Probability of willingness to pay road pricing based on the perspective of households in Jakarta

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Abstract. The determination of tariff is necessary for a city willing to implement electronic road pricing such as Jakarta. Therefore, this study was conducted to investigate the effect of household characteristics on the willingness and probability to pay more than IDR 20,000. The focus was on those commuting to work within the city where the majority of people work in the formal sector. Moreover, the Willingness to Pay IDR 20,000 was proposed as a variable while age, number of family members, income, vehicle ownership and the work type were used as the explanatory variables. The results showed the general effect of households in receiving ERP rates was low as indicated by the 16.9% recorded. However, family with total members of 4-5 people and owning a vehicle was observed to have a partially great and significant probability to increase the willingness to pay tariffs > IDR 20,000 while those earning income <IDR 5 million and working as private employees were discovered to have contributed negatively and significantly even though the probability was small. There is, therefore, the need for a comprehensive study when determining tariffs and the amount is recommended to be more expensive than public transport.

1. Introduction

Traffic jams often occur in urban areas, thereby causing frustrations as well as the loss of work time and several other valuable things [1]. This has led to the implementation of several efforts to overcome this problem and one of these is through the application of a congestion charge which has been reported to be providing several benefits compared to traditional methods such as building roads especially in areas with limited land [2]. An example of this charge is road pricing which is usually applied in major cities of the world to reduce congestion through the use of an electronic system, thereby, leading to its reference as an Electronic Road Pricing (ERP). The main objective of this system is to reduce inaccuracies in implementation and operational costs as well as to improve system performance [3].

Previous studies have provided important information on ERP implementation, especially its impact on mode choice and others. This is important due to the fact that the system usually implemented to reduce the use of private vehicles and, consequently, pollution [4][5][6][7]. It also has the ability to increase the speed of movement and reduce vehicle operating costs [8]. This is observed from the findings of the studies conducted in Stockholm which showed that ERP has the ability to reduce mileage and congestion by up to 25% [9].

The application of this method, however, requires considering several factors to ensure its effectiveness and some of the most important determinants is the appropriate tariff to reduce private vehicle use and public acceptance [10]. A study conducted in Singapore by Agarwal & Koo [11] showed
approximately 20% switch from the use of the private vehicle to public transportation for every S $ 1 increase in costs. Another study in Jakarta estimated the Willingness to Pay (WtP) of ERP to be IDR 24,000 [12]. Meanwhile, Prastomo [13], declares that the rate of IDR 20,000 could not make more people working around Sudirman Central Business District in Jakarta switching to public transport. From experience in Singapore and some countries in Europe, it suggested that rate is going up and down along with vehicle density level [2]. Consequently, for Jakarta case, strong reference is required for feedback in stipulating the basic rate of ERP application and willingness to pay above the basic rate.

Some of these studies, however, failed to specifically describe the probability of road users, especially those commuting to work, that are able to pay certain rates based on household characteristics. Therefore, this study was conducted to investigate the effect of household characteristics for those working in the formal sector of Jakarta on the WtP ERP. The major focus was on the work trip as observed in the charges implemented in Singapore, London, Stockholm, and Milan which are generally enforced during peak hours from morning to evening [2, 13, 14]. In this study, basic rate is assumed in the amount of IDR 20,000, then probability of WtP > IDR 20,000 will be determined in accordance with household characteristic. This stipulation shall be under an assumption that the implementation of ERP rate is subject to change depending on vehicle density level. In addition to probability of WtP, this study also suggested that household factor is significantly affecting ERP payment capability.

2. Method

This study was majorly focused on understanding the response of the road users to the road pricing implementation plan based on the household characteristics of formal sector workers in Jakarta. This involved using the WtP ERP probability > IDR 20,000 as the response variable (Y) while age (X1), number of family members (X2), income (X3), vehicle ownership (X4), and type of work (X5) were used as explanatory variables. The measurement of these variables was based on the nominal scale categorical data obtained by distributing questionnaires online through Google form to respondents as contained in Table 1. It is important to note that the respondents used in this research include the people working in the formal sector of Jakarta and travelling from home to work and vice versa daily. The questionnaire link was distributed to the respondents through visitation to the central office locations and through a network of friends and organizations. A total of 417 respondents participated in the research.

| Variable                  | Answer Choice                                                                 |
|---------------------------|-------------------------------------------------------------------------------|
| Age (X1)                  | (1) < 20 years old; (2) 20 – 30 years old; (3) > 30 – 40 years old; (4) > 40 – 50 years old; (5) > 50 years old |
| Number of family members (X2) | (1) 1 – 2 people; (2) 3 – 4 people; (3) 4 – 5 people; (4) 5 – 6 people; (5) > 6 people |
| Income (X3)               | (1) < IDR 5 million; (2) IDR million- 10 million; (3) > IDR 10 million- 15 million; (4) > IDR 15 million- 20 million; (5) > IDR 20 million |
| Vehicle ownership (X4)    | (1) Not owning a vehicle; (2) Motorbikes; (3) Car; (4) Cars and motorbikes    |
| Type of work (X5)         | (1) Government employees; (2) private employees; (3) Entrepreneur (4) Social worker / employee (5) Others |
| Willingness to Pay > IDR 20,000 (Y) | (1) No; (2) Yes                                                                 |

