

STUDY ON THE INFLUENCE TO URBAN TRAFFIC DEMAND STRUCTURE WITH THE ADVANCE INTO BUSINESS SOCIETY OF FEMALES

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Abstract: Recent participation in social affairs of females is remarkably seen in urban area. Therefore, to predict accurately the urban traffic demand under universality and applicability, it is required to analyze in detail the characteristics of females' travel demand. In order to meet such a requirement, it is important to catch the travel demand under a new concept of trip's sequential linked mechanism in each group of females' personal attributes. So, the linkage structure of trip purposes is firstly analyzed, and it is shown that every trip generation and attraction for females' groups is basically explained by trip productions and the preceding trips with some purposes. Then, the principal component analysis is applied to change rates on the trip productions in women. And, the changing structure of trip productions in females based on the person trip investigation is also discussed under the linkage structure of purposes in trip productions, generations and attractions.

1. INTRODUCTION

Changes of urban traffic in recent years are caused by paradigm shifts of society; the increase of aged persons, women's participation in social affairs, internationalization, changes of industrial structure, etc. In such various shifts, the advance to business society of female workers is causing a big change in the social system, and there is a lot of influence to urban traffic. Travel behaviors of females are different from males for the difference of working style, life style and so on. Therefore, it needs to analyze relevant travel behaviors of women in detail for the prediction of future travel demand.

The traditional four steps' model for the prediction of travel demand is generally used to understand the travel demand of citizens, in drafting a master plan on urban traffic. However, as the four steps' model is separately constructed in every step of travel demand, it is not enough to grasp essential relations among four models to reflect the paradigm shifts of society. Consequently, it is difficult to estimate essentially and exactly the travel demand with the universality and applicability. In order to meet such an issue, it is important to forecast the travel demand under introduction of a new concept on the linkage mechanism of trip purposes in every group of person attributes. That is, we propose a new model under the linkage structure of trip purposes in every group of personal attributes, although an individual trip chain model has already been proposed in other studies. The

linked structure for each group of trip purposes expresses statistically relationships between the preceding and following purposes. Our proposed models represent synthetically the travel relation among trip productions, generations and attractions, too. Therefore, if the impact of paradigm shifts of society will be predicted in trip productions, it will be directly reflected into trip generations and trip attractions. In addition, our proposed model is simple and suitable for a practical use.

Change rates of trip productions in females were given by the 1st (1972), 2nd (1983) and 3rd (1993) person trip investigations in Northern Kyushu Area, and the principal component analysis is applied to them. Then, change rates are lined up in order of absolute values of principal component scores in both positive and negative domains. The changing structure of trip production of females at the travel behavior is found by careful consideration of the curves of change rates lined up.

2. GROUPING OF PERSONAL ATTRIBUTES BASED ON THE CHARACTERISTICS OF TRIPS

To grasp precisely the trip characteristics, it is important how to classify individual personal attributes. Namely, not only the similarity in a distribution of trip productions and travel means but also other travel characteristics should be considered together.

To classify personal attributes, detailed divisions by a cross table of every 5 years of ages and 12 kinds of occupations are considered as in Table 1. The classification of every travel characteristics is analyzed by the cluster analysis on relations of personal attributes, and an ideal way of classification is examined. After all, it results in the groups of 32 categories for males and 36 categories for females. All groups for women are shown in Table 1.

In a viewpoint of the travel demand, the remarkable difference in the classification of occupations for males and females is found in no wife in male and no mining worker in female. Divisions of clerical and related workers are also different: 2 divisions for male and 4 divisions for female. The rest of groups of occupation have a few differences in subdivisions of ages between males and females.

Table 1. Grouping of ages in each occupation of females

Occupation	Clerical and related workers	Managers and officials	Sales worker	Agricultural workers	Workers in transportation	Production process workers	Mining workers	Service workers	Student	Child	House wife	Unemployed
age												
0 ~ 4												
5 ~ 9										27		
10 ~ 14										28		
15 ~ 19	1	5	9			16		20	24	29	30	34
20 ~ 24	1	5	9	12	14	16		20	25		30	34
25 ~ 29	2	5	10	12	14	16		20	26		30	34
30 ~ 34	2	6	10	12	14	17		21	26		31	34
35 ~ 39	2	6	10	13	14	17		21	26		31	34
40 ~ 44	2	7	10	13	15	17		22	26		32	34
45 ~ 49	2	7	10	13	15	18		22	26		32	35
50 ~ 54	3	7	10	13	15	18		22	26		32	35
55 ~ 59	3	7	10	13	15	19		22	26		32	35
60 ~ 64	4	8	10	13		19		22			32	35
65 ~ 69	4	8	10	13		19		23			33	35
70 ~ 74	4	8	11	13		19		23			33	36
75 ~ 79	4	8	11	13		19		23			33	36
80 ~ 84				13							33	36
85 ~ 89				13							33	36
90 ~ 94												36
95 ~ 99												36

Note: Blank is no trip or small size of samples.

Numbers in the table are Group No. for every category of females.

As mentioned above, the classification of personal attributes, which are defined by similarities of distributions in trip productions, trip purposes, relationships of origin and destination, modal choices, and the sequential linkage of trip purposes, was found. Therefore, the trip generation and attraction models of travel behaviors in each group of women can systematically be built up under consideration of trip productions. As a result, sequential linkage structural models of trip production, generation and attraction can be found.

3. RECENT TREND OF TRANSITION IN TIME SERIES OF FEMALES' TRIP PRODUCTION

To understand a recent trend of females' travel behaviors, the rate of trip productions in each group classified by nine occupations, which include housewife and the unemployed, is shown with years as in Figure 1. Rates of trip productions in housewives and agricultural workers are decreasing with years, while rates of trip productions for the clerical and related workers and the service workers are increasing. In particular, the rate of trips by housewives has greatly decreased from 45% to 35% in the past 20 years. On the other hand, the rate of trips by clerical and related workers has increased from 19% to 26%. The increasing trend of trip productions by unemployed females reflecting the advance of an aging society must also be noticed.

