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Willingness to Pay Model for Motorcyclists' Slight Injuries in Jember

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Abstract

The growth of transportation facilities and infrastructure is not in line with traffic growth, resulting in an increase in traffic crashes. The increasing trend in the number of crashes causing death occurs in developing countries, like Indonesia. The purpose of this study is to value the subjective cost of a slight crash. This study used the Willingness to Pay method to determine the probability of motorists to be willing to pay more to reduce the risk of traffic crashes using the binary logistic regression method. The results of the Willingness to Pay method provide conclusions namely gender, total income, marital status, and the experience of having an crash resulting in the probability of being willing to pay more to reduce the risk of crashes by 27% (for motorists who have had an crash one time) and 40% (for motorists who have had a crash twice).

Keywords: *Crash* characteristics, accident cost, stated preference, willingness to pay.

Abstrak

Pertumbuhan sarana dan prasarana transportasi tidak sejalan dengan pertumbuhan lalu lintas, yang mengakibatkan peningkatan kecelakaan lalu lintas. Tren peningkatan jumlah kecelakaan yang menyebabkan kematian terjadi di negara-negara berkembang, seperti Indonesia. Tujuan dari penelitian ini adalah untuk menilai biaya subyektif dari kecelakaan ringan. Penelitian ini menggunakan metode Willingness to Pay untuk menentukan probabilitas pengendara untuk bersedia membayar lebih untuk mengurangi risiko kecelakaan lalu lintas menggunakan metode regresi logistik biner. Hasil dari metode Willingness to Pay memberikan kesimpulan yaitu jenis kelamin, total pendapatan, status perkawinan, dan pengalaman mengalami kecelakaan yang mengakibatkan kemungkinan bersedia membayar lebih untuk mengurangi risiko kecelakaan hingga 27% (untuk pengendara yang memiliki mengalami kecelakaan satu kali) dan 40% (untuk pengendara yang telah mengalami kecelakaan dua kali).

Kata-kata Kunci: Karakteristik kecelakaan, biaya kecelakaan, preferensi tersurat, kesediaan membayar.

1. Introduction

Motorisation in some developing countries is skyrocketing as a result of population growth, while the transport infrastructure is undoubtedly poor (Sperling and Salon, 2002). Based on the data of Statistics Indonesia, the growth of motorised vehicles was 8.44% in 2010 until 2018. Over the period from 2010 to 2018, motorcycle numbers increased from 61 million to 120 million. The growth of transportation facilities and infrastructure is slower than the growth of traffic, increasing the number of traffic crashes. Widyastuti and Mulley (2005) suggested that the rising number of motorcycle ownership might be relating to the poor quality of public transport and the very reasonable price of motorcycles.

Meanwhile, the road inundated by motorcycle condition in developing countries causes the increase rate of the crash over past years. WHO data for 2018 illustrates that the low-income countries in Southeast Asia and Africa experience the highest fatal crash number (accounting for 26.6 and 20.7 per 100,000 population respectively, far higher than 18.2 of the world average). Several factors considered as the causes of the traffic crash. Goniewicz *et al.*, (2016) stated that there are three leading causing factors of traffic crash; they are human, vehicle, and environmental factors. Furthermore, the driver's behaviour of respecting or violating the driving rules and doing the correct behaviour affect the perceptions of crash risk level (Cardamone, Eboli and Mazzulla, 2014). Nevertheless, Widyastuti, (2012) stated that the lack of safe road environment and the limited safety protection features increase the traffic crash number.

The purpose of this study is to value the subjective cost of motorcyclist slight injury. Two-wheeled motorcycle considered as a risky transportation mode due to the complete task of operation and lack of

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riders' protection (Vasconcellos, 1995). Moreover, motorcyclists have bigger chances to suffer from fatal and slight injuries than car users (Widyastuti and Bird, 2004). The motorcycle-related crash will increase with the rocketed number of motorcycle. An increase in motorcycle and other vehicles on the major road is related to the escalating number of motorcycle crashes (Harnen *et al.*, 2006). Therefore, it needs special attention to the motorcyclist in terms of assessing the crash cost of this group.

The impact of a traffic crash is an increase in the poverty rate because it causes a lot of expenses, such as costs during crashes and costs after an crash, as well as the cost of lost productivity due to crashes. The losses suffered due to traffic crashes have an impact on the social-economic conditions of the region (Widyastuti, 2012). However, little attention has been paid to assessing the crash cost, especially in Indonesia. Whereas, casualty and the casualty's family in developing countries, including Indonesia, have to bear these costs by themselves (Mohan, 2002).

