THE INFLUENCE OF INCOME ON HOUSEHOLD CAR AND MOTORCYCLE OWNERSHIPS IN DENPASAR CITY, BALI

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Abstract: This study investigates the influence of household income on both car and motorcycle ownerships in the city of Denpasar using a Multinomial Logit Model. The household income is about 61%, 17% and 61% more likely to influence a household owning 1 motorcycle and 1 car, 2 or more motorcycles and 0 car, and 2 or more motorcycles and 1 car respectively than 1 motorcycle and no car. The probability of both car and motorcycle ownerships increases substantially by more than 4% in the next 20 years if household income in Denpasar city rises. This is particulary applied for the household owning 1 motorcycle and 1 car and 2 or more motorcycles and 1 car. The probability of a household owning 1 motorcycle and no car ownership however, drops significantly by almost 10% in the next 20 years if household income in Denpasar city increases. Consequently, the household income significantly influences both car and motorcycle ownerships in the city of Denpasar. A huge number of car and motorcycle uses on the road continously leads to serious transport problems in the city of Denpasar for the next few years. This is related to the negative impacts of transport in particular road safety and environmental impact. Improving the existing public transport and introducing a high quality public transport service within and to/from Denpasar city is urgently required. The fare of such high quality public transport service in Denpasar city however, must be sufficiently low to compete with the cost of riding a motorcycle. In addition, a significant amount of fare subsidy from both local and central government is considerably required

Keywords: Household Income, Motorcycle, Car, Ownerships.

PENGARUH PENDAPATAN RUMAH TANGGA TERHADAP KEPEMILIKAN MOBIL DAN SEPEDA MOTOR DI KOTA DENPASAR, BALI

Abstrak: Studi ini meneliti tentang pengaruh pendapatan rumah tangga terhadap kepemilikan mobil dan sepeda motor di kota Denpasar menggunakan Model Multinomial Logit. Pendapatan rumah tangga berturut-turut sekitar 61%, 17% dan 61% lebih besar mempengaruhi rumah tangga untuk kepemilikan 1 sepeda motor dan 1 mobil, 2 atau lebih sepeda motor dan 0 mobil dan 2 atau lebih sepeda motor dan 1 mobil daripada kepemilikan 1 sepeda motor dan 0 mobil. Peluang kepemilikan mobil dan sepeda motor meningkat lebih dari 4% dalam waktu 20 tahun mendatang jika pendapatan rumah tangga di kota Denpasar meningkat. Ini khususnya berlaku bagi rumah tangga yang memiliki 1 sepeda motor dan 1 mobil serta 2 atau lebih sepeda motor dan 1 mobil. Peluang rumah tangga memiliki 1 sepeda motor dan 0 mobil turun secara signifikan sekitar 10% dalam kurun waktu 20 tahun mendatang jika pendapatan rumah tangga di Denpasar meningkat. Hal ini berarti pendapatan rumah tangga secara signifikan mempengaruhi kepemilikan mobil dan sepeda motor di kota Denpasar. Tingginya jumlah mobil dan sepeda motor di jalan raya secara kontinyu akan menyebabkan permasalahan transportasi yang serius di kota Denpasar dalam kurun waktu mendatang. Hal ini terkait dengan dampak negatif dari transportasi khususnya keselamatan jalan dan dampak lingkungan. Memperbaiki pelayanan dan kualitas angkutan masal dari dan menuju kota Denpasar penting untuk segera diimplementasikan. Tarif dari angkutan masal di

kota Denpasar harus cukup rendah agar dapat bersaing dengan biaya penggunaan sepeda motor. Subsidi pemerintah pusat dan daerah sangat diperlukan dalam hal ini.

Keywords: Pendapatan Rumah Tangga, Sepeda Motor, Mobil, Kepemilikan.

INTRODUCTION

Population proportion in Indonesia is typically low income compared to that in developed countries in Eastern Asia including Singapore, Japan and South Korea. Many urban and rural areas in Indonesia show large socioeconomic differences and a general lack of urban public transport services. In Bali for instance, the use of public transport is only accounted for by 3 % (Statistics of Denpasar, 2009).

Small motorcycles are low-cost private transport modes and are the dominating private vehicles in Bali. They are accounted for by 85 % of all modes of transport in Bali. In the capital city of Denpasar, the number of registered motorcycles in 2007 was 390,000 of the total of 457,000 registered vehicles (Statistics of Bali Province, 2008). Motorcycle offers many advantages to the user (e.g. less cost, lower fuel consumption, better manoeuvrability and door-to-door transport). On the other hand, this mode brings to many serious transport issues including road accidents and discouragement of the use of public transport and other sustainable modes (Prabnasak, *et.al*, 2011). In fact, during period 2003-2007 there were 4,489 road accidents in Bali. Of these road accidents, on average 70% involved with motorcycles (State Police of Bali Province, 2008).