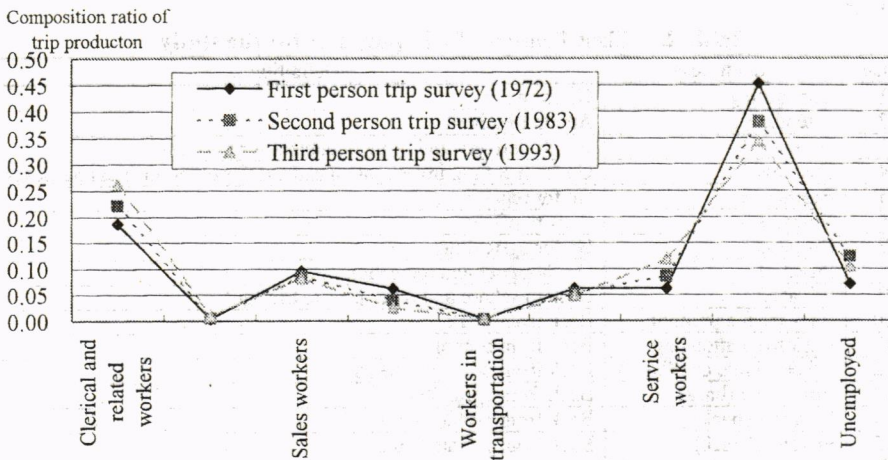


Figure 1. Rates of trip productions in each occupation of females

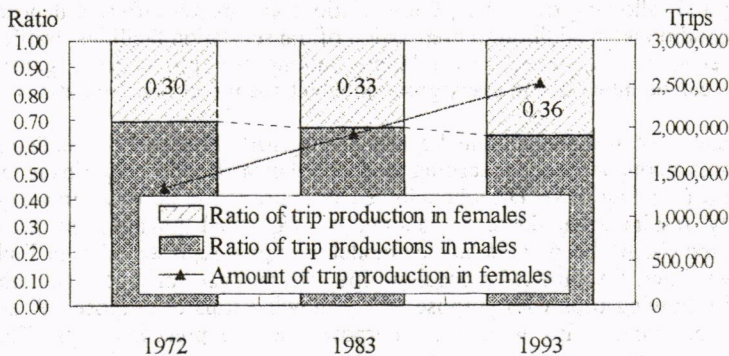


Figure 2. Transition of trip productions in females excluded housewives

Next, the transition of amount of trip productions in the whole females excluding the unemployed is shown in Figure 2. Bar graphs are the percentages of females and males in all the trip productions, and the line graph is females' gross trip productions. The ratio of females' travel demand increased with the times. The amount of females' trip productions in Fukuoka urban area has doubled in the past 20 years. Comparing with the population in the urban area, the increase of females' trip productions is much more and it is supposed that the urban travel demand is greatly affected by the participation of females into the society.

4. LINKED STRUCTURE OF TRIP PURPOSES IN EACH GROUP OF FEMALES

4.1 Table for linkage structure of trip purposes

There are various trip purposes such as commuting, attending-to-school, business, private purpose, etc. as shown in Table 2, which was obtained by the analysis of the similarity of trip characteristics. Most of persons start at a home-based trip and finish at a none-home-based trip to home. Therefore, most people produce two trips or more in a day and their trips are linked each other. In this case, these individual chains are classified by the similarity of trip characteristics in every group of personal attributes as mentioned in chapter 2.

Table 2. Classification of trip purposes for the study

code	Trip purposes	Definition
1	Commuting	Go for work
2	Attending	Attend to school
3	Business 1	Goods delivery and bring document for business
4	Business 2	Go for meeting, investigation and trip for other business purposes
5	Business 3	Go for repairing
6	Business 4	Back to office
7	Business 5	Go for agriculture
8	Private 1	Go shopping and recreation
9	Private 2	Back to school and other private trip (go)
10	Back from commuting	Back from work
11	Back from attending	Back from school
12	Other private trip (back)	Back from other private trip
13	Business 5 (back)	Back from agriculture
14	Private 1 (back)	Back from private trip 1
15	Private 2 (back)	Back from private trip 2

In a word, it can be easily guessed that the travel behaviors have some relations among preceding and following trips. And, these relations are greatly different depending on the personal conditions, in addition to preparation of transportation facilities, traffic conditions, etc. However, it is assumed that relations among trip productions, generations and attractions can be integrated in every group in which the travel characteristic is similar.

Our concept is not to show individual cycles of trip chain. A related connecting structure of trip purposes among attracted preceding trips and generated following trips is just a subject of our study (See Figure 3). The whole linked structure of trip purposes in a day at a group statistically results after the consideration of sequential linkages on preceding and following travels. At this point, a linkage model on trips is represented as in Table 3. A row in the table shows the attracted preceding trips with purpose "m" and a column shows the generated following trips with purpose "n". Following trips of purpose "n" are given by additional producing trips with same purpose and the preceded trips. The first trip generating in a day is the trip production without a preceding trip. Therefore, purposes of the preceding trip are given by 16 categories, adding the trip production.

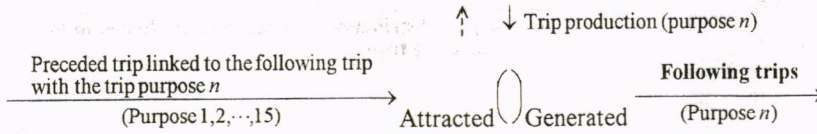


Figure 3. Basic concept of the linkage of trip purposes

Table 3. Cross-table for the linkage of purposes based on the relation between the attracted preceding trips and the generated following trips

Purpose of preceding trip \ Purpose of following trip	Purpose 1	... n ...	Purpose 15
Trip production a	...	t_{an}	...
Purpose 1		\vdots	
\vdots			
m	...	t_{mn}	...
\vdots		\vdots	
Purpose 15	...	t_{15n}	...
Total	G_1 ...	G_n ...	G_{15}

n : Number of puposes in following trip

m : Number of puposes in preceding trip

t_{an} : Amount of productions in the purpose n

t_{mn} : Amount of preceding attracted trips with pupose m and following generated trips with purpose n of following generated trip

G_n : Total trip generations for purpose n in following trips

For lack of space, it is impossible to show all the tables for linkage structure of trip purposes in every group of females. Therefore, to understand the tendency of the linkage of trip purposes, graphs on the relations between the attracted preceding trips and the generated following trips are shown for a few groups, using the data of the second PT investigation (1983).