The problems of people living in developing countries like Indonesia are difficult to imagine when a salary must be used for the hospital treatment caused by crashes. This condition could be even worse because a study (Kriswardhana and Widyastuti, 2015) found that Indonesian people cannot measure a specific price to pay when they face questions related to how much their willingness to pay. Consequently, no variables in the study are siginificant. Therefore, discrete choice modelling was performed to understand the willingness to pay. This method has been discussed as a useful technique to model the impacts of an event on individual or household characteristics and their preferences (Widyastuti, Mulley and Dissanayake, 2007).

The previous study in Surabaya, Indonesia, found that the most influential variables on reducing crash casualties are the age, income, and number of children (Widyastuti and Mulley, 2005). Surabaya is one of the metropolitan cities in Indonesia. Meanwhile, there is a lack of understanding of whether this model is acceptable for being applied in medium cities. Jember is one of the medium cities in Indonesia. Based on data from the Jember Police Traffic Unit during 2017-2019, there were 3,543 traffic crash cases. Therefore, the need for valuing the crash and casualty cost in a medium city is essential, and the result might be beneficial for the future road safety policies and supporting the investment on safer motorcyclists.

2. Literature Review

2.1 Study on estimating the crash and casualty cost

Several previous studies have been reported in valuing the casualty cost. Developed countries have adopted the Willingness to Pay (WTP) approach to measure crash cost, while most of developing countries have applied the Gross Output Method (Jacobs, 1995; Jacobs, Thomas and Astrop, 2000). Meanwhile, the human cost is individual and very subjective, based on the preferences and interests (Jones-lee, 1990). The Gross Output (Human Capital) method reviews the state of traffic crash victims to analyse the characteristics of crashes used to calculate the cost of a traffic crash. While the WTP method serves to determine the probability of the driver's desire to incur additional costs in an effort to reduce the risk of traffic crashes.

Gross output method is one of the methods used to estimate crash cost, especially in Indonesia. The idea of gross output method is the costs of crash related to the costs of vehicle damage, hospital facility, and administration as well as future lost output. Several studies agreed that human cost should be included when valuing the crash cost. Farida and Santosa (2018) stated that Gross Output (Human Capital) method is used to calculate the regional economic losses due to traffic crashes, through how to calculate the number of traffic crashes that have occurred then analysed the amount of loss experienced. Furthermore, research by Sugiyanto (2017) resulted in the crash cost based on the type of casualties. The fatal crash costs IDR 263 million, while the minor injury is IDR 1.9 million.

Saputra, Sugiyanto and Hardini (2016) implied that traffic crashes could be reduced by knowing how much a person wants to pay more to take care of his vehicle so as to avoid damage that can cause traffic crashes using the WTP method. Jones-lee (1990) mentioned that the value of individual life is reflected in their willingness to pay (or sacrifice) to get benefits or to avoid costs. Therefore, it can be assumed that the individual would be willing to pay some of their incomes to lower their probability of injury. Widyastuti (2012) stated that the WTP method was related to the people's willingness to pay for their safety improvements. Similarly, Eeckhoudt and Hammitt (2001) also suggested that the willingness to pay of people to lower the risk can be assessed by propagating the change of probability of injury. Furthermore, many studies identified that there is a relationship between the value of life and the socio-economic and demographic characteristics of each person. For example, Saputra, Sugiyanto and Hardini (2016) found that there is a correlation between WTP for reducing the probability of crash involving, age, and frequency of crash involvement. Moreover, Islam (2002) believe that WTP is an appropriate method to value non-market goods.

2.2 Stated preference and discrete choice modelling

The stated preference technique is a data collection technique refers to the approach to the opinion of respondents in dealing with various alternative choices. This technique uses an experimental design for creating alternative imaginary situations (Pearce and Özedemiroglu, 2002). This method is much more commonly used in the field of road safety. Furthermore, stated preference methods are preferred due to the broader applicability. People usually do not understand the risk reduction caused by safety devices improvements, but stated preference methods provide a better understanding of respondents to this information

