Valuing subjective cost of motorcyclists used willingness-to-pay in Surabaya

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Abstract. Motorcycles have increased for the last few decades and could increase more. Besides, the number of accidents is mostly dominated by motorcycles. It is caused by the motorcycles which stand on two wheels and are unstable while riding. Considering this problem, it is needed to know how the motorcyclists are willing to protect themselves from an accident. WTP method has been selected as this method which is commonly used in developed countries and recommended to be used in developing countries to calculate accident costs. This study used data obtained from the stated preference survey such as age, income, number of children, and willingness-to-pay choices. The equation model is obtained for each severity level by analyzing the data using SPSS software. The binary logit equation models show that an increase in age and income will improve the probability for motorcyclists to protect themselves from an accident, however when the number of children increases, it will reduce the probability. WTP value of motorcyclists on the risk reduction of serious injuries is 126,500,000 IDR, while WTP value of motorcyclists on the risk reduction of slight injuries is 13,000,000 IDR.

Keywords: accident, motorcycle, willingness-to-pay

1. Introduction
For the last few decades, the number of motorcycles has increased significantly in Indonesia. In 2018, the number of the motorcycles in Indonesia has reached 120,101,047 and could increase more [1–4], and even could exceed the population number [2]. Unfortunately, the increasing number of vehicles is usually followed with numbers of accidents, which also happened in Surabaya, which are dominated by motorcycles [5–8]. Moreover, it has been proved that motorcyclists have a high risk of having a traffic accident since the motorcycles stand on two wheels only [9–12]. Furthermore, the World Health Organization has informed that the accident is included in the top 10 causes of death in the world [13, 14]. Several factors such as human factor, vehicle factor, and environmental factor are factors that influence the occurrence of traffic accidents [15, 16]. Besides, one of the causes of motorcycle accidents is the lack of driving skills and awareness about traffic safety and its regulations [11].
Concerning about the highest number of motorcyclists, the subjective cost which is expressing pain, grief and suffering as the result an accident is needed to be carried out to know how the motorcyclists are willing to protect themselves from an accident. Subjective costs are costs needed to cover the suffering and bereavement experienced by accident victims [10]. Willingness-to-Pay (WTP) method has been selected as this method which has been commonly used in developed countries and it is recommended to be used in developing countries to calculate accident costs [17, 18].

2. Method

Data used in this study are primary data obtained from stated preference survey. A survey was conducted to citizens of Surabaya as respondents. Several locations that were surveyed were the city park, food court, and university. The respondents were given some willingness-to-pay choices by hypothetical situations [19]. In this case, these choices are how much they will spend their money to reduce the accident probability.

2.1. Binary logit model

From the stated preference survey, there were obtained some data such as age, income, number of children, and willingness-to-pay choices which will be analyzed. Data were analyzed using SPPS (Statistical Package for the Social Sciences) software. Furthermore, the binary logit equation model has been obtained to express people’s preferences on the reduction of accident probabilities. The general equation form of willingness-to-pay binary logit model can be seen in Equation 1. The significant level limits of the variables for the model used in this study are 0,1 where variables that have significance less than 0,1 still affect the equation model [20].

The utility function can be formulated as follows [18]:

\[ U = V + \varepsilon = \beta' x + \varepsilon \]  

\( U \) = the utility of willingness to pay the amount for severity reduction

\( V \) = the systematic (deterministic) component of the utility of willingness to pay the amount for severity reduction

\( \varepsilon \) = the random (disturbance or error) component of the utility of willingness to pay the amount for severity reduction

\( x \) = the vector of attributes that is related to the willingness to pay the amount for severity reduction

\( \beta' \) = the vector of unknown parameters

The probability of the binary model choice is estimated based:

\[ p = \frac{\exp \logit(p)}{1 + \exp \logit(p)} \]  

In other word

\[ p = \frac{\text{probability}}{1 + \text{probability}} \]

2.2. Willingness-to-pay (WTP) value

There are two stages to determine the subjective cost of an accident: the calculation of the average value of the willingness-to-pay and cost estimation. The equation used is as follows [21]:

Stage 1: Average value calculation of willingness-to-pay

\[ \bar{W} = \frac{\sum_{n=1}^{K} \left[ \sum_{i}^{N} P_{a(i)} W[i] \right]}{K} \]
Where:
- \( \bar{W} \) = individual willingness-to-pay average value
- \( n \) = willingness-to-pay choices
- \( K \) = total number of choices
- \( N \) = individual total number in the database
- \( i \) = each individual
- \( P_n(i) \) = alternative probability \( i \) chosen by individuals \( n \)
- \( W(i) \) = willingness-to-pay choices (yes or no)