Typical linkages on the purpose distribution of trips preceding the commuting, business 1 and private 1 trips are individually shown in Figure 4. The vertical axis is the rate of a purpose in preceding trips, in the case that the amount of following generated trips is assumed to be one. It is seen that the purposes of trips preceding the commuting trip are almost the trip productions, as in the case of males. Therefore, commuting trips can be completely assumed as the first starting trips in a day and are given only by trip productions. Trips for business 1 have various purposes in the preceded trips as in Figure 4(b). Purposes of trips preceding business 1 trips are business 1, commuting and production. Some of business 1 trips are repeated. Succeeding business 1 trips are somewhat affected by preceding trips of business 4 purpose, too. At the private 1 trips, half of preceding trips is the starting trips in a day (trip productions). This means that trips by housewives are greatly included. In addition, there is a slight trip generation of private 1 succeeded to trips of commuting and private 2.

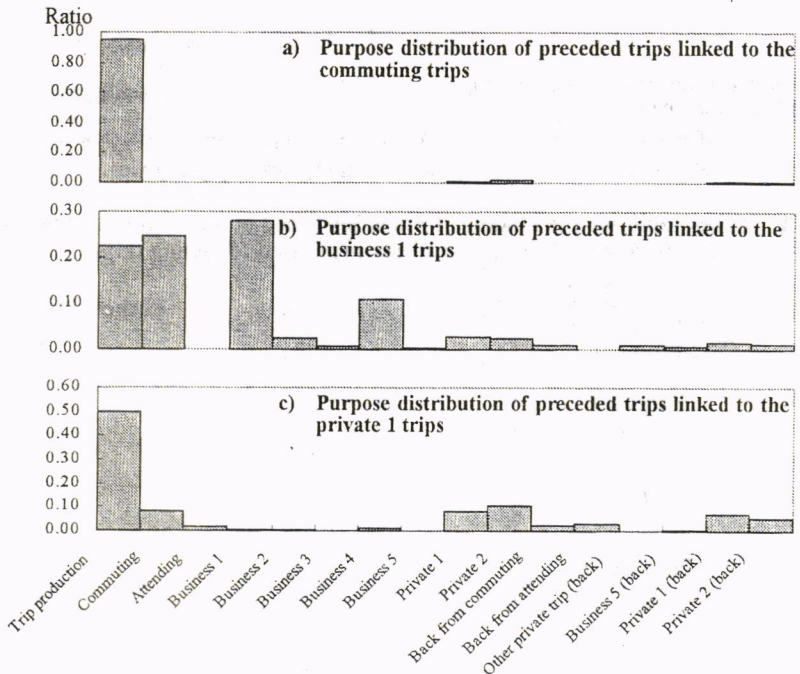


Figure 4. Purpose distribution in preceded trips linked to the following trip

4.2 Flow chart on linkage of trip purposes in each groups of females

As an overall frame, there is a similarity between the linkage structure of trip purposes for males and the one for females. However, there are a lot of different points if the structure is investigated into the detail. Therefore, the linkage structure of trip purposes in each group of females should be analyzed as a different matter to males. For the shortage of space, representative charts on sequential linkage structures of trip purposes for clerical and related women and the one for service women are shown in Figures 5 and 6. The chart of linkage structure of trip purposes for housewives that is the peculiarity of women is shown in Figure 7, too.

Figure 5 shows the linkage structure of trip purposes for all of 4 groups in clerical and related women. In the group between 25 and 49 old (Group 2) of clerical and related women, two patterns of sequential structure are found as in Figure 5. One is the simple structure composed of commuting trips, home trips and private trips intervening among them. Another pattern is the complex type of sequential linkage composed of commuting trips, business trips, private trips and home trips. In these patterns, it is different from the one of males at the fact in which private trips intervene in almost cases of females. Especially, repeating generations of private 2 trips (back-to-school, etc.) are scarcely seen in males with the same occupations, and the amount of generations of those trips in females is more than that in males. Moreover, there is a pattern that leads to going home through each business (business 5 is excluded) in the business zones after the attraction of commuting trip. Regarding the same clerical workers, there is a lot of repetition of preceded generations of business 3 trips (going for repairing) in the group 1 of young. There is also a lot of repeated generation of business 2 trips (meeting, etc.) in the age group 3. In the age group of 60 or more aged (the group 4), it can be pointed out that the rate of trip productions in each purpose is high, and that there is a little repetition of trip generations.

Study on the Influence to Urban Traffic Demand Structure with the Advance into Business Society of Females

