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The Motorcycle Usage Characteristics in Developing Countries: The Operation Cost and Ownership of Motorcycles in Makassar - Indonesia

Arifin ASRI [a], Muhammad Isran RAMLI [b], Nur ALI [c], Lawalenna SAMANG [d]

[a,b,c,d] *Graduate School of Civil Engineering, Engineering Faculty, Hasanuddin University, Makassar, 90-245, Indonesia*
[a] *E-mail: arifinasri@gmail.com*
[b] *E-mail: muhisran@yahoo.com*
[c] *E-mail: nuralimti@gmail.com*
[d] *E-mail: samang_l@yahoo.com*

Abstract: The present paper aims to grasp motorcycle usage characteristics in developing countries, particularly the motorcycle operation cost and ownership in Makassar, Indonesia. The study has conducted secondary and primary surveys in data collection for both characteristics respectively, from motorcyclist and households in the city. Then, we have analyzed some regression models for the motorcycle operation cost models. As well as, we have applied the multinomial logit model approach to analyze the relationship between the motorcycle ownership and some household characteristics. The analysis results show that the motorcycle operation cost components such fuel consumption, administration, maintenance, and oil utilization costs follow the polynomial models with significant results. In addition, the goodness of fit of the motorcycle ownership model is enough acceptable. Mostly exogenous variables significantly influence the motorcycle ownership. The results provide a basis for further studies such time valuation of motorcyclists, mode choice model of the households, etc.

Key Words: Motorcycle, operation costs, ownership, regression and logit model, Makassar.

1. INTRODUCTION

Nowadays, the motorcycle ownership has increased rapidly in many cities in Asian developing countries. For example, the average annual growth rate approximately of motorcycle is 11% in Bali, Indonesia (Wedagama and Dissayake, 2010a), and 14% in Hanoi City, Vietnam (Tuan and Shimizu, 2005).

The phenomenon leads to the road traffic problem such as traffic congestion increasing, traffic behavior changing from homogeneous to heterogeneous traffic, increasing of traffic accident, etc. Some impacts of the traffic situation involve the speed decreasing (Abulebu et al., 2012; Zakaria et al., 2011), the deceleration increasing (Azis et al., 2013), the driving cycle changing (Azis et al., 2013), the low safety traffic (Asri et al., 2011), the increasing of noise pollution (Hustim et al., 2012) and emission level (Arafah et al., 2013). Particularly the traffic safety, motorcycle safety constitutes an increasingly significant in the cities. For instance, motorcyclists contributed more than 60% of the road injuries on Malaysian roads (Radin et al., 1996). In Thailand, 76% of the injured accident victims are either motorcycle drivers or passengers (Hossain, 2006). In Indonesia, during 2003-2007 there were 70% of road accidents involved with motorcycles in Bali (Wedagama and Dissayake, 2010a; 2010b).

In responding the situation, many efforts remain to be made. One of the engineering approaches to overcome the motorcycle accident problem is segregating other road users from motorized traffic through an exclusive motorcycle lane that is restricted to motorcyclists with physical barriers and or markings. The effort has been implementing on Malaysian road (Law and Radin, 2005). In Indonesia, this road safety policy has been tried to be implemented in many big cities in Indonesia, such as, Jakarta, Yogyakarta, Makassar, etc. during January in 2007 (Asri, et al., 2011). However, the implementation was only pilot project in order to introduce the policy to road users.

Overall, the previous researches on motorcycle accident in developing countries has primarily focused on the issues of the effectiveness of rider equipment safety, i.e. helmet on reducing head injury severity (Chang, 2005), the investigation of influence factors caused motorcycles accident and injuries (Wedagama and Dissayake, 2010a; 2010b), medical investigation of motorcycles accidents (Hossain and Iamtrakul, 2007), causality cost of motorcyclist's slight injury (Widyastuti, 2007), comfortability of motorcycle excluxive lane (Law and Radin, 2005), and exclusive lane acceptability (Asri, et al., 2011).

