Examining the Variation of Household Vehicles Holding Behavior in the Chukyo Region in Japan

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Abstract

Japan began initial stage of motorization in 1960s. The motorization made life of human highly dependent on private cars. As a result, vehicle holding behavior in the household might have a change during this process. This study examines the variation of the household vehicles owning behavior in the Chukyo region in Japan. The vehicle type is classified into the light motor car and the ordinary motor one. Meanwhile, the impact of the ownership of trucks is not taken into consideration. The person trip survey data in 1971 and 2001 are used as the sample. A bivariate ordered probit model is proposed for analyzing the ownership of two types of private cars. Since the maximal likelihood estimation method was found to be low efficient, the Gibbs sampler algorithm is implemented in this study. The conclusions of this study are listed as follows. Firstly, age of the householder, numbers of workers and number of members (\(>=\) 25 years old) were significant factors with same effects both in 1971 and 2001. Secondly, gender of the householder, district, population density and density of railway stations changed their effects from 1971 to 2001. The households with female householder were unwilling to own the light motor car only in 1971. The residents living in Nagoya would not like to own the ordinary motor car in 2001. Population density and density of railway stations affected ownership of the light motor car only in 2001. Lastly, there was a substitution effect on ownership between the light motor car and the ordinary motor one only in 2001.

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1. Introduction

With the development of motorization society, the life of human has been highly dependent on the usage of private cars. Meanwhile, it may lead to many externalities to the environment of metropolitan, such as air pollution, traffic congestion and so on. The motorization may affect the vehicle utilization in the household in two aspects. On one hand, the number of vehicles has been increased obviously during the motorization process. On the other hand, the various types of vehicles has been designed and manufactured to satisfy the multiple purposes of usage.

Japanese car manufacturers have been improving their technology since 1955. As a result, the vehicle production increased drastically in the domestic market from 1965. From that time Japan has begun its motorization process. Although the world first oil crisis in 1973 might impact the automatic industry, Japan overcame this crisis by implementing strict cost reduction measures, energy and resource conservation initiatives, and unflagging export promotion efforts. Due to the bubble economy between 1987 and 1991, the vehicle production reached its peak at 13.5 million units in 1990 (Japan Automobile Manufacturers Association, 2013). Since Japanese car manufacturers were manufacturing affordable, reliable, and popular cars in the 1990s, Japan became the largest car manufacturing country in 2000.

In Japan the vehicles are mainly classified into the car and the truck. Moreover, the car is classified into the light motor car and the ordinary motor one. Meanwhile, the truck is classified into the light motor truck and the ordinary motor one. The household usually does not own a truck, since most of the activity demands can be satisfied by the light motor car or the ordinary motor one. The criterion of the light motor car is listed as follows (Japanese Ministry of Land, Infrastructure, Transportation and Tourism, 2012).
- The length is no more than 3.40 m.
- The width is no more than 1.48 m.
- The height is no more than 2.00 m.
- The displacement is no more than 660 cc.
- The capacity is no more than 4 seats.
- The cargo capacity is no more than 350 kg.

Compared to the ordinary motor car, the light motor one seems to be compact and environment-friendly. In the metropolitan area with an advanced subway or railway network, the merit of the light motor car seems obvious. The household could take the railway to commute or make a long-distance travel. Meanwhile, the short distance trip could be satisfied by the light motor car. The low displacement of it can help to relieve the problem of global warming. The Japanese government had carried out the policy on vehicle tax exemption (Japanese Ministry of Land, Infrastructure, Transportation and Tourism, 2013) to promote the purchase and usage of the light motor vehicle. Before prevailing of the next generation vehicles including plug-in hybrid electric vehicles, fuel cell ones and so on, the light motor car is treated as an ideal transportation mode for its eco-friendly merit.

The disaggregated behavioral models including nested logit model and multivariate ordered probit model were utilized in the previous studies to examine the vehicle ownership and type in the household level. Some studies utilized the nested logit structure (Feng et al., 2005; West, 2004). The upper level in the nest is representing the vehicle number in the household, while the combination of vehicle types conditional on the fixed number of vehicles is listed in the lower level. Others would prefer to employ the multivariate ordered probit model to analyze the vehicle ownership and type in the household level (Fang, 2008; Yang et al., 2013).