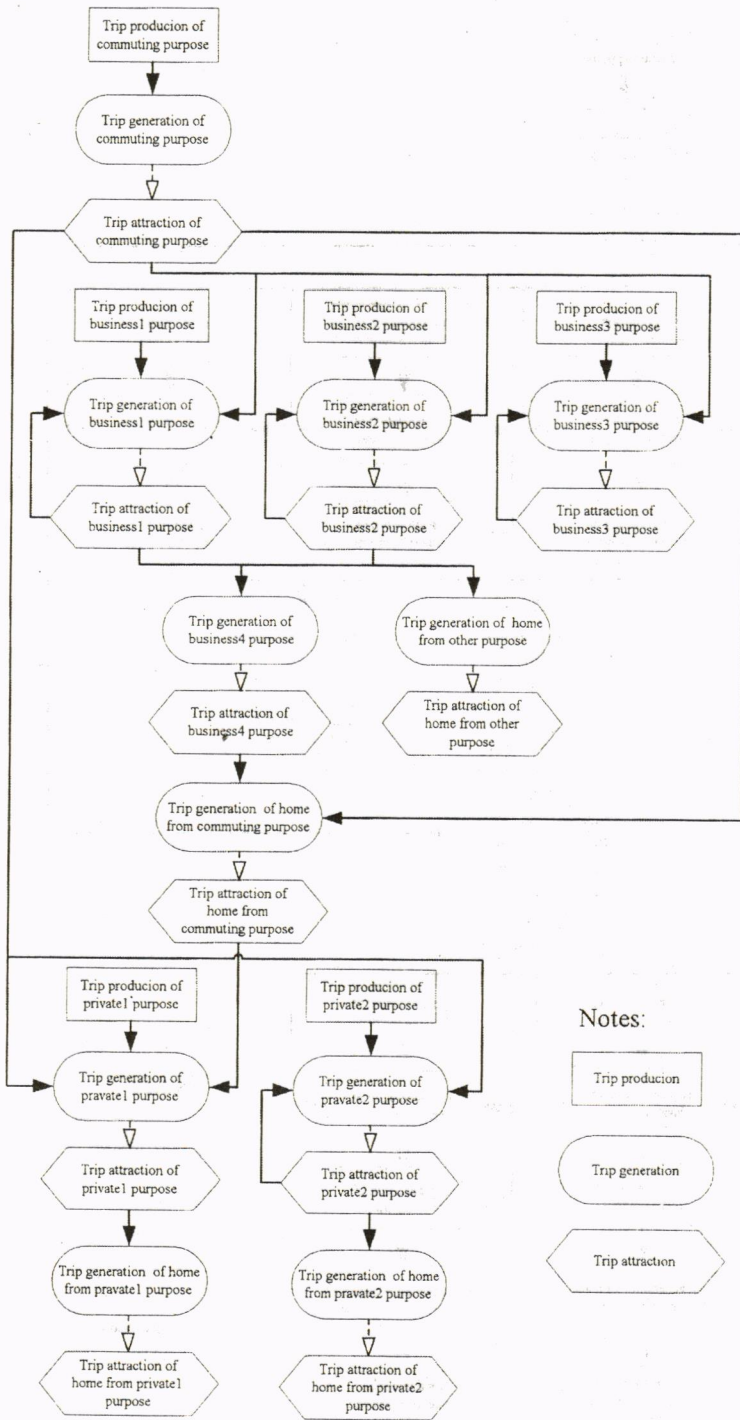


Figure 5. Sequential linkage structure of trips for the clerical and related women

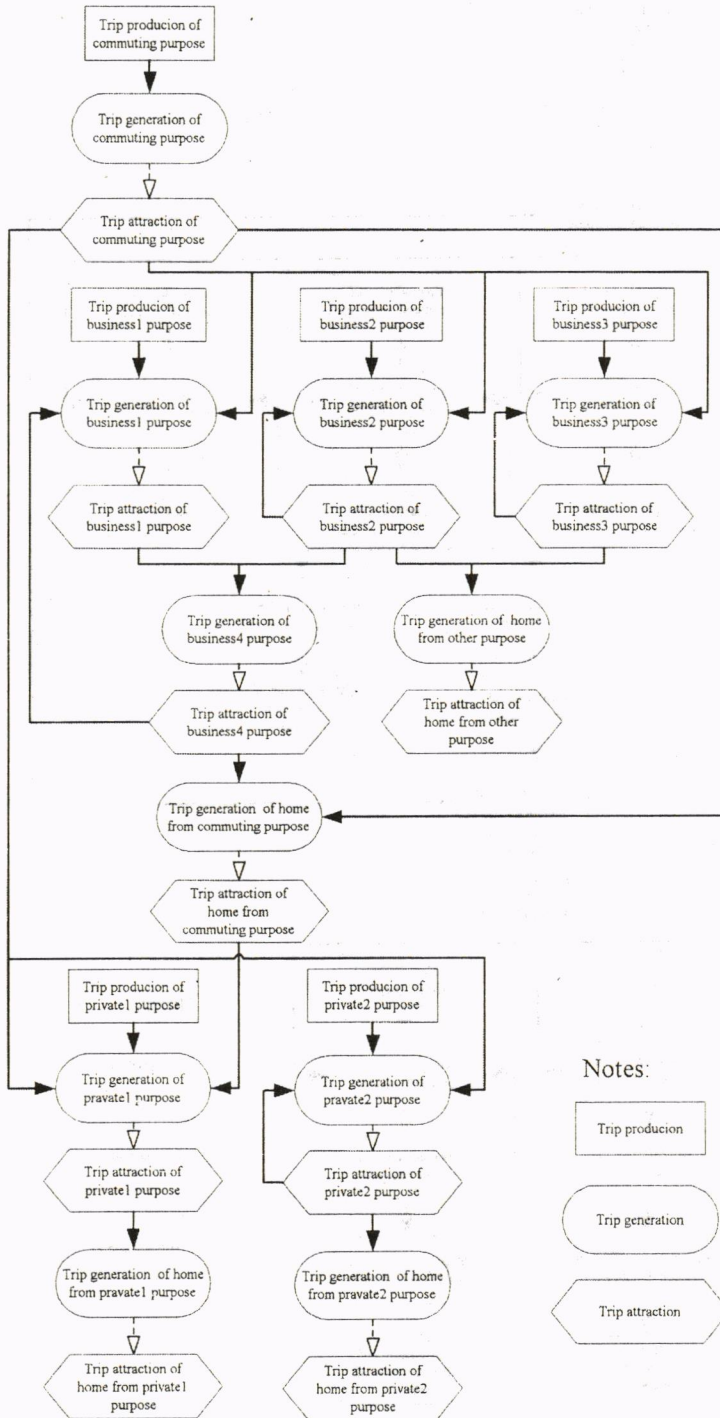


Figure 6. Sequential linkage structure of trips for service women

As for Figure 6, there are a lot of generations of business 2 trips (meeting etc.) and this purpose trip is repeated among the service workers. After returning to a company, they travel for the purpose of business 1 (delivery etc.) again. However, the skeleton of linkage structure of purposes is not so complex as a whole, because it is seen that female workers generate repeatedly the trips of business purpose less than the one of male workers. In addition, from considering the generations of business 1~3 trips after a commuting trip, it is supposed that service women travel with the various purposes of business. Skeletons for the trip linkages of the groups 21 and 22 in service women are shown by the sequentially linked structure in which the followed trips for business 4 are preceded by trip attractions of business 1. These skeletons are different from the one for the group 23 where lots of repeated generations of business 3 trips are included.

