CHARACTERISTICS OF PRIVATE CAR AND MOTORCYCLE OWNERSHIP IN INDONESIA

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Abstract: The main objective of this research was to develop Indonesian car and motorcycle ownership rate models at municipality and regency levels. The research was conducted using yearly aggregate data (1990-2000) from 21 municipalities and 28 regencies throughout Indonesia. In addition, 105 households from 4 municipalities and 3 regencies were interviewed. The car and motorcycle ownership rate model form was the quasi-logistic function and values of the saturation level were selected based on both previous research and the function boundary condition function. Both in the cross-sectional and longitudinal aggregate models, the wealth level was the most important factor in explaining the vehicle ownership rates variation. The higher the wealth level, the more sensitive car and motorcycle ownership was to the wealth level. In household level a proxy of wealth level (household monthly expenditure) was positively correlated with the number owned cars. As the wealth level increased, motorcycle ownership in a household decreased.

Key Words: car ownership, motorcycle ownership, Indonesia

1. INTRODUCTION

As in any other developing country, in Indonesia there is an increasing degree of motorization. High levels of road investment expenditure, an inadequate system for road user charges and insufficient public transport services encourage the use of private vehicles including private motorized vehicles. Considering the significant impact of the growth of this type of vehicle on many aspects of life, the development of private motorized vehicle ownership rate models for Indonesia is an essential step in transport, economic and social policy formulation.

Indonesian private motorized vehicle ownership rate models are needed for many practical purposes such as producing a rough prediction of the demand on the highway network and consequent energy consumption, introducing appropriate transportation demand management,

predicting income derived from car purchase tax / car registration tax and the contribution of the vehicle manufacturing industry to the economy. Vehicle ownership models have been researched and derived over a period of decades in many developing countries, but to date have not been comprehensively developed in Indonesia.

2. OBJECTIVES AND SCOPE OF THE RESEARCH

The main objective of this research was to develop Indonesian car and motorcycle ownership rate models at aggregate level, i.e. at municipality and regency levels. In order to provide some understanding of how household characteristics affect car and motorcycle ownership, a limited household based analysis was also carried out.

In considering the scope of the research, one consideration for the modelling process was the considerable variability in the level of development between different geographic areas in the country. Considering its role as a development centre for surrounding areas, major government and business activities are commonly concentrated in a municipality and as a result a municipality tends to be more developed than a regency. The demand for transport generated by such activities is then supported by substantial road network and as a result the level of wealth of a typical municipality resident is usually better than that of a regency resident. Previous research on vehicle ownership (Kenworthy and Laube (1999), Dargay and Gately (1999), Bhat and Pulugurta (1998), Prevedouros and An (1998), Bates et al (1981), and Fowkes (1977)) has indicated that the level of wealth level is one of the most important factors affecting the level of vehicle ownership. Land use and public transport services are the other two main factors of influence. It was proposed that a substantial number of socio-economic factors would be introduced in the model developed within this research to represent the level of wealth, land use, public transport service and other additional factors, whilst no direct adoption of variables suggested by previous research was made. Data availability and the appropriateness of particular variables for the Indonesian case were the two main factors considered in the variable selection.

A particular feature of Indonesian private motorized vehicle ownership is that two main types of models are needed, i.e. car and motorcycle ownership rate models. In the general research literature, car ownership rate models have been extensively produced by previous researchers, whilst motorcycle ownership rate models are relatively rare. This is understandable since motorcycle use in developed countries is generally not very high. This is not the case for Indonesia where the use of motorcycles may range from school / work trips to goods delivery trips. In addition, the highway network in Indonesia is still very limited both in length per km^2 of area and in quality, therefore a vehicle with more flexibility (in terms of manoeuvrability) such as the motorcycle will be preferred.

The research reported here was concerned mainly with car ownership forecasting at the aggregate level. A household based analyses was only developed from a limited sample of data surveyed for the research in order to provide an elementary description of household vehicle purchasing behaviour. It was anticipated that Indonesian household data from secondary sources, such as Central Agency of Statistics, might not support the data needs of household car ownership modelling, especially in terms of data availability.

3. LITERATURE REVIEW

Bhat and Pulugurta (1998) stated that car ownership modelling could be in the form of either aggregate or disaggregate models. In the aggregate model, car ownership is modelled typically at the zonal, regional or national level. At the disaggregate model, the household is used as the decision making unit and the forecasts at zonal, regional, or national level are obtained by aggregating over households. Oi and Shuldiner (1963) and Schor (1989) in Bhat and Pulugurta (1998) stated that disaggregate models are structurally more behavioural compared to aggregate models and are better able to capture the causal relationship between car ownership determinants and car ownership levels.

Jansson (1989) suggested an approach to study the car ownership development path over the life cycle of individuals of a particular generation and comparing the development paths of different generations to capture the dynamics of the growth in car ownership. Considering this approach, Lam and Tam (2002) prefered to use longitudinal analysis to construct their model.