Since the different classification of household vehicle types was in Japan compared to other countries, previous studies concerning the light motor car are very limited. The study proposed by Kobayashi et al. (2009) extended the BMOPT model proposed by Fang (2008) to analyze the ownership and usage of the light motor car and the ordinary motor one in the household. The sample was the data of national wide road traffic census in 1999 and 2005 in Japan. Their study observed impact of the population density and the accessibility of the railway system on the vehicles type and ownership. The population density or residential density was found to be an important factor for the vehicle ownership and usage in the household (Kobayashi et al., 2009; Fang, 2008). Meanwhile, the railway accessibility was seldom investigated as the explanatory variable in the proposed model on vehicle type choice in previous studies.

This study aims to reveal the household preference of owning the light motor car and the ordinary motor one in the household in the Chukyo region in Japan. Meanwhile, it also examines the variation of vehicle holding behavior
in the household from 1971 to 2001. In order to examine the impact of accessibility to the railway system on vehicle ownership, we prefer to use the density of railway stations as the explanatory variable rather than the number of the railway stations (Kobayashi et al., 2009). Since the truck is seldom owned by the household, the ownership of it is not considered in this study.

We utilize a bivariate ordered probit model (Greene, 2011) to model two types of vehicles in the household. The relationship between the light motor car and the ordinary motor one is measured by the correlation ratio of the error items. The Gibbs sampler algorithm is implemented in this study to estimate the parameters effectively and efficiently. The person trip survey data in this region in 1971 and 2001 are utilized to estimate the parameters in the model, respectively. The discussion of estimation results is carried out to understand the variation of vehicle holding behavior in the household.

The rest of this paper is organized as follows. Section 2 describes the basic statistic of sample data, and compares the aggregation results to analyze the variation of vehicle ownership in the household from 1971 to 2001. Section 3 describes the bivariate ordered probit model proposed in this study, the explanatory variables and the Gibbs sampler algorithm in this study. The estimation results of this model using the sample in 1971 and 2001 are shown in Section 4, along with a discussion based on the results. Finally, this study is concluded in Section 5 along with a discussion about future issues.

2. Data

The person trip survey data in 1971 and 2001 are used in this study. The data in 1971 is corresponding to the initial stage of the motorization society in Japan. Meanwhile, the data in 2001 is corresponding to the advanced stage of the motorization society. The Chukyo region is the third metropolitan region in Japan. It is supposed that it can represent the motorization process of motorization society in this study. There are four times of the person trip survey carried out in the Chukyo region. Since only the surveys in 1971 and 2001 classified the private car into the light motor car and the ordinary motor one, the survey data in 1981 and 1991 cannot be utilized in this study. The survey data in 2001 contained more areas than that in 1971, the research area is confined to the survey area in 1971. We use the criterion of city, district, town and village to divide the research area into 111 zone units, since the original small zones in 1971 and 2001 could not be matched exactly. The basic statistic of attributes of household characteristics in 1971 and 2001 are shown in Table 1.

Compared to the gender of householders in 1971, the ratio of male householders nearly does not change in 2001. Around 83% of the householders are male. For the age of householders, the householders over 60 years old take a ratio of about 36.3% in 2001. The ratio of them is only about 15.2% in 1971. It might indicate the aging problem in Japan. The sample distribution of different districts nearly keeps unchanged. The households with more than 3 members at a ratio of nearly 32% decreased, compared to that in 1971 around 53%. It might indicate that constitute of the household became smaller than before. This might be a crucial factor for the vehicle choice, since the more members in the household can induce more travel demand. The ratio of unemployed householders increased dramatically compared to that in 1971, since the aged householders take a ratio of 36.3%.

Table 2 shows the cross aggregation result concerning the vehicle ownership. As the initial stage of motorization in 1971, the private car was not prevailing in that time. About 77.18% of the investigated households did not own the light motor car or the ordinary motor one. Only 1.01% of the household would like to own these two types of cars at home. Around 6.41% of households owned the light motor car in the household. Meanwhile, the ratio of households owning the ordinary motor car was higher than that of the light motor car at a ratio of around 17.41%.