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(Lindhjem *et al.*, 2011). A study in India by Balakrishnan and Karuppanagounder (2020) performing stated preference to estimate road accident cost showed that travel cost, accident rate, age, occupation, and number of household member were variables which significantly influenced the decision-making of WTP. This research has two kinds of equality models, which are willing to pay (yes) and do not want to pay (no). A similar type of choice is formulated as follows (Ben-Akiva and Bierlaire, 1999):

$$P_{n(i)} = P_{yes} = \frac{e^{\beta' X_{yes}}}{e^{\beta' X_{yes}} + e^{\beta' X_{no}}} \quad (1)$$

where:

$P_{n(i)}$ = probability of individuals who are willing to pay

Rho-squared statistics (ρ^2) have been applied in measuring the suitability of the data used with the model, which are as follows:

$$\rho^2 = 1 - \frac{LL(\beta)}{LL(o)} \quad (2)$$

where:

LL (β) = focusing on log-likelihood with vector β criteria

LL (o) = beginning of log-likelihood (with all criteria set at zero or constant)

Discrete choice model is one of the methods that can be utilised for the data analysis relating to WTP of individual for the reduction in casualty severity of crashes (Widyastuti, 2012). Utility means a combination of straight lines of variables, as in the following equation:

$$U_j = \theta_j + \theta_1 X_1 + \theta_2 X_2 + \ldots + \theta_n X_n \quad (3)$$

where:

U_j = utility of choices

$X_1 \ldots X_n$ = attributes of each choice

The probability or risk of an object can be explained through the logistical model formulated as follows:

$$\ln(p/(1-p)) = \beta 0 + \beta 0 X\_1 + \ldots + \beta\_p X\_p \quad (4)$$

While in getting the p-value for logistical probability, the following formula is used:

$$p = \frac{exp(\beta 0 + \beta 0 X_1 + \ldots + \beta_p X_p)}{1 + exp(\beta 0 + \beta 0 X_1 + \ldots + \beta_p X_p)} = \frac{e^{(\beta 0 + \beta 0 X_1 + \ldots + \beta_p X_p)}}{1 + e^{(\beta 0 + \beta 0 X_1 + \ldots + \beta_p X_p)}} \quad (5)$$

Where:

p = Probability

β1...βp = Parameters of a characteristic

X1...Xp = Respondents' characteristics

3. Methodology

3.1 Case study location

In this research, the case study location for data collection is Jember Regency. Jember is the third biggest city in East Java Province, Indonesia. Based on the

Figure 1. Jember regency
Source: maps.google.com and jemberkab.go.id

Statistics Indonesia data, the Jember's population in 2015 was 2,409 million. Jember has an area of 3,293 km^2.

3.2 Stated preference and willingness to pay survey

Determination of the number of samples to fill out the questionnaire is needed in order to get optimal results. In determining the number of samples, the error tolerance limit is 5%. Primary data obtained directly in the field by interviewing people in Jember Regency. In this study, the locations chosen for distributing questionnaires were in the town square, shopping centers, and places where people gathered, such as restaurants or cafes. Respondents were randomly selected and had experienced a traffic crash.

This study used the stated preference choice modelling method, and a pilot survey was done to test the questionnaire. Several information including demographic information and the number of crashes were delivered in the questionnaire. Widyastuti (2012) stated that in the choice modelling scenario, giving respondents a realistic scenario is more essential than giving them a WTP value to choose from. Moreover, Kriswardhana and Widyastuti (2015) mentioned that open question method to value willingness to pay was not a proper method used in Indonesia, because some respondents found it was hard to assess or understood the objective of questions. Consequently, there were no independent variables significantly influenced the WTP variables.

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To facilitate these obstacles, easy to understand questions are required. The brake pad was used to provide an illustration of the WTP amount to reduce the crash risk. It was because most of two-wheeled motor vehicle drivers in Jember are unwilling to change brake pad until it is worn out; even though they know that the brake pad is a vital part of motorcycles, and it could lead to a worsen ijury if it is not maintained properly. Manufacturers suggest the brake pads must be changed every 8,000 km and it costs of around IDR 100,000 (cost of brake pad and replacement service). Therefore, the 25% reduction of probability involving in a crash would be every 6,000 km with IDR 25,000 as additional cost. Furthermore, based on the police accident record, the probability of slight injury is 27 in 100,000.

