THE POSSIBILITY OF TRANSPORTATION DEMAND MANAGEMENT IN OSAKA METROPOLITAN AREA: PERSONAL TRIP BASED ANALYSIS

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Abstract: To relax urban traffic congestion, TDM (Transportation Demand Management) schemes should be paid close attention to. However, in Japan, examples are few, and careful attentions are needed in implementing the schemes. This study attempts to grasp the possibility of TDM schemes in Keihanshin area by using the 3rd Personal Trip Survey Data (PT data) of Keihanshin District. Firstly, by the segmentation of the samples with the factors that may effect on the drivers commuting modal choice, the reasons why they drive to work are investigated. Secondly, by using the factors that may effect on the drivers commuting modal choice, modal choice logit model is constructed. Thirdly, the change of the choice probability by the change of the ratio of the samples that fit each factor is considered by the sensitivity analysis. Through these analyses, the feasibility of the TDM schemes at Osaka Metropolitan Area is discussed.

1. INTRODUCTION

Due to the increasing demand of the automobile use in recent years, urban traffic congestion becomes more and more serious. The traffic congestion not only causes personal problems such as loss of time, cost and mental composure, but also serious social problems of such as traffic accidents and air pollution. To relief traffic congestion, increasing traffic capacities by constructing new roads used to be the common strategy. However, increasing traffic capacity can never catch up with the speed of automobile increase, and furthermore, the new road construction may result in the increase of traffic demands. In addition, in the metropolitan areas, it is extremely difficult because of the spatial restrictions to construct new roads.

Recently, the environmental conservation is addressed to be a world-wide concern, and the automobile is regarded as one of the major sources of environmental destruction. The traffic control policies that follow to the amount of the traffic demands has broken down, and the new policies that manage the traffic demands are needed. TDM (Transportation Demand Management) is a usable strategy to relax the traffic congestion. TDM suggests reducing transportation demand by changing or modifying drivers' transportation behaviours. This strategy was originated from the United States. Due to the differences in cultural background, transportation system and availability of urban spaces, it remains unclear whether TDM schemes are efficient in Japan.

In order to check the efficiency of the TDM schemes, it is strongly required to grasp the travellers' behaviours in detail. Most important thing is to grasp the reason why the automobile commuters do not use the public transport, and which reason has a large effect if the conditions are improved.

Upon these backgrounds, this study has three objectives. First objective is to analyse the reason for the automobile commuters to use cars by the personal-trip based analyses. By segmenting the sample and cross aggregation analyses, the reasons why they use automobiles are analysed. Second objective is to construct the model that explains the drivers' commuting modal choice. The logit model is applied to explain the modal choice, and the parameters are estimated based on the personal trip data. Third objective is to check the sensitivity of the commuting modal choices in order to study the effects of the trip characteristics on the modal choice.

The personal trip data used in this study was collected from the third PT survey of Keihanshin (Kyoto, Osaka, and Kobe) Metropolitan Area in 1990 (Keihanshin Metropolitan Area Council, 1991). The characteristics of PT data are that the sample size is quite large but the questions are limited. In this study, as the analyses are proceeded based on the varieties of cross aggregations, a lot of samples are needed. Thus, this study is based on the PT data.

This paper consists of six chapters. The first chapter discusses the background and purpose of this study. The second chapter reviews the developments, deployment and expectations of various TDM schemes. The third chapter presents the results of the investigation of commuting in Osaka Metropolitan Area. The fourth chapter proposes the modal choice model, and discusses the change of the modal choice probability by the sensitivity analysis. The fifth chapter discusses the feasibility of introducing TDM schemes in Osaka metropolitan Area. The final chapter summarises the results and provides the perspective for the future.

2. TRANSPORTATION DEMAND MANAGEMENT SCHEMES

When the traffic demand is larger than the traffic capacity, the problem of congestion occurs. Serious traffic problems were encountered in the United States in the 1970's, so that TDM was implemented to ease the problems. Compared to TSM (Transportation System Management) which targets on the efficient use of transportation system, TDM aims to manage travellers' transportation behaviours. TDM schemes can be classified based on the approaches to relief traffic congestion: (e.g. Ota, 1992)

1. Spread a peak period of traffic,
2. Average use of roads,
3. Increase use of public transportation,
4. Increase use efficiency of cars,
5. Decrease occurrence of transportation demands,
6. Design one policy to achieve all aims mentioned above.

The approaches mentioned above have strong connections to each other. It would result a better effect if all the approaches were applied co-ordinately.

TDM schemes can be also classified based on the executive bodies;

1. Executed by the (local) government:
   The laws controlling transportation behaviours are constituted, including Road Pricing Schemes, TIA (Transportation Impact Assessment), Park and Ride, Kiss and Ride, and HOV (High Occupancy Vehicle) lane set-up.
2. Executed by non-government organisations:
   It includes flexitime, and modification of office hours and formats.
3. Executed by a Public-Private partnership:
   It includes Carpooling, and TMA (Transportation Management Association) sponsored by the local government.