According to Figure 7, travel behaviors of housewives are basically composed of two trips with a private purpose like shopping, hobby, recreation etc. They are the combination of a going trip and a returning trip. Though trips for attending-to-school are seen in a part of hobby trips, the amount of them is small, compared with private purpose trips. Therefore, the third flow chart in Figure 7 is not a main linkage structure for housewives.

Except for the above-mentioned categories of female occupations, simply linked structures of trip purposes are found for categories of agricultural workers, mining workers, students and children. They are basically composed of two trips of going and returning, and similar to those of males with the same occupations. The amount of trips of business 3 (going for repairing) in female managers and officials is not enough for analysis, and differs from the male in this viewpoint. In addition, there is a characteristic structure of sequential linked trips from private 1 to private 2 in the sales women. Namely, it is seen that their structures are concise, compared with the male. It is characterized by the facts that their trips do not link to business 3 trips, and that trips with other purposes have no linkage to business 2 trips of transportation workers, too.

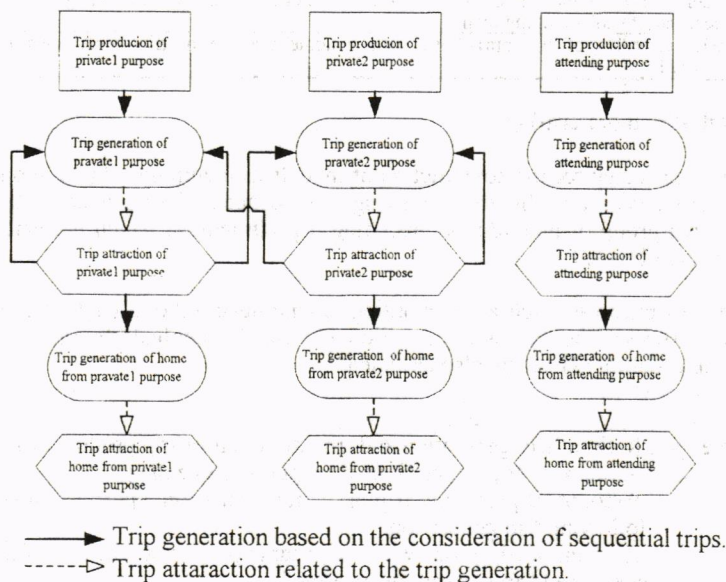


Figure 7. Sequential linked structure of trips for housewives

4.3 Modeling of trip generations and trip attractions

Based on the skeleton of linkage structure of trip purposes in every category of female occupations, models for trip generations and trip attractions can be proposed. These models for some workers originate to a model of commuting trip generation that is explained by the production of commuting trips, as in Figures 5 and 6. In a similar way, the generating and attracting models for children and students originate to attending-to-school models explained simply by trip productions. Models for other categories of occupations shall be almost constructed by originating to trip generation models in which the trip productions with the same trip purpose become a main explanation variable.

Models for trip attractions and trip generations succeeding the above originating models are explained by a set of trip productions, generations and attractions with some types of trip purposes, which depend on the skeleton of linkage of trip purpose as mentioned in the previous chapter. It is evident that travel activities are different in each personal attribute. So, models at every step in travel demand must be respectively built up in each group of personal attributes, keeping temporal and spatial transferability and reappearance of models. Sequential mechanism of trips is different among personal attributes. However, it can be said that six steps model, which is shown as in Table 4, is generally proposed on the basis of connecting mechanism in travel activities.

Table 4. Concept of modeling

Step1	Ratios of trip generations in trip productions are studied in each group. If ratios in all zones are almost constant in a group, it is appropriate to use the value as a model. If not, a model must be constructed by a multiple regression analysis, using explanatory variables.
Step2	Models for ratios of trip attraction in trip generation are constructed using trip generation in step 1.
Step3	Ratios of intermediate trip generation in the sum of trip production and trip attraction for mainly preceding purposes are modeled. In the same way of step 1, if the values of ratios are almost constant though all of zones, it is not necessary to construct the model.
Step4	Models for ratios of trip attraction in trip generation in step 3 are constructed.
Step5	Ratios of trip generations for home purpose in trip attractions for the preceding purpose are considered. In the same way of step 3, if the values of ratios are constant though all of zones, it is not necessary to construct the model.
Step6	Models for ratios of trip attractions with a home purpose to trip generations in step5 are constructed.

4.3.1 Model of trip generation

According to each step for the construction of models as mentioned above, models for trip generation are constructed by the following new concept. Using a cross table of trip linkage in each group of individuals, preceding trip attractions, which is related with trip generations, are obtained.

In each case of purposes such as commuting, attending-to-school, back-from-school and other private (back), the following equation (1) can be applied. In the case of other purposes, the equation (2) can be also assumed.

$$y_j = g_j / x_j \quad (1)$$

$$y_j = g_j / (x_{j0} + a_1 x_{j1} + a_2 x_{j2} + \dots + a_n x_{jn}) \quad (2)$$

where y_j : Ratio of trip generation and trip attraction(or trip production) in zone j;
 g_j : Amount of trip generations for a purpose in zone j;
 x_j : Amount of preceding trip attractions with some purpose linked with the following trip generation.
 x_{j0} : Amount of trip productions with same purpose as the one of the concerned trip generations in zone j;
 x_{ji} : Amount of trip attractions for some purpose as the concerned trip generations in zone j;
and a_i : ratio of trip generation by preceding trip attraction with purpose i.

If y_i on all zones can be seemed to be a constant in the purpose, the average of y_i is adopted for the model of trip generation. If it is not constant, models must be constructed by a multiple regression analysis. To determine whether it is adopted, the use of the coefficient of variation (σ/μ) can be proposed. Here, if the ratio of standard deviation by average of all zones is under 0.10, y_i is regarded as constant in the group. If not small value of σ/μ , a model of y_i will be constructed.