The modelling in valuing WTP consisted of an approach for the binary choices. The dependent variable in this study divided into 2 options. The binary choices are provided below:

OPTION A
Maximum speed: 70 kph
Change brake pad every: 6,000 km
Probability of slight injury: 20 in 100,000
Additional cost: IDR 25,000 per break pad changing

OPTION B
Maximum speed: 60 kph
Change brake pad every: 8,000 km
Probability of slight injury: 27 in 100,000
Additional cost: IDR 0 per break pad changing

Figure 2. Set of choices in the questionnaire

The options were obtained from the previous study conducted by Widyastuti and Mulley (2005) that was improved to adjust the condition of study location and current condition. The improvements are the additional cost and the frequency of changing the brake pad. The questionnaire was translated into Bahasa Indonesia. In the WTP questionnaire, the respondents were asked to express their WTP for a slight injury risk reduction.

Data was collected from February to March 2020. This study targeted respondents who had been involved in traffic crashes. The number of respondents was determined based on the population of Jember Regency. The importance of road safety, the impact of traffic crashes, and the fatality were explained. Then, the respondents were asked about their socio-economic characteristics, experience in traffic crashes, and the WTP to reduce the risk.

Table 1. Crash data, from 2017-2019

Description	2017	2018	2019
Number of crash	1,121	1,276	1,146
Fatal injury	347	383	331
Serious injury	13	20	13
Slight injury	1,275	1,504	1,335
Material loss (IDR)	1,068,900,000	1,379,200,000	1,093,150,000

4. Result and Discussion

4.1 Crash characteristics

Crash data from 2017 to 2019 were obtained from the Jember Traffic Police Unit, covering the number of events, the severity of the victims, and the characteristics of the crash.

According to **Table 1**, it can be seen that most crashes occurred in 2018 and resulted in many deaths, serious injuries and minor injuries compared to 2017 and 2019. Traffic crashes that occurred in Jember in 2017 to the year 2018 have increased by 13.8%. However, in 2018 until 2019, it decreased by 10.2%.

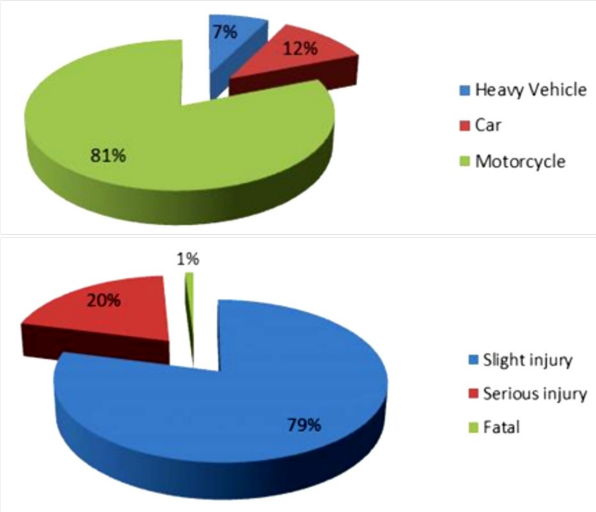

Figure 3. Type of vehicles involving and injuries in crashes, Jember, 2017-2019

It can be seen from **Figure 3** that 81% of vehicles involving in crashes in Jember was the motorcycle. Even though the study conducted by Kriswardhana *et al.* (2019) implied that most of motorcyclists in Jember has a driving license, the skill of motorcyclist is mostly poor. Furthermore, the most crash severity type is slight injury (accounting for 79%).

4.2 Model development

This study conducts a quantitative method with a self-administered questionnaire in order to make sure the respondents know the conceptual of the questionnaire. A total of 400 questionnaires were sent out among respondents at the city centres of Jember.

Table 2 contains the variables that are stated in the questionnaire. The results of these variables are used to find out what factors can influence the probability of the people of Jember in being willing to pay more to reduce the risk of crashes. As can be seen from **Table 2**, 69.75% of respondents are willing to pay more to

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Table 2. Demographic characteristics of respondents

Characteristics		*Frequency*	*Percentage*
Gender	Male	183	45.75
	Female	217	54.25
Age	<21 years old (y.o.)	58	14,5
	21- 30 y.o.	118	29,5
	31 - 40 y.o.	79	19.75
	41 - 50 y.o.	85	21.25
	51 - 60 y.o.	54	13.5
	>60 y.o.	6	1,5
Educational background	Primary school	0	0
	Junior high school	5	1.25
	Senior high school	168	42
	Graduate	227	56.75
Marital status	Married	258	64,5
	Single	142	35.5
Living with parents	Yes	154	38,5
	No	246	61.5
Occupation	Civil servant	100	25
	Private sector	140	35
	Entrepreneur	54	13.5
	Unemployment	106	26.5
Income	<IDR 499,999	15	3.75
	IDR 500,000 - Rp. 1,499,999	84	21
	IDR 1,500.000 - Rp. 2,499,999	94	23,5
	IDR 2,500,000 - Rp. 3,499,999	107	26.75
	IDR 3,500,000 - Rp. 4,999,999	68	17
	>IDR 5,000.000	32	8
Vehicle ownership	Motorcycle	271	67.75
	Car	6	1,5
	Motorcycle and car	92	23
	Do not have any vehicles	31	7.75
Crash involvement	1 time	264	66
	2 - 3 times	111	27,75
	More than 3 times	25	6,25
Willingness to pay more on increasing the safety	Agree to choose option A	279	69.75
	Agree to choose option B	121	30.25

