A STUDY OF MODE AND DESTINATION CHOICE MODEL BY USING MICRO-SCALE GIS DATA

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Abstract: The purpose of this study is to show the applicability and limitations of micro-scale GIS data to estimate mode and destination choice models. First, GIS database on activity points and transport network by modes are developed. Second, mode and destination choice models for shopping both in weekday and in weekend are estimated. In the model, point-to-point service levels of trips calculated by using micro-scale data are employeds. Parameters and vehicle km estimated by using micro-scale data are then compared with those estimated by using the zone system. Finally, we applied the model to the auto-use reduction scenarios in a local urbanized area. The results indicate that models estimated by using micro-scale data are useful for analyzing land use and service levels of modes more precisely.

Key Words: GIS, micro scale data, vehicle km reduction, travel behavior analysis

1. INTRODUCTION

In urban areas, increase of auto-use is one of the crucial issues, and travel demand management (TDM) is said to be an effective measure to solve the problems. Not a few researchers point out that an activity-based model is more useful than a trip-based model in order to analyze the TDM measures [1]. Although the travel demand analysis methods have been changed from aggregated models to disaggregated models and from trip-based models to activity-based models, aggregated zonal spatial units have been employed for every analysis. The sizes and the features of transport analysis zones sometimes affect the destination attractiveness or the service levels of trips when estimating travel demand models. In some cases when TDM measures are evaluated in detail, these effects might be limitations of the analysis.

Recently, micro scale GIS data on urban facilities and land use are under development in conurbations of Japan. When the activity points from a person trip survey are linked to the point data on GIS database, it becomes possible to analyze the effect of complicated facility locations in detail. Indices on accessibility and mobility might be estimated more precisely by calculating point-to-point service level of trip-chains.

In the Portland Metro [2] and the Chicago Metropolitan Area [3], accessibility index, pedestrian environmental factor and land use-mix index are employed for travel demand forecasting by using micro-scale data of GIS. The effectiveness of such kind of detailed indices, however, should be discussed more. And so far, point-to-point service levels of trip chains are not applied to estimate mode and destination choice models.

The purpose of this study is, therefore, to examine the effectiveness of GIS-based micro-scale data both for estimating mode and destination choice models and for auto-use reduction analysis. After the methodology is described, GIS database on activity points and transport network by modes are developed (§2). Later, mode and destination choice of shopping trips both in weekday and in weekend are estimated (§3). Parameters and vehicle km estimated by using micro-scale data are then compared with those estimated by using zone system (§4). Finally, we apply the model to the auto-use reduction scenarios in the local urbanized area (§5). Thus, the focal point of this paper is to show both the applicability and the limitations of the mode and destination choice models by using micro-scale GIS data.

2. METHODOLOGY

2.1 Data and Outline of the Study Area

In this study, mode and destination choice models of shopping trips in Oyama city are estimated by using data from the person trip survey of the Oyama-Tochigi Region conducted in 1999, in order to analyze vehicle km reduction in detail. The activity points available from the person trip survey are linked to GIS-based facility point data, and Digital Road Map data (including bus routes) in order to calculate point-to-point service levels by modes. Residential geographical points are available as GIS point data from the Oyama-Tochigi Region person trip survey, and it is relatively easy to understand the addresses of activity points from survey sheets. It is also a feature of the data that person trips both on a weekday and a weekend (Sunday) of the same person are available. Since addresses of activity points and sample households of person trip survey are to be linked to GIS database in the near future, it is not considered that the analysis in this study is a special case.

2.2 Assumptions

About 86% of destinations of shopping trips are located in the study area on weekdays and about 81% on weekends. Many of them are the large-scale retail stores. Therefore, in this study, shopping trips to the 14 large-scale retail stores in Oyama city [4)] are selected as the facilities to be analyzed. Here, we employed two types of large-scale retail stores indicated in the large-scale retail store act. The large-scale retail stores of type 1 have floors over 3000 m^2, and the large-scale retail stores of type 2 have floors from 500 to 3000 m^2.
In the study area, vehicle-km of commuting trips, school trips, business trips, serving passenger trips and trips to the hospitals cannot be neglected. This is the reason why shopping trip chains including these trips are also targeted of the analysis. Here, commuting trips, school trips, business trips, serving passenger trips and trips to the hospitals are regarded as "destination- fixed" activities, because we assume that the activity points of them are already decided at the beginning of a day.

