CAR OWNERSHIP: STATE OF THE ART OF MODELLING AND EMPIRICAL FINDINGS

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ABSTRACT

Car ownership level is probably one policy of the variables that has become a topic for continuous debates for many years. The factors affecting car ownership level are often very complicated that people might not be able to make an estimate of the car ownership level, not at the personal level nor at the household level. The literature has been demonstrated many approaches used in the model but there is not yet an agreement on the general approach model. The saturation factor put forward by some research has provided more complications. On the one hand, the idea of saturation level can be regarded as a brilliant one since it represents the ultimate level of socio-economic behaviour as well as a system capacity. On the other hand, the determination of saturation level, which is normally decided exogenously, is regarded by many as far from satisfying. Some argued that the saturation level is virtually impossible to predict since the level itself is also a dynamic.

In the research it is proposed to adopt Quarmby and Bates method with modifications, mainly to avoid the use of saturation level. Indonesian national data on car ownership shows that income is the most predominant factor affecting car ownership. The existence of enormous demand for car ownership has made the population density exempted from the model for Indonesian car ownership.

1. INTRODUCTION

Discussions on car ownership model have been attempted for many years. In the area of theoretical model it started with the casual model introduced in late 60s. Since then, many models have been developed to understand car ownership behaviour and how they are related with socio-economic characteristics of the society. They are varied from aggregate model on a national level based on growth curve (Tamner, 1962, 1974, 1978, 1981a, 1981b), the stock adjustment models which try to explain market behaviour (Smith, 1975, Morgridge, 1983, Tinbergen, 1984, Janson 1989) and a micro level decision making process (Ben-Akiva and Lerman, 1976) or household based (Bates, et al., 1978) and cross sectional models (Tamner, 1963, Benton and Kain, 1964). Another alternative

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2. CAR OWNERSHIP MODELS: STATE OF THE ART

An early work on extrapolatory models was based on the logistic (or Pearl-Reed) curve. Initially, it was developed in the very simple form (Tanner, 1965) and it simply fits the time series data to a logistic curve. The equation is based on the empirical observation that the rate of car ownership changes over time (Y) is linearly related to car ownership level (Parkes, 1990). This behaviour is performed by the following logistic curve which implies that for a given saturation level, the current ownership level is determined by the previous car ownership level. The model is therefore criticised because the factors that relate the economic performance are not explicitly taken into account (Parkes, 1990). The time trend was subsuming the effect of changes in the economy over time. The model was then revised by utilising Gross Domestic Product (GDP) to represent the state of the country’s economic and motivation cost to represent user’s affordability to maintain the ownership (Tanner, 1974). However, the model still includes a time trend.

Another model (Tanner, 1977), called “the power growth curve” was proposed since the evidence show that the data was not strictly consistent with the previous form. The model takes the following form:

\[
Y = \frac{S}{1 + (a(T - T) + b \log l + c \log P)^n}
\]  

(2.1)

and

\[
\frac{dY}{dt} = \frac{\partial}{\partial t} \left( \frac{n(S - Y)^{n-1}Y}{S_t^{1/n} - (a + \frac{b}{Y} + \frac{c}{Y})} \right)
\]

(2.2)

where \(S, T, n\) are exogenous variables and \(a, b, c\) are calibration constants.

The household models have basically different concepts and philosophy. Instead of using a deterministic approach, they provide a probabilistic result. It is also an econometric exercise. The method of Quarmby and Bates (1970, see Orttzar and Williamsen, 1994) utilises two independent variables, income and residential density although it recognises the existence of several other factors of interest, such as household size and vehicle price. The model is on the form of:

\[
P_0 = \frac{a_0 \exp{b_0 D c_0}}{1 - P_0 + P_0 + P_2 = 1}
\]

(2.3)

where

\[
P_0 = \text{annual family income},
\]

\[
D = \text{residential density},
\]

\[
P_1 = \text{probability of owning 0, 1, and 2 or more cars},
\]

\[
a, b, c, \alpha = \text{calibration constants}.
\]

Substituting \(P_0\) and taking the logarithm on both sides:

\[
\ln\left(\frac{P_0}{1 - P_0 - P_2}\right) = \ln a_1 + b_1 + c_1 \ln D
\]

