# Car Ownership in Households

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## SYNOPSIS

Car ownership in households is analyzed by disag-
gregate behavioral modeling technique.  Two models are
built to analyze characteristic features of car owner-
ship.  The results are (1) The number of driver licenses
in a household is, as a matter of course, most influ-
encing on car ownership and multi-ownership.  (2) Family
size is the second most influencing.  (3) Utilily
obtainable by owning second or third car is higher in
the household of primary industry than that of the
other industry.  (4) Inclination of household to be car
owner is stronger in a sparsely inhabited zone than in
a densely inhabited.

## 1.  INTRODUCTION

There are two kinds of techniques for modeling car ownership.
One is macroscopic and the other is microscopic.  In the former some
aggregated aspects of car ownership are dealt with by use of, for
instance, social and/or economical characteristics of the region
under study.  In the latter individual ownership is described by use
of some individual characteristics.

Since car ownership is an aspect of consummer's behavior, it

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will be possible to describe it by application of modeling techniques
used in consummer's behavioral science.  Recently, disaggregated
technique is coming into use in modeling car ownership of individuals
(for instance, households).  This technique is called disaggregate
behavioral model.  Morichi and others[1]-[4] tried to show that there
exist some characteristic differences among the three groups of
households; groups of no car, single car and two or more cars.  The
data used in their study are those obtained by questionaire carried
out in a part of Tokyo metropolitan area.  Hidano and Kashima[5]
built up two kinds of models which were combined to forecast the
whole car ownership in Japan at the end of this century.  One of
their two models is a trend model, that is, macroscopic model that
describes the aggregated number of registrations of cars, the other
is disaggregate behavioral model.  There are other studies; Kashima
[6], Akabane[7], Sasaki[8] and so on.

     Few works have been made on car ownership in regions except for
metropolitan area or the regions near by.  The authors have interests
in car ownership in local region since it may have another aspect
that is different from the one in metropolitan region, because of
undeveloped mass transportation, another state of industrialization,
relatively low land price and so on.  That is the reason why the
authors selected the southern part of Okayama Prefecture as study
area.  The paper is concerned with the relationship between car
ownership in households and their characteristics in the area.


2.  SOME ASPECTS OF CAR OWNERSHIP

     The second person trip survey was carried out in 1982 in the
southern part of Okayama Prefecture in which four cities and a group
of towns and villages were included.  The part is 1250 km$^2$ by area
where nearly $1200 \times 10^3$ of people live.  The data used in our study
were supplied with by the survey.  The part is called study area
hereafter in this paper.

2.1  Car Ownership in the Study Area
     Fig. 1 shows two kinds of car ownership rates in four cities and
a group of towns and villages in the study area.  Car ownership rate
is defined by percentage of households having at least one car and
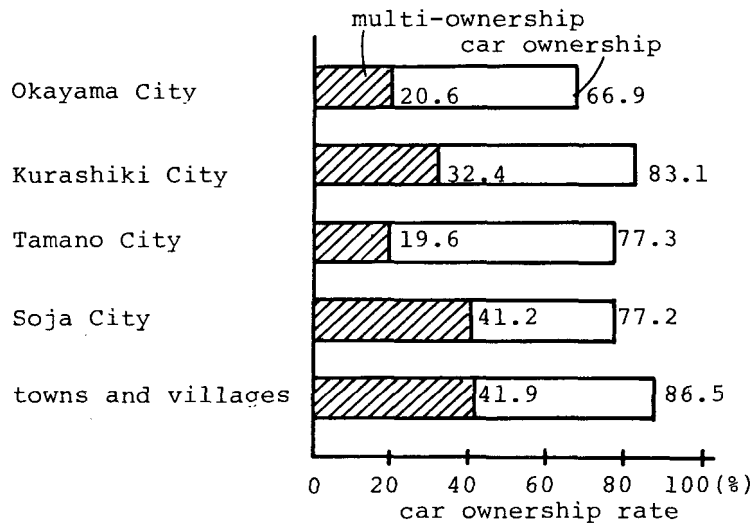multi-ownership rate by the one having at least two cars.

