Abstract: The purpose of this study is to value the subjective cost of slight and serious motorcyclist accident using the stated preference method which is applied into the willingness to pay (WTP) approach. Willingness to pay is one way to assess the cost and impact of road traffic casualties. The purpose of this study is to investigate a relationship between age, income and number of children of the respondent and their willingness to pay for reducing slight injury as a result of motorcyclist accident. Two binary discrete choice models have been determined to obtain the figure of the subjective cost. All the independent variables on both models have the expected signs and are significant at 5% level. The goodness of fit of the model to the data is expressed by $\rho^2$ and this too falls within the expected range of 0 - 1.

Key Words: motorcycle, stated preference, willingness to pay and discrete choice

1. INTRODUCTION

It is well known that value of statistical life (VSL) is the marginal rate of substitution between wealth and risk Rosen (1988). Valuing the financial burden of an accident casualty make possible of casualty and accident cost to be identified. The purpose of that is to ensure that the best figure is used in economic evaluation for investment at the national planning level for road safety improvement, Jacobs ((2000) and Downing (1997)). Furthermore, Downing (1997) has highlighted that the value has to reflect the real economic burden of casualty.

Morrall (1986), Viscusi (1993), Tengs (1995) and Strand (2002) mentioned that there are two main ways to determine the VSL, through revealed preferences or through stated preferences. Krupnick et al. (2002) stated that the favorable stated preference approach has been applied in the last 20 years. In more detail, Contingent valuation method (CVM) and choice experiments is commonly used as a method while using the stated preference method. Knowing that there are three classes of injury, slight, serious and fatal; this study looks only
in detail at slight injury, which is the accident class prevalent for the motorcyclist. This is not because fatal and serious injuries are not important but to explain methodology, each class of injury needs to be considered separately.

The purpose of this study is to value the subjective cost of motorcyclist slight injury using the stated preference method which is applied into the willingness to pay (WTP) approach. Recently Indonesia applied the Gross output method to value accident cost; however the fix percentage number which is used to analyze the subjective cost based on UK experience. In another hand, there is a different welfare system between UK and Indonesia which is meant the fix percentage number should be different. Mohan (2002) informed that there is a lack of welfare system by government in developing countries including Indonesia which is caused the casualty or the casualty’s family in Indonesia should bear these costs by themselves, while UK government provides some degree of protection to the families if the casualty’s injuries are sufficient to affect their earning ability. Also a compensation may be also be recovered through insurance or legal proceedings of the UK’s casualties. This approach is more suggested as nowadays many countries have moved into the WTP approach instead of the Gross Output method and the WTP approach has been done yet in Indonesia (Widyastuti and Mulley, 2005).

The WPT approach looks at the way in which individuals are willing to pay to avoid an accident. In the survey, individuals are asked to choose between scenarios which have an implicit risk reduction and associated money values. The questionnaire has therefore been devised to allow this choice to be made by making a trade between payment and risk reduction. As this poses hypothetical questions to the respondents, it is a stated preference approach.

Previous studies have provided evidence to suggest that individual WTP is likely to be different according to that individual circumstance, especially with respect to age, income and number of children in the household. As a result, the questionnaire seeks demographic information from respondents to include in the analysis. Discrete choice approach has been applied to analyze the data in which the following factors would be considered; the age, income and number of children of the respondents.

2. CASE STUDY LOCATION

For the purposes of this research, the study location for data collection is the Surabaya Metropolitan Area (Figure 1). Surabaya is the second biggest city in Indonesia and is the capital of the East Java province of Indonesia (Office of Surabaya Statistic, 2001). Based on Surabaya’s census survey in 2000, the population in Surabaya was 2,599,796 and this was distributed across 31-sub districts. Surabaya is located at 7°14’ South latitude and 112°44’ East longitude and has an area 326.37 km².
3. MOTORCYCLE ACCIDENT'S RESULT IN SURABAYA

