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Fundamental Analysis of Trip Patterns in Urban Area Considering Household Composition in Addition to Gender and Age

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Abstract

With increasing diversification of lifestyles in recent decades, it is becoming more necessary to consider factors other than gender and age, such as household composition, for accurate travel behavior analysis. In Japan, as a result of changing trends in society, such as the growing number of middle-aged singles or increase in the number of working mothers, travel behavior has become increasingly diversified. However, existing trip pattern research which focuses only on age and gender, is not able to capture variation based on household composition. This study found that same gender and age groups exhibit significantly different trip patterns compared to same household composition. This suggests that household composition is an important indicator for trip pattern analysis. Additionally, in order to capture travel behavior by household, the study argues that it is necessary to employ activity-based analysis, rather than trip-based analysis.

1. Background and Objectives

In Japan, the council for transport policy has made master plans for urban transportation based on the demand forecast by applying travel behavior analysis for about 45 years. In the Tokyo Metropolitan Area, the 4-step method was first applied in the master plan of 1972. After that, a disaggregate model was applied in the master plan of 1985. A logit model was used for the mode choice model in this master plan. A probit model which is one of non-IIA models was used for the railway route choice model in the master plan of 2000 in order to assign passenger volume to each railway line more precisely. In the latest master plan in 2016, models are calibrated by gender and age group. For each

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master plan, the method of demand forecast was improved by applying more sophisticated models, as describe in Hibino et al. (2011), Kato et al. (2017), among others.

On the other hand, with increasing diversification of lifestyles in recent decades, it is becoming more necessary to apply an activity-based model rather than the 4-step method, which has some limitations, as pointed out in Kitamura (2003). In addition, it is important to consider factors other than gender and age, such as household composition, for accurate travel behavior analysis. In Japan, as a result of the changing trends in society, such as the growing number of middle-aged singles and increase in the number of working mothers, travel behavior has become increasingly diversified.

However, existing trip pattern research which has focused on only age and gender is not able to account for variation based on household composition. The objective of this study is to identify the difference in the number of trips and the trip patterns by gender, age group, and household size using the latest available statistical data. This study is a fundamental analysis of trip patterns suggesting the use of activity-based models to achieve more precise results for practical application. The ultimately purpose of the study is to employ an activity-based model in consideration of household composition for the next master plan.

2. Literature Review and Scope

Changes in household composition are expected in the Tokyo Metropolitan Area in the near future, such as an increase in the number of single-senior and dual-income households. It has become important to consider such household composition when analyzing travel behavior and demand forecast. Below is a brief review of studies on travel behavior analysis, particularly those focusing on household composition.

The study of activity-based models began in the 1970s mainly in the United States and Europe. Some existing papers (e.g., Chapin (1974), Jones et al. (1983), Pas (1984) etc.) related to travel behavior have already pointed out that age, gender, and household composition such as household type, household size, and household relationships affect activity. However, at that time, there are no instances of household composition being considered in practical application.

In addition, in recent years a few papers (e.g., Ben-Akiva and Bowman (1998), Shiftan (2008), Glickman et al. (2015) etc.) have calibrated activity-based models which take into account how household decisions like residence choice or car ownership can influence individual activity. On the other hand, Vovsha et al. (2004) point out that despite the amount of research recognizing the importance of household composition, in the United States there are few applications of the activity-based model in practical transportation planning which consider these factors. For relatively short term forecasting, the impact of household composition is somewhat less significant. Little attention has been given to the actual situation of the relationship between household composition and travel behavior.

This research tries to identify the characteristics of actual trip pattern using real statistical data toward practical application. The study represents an empirical research on trip pattern differences by household composition.

3. Target Area and Data

Target Area of this study is the Tokyo Metropolitan Area in Japan. Figure 1 shows the Target Area. The area is spread over a radius of approximately 80 km and has a population over 35 million.

The study uses the 5th Tokyo Person Trip Survey data (herein after, Tokyo PT data) from 2008 which is the latest. The survey is conducted every 10 years. The number of zones is over 1,600 and sampling rate is approximately 2%. The total number of samples in the data is 733,873 and the number of samples with 1 trip or more is 629,098 (85.7%). Collecting activity data on all members of each household is one of the characteristics of the survey.

Table 1 shows sample size by gender, age group, and household size. 12.3% are 1-person households, 28.3% are 2-person households, 24.4% are 3-person households, 23.9% are 4-person households, and 11.1% are 5-person households or more.
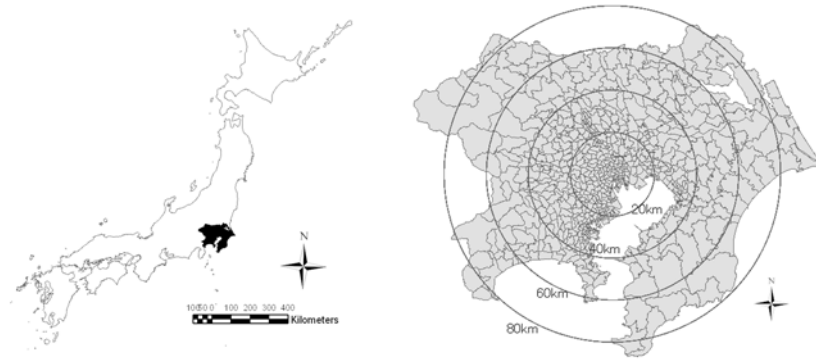
Fig. 1. Target Area.