(2.6)

As the income increases, the left hand equation should also increase, or the denominator should be decreased and at the ultimate stage, \(P_0\) tends to approach (1 - \(P_1\)). However, as \(P_2\) is nearly zero for very high incomes, \(P_0\) would tend to 1. When it is expected that in practice, the maximum value of \(P_0\) would be less than 1, then term saturation level is introduced and the Equation (2.7) becomes:

\[
\ln\left(\frac{P_0}{S(1 - P_0 - P_2)}\right) = \ln a_1 + b_1 + c_1 \ln D
\]

(2.7)

The following figure shows the relation between car ownership level and family incomes in Quarmby and Bates model.

![Figure 2.1 Car ownership and family income](source: Orttzar and Williamsen, 1994, no. 410)
The latter model developed by Bates et al. (1978) for the Regional Highway Traffic Model (RHTM). The model explains the probability of a person/household related to their incomes (Bates, 1978). The form of the model allows a saturation level and follows a logit log-logistic curve:

\[ P_1(I) = \frac{S_1}{1 + \exp(-a - b \cdot I)} \]  
(2.8)

\[ P_{2r}(I) = \frac{S_2}{1 + \exp(-a - b \cdot I)} \]  
(2.9)

where

- \( P_1(I) \) : probability of household with income \( I \) owning 1 or more cars,
- \( P_{2r}(I) \) : probability of household with income \( I \) owning 2 or more cars, given that it has 1 car,
- \( S_1, S_2 \) : saturation levels,
- \( I \) : car purchase income level,

and \( a, b, a, b \) are calibration constants.

Car ownership level is then given by the following formula:

\[ y = \frac{P_1(I) - (2 - D) P_{2r}(I)}{1 + \exp(a - b \cdot I)} \]  
(2.10)

where

- \( y \) : car per head of population,
- \( k2r \) : average number of car, given that it has two or more cars,
- \( H \) : average household size.

The above model has been criticized as inferior to a properly calibrated extrapolatory model under two reasons (Fowkes et al., 1979):

a) car purchase income is virtually impossible to forecast,

b) many factors affect car ownership growth, of which car purchasing income is but one; the time trend in the simple extrapolatory model can be regarded as a proxy in all of them.

It is also argued that such a model is more suited to the disaggregate contract for which they were initially developed. It is furthermore acknowledged that the household-based model omits the possibilities that the variables may contribute very little to the explanation of changes over time (Bates, 1978). The model is also argued to fail to reflect a large variation in the extent of car use between different member of household.

The refinement of the model was made by incorporating the income, retail price index and license ownership (Smith, 1981). The model is as follows:

\[ P_1(I) = \frac{S_1}{1 + \exp(-a - b \cdot I)} \]  
(2.11)

and

\[ P_{2r}(I) = \frac{S_2}{1 + \exp(-a - b \cdot I)} \]  
(2.12)

where:

- \( I \) : Income,
- \( RPI \) : Retail Price Index,
- \( LPA \) : License per Adult (age of > 18), which is determined with the following equation:

\[ LPA = \frac{S_{LPA}}{1 + \exp(a - b \cdot I)} \quad A \text{ and } B \text{ are calibration constants} \]

- \( S_{LPA} \) : Saturation Level for Driving Licence.

The extrapolatory and household-based model are both very much depend upon the level of saturation. In studies that estimate saturation level, there seem to be three concepts (Button et al., 1980),

1. (1) as a statistical measure of an upper asymptote which may change as more data become available,
2. (2) a ceiling which is not possible for people to exceed,
3. (3) an average long-term level of car ownership variable predicted by the model.

Early estimate in saturation level was based upon the linear relationship between the changes in car ownership and the level of car ownership. The saturation level can be determined as an intercept of the regression line with the zero growth. The method was argued to be a wrong way around and it was suggested that it should be based on reversing car ownership or growth rate (Adams, 1974, revised 1975). In the light of the controversy, it is suggested to fix the model (or its inverse) directly to the data (Kirby, 1976). The approach however is proved to be inadequate due to the following objections (Orruzar and Willumsen, 1994):

1. (1) the model is not sensitive to policy variables; the method to determine the saturation level is inappropriate when validated by using data from the USA,
2. (2) the saturation level is assumed constant.