In addition, TDM schemes can be classified based on the types of enforcement:

1. Arbitrary enforcement:
   It includes Trip Reduce Ordinances, TIA, Growth Management, Road Pricing, and parking management.
2. Voluntary involvement:
   It includes carpooling, TMA, flexitime.

3. CURRENT COMMUTING BEHAVIOURS IN OSAKA METROPOLITAN AREA

In Osaka Metropolitan Area, the traffic congestion has been a serious problem during peak hours. Using the analyses on the PT data, the present commuting behaviours in this area are analysed. By investigating the characteristics of the individual commuters, and analysing the relationship between their characteristics and their commuting modal choice, the reason why they use the automobiles in commuting is discussed. There are some analyses that explored the possibility of introducing TDM schemes in Osaka Area (Nitta et al, 1995; Odani et al, 1995; Taniguchi et al, 1997). Those analyses are based on the questionnaire surveys, therefore, the sample size are limited though the drivers' behaviours are analysed in detail. Also these researches are based on the stated preference survey to check the validity of the TDM schemes. On the contrary, this study attempts to check the possibility of the TDM schemes based on the PT data, which is a typical revealed preference survey.

3.1 Data Used for the Analysis

As mentioned in chapter 1, the data analyzed in this study were picked up from the third PT survey of Keihanshin Metropolitan Area in 1990. At that time, the total population lived in the area of Keihanshin were around 20,410,000 persons. The extraction percentage of third PT survey was about 2%, and 382,000 persons were picked up.

Because this research concerns with the traffic problems in Osaka Metropolitan Area, the investigation was focused on the samples that commuted to Osaka City. The criteria for the sample selection are as follows:

- commuters to Osaka City (except those who worked at home);
- commuters who owned driver's license;
- commuters who uses automobiles or public transportation;
- commuters who used the same mode of transportation for the trips to work and to home

There were 19,916 samples that fitted the four criteria mentioned above. These subjects were then categorised into three groups:

- Type I : commuters who go directly to their regular offices, and go home directly from their regular offices,
- Type II : commuters who go directly to the work places that are not their regular offices,
- Type III : commuters who go home directly after finishing work outside their regular offices.

The results of the cross aggregation of these types of commuters and their choices of transportation modes were shown in Figure 3-1. Note that there are some samples that are included both Type II and Type III. In this figure, those samples are calculated separately. It is suggested that comparing with Type I commuters that are dominant, Type II and III commuters tend to use the automobiles. The commuting behaviours were different among these groups. Therefore, commuting behaviours of Type II and III will be discussed separately from Type I commuters.

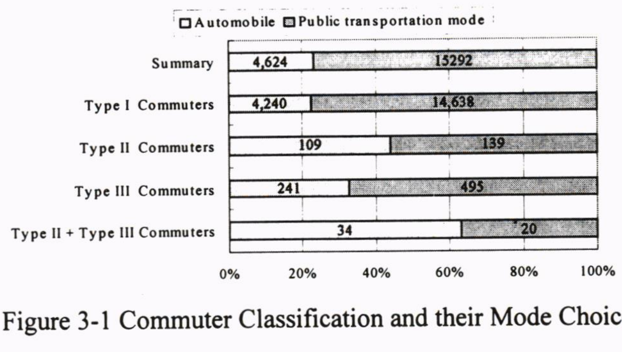


Figure 3-1 Commuter Classification and their Mode Choice

3.2 Analyses on the Commuting Modal Choices of Type I Commuters

3.2.1 Relationships between Personal Characteristics and Modal Choices

Based on sex, age and occupation, the factors contributing to selection of transportation modes in commuting were investigated. The results suggest that male commuters used cars more (25.6%) than female commuters (10.6%). Also, the increase of taking personal vehicle positively correlated with the increase of commuters' age. The difference was especially significant at the age of 20-30. The average commuting rate by car is 23.2% whereas the commuting rate by car of the commuter with 20 eras is 15.6%.

Relationship between the occupation and commuting modal choices are analysed next. There were seven occupation categories in the PT study. Figure 3-2 shows that the engineer/construction and the transportation/communication workers used automobiles more than the samples of other occupations. In contrast, the occupation of managing occupation used personal vehicles fewer.

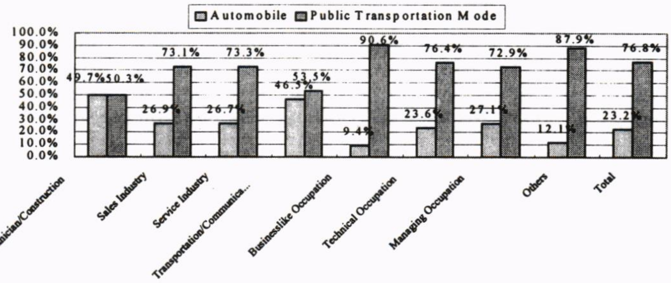


Figure 3-2. Occupation and Commuting Modal Choices

3.2.2 The Relationship between Trip Characteristics and Modal Choices

In this section, how trip characteristics affect on commuting modal choices is discussed. Four trip characteristics, departure location, destination location, travelling distance and departure time, were analysed.