The number of the trip chains to be analyzed is shown in Table 1. The number of trip chains on weekdays is less than that on weekends, but differential of shopping trips per person is not so large. Percentage of the trip chains that include only one home-based shopping trip is about 55% on weekdays and about 64% on weekends, and this might mean that patterns of trip chains should be considered. Proportion of the trip chain that include only one shopping trip is about 95% and this is the reason why we assume that the number of shopping trips are not to be changed. Additionally, the number of "destination-fixed" activities is also assumed to be unchanged.

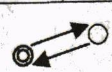
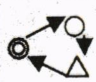
Table 1. The number of Trip Chains and Shopping Trips to Be Concerned

	Total Number of Trip Chains	Total Number of Shopping Trips	Number of Shopping Trips per Trip Chain
Weekday	350	362	1.03
Weekend	564	602	1.07
Total	914	964	1.05

When trip chains are modeled, modal shift from private vehicles and public transport modes to walk might be considered in the second or later trips, in short non-home-based trips. Only less than 2% of sample non-home-based trips change their modes, however, it is assumed that modes of non-home-based trips are not shifted from those of home-based trips. Because modal shares of train and motorcycle, each is less than 1%, mode choice behavior of walk, bicycle, car and bus is modeled.

It is advisable that the mode and destination models are estimated by days and by trip chain patterns. After several patterns of mode and destination choice hierarchies are examined, the models are estimated by trip chain patterns and by scale of stores as shown in Table 2, because the number of samples is limited. In model 5, store type choice behavior is not considered in order to simplify the analysis. 6 of the 14 concerned stores belong to type 1 and others belong to type 2.

Table 2. Mode and Destination Choice Trees Corresponding to Trip Chain Patterns

Choice Tree	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Level 1 (Store Scale) Type 1 Type2	✔	✔	✔	✔		
Level 2 (Stores) Type 1: 6 stores Type 2: 8 stores	✔	✔	✔	✔	✔	✔
Level 3 (Modes) 4 Modes	✔	✔	✔		✔	
Trip Chain Pattern ◎ Home, ○ Store △ "destination-fixed" activity point					Two shopping trips w/o DFA[1)]	
	Week Day	Week End	Both	Both	Both (HB)	Both (NHB)
Number of Sample	193	363	79	241	38	50

1) means the destination-fixed activity

2.3 Spatial Indices by Using Micro-Scale GIS Data

Traditional mode and destination choice models have employed zonal aggregated factors such as density and total number of facilities. When analyzing the effects of pedestrian environment improvement or the changes of facility location to vehicle km precisely, however, such traditional models have several limitations. Thus, in this study, we employ several factors defined as follows in order to analyze the relationship between facility locations and vehicle km in detail.

First, the number of retail stores located around the concerned facilities is employed because this is assumed to be an effective index in order to examine the shop accumulation as attractiveness of the destination. In the existing studies [5)], for example, a micro-scale land use index that is calculated by disaggregating zonal land use area is employed, but such an index is not always precisely suitable for the analysis. Second, accessibility index between homes of sample households and destinations are used, by calculating point-to-point distance. Third, a kind of pedestrian environmental factor is calculated. In the Portland Metro and the Chicago Metropolitan Area, density, for example, the width and the slope of pedestrian is considered to estimate area-wide travel demand by using digital road network on GIS. In the study area, the effect of slope or pattern of roads to mode choice of walk is not thought to be significant. Here, ratio of roads with pedestrian oaths is calculated to represent attractiveness of walk trip around facilities. Here, the "pedestrian path" means both mound-up type pedestrian path and flat type pedestrian path divided physically by blocks, which are the targets of the redevelopment plan in the core of the study area.

