STRUCTURE OF CAR OWNERSHIP AND PLANNING OF PARKING FACILITIES IN HOUSING COMPLEX

Ki-Young LIM
Doctoral Course
Department of Civil Engineering
Kyushu University
6-10-1, Hakozaki, Higashi-ku, Fukuoka,
812- 81 Japan
Fax : +81-92-642-3278
E-mail : kylimaug@nuri.net

Takeshi CHISHAKI
Professor
Department of Civil Engineering
Kyushu University
6-10-1, Hakozaki, Higashi-ku, Fukuoka,
812- 81 Japan
Fax : +81-92-642-3276
E-mail : chishaki@civil.doc.kyushu-u.ac.jp

abstract : In housing complex, an illegal on-road parking are getting more serious because of the shortage of parking spaces. The problem is caused by inaccurate prediction of car ownership and insufficient installation of off-road parking spaces. In order to solve the parking problem in housing complex, this paper describes the relations among car ownership structure of a household, socio-economic characteristics, parking facilities and the life cycle stage which may be a effective element to explain the household's car ownership, using the survey data on car ownership and utilization of car at eight housing complexes in Fukuoka city in Japan.

1. INTRODUCTION

Recently, because of the increase of multi-car ownership households and the diversification of car use, the structure of car ownership has become complicated. In residential area, especially in housing complex, the traffic interference and the inconvenience at parking are occurred by the shortage of parking spaces and the illegal on-road parking. Therefore, it is a difficult problem whether the establishment of parking facilities as a safekeeping place in housing complex follows the demand of car ownership sufficiently or not. And, the direction of parking demand management should be also groped. Such parking problems in housing complex are caused by inaccurate prediction of car ownership and insufficient installation of parking spaces, which are different according to the characteristics of housing complex and the structure of household in apartment area[Kubota, 1992].

The previous studies on the car ownership can be generally divided into two groups, that is, one is the aggregate analysis of the area and the city level by Kain(1982) and Tanner(1979), and the other is the disaggregate behavioral model of household and individual level by Ben- Akiva et al(1974) and Lerman(1976). However, it is necessary to describe a household and an individual as analyzing unit in the structure of car ownership because they depend on the characteristics of household such as income, driving license holders in household and so on, and it is important to analyze in details the relations among household and individual characteristics and car ownership.

A concept of "Life Cycle Stage" of household will be also effective for the structural analysis of car ownership [Chicoine et al, 1984][Zimmerman, 1982]. And, the previous studies about car ownership based on the concept of life cycle stage were reported by Morichi et al(1984) and Sasaki et al(1986), which aimed at general household. However, the structure of car ownership of a household in housing complex is not sufficiently made clear, in which the parking problem is more serious and the car ownership is strictly restimited.

In order to examine the establishment standard of parking facilities for planed housing

complex, this paper studies the relations among the car ownership of household, socio-economic characteristics and parking facilities, using the concept of life cycle stage and the survey data at eight existing housing complexes in Fukuoka city, Japan.

2. OUTLINE OF THE SURVEY

The survey is designed to collect revenant data for analyzing the characteristics of household and the structure of car ownership. A set of questionnaire was distributed to every household in eight housing complexes, in which one is the questionnaire for household distributed to households, and the other for individuals to household members above the schoolchild. Moreover, the questions in the questionnaire for households and individuals are as shown in Table 1.

The survey was made on eight housing complexes in Fukuoka city, which were selected through considering the distance from downtown, the number of households, the establishment percentage of parking lots and the distance to the nearest railway station. In each complex, 100 households were choiced randomly.

As for the survey, the interviews visited a home, and requested questionnaire's cooperation.

Table 1. Questions for the household and the individuals

Household	Individual
1. Household composition formality	1. Occupation
2. Number of household members	2. Sex
3. Number of children	3. Age
4. Number of worker	4. Relation with householder
5. Annual income of household	5. Address
6. Habitation kind	6. Walking time to nearest station
7. Age of householder	7. Walking time to nearest bus stop
8. Sex of householder	8. Consciousness of usual expense of car
9. Occupation of householder	9. Consciousness of economical bear of car
10. Drive license possession by householder	10. Consciousness of crime prevention of car
11. Car number of possession	11. Consciousness of traffic trouble of car
* Only non-ownership household of car	12. Consciousness of wealth of car
12. Ownership career of car	13. Consciousness of convenience of car
* Only ownership household of car	
13. Main user of car	
14. Type of car by engine displacement	
15. Usual purpose of car	
16. Times of car using	

