800 departures /day. On the contrary, load factor of the railways mode decrease dramatically to less than 0.5. Furthermore, the worst case occurred to the airways, that they must close their services in this corridor.

After the Cipularang toll operation, PT. Kereta Api Indonesia as the operator in the railways service experienced loss continuously, and finally in year 2010 it must close the conventional rail service and keep only the high speed rail service.

![Figure 1 Load Factor of transportation mode for Jakarta- Bandung corridor before and after the operation of the Cipularang Toll (year 2005 – 2010)](image)

Figure 1 shows the comparison of load factors for each transportation mode for Jakarta Bandung corridor, before and after the operation of Cipularang toll. From that chart, it is seen that demand for railway was the highest before the operation of Cipularang toll, followed by buses. However, it reduced dramatically after the Cipularang toll operation, for the railway as well as for the highways. On the contrary, travel (shuttle bus) came up as the popular option for passengers.

### 2.2. Jakarta - Surabaya Corridor

Surabaya, the capital city of East Java province, is one of the trade centers in Indonesia. A lot of people come to Surabaya doing business activities, including people from Jakarta. Similar to Jakarta Bandung corridor, several mode choices are provided for Jakarta Surabaya corridor; they are: highways, railways, airways, and seaways.

Trend of mode choice for Jakarta- Surabaya corridor will be compared and elaborate for three time intervals: before 1997, that is before Indonesia faced the economic crisis; between 1997 and 1999, that is when Indonesia faced the economic crisis; and 1999 afterwards, after...
Indonesia managed to survive the crisis. For the railway modes, refer to table 2, it is seen that before and during the crisis, the load factor was greater than 0.7, which indicates a good occupancy rate. Furthermore, during the crisis, the frequency of service per day was increased, indicating increase demand for this mode. However, from 1999 afterwards, the load factor decreases continuously to less than 0.7 and also the frequency of its daily service is cut back to 6 times per day, which only 50 per cent of the previous period.

On the other hand, by examining the graph in Figure 2, it is seen that before and when the crisis happened, there was a significant decrease in domestic flight passenger’s demand, which was contrast with the railways. Furthermore, after the crisis and the government policy on the liberalization of air transport fare, the passengers demand was increased, while at the same time, there was significant decrease in railways.

<table>
<thead>
<tr>
<th>Year</th>
<th>Frequency /day</th>
<th>Load Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1997</td>
<td>8</td>
<td>&gt; 0.7</td>
</tr>
<tr>
<td>1997-1999</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>After 1999</td>
<td>6</td>
<td>&lt; 0.7</td>
</tr>
</tbody>
</table>

Source: PT. Kereta Api Indonesia

It seems that the air fare liberalization policy, which was aimed to stimulate the economic growth, also gave impact to the trend of transport mode choice. Lots of new airline business emerged. For comparison, before the economic crisis, the there were only two domestic airlines: Garuda Indonesia and Merpati Nusantara; while after the policy issued, more than 6 airlines are now operating. Airways transportation become very competitive, since they offer low tariff to customers. The tariffs are not only competitive among the airlines, but also not differ significantly with the railway tariff, relative to the travel time (refer to Figure 3). Henceforth, right after that policy, the railways got the impact; the passengers were shifted to airways, so that the railways services were cut down.
As for highways and seaways mode, since they take longer travel time compared to airways and railways, so these modes were not much affected by the above mentioned condition. Their occupancy level are quite stable (which is low), as well as the tariffs.

### 2.3. Growth of Vehicle Number vs Road Length

Existing condition of number of vehicle growth is showed by figure 4, while the road length progression are showed by figure 5 and figure 6.
From Figure 5 it is seen that the road length in Jakarta, for any types, have almost no progression. The same condition applies for toll road, as shown by Figure 6, where the development of toll road is almost stagnant. On the contrary, by looking at Figure 4, the numbers of vehicles grow steadily, even more very significant for the motorcycle. This trend is exaggerated by heavy traffic in Jakarta, so that the passengers changed their transportation mode to motorcycle instead of bus or train.

3. METHODOLOGY AND MODEL DEVELOPMENT

Based on literature study and existing data, several methods are used for the data analysis. Descriptive statistics is applied for data summary, such as line charts and bar charts. For deeper elaboration on certain factors that affect transportation mode choice, charts of those factors segmented by other factors are presented. To overcome the unbalanced sample size of respondents for each transportation mode, most of data analyses are using percentages.