Compared to the tabulation result in 1971, the ownership of these two kinds of private cars changed dramatically. Only 19.15% of households investigated in 2001 did not owning any private cars. Meanwhile, households owning these two kinds of private cars increased obviously from 1.01% to 19.08%. Compared to the ratio of households owning the light motor car in 1971, this ratio increased around 3 times from 6.41% to 24.05%. The ratio of households owning the ordinary motor car increased from 17.41% in 1971 to 75.89% in 2001.
Table 1. Basic statistic of the sample data in 1971 and 2001

| Attribute                          | Percentage [1971] | Percentage [2001] |
|-----------------------------------|-------------------|-------------------|
| Gender of the householder         |                   |                   |
| Male                              | 82.8%             | 82.5%             |
| Female                            | 17.2%             | 17.5%             |
| Age of the householder            |                   |                   |
| <= 19 years old                   | 4.8%              | 0.4%              |
| >= 20 & <= 29 years old           | 18.3%             | 7.6%              |
| >= 30 & <= 39 years old           | 26.9%             | 15.9%             |
| >= 40 & <= 49 years old           | 20.6%             | 16.4%             |
| >= 50 & <= 59 years old           | 14.2%             | 23.4%             |
| >= 60 years old                   | 15.2%             | 36.3%             |
| District                          |                   |                   |
| Nagoya                            | 34.3%             | 32.1%             |
| Aichi (Excluding Nagoya)          | 44.7%             | 45.9%             |
| Mie                               | 5.9%              | 7.2%              |
| Gifu                              | 15.1%             | 14.8%             |
| Household member                  |                   |                   |
| 1                                 | 17.1%             | 19.1%             |
| 2                                 | 11.5%             | 29.9%             |
| 3                                 | 19.0%             | 19.4%             |
| 4                                 | 27.8%             | 18.6%             |
| 5                                 | 13.4%             | 8.0%              |
| >=6                               | 11.3%             | 5.0%              |
| Occupation of the householder     |                   |                   |
| Farmer                            | 5.2%              | 1.8%              |
| Production worker                 | 32.3%             | 17.3%             |
| Salesman                          | 5.4%              | 6.2%              |
| Servicer                          | 8.1%              | 6.8%              |
| Communication worker              | 10.5%             | 4.2%              |
| Security worker                   | 9.5%              | 1.2%              |
| Clerical officer                  | 0.2%              | 7.0%              |
| Engineer                          | 6.3%              | 14.0%             |
| Manager                           | 8.8%              | 9.6%              |
| Other officers                    | 1.3%              | 5.1%              |
| No occupation                     | 12.4%             | 26.8%             |
Table 2. Tabulation of vehicle ownership

| Sample in 1971 [N=64416] | Number of ordinary motor cars |
|----------------------------|-------------------------------|
|                            | 0    | 1    | >=2  | Total |
| Number of light motor vehicle |     |      |      |       |
| 0                          | 0.7718 | 0.1514 | 0.0126 | 0.9358 |
| 1                          | 0.0525 | 0.0077 | 0.0012 | 0.0613 |
| >=2                        | 0.0017 | 0.0006 | 0.0006 | 0.0029 |
| Total                      | 0.8259 | 0.1597 | 0.0144 | 1.0000 |

| Sample in 2001 [N=85047] | Number of ordinary motor cars |
|----------------------------|-------------------------------|
|                            | 0    | 1    | >=2  | Total |
| Number of light motor vehicle |     |      |      |       |
| 0                          | 0.1915 | 0.3593 | 0.2087 | 0.7595 |
| 1                          | 0.0429 | 0.1260 | 0.0467 | 0.2157 |
| >=2                        | 0.0067 | 0.0112 | 0.0069 | 0.0248 |
| Total                      | 0.2411 | 0.4965 | 0.2624 | 1.0000 |

3. Model Instruction

3.1. Model Specification

Let two latent continuous variables \( y_{1i}^* \) and \( y_{2i}^* \) represent the preference for holding the light motor car and the ordinary motor one, respectively. The equation system for discrete choice of these two types of cars is represented as follows.

\[
\begin{align*}
    y_{1i}^* &= x_{1i}^T \beta_1 + \epsilon_{1i} \\
    y_{2i}^* &= x_{2i}^T \beta_2 + \epsilon_{2i}
\end{align*}
\]

where,

- \( i \) : indexing the household in the sample (\( i = 1, \ldots, N \)),
- \( k \) : the list number of the equation (\( k = 1, 2 \)),
- \( x_{ki} \) : the vector of explanatory variables in the \( k \)th equation for the household \( i \),
- \( \beta_k \) : the vector of parameters in the \( k \)th equation, and
- \( \epsilon_{ki} \) : the error item in the \( k \)th equation for the household \( i \).