Basically, in order to find solution addressed to problem caused by motorcycle, firstly we have to have more attention to the motorcycle usage characteristics such as motorcycle operation costs, motorcycle ownerships, etc. However, only a few previous studies have focused on these matters for Asian developing cities. For instance, Tuan and Shimizu (2005) have studied the household motorcycle ownership behavior in Hanoi City, Vietnam. Through discrete choice analysis, the study showed that the increases in number of workers or students, motorcycle price, income, and previous transactions significantly influence the transaction decisions. For Indonesia case, Putranto et al (2007) have studied characteristics of private car and motorcycle ownership using aggregate data (1990-2000) by the quasi-logistic model. The study found that the household monthly expenditure was positively correlated with the number owned cars. As well, the income influenced motorcycle ownership of household in Bandung using multinomial logit model (Petragadia et al (2007). In addition, Senbil et al (2006) have studied the motorcycle ownership and use in Jabotabek (Indonesia) Metropolitan Area. They indicated that socio-economic and demographic characteristics were effective on the motorcycle ownership and its use.

In order to contribute in this research field, the present paper attempts to grasp the motorcycle operation costs and the motorcycle ownership of households in Makassar, Indonesia. For the purpose, this study applies the regression models for the motorcycle operation cost aspects, and the multinomial logit (MNL) model approach in developing a relationship between the motorcycle ownership and some household characteristics.

The rest of this paper is presented as follows. The next section presents data collections, then, the analysis result, such the results of the motorcycle operation cost models, and the motorcycle ownership model respectively. Finally, the paper provides a conclusion.

2. DATA COLLECTIONS

The present paper has utilized two data-sets which have been collected separately. The firstly data-set related to the operating costs of motorcycles is collected from secondary survey of the database of Transportation Engineering System Laboratory in Civil Engineering Department of Hasanuddin University. The secondly data-set about the motorcycle ownership of households is collected through a primary survey. The data collections of both data-sets are

explained in the following paragraphs.

The present study utilizes the motorcycle operating cost data from a survey result which carried out by Transportation Engineering System Laboratory of Civil Engineering Department, Hasanuddin University, and Indonesian Society of Transportation, Branch of South Sulawesi in January 2007. The survey was conducted at three primary roads in Makassar City, i.e. Yani Street, Sudirman Street, and Pettarani Street, in order to measure and grasp the operational characteristics of motorcycles in Makassar, South Sulawesi, Indonesia. The survey took two hours duration to interview randomly 500 motorcyclists on each road. On the survey, the surveyors stopped the motorcyclists whom were passing on the roads to the road side. Then, they interviewed them about their socio demography, origin-destination trip, and some aspects of the motorcycle operating costs.

In the other side, this study collects data from seven residential areas in the northern part of the city. The survey which conducted during February 2007 was carried out in order to grasp household characteristics in the residential areas addressed to the motorcycle ownership. The survey based on an interviewing method using a questionnaire sheet which consist of questions of the household characteristics, such house types, car ownership, family size, trip number in a day, worker number of family member, and income of households. Table 1 presents the attributes or attitudes of each characteristic. There are 686 respondents as representative of the households (approximately 10% – 30% of population), which selected randomly from the residential areas in this survey. Table 2 shows the description of the residential areas such, name, location, house number and sample size in the survey.

