Study of determining the toll fare for the Yogyakarta-Solo corridor

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Abstract. As part of the government policy related with the development of road infrastructure, the acceleration of the toll road investment is expected to be able to push the road network performance and the regional economy. One of the plans is the development of Yogyakarta-Solo toll road with the length of segment is ± 40.5 Km. The basic toll rate is set in the beginning during the concession time as one of the parameters of a toll road investment. Based on the design of particular toll road, this research is then done to determine the particular basic toll rate. The methods that may be used as approaching the determination of the particular rate, such as: Saving of Vehicle Operating Cost Method (saving of VOC), Willingness to Pay (WTP), and Ability to Pay (ATP). From the toll rate calculation results based on the saving VOC and ATP/WTP analysis result, with the assumptions for the toll road to begin operating in the year 2018, hence the proposed value of the Yogyakarta-Solo toll rate is Rp. 26.000 (+ Rp. 675/km).

Keywotds: saving VOC, ATP/WTP, Toll rate

1. Introduction
The strategic issue that was faced in organizing the road, especially national roads is the lack of the inadequate primary road network in serving the through traffic. Toll road is a public road that is a part of road network system and a part of national road whose users are required to pay toll rate. According to the mandate UU no. 38 year 2004 and PP No. 15/2005 about Toll Road, the General Plan of Toll Road Network is then set by Minister of Public Works as reference for the development of toll road network and investment, where the initial toll rate becomes the parameter in the toll road investment, with the adjustment of toll rate that is done once in every 2 years based on the inflation index.

Toll rate is a cost that must be spent by the users of toll roads to pay the toll roads services and as for that, there is a benefit for the particular service [1]. The toll rate itself is a subject of negotiation between the government and the potential toll road investors. The methods that may be used as approaching the determination of the toll rate are saving of Vehicle Operating Cost Method (saving VOC), Willingness to Pay (WTP), and Ability to Pay (ATP).

According to Perpres No. 38/2015, cooperation with private enterprises is possible in an effort to speed up the implementation of infrastructure provision, which includes the providing of road infrastructure including toll roads. The particular cooperation by all means is to meet the funding needs sustainably, as well as to increase the quantity, quality and efficiency of services through fair competition, as well as improving the quality of infrastructure management and maintenance, and encouraging the use of the principle of user paying for the services received. Associated with this, the determination of rate must then be able to balance two interests, i.e. from the investment interest point of view and from the toll roads users point of views.
Yogyakarta-Solo Toll Road is an intercity toll road that connects the City of Yogyakarta and City of Solo with length of planned trace of ± 40.5 Km that was planned in 2016.

![Figure 1. Corridor Of Yogyakarta-Solo Toll Road.](image)

Based on the conditions mentioned above, analysis of determining the Yogyakarta-Solo toll road fare which is adjusted with the ability and willingness of the direct users is then necessary to be done, as comparison data with the rate that has been determined by the government, so that the development of the particular toll road can be held as well as possible.

2. Literature Review

2.1. Study of The Development of Toll Roads in Indonesia

The history of developing toll roads in Indonesia was started in 1978 with operating the Jagorawi toll road with length of ± 59 km, which connects Jakarta, Bogor, and Ciawi. Development of toll roads in Indonesia is still considered as very slow, since 1978 until 2008 only 684 km of toll road was built in Indonesia. It is still very far compared to Malaysia and China that have already built toll roads for about 1500 km and 40,000 km even though both particular countries have just recently built toll roads in 1980 and 1990. The progress of roads up to 2005 or 25 years of toll roads development in Indonesia is that only 600 km in total.

| No | Toll Road  | Operation (km) | Program (km) | Priority (km) | Potensial (km) | Total (km) |
|----|------------|----------------|--------------|---------------|----------------|------------|
| 1  | Sumatera   | 43             | 60           | 223           | 2522           | 2848       |
| 2  | Jawa       | 750            | 983          | 181           | 483            | 2400       |
| 3  | Kalimantan | -              | 84           |               |                | 84         |
| 4  | Bali       | 10             | -            |               | 10             | 10         |
| 5  | Sulawesi   | 17             | 39           |               | 63             |            |
| TOTAL |          | 820            | 1043         | 534           | 3008           | 5405       |

According to table 1, shows that the total length of planned toll roads and are already in operation in Indonesia, to encourage the growth of toll roads development in Indonesia, the government...
encourages a development of 28 toll road projects which included the JORR II and Trans Java Toll Roads.