The high number of motorcycle ownership as well as motorcycle accident indicates the importance of a study focused on motorcycle particularly in developing countries. Therefore, a study on motorcycle ownership based on local household characteristics is essential in present and future study of mode choices. In addition, a study on car ownership is also essential because if both car and motorcycle owned by a household, each normally will have a relation of substitution (Hsu and Lin, 2007).

Furthermore, a study on car and motorcycle ownerships based on local household characteristics is essential in present and future study of mode choices. Within a local boundary, a study on car and motorcycle is required in order to identify solution and regulation concerning car and motorcycle in the traffic system, while a study on mode choice analyses a mode shift to/from car and motorcycle and its effect on the road network (Leong and Sadullah, 2007).

The objective of this paper is to study both car and motorcycle ownerhsips in the city of Denpasar, Bali with a disaggregate choice model using a Multinomial Logit Model. The model is constructed to analyse the influence of local household income on car and motorcycle ownerships using Monang Maning residential area in Denpasar city as the case study. This residential area is selected because it is one of densely populated area in Denpasar. The model results would identify car and motorcycle ownerships pattern which could be used to support transport policies to control the future use of these private vehicles in the city of Denpasar.

LITERATURE REVIEW

Previous Studies

There were many studies have been conducted in relation to the nature of private vehicle (e.g car and motorcycle) ownerships in Southeast Asia region including by Leong and Sadullah, (2007), Hsu and Lin (2007), Hsu, *et al* (2007), Putranto (2003), Wedagama (2009a; 2009b) and (Prabnasak, *et.al*, 2011). Each

region has its own kind such as household characteristics, income, car and motorcycle ownerships. The number of such studies is still quite small however, relative to those in developed countries (Prabnasak, *et.al*, 2011).

In general, previous studies (e.g. Leong and Sadullah, (2007); Hsu and Lin (2007); Hsu, *et al* (2007); Putranto (2003) and Prabnasak, *et.al*, (2011)) show that household income as well as the motorcycle ownership tends to increase until the income reaches a certain level. However, once income exceeds that level the degree of motorcycle ownership is likely to reduce and the degree of car ownership will eventually exceed it. Apparently, most reported studies indicated that income should have a significant effect on household vehicle ownerships. Motorcycle is popular amongst low and medium income people while private cars is greater for high income households (Prabnasak, *et.al*, 2011).

Wedagama (2009a) studied a motorcycle ownership in the city of Denpasar, Bali. The study results showed that the local household income may have a possibility to influence the motorcycle ownership. In this previous study, a single-modal (motorcycle) ownership model was constructed using MNL regression. A joint car-motorcycle ownership model using MNL regression however, is developed for the current study. Meanwhile, using the same set of data, Wedagama (2009a) also studied both

car and motorcycle ownerships in the city of Denpasar, Bali using Poisson regression model. This previous study also indicated that income may have a relation to both car and motorcycle ownerships.

Multinomial Logit Model

The Multinomial Logit (MNL) model is used to determine the probabilities of choice from each alternative ownership categories based on utility functions that are estimated for each alternative. One category is selected as the reference category, normally the first, the last or the value with the lowest or the highest frequency. The probability of each category is compared to the probability of reference category. For categories $i = 2....K$, the probability of each category is as follows (Borooah, 2001; Washington, *et.al*, 2003):

$$\Pr (Y = i) = \frac{\exp(Z_i)}{1 + \sum_{h=2}^{K} \exp(Z_{hi})} \quad .... \quad (1)$$

Where: $\alpha_i + \sum_{h=1}^{H} \beta_{ih}x_{ih} = Z_i.$

For the reference category,

$$\Pr (Y = 1) = \frac{1}{1 + \sum_{h=2}^{K} \exp(Z_{hi})} \quad .... \quad (2)$$

After rearranging equation (1) and (2), the MNL model can be written as follows:

$$\mathrm{Ln}(\frac{P(Y=i)}{P(Y=1)}) = \alpha_i + \sum_{h=1}^{H} \beta_{ih}x_{ih} = Z_i \quad ..... \quad (3)$$

Where:

i	:	the number of ownership categories
β_{ih}, X_{ih}	:	vectors of the estimated parameters and predictor variables respectively
$\dfrac{P(Y=i)}{P(Y=1)}$	:	the probability of each private vehicle ownerships with, in this case, the first category as the reference.