Table 1 The attributes or attitudes of the households characteristics in the questionnaire

Variable Type	Attribute/Attitude Variable				
1. Motorcycle Ownership (Unit)	a. 0	b. 1	c. 2	d. > 2	
2. House Type (m^2)	a. ≤ 40	b. 40 – 50	c. 50 – 60	d. 60 – 70	e. 70 – 100 f. 100 – 150 g. > 150
3. Family Size (Person)	a. ≤ 2	b. 3 – 4	c. 5 – 6	d. 7 – 8	e. > 8
4. Income (IDR $1x10^6$)	a. ≤ 0.5	b. 0.5 – 1.0	c. 1.0 – 1.5	d. 1.5 – 2.0	e. > 2.0
5. Car Ownership (Unit)	a. 0	b. 1	c. 2	d. > 2	
6. Worker Number (Person)	a. 0	b. 1	c. 2	d. 3	e. > 3
7. Trip Number (Time/Day)	a. 0	b. 1	c. 2	d. 3	e. > 3

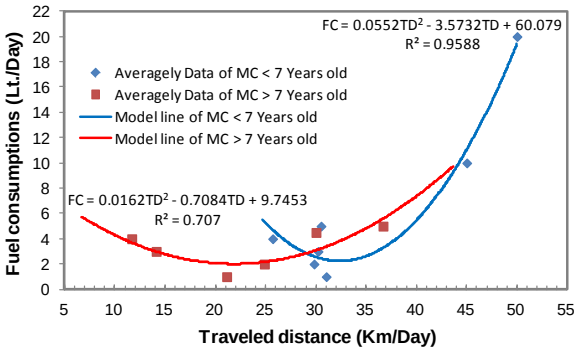
Table 2 Descriptions of the residential areas and the number of sampling

The Name of Residential Areas	District Location	Width Area (Ha)	House Number (Units)	No. Sample (Households)
1. Bukit Baruga (BB)	Tello	50.0	750	200
2. Bukit Khatulistiwa (BK)	Biringkanaya	10.0	425	116
3. Citra Sudiang Indah (CSI)	Biringkanaya	50.0	900	92
4. Griya Mulya Asri (GMA)	Biringkanaya	3.4	175	36
5. Nusa Tamalanrea Indah (NTI)	Tamalanrea	25.0	1055	110
6. Sudiang Nusa Indah (SNI)	Biringkanaya	5.0	98	11
7. Telkomas	Tamalanrea	10.0	315	121

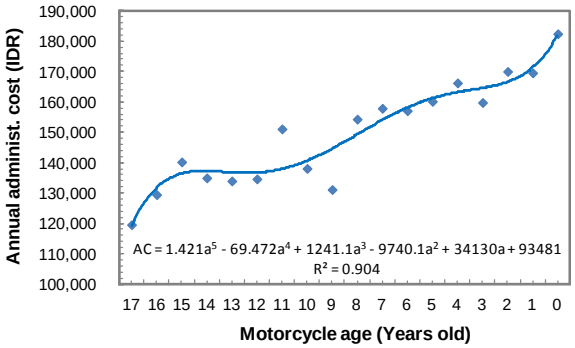
3. THE MOTORCYCLE OPERATION COSTS IN MAKASSAR CITY

In order to grasp the characteristics of the motorcycle operation costs, we adopt some regression models such as the polynomial regression model, linear regression model, exponential model, and logarithmic model. The best fit model among the models is chose as

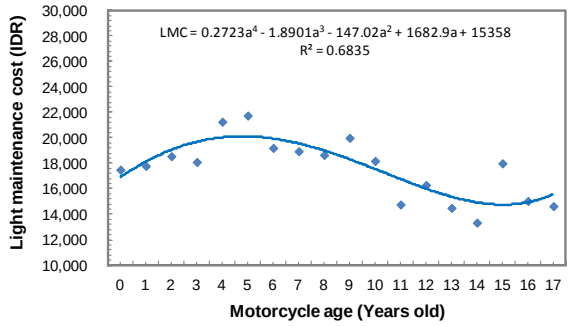
the selected model. In this regard, we have developed models of six characteristics of the motorcycle operation costs, i.e. the fuel consumption (FC), the annual administration cost (AC), the light maintenance cost (LMC), the heavy maintenance cost (HMC), the oil utilization cost (OC), and the tire cost (TC). Through the data analysis, the selected models for the six aspects of the motorcycle operation costs are presented in Figure 1a, Figure 1b, Figure 1c, Figure 1d, Figure 1e, and Figure 1f, respectively. We will explain the phenomena of each motorcycle operation cost characteristics regarding the results of the regression models.