Linear regression analysis is a well known powerful econometric method for analyzing the relationships among variables. It is also useful to predict the value of one variable given the information of other variables, as well as to look for the trend in one factor when the other factors are changed. In this paper, load factor will be regressed using travel time, access egress time, tariff and frequency of departure per day. The regression result will confirm the trends found in descriptive analysis.

3.1. Linear Regression Analysis

Linear regression is one of the method that can be used to predict the value of one variable (i.e. the dependent variable), given the value of other variables (i.e. the independent variables).

The model is:

\[ y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \epsilon \]  (1)
Where:

- $y$ is the dependent variable, in this case is the load factor of each transportation mode.
- $x_1, x_2, \ldots, x_k$ are independent variables, in this case:
  - $x_1 =$ tariff (Rupiah)
  - $x_2 =$ travel time (hours)
  - $x_3 =$ access & egress time (hours)
  - $x_4 =$ frequency (departure/day)
- $\beta_0, \beta_1, \ldots, \beta_k$ are the regression coefficients
- $\epsilon$ is the error that measures the unexplained variability

To estimate the regression coefficients, least squares method is applied. For simple regression model, the parameter estimates are given by:

$$
\hat{\beta}_0 = \frac{\sum y (\sum x^2) - (\sum x)(\sum xy)}{n (\sum x^2) - (\sum x)^2},
$$

(2)

$$
\hat{\beta}_i = \frac{n (\sum xy) - (\sum x)(\sum y)}{n (\sum x^2) - (\sum x)^2}
$$

(3)

While for the multiple regression, the estimates of parameters are obtained by solving the system simultaneously.

$$
\hat{\beta} = \begin{pmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_k \end{pmatrix} = \left[ X^T X \right]^{-1} X^T Y
$$

(4)

To assess the utility of the model, the coefficient of determination will be used, which is given by:

$$
R^2 = 1 - \frac{SSE}{SST}
$$

(5)

Where SST is the sum square total.

4. THE ANALYSIS

4.1. Jakarta—Bandung Corridor

The analysis for mode choice trend in Jakarta – Bandung corridor will be divided into 2 parts, before and after the operation of the Cipularang toll. Supporting data for various transportation modes in this corridor is provided in Table 3.
Based on the table 3, it can be seen that air mode is the fastest, since it only take 25 minutes to travel by. On the other hand, railways takes around six to ten times longer than air mode to travel by, and the longest one is the highway mode, which takes around ten to twelve times longer, compared to air mode. As for the total cost, air mode is the highest, while highway mode is the lowest. However, aside from higher cost than highway, railways load factor is higher, even the highest among those three modes, that is 0.7 – 1.7. Load factor 1.7 indicates that demand for railway is considerably high, and suggests the need for more services.

Table 4 Data for various modes of transportation after the operation of the Cipularang toll. for Jakarta – Bandung corridor

<table>
<thead>
<tr>
<th>Mode</th>
<th>Class</th>
<th>Dist. (km)</th>
<th>Time (min)</th>
<th>Fare (Rp)</th>
<th>Load Factor</th>
<th>Access</th>
<th>Egress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>AC/Luxury</td>
<td>122-179</td>
<td>150-180</td>
<td>45000-50000</td>
<td>0.5</td>
<td>1-10</td>
<td>1-5</td>
</tr>
<tr>
<td></td>
<td>2nd class</td>
<td></td>
<td>150-180</td>
<td>35000</td>
<td></td>
<td>30</td>
<td>5-30</td>
</tr>
<tr>
<td></td>
<td>Ordinary</td>
<td>174</td>
<td>210-240</td>
<td>25000</td>
<td></td>
<td>16</td>
<td>240</td>
</tr>
<tr>
<td>Conv. Rail</td>
<td>First class</td>
<td>173</td>
<td>180-210</td>
<td>60000-65000</td>
<td>0.5-0.7</td>
<td>2-20</td>
<td>1-5</td>
</tr>
<tr>
<td></td>
<td>2nd Class</td>
<td></td>
<td>180-210</td>
<td>30000</td>
<td></td>
<td>8</td>
<td>30-120</td>
</tr>
<tr>
<td>Air</td>
<td>Normal Fare</td>
<td>163</td>
<td>25</td>
<td>502000</td>
<td>&lt; 0.7</td>
<td>5-30</td>
<td>2-10</td>
</tr>
<tr>
<td></td>
<td>Disc/LC fare</td>
<td></td>
<td></td>
<td>300000</td>
<td></td>
<td>1</td>
<td>30-120</td>
</tr>
<tr>
<td>Travel</td>
<td>120-150</td>
<td>90-120</td>
<td>50000-70000</td>
<td>800</td>
<td>6720</td>
<td>1-5</td>
<td>1-3</td>
</tr>
<tr>
<td></td>
<td>120-150</td>
<td>90-120</td>
<td>150000</td>
<td>32000</td>
<td></td>
<td>50000</td>
<td></td>
</tr>
</tbody>
</table>