Stage 2: Value estimation of accident costs
\[
VOCC = \frac{\bar{W}}{\beta}
\]  
(5)

Where:
- \( VOCC \) = subjective cost as a result of an accident
- \( \bar{W} \) = average willingness-to-pay per individual to avoid accidents
- \( \beta \) = changes in statistical risk

2.3. Willingness-to-pay (WTP) choices
The WTP choices in the form of reducing the risk probability for serious injuries and slight injuries are provided to be chosen by respondents. The choices provided are reductions of the accident risk probability by 25% and 50% for each severity level. The choice in the form of a percentage is equipped by the amount of money that must be spent by the respondents. The detail of WTP choices can be seen in Table 1.

| Severity level     | Additional cost          | 0% reduction | 25% reduction | 50% reduction |
|--------------------|--------------------------|--------------|---------------|---------------|
| Serious injury     |                          | -            | 7,200 IDR     | 14,400 IDR    |
| Slight injury      |                          | -            | 5,600 IDR     | 11,200 IDR    |

3. Result and Discussion

3.1. Respondent characteristics
There are variations in respondents based on the stated preference survey results. The characteristics grouping can be seen in figure 1 – figure 3. Figure 1 shows the lowest percentage is age category of more than 44 years old by 2.0% and the highest percentage is age category of 20 – 24 years old by 37.5%. Figure 2 shows the lowest percentage is income category of more than 6,250,000 IDR by 1.2% and the highest percentage is income category of 2,500,000 IDR – 3,750,000 IDR by 30.9%. Figure 3 shows the lowest percentage is number of children category of “have no children” by 61.3% and the highest percentage is number of children category of “have 4 children” by 37.5%.
Figure 1. Respondent characteristics based on age

Figure 2. Respondent characteristics based on income
3.2. Binary logit model analysis

There are some data obtained from the stated preference survey, but the data that affect the binary logit model are age variable, income variable, and number of children variable from each respondent as in previous studies [8, 18, 22–25]. The three variables mentioned earlier (age, income, and number of children) were analyzed for the choice of WTP using the binary logit model by SPSS software. There are two binary logit models that have been analyzed for each severity category, which are reducing accidents probability by 50% and 75%. The results of the binary logit model analysis using SPSS software can be seen in table 2 – table 3.

| Variable           | Parameter | p-value | Exp (β) | Parameter | p-value | Exp (β) |
|-------------------|-----------|---------|---------|-----------|---------|---------|
| Reduction by 25%  |           |         |         | Reduction by 50% |
| Age               | 0.142     | 0.006   | 1.153   | 0.099     | 0.036   | 1.104   |
| Income            | 0.393     | 0.073   | 1.481   | 0.376     | 0.066   | 1.457   |
| Number of children| -1.429    | 0.000   | 0.240   | -1.186    | 0.000   | 0.305   |
| Constant          | -2.307    | 0.046   | 0.100   | -1.455    | 0.167   | 0.233   |

| Variable           | Parameter | p-value | Exp (β) | Parameter | p-value | Exp (β) |
|-------------------|-----------|---------|---------|-----------|---------|---------|
| Reduction by 25%  |           |         |         | Reduction by 50% |
| Age               | 0.121     | 0.019   | 1.129   | 0.091     | 0.047   | 1.095   |
| Income            | 0.383     | 0.075   | 1.457   | 0.332     | 0.096   | 1.393   |
| Number of children| -1.125    | 0.001   | 0.325   | -1.152    | 0.000   | 0.316   |
| Constant          | -1.938    | 0.091   | 0.144   | -1.192    | 0.245   | 0.304   |

Table 2 and table 3 show the SPSS output of binary logit biner analysis. Every variable has p-value less than 0.1 in which the variable is still significant to the equation model. The binary logit model equation for each willingness-to-pay choice can be written as follows:
• Binary logit equation model for reducing the risk of serious injuries by 25%

\[
\text{Logit}(p) = \ln \left( \frac{p}{1-p} \right) = -2.307 + 0.142 \text{Age} + 0.393 \text{Income} - 1.429 \text{Number of children}
\]

• Binary logit equation model for reducing the risk of serious injuries by 50%

\[
\text{Logit}(p) = \ln \left( \frac{p}{1-p} \right) = -1.455 + 0.099 \text{Age} + 0.376 \text{Income} - 1.186 \text{Number of children}
\]

• Binary logit equation model for reducing the risk of slight injuries by 25%

\[
\text{Logit}(p) = \ln \left( \frac{p}{1-p} \right) = -1.938 + 0.121 \text{Age} + 0.383 \text{Income} - 1.211 \text{Number of children}
\]

• Binary logit equation model for reducing the risk of slight injuries by 50%

\[
\text{Logit}(p) = \ln \left( \frac{p}{1-p} \right) = -1.938 + 0.121 \text{Age} + 0.383 \text{Income} - 1.211 \text{Number of children}
\]

From the 4 equation models that have been obtained, they show the similarity. It can be interpreted that every increase in age and income will increase willingness-to-pay log probability, but if the number of children increases it will reduce willingness-to-pay log probability. To prove the equation, 3 scenarios of variable change were performed. For scenario 1, the age variable is increased, but the income variable and number of children variable are constant. For scenario 2, the income variable is increased, but the age variable and number of children variable are constant. And for scenario 3, the number of children variable is increased, but the age variable and income variable are constant. The analysis result can be seen in table 4 – table 7.