Table 2. Outline of housing complex and collected percentage in survey

Housing complex	Number of household members	Establishment percentage of parking space	Distance to the nearest railway station	Distance from downtown	Collected percentage in survey
Nata	1088	100%	0.1Km	10.7Km	74%
Wakaba	558	71	0.7	8.2	74
Katakasu	1152	51	0.8	1.8	62
Baikoen	503	65	2.0	2.8	74
Tsutsumi	906	73	3.8	5.1	75
Aburayama	464	97	4.8	6.2	78
Fukushige	810	60	1.5	7.2	79
Jurokawa	511	87	1.3	8.5	71

Only the cooperating household followed the procedure of keeping and collecting questionnaire. Also, the survey day was from the middle ten days of the month in April, 1996 to the last ten days in May, and the distribution and collection of questionnaire were implemented to four times in the total only on Saturday and Sunday.

The percentage of effective collection in each complex is 79% at the highest, 62% at the lowest and the total collecting percentage is 73%. Also, the households of questionnaire which can not have collected are due to refusal or absence. The outline of housing complexes and the collecting percentage of questionnaire are as in Table 2.

3. SETTING OF LIFE CYCLE STAGE

The life cycle in a household is the process of forming, growing, ripening and declining change of the household as marriage, birth, growth and independence of child, retirement and death of householder. The life cycle stage is one step that a household is divided into some steps, and it is composed of the characteristics of a household such as the relation, the age composition among household members. Therefore, if there is the same life cycle stage, it is possible to say that the household characteristics are the same.

There are some classification method on the life cycle stage, but the classification method by Transport Studies Unit at Oxford university, United Kingdom, is easy to understand and is clear in the definition. This method classifies household into eight steps in the existence or non-existence of child, the age of the youngest child and householder. Therefore, in this study, the classification method of TSU is accepted and each life cycle stage is definited as in Table 3. In this table, as for the household of single body, a part is contained in either of 1, 7 and 8 of the life cycle stage. In this classification, the sampled households which can be analyzed are 496.

Table 3. Description and Definition of Life Cycle Groups by TSU

LCS	Description of group	Definitive features
1	Younger (married) adults without children	Householder under 35 and no children
2	Household with pre-school children	All children under 5
3	Household with pre-school children and young school children	Youngest child under 5 and another child 5 or over
4	Household with young school children	Youngest child 5 or over but under 12
5	Household with older school children	Youngest child 12 or over but under 16
6	Household of adults, all of working age	Youngest child 16 or over
7	Older adults, no children	Householder over 35 unless in Group 8
8	Retired persons	Householder over 55 and non-worker

The composition rates of life cycle stages in every housing complex which were found from questionnaire are as shown in Figure 1. In each housing complex, the composition rates of life cycle stages are different. The composition rates of LCS6 are high in Nata and Wakaba and the composition rates of LCS7 are high in Baikoen, Tsutsumi and Aburayama.

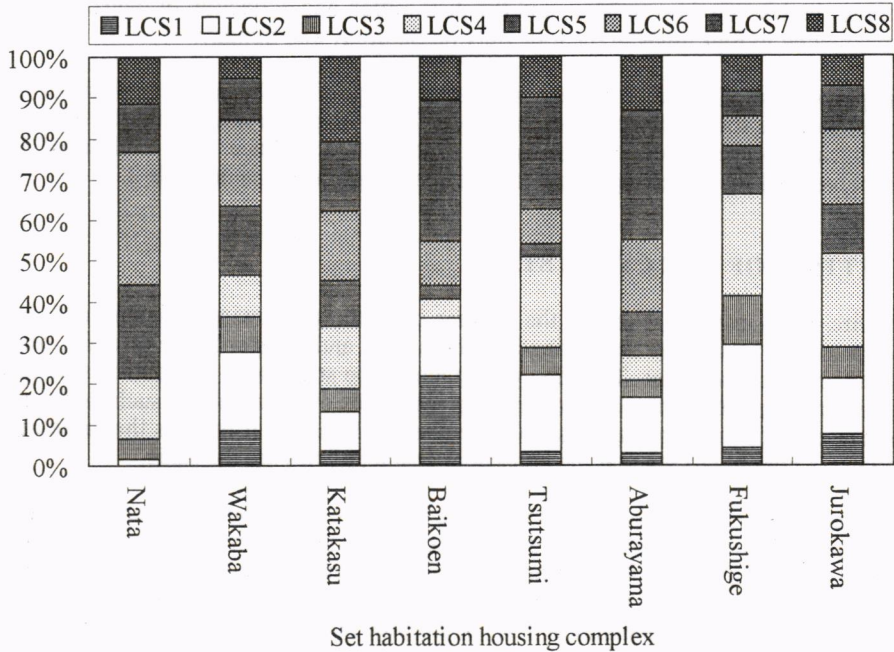Also, the composition rates of LCS8 are high in Katakasu and it is possible to say that there are many