4.3.2 Model of trip attraction

In the same way of trip generation, trip generations for preceding purpose, which is related to trip attractions for a purpose, is selected, using a cross table of trip connection in each group. Then, trip attraction models can be constructed using the ratio of trip attraction for a purpose by trip generation. However, attracted trips are different in each zone. Therefore, trip attraction is divided into 2 groups in each purpose to grasp characteristics in OD; trips originated from a zone and destined to the same zone, x'_j , and trips originated from a zone and attracted to other zone, x''_j . A model for the ratio (κ) of x'_j are constructed by trip generations and the one for the ratio (ρ) of x''_j , by trip attractions.

$$\kappa_j = x'_j/g_j \quad \rho_j = x''_j/x_j \quad (3)$$

where x_j : Amount of trip attraction in each purpose in zone j;
and g_j : Amount of trip generation in each purpose in zone j.

Then, the following equation for trip attractions is obtained from these 2 models.

$$x_j = \kappa_j/(1-\rho_j) \times g_j \quad (x_j = x'_j + x''_j) \quad (4)$$

4.3.3 Application and reappearance of models

Models for trip generations and trip attraction are applied in each group of individuals. For the shortage of paper, results of models in the group 1 of clerical and related women are shown. Also, as for trip purposes, they are checked in their reappearance. For example, the ratio of trip generation by attractions for commuting trip and business 1 trip in the group 1 are found as in Table 5. The ratio of commuting trips to trip productions using the equation (1) is regarded as constant by zone (1.005), because of small value of σ/μ . And the ratio of business 1 trips uses the equation (2).

On the other hand, in the business 1 trips on the group 1 in clerical and related women, the large σ/μ , and the model is constructed as in Table 6. Correlation coefficient and F-value are high. Models for another trip purposes in other groups are constructed in the same way. From these models, relationships between the observed and predicted trips in each purpose are shown in Table 7. It can be found that the estimated trip generation corresponds with the observed one. As mentioned above, trip attractions are forecasted by the use of κ and ρ after finding trip generations. For example, the result of trip attractions for commuting in the group 1 of female is shown in Table 6, and the observed and estimated trips are shown in Table 7. The precision of models is no problem. These explanatory variables of models by multiple regression are shown as in Table 8.

Table 5. Ratio of trip generations by attractions for the group 1

Clerical and related workers(female)		Commuting	Business 1
Coefficient	Trip production	————	————
	Trip attraction of commuting (a1)	————	0.019
	Trip attraction of business 1 (a1)	————	0.128
y_j	Average μ	1.005	1.082
	Dispersion σ^2	0.0001	2.143
	σ/μ	0.010	1.353
	Corration coefficient	1.000	0.991

Table 6. Models of trip generations (business 1) and attractions (commuting) for clerical and related women

	Trip generation(business 1)		Trip attraction(commuting)			
	Variables	Parameter	κ model		ρ model	
			Variables	Parameter	Variables	Parameter
Explanatory variables	1	-0.0003	21	-2.148	18	-1.018
	14	20.432	18	1.538	7	-4.351
	16	-1.833	14	-8.088	3	-15.125
Constant		-5.121		2.423		9.276
F-value		10.356		6.263		2.926
Correlation coefficient		0.903		0.705		0.573

Table 7. Reappearance of trip generation & attraction in every trip purpose

Trip generation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Standard error	210	84	190	128	34	155	57	1164	1638	247	352	147	49	750	915
Average of actual	7626	7137	1230	812	203	1367	415	13514	9449	6509	6905	512	355	11214	6250
Rate of standard error(%)	2.8	1.2	15.4	15.8	17.0	11.4	13.7	8.6	17.3	3.8	5.1	28.8	13.9	6.7	14.6
RMS error	647	127	197	124	36	153	80	3696	2065	333	372	170	48	3216	3586
Correlation coefficient	1.000	1.000	0.995	0.993	0.986	0.998	0.995	0.997	0.986	1.000	0.999	0.976	0.995	0.998	0.991
Trip attraction	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sstandard error	2302	1226	397	565	174	419	194	2202	5584	1728	874	333	258	2131	1740
Average of actual	7983	7294	1238	805	209	1346	416	13519	9451	6199	6765	523	356	11135	6235
Rate of standard error(%)	28.8	16.8	32.1	70.1	83.5	31.1	46.6	16.3	59.1	27.9	12.9	63.7	72.4	19.1	27.9
RMS error	2874	1196	551	696	264	446	195	2253	8593	2008	856	595	296	2096	1733
Correlation coefficient	0.986	0.986	0.979	0.907	0.667	0.981	0.942	0.991	0.856	0.956	0.991	0.728	0.866	0.983	0.958

Table 8. Explanatory variables

1	Population density	12	Primary industrial work force / Night population
2	Daytime population / Night population	13	Secondary industrial work force / Night population
3	Female population / Night population	14	Tertiary industrial work force / Night population
4	Student resident repopulation / Night population	15	Primary industrial employee / Night population
5	Student population / Night population	16	Secondary industrial employee / Night population
6	Ratio of primary industrial work force	17	Tertiary industrial employee / Night population
7	Ratio of secondary industrial work force	18	Primary industrial employee / Primary industrial work force
8	Ratio of tertiary industrial work force	19	Secondary industrial employee / Secondary industrial work force
9	Ratio of primary industrial employee	20	Tertiary industrial employee / tertiary industrial work force
10	Ratio of secondary industrial employee	21	Employee / Work force
11	Ratio of tertiary industrial employee		

5. PRINCIPAL COMPONENT ANALYSIS OF FEMALE TRIP BEHAVIORS

In the preceding chapter, we attempted the consideration about travel behaviors of females in detail. And, the sequential linkage structure of trip purposes in each group for females was found. However, to clarify about the future trip behaviors with the paradigm shift of the society, it is necessary to consider not only trip volume by the built models but the change in a sequential structure of trip purposes. As mentioned in the previous chapter, sequential linkage for trip generations and attractions are essentially explained by originated trip productions and preceded trip attractions. Therefore, the travel change by the social participation of women can be sufficiently understood by the analysis of their originating trip productions. The principal component analysis is applied to the distribution of purposes for trip productions, and the results are discussed to make the change of travel behaviors clear.