**Table 4. Probability scenario for the risk reduction of serious injuries in traffic accidents by 25%**

| Scenario | Age | Income       | Number of Children | Logit p | Probability | Probability (%) |
|----------|-----|--------------|--------------------|---------|-------------|----------------|
| 1        | 20  | 3,000,000 IDR| 1                  | 0.283   | 0.570       | 57.0%          |
|          | 30  | 3,000,000 IDR| 1                  | 1.703   | 0.846       | 84.6%          |
|          | 40  | 3,000,000 IDR| 1                  | 3.123   | 0.958       | 95.8%          |
| 2        | 20  | 3,000,000 IDR| 1                  | 0.283   | 0.570       | 57.0%          |
|          | 20  | 4,000,000 IDR| 1                  | 0.676   | 0.663       | 66.3%          |
|          | 20  | 5,000,000 IDR| 1                  | 1.069   | 0.744       | 74.4%          |
| 3        | 40  | 3,000,000 IDR| 1                  | 3.123   | 0.958       | 95.8%          |
|          | 40  | 3,000,000 IDR| 2                  | 1.694   | 0.845       | 84.5%          |
|          | 40  | 3,000,000 IDR| 3                  | 0.265   | 0.566       | 56.6%          |

**Table 5. Probability scenario for the risk reduction of serious injuries in traffic accidents by 50%**

| Scenario | Age | Income       | Number of Children | Logit p | Probability | Probability (%) |
|----------|-----|--------------|--------------------|---------|-------------|----------------|
| 1        | 20  | 3,000,000 IDR| 1                  | 0.467   | 0.615       | 61.5%          |
|          | 30  | 3,000,000 IDR| 1                  | 1.457   | 0.811       | 81.1%          |
|          | 40  | 3,000,000 IDR| 1                  | 2.447   | 0.920       | 92.0%          |
| 2        | 20  | 3,000,000 IDR| 1                  | 0.467   | 0.615       | 61.5%          |
|          | 20  | 4,000,000 IDR| 1                  | 0.843   | 0.699       | 69.9%          |
|          | 20  | 5,000,000 IDR| 1                  | 1.219   | 0.772       | 77.2%          |
| 3        | 40  | 3,000,000 IDR| 1                  | 2.447   | 0.920       | 92.0%          |
Based on table 4 – table 7, scenario 1 proves that with age increment, but income and number of children are constant, the probability of reducing a traffic accident risk will increase. Scenario 2 proves that with income increment, but age and number of children are constant, the probability of reducing a traffic accident risk will increase. Meanwhile, scenario 3 proves that with the number of children increment, but age and income are constant, the probability of reducing a traffic accident risk will decrease.

3.3. Willingness-to-pay (WTP) value analysis
Willingness-to-pay (WTP) value of the risk reduction of serious injuries by 25% is 121,120,670 IDR and willingness-to-pay (WTP) value of the risk reduction of serious injuries by 50% is 132,165,695 IDR. Hence, the average willingness-to-pay (WTP) value of the serious injuries risk reduction is 126,143,182 IDR or can be rounded to 126,500,000 IDR

Whereas, willingness-to-pay (WTP) value of the risk reduction of slight injuries by 25% is 13,069,431 IDR and willingness-to-pay (WTP) value of the risk reduction of serious injuries by 50% is 12,472,838 IDR. Hence, the average willingness-to-pay (WTP) value of the serious injuries risk reduction is 12,771,134 IDR or can be rounded to 13,000,000 IDR.

4. Conclusion
Variables that affect the WTP choices are age, variable, and number of children. Variables in each equation have a significance level less than 0.1 so that it is still acceptable and has an effect on the equation model. The four equation models that have been obtained show the similarity. It can be interpreted that increases in age and income will improve the probability for motorcyclists to protect themselves from an accident, however, when the number of children increases, it will reduce the
probability. WTP value of motorcyclists on the risk reduction of serious injuries is 126,500,000 IDR, while WTP value of motorcyclists on the risk reduction of slight injuries is 13,000,000 IDR.

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