Figure 1. Composition rates of life cycle stages in each housing complex

Table 4. Classification of housing complex by composition rates of life cycle stages

Group	LCS1	LCS2	LCS3	LCS4	LCS5	LCS6	LCS7	LCS8	Housing complex
A	21.9	14.1	0.0	4.7	3.1	10.9	34.4	10.9	Baikoen
B	6.8	19.3	9.4	19.8	13.5	15.1	8.9	7.3	Wakaba, Fukushige, Jurokawa
C	0.0	1.6	4.9	14.8	23.0	32.8	11.5	11.5	Nata
D	3.4	14.0	5.6	14.0	8.4	14.5	25.7	14.5	Katakasu, Tsutsumi, Aburayama

old household as a whole. In Fukushige, the households of LCS2 and LCS4 which belong to the young household account for 25.0% respectively, and the sum of the two kinds of households reach a half of total households. The households which correspond to LCS1 in the Nata and LCS3 in Baikoen were not obtained.

If the similarity of distribution of life cycle stages in each housing complex is classified by the cluster analysis, the housing complex can be divided into four group. The distribution situations of the life cycle stages in all kinds are given as in Table 4.

Group A is the housing complex of coexisting group, where is composed of the young household which the developing possibility by the generation of child is high, and the old household.

The household in group B is distributed over various life cycle stages, but LCS7 and 8 of the old household has fewer than the other groups. Wakaba, Fukushige and Jurokawa are included into Group B.

Also, group C which contains Nata is the housing complex, in which there are especially many households of LCS5 and LCS6, and the old household is coexisted.

In group D, there are few young households and ripened households and there are many old households. LCS2, 4, 6 and 8 are equally distributed about roughly 14%. Katakasu, Tsutsumi and Aburayama belong to Group D.

4. CHARACTERISTICS AND STRUCTURE ANALYSIS OF CAR OWNERSHIP

4.1 Relation with Traffic Environment Conditions

The percentage of car ownership in eight housing complexes are 61% to 86%. Figure 2 shows the relations between car ownership percentage and the distance to the nearest railway station, the distance from CBD in the city and the establishment percentage of parking space, respectively.

When seeing these, it seems not to be a distance to the nearest railway station in the relation, but for the distance from CBD, the more it goes to the suburbs, the higher the car ownership percentage becomes. That is, it is founded that the condition of the access to the railway station doesn't influence car ownership and that the distance from downtown influences more strongly.

Also, when seeing the relation with the establishment percentage of parking spaces, for the household of one car ownership, the special relation aren't seen. However, when the establishment percentage of parking space gets to be near 100%, the increasing tendency of the household of multi-car ownership can be.

4.2 Relation with Household Characteristics

The relations between car ownership percentage and annual income of household, the number of household members, the number of driving license of car ownership persons are shown in Figure 3. It is possible to say that the car ownership percentage tends to become high generally with the increase of income of household. Especially, in the household that annual income is equal to or more than 10,000,000 yen, the one car ownership households decreases, while the multi-car ownership households increase.

In the number of household composition members and driving license holders, the more the number of people is, the higher the car ownership percentage. Especially, when the number of driving license of car ownership persons exceeds three, multi-car ownership household becomes more than households of one car ownership.

The relations between the driving license of householder, and the type of habitation and the car ownership percentage are shown in Tables 5 and 6. It is possible to say clearly that the car ownership percentage of household which householders have the driving license is higher than the household which householders does not have the driving license.

Also, in the case of households of one car ownership, the car ownership percentage of condominium housing is high, but in the case of households of multi-car ownership, there is no difference between condominium housing and rental housing. On the whole, the car ownership percentage in the household is about 10% higher at the condominium housing than at the rental housing.

4.3 Relation with Life Cycle Stages

Fig.4 shows the relation between life cycle stage and car ownership percentages. The car ownership percentages from LCS1 to LCS6 is high, while the car ownership percentages in LCS7 and LCS8 decrease steeply. Among these, as for the household of LCS7, because the child was independent by marriage or employment, the car ownership percentages drops.