Using Maximum Likelihood estimation, a set of utility function coefficients which makes the model best fit the calibration dataset are estimated. In oder to optimise the model performance, explanatory variables can be selected to remain in or

out of the model. Coefficients with significance value of 5% or t-statistics value greater than 1.96 are considered statistically significant. The equation above expressed the logit (log odds) as a liner function of the independent factors

(Xs). Therefore, equation (3) allows for the interpretation of the logit weights for variables in the same way as in linear regressions.

DATA DESCRIPTION

The capital city Denpasar is located in the Southern Bali. It has an area of 12.398 km^2 and the population is about 628,909 in 2008 (Statistics of Denpasar, 2009). Home interview survey was carried out in

2008 in Monang Maning residential area in Denpasar city. This residential area is one of densely populated area so it is considered as good representation of local households in Denpasar. In addition, this area is considered to have a high variability in terms of income, household size, type of occupation and number of students. In total, 316 questionnaires were distributed, however only 301 responses are effective and used for this study.
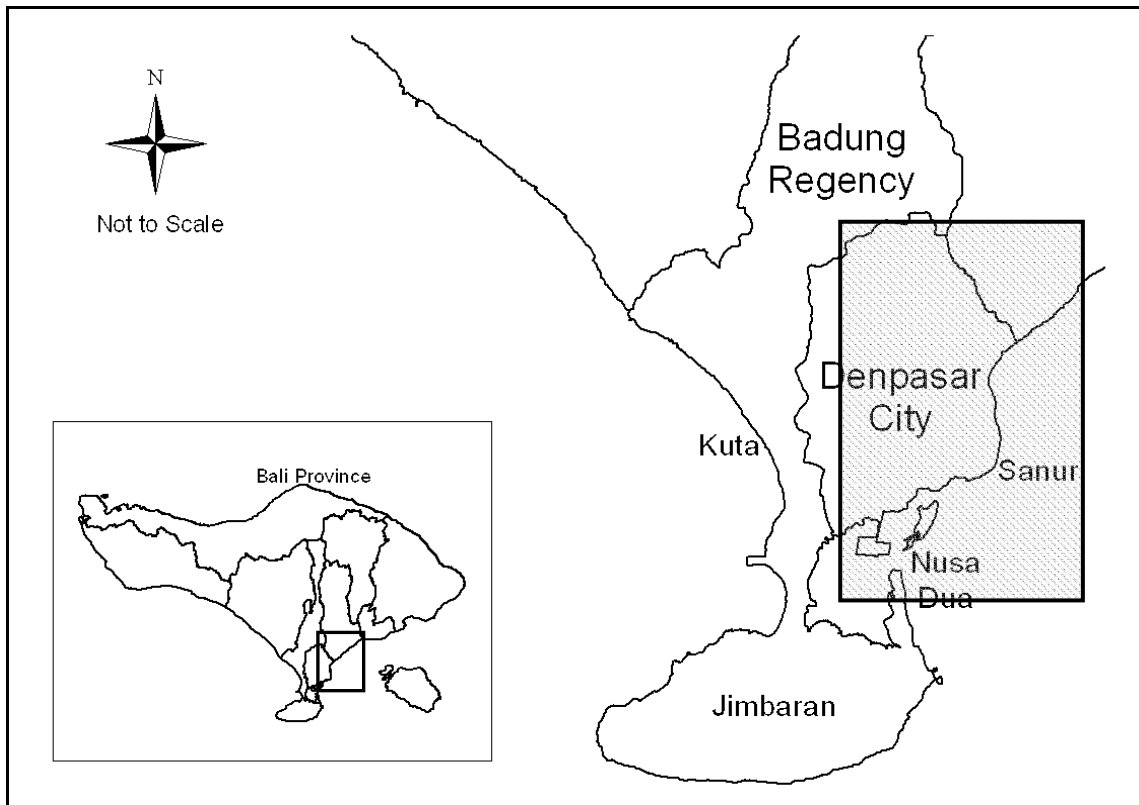

Figure 1 Case study area

The dependent or response variable is car and motorcycle ownerships, which is nominal in nature. Independent (predictors) consist income which is continuous variable and number of household member and students in the household which both are categorical. Categorical variables are represented with dummy variables following the coding system in SPSS, software used in this study. Study variables and their codes are shown in Table 1.