Fig. 1  Car ownership

Fig. 1 shows the followings;
(1) Car ownership is developed less in the cities than in towns and
villages.  Okayama City has the lowest car ownership rate among
cities since it is the most urbanised part in the study area, while
the group of towns and villages has the highest rate.
(2) Soja City and the group of towns and villages have the highest
multi-ownership rate, just over 40 percent, while Okayama and Tamano
Cities have nearly half of the rate.
(3) Some characteristic differences are suggested to exist between
households' behaviors in car owning in urbanised area and the ones in
nonurbanised area.

2.2  Car Ownership and Household Characteristics
     Fig. 2 (a),(b) and (c) show car ownership rate together with
multi-ownership rate, for household characteristics; the number of
driver licenses, family size and the number of workers.
     The followings are stated;
(1) There exists close relationship between the number of driver
licenses and car ownership, though a matter of course.
(2) The family size and the number of workers in a household also
have an influence on car ownership.. Fig. 2 (b) and (c) are similar
to each other.  That is, multi-ownership rate grows nearly linearly
with family size and the number of workers in a household, while car

ownership rate makes such a rapid growth in smaller family size or
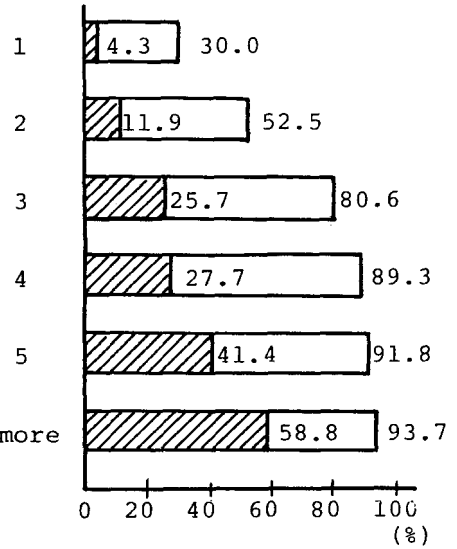the smaller number of workers.

(3) Fig. 2 (d) shows that certain difference in multi-ownership comes
out by grouping households by industry in which any one of the
workers in the household is engaged.  Note that a household having,
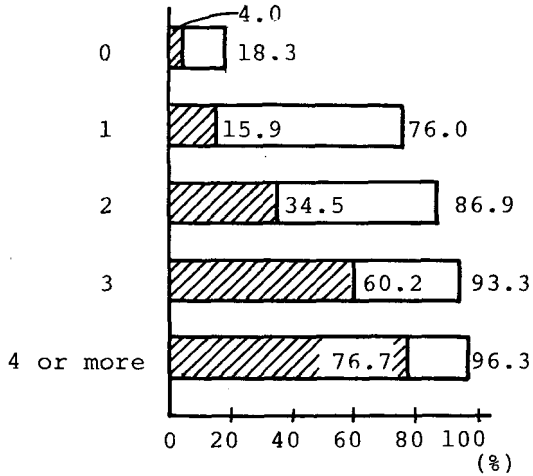
the number of
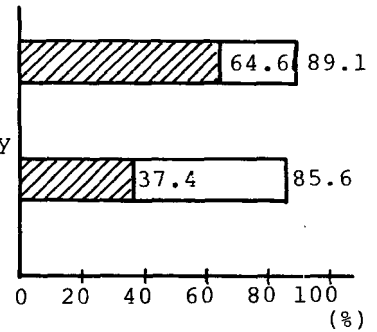driver licenses                              family size
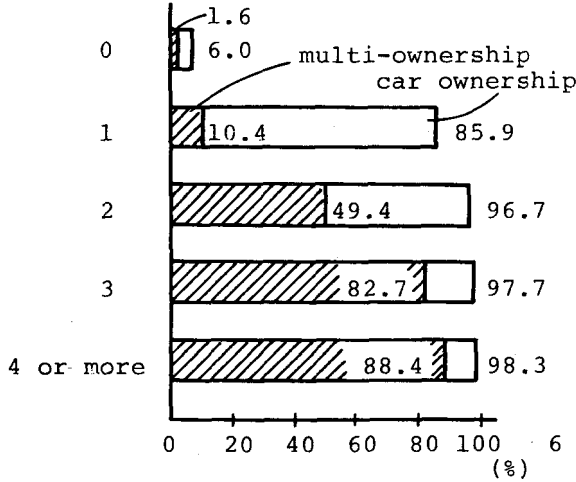


(a)  driver licenses

(b)  family size

the number of
    workers



(c)  workers

(d)  industry

Fig. 2  Car ownership rate for household characteristics

for instance, two workers one of whom is engaged in primary industry and the other in secondary is, for convenience, counted as the household of primary industry and the one of secondary, respectively.