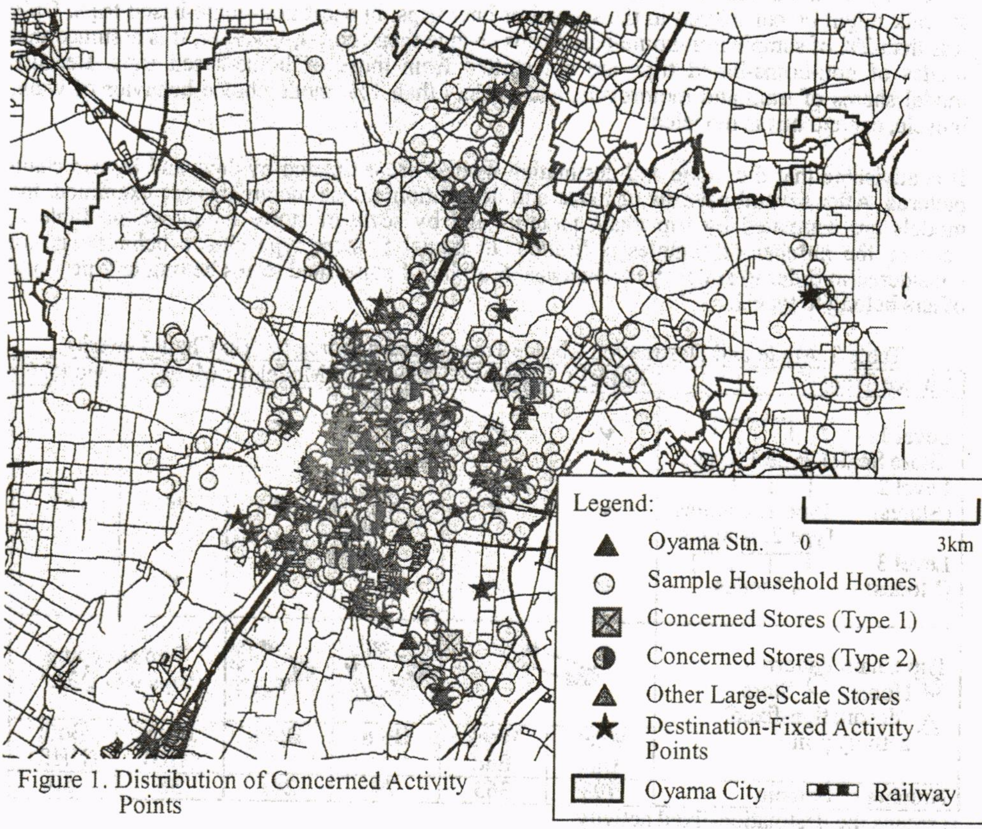


Figure 1. Distribution of Concerned Activity Points

In this study, we assume that facility location pattern accessible by walk is desirable for the less auto-dependent. This is the reason why three indices described above are calculated by considering walk distance limitations of road network.

2.4 Development of GIS Database

The sample residential points of the Oyama-Tochigi Region Person Trip Survey are mapped on the GIS. Additionally, in this study, other activity points described in the survey are input as GIS point data by referring the Zenrin Housing Map and the NTT Town Page (Figure 1).

Velocities of walk trips and bicycle trips are set to 4km/h and 12km/h, respectively according to a textbook [5]. Because velocities of road network by times-of-day and by directions are not shown in the existing statistics in Japan, we assume 24km/h in the DID and 38km/h outside of the DID, respectively. Average velocities of bus trips are calculated by using timetables. In the study area, it is considered that the effect of congestion in the core area is not so significant. Point-to-point trip times of each trip chain are then calculated by using these velocities by modes.

Since many of the concerned facilities are located within 3-5 km from the central station, we assume that availability of modes and destinations by types of trip chains are mainly affected by trip distance. Thus, the availability of them is defined as shown in Table 3. These trip distance limitations are calculated in order to cover 90% of actual trip distance. Spatial indices defined in 2.3 are also calculated by using availability of modes and destinations. Here, both trip distance and trip time are calculated by using minimum path distance of the road network. When considering the availability of modes, household attributes such as vehicle ownership and personal attributes such as driver license ownership are also examined.

Table 3. Availability of Modes and Destinations [i)]

	Modes			
Scale of Stores	Walk	Bicycle	Car	Bus
Type 1	Round trips with only one shopping trip: less than 1.1km	0.2-3km	0.3km +	Access to bus stop: 0.3km Egress from bus stop: 0.3km Total trip distance: 2km +
	Other: less than 0.5km			
Type 2	Round trips with only one shopping trip: less than 0.85km	0.2-2km	0.3-4km	
	Other: less than 0.5km			

i) Each distance means that distance from the previous place to concerned stores.

3. ESTIMATION RESULTS OF THE MODEL

In order to discuss the applicability and the limitations of the mode and destination models estimated by using micro-scale GIS data, models estimated by using the traditional zone system should be compared to. In this study, the former models are called as "point-to-point-based" models and the later models as "zone-based" models. The smallest zones (C zone) are employed to estimate the zone-based models (Figure 2).