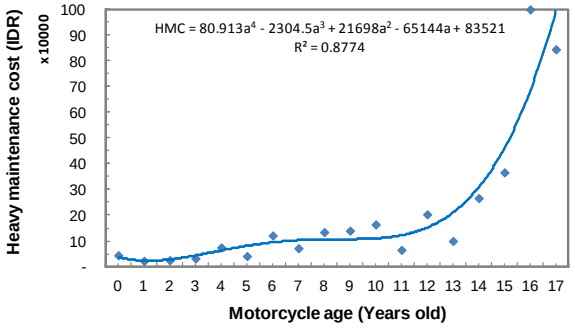
a. Fuel consumptions



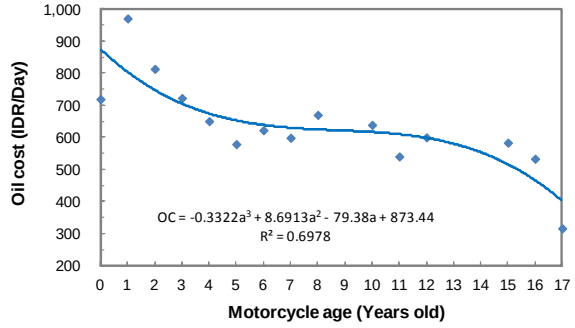
b. Annual administration costs



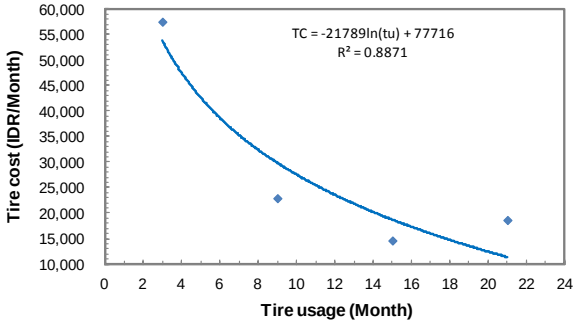
c. Light maintenance costs



d. Heavy maintenance costs



e. Oil utilization costs



f. Tire utilization costs

Figure 1 Motorcycle operation costs

3.1 The fuel consumption model of the motorcycle in Makassar City

The fuel consumption model of the motorcycle in this study describes a relationship between the motorcycle fuel consumption in litters per-day and traveled distance of the motorcycle in

km per-day. The relationship model is visualized in Figure 1a.

Figure 1a presents that the motorcycle fuel consumption follows the polynomial model in orde-2. In this case, we divided the motorcycles into two categories regarding their age, i.e. the motorcycle which has age is equal or less than 7 years old (MC <= 7 years old category), and the motorcycle which has age is more than 7 years old (MC > 7 years old category). The model equation of the former category is $FC = 0{,}0552TD^2 – 3{,}5732TD + 60{,}079$ with the R^2 value about 0.9588. Meanwhile, the last catgeory has the model equation as fllows: $BBM = 0{,}0162JP^2 – 0{,}7084JP + 9{,}7453$ with the R^2 value about 0.7070. Regarding the trend lines or curves of both models as shown in Figure 1a, there are optimum conditions of the motorcycle fuel consumption. The optimum conditions indicate that the efficiency of the motorcycle in consuming gasoline related to its traveled distance. In comparison of both curves, the motorcycle equal or less than 7 years old category has traveled distance longer than the other one category. In the other words, the motorcycle which has age equal or less than 7 years old is more efficient than the motorcycle which is older than 7 years old on the fuel consumption.