Also, there are many households of multi-car ownership in LCS6 which reached an age with all workable children compared with the others. This fact proves that the households with
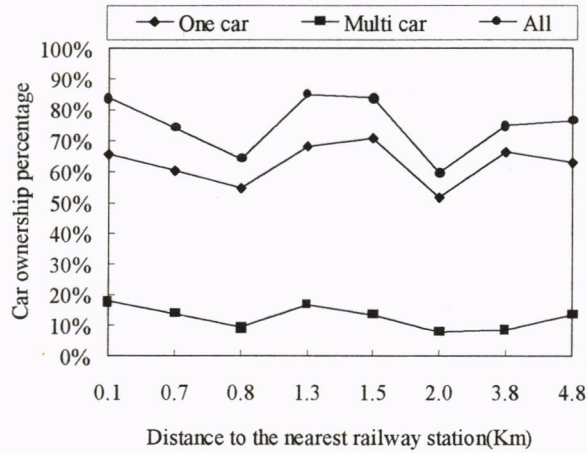
(a) Distance to the nearest railway station and car ownership
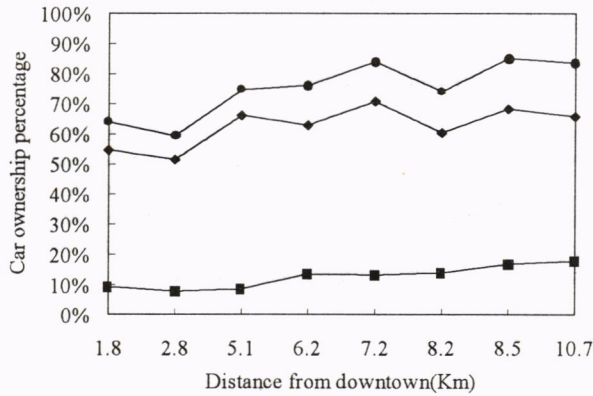
(b) Distance from CBD and car ownership
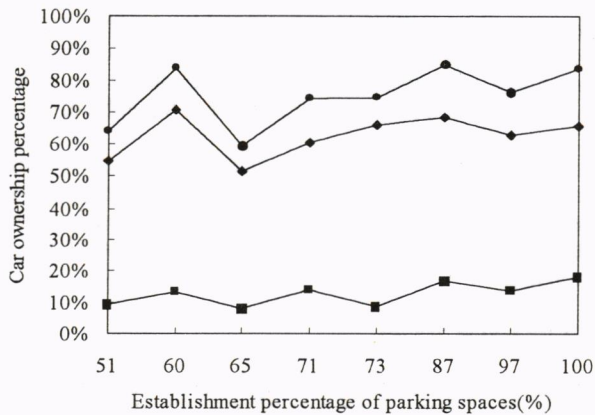
(c) Establishment percentage of parking spaces and car ownership
Figure 2. Conditions of housing complexes and car ownership percentages
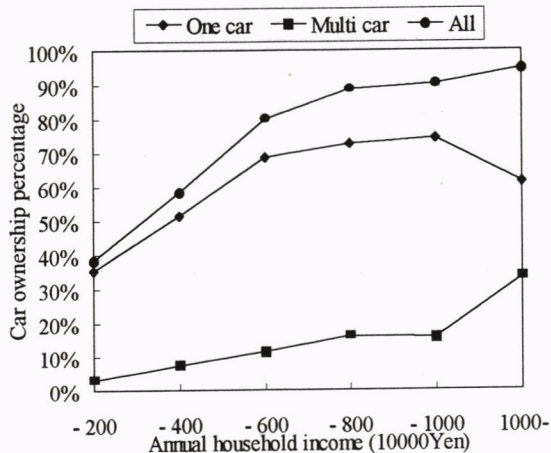
(a) Annual household income and car ownership percentage

(b) Number of members in a household and car ownership percentage

(c) Persons of driving license holders in a household and car ownership percentage