Table 4. The goodness of fit test

-2 Log likelihood	*Cox & Snell R Square*	*Nagelkerke R Square*	*Hosmer and Lemeshow Test*	
			Chi-square	*Sig.*
301.939	0.376	0.532	8.653	0.372

Table 3. A cross classification between income and choosing option A

Income	*Choosing Option A*
<Rp. 499.999	13%
Rp. 500.000 - Rp. 1.499.999	36%
Rp. 1.500.000 - Rp. 2.499.999	49%
Rp. 2.500.000 - Rp. 3.499.999	92%
Rp. 3.500.000 - Rp. 4.999.999	97%
>Rp. 5.000.000	100%

increase their safety. Meanwhile, the descriptive statistics for the respondents are discussed in the following. It can be seen that the proportion of productive ages (ranging from 21 to 50 years old) is approximately 70%. Most of the respondets comprised diploma or bachelor degree (accounting for 56.75%). Moreover, 35% of the respondents work in private sectors. Among the motorcyclists, 26.75% earned IDR 2,500,000 – IDR 3,499,999.

In terms of a cross classification between respondents' income and willingness to choose option A, **Table 3** shows that increasing in income leads to behaviour of choosing option A (willing to pay more to reduce the frequency of crashes). Moreover, 78% of married respondents are willing to choose option A. These variables are then modelled in the logistic regression.

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Table 5. Parameter estimation

Variable	*Coeff.*	*S.E.*	*Sig.*	*Exp(B)*
Gender*	-0.914	0.334	0.006	0.401
Age	-0.069	0.174	0.691	0.933
Educational background	-0.626	0.391	0.109	0.535
Occupation	-0.198	0.222	0.374	0.821
Income*	-1.996	0.270	0.000	0.136
Vehicle ownership	0.163	0.233	0.483	1.177
Crash involvement per year*	-0.632	0.255	0.013	0.531
Marital status*	-2.028	0.571	0.000	0.132
Residence information	-0.693	0.409	0.090	0.500
Constant	7.903	1.607	0.000	2704.094

The conclusion of the model in this study can be seen in the Nagelkerke R^2 showing a value of 0.532 or 53.2%, providing an explanation of the variation in the change in the category of willingness to pay more than 53.2% on the independent variables in this study. According to the Hosmer and Lemeshow Test (H-L Test), it can be seen that in this research model has a chi-square probability value (Chi-square = 8.653; p = 0.372> 0.10) which exceeds the value of 10% (0.10) indicates that the value is acceptable; thus, it also indicates that the model is valid.

Coeff. is coefficients, S.E. is standard error, Sig. is significance level, *variables were statistically significant at the 0.05 level.

The value of constant is higher than other variables' coefficient. Constant described as the mean response value when all predictor variables are set to zero. The significance test shows that the explanatory variables that have a sig. value <0.05 are respondent's gender, income, and the number of crashes per 1 year, and marital status. Therefore, the general estimated equation was obtained:

Logit (p) = ln (p / 1-p) = 7.903 - 0.914 gender - 1.996 income - 0.632 number of crash - 2.028 marital status. This model indicates that female is more likely to pay more in reducing the chance of crashes. Moreover, the increase of income and number of crashes would increase the probability of people to pay more. A negative sign of coefficient of marital status variable indicates that married respondents' tend to pay more, compared to another group.

Among individual characteristics, income was found to be significant and positively associated with WTP, which suggested that lower income category was less willing to pay for crash risk reduction. This finding confirmed the earlier studies (Chaturabong, Kanitpong and Jiwattanakulpaisarn, 2011; Yusoff *et al.*, 2013; Mon *et al.*, 2018) which reported respondents with higher income were more willing to pay for their increase in safety. Furthermore, motorcyclists who experienced prior road crashes were more willing to pay for risk reduction than those who did not have experiences in road crashes. This results was fitted with findings from earlier research (Dissanayake, 2009; Haddak, Lefèvre and Havet, 2016; Mon *et al.*, 2018).