3.2 The annual administration cost (AC) model of the motorcycle in Makassar City

The annual administration cost of motorcycles in this study includes various costs which appear in processing of operating permit of the motorcycle annually, such as annual tax, the cost of the operating permit document, etc. In this study, the annual administration cost of the motorcycle (AC) is modeled to the motorcycle age (a).

Regarding the model analysis, we selected the polynomial model in orde-5 as the best model, as shown in Figure 1b. The model equation is $AC = 1.421a^5 - 69.472a^4 + 1241.1a^3 - 9740.1a^2 + 34130a + 93481$ which has R^2 approximately 0.904. The trend line of the model decreases in following the increasing of the motorcycle age.

3.3 The maintenance costs (MC) model of the motorcycle in Makassar City

The maintenance costs (MC) of the motorcycle which analyzed in this study consist of two cost types, i.e. the light maintenance cost (LMC), and the heavy maintenance cost (HMC). We have developed models of both maintenance cost types in relating to the motorcycle age.

Figure 1c and Figure 1d present the selected models for both maintenance cost types. The figures show that the selected models follow the polynomial model in orde-4. The equation of both model respectively, are $LMC = 0.2723a^4 - 1.890a^3 - 147.02a^2 + 1682.9a + 15358$, and $HMC = 80.913a^4 - 2304.5a^3 + 21698a^2 - 65144a + 83521$ which have R^2 approximately 0.6835 and 0.8774, respectively.

The trend line of the model decreases in following the increasing of the motorcycle age. Further, Figure 1c shows that the young motorcycle age has small light maintenance cost at the beginning. However, the LMC increases regarding the increasing of the motorcycle age until 5 years old. Through the age, the LMC of the motorcycle decreases until 15 years old. Differently, the heavy maintenance cost of the motorcycle has increasing trend regarding the increasing of the motorcycle age. Generally trend line of the HMC model as shown in Figure 1d shows that the increasing trend has slope slightly until 10 years old. However, after the age, the HMC of motorcycle has steep slope significantly.

3.4 The oil utilization costs (OC) model of the motorcycle in Makassar City

We have analyzed some relationship models between the oil utilization costs (OC) and the

motorcycle age (a), in this study. Regarding the results, we have selected the polynomial model in orde-3 as the best model.

Figure 1e provides the selected model of the oil utilization cost. In this regard, the selected model follows the polynomial model in orde-3 which has equation as follows: OC = $0.3322a^3 + 8.6913a^2 - 79.38a + 873.44$, and R2 of the model is 0.6978. The curve of the model shows that the oil utilization cost of the motorcycles is high at the beginning of their age. However, the oil cost has slope slightly at the interval 5 until 10 years old. After that, the OC of motorcycle decrease significantly in following the increasing of the motorcycle age.

3.5 The tire utilization costs (TC) model of the motorcycle in Makassar City

The present study has developed a relationship model between the tire utilization costs (TC) in IDR per-month and the duration of the tire usage (tu) in the month unit. Regarding selection the result from some approach models, we have obtained the logarithmic model as the best model.

Figure 1f presents the best model of the tire utilization cost. In this regard, the selected model has equation TC = -21789Ln(tu) + 77716 with R^2 value about 0.8871. The figure also shows that the tire utilization cost of the motorcycle in Makassar City becomes low when the duration of the tire usage is increase. The phenomenon is in-line with the common sense of the unit cost of certain goods utilization.

4. THE MOTORCYCLE OWNERSHIP IN MAKASSAR CITY

4.1 Multinomial logit (MNL) model construction on the motorcycle ownership

In order to grasp the motorcycle ownership of the households in Makassar City, we adopt the multinomial logit model approach. Regarding the MNL model conception (see Ramli et al., 2010; and Asri et al., 2011 for example), this study constructs the relationship model between the motorcycle ownership as response variable (Y) and some identified characteristics of households as exogenous variables (X_i). The MNL model for the motorcycle ownership which considers seven exogenous variables and the model construction is expressed as follows:

$$P(Y|X) = \frac{e^{-(\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7)}}{1+e^{-(\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7)}} \quad (1)$$

Where, X_1, …, X_7 are the variables of house type, family size, income, car ownership, worker numbers, and trip numbers, respectively, while Y is the motorcycle ownership which divided into 4 motorcycle ownership categories, i.e. 0, 1, 2, and > 2 units. β_i is parameter of X_n that should be estimated, and β_0 is a constant of the model.