Figure 3. Household characteristics and car ownership percentage

Tables 5. Householder's driving license and car ownership percentage

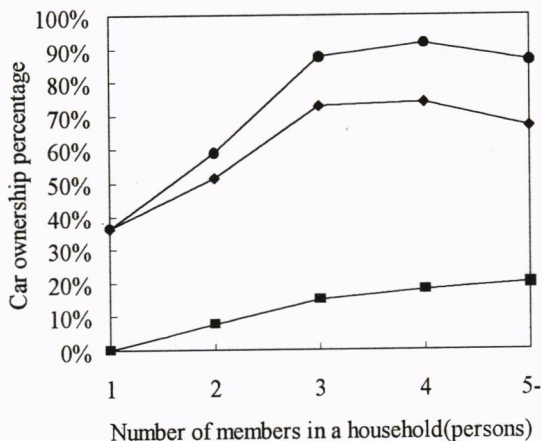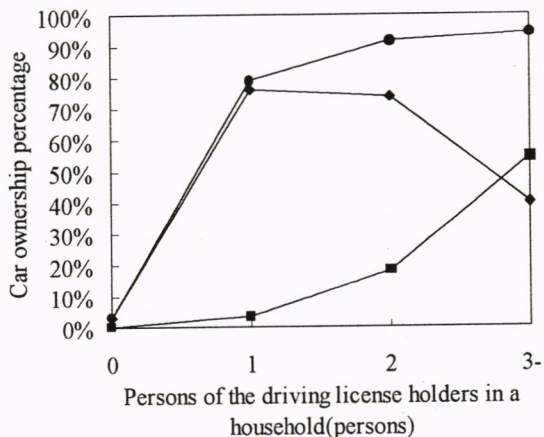|	License	No license
One car	72.9%	20.6%
Multi car	15.0%	3.1%
All	87.9%	23.7%

Table 6. Type of habitation and car ownership percentage

	Condominium	Rental
One car	69.0%	59.0%
Multi car	12.5%	12.8%
All	81.5%	71.8%
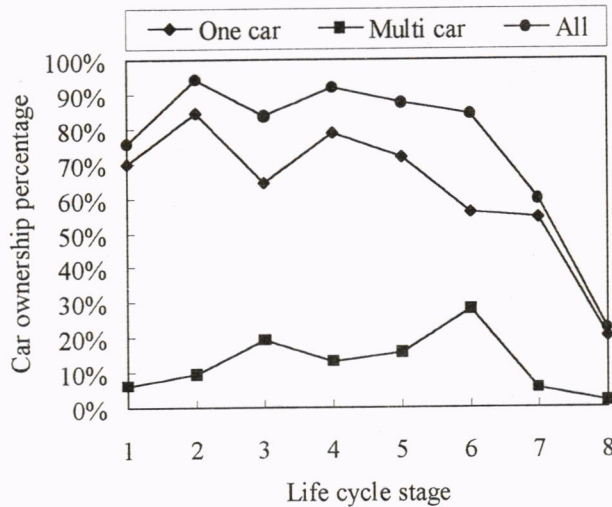
Figure 4. Life cycle stage and car ownership percentage

the 2nd car ownership according to the growth of the child increse.

5. STRUCTURE ANALYSIS OF CAR OWNERSHIP

5.1 Factor Analysis of Car Ownership and Car Non-ownership

Based on the explanation variables selected and categorized from the previous discussion, the ownership and the non-ownership of the car of a household is seen as an external criterion according to quantification theory II. In case of the car ownership household, we analyze the conditions of the multi-car ownership, too.

Table 7 shows the analysis results of the ownership and the non-ownership of car. The coefficient of correlation is 0.7221, the hit ratio is 86.1% for ownership, 80.9% for non-ownership. It is possible to say that the result is not so bad. Also, it agrees with contents as mentioned-above on the each category score.

It is seen that numbers of the driving license holders and life cycle stage have the comparative explanation powers in the ownership and the non-ownership of car. It can be understood that car driving license of the householder, the household annual income and the type of the habitation have explanation powers.

Table 7. Factor analysis by quantification theory II on car ownership and non-ownership

Item	Category	Frequency	Category score	Range (Partial correlation)
Number of driving license holders (persons)	0	67	1.4565	1.7741 (- 0.3378)
	1	183	- 0.1210	
	2	211	- 0.3176	
	Over 3	35	- 0.2407	
Household annual income (10,000Yen)	- 400	159	0.1664	0.5468 (- 0.1415)
	400 - 1000	298	- 0.0390	
	1000-	39	- 0.3804	
Type of habitation	Condominium	184	- 0.1644	0.2613 (- 0.1276)
	Rental	312	0.0969	
Driving license of the householder	Non-ownership	97	0.4966	0.6173 (0.1587)
	Ownership	399	- 0.1207	
Life cycle stage	1	33	0.1769	0.8105 (0.2350)
	2	72	- 0.3235	
	3	31	0.1209	
	4	75	- 0.2527	
	5	57	- 0.2368	
	6	82	- 0.0304	
	7	92	0.2429	
	8	54	0.4870	
External criterion	Non-ownership	122	1.2643	R=0.7221
	Ownership	374	- 0.4124	
Hit ratio	Non-ownership	80.9%		
	Ownership	86.1%		

Table 8. Factor analysis of quantification theory II on one car ownership and multi-car ownership