Figure 3-3 shows the results on the correlation of departure location and modal choices. This figure suggests that the ratio of automobile commuters decrease if the departure locations are distant from Osaka Area. It is also noted that the use of automobiles was high among those who departed within Osaka City. To study the correlation of destination and modal choices, Osaka City is divided into eight destination areas. The result is shown in Figure 3-4. The results show that less than 10% of those who travelled into the CBD areas used cars as a commuting mode. This number is much lower than those travelling towards the other areas of Osaka City are. It is pointed out that commuters who depart and arrive inside Osaka City tend to use automobile more. Therefore, for the commuters who depart inside Osaka City, the difference of automobile commuting ratio among OD pairs are analysed. The OD pairs where the ratios of automobile use are over 70%, are plotted in Figure 3-5, together with the locations of the railway network. The results indicate that the use of the automobiles were much higher in the western, the southern and the eastern parts of Osaka City. In the aspect of commuting inside the city, the use of automobiles is very high in the circular direction. This implies that the public transportation system is not enough in this direction.

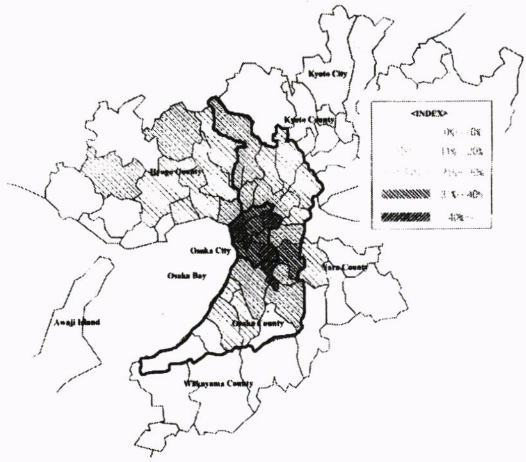


Figure 3-3. Correlation of Departure Location and Commuting Rate of Automobiles

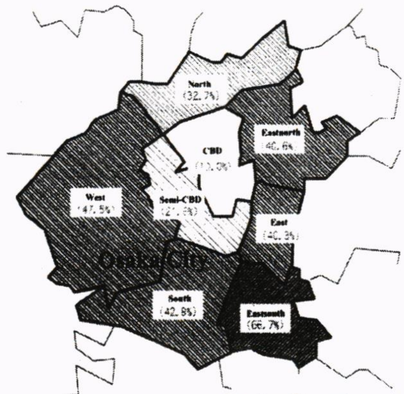


Figure 3-4. Correlation of Destination Location and Commuting Rate of Automobiles

Choice of using on automobiles might be due to the lack of the public transportation. To verify this, the average time spent was compared between the public transportation and automobiles. In Figure 3-6, the horizontal axis stands for the difference of average time spent on the road between the two groups. For example, 'A: 21-24min.' means that automobile is from 21 to 24 minutes faster than the public transportation. The vertical axis in this figure stands for the percentage of using automobiles in commuting. It was revealed that the use of automobiles dramatically increase when it saved 6 minutes or more in comparison with using public transportation. It was also observed that the difference of average time spent on the road between the two groups has a linear relationship to the use of automobiles in commuting. By looking at Figure 3-6, outside the JR Osaka Ring (the ring railroad around CBD and Semi-CBD areas), there is no ring railroad network. Combing the results shown in the Figures 3-5 and 3-6, the public transportation service is not adequate outside the service area of the JR Osaka Ring. It results the increase of using automobiles in commuting.

Figure 3-7 shows the cross aggregation result of the arrival time at the office and the probability of using automobiles. When the arrival time is earlier, the ratio of using automobiles increases. It has a linear relationship between the arrival time at the office and the ratio of using automobiles. Based on the linear regression analysis, over 50% of those who arrived earlier than 7:18 AM commute with automobiles.

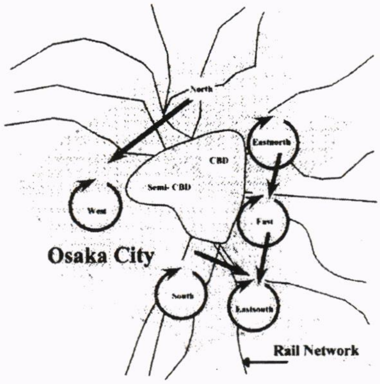
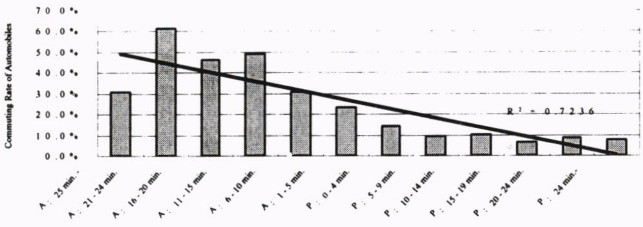


Figure 3-5. OD Pairs that the Commuting Rate of cars is above 70%



*A: cars
P: Public Transportation Means
The left side is the cars faster, and the right side is the public transportation means faster.