5.1 Principal component analysis of females' travel behavior

Rates of trip purposes for each female group based on the data of the 1983 and 1993 PT surveys in Northern Kyushu area are calculated and the differences are found. The principal component analysis is applied to the difference data. Only the contents especially needed in this study are shown in Table 9. The cumulative proportion up to 6th components is 90.3%. The 1st component means the change of commuting travels. The 2nd component is understood as the change of attending-to-school travels in the short distance. The 3rd component is the change of business 5, and the 4th component is the change of businesses 3 and 4. The 5th and 6th components mean the changes of businesses 2 and 1.

Table 9. Results of principal component analysis for changing rates of trip purposes

Principal component	Z1	Z2	Z3	Z4	Z5	Z6	
Eigenvalue	3.834	3.168	2.409	1.954	1.314	0.875	
Proportion	25.6%	21.1%	16.1%	13.0%	8.8%	5.8%	
Cumulative proportion	25.6%	46.7%	62.7%	75.8%	84.5%	90.3%	
Factor loading	1 Commuting	0.402	-0.027	-0.058	-0.381	0.118	0.189
	2 Attending	0.032	0.519	-0.001	-0.008	-0.269	-0.205
	3 Business 1	-0.300	0.150	-0.242	0.121	0.023	0.564
	4 Business 2	0.304	-0.024	0.219	0.261	0.405	-0.362
	5 Business 3	-0.010	-0.003	0.186	0.397	-0.171	0.383
	6 Business 4	-0.256	0.178	0.062	0.428	0.341	0.028
	7 Business 5	-0.157	0.117	0.420	-0.298	0.344	0.099
	8 Private 1	0.151	-0.215	0.370	0.226	-0.370	-0.129
	9 Private 2	-0.368	-0.273	-0.149	0.024	-0.086	-0.411
	10 Back from commuting	0.368	-0.066	-0.388	-0.167	0.053	0.072
	11 Back from attending	0.035	0.518	-0.004	-0.010	-0.268	-0.213
	12 Other private trip (back)	0.326	0.036	-0.115	0.375	0.370	0.018
	13 Business 5 (back)	-0.149	0.077	0.493	-0.331	0.163	0.078
	14 Private 1 (back)	0.240	-0.300	0.304	0.090	-0.312	0.246
	15 Private 2 (back)	-0.291	-0.413	-0.129	-0.072	0.079	-0.110

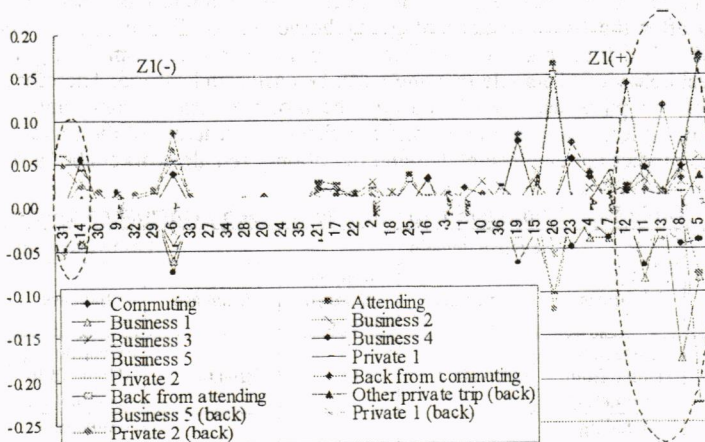


Figure 8. Curves of the changed rates of trip purposes in groups arranged in order to the 1st principal component scores

5.2 Consideration of the changed structure of travel behavior under the results of principal component analysis

By the way, the relevant problem is how to read the change in the travel behavior from a result of this principal component analysis. First of all, the principal component scores of each group are obtained. Then, if the score is lined up in order of the values, the groups with large scores or with small scores can be extracted. In this case, some groups with the

same types of largely changed trip purpose distribution are found and we can understand the changed structure of trip productions in the group. Therefore, the various types of groups with the changed composition of trip purposes will be clarified, according to every principal component.

Figure 8 shows the curve for every rate of trip purposes under the groups lined in the order of the 1st principal component scores. As a result, we can pick up the groups of housewives (group 31) and transportation workers (group 14) in the negative domain, in which the commuting trips decrease while the private trips increase. On the other hand, it is clear that the groups of managers (groups 5 and 8), agricultural workers (groups 12 and 13), and aged sales workers (group 11) are quite the opposite sites.

The curves of changed rates in another principal components are plotted as in a way of Figure 8. As a result, pair of purposes with large changing rates in every component is obtained as in Table 9. Z2(-) curve is for the negative domain of the second principal component, and we can find the decreasing of attending-to-school trips in place of the increasing of business 1 trips. Z2(+) shows the opposite state of Z2(-). In other components, we can obtain almost the same result too, though there are a few cases of different results among the positive and negative domains.

In Table 10, the groups with trip purpose largely changed are understood. And, the character of commuting, those the trip production is increasing, is shown in Z1. Especially, we can find large change in the female managers (group 5, 8) from this table. Commuting trips by agricultural workers (group 12, 13) are also increasing, as shown in the negative domain of Z3. This means that agricultural women work for not only agriculture but also another job as a temporary employee. The change in other groups can be understood from this table.

The change for the sequential structure of female manager's travel purpose is shown in the sequential structure, it is Figure 9. A linkage structure of trip purposes in the groups has no trip generation of the business 3. Moreover, it is characterized that there is no trip generation after the trip attraction of going home. In the figure, a bold line means the increase of linked trips, and a dotted line shows the decrease. From the figure, the change of the travel behavior of female managers can be easily understood. Therefore, if a linkage structure of trip purposes is analyzed and the model of trip demand under the changed linkage, the result is useful to understand the changing structure of the travel behaviors and effective to predict relevant travel demand in not only female workers but also every group of women.