Item	Category	Frequency	Category score	Range (Partial correlation)
Number of driving license holders (Persons)	0	2	1.0711	3.4170 (0.3669)
	1	145	0.8422	
	2	194	- 0.2414	
	Over 3	33	- 2.3459	
Household annual income (10,000Yen)	- 400	86	0.0172	0.5468 (0.0763)
	400-1000	251	0.0706	
	1000-	37	- 0.5187	
Life cycle stage	1	25	0.4578	0.8105 (0.1173)
	2	68	0.3877	
	3	26	- 0.4656	
	4	69	0.0177	
	5	50	- 0.2220	
	6	69	- 0.1656	
	7	55	- 0.0483	
	8	12	- 0.1441	
External criterion	One car	311	0.1853	R=0.4117
	Multi car	63	- 0.9147	
Hit ratio	One car	63.7%		
	Multi car	79.4%		

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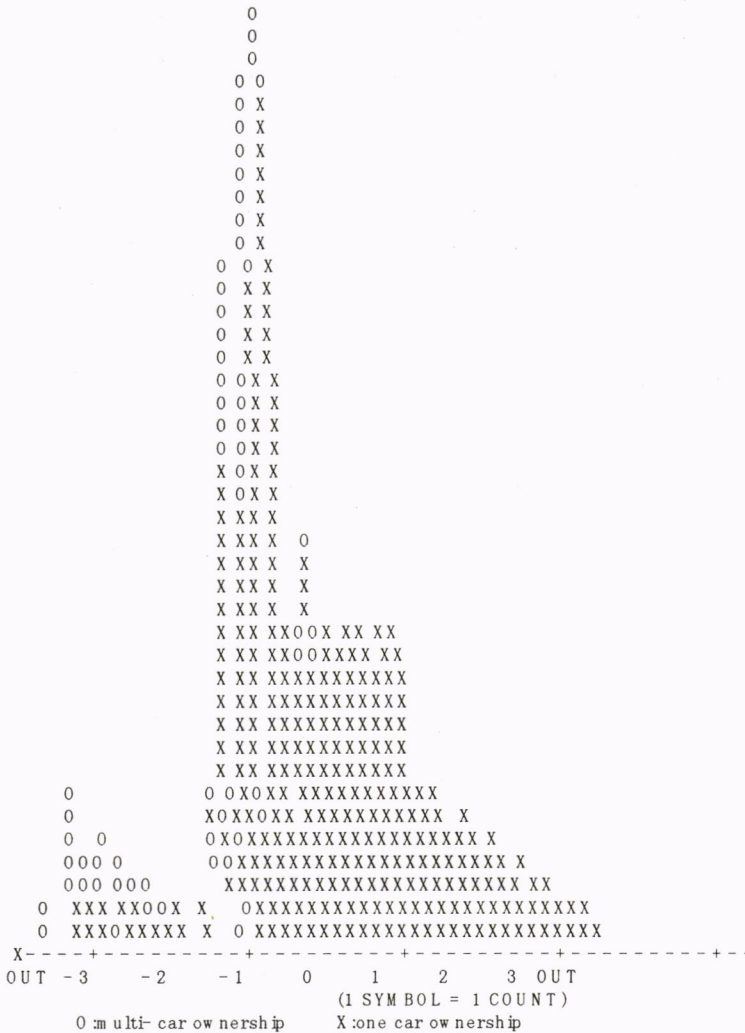
Figure 5. Score plot of one car ownership and multi-car ownership

Also, the result of factor analysis of one car ownership household and multi-car ownership household is shown in Table 8. The coefficient of correlation is 0.4117, so it is difficult to say that the precision is adequate. However, it is possible to say that there are explanation powers in number of ownership persons with car driving license, life cycle stage, household annual income to analyze one car ownership or multi-car ownership at least, as shown in Figure 5.

Also, it is possible to say that the possibility to become multi-car ownership is high when numbers of driving license holders are more than one, income of household is high and life cycle stage is equal to or more than category 3.

5.2 Prediction Model of The Probability of Car Ownership

Using the explanation variables which are gotten by the factor analysis of car ownership at the previous section, a prediction model of the probability of car ownership based on the logistic regression analysis is constructed as follows:

$$P=\frac{1}{1+e^{4.0368-1.0629X_1-0.3036X_2-0.9592X_3-2.1193X_4-0.6904X_5-2.3029X_6-0.6320X_7-1.9831X_8-1.8319X_9-1.3556X_{10}-0.5260X_{11}}}$$

(1)

where, X_1 : number of driving license holders (person)
X_2 : household annual income (1- 6, low=1, high=6)
X_3 : type of habitation (condominium=1, rental=0)
X_4 : car driving license of householder (ownership=1, non- ownership=0)
X_5 : LCS1=1, others are 0
X_6 : LCS2=1, others are 0
X_7 : LCS3=1, others are 0
X_8 : LCS4=1, others are 0
X_9 : LCS5=1, others are 0
X_{10} : LCS6=1, others are 0
X_{11} : LCS7=1, others are 0

When giving official approval to a degree of fitness, it is possible to say that the estimated formula is fitted as in Table 9.