The second argument gained many supports since saturation level estimators could not be expected to be constant under unstable traffic management regime (Davies and Morrison, 1976) and dependent on macro's attitudes (Bolland, 1981). A series of
studies in car market (Davies and Mogridge, 1976, Mogridge, 1983) proposed to use a non-saturation model formulation which is of the form:

\[
\log \frac{1}{1 - c/d} = a + b.c
\]

(2.13)

This form of model allows naturally for argument that, using logistic model, successive estimate of saturation level has been increasing but at a decreasing rate.

Third main issue in the area of car ownership is the demand on the car market. It reflects the behaviour of user and will subsequently determine the level of car ownership. Most of car market models consider income and credit availability (Amstrong and Oeting-Snee, 1978), rental price (Johnson, 1975) and hire-purchase (Parikesit, 1990) as factors that establish the car market. Another point was argued whether new car and used car sales have similar influencing variables since car is also considered a status symbol (Smart, 1989) since there is a low degree of substitution between new and used car market (Smith, 1975, Smart, 1989). In the new car registration, there are two possibilities. First it is a merely an "echo effect"; the owner will keep their cars in a certain period of time before replacing them. Second there is an allowance to postpone their willingness to purchase a car in response to the economical performance. The latter was due to the argument that by keeping the current car, they will loose its convenience but not the utility. It is however an indication of a post-pon demand in relation with the state of economy (Parikesit, 1990). The new car market is further very elaborate since it is affected by the expectation, income, government legislation and regional agreement, and marketing initiatives.

### 3. CAR OWNERSHIP FOR INDONESIA: Empirical Evidence

One of the biggest issues in national transportation policy is car ownership. Car ownership certainly encourages people to use it. Higher car ownership encourages people to drive their cars instead of public transport. As the car ownership increases the probability of car usage over public transport usage will also increase. Data from Central Bureau of Statistics show that private car ownership has been growing, from 5.169 cars per 1.000.000 persons in 1982 to 10.791 cars per 1.000.000 persons in 1995 which is most doubled in 12 years. This is a remarkably high grow for a country-wide car ownership although the absolute value of car ownership is relatively lower than that of developed countries or even Asian Newly Industrialised Countries. Time series data on car ownership between 1982 to 1995 can be seen in the Figure 2.

![Figure 2. Time Series Data on Car Ownership](image-url)

This remarkable growth has been mostly attributable to the increase of wealth represented by the growth of GDP per capita as a proxy of income. As the income increase than the peoples' purchasing power for tertiary goods to improve the quality of life increase as well. People are able to purchase private cars to improve their mobility. Various financing schemes available are also the factors encouraging people to own car. It is very interesting to see what is going to be the trend after the government launched the so called "National Automobile" programme which basically an affordable car from the price point of view. From 1982-1995 car ownership grow in logarithmic term, showing that the people have their limitation to allocate their expenditure on cars. With the increase of income, at the certain level people are allocating their income to other things, that is not exclusively on buying cars.
Figure 3. Car Ownership and Purchasing Power

It is interesting to see the development of car ownership with respect to population density. In developed countries, car ownership tends to decrease with the increase of population density. It shows that higher density will create demand for travel with public transport and walk. This is particularly true for urban areas where public transport scheme are encourage to alleviate traffic congestion. High density means also compact urban area where the accessibility for other services are higher than low density area. The car ownership data for Indonesia show that the argument does not apply. In the contrary, when the population density increases from 79.74 persons/Km² in 1982 to 101.75 persons/Km² in 1995, the car ownership also increases. Interestingly, it increase exponentially, which demonstrate higher temptation to own car. The graph showed in Figure 4 also demonstrate that there is a reservoir for demand in private car ownership. As soon as people are reaching their "car purchase income level" they are just like a pent-up demand, waiting to release their demand to own car. Psychologically, this is due to a very positive attitude of owning car. A private car becomes a symbol of status and not a mere symbol of demand.