Attributes of each store, such as parking costs per hour or special discount days of week, should also be employed by a telephone interview survey. Because all of those attributes are not available, we only employ floor area of the concerned stores, dummy variable on the item dealt by each store (if foods is dealt = 1, otherwise = 0), the DID dummy variable (DID = 1, otherwise = 0) and the shopping activity duration that the parking cost is free. Besides, total

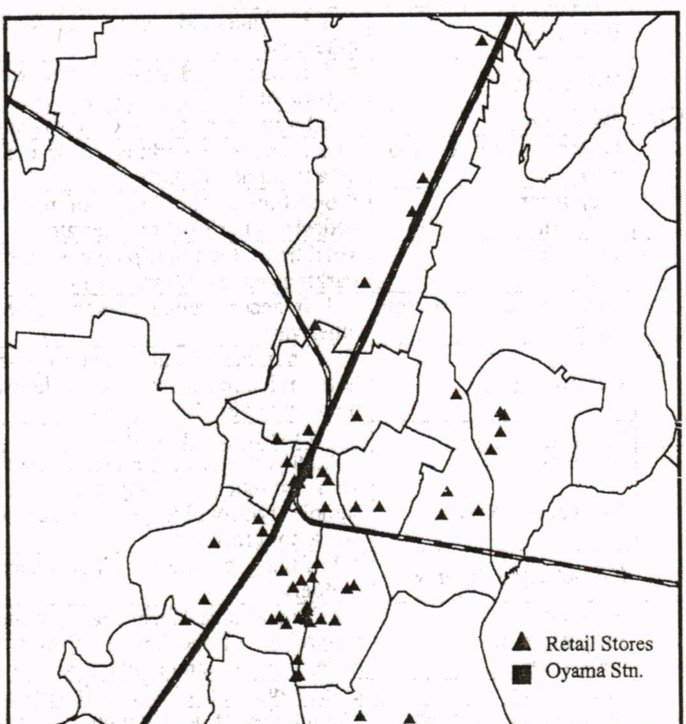


Figure 2. Boundary of the C Zones and Distribution of Retail Stores in the Study Area

number of stores around the concerned facilities accessible on foot, dummy variable of facility location (if store is located from sample homes within distance accessible on foot = 1, otherwise = 0) and the proportion of pedestrian are also employed (Table 4).Parameters of the point-to-point-based and the zone-based mode choice models are estimated as shown in Table 5, and their hit ratios are relatively high. On the other hand, parameters of the point-to-point-based and the zone-based destination choice models are shown in Table 6 and Table 7. The personal attributes and the household attributes are not always statistically significant. It is considered that this is because these attributes are already examined when the availability of modes and destinations are established. Blank variables in the tables mean that they are omitted because t-values of them are not statistically significant at 10% level. Additionally, t-values of dummy variables are not statistically significant at 10% level. Logsum variables are statistically significant and parameters of them are within 0 and 1, which indicates that mode and destination choice hierarchy assumptions are appropriate.

Table 4. Independent Variables Examined for Model Estimation

Level	Alternatives	Variables	Contents
Level 1	Types of Store	Logsum of level 2	Logsum utility of store choice
		Type 1 Dummy	= 1 if Type 1, = 0 otherwise
Level 2	Individual Stores (Mode 1-3, 5)	Logsum of level 3	Logsum utility of mode choice
		Floor area	Floor area of concerned stores ($100m^2$)
		Total floor area around concerned stores	Total floor area around concerned stores within the distance of walk limitation
		Location dummy 1	= 1 if concerned stores are located within the distance of walk limitations from sample homes, = 0 otherwise
		Location dummy 2	= 1 if concerned stores are located within the distance of walk limitations from "destination-fixed" activity points, = 0 otherwise
		Item dummy	= 1 if concerned stores deal food, = 0 otherwise
		DID dummy	= 1 if concerned stores are located the outside of the DID, = 0 otherwise
	(Model 4, 6)	Travel time	Total travel time of trip chains (minutes)
		Parking space per floor area	The number of parking space per floor area (vehicles/$100m^2$)
		Proportion of pedestrian	Proportion of the length of roads with pedestrian per total road length.
Level 3	Car	Travel time	Total travel time of trip chains (minutes)
		Parking space	Parking space (100 vehicles)
		Accompanied person dummy	= 1 if accompanied person exists, = 0 otherwise
		Car ownership	Total number of cars owned by sample households per the number of household members over 18 years old
		Gender	= 1 if male, = 0 otherwise
	Bicycle	Travel time	Total travel time of trip chains (minutes)
		Bicycle ownership	Total number of bicycles owned by sample households per the number of household members
		Housekeeper dummy	= 1 if the trip maker is a housekeeper, = 0 otherwise
	Walk	Travel time	Total travel time of trip chains (minutes)
		Proportion of pedestrian	Proportion of the length of roads with pedestrian per total road length.
	Bus	Travel time	Total travel time of trip chains (minutes)
		Average waiting time	The number of operated buses per hour

Table 5. Estimation Results of Mode Choice Models i) ii)