Also, the classification table on car ownership, it is shown as in Table 10. The hit ratio of the non- ownership of the car is 63.11%, while the hit ratio of the car ownership is 95.72%. Moreover, the whole hit ratio is 87.70%.

Table 9. Goodness of fit of the model in car ownership

- 2LL	Chi- square	Df	Significance	Judgement
304.11	249.29	11	0.000	*

* : Rejected in 0.01

Table 10. Classification table in car ownership

Observed	Predicted		Hit
	Non-ownership	Ownership	ratio
Non-ownership	77	45	63.11%
Ownership	16	358	95.72%
Total	93	403	87.70%

The logistic regression analysis on multi-car ownership for car ownership household is also applied, and relevant result is obtained as follows:

$$P=\frac{1}{1+e^{4.3903-1.4719X_1}}$$

(2)

where, X_1 : number of driving license holders (person)

From the result of the analysis, it is possible to say that the gotten explanation variable is only numbers of driving license holder and they are fit as a result of official approval as shown in Table 11.

Table 11. Goodness of fit of the model in multi-car ownership

- 2LL	Chi- square	Df	Significance	Judgement
290.99	48.16	1	0.000	*

* : Rejected in 0.01

Table 12. Classification table in multi-car ownership

Observed	Predicted		Hit
	One car	Multi-car	ratio
One car	297	14	95.50%
Multi-car	44	19	30.16%
Total	341	33	84.49%

The classification table of multi-car ownership, it is also obtained as in Table 12. It is seen that the hit ratio of one car ownership is 95.50%, while the hit ratio of multi-car ownership percentage is 30.16%. The whole hit ratio is 84.49%.

6. RELATION BETWEEN CAR ONWNERSHIP AND PARKING FACILITIES

In every housing complex, the estimating number of car ownership based on the probability model of car ownership and the establishing number of parking facility are given in Table 13. In this study, it is merely supposed and estimated that the number of car ownership is two, because there are multi-car ownership household, but most of them have two car ownership.

The shortage number of parking facilities is an important index to develop parking facility according to the estimated number of car ownership. The shortage percentage of parking facilities is that the shortage number of parking facility is divided by the number of household. Seeing the shortage number of parking facility, it is clear that the parking facilities are insufficient in housing complex except for Aburayama.

In housing complex of group A, the shortage problem of parking facilities is supposed to get more serious with the growth of life cycle stage in future.

In housing complex of group B, the shortage percentage of parking facilities is higher than the other groups.

The housing complex in group C is rather shorting in parking facilities at present, but it is possible to say that the shortage problem of parking facilities will rather decrease through the development of life cycle stage in future.

It is seen that any more shortage problem of parking facilities doesn't occur for a while because there are many old households in housing complex of group D. However, when the household composition changes from group D to group A, it is considered that the shortage problem of parking facilities would happen again.

Table 13. Estimation of car ownership and parking facilities

Group	Housing complex name	Number of household	Estimated car ownership (stands)	Parking facilities establishment (stands)	Parking facilities shortage (stands)	Parking facilities shortage (%)
A	Baikoen	503	338	326	12	2.4
B	Wakaba	558	490	395	95	17.0
	Fukushige	810	786	485	301	37.2
	Jurokawa	511	519	444	75	14.7
C	Nata	1088	1105	1088	17	1.6
D	Katakasu	1152	847	590	257	22.3
	Tsutsumi	906	753	659	94	10.4
	Aburayama	464	415	450	-35	-7.5