Table 1 Study Variables

No	Description	Variable Name and Coding
1.	Car and Motorcycle ownerships	1Mc 1Car : A household owns both 1 motorcycle and car 2$^+$Mc 0Car : A household owns ≥ 2 motorcycles and no car 2$^+$Mc 1Car : A household owns ≥ 2 motorcycles and 1car 1Mc 0Car : A household owns 1 motorcycle and no car
2.	Total household	Income

		income per month	
3.	Number of household member	Household_size=1 : Less than 4 persons in a household Household_size=2 : More than 4 persons in a household	
4.	Number of student in the household	Student=0 : No student in a household Student=1 : One student in a household Student=2 : More than one student in a household	

MODEL DEVELOPMENT AND ANALYSIS

This study constructs a Multinomial Logit model based on a common joint car and motorcycle ownerships approach. The output of the model is probabilities of various combinations of cars and motorcycles in household. It is cosidered the that joint model could possibly have a greater benefit as they allow full interaction between variables controlling car and motorcycle ownership. A joint model could potentially produce more realistic outputs than the single-modal ownership model. In addition, a joint model is considered having a better representation of the trade-off between car and motorcycle ownerships (Prabnasak, *et.al,* 2011).

As described earlier, the dependent variable is a joint model of household car and motorcycle ownerships. As the reference or the base category for the

dependent variable is a household owning 1 motorcycle with no car (1Mc 0car). Estimated coefficients measure the change in the logit for a one-unit change in the predictor variable while keeping the other predictor variables constant. A positive and negative estimated coefficient implies an increase and a decrease respectively in the likelihood that a household owning 1 motorcycle and car [1Mc1Car], 2 or more motorcycles and 0 car [2+Mc0Car], and 2 or more motorcycles and 1 car [2+Mc1Car]. Significance (sig.) value indicates whether or not a change in the predictor significantly changes the logit at the acceptance level. If sig. value is greater than the accepted confidence level (greater than 5% or confidence level of 95%), then there is insufficient evidence that a change in the predictor affects the response category with respect to the reference category.

Table 2 A Join Model Result

Variables	1Mc1Car		2+Mc 0Car		2+Mc1Car	
	β	Sig.	β	Sig.	β	Sig.
Constant	-2.188	0.000	-1.718	0.005	-2.858	0.000
Income	0.473	0.000	0.156	0.203	0.473	0.000
[Household_size=1]	0.213	0.635	-1.202	0.003	-1.557	0.002
[Student=0]	-0.474	0.337	1.547	0.001	0.664	0.211
[Student=1]	-0.057	0.905	1.591	0.001	1.128	0.022
No. observation	301					
Pseudo R² value	0.203					
Final Model (sig.)	0.000					
Data Proportion accuracy	34.2%					
Model prediction accuracy	45.5%					

Note: the reference category is: 1Mc0Car, [Household_size=2] and [Student=2]
Where:

Income		Total income of a household per month
Household_size=1	:	Less than 4 persons in a household
Household_size=2		More than 4 persons in a household
Student=0	:	No student in a household

Student=1	:	One student in a household
Student=2	:	More than one student in a household
1Mc 1Car	:	A household owns both 1 motorcycle and car
2^+Mc 0Car	:	A household owns ≥ 2 motorcycles with no car
2^+Mc 1Car	:	A household owns ≥ 2 motorcycles and 1car
1Mc 0Car	:	A household owns 1 motorcycle with no car

Based on Table 2, local household income is significant predictor variables at 95% on categories of a household with 1Mc1Car and 2^+Mc1Car. Meanwhile, for 2^+Mc0Car, income is significant at 20% or with 80% confidence interval. The value of Exp(β) for income on 1Mc1Car, 2^+Mc 0Car and 2^+Mc 1Car are 1.605, 1.169 and 1.605 respectively which implies that the odds increased by 61% (1.605 - 1.0 = 0.605), 17% and 61% respectively. Hence, income is about 61%, 17% and 61% more likely to influence a household owning either 1 motorcycle and car, 2 or more motorcycles and 0 car, and 2 or more motorcycles or 1 car respectively than 1 motorcycle with no car. Local household income therefore, is considered significant to influence both car and motorcycle ownerships.