Figure 3-6. The Relationship of the Difference of Using Time by Cars and Transit and the Commuting Rate of Personal Vehicles

In summary, the availability and accessibility of public transportation has a great impact on choice of transportation means. Because the ratio of using automobiles were very high inside Osaka City, it is very important to improve the public transportation insider Osaka City.

In this section, how personal and trip characteristics of the commuters affects on the choice of transportation means was studied. In the next section, commuting trip is considered as a first part of a trip chain, and the relationship between commuting modal choice and activities after arriving company are analysed.

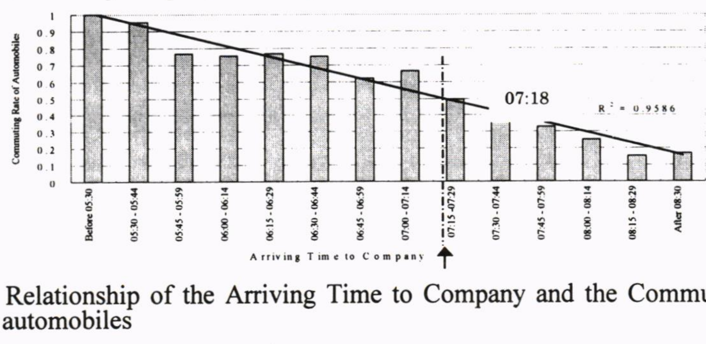


Figure 3-7. Relationship of the Arriving Time to Company and the Commuting Rate of automobiles

3.2.3 The Relationship between Activities after Commuting and Commuting Modal Choice

The samples used in this section are only Type-I commuters. Also, only the samples that made more than four trips were picked up. Consequently, 2,170 samples are picked up. Among them, 1,627 samples commuted with public transportation (75% of the samples investigated), and 543 with automobiles (25% of the samples investigated). This is rather higher than the ratio of commuting by automobiles for Type I commuters, shown in Figure 3-1.

In the PT survey, it was not recorded whether automobile used for commuting was the same vehicle used for the following business trips. Therefore, the following studies were based on the ownership of the automobiles; private-owned or company-owned automobiles. Combined the selection of commuting transportation modes, the aggregation results of selection of transportation modes used for the following business trips are presented in Table 3-1. Among those who commuted with automobiles, less than 7% of them used transportation modes other than automobiles for business trips. That is, more than 90% of them used automobiles for the following business trips. Based on the ownership of the automobiles used, about 70% of the car-commuting samples use the automobiles of the same belongings in the following business trip. Moreover, the more trips a person made at one day, the more likely he/she uses an automobile. On the other hand, approximately 50% of those who commuted with public transportation systems used public transportation for business trips.

The relationship between the number of trips using automobiles and ratio of car commuting was examined. The results are shown in Figure 3-8. It was found that there was a higher trend to commute with automobiles when the person made more business trips during a day.

In this section, the relationship between activities after commuting and the selection of commuting transportation modes is analysed. The data suggested that those who use automobiles for business trips were more likely to commute with automobiles. It was also observed that the person is more likely to commute with automobiles when he/she made more business trips.

Table 3-1. Relationship between the Commuting Modal Choice and the Modal Choice of Business Trips after Commuting

Traffic means In Commuting		Traffic Means of Using in Business Trips				
		Transit	Car		Taxi	Total
			Same Belonging	Different Belonging		
Personal Vehicles	No. of Samples	33 6.4%	321 62.2%	160 31.0%	2 0.4%	516 100.0%
	No. of Total Trips	41 4.5%	593 65.5%	270 29.8%	2 0.2%	906 100.0%
	No. of Average Trips	1.242	1.847	1.688	1.000	1.756
Transit	No. of Samples	728 53.3%	563 41.2%		75 5.5%	1366 100.0%
	No. of Total Trips	950 47.0%	975 48.2%		96 4.8%	2021 100.0%
	No. of Average Trips	1.305	1.732		1.280	1.480

3.3 Commuting Behaviours of Type II and III Commuters

Section 3.2 discussed the behaviours of Type I commuters, who go to and come from their regular office directly, in detail. In this section, the behaviours of Type II and III commuters are analysed. Again, Type II commuters are those who practise job duties before arriving their regular office, and Type III commuters are those who go home directly after practising job duties outside the regular office. From Figure 3-1, there are 143 Type II commuters and 275 Type III commuters.