Difference between car ownership percentage and establishment
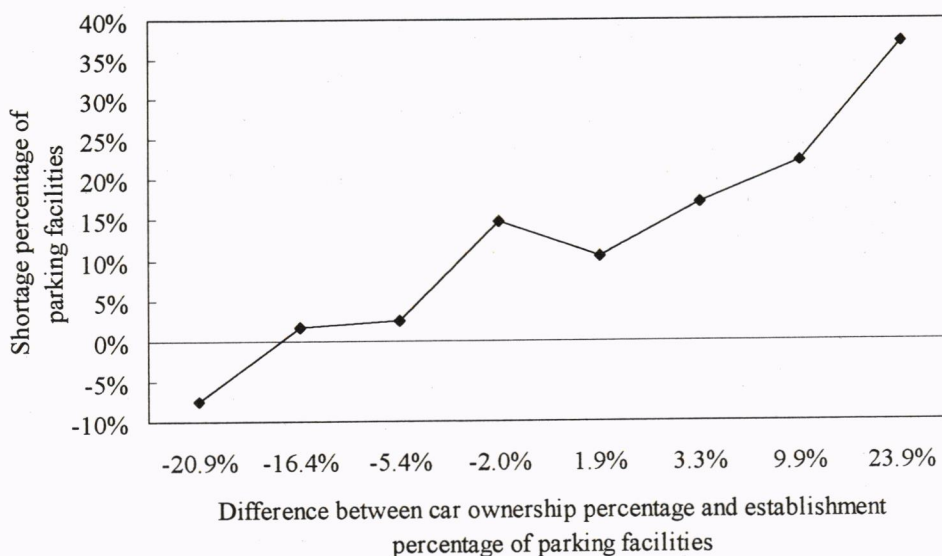percentage of parking facilities

Figure 6. Shortage percentage of the parking facilities in each housing complex

In each housing complex, the shortage percentage of parking facilities through the difference between car ownership percentage and establishment percentage of parking facilities is shown in Figure 6. It is seen that the shortage percentage of parking facilities becomes high when the difference between car ownership percentage and revenant establishment percentage of parking facilities becomes big. Therefore, the fact is described that the shortage problem of parking space can be solved whether restrain the car ownership of households in housing complex or build more parking space.

7. CONCLUSION

In this paper, the structure of car ownership under life cycle stage and parking facilities in housing complex is studied, and the following conclusions are obtained.

(1) The sampled housing complexes are divided into four groups if the similarity of the distribution of life cycle stage in each housing complex is classified by cluster analysis.

(2) The car ownership has no relation to the nearest railway station, but is related to the distance from CBD. Also, the one car ownership has no relation, but the multi-car ownership has relation to the establishment percentage of parking space.

(3) The more the annual income of household, the higher the car ownership. Especially, when the annual income of household exceeds 10,000,000Yen, multi-car ownership increases.

(4) For the number of members and driving license holders, the more the number of persons, the higher the car ownership. Especially, when the number of persons of driving license holders exceed 3 persons, multi-car ownership is high.

(5) When the householder has driving license, the car ownership is high. Also, in case of the household with one car ownership, the car ownership of condominium housing is high. In case of the households with multi-car ownership, there is no difference between condominium housing and rental housing.

(6) The car ownership from LCS1 to LCS6 is high, while LCS7 and 8 show that the car ownership is decreased.

(7) The explanation powers to the ownership and non-ownership of car are high in order of the number of driving license holders, life cycle stage, driving license of householder, annual income of household and type of habitation.
(8) The explanation factor of multi-car ownership in the formulated model in this paper is only the number of driving license holders.
(9) In housing complex of group A and B, the shortage problem of parking facilities will get more serious with the growth of life cycle stage in future. The shortage problem of parking facilities through the development of life cycle stage in future will be rather released in housing complex of group C and D.

REFERENCES

Ben-Akiva, M. and Lerman, S.R. (1974) Some Estimation Results of a Simultaneous Model of Auto Ownership and Mode Choice to Work, **Transportation 3**, Vol.3, No.4, 357- 376.

Chicoine, J.E. and Boyle, D.K. (1984) Life-Cycle Concept: A Practical Application to Transportation Planning, **TRR 987**, 1- 7.

Kain, J.F. (1982) Forecasting Car Ownership and Use, **Urban Studies**, Vol.2

Kubota, H. (1992) **Parking Space of Residential Area** (In Japanese), Toyota City Transportation Institute, Toyota.

Lerman, S.R. (1976) Location, Housing, Automobile Ownership, and Mode to Work: A Joint Choice Model, **TRR 610**, 6- 11.

Tanner, J.C. (1979) Car Ownership and Public Transport, Transport and Road Research Laboratory, **Supplementary Report 464**, UK.

Morichi, S., Tamura, T., Yai, T. and Kin, T. (1984) Analysis of Automobile Ownership and Use, **PAPERS on CITY PLANNING** (In Japanese), No.19, 49- 54.

Sasaki, T., Asakura, Y., Kimura, H. and Wada, A. (1986) Car Ownership and Usage in Relation to Household Life Cycle Stage, **PAPERS on CITY PLANNING** (In Japanese), No.21, 145- 150.

Zimmerman C.A. (1982) The Life Cycle Concept as a Tool for Travel Research, **Transportation 11**, 51- 69.