Figure 4. Car Ownership and Population Density

The discussion on car ownership forecasting methods has also been going for many years. Car ownership grows in a very good linear relationship with time and to do other socio-economic and demographic parameters. Those have been the cause why there are many approaches to forecast car ownership. The key question is to what extent each parameter affects car ownership. One particular issue is saturation level that normally determined exogenously. How valid is the use of saturation level, and how to obtain them?

In the research it is proposed to adopt Quarmby and Bates method with modifications, mainly to avoid the use of saturation level. The equation shows that as the income increase, the left hand equation should also be increased, or the denominator would increase. The value of $P_c$ tends to approach (1-$P_c$). As $P_c$ will approach zero at the very high income, $P_c$ will approach 1 when the value represents the probability of owning one or more cars. INC represents income. Population density has been proven to be irrelevant alternative since there is a distortion in the perception, and the number of people in the area, i.e. population density does not represent the behaviour and there is a reservoir of car ownership demand although it is also possible to include other factors and applying the same principle. The approach would be best applied at the personal level since the maximum probability of owning more than one car (that is $P_c$) is 1. It means that people are divided into two groups, first group belong to non car owning and the second is the (one) car owning. The calibration of the model can be obtained through the following formula:
ln([PCO](1-PCO)) = ln(a) + bINC
PCO = 1-PCO

where:
- PCO: probability of a person owning a car,
- PCCo: probability of a person not owning a car,
- INC: income per capita, represented by GDRP per capita

From the data obtained and the procedure showed above, equation parameter in (3.1) becomes:

\[ \ln(a) = 12.084 \]
\[ b = 2.224,1 \]
\[ \ln([PCO](1-PCO)) = 12.084 + 2.224,1 \text{INC} \]

with the value of \( R^2 \) of 0.889

With such simple equation, we can obtain the car ownership equation for Indonesian data. Of course this is only an initial development of car ownership forecast model for Indonesia. With high value of \( R^2 \), one can see that income can be a single parameter that determine the level of Indonesian car ownership. This has not been an exclusive case for Indonesia, but also a phenomenon seen and learned from China data and other developing countries. They show a similar pattern of car ownership development.

4. CONCLUDING REMARKS

So many factors affecting a decision to own a car has complicated car ownership modelling. Public transport service (Fairhurst, 1975), accessibility measures (Bates et al., 1978), the level of urbanisation, exchange rates, and the effect of secular growth (Ashworth and Weaver, 1981), gasoline price and vehicle fuel efficiency (Newman and Kenworthy, 1991) are among other affecting factors. A world wide data (Newman and Kenworthy, 1991) show that car ownership has a high correlation value with urban density (-0.7801), and job density (-0.7793).

The existence of pent-up demand is also an area of further research. As the income increases, some people who previously postponed their decision to purchase a car, would suddenly buy a car and release their temptation to own cars. Another possibility is that there are some people that allow a certain lag time before buying a car to ensure the state of economy. Therefore the increase of car ownership level appeared a certain period after the increase in the income. This explanation would also apply to a lagged effect in the downturn in car ownership level when the state of economy is worsen. Data from Indonesian Statistics shows that although car ownership at the national level is still very low, the growth of is remarkably high. This growth represents the high expectation of car ownership.

5. REFERENCES

--------, 1987, Statistik Indonesia 1985, BPS, Jakarta.


PENGARUH PENULANGAN GESER PADA BALOK BETON NON-PASIR DENGAN AREGAT LEMPUNG BEKAH

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ABSTRACT

The purpose (aim) of this research was to obtain the shear force could be retained by shear-reinforcement of no fines, reinforced concrete beams. Ten no-fine beams (150 mm width, 200 mm height, 2000 mm long) with 8 D16 flexural reinforcement and 8 mm or diameter of shear reinforcement provided at various distance were padded. The water-cement ratio of the mix was 0.40, and the volumetric ratio between cement and aggregate was 1/4. The aggregate used was artificial light-weight made of expanded shale from Cilacap.

The results showed that for beam with 6 mm in diameter, the shear force that could be retained by shear-reinforcement Vₕ could be expressed by formula: Vₕ = 33.73 - 0.16s, and for beam with shear-reinforcement of 8 mm in diameter, the formula becomes: Vₕ = 46.77 - 0.048s. Where s was the spacing of the shear reinforcement.

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