Whilst a limited household survey is proposed as part of the research here, it is often practically difficult to obtain panel data, especially at the household level. Deaton (1985) introduced the use of 'pseudo-panel' data, i.e. repeated cross sectional data to overcome this problem. Samples for each year include different households, so that particular households cannot be traced over time. Dargay (2002) stated that in this approach households can be grouped into cohorts based on common shared characteristics. These cohorts will then be traced over time. If 'pseudo-panel' data is still difficult to obtain, a Retrospective Multiple-Cohort Study Based on a Single Cross-Sectional Survey can be an alternative. This design locates individuals on the basis of a single cross-sectional survey, and reveals retrospective longitudinal data from them (Mason and Fienberg (1985)). The disadvantages of this design include memory decay in the respondents (so the response will be less accurate) and as with other cross-sectional surveys, it may simply be dealing with survivors (so the sample will be less representative in terms of historical comprehension).

As suggested by previous research on vehicle ownership (Kenworthy and Laube (1999), Dargay and Gately (1999), Prevedouros and An (1998), and Bates et al (1981)), the level of wealth is deemed to be one of the most important factors affecting the level of vehicle ownership. Land use and public transport service are two other primary factors. In the light of these previous findings, a substantial number of socio-economic factors were introduced into the model development process of this research in order to represent the wealth level, alongside a number of land use, public transport service and other additional factors.

4. SAMPLING AND DATA COLLECTION

The sampling and data collection process for the research took place at two levels, the first in order to provide data for aggregate models and the second to obtain data for a smaller bu more detailed household survey to provide better understanding of vehicle ownership behaviour.

Aggregate models (municipality and regency based) were developed using secondary data obtained from the Indonesian Central Agency of Statistics, Ministry of Manpower, Ministry of Settlement and Regional Development, Ministry of Transport and Communication, Central Agency of Meteorology and Geophysics, Traffic Division of National Police, Regional Revenue Office and any other related sources of data. The municipality dataset consists of 21 areas, whilst the regency dataset consists of 28 areas. The analysis included yearly data from

1990 to 2000 to represent various socio-economic conditions of Indonesia, including the economic crisis that arose after the end of 1997.

The data collection process was carried out in Indonesia and as these data are in general not publicly available (though published records, internet sites etc), it was necessary to travel to Indonesia to undertake data collection in person with assistance from a team of students from the University of Tarumanagara, Jakarta, Indonesia. These students have a background in transport studies and are familiar with local conditions and appropriate training was given to the interviewers.

The target population for the research included all the regencies and municipalities in Indonesia. Since this is rather large (more than 300 areas), a sample was drawn. As a first stage, a selection of provinces was taken and from that a sample of regencies and municipalities was drawn. The sampling method was a combination of quota sampling and systematic sampling. This finally resulted in a sample consisting of 21 municipalities and 28 regencies with a wide range of characteristics.

Problems in the data collection process were found to vary from area to area and between the different variables on which information was collected. Two main problems exist in attempting to use secondary data in Indonesia, i.e. weak database systems and the existence of non-standard terminologies. Although every effort was made to collect the most reliable data for the research, limitations still remained within the data and therefore the models. As the vehicle ownership rate level in Indonesia was still clearly far from the saturation level (as was apparent from datasets of most areas in the sample), arbitrary saturation levels were introduced in the model calibration process.

In addition to the aggregate database, a limited number of samples were also taken for a historical household vehicle ownership study. The respondents were from 4 municipalities and 3 regencies (mostly in Java). The basis of selection was driven mainly by the potential to obtain data from the particular area, as practical constrains made data collection from many areas difficult. Despite that, the areas selected show variability in characteristics such as population density and per capita income.

The number of respondents in each regency and municipality was 15, resulting in a total number of respondents of 105 (from 7 different areas). From each economic status group (low, medium and high), a relatively equal number of households were selected in order to obtain a representative sample (neglecting the fact that percentage of households in each groups is naturally not equal and can be significantly different between regions). The selection was carried out by appraising the level of luxury of the exterior of a house. A better approach to estimate the wealth level of a household was revealed later after obtaining the household monthly expenditure.

It should be noted that the percentage of Indonesian-Chinese households in the selected sample from Jakarta, Bandung, Bandar Lampung, Bekasi and Garut are 100%, 93%, 73%, 33% and 33% respectively. This does not reflect the percentage of Indonesian-Chinese households in the general population, i.e. approximately less than 10%. However, ethnicity balance control was maintained during the study in Yogyakarta Municipality and Bantul regency by selecting less than 10% Indonesian-Chinese households (approximately less than 2 households per area). The characteristics of the Indonesian-Chinese household were

considered to be rather different to other ethnicities as this particular group has a very strong business involvement in Indonesia, a factor which might affect vehicle ownership characteristics. Statistical techniques that were used in household analysis were therefore appropriately selected to minimize the possible bias due to the ethnicity issue.

The subsequent analysis (described below) indicated that not every household in the sample owned a car. Some households owned motorcycles as their only motorized vehicle, but there were no households in the sample that did not own any motorized vehicle. Although this outcome was not as a result of a deliberate selection, it is recommended that in the further research, the sampling frame could be broadened to include non-motorized vehicle owner households.