Car ownership turned out to be described by some measure of urbanization and characteristic factors of households. These factors are used in the following.

## 3. CAR OWNERSHIP MODEL

Disaggregate behavioral modeling technique is applied to make some quantitative description of car ownership in the households.

### 3.1 Disaggregate Behavioral Model

One of the key assumptions in the theory of disaggregate behavioral model is that he chooses the one of maximum utility when he selects one from among alternatives. Mathmatical presentation is as follows;

Alternative i is chosen when

$$U_{in} > U_{jn}, \quad i \neq j, \quad i,j \in A_n \tag{1}$$

where

$U_{in}$; utility that an individual n gets by choosing alternative i,

$A_n$ ; a choice set given to an individual n.

$U_{in}$ is assumed random variable consisting of a deterministic and a random parts as follows;

$$U_{in} = V_{in} + \varepsilon_{in} \tag{2}$$

where

$V_{in}$; deterministic part

$\varepsilon_{in}$; random part.

Probability $P_{in}$ that an individual n chooses alternative i is expressed by

$$P_{in} = \text{Prob}(U_{in} > U_{jn}; \quad i \neq j, \quad i,j \in A_n)$$

$$= \text{Prob}(V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}; \quad i \neq j, \quad i,j \in A_n) \qquad (3)$$

Assuming that $\varepsilon_{in}$ follows Gumbel distribution, we get

$$P_{in} = \frac{\exp(V_{in})}{\sum\limits_{j \in A_n} \exp(V_{jn})} . \qquad (4)$$

This is called multinomial logit model. [9],[10]

Binary logit model is obtained as a special case of the model obtained above.  That is,

$$P_{1n} = \frac{1}{1 + \exp(-\lambda(\sum\limits_k \theta_k X_{1nk} - \sum\limits_k \theta_k X_{2nk}))} , \qquad (5)$$

$$P_{2n} = \frac{\exp(-\lambda \sum\limits_k \theta_k X_{2nk})}{1 + \exp(-\lambda(\sum\limits_k \theta_k X_{1nk} - \sum\limits_k \theta_k X_{2nk}))}$$

$$= 1 - P_{1n} , \qquad (6)$$

where

$\quad X_{ink}$ ; value of variable $X_k$ disaggregated to an individual n with respect to alternative i,

$\quad \theta_k$ and $\lambda$ ; parameter, but $\lambda = 1$.

Pay attention to the assumption that deterministic part of utilily is linear with respect to variables.

The model is specified by estimating the set of parameters. Maximum likelihood method is usually applied to estimate the parameters.

3.2  Model

It is most likely that a household owns one car at a time.  That is, a household has the first car at a certain time and the second at sometime later.  Our model of car ownership in the household consists of two submodels as shown in Fig. 3.  One is just like a discriminator that puts each household under study into any one of the two groups; no car group and car group.  Each of the latter group has at least one car.  The other does a similar thing, that is, it discriminates between household having one car and the one of two or
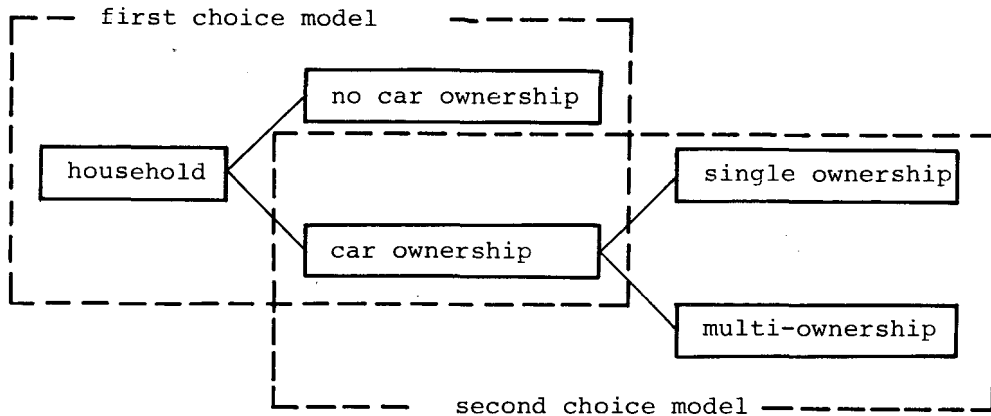
Fig. 3   Model