Model		Model 1		Model 2		Model 3		Model 5	
Independent Variables		PB	ZB	PB	ZB	PB	ZB	PB	ZB
Travel time (minute)		-0.033 (-2.68)	-0.197 (-3.56)	-0.026 (-3.49)	-0.131 (-2.36)	-0.014 (-2.65)	-0.203 (-2.52)	-0.145 (-3.53)	-1.059 (-1.66)
Car	Parking Space	0.0256 (2.51)	1.1389 (2.02)	0.2235 (4.01)	2.1959 (4.90)	0.2163 (4.24)	3.0559 (1.80)		
	Accompanied Person Dum.	1.8325 (2.82)		1.4534 (6.02)		2.4249 (2.93)			
Bicy-cle	Bicycle Ownership	0.4069 (3.57)	0.0185 (3.17)	0.6619 (3.15)		2.3771 (2.57)			
Walk	Proportions of Pedestrian	0.0111 (3.11)		0.0135 (3.02)		0.0504 (3.89)			
# Sample		193		363		79		38	
ρ^2		0.196	0.181	0.313	0.225	0.398	0.197	0.520	0.284
Hit R (Total, %)		74.09	72.79	85.43	74.95	85.71	82.41	92.11	92.11
Hit R (Car, %)		84.78	78.40	89.71	87.23	86.11	84.74	93.10	93.10

i) Numbers in the parentheses are t-values of each parameter.
ii) "PB" means point-to-point-based model and "ZB" means zone-based model.

Table 6-1. Estimation Results of Destination (Type 1) Choice Models of Level 2 i) ii)

Model	Model 1		Model 2		Model 3		Model 5 iii)	
Independent Variables	PB	ZB	PB	ZB	PB	ZB	PB	ZB
Logsum	0.5238 (2.95)	0.4677 (8.65)	0.3665 (8.12)	0.1208 (11.59)	0.3007 (2.76)	0.3574 (2.15)	0.9315 (3.91)	0.8303 (3.02)
Floor Area (100 m^2)	0.0215 (2.89)	0.0033 (6.12)	0.0071 (4.09)	0.0046 (10.34)	0.0039 (3.10)	0.0029 (4.72)		
Floor Area around Concerned Stores	0.0349 (2.83)		0.0108 (5.87)		0.0011 (3.03)			
Location Dummy	2.2162 (3.62)		1.3134 (4.18)		3.8010 (3.32)			
DID Dummy	-19.02 (-2.87)		-6.86 (-6.80)					
Item Dummy	-2.226 (-4.33)		-0.768 (-2.97)		-0.898 (-3.17)			
# Sample	122		269		49		38	
ρ^2	0.410	0.445	0.291	0.402	0.248	0.165	0.292	0.171
Hit R (%)	68.03	69.67	64.89	60.97	63.06	46.94	81.56	47.37

i) Numbers in the parentheses are t-values of each parameter.
ii) "PB" means point-to-point-based model and "ZB" means zone-based model.
iii) Types of stores are not divided.

Table 6-2. Estimation Results of Destination (Type 2) Choice Models of Level 2 [i) ii)]

Model	Model 1		Model 2		Model 3	
Independent Variables	PB	ZB	PB	ZB	PB	ZB
Logsum	0.7970 (5.24)	0.5798 (8.62)	0.6998 (3.16)	0.3287 (9.86)	0.5174 (3.55)	0.6249 (4.42)
Floor Area (100 m^2)	0.0666 (3.70)		0.0932 (3.84)	0.0209 (1.97)	0.2064 (3.89)	0.0482 (2.67)
Floor Area around Concerned Stores	0.0051 (1.94)		0.0013 (1.91)		0.0026 (1.89)	
Location Dummy	0.6881 (2.11)		1.7536 (3.52)		2.4051 (3.15)	
Item Dummy	-0.95 (-3.18)					
# Sample	71		94		30	
ρ^2	0.531	0.328	0.341	0.297	0.303	0.218
Hit R (%)	71.83	39.44	68.82	46.81	86.67	33.33

i) Numbers in the parentheses are t-values of each parameter.
ii) "PB" means point-to-point-based model and "ZB" means zone-based model.