5. MODEL FORM AND HOUSEHOLD SURVEY

5.1. Aggregate Model Form

The suitability of any particular model form is based mainly on the theoretical appropriateness and practicability with respect to the analysis methodology. Use of the basic logistic formulation will result in neglecting the contribution of other factors (other than time trend) to the variation in vehicle ownership rates. For vehicle ownership modelling in the developing countries, Button and Ngoe (1991) suggested the use of a quasi-logistic function. The model is not only easy to calibrate, flexible and relatively straightforward to interpret, but has already proved statistically satisfactory to be used in the developing countries (for example the household model by Cundill (1986) and aggregate model by Button and Ngoe (1991)). Whilst models with more sophisticated features such as a power growth function, Gompertz function or log-quadratic function (Medlock et al (2002)) are available, their level of sophistication was assessed to be beyond the requirements for an Indonesian model. Taking these factors into consideration, the quasi-logistic function was chosen with the following formulation:

$$C_t = \frac{S}{1 + e^{-a} X_1^{-b_1} X_2^{-b_2} \ldots\ldots X_n^{-b_n}} \qquad (1)$$

where

C_t is the car or motorcycle ownership per 1000 population in year t (replaced with M_t for motorcycle ownership modelling)

S is the saturation level of car or motorcycle ownership per 1000 population

X_n are a set of explanatory variables

a, b_n parameters to be estimated

Due to differences in the geographical context, no attempt was made to directly adopt variables suggested by previous research. Data availability and the appropriateness of a particular variable for the Indonesian case were the two main factors considered in the preliminary variable selection process. This resulted in the following initial set:

X_1: per capita Gross Regional Domestic Product (GRDP), as a 1993 prices
X_2: consumer price index (using 1988/1989 base years)
X_3: ratio between minimum physical needs and minimum regional wage
X_4: population density per km^2 area
X_5: road length (km per 1000 km^2 area)
X_6: number of bus seats per 1000 population
X_7: average ground elevation (m)
X_8: yearly rainfall (mm)

The model contains a saturation level term, S and two basic methods exist of estimating the value of this term. The first is the regression procedure suggested by Tanner (1962) in Button et al (1982) and the second is the heuristic method suggested by Whorf (1974). The first method (which assumes that G_t, the proportional rate of change of C_t decreases as C_t increases) is applicable only to the UK and most European Countries. In the USA, Australia, Canada and New Zealand G_t has been found to be relatively constant as C_t increases (Tanner (1978) and Button et al (1980)). Button and Ngoe (1991) found that since developing countries were still far from saturation level, the vehicle ownership models used by these countries were in fact only marginally sensitive to the saturation level selected. Their work proved that even a log-linear function that has no saturation level in its formulation had a high explanatory power when it was used to explain the trend of vehicle ownership. They concluded that further comparisons between the quasi-logistic models and the log-linear model indicated a considerable degree of similarity. This implies that the saturation levels used are unlikely to dominate the quasi-logistic results. However, for longer term forecasting they suggest the use of the quasi-logistic model instead of log-linear model to allow movement towards a saturation level. Button and Ngoe (1991) produced 5 groups of models based on numbers of cars per person and per capita GNP in 1986 of each country. The saturation value suggested in the appropriate group for Indonesia forms an appropriate initial value in the iterative process of finding the most suitable value for *S*.

The analysis to specify the model parameters was undertaken with firstly cross sectional data, then longitudinal data and finally with pooled data (ie using all variables through time). The results presented in section 6 are presented for each of these approaches.

5.2 Household Survey

A limited number of samples were selected for the detailed household analysis. The respondents were from four municipalities and three regencies, mostly in Java, with the basis of selection being primarily the practical ability to obtain data from the area. The number of respondents in each regency and municipality was deliberately determined as 15, resulting in a total number of respondents of 105. Several observations could be made regarding the quality of the survey. Firstly, although attempts were made to obtain data from households representing various economic levels, there was no guarantee that all economic levels would be proportionally represented in the sample. As a result, the economic levels in the household data might not represent the aggregate economic levels of the area. Secondly, there were no instances of non-motorized vehicle owner households in the sample. Consequently, for any particular area the household vehicle ownership rate data may not necessarily represent the vehicle ownership data at aggregate level. Thirdly, control on the sample ethnic proportions only took place for Yogyakarta and Bantul. A representative ethnicity proportion for other areas was not achieved within the data collection and this should be taken into consideration within interpretation of the data analysis. To minimize the possible bias due to the ethnicity issue, statistical techniques were selected for use in the household analysis which wouldn't

exacerbate the issue, i.e. Spearman Correlation Analysis and Cramer Contingency Coefficient Analysis.

The data were collected by the method of questionnaire between September 2001 and March 2002. The questions were regarding age, employment history, vehicle ownership history and vehicle use.