more cars.  The submodels are called first choice model and second
choice model, respectively, hereafter in this paper.

### 3.3   Parameter Estimation

The model was applied to predict car ownership of the household
in the study area.  The variables adopted are family size, the number
of workers in a household, the number of driver licenses in a
household and population density in a certain area where the
household is located.  The second variable, the number of workers, is
classified into two variables; the number of workers engaged in
primary industry and the one in secondary or tertiary industry.  The
reason of classification of the number of workers is that car
ownership is, as was seen in Fig. 2 (c) and (d), dependent on both
the number of workers and the kind of industry they are engaged in.
Population density is, though it is one of the aggregated regional
features, introduced in consideration of experiential fact that it
often affects car ownership as observed in Fig. 1.

Assuming that deterministic part V of utility is a linear
function of these variables, calculation was carried out to estimate
parameters.

The parameters estimated are shown in Table 1.
(1) The two submodels are satisfactorily significant since the value
of $\bar{\rho}^2$ and hit ratio are both large enough.
(2) The most influencing variable in the first choice model is, as a
matter of course, the number of driver licenses, which has the
largest t-value.  We can make use of this number in car ownership

forcasting.  The second most influencing variable in the first choice
model is family size that has the second largest t-value, while the
number of workers, both primary and secondary or tertiary, has only a
little influence upon car ownership
(3) As to the number of driver licenses in the second choice model,
nearly the same thing can be said as in the first choice model.
Concerning, however, t-value to both family size and the number of
workers, a remarkable contrast is seen between two models.  This
contrast is one of the important aspects of car ownership that we
have expected to find through this analysis.

Table 1.  Parameter Estimation

| model / variable | First choice model θ (t-value) | Second choice model θ (t-value) |
|---|---|---|
| family size | 0.256 (7.81) | 0.430 (1.55) |
| the number of workers | | |
|    primary industry | 0.240 (1.61) | 0.851 (9.53) |
|    secondary or tertiary industry | 0.172 (2.69) | 0.301 (6.60) |
| the number of driver licenses | 3.073 (34.15) | 1.569 (25.86) |
| population density | −0.000106 (−7.20) | −0.000152 (−8.72) |
| constant | −2.363 (−18.88) | −3.652 (−25.81) |
| $\bar{\rho}^2$ | 0.604 | 0.291 |
| hit ratio | (whole) 91.4 (%) | (whole) 77.2 (%) |
| | (car ownership) 98.4 (%) | (multi-cars) 55.7 (%) |
| | (no car) 70.6 (%) | (single car) 89.2 (%) |

(4) Attention is also to be paid to the finding that the value of parameter to primary industry is larger than that to secondary or tertiary, especially in the second choice model. This implies that utilily obtainable by owning second or third car is higher in the household of primary industry than in the household of the other industry.

(5) Population density has a significant contribution to car ownership in both the first and the second choice models. Negative signs in both of the models implies that inclination of people to be car owner is stronger in a sparsely inhabited zone than in a densely inhabited.

## 4. CONCLUDING REMARKS

Disaggregate behavioral method of analysis was applied to study relationship between car ownership and some household and regional characteristics. Though some of the results are what we had expected to get, it is also fact that there are some important aspects of car ownership left unanalyzed because of the limitation of the data available. For instance, ages of family members, annual income of households, some characteristics of the location of each household and so on were not available.

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