Severity

Despite the fact that skill is required to control the stability and safety of a motorcycle, obtaining a motorcycle driving license in Indonesia is easier than obtaining a car license. In another hand, as there is generally no body protection covering the rider, motorcyclists can be seen as relatively vulnerable road users. Moreover, in Figure 2 clearly shows that the number of motorcycle casualties in 2001 is higher than those for cars. It also shows the severity of motorcycle casualties is higher than the severity of cars. The biggest difference between motorcycle and car severity is the fatal category which 15 times higher for motorcycle. It can be concluded that the most likely impact of a motorcycle accident will be some degree of casualty whereas a car is more likely to have a damage-only accident.
Casualty by age

The 319 motorcycle casualties recorded in 2001 in Surabaya comprise 58 fatalities, 87 serious injuries and 174 slight injuries. The age distribution of casualties is presented in Figure 3 below where 41% were in the 20-29 age groups. This figure may reflect the fact that motorcycle users tend to be at the younger end of the age group in employment. This has an important impact for the indirect cost of the casualty as this would be higher for this age group. This is because the loss of productivity is equal to unproductive time multiplied with wages; if the casualty dies at 25 years old, when retirement age is 60 years old, unproductive time is 35 years. Moreover, if casualty dies with a good wages, then the loss of productivity will be higher than somebody who dies at an older age.

![Figure 3 Motorcyclist casualties in 2002 by age group](source)

4. DISCRETE MODEL FOR BINARY CHOICES

As already identified, discrete choice modeling is being used in this study for the analysis of the data relating to an individual’s WTP for the reduction in risk of different types of accident severity in a motorcycle accident.

The vast improvement now made to computer technology also makes it possible to overcome some of the computational difficulties that have hindered previous developments of these models. Now, there are many programs that assist with the analysis of discrete choice models. In this study, SPSS is used because of its ready availability even in developing countries, including Indonesia.

A number of standard approaches to discrete choice modeling are available. The purpose of this section is to give an outline of how the underlying theory applies to the analysis of the questionnaire in this study. In terms of approach, this study outlines the approach of Ben-Akiva and Lerman (1985) which viewed the utility of any alternative could be as a random variable in which if any alternative $i$ have been selected by person $n$ from choice set $Cn$ then the probability formula is
In this study, the binary model consists of two choices, willing to pay for a such severity reduction (yes) and unwilling to pay (no). The utility functions for the binary choices are formulated as follow:

\[ U_{yes} = V_{yes} + \varepsilon_{yes} = \beta'x_{yes} + \varepsilon_{yes} \]  
\[ U_{no} = V_{no} + \varepsilon_{no} = \beta'x_{no} + \varepsilon_{no} \]

where

- \( U_{yes} \): the utility of willing to pay the amount for severity reduction.
- \( U_{no} \): the utility of unwilling to pay the amount for severity.
- \( V_{yes} \): the systematic (deterministic) component of utility of willing to pay the amount for severity reduction.
- \( V_{no} \): the systematic (deterministic) component of utility of unwilling to pay the amount for severity reduction.
- \( \varepsilon_{yes} \): the random (disturbance or error) component of utility of willing to pay the amount for severity reduction.
- \( \varepsilon_{no} \): the random (disturbance or error) component of utility of unwilling to pay the amount for severity reduction.
- \( x_{yes} \): the vector of attributes that are related to the willing to pay the amount for severity reduction.
- \( x_{no} \): the vector of attributes that are related to the unwilling to pay the amount for severity reduction.
- \( \beta' \): the vector of unknown parameters

The choice probability for the willing to pay the amount for severity reduction can be written as follows:

\[ P_n(i) = \frac{e^{\beta'x_{yes}}}{e^{\beta'x_{yes}} + e^{\beta'x_{no}}} \]

where

- \( P_n(i) \): the probability that individual \( n \) chooses the willing to pay the amount for severity reduction.

The estimation of discrete choice models involves an investigation for the beta-values (parameter estimates) and is based on the Maximum Likelihood (ML) method (Ben-Akiva and Lerman, 1985). The Maximum Likelihood (ML) method is based on the idea that although a sample could originate from several populations, a particular sample has a higher probability of having been drawn from a certain population than from others. Therefore the ML estimates are the set of parameters, which will generate the observed sample most often (Ortuzar and Willumsen, 1994).