6. ANALYSIS RESULTS

6.1 Descriptive Analysis of the Aggregate Data

Initially a basic descriptive analysis of the data was used to give an overview of the characteristics of different regions and indicate the main variations in the data. This is summarised in Tables 1 and 2.

Table 1 Summary of the Collected Aggregate Data from Municipalities

Variables	N	Minimum	Maximum	Mean	Standard Deviation	Coefficient of Variation
Per Capita GRDP (1993), Ind. Rp.*	166	1,261,697	9,895,921	2,983,712	1,890,078.0	0.63
Consumer Price Index (1988/1989)	223	100	458	199	88.6	0.45
Min. Regional Wage/Min. Physical Needs, %	231	36	165	86	21.4	0.25
% of Working Population Aged >10	93	31	96	50	15.4	0.31
% of Population Aged 15-24	101	18	31	23	3.1	0.14
Population Density per Km^2 Area	220	153	15,314	5,449	4,550.2	0.83
Road Length (Km) per 1,000 Km^2 Area	178	331	13,576	4,586	3,155.1	0.69
Number of Public Bus Seats/1000 Population	184	9	323	74	51.7	0.70
Average Elevation above Sea Level, m	231	1	768	94	179.8	1.91
Yearly Rainfall, mm	172	330	4,114	2,069	740.0	0.36
Number of Car/1000 Population	190	2	183	43.1	40.0	0.93
Number of Motorcycle/1000 Population	197	3	786	140	155.0	1.10
Valid N (listwise)	48					

***** According to Oanda Corporation (2001), average inter-bank currency rate in 1993 is £ 1 = Rp. 3,126 or US$ 1 = Rp. 2,103

Table 2 Summary of the Collected Aggregate Data from Regencies

Variables	N	Minimum	Maximum	Mean	Standard Deviation	Coefficient of Variation
Per Capita GRDP (1993), Ind. Rp.*	241	453,069	6,208,320	1,362,087	963,737.7	0.71
Consumer Price Index (1988/1989)	92	100	529	207	93.6	0.45
Min. Regional Wage/Min. Physical Needs, %	306	36	136	83	20.4	0.25
% of Working Population Aged >10	137	39	74	57	7.6	0.13
% of Population Aged 15-24	139	16	22	19	1.4	0.08
Population Density per Km^2 Area	292	2	2,184	464	529.2	1.14
Road Length (Km) per 1,000 Km^2 Area	253	9	2,290	639	630.4	0.99
Number of Public Bus Seats/1000 Population	257	0	74	18	14.3	0.78
Average Elevation above Sea Level, m	308	1	1,300	295	351.6	1.19
Yearly Rainfall, mm	252	659	11,045	2,327	1,103.3	0.47
Number of Car/1000 Population	276	1	33	5	5.3	1.06
Number of Motorcycle/1000 Population	276	1	197	32	34.4	1.08
Valid N (listwise)	40					

***** According to Oanda Corporation (2001), average inter-bank currency rate in 1993 is £ 1 = Rp. 3,126 or US$ 1 = Rp. 2,103

To summarise the main findings, the level of wealth between municipalities and regencies (as indicated by the mean per capita GRDP) was found to be significantly different-in municipalities it was more than twice the value in regencies. An initial comparison with other socio-economic variables suggests that only the mean per capita GRDP was clearly related to car and motorcycle ownership rates. Although no detailed data is reported in this paper, between 1990 and 2000 to some extent population and per capita GRDP (including during the peak of economic crisis between 1997 and 1998) were growing. No data on the relative growth of wealthy population was available. Comparing the vehicle ownership rates overall, the mean car ownership rate in municipalities was more than four times that in regencies, whilst the mean motorcycle ownership rate in municipalities was more than eight times that in regencies. When other explanatory variables are considered however, the mean values of variables representing price, purchasing power, working force and age structure were roughly equal within municipalities and regencies. The level of wealth for the area seems to also have a considerable effect on the road density (km road length / km^2 area) and public transport service availability (per 1000 population). The mean road density in municipalities was more than seven times that in regencies whilst the mean number of public bus seats per 1000 population in municipalities was more than four times that in regencies**.**

6.2 Descriptive Analysis of the Household Data

Considering the data collected at household level, the characteristics of household and vehicle ownership were found to vary widely (Table 3). The coefficient of variation was calculated in order to be able to compare between variables measured in different units. The coefficient of variation in household monthly expenditure (representing income) was found to be similar to the coefficient of variation in the number of cars or motorcycles currently owned and also the estimated 1999 value of vehicles currently owned. These coefficients of variation were rather high, indicating that the sample contained a wide range of data both on the income and ownership sides.