Furthermore, this study adopts the maximum *likelihood* theory in estimating the parameter values of the MNL model (Koppelman and Bhat, 2006; Train, 2009). In this regard, we applied the statistical package software, i.e. SPSS Version 17.0 for the estimation.

4.2 The characteristics of the motorcycle ownership

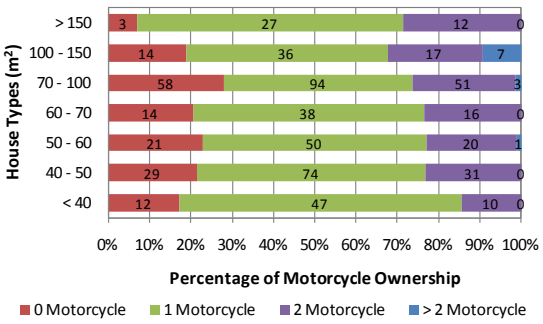
Table 3 provides the summary description of the primary survey data in this study, such mean, standard deviation, skewness, and kurtosis of each the household characteristic. Table 3

indicates that all of the exogenous variables have data in following the normal distribution. Therefore, we include all of those variables in calculating of the logit model in further analysis steps.

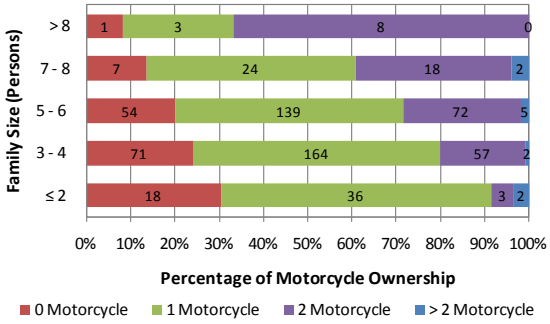
Table 3 Descriptions of Variable Data

Variable Type	Variable Title	Mean	Std. Dev.	Skewness*	Kurtosis
1. Motorcycle Ownership (Unit)	Y	1.0423	0.7166	0.200*	-0.373
2. House Type (m^2)	X_{HT}	69.4723	35.96724	2.115*	4.590
3. Family Size (Person)	X_{FZ}	5.0175	1.6451	0.382*	0.383
4. Income (IDR $1x10^6$)	X_{Inc}	1.759	0.5104	-0.862*	-0.181
5. Car Ownership (Unit)	X_{CO}	.8455	0.7464	0.491*	-0.351
6. Worker Number (Person)	X_{WN}	1.5350	0.7175	0.341*	-0.061
7. Trip Number (Time/Day)	X_{TN}	1.1137	1.0975	0.950*	0.332

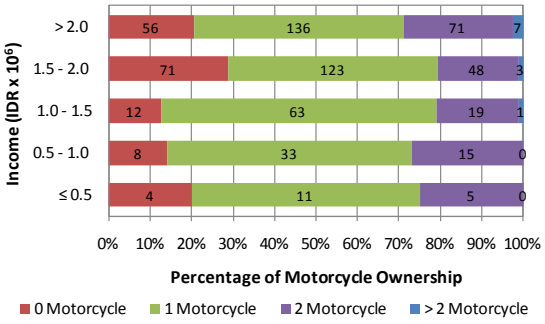
*Note: * The variable has followed the normal distribution*