For a sample of \( N \) observations, the following log likelihood function as proposed by Ben-Akiva and Lerman (1985) is considered for the model estimation:
\[
L = \sum_{n=1}^{N} \left( y_{yes}^{n} \log \left[ \frac{e^{\beta_{yes}x}}{e^{\beta_{yes}x} + e^{\beta_{no}x}} \right] + y_{no}^{n} \log \left[ \frac{e^{\beta_{no}x}}{e^{\beta_{yes}x} + e^{\beta_{no}x}} \right] \right) \tag{5}
\]

where

\[
y_{yes}^{n} = 1 \quad \text{if individual chose willing to pay the amount for severity reduction}
\]

Furthermore to measure the goodness of fit of the model and the data used, the Rho-squared \( (\rho^2) \) statistic was applied. It is calculated as:

\[
\rho^2 = 1 - \frac{LL(\beta)}{LL(o)} \tag{6}
\]

Where, \( LL(o) \) is the initial log-likelihood (with all parameters set at zero) and \( LL(\beta) \) is the log-likelihood convergence with parameter vector \( \beta \).

5. DESCRIPTIVE OF RESPONDENT DATA

One hundred and eighty responses were obtained. The sample gender was predominantly male (73%) and 46% of sample fell into the age range 20-29. This is in line with the total number of accident as reported in Police accident records, which revealed that most of motorcyclist casualties are predominantly between 20 and 29 year old (Figure 4).

Grouping the sample into three income groups shown that 75% of respondents have less than Rp. 1,000,000 for income (Figure 5). This result is inline with previous survey done by Transportation Laboratory FTSP-ITS (2002) which identified the income of motorcyclist as between Rp. 500,000 – Rp 1,000,000 in 2002.
Table 1 shows the statistical descriptive of the age, income and number of children which are use as the variable on the model.

![Figure 5 Representation of respondent by group of monthly income (Rp)](image)

6. MODEL ESTIMATION, RESULTS AND DISCUSSION

The binary choices

Figure 6 shows the structure of the choice for willingness to pay (WTP) offered to respondents in the questionnaire relating to the hypothetical scenario of reducing the risk of a slight injury following a motorcycle accident. Two sets of binary choices for 25% and 50% were given to the respondents.
The questionnaire has been done by face to face. The binary choices delivered to the respondent as seen in Figure 7.

**Interpretation of the first binary model: 25% risk reduction**

Many studies including TRL (1995), Ghee, C., D. Silcock, et al. (1997) R. Silcock and TRL (2003) and Widyastuti and Bird (2004) identified that income, age and no of children are variables influencing the subjective cost of the severity and so these are included as determinants of the individual’s willingness to pay and tested in the first modeling. The results are shown in Table 1 below. All the independent variables have the expected signs and are significant at 5% level. The fit of the model to the data is expressed by $\rho^2$ and this too falls within the expected range of 0 - 1.

The logit model which predicts the willingness to pay for a 25% reduction in slight motorcyclist injury is:

$$Logit(p) = \ln\left(\frac{p}{1-p}\right) = 2.80 - 0.01 \ Age + 0.01 \ Income + 0.52 \ Number \ of \ children$$

Statistical significance is shown by the t-statistic and also the p-value. Generally a t-statistic of greater than 2 can be considered significant. The p-value gives the value at which the decision would switch between accepting or rejection $H_0$ and for a significance level of 5%,
this means that the p-value must be less than 0.05 to be significant.

This model shows the relationship between the independent variables (in this case age, income/10,000 and the number of children in the family) and the dependent variable, willingness to pay where the dependent variable is on the logit scale. For a positive coefficient, the interpretation would be that, holding everything else constant, a one unit increase in the independent variable would predict the coefficient log odds change in willingness to pay.