Table 3 Summary of the Collected Household Data

Variables	N	Minimum	Maximum	Mean	Standard Deviation	Coefficient of Variation
No. of Main Household Members	105	2	8	4.4	1.3	0.30
No. of Servants	105	0	4	.9	1.1	1.22
No. of Visitors	105	0	3	.2	.5	2.50
Age of Household Head	103	25	70	46.5	9.7	0.21
No. of Working Household Members	105	1	6	1.6	.9	0.56
No. of Student Household Members	105	0	5	1.8	1.2	0.67
No. of Household Members Aged >=16	105	1	8	3.4	1.4	0.41
No. of Household Members Aged >=18	105	1	8	3.1	1.3	0.42
No. of Male Household Members	105	1	4	2.2	.8	0.36
No. of Female Household Members	105	1	6	2.3	1.0	0.43
No. of Cars Owned at Present	105	0	5	1.1	1.2	1.09
No. of Motorcycles Owned at Present	105	0	3	.8	.9	1.13
Est. '99 Value of Presently Owned Vehicle (Rupiah)	70	2,153,010	975,820,136	139,825,382.9	199,095,780.5	1.42
Household Monthly Expenditure (Rupiah)	101	400,000	20,000,000	3,654,455.4	3,653,054.2	1.00
Valid N (listwise)	66					

Perhaps not surprisingly, it was found that each area had different characteristics (Table 4). Although the number of main household members in each area was approximately the same, large urbanized areas such as Jakarta and Bandung employed considerably more servants than other areas. This appeared to be related to other wealth level indicators such as vehicle value and household expenditure, in which Jakarta and Bandung also show the highest figures. The number of cars owned seems to be related to household expenditure, although a high value of

mean motorcycle ownership in Yogyakarta and Bantul did not seem to be related to household expenditure. In these areas, the high household motorcycle ownership rate at household level was found to be consistent with the motorcycle ownership rate at the aggregate level.

Table 4 Mean of the Collected Household Data by Area

Variables	Bantul	Bekasi	Garut	Bandar Lampung	Bandung	Jakarta	Yogyakarta
No. of Main Household Members	4.1	4.6	4.4	4.8	4.5	4.7	4.1
No. of Servants	.1	1.1	.6	.6	1.7	1.7	.5
No. of Visitors	.0	.1	.0	.2	.2	.7	.0
Age of Household Head	43.3	43.2	45.9	49.1	45.5	50.9	48.4
No. of Working Household Members	1.4	1.4	1.5	2.2	1.3	1.7	1.8
No. of Student Household Members	1.7	2.3	1.9	1.4	2.1	1.8	1.6
No. of Household Members Aged >=16	3.2	2.9	3.2	3.3	3.6	3.9	3.5
No. of Household Members Aged >=18	2.9	2.5	2.9	3.3	3.5	3.9	3.1
No. of Male Household Members	1.8	2.5	1.9	2.5	2.0	2.5	2.1
No. of Female Household Members	2.3	2.1	2.5	2.3	2.5	2.2	2.0
No. of Owned Car at Present	.7	1.6	1.1	.7	1.8	1.5	.5
No. of Owned Motorcycle at Present	1.6	.3	.6	.3	.6	.5	1.5
Est. '99 Value of Presently Owned Vehicle (Rupiah)	54,329,282.2			138,119,493.1	155,179,674.4	267,592,277.5	81,163,579.5
Household Monthly Expenditure (Rupiah)	2,636,666.7	3,928,571.4	1,885,714.3	2,110,714.3	5,392,857.1	7,066,666.7	2,473,333.3

6.3 Cross-Sectional Modelling Results

In this section a summary and interpretation of the cross-sectional models produced, following the general structure of equation (1) is provided. Tables 5 through 8 show the models coefficients.

Table **5** Regression Coefficients of Cross-Sectional Car Ownership Rate Models in the Municipalities

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
b_0 (p_0)	-23.047 (0.004)	-23.468 (0.004)	-22.549 (0.003)	-24.695 (0.002)	-24.442 (0.002)	-20.23 (0.015)	-27.699 (0.002)	-30.863 (0.001)	-21.933 (0.010)	-21.324 (0.015)	-23.072 (0.010)
b_1 (p_1)	1.195 (0.021)	1.196 (0.022)	1.151 (0.020)	1.296 (0.010)	1.273 (0.001)	1.189 (0.031)	1.469 (0.006)	1.647 (0.003)	1.315 (0.021)	1.273 (0.028)	1.391 (0.018)
b_6 (p_6)	0.692 (0.021)	0.777 (0.024)	0.707 (0.030)	0.714 (0.039)	0.731 (0.041)		0.802 (0.042)	0.914 (0.020)			
Adjusted R^2	0.355	0.345	0.353	0.379	0.364	0.191	0.350	0.405	0.222	0.198	0.232
p_{model}	0.009	0.011	0.010	0.007	0.008	0.031	0.010	0.005	0.021	0.028	0.018

Notes:
b_0 and p_0 : the constant and the significance level of the constant
b_1 and p_1 : the regression coefficient and the significance level of the per capita GRDP in 1993 value
b_6 and p_6 : the regression coefficient and the significance level of the no. of bus seats per 1,000 population
p_{model} : the significance level of the F statistic (regression mean square / residual mean square)

Table 6 Regression Coefficients of Cross-Sectional Motorcycle Ownership Rate Models in the Municipalities