Source: Ministry of Transportation, 2010
Based on survey, as shown in Figure 7, it is revealed that passengers were very concern about travel time, which is agreeably met by the air mode. However, since the cost is high, then for medium lower class income passenger, railway was the best choice at the moment. It was cheaper than air mode, yet faster than highway.

![Figure 7 Trends for Factors in Choosing Transportation Mode (in Percentage)](image)

It is also revealed from figure 8, that travel time and cost are important factors that determine the choice of transportation mode. On the horizontal axis is the income class, where 1 represents the lowest income class and 5 represents the highest income class. It is obvious that for lower income class, cost is the most considerate factor, then followed by travel time. On the other hand, for higher income class, comfort and practicality become important factor to account for.

4.2. Jakarta- Surabaya corridor
The analysis of Jakarta – Surabaya corridor will consist of descriptive statistics of the surveyed data and linear regression analysis for the existing data.
4.2.1. Descriptive statistics of the surveyed data
Based on the processed data from the survey,

![Figure 9 Factors considered in Transportation Mode choice](image)

the chart on figure 9 shows factors that are taken into consideration in choosing transportation mode of passengers departed from Surabaya using various modes of transportation. Majority of passengers preferred comfort, and then followed by fast travel time, and practicality. Cost seems not be a great deal for them. Based on the interview, this is because the faster they reach their destination; they can do their business well, so that travel cost can be accommodated quite well; instead of choosing cheaper mode but with the risk of losing their business. The practicality, which represents the ease to access and egress, is also important. To sum up, from this chart it is suggested that a comfortable transportation mode, with tight schedule and easiness for access and egress is preferred than just a low cost transportation mode.

Furthermore, a deeper insight of factors by expenses class is shown by the chart below.

![Figure 10 Factors of Transportation Mode choice by Expenses class](image)

As the chart in figure 10 reveals, comfort is the most important factor, despite of the passengers’ expenses class. High expenses class were very concern about the travel time,
while the lower expenses class were more concern for the practicality as well as the travel time. Safety is the last factor that taken into the consideration by all classes expenses passenger.

![Figure 11 Trend of Transportation Mode choice by Expenses class](image)

Unlike for Jakarta Bandung case, where data about Income class data were used, for Jakarta Surabaya case, we use Expenses class data, since income data were not recorded for most of respondents for this case. Expenses class 1 to expenses class 5 represent the lowest to the highest expenses class passengers, consecutively. The chart shows that airplane is a considerably accepted option for passengers across classes. Travel agent is favored by higher expenses class passenger, while ship is well used by lower expenses class passenger. It is also seen that bus mode is not well accepted, considering lower trend compared to other mode.

![Figure 12 Load Factor for train and airplane](image)

As for the trend of transportation mode by time series observation, as shown by figure 12, we can see that train occupancy is quite stable, while the airplane is increasing right after the liberalization of airfare tariff. Unfortunately we do not have data for bus load factor. However, by referring to 11, we can deduce that the load factor for bus is lower, since it is less preferred by passengers across expenses classes.
4.2.2. Linear Regression Analysis of The Existing Data

a. The regression equation for the railways mode is

load factor = 1.37 + 0.000001 tariff - 0.108 travel time - 0.046 access egress + 0.0381 freq  