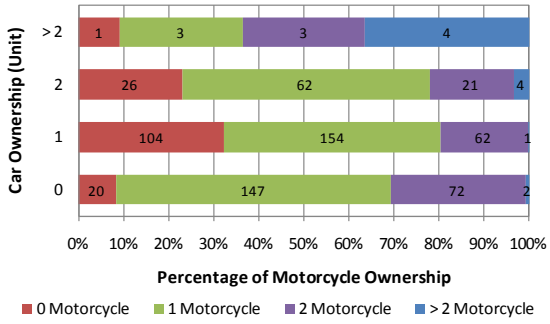
a. House Types vs. Motorcycle Ownership



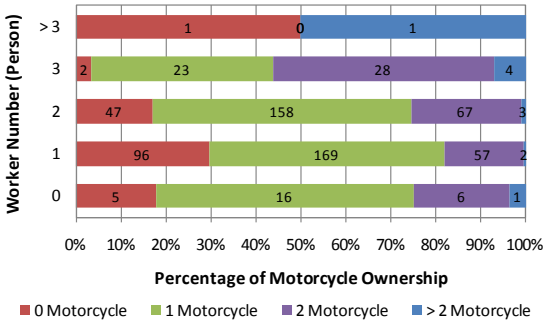
b. Family Size vs. Motorcycle Ownership



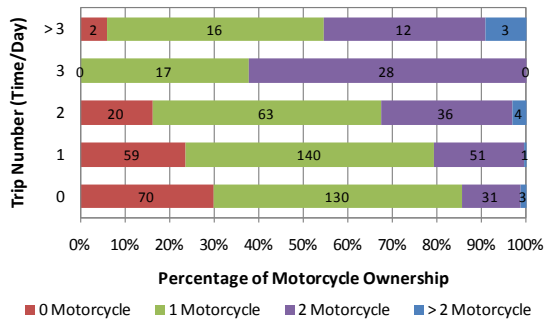
c. Income vs. Motorcycle Ownership



d. Car Ownership vs. Motorcycle Ownership



e. Worker Number vs. Motorcycle Ownership



f. Trip Number vs. Motorcycle Ownership

Figure 2 Households characteristics related to motorcycle ownership

Furthermore, Figure 2 shows the characteristic of motorcycle ownership related to each characteristic of the households. Figure 2a shows that the ownership with 1 unit motorcycle has dominated all house types of the households. The figure also shows that number of house types of households mostly similar between they do not have motorcycle and have motorcycle 2 units. This phenomenon is similar in income characteristic view as shown in Figure 2c. Regarding the family size characteristic, Figure 2b also presents that the households have 1 unit motorcycle majority. However, in case of the households having family member > 8 persons, the motorcycle ownership with 2 units is dominant. Figure 2d indicates that the households having 1 unit car are similar t the motorcycle ownership phenomenon, i.e. mostly the households have 1 unit motorcycle, and the households do not having and having 2 units motorcycle are equal. However, the households having more than 2 cars are dominant having 2 units motorcycle. In addition, Figure 2e shows that the increasing of worked family member of the households leads to the increasing of motorcycle ownership. As well as, the increasing of trip number of the households members increase the motorcycle ownership of the households, as shown in Figure 2f.

4.3 The calibration and validation results of the motorcycle ownership model

Calibration and validation of the MNL model in estimating and assessing the parameters values of the motorcycle ownership model were conducted through statistical methods. There were two kinds of statistical test which conducted, i.e. significant test (i.e. *p* value) in order to evaluate contribution of each variable itself to the model, and goodness of fit statistic test in order to validate the goodness of fit of the model. Table 4 provides the parameters values and statistical indicators of the model.