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
b_o (p_0)					-5.718 (0.001)		-6.034 (0.001	-6.675 (0.002)	-6.572 (0.003)	-6.748 (0.001)	-7.322 (0.002)
b_6 (p_6)					0.875 (0.029)		1.003) (0.016)	1.189 (0.013)	1.174 (0.017)	1.205 (0.009)	1.390 (0.008)
Adjusted R^2					0.197		0.241	0.257	0.239	0.286	0.294
p_{model}					0.029		0.016	0.013	0.017	0.009	0.008

Table 7 Regression Coefficients of Cross-Sectional Car Ownership Rate Models in the Regencies

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
b_o (p_0)	-10.581 (0.000)	-12.813 (0.000)	-17.188 (0.000)	-18.589 (0.000)	-19.564 (0.000)	-20.844 (0.000)	-9.463 (0.025)	-18.234 (0.000)	-6.876 (0.140)		
b_1 (p_1)	0.323 (0.001)	0.535 (0.012)	0.806 (0.001)	(0.903 (0.001)	0.950 (0.001)	1.025 (0.001)	0.823 (0.001)	0.881 (0.002)	0.544 (0.048)		
b_3 (p_3)	1.199 (0.011)										
b_5 (p_5)			0.185 (0.035)	0.202 (0.033)	0.254 (0.011)	0.297 (0.006)		0.218 (0.041)			
b_6 (p_6)		0.188 (0.032)							0.296 (0.044)		
b_8 (p_8)							-0.885 (0.009)		-0.782 (0.017)		
Adjusted R^2	0.345	0.284	0.332	0.325	0.372	0.382	0.399	0.286	0.336		
p_{model}	0.002	0.006	0.002	0.003	0.001	0.001	0.001	0.006	0.005		

Table 8 Regression Coefficient of Cross-Sectional Motorcycle Ownership Rate Models in the Regencies

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
b_o (p_0)			-19.420 (0.000)	-22.544 (0.000)	-22.964 (0.000)	-21.354 (0.000)	-19.116 (0.000)	-17.505 (0.000)	3.732 (0.184)		
b_1 (p_1)			0.977 (0.004)	1.177 (0.003)	1.215 (0.001)	1.117 (0.001)	1.000 (0.001)	0.898 (0.003)			
b_5 (p_5)			0.342 (0.010)	0.391 (0.007)	0.381 (0.004)	0.355 (0.003)	0.264 (0.018)	0.261 (0.020)			
b_8 (p_8)									-0.892 (0.017)		
Adjusted R^2			0.295	0.318	0.379	0.395	0.348	0.296	0.168		
p_{model}			0.005	0.003	0.001	0.001	0.002	0.005	0.017		

Notes:
b_0 and p_0 : the constant and significance level of the constant
b_1 and p_1 : the regression coefficient and significance level of per capita GRDP in 1993 value
b_3 and p_3 : the regression coefficient and significance level of the ratio between minimum physical needs minimum regional wage
b_{5t} and p_5 : the regression coefficient and significance level of the road length in km per 1,000 km^2 area
b_6 and p_6 : the regression coefficient and significance level of the no. of bus seats per 1,000 population
b_8 and p_8 : the regression coefficient and significance level of the yearly rainfall
p_{model} : the significance level of the F statistic (regression mean square / residual mean square)

6.4 Longitudinal Modelling Results

In this section a summary and interpretation of the longitudinal modelling process is provided. The key findings are as follows:

- Whilst in some municipalities, the car ownership rates were found to be more sensitive than the motorcycle ownership rates to per capita GRDP (X_1), in major tourist and student destinations the motorcycle ownership rates were more sensitive than the car ownership rates to per capita GRDP (X_1).
- In the regencies, the car and/or motorcycle ownership rates in the areas with relatively high X_5 (length of road in km per 1,000 km^2 area) such as Bekasi, Sidoarjo and Gianyar were more sensitive to X_5. Geographically, these areas have an immediate border with large municipalities and therefore were more urbanized than the remaining regencies in the sample. As a consequence the car and motorcycle ownership rates in regencies with a direct border to a municipality were more sensitive to X_5 than regencies where this was not the case.

6.5 Pooled Modelling Results

The final approach of the modelling process was to produce a pooled model, where data for all years on all areas were analyzed together. The models coefficients are summarized in Table 9.