The binary logistic equation principle was used to obtain an overview of the WtP road pricing response variable and the model is in the form of a linear equation as presented in the following equation.

\[
\ln \frac{\pi(x)}{1-\pi(x)} = \beta_0 + \beta_1 x_1 + \ldots + \beta_p x_p 
\]
The coefficient value on the logistic regression output shows the effect of the explanatory variables on the response variable (Y). A negative value indicates the possibility of a Yes decision is reduced or a negative effect towards Y = 2 (“yes”) while a positive value indicates an increment in the probability for the Y = 2 decision.

This study focused on estimating the probability of the Y = 2 proportion in the population of each variable with a significant effect, therefore, the following equation was applied.

\[ \frac{P}{1-P} = \text{Exp}\beta x_{ni} \]  

Where, \( \text{Exp}\beta x_{ni} \) is the value of the odds ratio generated from the logistic equation analysis and \( p \) is the probability.

3. Results and discussion

The results show the existence of positive and negative coefficients in the logistic regression equation as shown for each variable in Table 2. This means the \( X_1 \) variables with a positive effect on WtP> IDR 20,000 were \( X_1(1) \) and \( X_1(3) \) while all the \( X_2 \) variables had positive coefficients. Meanwhile, \( X_3 \) and \( X_4 \) were observed to have one negative coefficient from each category and all the categories in \( X_5 \) had negative values. This shows there are variables in the model with the probability to increase the “yes” decision for WtP > IDR 20,000 while there are others with the ability to reduce the decision.

**Table 2. Logistic regression equation analysis result.**

| \((X_{ni})\) | \(\beta\) | S.E. | Wald | df | Sig. | Exp(\(\beta\)) | \(p\) |
|-------------|---------|------|------|----|-----|----------------|-----|
| \(X_1\)     |         |      |      |    |     |                |     |
| \(X_{1(1)}\)| 0.307   | 0.350| 0.772| 1  | 0.380| 1.360          |     |
| \(X_{1(2)}\)| -0.013  | 0.369| 0.001| 1  | 0.972| 0.987          |     |
| \(X_{1(3)}\)| 0.687   | 0.397| 3.001| 1  | 0.083| 1.988          |     |
| \(X_2\)     |         |      |      |    |     |                |     |
| \(X_{2(1)}\)| 0.954   | 0.590| 2.614| 1  | 0.106| 2.596          |     |
| \(X_{2(2)}\)| 0.714   | 0.548| 1.699| 1  | 0.192| 2.043          |     |
| \(X_{2(3)}\)| 1.182   | 0.572| 4.271| 1  | 0.039| 3.261          | 0.765|
| \(X_3\)     |         |      |      |    |     |                |     |
| \(X_{3(1)}\)| -1.441  | 0.487| 8.768| 1  | 0.003| 0.237          | 0.192|
| \(X_{3(2)}\)| -0.295  | 0.425| 0.480| 1  | 0.488| 0.745          |     |
| \(X_{3(3)}\)| 0.407   | 0.443| 0.844| 1  | 0.358| 1.502          |     |
| \(X_{3(4)}\)| 0.548   | 0.498| 1.211| 1  | 0.271| 1.729          |     |
| \(X_4\)     |         |      |      |    |     |                |     |
| \(X_{4(1)}\)| -0.079  | 0.643| 0.015| 1  | 0.903| 0.924          |     |
| \(X_{4(2)}\)| 0.731   | 0.330| 4.926| 1  | 0.026| 2.078          | 0.675|
| \(X_{4(3)}\)| 0.633   | 0.381| 2.759| 1  | 0.097| 1.884          |     |
| \(X_5\)     |         |      |      |    |     |                |     |
| \(X_{5(1)}\)| -0.177  | 0.401| 0.194| 1  | 0.660| 0.838          |     |
| \(X_{5(2)}\)| -1.073  | 0.345| 9.675| 1  | 0.002| 0.342          | 0.255|
| \(X_{5(3)}\)| -0.302  | 0.343| 0.777| 1  | 0.378| 0.739          |     |
| \(X_{5(4)}\)| -1.148  | 0.891| 1.658| 1  | 0.198| 0.317          |     |
| Constant    | -1.528  | 0.713| 4.595| 1  | 0.032| 0.217          |     |
The results in Table 2 showed $X_{2/3}$, $X_{3/4}$, $X_{4/2}$, and $X_{5/2}$ have a significant effect on the model and this means the probability to pay WtP > IDR 20,000 from the household with 4-5 family members and $\beta$ positive is 3.261 times compared to the others. Meanwhile, the probability of a reduction for those with income < IDR 5 million and $\beta$ negative coefficient was recorded to be 0.237 times. The value of the probability of an increase for those owing motorbikes with a $\beta$ positive was found to be 2.078 times while private employees with $\beta$ negative had a probability of reduction recorded to be 0.342 times.