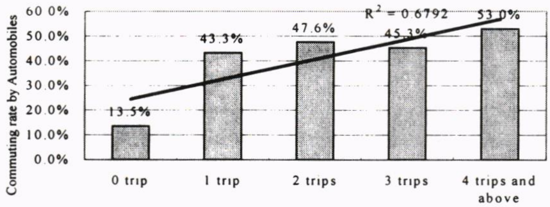


Figure 3-8. Relationship of the Number of Business Trips by Automobiles and the Automobile Probability in Commuting Mode Choice

Figure 3-9 shows the differences of the share of occupations among Type I, II and III commuters. It can be said that the share of the occupations is quite different if the types of the commuters are different. It reveals that in sales industry, there is a greater percentage of Type III commuters. In contrast, for those who involved in the technical and professional fields, the share of Type II commuters is large. Also for the samples in the management field, the share of the both Type II and Type III commuters are large. On the other hand, for those who in the technical, transportation, communication and administrative fields, the shares of the Type I commuters is quite large.

Next, the number of the trips of Type II commuters make before getting to their regular office is aggregated (Figure 3-10). From this figure, about 60% of the Type II commuters went to the workplaces other than their regular office only once. Then, what kinds of trips may happen for Type II commuters before going to their regular office is analysed. Figure 3-11 shows the results of the aggregation. The figure shows that the business meetings, discussions, account receivable collections and seeing doctors consist of 40% of overall purposes.

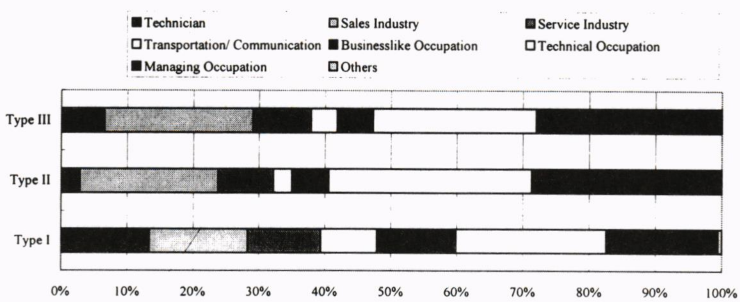


Figure 3-9. Shares of the Occupations among the Three Types of Commuters

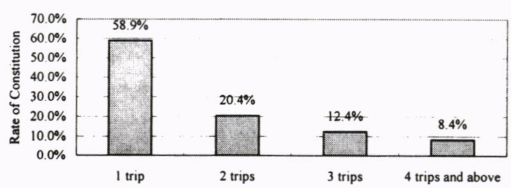


Figure 3-10. The Numbers of Business trips of the Type II commuters before arriving their regular office

The characteristics of Type III commuters are also analysed in a same manner as is the case of Type II commuters. Figure 3-12 and 3-13 show the aggregation of the numbers of trips that Type III commuters made after leaving their regular offices and before coming home, and the share of trip purposes, respectively. From Figure 3-12, most of the Type III commuters go only one workplace before going home. The percentages of the commuters who made only one trip before going home are much higher than the percentage of the commuters who made only one trip before commuting to their regular office. By looking at Figure 3-13, the purposes of the trips made by Type III commuters before going home are mostly business meetings and selling/delivery.

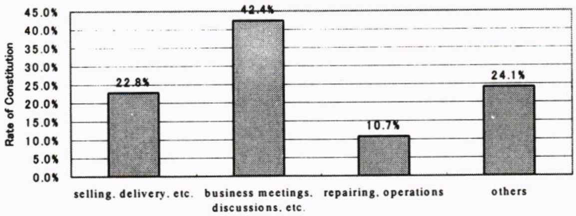


Figure 3-11. Purpose of Trip to Practice Job Duties before Arriving the Office

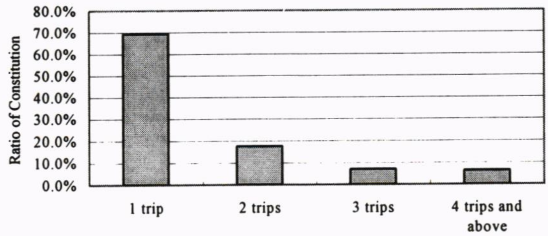


Figure 3-12. Numbers of Business Trips of the Type III Commuters before Going Home

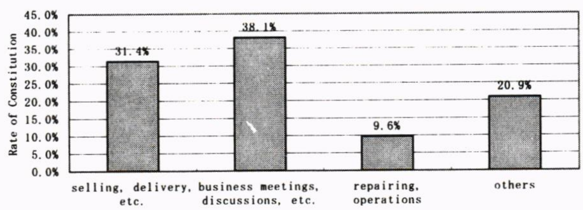


Figure 3-13. Purpose of Trips before Arriving at the Regular Office

From the analyses in this section, it can be said that the behaviours of Type II and III commuters are quite different from the automobile commuters who go directly to their offices and go home directly from their offices. It is also found that going the workplaces other than their regular offices, or going home directly from such workplaces may be one of the strong reasons to use the automobiles.