Table 9 Regression Coefficients of the Pooled Models

Area Type	Municipality		Regency	
Vehicle Type	**Car**	**Motorcycle**	**Car**	**Motorcycle**
b_o (p_0)	-29.032 (0.000)	-21.202 (0.000)	-17.723 (0.000)	-15.639 (0.000)
b_1 (p_1)	1.450 (0.000)	0.918 (0.000)	0.806 (0.000)	0.907 (0.000)
b_4 (p_4)	0.157 (0.014)	0.422 (0.000)		
b_5 (p_5)			0.203 (0.000)	0.307 (0.000)
b_6 (p_6)	0.832 (0.000)	1.158 (0.000)	0.225 (0.000)	0.101 (0.015)
b_7 (p_7)	0.099 (0.007)			-0.060 (0.017)
b_8 (p_8)		-0.333 (0.038)		-0.313 (0.005)
Adjusted R^2	0.469	0.445	0.447	0.392
p_{model}	0.000	0.000	0.000	0.000

Notes:
b_0 and p_0 : the constant and significance level of the constant
b_1 and p_1 : the regression coefficient and significance level of per capita GRDP in 1993 value
b_4 and p_4 : the regression coefficient and significance level of the population density
b_{5t} and p_5 : the regression coefficient and significance level of the road length in km per 1,000 km^2 area
b_6 and p_6 : the regression coefficient and significance level of the no. of bus seats per 1,000 population
b_7 and p_7 : the regression coefficient and significance level of the ground elevation above sea level
b_8 and p_8 : the regression coefficient and significance level of the yearly rainfall
p_{model} : the significance level of the F statistic (regression mean square / residual mean square)

The main findings were as follows:

- In general, the level of wealth was the main factor affecting car and motorcycle ownership in both municipalities and regencies.
- For models of motorcycle ownership, yearly rainfall was one of the significant explanatory variables.
- For the regency motorcycle ownership rate model, average ground elevation was found to be a significant explanatory variable.

6.6 Household Analysis Results

The data collected at household level were not used to fit models, but rather to gain an understanding of the factors influencing vehicle ownership. The following results were found:

- In general, the higher the number of household members, the higher the number of cars owned, whilst for the motorcycle this was only true in the non-car owning household. In areas in which the use of the motorcycle was very high as a means of student transport, the number of students and number of household members aged 16 or more appeared to be closely related to the number of motorcycles.
- The higher the level of wealth, the higher the number of cars in a household and the lower the number of motorcycles in a household. This was believed to be because once a certain wealth level was reached, a household could afford to own more expensive private transport modes.
- Wealthier households tended to own newer vehicles which were purchased more recently. In the case of the car, this was not only concluded from the figures showing the number of cars currently owned, but also from the holding duration of cars previously owned. In general these vehicles have more seats and larger engine sizes (hence more power) to accommodate more people in a single trip.
- Households which have already sold a high number of motorcycles tend to currently own newer vehicles (in terms of production age). However it is interesting to note that these households tended to replace them with other motorcycles rather than cars.
- Compared to other occupations, businessmen and businesswomen were more likely to sell their cars and replace them with new cars. This was presumed to be as a result of historical changes in the nature of each business which required different specifications of cars.
- The older the head of the household and the longer the period of employment of head of the household, the older the car (vehicle) tended to be when it was sold (in terms of production age). This may be explained as historically the opportunities to purchase a car or vehicle were fewer than is the case now, both in terms of access to car (vehicle) sales and levels of personal wealth.

7. CONCLUSIONS

The main objective of the research was to establish one or more vehicle ownership models for Indonesia, in the light of the lack of any established models to date and the high potential use for such a mode1. This work therefore represents an important and original contribution to policy development and planning processes. The research was undertaken with the perspective that vehicle ownership models that have been developed in other countries might not be directly applicable in Indonesian conditions. Even in the early stage of research, i.e. in the data collection process, the problems encountered affected the choice of explanatory variables and therefore ultimately the models produced. The final selection of explanatory variables was a compromise between the need to use the most reliable and valid variables and the availability of the data.

The chosen model form, i.e. the quasi-logistic model was easy to calibrate, flexible and relatively straightforward to interpret and has already proved statistically satisfactory for use in developing countries (for example the household model by Cundill (1986) and aggregate model by Button and Ngoe (1991)). Three types of modelling were undertaken ie cross section, longitudinal and pooled models. In addition to this, a more detailed household survey was carried out which was necessarily more limited in geographic coverage, in order to provide further understanding of the vehicle ownership process.

For the cross-sectional models, in general per capita GRDP (X_1) was found to explain the variation in car and motorcycle ownership rates well. Other important explanatory variables were road length in km per 1,000 km^2 area (X_5) and number of bus seats per 1,000 population (X_6). Rather than acting directly as factors affecting car and motorcycle ownership X_5 and X_6 seem to be acting as proxies for the wealth of an area. In general the higher the value of X_1, the more sensitive the car or motorcycle ownership rate to X_1; the higher X_5, the more sensitive the car or motorcycle ownership rate to X_5 and the higher X_6, the more sensitive the car or motorcycle ownership rate was to X_6. If X_1 was considered to reflect income, whilst X_5 and X_6 were considered as proxies of income, the findings were entirely consistent with previous research by Button and Ngoe (1991) in developing countries. This revealed that the car ownership rate in countries within a higher income group tend to be more sensitive to income.

The values of the adjusted R^2 in the cross-sectional models were relatively low. This was probably caused by the need to use additional explanatory variables. One of the theoretically valid explanatory variables was the vehicle price index but this was unfortunately only available in a limited number of areas and was therefore not practical for inclusion in this research. A further factor contributing to model quality was the limited number of cases available in each analysis.