Table 10. Change of trip purposes at each principal component

Principal component	Negative domain			Positive domain		
	Decrease	Increase	Group No. changed largely	Decrease	Increase	Group No. changed largely
Z1	·Commuting ·Home from commuting	·Private 2	31,14	·Private 2	·Commuting ·Home from commuting	5,8,11,12,13
Z2	·Attending ·Home from attending	·Business 1	8,11	·Business 1	·Attending ·Home from attending	25,26
Z3	·Business 5	·Commuting	12,13	·Commuting	·Business 5	8,11
Z4	·Business 4 ·Business 3	·Business 5 ·Business 5 (back)	5,6,11,19,23	·Business 5 ·Business 5 (back)	·Business 4 ·Business 3	12,13
Z5	·Business 2	·Private 1	13,15	·Private 1	·Business 2	5
Z6	·Business 1	·Business 2	8	·Business 2	·Business 1	15

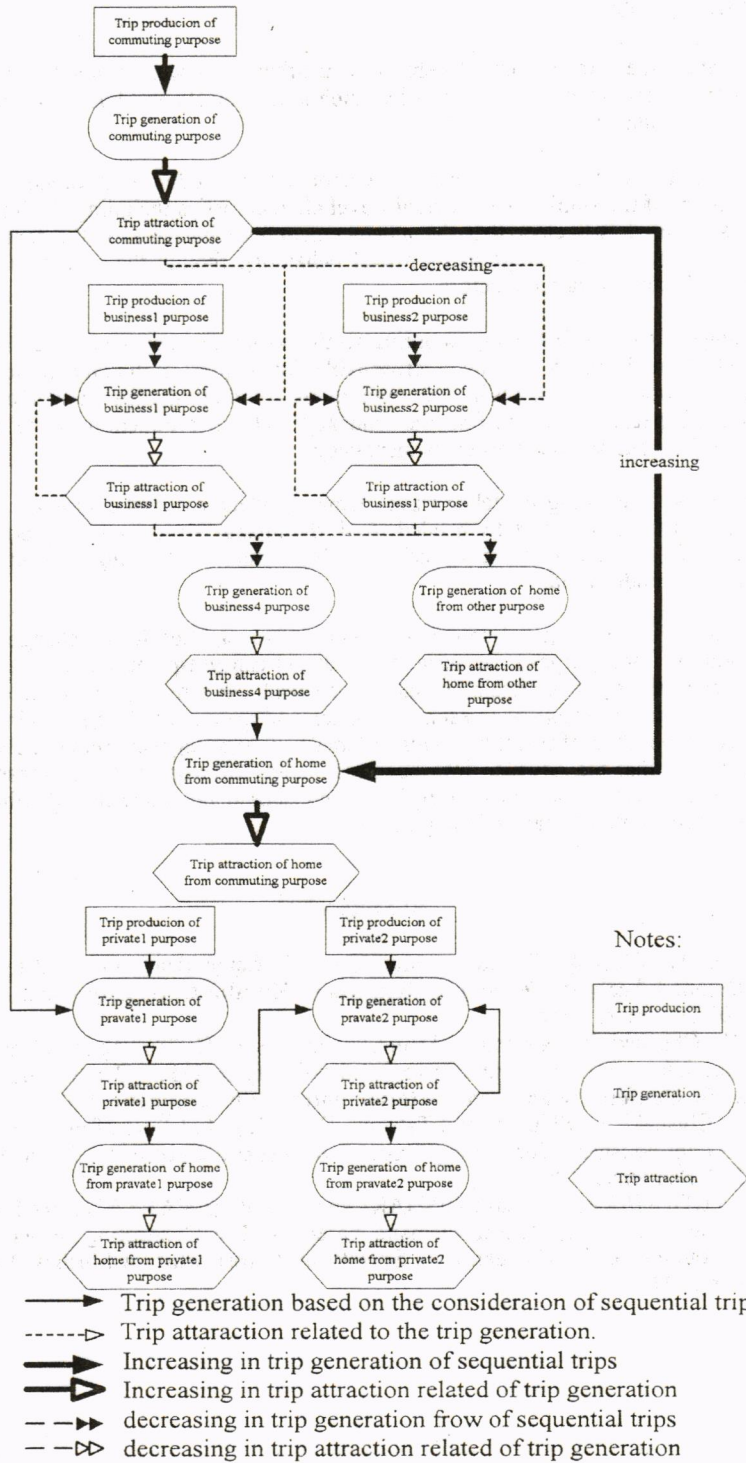


Figure 9. Change in the 10 years from 1983 to 1993 of sequential structure of trip purposes for female manager & officials

6. CONCLUSION

In this paper, the females' travel behaviors in urban area were studied, concerning the recent trend of the large participation of women in the society and business. Summaries of results are as follows.

It was found that occupations and ages of women are grouped into 32 categories, under the consideration of the similarity of several travel characteristics including the linkage of trip purposes. And, it was clear that the advancement into business of the female workers especially brings a big change to the travel behaviors, though the paradigm shift of the society is affected by various factors.

The change in the trip behavior according to the social advancement in female activities was studied in detail, proposing a cross-table for sequential linkage structure in trip purposes of women. As a result, the amount of commuting trips in women is largely increasing. Especially, we can find the tendency that trip production of the clerical and related workers and service workers is increasing.

Therefore, the forecasting model of travel demand, which can make allowance for such a changing structure, is essentially needed. And, the linkage structure of trip purposes must be considered in detail using a technique by which the change structure can be systematically understood.

In the chapter 5, the principal component analysis was applied to the change rate of trip productions in each purpose. Because this analysis can grasp the result of the principal component in the sight, a certain change can be read. As a result, we can understand the change rate of trip productions in each occupation and the main trip purposes in each group. Therefore, the change of travel behavior in female manager appears remarkably and it can be understood that the advance into business society of women has increased. We can emphasize that the prediction of travel demand should be modeled with the changing structure of sequential linkage of trip purposes.

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