These two equations system concerning the latent variables can be written into a seemingly unrelated regression form (Koop, 2003) as follows.

\[
\begin{align*}
    y_{1i}^* &= x_i^T \beta + \epsilon_i
\end{align*}
\]

where, the error vector has an independent and identical bivariate normal distribution with zero means and unrestricted covariance matrix represented as follows.

\[
\begin{align*}
    \epsilon_i &\sim i.i.d. \text{MVN}(0, \Sigma)
\end{align*}
\]

The relationship between latent variables and observed ones is illustrated as follows.
where, $\alpha_{11}$ and $\alpha_{12}$ are the threshold values of the ordered probit model which is used to measure the ownership of light motor cars. For constraining the lowest and highest threshold values is equivalent to constraining one cut point and the variance for identification when the ordered probit model is estimated (Nandram and Chen, 1996). In this study we utilize the same setting method in Fang’s study. $\alpha_{11}$ and $\alpha_{12}$ are set to be -0.431 ($\Phi^{-1}(1/3)$) and 0.431 ($\Phi^{-1}(1/3)$), respectively ($\Phi^{-1}$ indicates the inverse of normal cumulative density function). The same setting method can be applied to the threshold values $\alpha_{21}$ and $\alpha_{22}$ in the ordered probit model measuring the ownership of ordinary motor cars.

3.2. Model Estimation

Since the sample share of households owned more than one light motor car were very small shown in Table 2, the maximal likelihood estimation method seems low efficient. In this study we utilize the Bayesian Markov Chain Monte Carlo method (Brooks et al., 2011) to estimate parameters. We implement the Gibbs sampler algorithm to draw random numerical value or matrix from the conditional distribution for latent variables $y_i^*$ and unknown parameters $\beta$ and $\Sigma$. Each iteration of the Gibbs sampler is conducted by the order of $y_i^*$, $\beta$ and $\Sigma$ listed as follows.

\[ y_i^* \mid \beta, \Sigma, y_i \sim \pi(y_i^* \mid \beta^{(k-1)}, \Sigma^{(k-1)}, y_i) \]  
\[ \beta \mid \Sigma, y_i^* \sim \pi(\beta \mid \Sigma^{(k-1)}, y_i^{(k)}) \]  
\[ \Sigma \mid y_i^*, \beta \sim \pi(\Sigma \mid y_i^{(k)}, \beta^{(k)}) \]

where,

$\pi$: the conditional posterior distribution, and

$k$: the order of the iteration in the Gibbs sampler.

Sampling the latent variables $y_i^*$ from the truncated multivariate normal distribution can be realized through drawing from a series of full conditional distribution of each element of $y_i^*$ given all the other variables (Geweke, 1991). It is not difficult to prove that equations 9-10 can draw a sample from the full conditional distribution for $y_i^*$, respectively.

\[
y_i^* = \begin{cases} 
\mu_{y_i} + \sigma_{y_i} \Phi^+(U(1-\Phi((-0.431 - \mu_{y_i}) / \sigma_{y_i})) + \Phi((-0.431 - \mu_{y_i}) / \sigma_{y_i})), & \text{if } y_i \geq 2 \\
\mu_{y_i} + \sigma_{y_i} \Phi^+(U(\Phi((-0.431 - \mu_{y_i}) / \sigma_{y_i})) - \Phi((-0.431 - \mu_{y_i}) / \sigma_{y_i})) + \Phi((-0.431 - \mu_{y_i}) / \sigma_{y_i})), & \text{if } y_i = 1 \\
\mu_{y_i} + \sigma_{y_i} \Phi^+(U(\Phi((-0.431 - \mu_{y_i}) / \sigma_{y_i}))), & \text{if } y_i = 0 
\end{cases}
\]
where,

- $U$: a random variable following the uniform distribution between 0 and 1,
- $\mu_{j-1}$: the mean of equation $j$ fully conditional on the other equation, and
- $\sigma_{j-1}$: the standard variance of equation $j$ fully conditional on the other equation.