4. COMMUTING MODAL CHOICE MODEL

In the previous chapter, the commuting behaviours in terms of aggregated level are analysed. Many factors that may affect on the modal choice of commuting are found by the aggregation analyses. However, it is very difficult to observe how much one factor may affect on the mode choice comparing with other factors in detail only by the aggregation analyses. In this chapter, based on the analysis of the previous chapter, the modal choice model of commuting is modelled. The logit model (Ben-Akiva and Lerman, 1985) is applied to explain the modal choice behaviours, and the estimation is made by the PT data. The aim of this chapter is to quantify and compare with the effect of the factors discussed in the previous chapter.

4.1 The Samples and Explanatory Variables

In chapter 3, the reasons why commuters decide to select automobiles are discussed. The reasons that may effect on the commuting modal choices are as follows:

1. Going to work early in the morning,
   Samples whose departure time of their home is before 5:48AM, or whose arrival time at their office is before 7:18AM
2. Coming home late at midnight,
   Samples whose latest job ends after 9:00PM or samples coming home after 10:00PM.
3. Commuters practising job duties before going to their regular office,
4. Commuters go home directly after practising job duties outside the regular office,
5. Living in the area with poor public transportation systems,
6. Cars are necessary during office hours.

Among the above reasons, reasons from 1 to 4 are applied as dummy (0 or 1) variables. To explain the reason 5, the differences of the travel times between automobile commuting and public transport commuting are applied. The travel time of each mode is calculated by calculating the averages of the samples that has same mode and same OD pair. Also, for reason 6, the number of business trips by automobiles in the office hours is applied. In addition to these reasons, the occupations and industrial categorisation of the samples are applied as explanatory variables, together with the distance of commuting.

Since the time difference of taking transportation vehicles is applied as one of the explanatory variables, the OD selected should contain at least one sample from "automobiles" and "public transport", respectively. From this concept, 4,619 samples of automobile commuters and 14,270 of public transport commuters are sampled.

The parameters are estimated with the help of the Logistic Procedure of SAS (SAS Institute, 1990).

4.2 The Analysis of the Estimation Result

Table 4-1 shows the estimation result of commuting modal choice. Table 4-2 presents the average values of the explanatory variables by different types of transportation modes. The positive sign "+" of the parameters enhance the possibility to using public transport, in the meanwhile, "-" of the parameters enhance the possibility to select automobiles as a mode to commute.

From the estimation results, the following findings are got:

- Commuting distance is one of major factors in selecting transportation vehicles,
- Because the commuting time differences are the time spent by cars minus that by public transport, the sign of the parameter meets the intuition. This result leads to the conclusion that the chance to select the public transport can be highly increased by improving their services,
- In comparison of every commuting purposes, "commuters going to work early in the morning" (parameter = -1.78, t = 22.303) and "Type II commuters" (parameter = -1.213, t = 8.916) have greater tendency toward commuting by automobiles,
- The estimated parameter of the numbers of business trips by automobiles implies that the trips with or without job duties have a huge influence upon the selection of transportation means for commuting. Furthermore, significant differences between the average values of the commuters by automobile and those by public transport are observed (see Table 4-2).
- On the aspect of commuters' occupations, it is found that:
  1. Those who belong to clerical occupations often stay in the office (parameter =0.914). They tend not to use automobiles for commuting.
  2. Those who are engineers (parameter =-0.7968), managing occupation (parameter =-0.3264) and in transportation/communication industry (parameter =-0.5700) have greater tendencies to use automobiles as a commuting mode.

From the likelihood ratio (0.201) and hit ratio (0.793), this model has enough accuracy.

Table 4-1 The Estimation Result of the Model

Samples: 18,889 (Commuters by Cars: 4,619, Commuters by Transit: 14,270)

	Explanatory Variables	Kind of Explanatory Variables	Value of Parameters	t-Value
	Alternative Specific Dummy Variable	-	0.265	6.268
	Distance of Commuting (km)	Continuous Variable	0.074	30.163
	Difference of Using Time in Commuting (min.)	Continuous Variable	0.015	11.984
Type of Commuting	Going to work early in the morning	Dummy Variable	-1.780	-22.303
	Coming home late in midnight	Dummy Variable	*	*
	Commuters practice job duties before going to the office	Dummy Variable	-1.213	-8.916
	Commuters go home directly after practising job duties outside the regular office	Dummy Variable	-0.258	-2.637
	No. of Business Trips by Car in Office Hours	Continuous Variable	-0.558	-16.657
Occupation	Engineer	Dummy Variable	-0.797	-11.207
	Sale Industry	Dummy Variable	*	*
	Service Industry	Dummy Variable	*	*
	Transportation/ Communication Industry	Dummy Variable	-0.570	-6.390
	Clerical Occupation	Dummy Variable	0.914	16.415
	Technical/ Professional Occupation	Dummy Variable	*	*
	Managing Occupation	Dummy Variable	-0.326	-6.078
Industry	Construction Industry	Dummy Variable	-0.378	-5.763
	Manufactory Industry	Dummy Variable	*	*
	Wholesale Business	Dummy Variable	*	*
	Retail Business	Dummy Variable	*	*
	Finance, Insurance Industry/ realtor	Dummy Variable	0.577	7.037
	Transportation/ Communication Industry	Dummy Variable	*	*
	Service Industry	Dummy Variable	*	*
	Electricity, Gas, Water Supply Industry	Dummy Variable	0.297	2.363
	Official	Dummy Variable	0.448	4.773