Equation (2) was also used to analyse the probability (p) of each variable with a significant effect and the results presented in Table 2 showed the family with 4-5 members and owning motorbikes had very large or probability close to 1. Meanwhile, those with income < IDR 5 million and working as private employees had a quite small probability of reduction as observed in the value approaching 0.

This logistic regression model statistically fulfilled the goodness of fit requirements with the omnibus found to be significant at 95% confidence level and this means the variable X significantly affected WtP ERP simultaneously. Furthermore, the Hosmer and Lemeshow test showed $\alpha$ value of 0.292 more than 0.05 and this indicates the ability of the model to explain the data and lack of difference with the observation value. The Nagelkerke value obtained also showed the X variable in the model contributed 16.9% in influencing the decision of WtP ERP > IDR 20,000 while the remaining 83.1% was due to other variables outside the model.

Table 3. Classification.

| Observed | Predicted | Percentage Correct |
|----------|-----------|---------------------|
|          | WtP ERP > 20000 | No | Yes |                |
| WtP ERP > 20000 | No       | 278 | 20  | 93.3           |
|            | Yes      | 90  | 29  | 24.4           |
| Overall Percentage | | | | 73.6 |

The frequency data in Table 4 showed the majority of respondents selected “no” for the tariff scheme > IDR 20,000 and this provides a general description that setting IDR 20,000 as the maximum ERP rate does not lead to the reduction in the volume of vehicles on roads where the system is implemented. This finding is slightly different from Syaukat et al. [12] which showed that the WtP of the Jakarta community to ERP is IDR 24,200. The rate of IDR 20,000 is considered very small when compared to several countries that have implemented ERP. For example, the highest ERP rate in the UK is £ 11.5 (IDR 228,690) and the highest during the peak hours in Stockholm is SEK 20 (IDR 33,672) [15]. Meanwhile, the implementation of ERP rates in Singapore is based on roads and the values have been reported to be different for each hour [2].

The household perspective, however, showed that low income and private employees are the challenges facing the WtP ERP > IDR 20,000. This is understandable due to the additional costs usually incurred by travellers using private vehicles and this is a certain probability to be considered by the government in setting the tariff scheme more than IDR 20,000. Meanwhile, motorcycle users were observed to have the possible willingness to pay ERP > IDR 20,000 and the effect is expected to shift in case the system also applies to motorbikes. This means there is a big probability that motorcycle users will not switch to public transportation when the tariff scheme is > IDR 20,000. It is important to note that motorcycle users are responding positively to ERP even though it seems they are not yet mandated to pay the fee in Jakarta [3].
**Table 4.** Data on the frequency of respondents' answers.

| Variable                  | Frequency | %    |
|---------------------------|-----------|------|
| Age                       |           |      |
| 20 - 30 years old         | 177       | 42.4 |
| >30 - 40 years old        | 97        | 23.3 |
| >40 - 50 years old        | 61        | 14.6 |
| >50 years old             | 82        | 19.7 |
| The number of family members |       |      |
| 1 - 2 people              | 80        | 19.2 |
| 3 - 4 people              | 212       | 50.8 |
| 5 - 6 people              | 99        | 23.7 |
| > 6 people                | 26        | 6.2  |
| Income                    |           |      |
| < IDR 5,000,000           | 152       | 36.5 |
| IDR 5,000,000 – 10,000,000| 127       | 30.5 |
| > IDR 10,000,000 – 15,000,000 | 55     | 13.2 |
| > IDR 15,000,000 – 20,000,000 | 34     | 8.2  |
| > IDR 20,000,000           | 49        | 11.8 |
| Vehicle ownership         |           |      |
| No                        | 33        | 7.9  |
| Motorbikes                | 210       | 50.4 |
| Car                       | 49        | 11.8 |
| Motorbikes and Car        | 125       | 30.0 |
| Type of work              |           |      |
| Government employees      | 62        | 14.9 |
| Private employees         | 148       | 35.5 |
| Entrepreneur              | 103       | 24.7 |
| Social employees          | 9         | 2.2  |
| Others                    | 95        | 22.8 |
| WtP ERP > 20000           |           |      |
| No                        | 298       | 71.5 |
| Yes                       | 119       | 28.5 |

The government is expected to ensure public transportation is adequate, comfortable, reliable and safe when ERP is implemented in order to make the public accept the applicable tariff scheme. It is important to understand that the optimization of the price is a crucial point and highly dependent on road conditions as well as congestion [16]. This is based on the principle that public transportation should be the cheaper option when the ERP fare scheme is implemented [17].

### 4. Conclusion

The contribution of household characteristics towards WtP road pricing > IDR 20,000 was observed to be generally low but the variables of family members and motorcycle ownership partially have a positive and significant effect with their probability approaching 1. Meanwhile, income < IDR 5 million and private employees variables significantly reduced the opportunity of WtP > IDR 20,000 with a small probability compared to the previous variables. It is, therefore, advisable to conduct a comprehensive study related to the tariff determination in order to obtain the optimum tariff based on road conditions, traffic, and economic growth aspects.

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