The calculation of the full conditional mean and variance is equally straightforward according to Poirier (1995). If the prior distribution of $\beta$ is multivariate normal distribution with the mean $\beta_0$ and the covariance matrix $V_0$, it is not difficult to derive the conditional posterior distribution of $\beta$ illustrated as follows.

$$ \beta | y^*_i, \Sigma - N(\tilde{\beta}, \tilde{V}) $$

$$ \tilde{V} = (V_0^{-1} + \sum_{i=1}^N x_i^T \Sigma^{-1} x_i)^{-1} $$

$$ \tilde{\beta} = \tilde{V}(V_0^{-1} \beta_0 + \sum_{i=1}^N x_i^T \Sigma^{-1} y^*_i) $$

where, $N$ is the number of households in the sample. Sampling from a multivariate normal distribution can be implemented referring to the method mentioned by Greene (2011). We set $\beta_0$ to be a column vector of zeros, and $V_0$ to be diagonal matrix with 1000 on the diagonal. If the prior distribution of $\Sigma$ is supposed to be an Inverse-Wishart distribution with the freedom $v$ and the scale matrix $\Psi$, the conditional posterior distribution can be derived as follows.

$$ \Sigma | y^*_i, \beta - W^{-1}(v + N, \sum_{i=1}^N (y^*_i - x_i \beta)(y^*_i - x_i \beta)^T + \Psi) $$

where, $W^{-1}$ represents the Inverse-Wishart distribution. We set $v$ to be 10, and $\Psi$ to be an identical matrix. The generation of matrix following the Inverse-Wishart distribution is implemented by Bartlett decomposition (Smith and Hocking, 1972).

We use GAUSS 3.2 to implement the Gibbs sampler algorithm illustrated above. We take 11000 times of iterations and burn the first 10000 times. The remaining 10000 draws are used to estimate parameters of the posterior inference. Meanwhile, the Geweke diagnostic test indicates a high degree of convergence and accuracy within the number of iterations. Compared to the maximal likelihood estimation method, the Gibbs sampler algorithm implemented in this study is found to be more effective and efficient.

### 3.3. Explanatory Variables

The household specific variables and neighborhood variables are included in the model. The household specific variables are derived from the individual attributes for each household in the person trip survey data. The neighborhood variables are calculated by the unit of the divided zone. The explanation of these explanatory variables is listed in Table 3.
Table 3. Explanatory variables

| Name                  | Description                                                                 |
|-----------------------|-----------------------------------------------------------------------------|
| Nagoya (dummy)        | 1 if the household is in Nagoya; 0 otherwise.                               |
| Age (dummy)           | 1 if age of the householder is 60 years older or above; 0 otherwise.        |
| Workers               | Number of workers in the household                                          |
| Member25              | Number of family members in the household (>= 25 years old)                |
| Female (dummy)        | 1 if the householder is female; 0 otherwise.                                |
| Log (population density) | The population density is calculated based on the zone level using the person trip survey data. |
| Density of railway stations | The number of railway stations divides area (unit: km²) based on the zone level. The area of the zones in this study is coming from the digital map. |

4. Results and Discussion

In order to examine the variation of the vehicle holding behavior, we estimated the model using the data in 1971 and 2001, respectively. Then we compared the difference of the estimated parameters to observe explanatory variables which had changed its effect. The estimation results of these two samples are shown in Table 4 and Table 5, respectively.

Table 4. Model estimation result [1971]

| Explanatory variable       | Light motor car |                  | Ordinary motor car |                  |
|----------------------------|-----------------|------------------|---------------------|------------------|
|                            | Parameter       | T-statistic      | Parameter           | T-statistic      |
| Nagoya (dummy)             | -0.059          | -2.90            | 0.022               | 1.46             |
| Age (dummy)                | -0.083          | -5.12            | -0.061              | -5.08            |
| Workers                    | 0.016           | 2.64             | 0.027               | 6.12             |
| Member25                   | 0.059           | 8.78             | 0.053               | 10.86            |
| Female (dummy)             | -0.090          | -5.55            | -0.089              | -7.36            |
| Log (population density)   | -0.010          | -0.93            | -0.021              | -2.58            |
| Density of railway stations| -0.035          | -1.02            | -0.081              | -3.26            |
| Constant                   | -1.488          | -18.55           | -1.020              | -17.45           |

For the ownership of the light motor car, district, age of the householder, number of workers, number of members (>= 25 years old) were important factors both in 1971 and 2001 and had the same sign. The gender of householder was found to be a significant factor only in 1971. It might indicate that the household with the female owner was not reluctant to own the light motor vehicle compares to that in 1971, due to the impact of motorization society. The population density and density of railway station were found to be significant factors only in 2001. It was shown that these two factors did not affect the ownership of the light motor car in 1971. It might indicate two facts mentioned as follows. Firstly, the differential in income between urbanized area and rural area widened from 1971 to 2001 and the households in urbanized area preferred ordinary motor car to light motor car, since the light motor car was cheaper than the ordinary motor one. Secondary, along with the development of public transportation network in the urbanized area, it became unnecessary for households in such area to save money for operating the light motor vehicles. The alternative specified constant of the light motor car in 2001 was found to be minus sign with the 1%
significance level indicated that in general the households did not have a preference to own or not to own light motor cars in 2001, due to the impact of the motorization society.