*The explanation variable which was rejected in 5% significant level
Likelihood-ration Index: 0.201; Hit-ratio: 0.793

4.3 The Sensitivity Analysis of the Commuting Modal Choice Model

In this section, by supposing an average individual, the influence of the change of each explanatory variable on the modal choice probability is investigated. There set some scenarios about the share changes of the commuters such as the decrease of the commuters going to work early in the morning. The aim of this study is to find the decrease of which commuters can be regarded as the most effective schemes.

Firstly, the scenarios are what will happen for decreasing the percentages of commuters going to work early in the morning, Type II commuters and Type III commuters. Figure 4-1 shows the result of which from 0 to 50% decrease of those commuters. The horizontal axis represents for the probability of choosing automobiles. From this figure, if the percentages of the commuters going to work early in the morning decrease, the automobile demand will be reduced greatly.

The discussion arouses that it is not a large problem to commute by automobiles early in the morning because the road congestion is not serious. However, by the complementary analysis, it is found that commuters going to work early in the morning go home during the evening peak hours. Therefore, to implement some schemes that may prevent from commuting by automobiles early in the morning will be efficient to relax the traffic congestion in the evening peak hours. Because the samples of the commuters going to work early in the morning by car were 703 persons and about 15% of the whole samples of commuters by car. Hence, when the commuters going to work early in the morning by car decreasing once, it thinks that the huge effect of the traffic relaxation comes out. Looking at the results of Type II and III commuters, it can be said that change of the percentages of them do not have much effects on the change of automobile choice probabilities. This is because the percentage of the samples that meets those conditions is few.

Table 4-2 Details of the Explanatory Variables

Name of Variables	Parameter	Corresponding Person in the Commuters by Car	Corresponding Person in the Commuters by Transit	Ave. of Commuters by Car	Ave. of Commuters by Transit	Total	Whole Average
Dummy Variable	0.265	4619	14270	1.0000	1.0000	18889	1.0000
Commuting Early in the Morning	-1.780	703	312	0.1522	0.0219	1015	0.0537
No. of Business Trips by Car in Office Hours	-0.558	1471	1052	0.3185	0.0737	2523	0.1336
Commuters Practice Job Duties before Going to the Office	-1.213	143	146	0.0310	0.0102	289	0.0153
Commuters Go Home Directly after Practicing Job Duties Outside the Regular Office	-0.258	274	478	0.0593	0.0335	752	0.0398
Engineer	-0.797	587	553	0.1271	0.0388	1140	0.0604
Transportation/ Communication Industry	-0.570	376	396	0.0814	0.0278	772	0.0409
Businesslike Occupation	0.914	529	4808	0.1145	0.3369	5337	0.2825
Managing Occupation	-0.326	821	2051	0.1777	0.1437	2872	0.1520
Construction Industry	-0.378	544	1016	0.1178	0.0712	1560	0.0826
Finance/ Insurance Industry/ realtor	0.577	221	1794	0.0478	0.1257	2015	0.1067
Electricity, Gas, Water Supply Industry	0.297	101	391	0.0219	0.0274	492	0.0260
Official	0.448	161	1030	0.0349	0.0722	1191	0.0631
Distance of Commuting	0.074	*	*	11.3	17.8	*	16.2159
Difference of Using Time in Commuting	0.015	*	*	-6.4	1.3	*	-0.6117

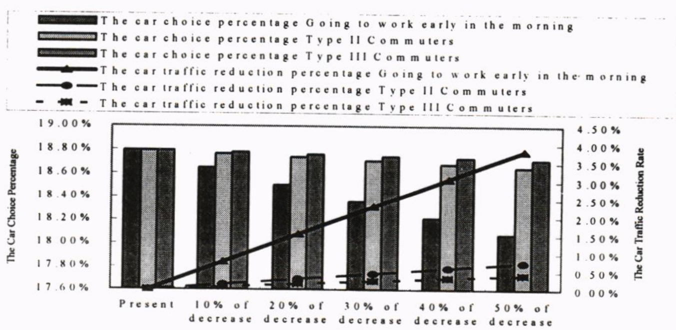


Figure 4-1 Change of the Commuting Modal Choice by the Decrease of the Corresponding Persons

Secondly, what happens if the number of business trips by automobiles during office hours decreases, is analysed. The result is shown in Figure 4-2. The index '0.02' represents that the average number of business trips decreases as much as 0.02. From this figure, if the

0.10 of the average business trips decreased, about the decrease of 4.50% of the commuting by automobiles is expected.