Table 2 The result of first model for 25% motorcyclist slight injury prevention

<table>
<thead>
<tr>
<th>Variable</th>
<th>parameter</th>
<th>p-value</th>
<th>t-statistic</th>
<th>exp (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Choice Rp. 700</td>
<td>2.80</td>
<td>0.00</td>
<td>4.18</td>
<td>16.43</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.10</td>
<td>0.00</td>
<td>-3.39</td>
<td>0.91</td>
</tr>
<tr>
<td>Age</td>
<td>0.01</td>
<td>0.00</td>
<td>3.05</td>
<td>1.01</td>
</tr>
<tr>
<td>Income</td>
<td>0.52</td>
<td>0.02</td>
<td>2.39</td>
<td>1.69</td>
</tr>
<tr>
<td>No of children</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td></td>
<td></td>
<td></td>
<td>182</td>
</tr>
<tr>
<td>LL (O)</td>
<td></td>
<td></td>
<td></td>
<td>-97.10</td>
</tr>
<tr>
<td>LL (β)</td>
<td></td>
<td></td>
<td></td>
<td>-87.68</td>
</tr>
<tr>
<td>ρ²</td>
<td></td>
<td></td>
<td></td>
<td>0.10</td>
</tr>
</tbody>
</table>

For the purposes of this study it is more useful to convert the odds ratio into predictive probability statements as described in the previous section. However, this means that different values have to be put into the equation in order to convert the results into a predictive probability statement for individuals with particular characteristics. For these results, the probability of a person would be willing to pay to reduce the risk by 25% of a slight motorcyclist injury reduction can be calculated from the model. If this is a person who is 20 years old and has an income of Rp. 750,000 with no children, then the probability of this person willing to reduce the risk by 25% of slight injury is, substituting values for age, income and number of children in the equation.

\[
\text{Logit}(p) = \ln\left(\frac{p}{1-p}\right) = 2.80 - 0.01 \ Age + 0.01 \ Income + 0.52 \ Number \ of \ children
\]

\[
\text{Logit}(p) = \ln\left(\frac{p}{1-p}\right) = 2.80 - 0.10 \times 20 + 0.01 \times (750,000/100,000) + 0.52 \times 0 = 1.76
\]

And the probability is therefore:

\[
p = \frac{\exp^{\text{Logit}(p)}}{1 + \exp^{\text{Logit}(p)}} = \frac{\exp^{1.76}}{1 + \exp^{1.76}} = 0.85
\]

The interpretation of this is that the probability would be 0.85 that a person with these characteristics would be willing to pay 1 Rp. 700 to reduce the risk of a slight motorcyclist injury by 25%. Alternatively, 85% of people holding these characteristics would be willing to

1 When the data are being collected, 1 US$ equal with around Rp. 9,000.00, which could be used to buy lunch (rice and meat) and drink or to buy Mc. Donald burger and ice cream cone.
pay Rp. 700 to reduce the risk of a slight motorcyclist injury by 25%.

The results therefore show that income and number of children increase, the probability that an individual is willing to pay Rp 700 to reduce the risk of a severe motorcycle accident increase but that increasing age decreases this probability. This might be because people with higher income are more aware of reducing the risk and the presence of more children means that they are more conscious of the consequences of an accident. Conversely, the older people are, the lower the chance is that they would be willing to pay for lowering the risk and this could be because most motorcyclists are from the young generations.

**Interpretation of the second binary model: 50% risk reduction**

The model of reducing the risk by 50% a slight motorcyclist injury also has been tested with age, income/10,000 and the number of children in the family. The result is shown in Table 2 below. All the independent variables have the expected signs and are significant at 5% level. The fit of the model to the data is expressed by $\rho^2$ and this too falls within the expected range of 0 -1.