In this study a sensitivity analysis of household income is used to investigate the effect of the variable over the model. This is based on an assumption that household income is the only factor changing over the time. Based on Table 2, the joint models are obtained as follows:

$$\text{Ln}\,\frac{P(1Mc1Car)}{P(1Mc0Car)} = 0.473*\text{Income};$$

$$\text{Ln}\,\frac{P(2^+Mc0Car)}{P(1Mc0Car)} = 0.156*\text{Income};$$

$$\text{Ln}\,\frac{P(2^+Mc1Car)}{P(1Mc0Car)} = 0.473*\text{Income} \quad (4)$$

Meanwhile, local household income in the city in Denpasar is determined using Gross Domestic Product (GDP) of Denpasar. The influence of household income on both car and motorcycle ownerships is examined on the assumption that an increase in local household income presents in the input dataset affecting the model outputs. In order to do so, an increase in GDP of Denpasar is calculated every 5 years for the next 20 years. From 2005 to 2009, average annual growth of GDP in Denpasar is 2% (Statistics of Denpasar, 2009). The probability of income to influence both car and motorcycle ownerships is computed using equation (1) as shown in Table 3. Thus, the percentage change of income effect probability on both car and motorcycle ownerships is shown in Table 4.

Table 3 Income Effect Probability on both Car & Motorcycle Ownerships

Year	Probability			
	1Mc1Car	2+Mc0Car	2+Mc1Car	1Mc0Car
2008	0.23	0.07	0.23	0.48
2013	0.24	0.08	0.24	0.45
2018	0.25	0.08	0.25	0.43
2023	0.26	0.08	0.26	0.40
2028	0.27	0.09	0.27	0.38

Table 4 Percentage of Probability Change of Income Effect

Year	% Probability Change			
	1Mc1Car	2+Mc0Car	2+Mc1Car	1Mc0Car

2008	-	-	-	-
2013	1.06	0.35	1.06	-2.46
2018	2.10	0.69	2.10	-4.90
2023	3.13	1.03	3.13	-7.30
2028	4.15	1.37	4.15	-9.66

DISCUSSIONS

The probability of car and motorcycle ownership rises substantially by more than 4% in next 20 years if household income in Denpasar city increases. This is particulary applied for a household owning 1 motorcycle and car and 2 or more motorcycles and 1 car. In contrast, the probability of a household owning 1 motorcycle and no car ownership drops significantly by almost 10% in next 20 years if household income in Denpasar city increases. It looks obvious that if the existing condition carries on into the future ('business as usual'), the number of car and motorcycle in the city of Denpasar will significantly increase.More specifically, if the income for the next 20 years increases the huge demand for motorcycles is still exists.

A combination of a great number of private car and motorcycle uses on the road could subsequently lead to serious transport problems in the city of Denpasar for the next few years. This is connected to the negative impacts of transport in particular road safety and environmental impact. To overcome this situation, household vehicle ownership may need to be restrained using a transport policy such as the price mechanism through an increase in vehicle expenditures by rising vehicle tax, fuel cost and parking fare (Prabnasak, *et.al*, 2011)..

Before applying such policies however, improving the existing public transport or introducing a high quality public transport service within and to/from Denpasar city must be firstly implemented. So that people travels within and to/from Denpasar city have the main alternative modes of transport once the price mechanism policy is applied.

In introducing a high quality public transport service in Denpasar city however, the fare must be sufficiently low to compete with the cost of using a motorcycle (Wedagama, 2009a). Simultaneously, the service quality must be high enough to negotiate the main advantage of motorcycle (i.e. door-to-door service). Since the quality of service is certainly related to the operation cost, a significant amount of fare subsidy is urgently required (Prabnasak, *et.al*, 2011).

CONCLUSIONS

The influence of household income on both car and motorcycle ownerhsips in the city of Denpasar are investigated using a Multinomial Logit Model. The household income is about 61%, 17% and 61% more likely to influence a household owning either 1 motorcycle and car, 2 or more motorcycles and 0 car, and 2 or more motorcycles and 1 car respectively than 1 motorcycle and no car. The probability of car and motorcycle ownership rises substantially by more than 4% in next 20 years if household income in Denpasar city increases. This is particulary applied for the household owning 1 motorcycle and car and 2 or more motorcycles and 1 car. In contrast, the probability of a household owning 1 motorcycle and no car ownerships drops significantly by almost 10% in next 20 years if household income in Denpasar city increases. The household income therefore, is considered significant to influence both car and motorcycle ownerships in the city of Denpasar.

A combination of a great number of private car and motorcycle use on the road could subsequently lead to serious transport problems in the city of Denpasar for the next few years. This is connected

to the negative impacts of transport in particular road safety and environmental impact. Improving the existing public transport or introducing a high quality public transport service within and to/from Denpasar city is urgently required. The fare of such high quality public transport service in Denpasar city however, must be sufficiently low to compete with the cost of using a motorcycle. In addition, a significant amount of fare subsidy from both local and central government is considerably required

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