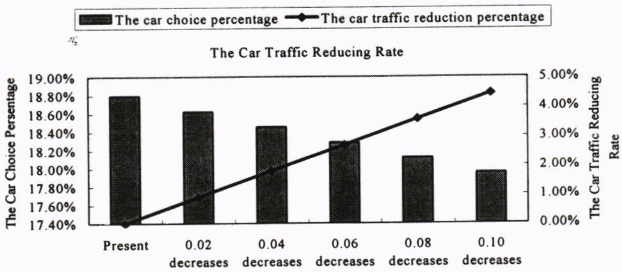


Figure 4-2. Change of the Automobile Choice Probability by the Decrease of the Automobile Business Trips During Office Hours

Thirdly, to see the effect of improvement of the service levels of the public transportation, the travel time by the public transport is assumed to decrease from 2 to 10 minutes. In this case, the improvement of the road traffic congestion by the decrease of the automobile commuting demand is neglected. The calculation results are shown in Figure 4-3. From the figure, if the time spent in taking public transportation is shortened by 10 minutes, then there will be 11% of samples choosing to take public transportation. Note that the analyses are made by the average value, so saving 10 minutes needs a lot of works on improving the infrastructure of public transportation as a whole.

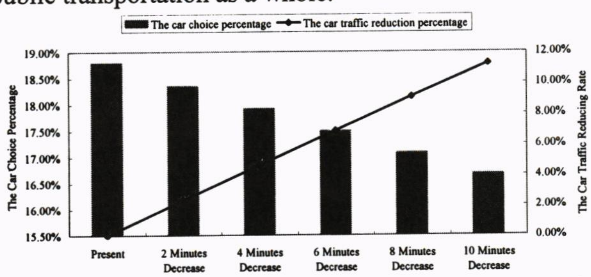


Figure 4-3 Change of the Commuting Mode Choice Probability by the Decrease of the Travel Time of the Public Transportation

5. FEASIBILITY OF TDM SCHEMES IN OSAKA METROPOLITAN AREAS

Based on the discussions at the previous chapters, the feasibility of the individual TDM schemes is discussed here.

5.1 Feasibility of Road Pricing Schemes

Road Pricing is a strategy to control traffic capacity by collecting tolls on specific roads. The revenues by the tolls could be used to improve public transportation, to construct facilities for Park and Ride to build the annular roads that have been discussed for years. Overall, "Road Pricing" is not only a strategy to solve the problems caused by traffic congestion, but also a finical resource to improve the facilities and services of public transportation systems.

As presented in Chapter 3, there is a higher rate to commute with cars in circular direction around the city centre. This observation suggests insufficiency of circular public transportation systems (see Figure 3-5). It can also be said that a large proportion of commuters travels to the CBD areas. How would it affect the traffic conditions in Osaka Metropolitan Area if 'Cordon Pricing' such as the Toll Ring system in Bergen, Norway (Ohta, 1989) is implemented. The cordon lines will be set up to surround the central districts. Consequently, tolls will be collected from the vehicles going through the cordon lines. It is expected that this enforcement would reduce commuting automobiles towards the centre of the city as well as to create financial resources for public transportation improvement. For example, the funds could be used to build a loop for train, which would relief the traffic congestion outbound to the city centre. However, in this case, the people who pay the tolls do not always get the revenues by the construction of the ring public transport. It needs to be carefully evaluated the transportation network for the trip toward the city centre and the trips in the circular direction.

5.2 Feasibility of the Other TDM Schemes

Park and Ride could be a valuable strategy for the newly established stations around Osaka Metropolitan Area. The drawback of this strategy is that it requires constructions of roads approaching to the stations and parking lots nearby the stations. Alternatively, carpooling could be a useful strategy in Osaka and surrounding satellite cities.

This chapter discussed the possibilities of the implementation of some TDM schemes. It would require a great understanding and support for the public to overcome the difficulties of implementation.

6. CONCLUSION

Using the samples collected in the third Person Trip Survey in Keihanshin District, the possibilities of TDM implementation in Osaka Metropolitan Area are discussed. Firstly, the TDM schemes up to date are reviewed. Secondly, commuters' mode choice behaviours are analysed aggregately. The samples analysed in these studies were divided into several segments, and the differences among these segments were carefully examined. Meanwhile, a model on modal choice was constructed based on the results of the studies. All possible variables involved in the model were compared. Based on the PT data and the analysed results, the implementation of TDM systems were explored in the end of these studies.

The future works are listed as below:
- Above studies were only focused on the automobile commuters. In fact, the traffic congestion related to public transportation is also a severe problem. The capacity of public transportation needs to be investigated.
- In order to evaluate the feasibility of the various TDM schemes, the simulation model that explains the traffic conditions of the entire city is needed. The model proposed in this paper could be used as a sub-model of such simulation model.

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