![Image showing Corridor of Yogyakarta-Solo Toll Road.](image)

Figure 2. Corridor of Yogyakarta-Solo Toll Road.

2.2. Toll Rate Determination System

In determining the value of toll rate in Indonesia, calculations based on saving of Vehicle Operating Cost (saving VOC), investment feasibility, Ability to Pay and Willingness to Pay by the toll users are used (Panjaitan, 2013).

2.2.1 Relationship Between Toll Rate and ATP/WTP.

In economic theory, toll rate can be defined as a price or cost that is charged as compensation in a consumption of a product, for both goods and services. Therefore, service rate for transportation can be defined as a rate that is charged as compensation in a consumption of transportation service.

| No  | Toll Road              | Length (km) | Toll Fare (Rp/km) | Toll Fare (Rp) |
|-----|------------------------|-------------|-------------------|----------------|
| 1   | Kertosono - Mojokerto  | 14.41       | 10,000.00         | 694            |
| 2   | Surabaya – Gersik      | 20.70       | 12,000.00         | 580            |
| 3   | Semarang – Solo        | 22.95       | 13,500.00         | 588            |
| 4   | Kanci – Pejagan        | 35.00       | 21,500.00         | 614            |
| 5   | SS waru – Juanda       | 12.80       | 7,000.00          | 547            |
| 6   | Tanggerang – Merak     | 73.00       | 36,000.00         | 493            |
| 7   | Semarang seksi ABC     | 24.75       | 8,000.00          | 323            |
| 8   | Palimanan – Kanci      | 26.30       | 5,000.00          | 190            |
| 9   | Cikampe – Padalarang   | 58.50       | 34,000.00         | 581            |
| 10  | Surabaya – Gempol      | 10.20       | 4,000.00          | 392            |
| 11  | Surabaya – Mojokerto   | 1.89        | 2,500.00          | 1323           |
| 12  | Jakarta – Tanggerang   | 27.00       | 5,000.00          | 185            |
| 13  | Jakarta – Cikampek     | 72.00       | 12,000.00         | 167            |
| 14  | Jagorawi               | 50.00       | 8,000.00          | 160            |
Ability to Pay (ATP) can be defined as individual ability to pay an amount of money to produce utility value of a consumption of a product, for example infrastructure services of toll roads. Hence, ATP analysis is a study of individual spending patterns that are rational, specifically in a consumption of infrastructure services of toll roads. Willingness to Pay (WTP) is the users’ will to give rewards for the services earned. The concept development of this ATP/WTP needs to be done, because the implementation of toll rates needs to consider the investment side and road users’ point of view, so that both particular interests can be considered proportionally [4].

ATP values are analyzed by using the following equation:

\[ ATP = \frac{I_x P_p P_t}{T_r} \]  

where:
- \( I_x \) = level of respondent’s income
- \( P_p \) = percentage of transportation budget per month
- \( P_t \) = percentage of transportation cost allocation per destination
- \( T_r \) = total length of trip of respondent per month

The importance of information about Willingness to Pay (WTP) essentially to protect the consumers from abuse of monopoly power that is owned by a company in the supplies of high quality and highly priced products. The target of WTP is to get the most optimum and most realistic toll rate value according to the ability and willingness to pay the road users however still attracts investors to invest. Eventually, the toll rate is calculated referring to the process or calculation procedure as mentioned in the previous section. The main issue of calculating the toll road rate according to the WTP is that the rate will be set at the %-tile numbers or on the percentage rate of willingness to pay.