Table 4 Result calculation of parameters values

Variables	Para-meters	Parameter values of utility functions of each MC ownership category								
		1 Unit Motorcycle			2 Units Motorcycle			> 2 Units Motorcycle		
		B	Sig.	Exp(B)	B	Sig.	Exp(B)	B	Sig.	Exp(B)
Constant	β_o	-0.061	0.902		**-2.891**	**0.000**[1]		**-4.690**	**0.022**[1]	
HouseType	β_{XHT}	**0.007**	**0.044**[1]	1.007	**0.010**	**0.009**[1]	1.010	.004	0.591	1.004
FamilySize	βX_{FZ}	0.084	0.265	1.087	**0.296**	**0.001**[1]	1.344	-.107	0.668	0.898
Income	βX_{Inc}	-0.122	0.660	0.885	0.029	0.931	1.029	-.985	0.371	0.373
CarOwn	βX_{CO}	**-0.791**	**0.000**[1]	0.453	**-1.206**	**0.000**[1]	0.299	**1.071**	**0.059**[2]	2.919
FamilyWork	βX_{WN}	**0.582**	**0.001**[1]	1.789	**0.735**	**0.001**[1]	2.086	**1.089**	**0.024**[1]	2.972
TripNumber	βX_{TN}	**0.258**	**0.023**[1]	1.294	**0.595**	**0.000**[1]	1.813	**.658**	**0.013**[1]	1.930
Number of observation							686			
Likelihood ratio, ρ^2:										
- Cox and Snell							0.194			
- Nagelkerke							0.220			
- McFadden							0.101			
Hit Ratio (%)							54.2			

Note: [1] Significant at 95%, [2] Significant at 80%
The reference category is the motorcycle ownership = 0

Table 4 shows that the motorcycle ownership model has enough acceptable level overall statistical fit indicators. Three pseudo-ρ^2 indicators, i.e. Nagelkerke pseudo-ρ^2, Cox and Snell pseudo-ρ^2, and McFadden pseudo-ρ^2 provided values in range 0.1 until 0.3. Regarding Ramli

et al., (2010), and Asri et al., (2011), the values still indicate that the model could acceptable in enough significant level due to the sample size of the study is so large. In providing an additional insight, Table 3 also shows the hit ratio value, correct percentage between observed data and predicted model, more than 50% that indicated the model is acceptable to describe the relationship between the motorcycle ownership and the household characteristics.

Furthermore, as shown in Table 4, mostly of the model variables have influenced the motorcycle ownership model significantly, except the household income variable. However, their influence are various for each category of the motorcycle ownership. The household characteristics of car ownership, number of worked family member, and number of trip in a day are three variables that significantly influenced the utility of the three categories on the motorcycle ownerships in the model. Meanwhile, the house type characteristic of the households only influenced significantly on both motorcycle ownership categories, i.e. the "1 unit motorcycle ownership", and the "2 units motorcycle ownership" categories. In addition, the family size characteristic is significant on the "2 unit motorcycle ownership" category only. In addition, the income effect in this study is contrary to the previous studies (Putranto, 2007 and Petragradia, 2009). The ineffectiveness of the household income level on the motorcycle ownership due to the motorcycle purchasing agent proposes very easy system in buying a motorcycle, nowadays.

5. CONCLUSSION

Six components of the motorcycle operation costs, i.e. the fuel consumption (FC), the annual administration cost (AC), the light maintenance cost (LMC), the heavy maintenance cost (HMC), the oil utilization cost (OC), and the tire cost (TC) in Makassar City, Indonesia have been analyzed using some regression models approach. As well as, the influenced of household characteristics such house type, family size, income, car ownership, number of worked family member, and trip number in a day, on the motorcycle ownership of the households have been explored in this paper, through utilization of multinomial logit (MNL) model approach.

The motorcycle operation cost components such fuel consumption, administration, maintenance, and oil utilization costs follow the polynomial models with significant results. In addition, the household characteristics such car ownership, number of worked family member, and trip number in a day, have become three primary variable that influenced the motorcycle ownership of the households. Even though, the house type and family size characteristics are also significant at certain levels of the motorcycle ownership. Finally, the results may lead to the influence on the time valuation of the motorcyclists and travel mode choice of the households, in further studies of this paper.

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