4.3 Interpretation of the model and discussion

The probability value of the willingness of the people of Jember Regency to pay more in order to reduce the risk of traffic crashes is obtained by changing the odds ratio to the probability of prediction; therefore, it is necessary to put the category number on the model variable. For these results, the probability of a person who is willing to pay more in reducing the risk of slight injury can be calculated using the model.

If the person who is male (1), income between IDR 1,500,000 and 2,499,999 (3), 1 time involvement in crash (1), then the probability model is presented below:

$$\text{Logit (p)} = \ln(p/1\text{-}p) \quad (6)$$

$$= 7.903 - 0.914\,(1) - 1.996\,(3) - 0.632\,(0) - 2.028\,(0)$$

$$= 1.001$$

And the probability:

$$p = 1 - \frac{e^{1.001}}{1 + e^{1.001}} = 0.269 \quad (7)$$

The interpretation of the model is that a person who is male, income between IDR 1,500,000 and 2,499,999 (3), 1-time involvement in the crash (0) would be willing to pay IDR 25,000 to reduce the risk of a slight injury by 26.9%. The result shows that the increase of income will increase the probability of people to choose option A (willing to pay IDR 25,000 to reduce the risk of a motorcyclist slight injury). It might be because higher-income people are more aware of safety.

Furthermore, if the crash involvement changed and the other characteristics are still identical, the probability will be:

$$\text{Logit (p)} = \ln(p/1\text{-}p)$$

$$= 7{,}903 - 0{,}914\,(1) - 1{,}996\,(3) - 0{,}632\,(2) - 2{,}028\,(1)$$

$$= 0.369$$

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$$p = 1 - \frac{e^{0.369}}{1 + e^{0.369}} = 0.409 \quad (8)$$

The result indicates that people with experiences in crashes more than one time, 2-3 times in this case, shows an increase in probability to minimise the risk of injury by 40.9% (compared to 26.9% on the category of one time involving in an crash). It is probably because people who experience traffic crashes are more aware of their safety.

A study conducted in Surabaya-Indonesia by Widyastuti, Mulley and Dissanayake (2007) implied that the subjective cost of motorcyclist slight injuries are affected by variables such as age, income, and number of children. While a recent study in Surabaya (Utanaka and Widyastuti, 2019) found that only income and number of children that were significant in influencing the willingness to pay more to reduce the probability of crash. Yusoff *et al.* (2013), who conducted research in valuing fatal injury cost, found that factors influencing the WTP were income, vehicle ownership, occupation, race, risk perception, gender, and crash experience. Moreover, in terms of car driver's, Mon *et al.* (2018) stated that individual income and household income were variables significantly influence the WTP; while education did not influence the WTP. The result of modelling in this study found that income, crash experience, and gender were significantly influenced the WTP. Therefore, it can be said that some variables of willingness to reduce the risk of crashing are particulary similar; however, some different significant variables might be caused by the special characteristics of every case study location.

5. Conclusions

For more than a decade, in Jember, the number of motorcycle has seen a dramatic growth. In Jember, the motorcycle is the most popular transportation mode. Increasing in the number of motorcycles would escalate the motorcyclists' number of crashes. Slight injury is the type of severity that mostly happens. Therefore, this WTP study intended to value the cost of slight injury of motorcyclists. In this study, the notion of changing of brake pad was performed as a main scenario because Indonesian motorcyclists are generally reluctant to change brake pads until they are completely worn out; whereas, they are a vital part of the safety and useful mechanism of motorcycles. Several main findings of this study are presented as follows:

1. The discrete choice technique is proven as a valuable tool to understand the WTP behaviour.
2. Several demographic characteristics considered influential in willingness to pay more to reduce the risk of crashes; they are gender, income, and the number of involvement in crashes. Higher-income is associated with a more willing to pay more in lowering the probability of involving in traffic crashes.
3. People who were experienced several crashes are more aware of their safety, because they agree to pay more in order to be safer. This study, therefore, has some differences with the previous study conducted in Surabaya, except for the income variable.
4. The final model developed in this study although it may need further adjustment and improvement could be the basic model in valuing the slight injury cost of the motorcyclist.

Further research could develop the cost of other severity types and involve other drivers, car drivers, for example

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