The result of WTP analysis that has been done are shown in the following:

- The average of percentage value of users who are willing to pay the rates worth WTP\(_{\text{direct}}\) is ± 70.5%, for the intercity toll roads (BPJT 21012),
- The particular average value represents the region that is connected with the particular toll roads.

Furthermore, the toll rate based on WTP (is now known as WTP\(_{\text{optimal}}\)) is set at the average number of %-tile, which is 70% and 60% respectively, for Yogykarta-Solo toll road.

On the basis of comparative analysis between WTP and ATP, applying the following principles can do the policy recommendation of toll road rate determination:

1. Due to WTP being a function of toll road service level, when the value of WTP is still less than the ATP value, then there is a possibility to increase the rate value by improving the toll road service levels.
2. Due to ATP being a function of Ability to Pay, then the value of toll rate applied cannot be greater than the targeted value of ATP.
3. The government intervention in the form of direct or cross-subsidy is needed in a condition where the prevailing toll rates are higher than the ATP value, to get a maximum toll rate that is equivalent to the ATP value.
2.2.2 Saving of Vehicle Operating Cost (saving VOC).
The determination of toll rate is based on the profit that is resulted from savings of vehicle operating costs and amount of time. The amount of this profit, which is more commonly referred as the Benefit of Vehicle Operating Cost (BVOC) can be calculated by using the following equation [2]:

\[
BKBOK = [(BOKn \times Dn) - (BOKt \times Dt) + (Dn/Vn - Dt/Vt)] \times Tv
\]  
(2)

Where:
- \(BKBOK/BVOC\) = Benefit of Vehicle Operating Cost (Rp)
- \(BOKn\) = Vehicle Operating Costs on Non-Toll Roads (Rp/km)
- \(BOKt\) = Vehicle Operating Costs on Toll Roads (Rp/km)
- \(Dn\) = Distance Travelled on Non-Toll Roads (km)
- \(Dt\) = Distance Travelled on Toll Roads (km)
- \(Vn\) = Speed of Vehicles on Non-Toll Roads (km/hour)
- \(Vt\) = Speed of Vehicles on Toll Roads (km/hour)

3. Methodology

3.1. Research Framework
To fulfill the targeted time and substance required, methodology and activity stages in Analysis of Toll Rate Determination is arranged as shown below:
On the flow diagram displayed above, shows that analysis of toll rate determination is calculated based on the ATP-WTP and saving VOC values. ATP-WTP is a reflection of ability and willingness to pay toll road users calculated from the proportion of transportation expenditure and logit model analysis based on the data of stated preference interview.

On the stated preference survey, respondents are requested to choose route between toll road and non-toll road for their daily routine journeys. Hereinafter, the total data sample that needs to be collected depends on the data characteristics in the field.

3.2. Data Requirements
In relation to the need to establish the number of sample that will be interviewed on the survey, the number of data collected define the sample size as shown below [9]:

\[ n = \left( \frac{Z \sigma}{X - \mu} \right) \]

where:
- \( \sigma \) = standard deviation
- \( Z \) = function of reliability, \((1-\alpha)100\%\)
- \( X - \mu \) = error that can be accepted

With reliability = 95%, normal raw distribution \( Z_{\alpha/2} \) produced = 1.96 or \( Z_{0.025} = 1.65 \) for confidence level = 90%. After that, with the assumption of the desired errors are 5% and 10%, then the amount of respondents needed for the stated preference survey activity are shown in the table below.
| Percentage Error | Reliability | Data Requirement |
|------------------|-------------|------------------|
| 5%               | 1.65        | 165              |
| 10%              | 1.65        | 73               |

Description: average 0.45; standard deviation 0.39

On the issue of Yogyakarta – Solo toll road, analysis was done on the 175 data of respondents (from a total of 200 respondents that were interviewed). Based on Table IV.1, it shows that the behavior analysis of choosing this route has an error value of 5% and confidence level of 90%.