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.373</td>
<td>1.814</td>
<td>0.76</td>
<td>0.468</td>
</tr>
<tr>
<td>tariff</td>
<td>0.000000079</td>
<td>0.00000046</td>
<td>1.70</td>
<td>0.123</td>
</tr>
<tr>
<td>travel time</td>
<td>-0.1080</td>
<td>0.2100</td>
<td>-0.51</td>
<td>0.619</td>
</tr>
<tr>
<td>access egress</td>
<td>-0.0457</td>
<td>0.1022</td>
<td>-0.45</td>
<td>0.665</td>
</tr>
<tr>
<td>frequency</td>
<td>0.038139</td>
<td>0.009202</td>
<td>4.14</td>
<td>0.003</td>
</tr>
</tbody>
</table>

S = 0.0967085   R-Sq = 86.7%   R-Sq(adj) = 80.9%

Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>4</td>
<td>0.55097</td>
<td>0.13774</td>
<td>14.73</td>
<td>0.001</td>
</tr>
<tr>
<td>Residual Error</td>
<td>9</td>
<td>0.08417</td>
<td>0.00935</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>0.63514</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Using data from year 1997 to 2010, for the railways mode, according to the linear regression results, there is a statistically significant correlation between frequency (number of departures per day) and load factor. Positive coefficient states that high load factor results in increase of frequency, and when the load factor is low, reduction on frequency is needed. The regression result also shows the positive correlation between tariff and load factor, while they are negative for travel time and access egress time; although not statistically significant. This might be because the variation in travel time and access egress time is small, so that variation does not affect the model significantly.

An interesting finding is that the regression coefficient for tariff is positive, which implies high tariff increase the load factor. However, this is not the case, since the passengers will prefer the less expensive one, if they have another option, with the same service. This reveals that when there is an increasing in load factor, the operator tends to increase the tariff. Overall, the model fit is good, as shown by the Analysis of Variance, where the p-value is .001. Furthermore, around 87 per cent of load factors variation can be explained using those factors (i.e. tariff, travel time, access egress time, and frequency).

b. The regression equation for airways mode is

load factor = 0.446 - 0.000000 tariff + 0.332 travel time + 0.0234 access egress

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.4457</td>
<td>0.6388</td>
<td>0.70</td>
<td>0.501</td>
</tr>
<tr>
<td>tariff</td>
<td>-0.00000035</td>
<td>0.00000005</td>
<td>-6.41</td>
<td>0.000</td>
</tr>
<tr>
<td>travel time</td>
<td>0.3323</td>
<td>0.5249</td>
<td>0.63</td>
<td>0.541</td>
</tr>
<tr>
<td>access egress</td>
<td>0.0234</td>
<td>0.03869</td>
<td>0.61</td>
<td>0.558</td>
</tr>
</tbody>
</table>

S = 0.0752405   R-Sq = 81.3%   R-Sq(adj) = 75.7%
### Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>3</td>
<td>0.246512</td>
<td>0.082171</td>
<td>14.51</td>
<td>0.001</td>
</tr>
<tr>
<td>Residual Error</td>
<td>10</td>
<td>0.056611</td>
<td>0.005661</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>0.303123</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data from the same years were also used to fit the linear regression for airways mode. Load factor is regressed with tariff, travel time, and access egress time. Overall, the model fit is good, and level of accuracy is around 81 per cent. The most significant factor is tariff, with negative coefficient, which implies that low tariff attracts more passengers to choose this mode. Even though the travel time and access egress time coefficients are positive, which are not as expected, but they are not statistically significant. Furthermore, this implies that although it takes longer time for access and egress, but it is not a significant matter, since the trip is a long distance, fast travel time can encounter the total time for the trip.

### 5. CONCLUSION

From this study, it can be concluded that:

1. For Jakarta - Bandung corridor, which represents mid-distance area, bus and railway are good option for transportation. However, railway was left behind after the operation of Cipularang toll. On the other hand, although airfare is less expensive than before, but the occupancy is still low, which result as the concentration in only one mode of transportation that is highway.
2. For Jakarta Surabaya corridor, which represents long-distance area, a comfort and less travel time are the most important factors considered by passengers, regardless of their economic condition. Train and ship is more opted by lower expenses class passengers, however if they can provide the comfort, they can be potential options, and bus is less preferred amongst all.
3. Because the growth of road length is not proportional to the growth of number of vehicles, where road length is almost stagnant, while number of vehicles increasing consistently, railways mode could be a good option as an intercity connection, however it must be supported by improving its infrastructures and facilities.

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