Table 5. Model estimation result [2001]

| Explanatory variable      | Light motor car |          | Ordinary motor car |          |
|---------------------------|-----------------|----------|---------------------|----------|
|                           | Parameter       | T-statistic | Parameter       | T-statistic |
| Nagoya (dummy)            | -0.145          | -11.29   | -0.057              | -6.75    |
| Age (dummy)               | -0.178          | -25.02   | -0.258              | -53.91   |
| Workers                   | 0.090           | 23.85    | 0.163               | 58.91    |
| Member25                  | 0.126           | 30.12    | 0.226               | 73.54    |
| Female (dummy)            | -0.010          | -1.04    | -0.206              | -34.64   |
| Log (population density)  | -0.149          | -22.61   | -0.019              | -3.94    |
| Density of railway stations | -0.093         | -3.15    | -0.301              | -16.79   |
| Constant                  | 0.016           | 0.33     | -0.313              | -8.61    |
| Variance of the light motor car | 0.370     |          | 68.70               |          |
| Covariance                | -0.114          |          | -60.91              |          |
| Variance of the ordinary motor car | 0.240   |          | 120.64              |          |
| Number of samples         | 85047           |          |                     |          |

For the ownership of the ordinary motor car, age of the householder, number of workers, number of member (>= 25 years old), gender of the householder, population density, and density of railway stations were significant factors both in 1971 and 2001 and had the same sigh. The explanatory variable Nagoya (dummy) was significant only in 2001. It indicated that there was an obvious difference of ownership of the ordinary motor car between the areas inside and outside Nagoya, due to the realization of motorization society. The residents living in Nagoya were unwilling to own the ordinary motor car in 2001, since the subway system in Nagoya was efficient and effective in 2001.

According to the estimation results of the samples in 1971 and 2001, it was found that the substitution effect on ownership between the light motor car and the ordinary motor one only existed in 2001. The estimation results showed us that the motorization process in this region impacted the ownership of the light motor vehicle more obviously than that of the ordinary motor one, since there are more factors changing effects from 1971 to 2001. It might indicate that the light motor vehicle was become more and more popular during the process of motorization society especially for the female householder, for its cheap price and low displacement. With the development of motorization society, the ownership of the ordinary motor vehicles inside Nagoya and outside Nagoya has turned up an obvious difference. It indicated the fact that as the center of the Chukyo region, Nagoya had smaller number of ordinary vehicles than other districts, compared to that in 1971. This might result from the fact that the sufficient subway or railway system in Nagoya had a significant effect on the ownership of ordinary motor vehicles. As a result, the household living here was unwilling to own one ordinary motor vehicle.

5. Conclusions

This study analyzed the variation of vehicle holding behavior in the Chukyo region in Japan from 1971 to 2001. The vehicle type was classified into the light motor car and the ordinary motor one. The impact of the truck in the household was not taken into consideration. The 1st and 4th person trip survey data in this region were used in this study, which were collected in 1971 and 2001, respectively. A bivariate ordered probit model was applied to estimate the parameters of the proposed model using the data in 1971 and 2001, respectively. In order to estimate the model efficiently, the Gibbs sampler algorithm was implemented using GAUSS 3.2. The estimation results
suggested the importance of household and neighborhood characteristic factors in 1971 and 2001, as well as the variation of vehicle holding behavior in this region.

It was shown that age of the householder, number of workers, number of members (>= 25 years old) were the important factors for owning the light and ordinary motor car both in 1971 and 2001. The residence in Nagoya affected ownership of the light motor car in 1971 and 2001. Meanwhile, it affected ownership of the ordinary motor car only in 2001. The gender of the household impacted the ownership of ordinary motor cars in 1971 and 2001. Meanwhile, it only impacted the ownership of light motor cars in 1971. The population density and density of railway stations were significant factors for ownership of the ordinary motor car in 1971 and 2001. They affected the ownership of the light motor car only in 2001. It was found that there was a substitution effect on the ownership between the light motor car and the ordinary motor one only in 2001.

As the future task, we will analyze impact of life stage or life style on the ownership of the light motor car in the household level. The proposed ordered probit model in this study will also be utilized in the next research work.

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