4. Analysis Results

4.1 Toll Rate Analysis Based on ATP

To calculate the value of Ability to Pay (ATP) from the toll roads users then data and information shown below are needed:

1. Income Level of Respondents
2. Respondents Expenditure Allocation Pattern for Transportation and Toll
3. Travel and Frequency Patterns of Toll Road Usage

From the results of data collection, description of the distribution pattern for Ability to Pay (ATP) from the toll roads users are shown below:

| Class (Rp/Km) | Frequency | Valid Percent | Cumulative ATP |
|--------------|-----------|---------------|----------------|
| 1 - 50       | 0         | 0.0%          | 100.0%         |
| 51 - 100     | 0         | 0.0%          | 100.0%         |
| 101 - 150    | 0         | 0.0%          | 100.0%         |
| 151 - 200    | 0         | 0.0%          | 100.0%         |
| 201 - 250    | 0         | 0.0%          | 100.0%         |
| 251 - 300    | 32        | 10.7%         | 100.0%         |
| 301 - 350    | 60        | 20.0%         | 89.3%          |
| 351 - 400    | 60        | 20.0%         | 69.3%          |
| 401 - 450    | 80        | 26.7%         | 49.3%          |
| 451 - 500    | 44        | 14.7%         | 22.7%          |
| 501 - 550    | 18        | 6.0%          | 8.0%           |
| > 551        | 6         | 2.0%          | 2.0%           |
| Total        | 300       | 100.0%        |                |
For passenger’s vehicles based on the table above, it sows that the distribution pattern of the ATP value is relatively spread evenly (see at Table 4). The average value of ATP produced is Rp 415 per kilometer.

### 4.2 Rate Analysis Based on WTP

WTP is represented as a savings value of travel or trade off between travel time and the cost of the toll rate. WTP is set at 60% and 70% respectively; respondents are willing to pay at the particular set of WTP values. On Figure 5 produced, as shown below:

![Figure 5. Graph of Willingness to Pay (WTP).](image)

When WTP was stated as a result of the division between travel time coefficient and the toll road cost coefficient, which was Rp 24.872, with 59.92% respondents who have the will to pay. On the condition of 50% respondents who are willing to pay, WTP\_produce (or also known as WTP50%) is Rp 27.347.

### 4.3 Rate Analysis Based on Saving Of Vehicle Operating Cost (saving voc)

Calculation of components of vehicle operating costs is done by using the component formula, which was developed by Institute of Research and Industry Affiliation of Institute Technology of Bandung (IRIA-ITB) whereas the component of capital interest was developed by a clan through the project of Road User Costs Model. The value of BVOC for passengers’ vehicles produced is Rp 415 per kilometer.

### 4.4 Toll Rate Calculation

The main issue for toll rate calculation based on WTP is that the particular rate will be set on %-tile numbers (or on the percentage of the willingness to pay). The toll rate calculation that was produced on the result of ATP, WTP (preferences from the potential toll road users and analysis), and saving VOC, the proposed numbers of Yogykarta – Solo Toll Rate are shown on the table below:
5. Conclusion
The results produced from the analysis are the following:

- From the result of Ability to Pay (ATP) analysis on the respondents of the potential Yogyakarta – Solo Toll Road users, it can be concluded that the average value of ATP respondents is Rp 415 per kilometer.
- From the result of Willingness to Pay (WTP) analysis on the respondents of the potential toll road users, on the condition of 50% respondents having the will to pay, the value of WTP (or also known as WTP50%) is Rp 27,347.
- From the result of toll rate calculation based on the BVOC analysis, the amount of toll rate produced is Rp 567 per kilometer.
- From the result of toll rate calculation based on the BVOC analysis and ATP/WTP, assuming the operation of the toll road begins in 2018, then the proposed Yogyakarta – Solo toll rate is Rp 26,000 (+ Rp. 675/km).
- The results of toll rate analysis based on ATP/WTP shows that the value of WTP is greater than ATP, this shows that the user’s desires to pay the transportation service is greater than the ability to pay. This is possible for the users who have a relatively low income but the utility to such services is very high up to the user’s desire to pay for the services is more affected by the utility, in this case the users are called Captive Riders.

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