Table 6-3. Estimation Results of Destination Choice Models of Level 2 [i) ii)]

Model	Model 4				Model 6	
Type of Stores	Type 1		Type 2			
Independent Variables	PB	ZB	PB	ZB	PB	ZB
Travel Time (minutes)	-0.160 (-4.32)	-0.258 (-8.29)	-0.140 (-3.35)	-0.296 (-8.27)	-0.098 (-2.74)	-0.076 (-1.72)
Parking Space per Floor Area (100 m^2)	0.0031 (3.60)		0.0045 (2.89)			
Floor Area around Concerned Stores	0.0003 (2.31)		0.0011 (1.68)			
Proportion of Pedestrian	0.0640 (2.94)		0.0916 (2.74)			
Location Dummy	1.1469 (3.07)		3.7000 (3.33)			
Item Dummy	-1.854 (-3.71)					
# Sample	138		103		50	
ρ^2	0.183	0.243	0.223	0.215	0.175	0.186
Hit R (%)	63.40	47.10	64.71	42.72	70.00	44.00

i) Numbers in the parentheses are t-values of each parameter.
ii) "PB" means point-to-point-based model and "ZB" means zone-based model.

Table 7. Estimation Results of Destination Choice Models of Level 1 [i) ii)]

Model	Model 1		Model 2		Model 3		Model 4	
Independent Variables	PB	ZB	PB	ZB	PB	ZB	PB	ZB
Logsum of Type 1	0.1657 (4.14)	0.3545 (1.56)	0.2236 (2.84)	0.4434 (1.98)	0.1492 (6.64)	0.3707 (2.20)	0.8270 (4.73)	0.2115 (6.30)
Logsum of Type 2	0.1022 (3.59)	0.6736 (2.19)	0.8542 (5.13)	0.2629 (1.20)	0.0763 (2.82)	0.2212 (1.54)	0.6694 (5.84)	0.4957 (6.16)
Type 1 Dummy	6.3702 (3.16)	0.4924 (3.16)	1.4123 (2.59)	0.3342 (1.27)	0.6895 (7.61)		0.8015 (2.17)	3.8307 (5.64)
# Sample	193		363		79		241	
ρ^2	0.347	0.170	0.235	0.192	0.242	0.152	0.191	0.249
Hit R (%)	74.25	63.21	77.13	74.1	67.09	62.03	78.01	81.74

i) Numbers in the parentheses are t-values of each parameter.
ii) "PB" means point-to-point-based model and "ZB" means zone-based model.

The variables defined in section 2.3 are statistically significant in the point-to-point-based models, but some of them are not significant or are impossible to be employed in the zone-based models. It can be said that, for example, there are limitations to employ pedestrian environmental factors when zonal aggregate level of services are used. Rather, estimation results point out that it becomes possible to verify hypotheses of indices by using micro-scale geographical data.

4. REPRODUCTION OF VEHICLE KM

In the following, vehicle km estimated by using micro-scale GIS data is compared with that estimated by using zonal aggregated data. In order to show the goodness of reproduction of vehicle km here, total "point-to-point-based" actual vehicle km is calculated by using road network distance between revealed destinations, and total "point-to-point-based" reproduced vehicle km is estimated by using point-to-point road network distance between destinations estimated by the point-to-point-base models. Total "zone-based" actual vehicle km is then calculated by using average zonal distances between revealed destinations, and total "zone-based" reproduced vehicle km is also estimated by using zonal distances between destinations estimated by the zone-base models. Here, each of the vehicle km is expanded by expansion factors of the Oyama-Tochigi Region person trip survey. In this person trip survey, accompanied household members of trips by car are depicted. By considering the combination of accompanied passengers of car trips, trip km by car is converted to vehicle km. Because it is advisable to employ the expansion factors suitable for the micro-scale analysis, in the next step, we plan to develop a methodology to establish the expansion factors themselves.

As shown in Figure 3, it is indicated that reproduced vehicle km estimated by point-to-point-based models and by zone-based models are relatively high. Both zone-based actual and reproduced vehicle km are, however, larger than point-to-point-based actual and reproduced vehicle km. This is mainly because revealed trip km in the person trip survey is relatively larger than road network distance. At this level, however, it is difficult to conclude that vehicle km or trip km is calculated more precisely by road network distance than by zonal distance. Thus in the next step, we apply the models to vehicle km reduction scenarios.