The logit model of 50% motorcyclist slight injury prevention on the binary choices is:

$$\text{Logit}(p) = \log \left( \frac{p}{1-p} \right) = 2.89 - 0.10 \text{ Age} + 0.01 \text{ Income} + 0.54 \text{ Number of children}$$

This model shows the relationship between the independent variables and the dependent variable, where the dependent variable is on the logit scale. The logit model of 50% slight motorcyclist injury prevention on the binary choices has shown that the coefficient of the income and numbers of children has positive sign, while the age has negative sign.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter</th>
<th>p-value</th>
<th>t-statistic</th>
<th>exp ($\beta$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Choice Rp. 1,300</td>
<td>2.89</td>
<td>0.00</td>
<td>4.38</td>
<td>18.02</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-0.10</td>
<td>0.00</td>
<td>-3.51</td>
<td>0.91</td>
</tr>
<tr>
<td>Income</td>
<td>0.01</td>
<td>0.00</td>
<td>2.86</td>
<td>1.01</td>
</tr>
<tr>
<td>No of children</td>
<td>0.54</td>
<td>0.01</td>
<td>2.50</td>
<td>1.71</td>
</tr>
<tr>
<td>Observations</td>
<td></td>
<td>182</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$LL (O)$</td>
<td></td>
<td>-100.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$LL (\beta)$</td>
<td></td>
<td>-91.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho^2$</td>
<td></td>
<td>0.09</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 Estimation result for 50% slight motorcyclist injury prevention

Using the case shown in the earlier model (refer to Section), if there is a person who is 20 years old and has income Rp. 750,000 and has no children, then the probability this person would be willing to pay to reduce the risk by 50% of a slight motorcyclist is

$$\text{Logit}(p) = \ln \left( \frac{p}{1-p} \right) = 2.89 - 0.10 \times 20 + 0.01 \times \left( \frac{750,000}{10,000} \right) + 0.54 \times 0 = 1.68$$
The interpretation of this is that the probability would be 0.84 that a person with these characteristics would be willing to pay Rp. 1,300 to reduce the risk of a slight motorcyclist injury by 50%.

As before, using the three category version of the education variable gives an increase in from 0.09 to 0.1 although the education parameters, as in the earlier model, are not in themselves significant. This is shown in Table 2 and 3 where it can be seen that the values, signs and significance of the other variables have remained the same or very similar.

Both the binary logit model results discussed above demonstrate:

1. The amount of willingness to pay for either the 25% risk reduction or the 50% risk reduction of a slight motorcycle injury accident is significantly affected by
   - Age: increasing age, holding everything else constant, decreases the probability that an individual would be willing to pay either 700Rp for a 25% risk reduction or 1300 Rp for a 50% risk reduction of a slight motorcyclist injury.
   - Income: increasing income, holding everything else constant, increases the probability that an individual would be willing to pay either 700Rp for a 25% risk reduction or 1300 Rp for a 50% risk reduction of a slight motorcyclist injury.
   - Number of children in the family, holding everything else constant, increases the probability that an individual would be willing to pay either 700Rp for a 25% risk reduction or 1300 Rp for a 50% risk reduction of a slight motorcyclist injury.

2. The amount of willingness to pay for either the 25% risk reduction or the 50% risk probabilities for individuals with the same characteristics.

7. MODEL ESTIMATION, RESULTS AND DISCUSSION

This study develops a model to investigate a choice behavior of people in the motorcyclist slight injury reduction in which figuring the subjective cost of the casualty. The model incorporates SP data sources in Surabaya-Indonesia as a case study.

Two binary discrete choice models were developed in this study to analyze individual preferences on the reduction of motorcyclist slight injury reduction, which are 25% and 50%. The model has been tested with the age, income and number of children.

Both model shows that the independent variables which are consist of age, income and number of children have the expected signs and are significant at 5% level. The fit of the model to the data is expressed by $\rho^2$ and this too falls within the expected range of 0 -1. Regarding the result above, both model shown identical sign and significant at level 5%

The results also show that the subjective cost of motorcyclist slight injury is affected by the age, income and number of children. Therefore this study suggest to analyse the value of motorcyclist slight injury based on those variables, which meant the subjective cost of the older motorcyclist would be smaller than the younger motorcyclist. However the subjective
cost of the higher income would be higher than the lower income, and the more children the
motorcyclist have the higher the subjective cost generated. Consider on this model therefore
the casualty cost suggested to determine based on the demographic of the casualties rather
than the severity class.
The authors also would like to expand the model for other classes’ injury. Moreover the other
method t could be analyzed based on such circumstances of the respondents, income and age.

8. CONCLUSIONS

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