In contrast to the cross-sectional analysis, with the longitudinal models the values of adjusted R^2 were very high. In the longitudinal analysis, where each area was analysed separately using a time series of 11 years, the trend of the data for every variable tended to be similar. As a result of this consistent trend pattern, many significant correlations were obtained between the independent variables and the dependent variables. Unfortunately this was accompanied by considerable numbers of collinearities between independent variables. As a result, except for a very few cases, only one independent variable was included in the model for each area.

The findings from the longitudinal models can be summarized as follows. Firstly, in some municipalities car ownership rates were more sensitive to per capita GRDP (X_1) than motorcycle ownership rates. In major tourist and student destinations such as Yogyakarta however, motorcycle ownership rates were more sensitive to per capita GRDP (X_1) than was the case with car ownership rates. Secondly, considering the effect of the length of road in km per 1,000 km^2 area (X_5), the ownership of private vehicles in areas with a higher X_5 was higher compared to those areas with a lower value of X_5 (length of road in km per 1,000 km^2 area).

The main findings from the pooled models were as follows. Firstly, in general the level of wealth was found to be the main factor affecting car and motorcycle ownership in both municipalities and regencies. Secondly, in the motorcycle models, yearly rainfall was one of the key variables and this seems intuitively reasonable. Thirdly, in the regency motorcycle ownership rate model, average ground elevation was found to be one of the significant

variables. The explanation for this may be the practical difficulties in driving particular vehicles at a high level of elevation. Compared to the pooled models, the longitudinal models provided a better fit to the observed values and the use of longitudinal models for forecasting is therefore proposed.

Despite the fact that the household analysis was carried out using a limited number of samples, there were some important findings that can be summarized here. In general, the higher the number of household members the higher the number of cars but for the motorcycle this was only true in the non-car owning household. In areas in which the use of motorcycle was very high as a means of student transport however, the number of students and number of household members aged 16 or more were strongly associated with the number of motorcycles. It was also found that the higher the level of wealth in the household, the higher the number of cars and the lower the number of motorcycles. This was because once a certain level of wealth had been reached, a household could afford to own more expensive private transport modes. Finally, wealthier households tended to own newer vehicles which were purchased more recently. In general these vehicles have more seats and larger engine sizes to accommodate a greater number of people in a more powerful vehicle.

From the analysis of vehicle holding characteristics in a household, several conclusions could be made. Firstly, households which have already sold a greater number of cars tend to currently own newer vehicles in terms of both purchasing and production ages. Households which have already sold a high number of motorcycles also tend to currently own newer vehicles in terms of production age, however these households tended to replace them with other motorcycles rather than cars. Secondly, compared to other occupations, businessmen and businesswomen were more likely to sell their cars and replace them with new cars. Finally, the older the household head and the longer their time of employment, the older the car (vehicle) when it was sold in terms of production age.

There were some areas in this study that required further research. This could be in terms of the robustness of the model or in the level of aggregation of the model.

A good model requires appropriate model specification, which allows the data to be well fitted into the model, whilst maintaining its possible use for forecasting. These ideal characteristics are quite difficult to achieve. Considering the wide range of characteristics in the longitudinal models of 48 different areas in Indonesia, it might be appropriate to concentrate on a particular group of areas which share similar characteristics, e.g. metropolitan cities, tourist destination areas, small islands, etc., whilst maintaining the level of aggregation in the municipality and regency. Therefore, instead of attempting to produce a general model, it might be more appropriate to develop more area specific models. In terms of included variables, there might be other appropriate variables that should be considered. For example, instead of just represented by number of bus seats per 1,000 population, public transport services availability could be represented by other variables such as ratio between bus fares and cost of fuel per km of private vehicle travel, availability of other public transport modes, service frequency, accessibility of public transport services to important locations, etc.

In terms of the level of aggregation, the development of national based models or provincial based models might be considered. With a higher level of aggregation the data are anticipated to be more available compared to the data for municipalities or regencies models. Moreover, the model development in different levels of aggregation might have different purposes. Whilst the models at the municipalities and regencies level might be used mainly to assist city

and regional planning (e.g. transport demand management), the model at national level might be used for more strategic issues such as policies in national vehicle industries, national energy and environmental sustainability, etc. As the data from higher levels of aggregation might be more available, the length of the observed period might be longer, allowing more accurate analyses and providing the opportunity to compare the appropriateness of different forms of models.

In contrast, the level of aggregation might also be lowered, i.e. to the household level. As suggested from the limited number of observations at the household level analysed in this research, it seems that this kind of analysis was more behavioural, i.e. the reason behind the decision of owning the vehicle could be more immediately revealed from household analysis. Therefore analysis at this level of aggregation in Indonesia is highly recommended to be integrated with the aggregate model. However, it should be noted that it might not be easy to use the household model to forecast the future number of registered private vehicle in Indonesia as the databases of household characteristics are less available compared to the aggregate databases. Therefore, rather than directly obtain the data from readily available datasets, one might need to collect the required data by oneself.

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