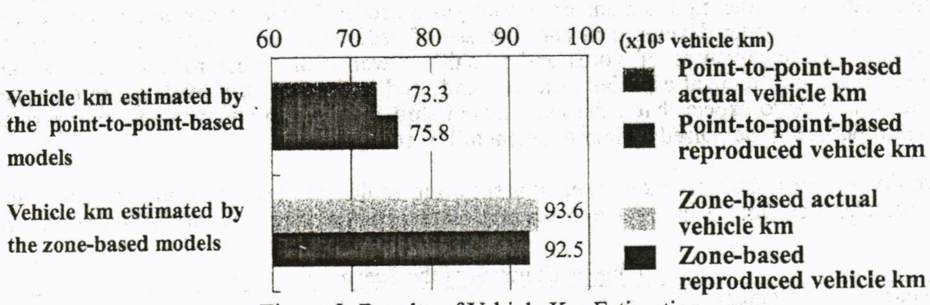


Figure 3. Results of Vehicle Km Estimation

5. ANALYSIS OF VEHICLE KM REDUCTION SCENARIOS

In the study area, lots of large-scale retail stores have been constructed along major roads in the suburb after 1990 (Figure 4). In this section, the core area is defined as the area where is targeted by the redevelopment plan. Parking spaces per floor area of the concerned stores located in the core area are about 7 vehicles/100m^2, but those of stores located in the suburb are about 15 vehicles/100m^2. If such situations affect to increase the attractiveness of and the total vehicle km to the stores located in the suburb, it is considered to be a crucial issue to modify the balance of stores' attractiveness from a viewpoint of auto-use reduction. In this section, therefore, we examine several scenarios to reduce vehicle km by increasing the

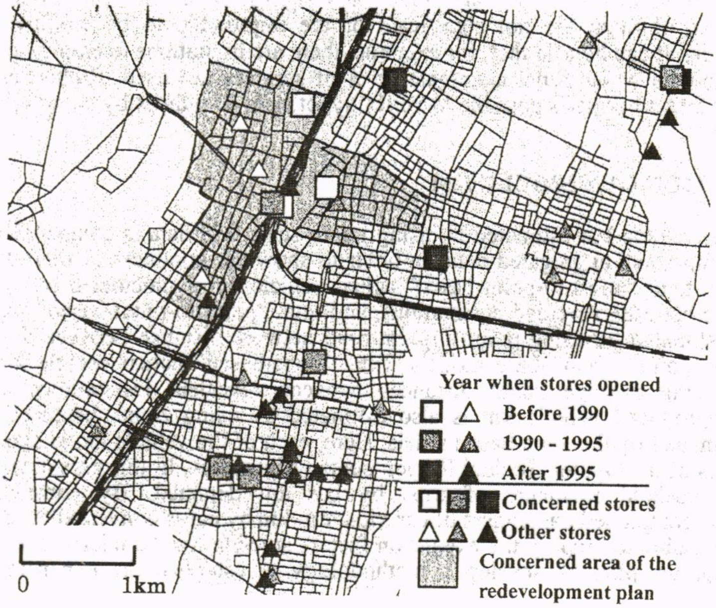


Figure 4. Year When Stores Opened around Oyama Station (▲)
(Stores that is not shown in the figure are opened from '90-'95)

attractiveness of stores located in the core area.

It is pointed out that vehicle km could be reduced when stores are located properly both in the core and in the suburb [7]. In this study, in order to show the necessity of commercial land use development in the suburb in order to reduce vehicle km to some extent, vehicle km is estimated by considering situations of several years ago. Pedestrian roads around the central station are also under development and increase of pedestrian environment is considered to increase the attractiveness of stores and to shift to walk from other modes. Because bus operations is not frequent especially on weekends and in daytime of weekdays, on the other hand, it is hard to expect that a dramatic modal shift from car to bus by improving service level of buses will be caused by improvement of bus schedules.

Considering these circumstances, scenarios shown in Table 8 are examined. In scenarios 1 and 2, vehicles per floor area of the concerned stores in the core area are increased to 10

Table 8. Contents of the Scenarios

Scenario	Contents
Scenario 1	To increase parking space of the concerned stores in the redevelopment planning area to 10 vehicles/100m^2
Scenario 2	To increase parking space of the concerned stores in the redevelopment planning area to 15 vehicles/100m^2
Scenario 3	To increase floor area by 1.2 times of the concerned stores in the redevelopment planning area.
Scenario 4	To increase floor area by 1.5 times of the concerned stores in the redevelopment planning area.
Scenario 5	Location of retail stores from 1990 to 95
Scenario 6	Location of retail stores before 1990
Scenario 7	To increase the proportion of pedestrian to 100% in the redevelopment planning area.

vehicles/100m^2 and 15 vehicles/100m^2, respectively. In the local conurbations, parking demand of stores which's floor area are over 1000m^2 should be regulated. Floor areas of the concerned stores are over 1000m^2. Floor areas of the concerned stores in the core area are then increased by 1.2 times and by 1.5 times in scenarios 3 and 4. In scenarios 5 and 6, vehicle km is estimated under the situation from 1990 to 1995 and before 1990, respectively. We also examined the effect of pedestrian environment improvement in scenario 7, according to the redevelopment plan in the study area. In short, the proportion of pedestrian paths of roads where are the redevelopment plan is increased by 100%.

In the scenarios 3-7, the current parking spaces are employed, and in scenarios 1, 2, and 5-7, the current floor areas are employed to estimate vehicle km. In the scenario 5 and 6, locations of facilities except for the large-scale retail stores are not changed at all. Similar to the reproduced vehicle km calculation, the number of trips is expanded by using the expansion ratios of the Oyama-Tochigi Region person trip survey.

As shown in Figure 5, when the point-to-point-based models are applied to the scenario analysis, the following results are shown. First, results of the scenarios 1 and 2 show that vehicle km decrease as parking spaces in the core area increase. Reductions of vehicle km of scenarios 3 and 4 are smaller than those of the scenario 1 and 2. Reduction ratio of vehicle km of scenario 6 is smaller than that of scenario 5, which show that paying attentions to store locations are necessary to reduce vehicle km to some extent. It is also indicated that promotion of pedestrian environment development can reduce vehicle km a little by the result of scenario 7.

On the other hand, when the zone-based models are applied, vehicle km reduces in the same manner as those estimated by the point-to-point-based models, but reduction ratios of vehicle km are smaller than those estimated by the point-to-point-based models. Especially in the scenarios 1 and 2, reduction ratios of vehicle km estimated by the zone-based models are smaller than those by the point-to-point-based models. It is considered that these situations are caused because sensitivity of parking space becomes smaller by aggregating the number of parking spaces.

These results do not indicate that the impact of vehicle km reduction can be analyzed more precisely by using micro-scale GIS data than by using zonal aggregated data immediately, because in some cases, for example, to evaluate the effect of major road scheme, it is advisable to estimate vehicle km by using zonal data. As a result of the analysis in this section, however, it is suggested that the point-to-point models estimated by using micro-scale GIS data are useful in the cases, for example, to evaluate the impact of parking space or pedestrian environment improvement more precisely.

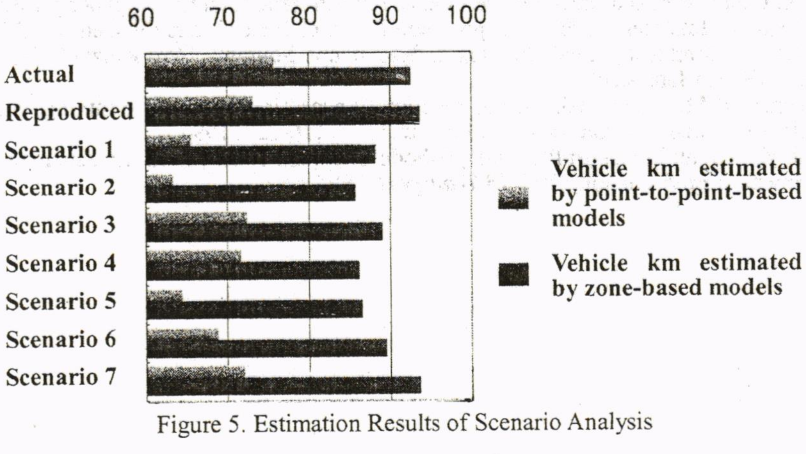


Figure 5. Estimation Results of Scenario Analysis

6. CONCLUSIONS

This study proposed mode and destination choice models in order to analyze vehicle km more precisely by developing activity point database in GIS. Then impacts of vehicle km reduction are examined by using proposed models and by using traditional zone-based models. The following results are pointed out.

(1) By using micro-scale GIS data, hypotheses examination of indices such as pedestrian environmental factor and land use agglomeration around the concerned facilities becomes possible.
(2) By calculating point-to-point service level of modes between activity points, more precise accessibility can be employed in order to estimate mode choice models.
(3) Scenario analysis results show that point-to-point-based models are useful in order to evaluate impact of urban planning in micro-scale more precisely than zone-based models in some cases such as parking space and pedestrian environment improvement more precisely.

At the next step of this study, the mode and destination choice models should be applied to activity-based micro-simulations. We plan to survey spatial-temporal activity limitations of the sample households of the person trip survey and to develop a methodology to expand the sample of trip makers. In this study, commuting trips, school trips, business trips, passenger serving trips and trips to hospitals are assumed to be "destination-fixed" activities. In some cases, however, destinations of these trips could be changed. When estimating destination choice models for trip chains that include more than two destinations, combination of destinations (facilities) and their level of service by modes should be considered.

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