Table 1. Sample size by gender, age group, and household size.

	Male					Female					Total
	1-person household	2-person household	3-person household	4-person household	5-person household and more	1-person household	2-person household	3-person household	4-person household	5-person household and more	
5 - 9	5 (0.0%)	338 (0.0%)	2,674 (0.4%)	7,857 (1.1%)	3,835 (0.5%)	3 (0.0%)	300 (0.0%)	2,642 (0.4%)	7,682 (1.0%)	3,571 (0.5%)	28,907 (3.9%)
10 - 14	7 (0.0%)	398 (0.1%)	2,515 (0.3%)	8,111 (1.1%)	4,595 (0.6%)	10 (0.0%)	444 (0.1%)	2,717 (0.4%)	7,865 (1.1%)	4,396 (0.6%)	31,058 (4.2%)
15 - 19	171 (0.0%)	453 (0.1%)	2,524 (0.3%)	7,223 (1.0%)	4,486 (0.6%)	143 (0.0%)	526 (0.1%)	2,606 (0.4%)	6,808 (0.9%)	4,261 (0.6%)	29,201 (4.0%)
20 - 24	1,886 (0.3%)	727 (0.1%)	3,100 (0.4%)	5,895 (0.8%)	3,381 (0.5%)	2,029 (0.3%)	1,089 (0.1%)	3,433 (0.5%)	6,211 (0.8%)	3,441 (0.5%)	31,192 (4.3%)
25 - 29	4,168 (0.6%)	2,694 (0.4%)	4,573 (0.6%)	4,346 (0.6%)	1,843 (0.3%)	3,951 (0.5%)	3,820 (0.5%)	5,384 (0.7%)	4,879 (0.7%)	1,921 (0.3%)	37,579 (5.1%)
30 - 34	4,466 (0.6%)	5,639 (0.8%)	7,918 (1.1%)	5,270 (0.7%)	1,582 (0.2%)	3,961 (0.5%)	6,654 (0.9%)	8,558 (1.2%)	6,354 (0.9%)	1,923 (0.3%)	52,325 (7.1%)
35 - 39	4,584 (0.6%)	6,047 (0.8%)	9,186 (1.3%)	8,135 (1.1%)	2,464 (0.3%)	3,929 (0.5%)	6,694 (0.9%)	9,339 (1.3%)	9,675 (1.3%)	3,183 (0.4%)	63,236 (8.6%)
40 - 44	3,842 (0.5%)	5,199 (0.7%)	7,242 (1.0%)	8,655 (1.2%)	3,157 (0.4%)	3,116 (0.4%)	5,475 (0.7%)	7,435 (1.0%)	9,715 (1.3%)	3,620 (0.5%)	57,456 (7.8%)
45 - 49	3,168 (0.4%)	4,251 (0.6%)	5,437 (0.7%)	7,953 (1.1%)	3,281 (0.4%)	2,438 (0.3%)	4,483 (0.6%)	6,039 (0.8%)	8,017 (1.1%)	3,550 (0.5%)	48,617 (6.6%)
50 - 54	2,773 (0.4%)	4,062 (0.6%)	4,952 (0.7%)	6,846 (0.9%)	3,202 (0.4%)	1,988 (0.3%)	5,127 (0.7%)	6,436 (0.9%)	6,575 (0.9%)	2,886 (0.4%)	44,847 (6.1%)
55 - 59	3,438 (0.5%)	7,223 (1.0%)	7,781 (1.1%)	6,617 (0.9%)	2,755 (0.4%)	3,178 (0.4%)	10,745 (1.5%)	9,912 (1.4%)	5,820 (0.8%)	2,032 (0.3%)	59,501 (8.1%)
60 - 44	3,114 (0.4%)	11,846 (1.6%)	9,542 (1.3%)	4,765 (0.6%)	1,625 (0.2%)	4,118 (0.6%)	16,345 (2.2%)	10,047 (1.4%)	3,396 (0.5%)	1,190 (0.2%)	65,988 (9.0%)
65 - 69	2,467 (0.3%)	16,003 (2.2%)	8,812 (1.2%)	2,786 (0.4%)	1,067 (0.1%)	4,882 (0.7%)	17,444 (2.4%)	7,385 (1.0%)	1,895 (0.3%)	1,073 (0.1%)	63,814 (8.7%)
70 - 74	1,905 (0.3%)	15,342 (2.1%)	5,919 (0.8%)	1,380 (0.2%)	960 (0.1%)	4,914 (0.7%)	13,646 (1.9%)	4,449 (0.6%)	969 (0.1%)	1,098 (0.1%)	50,582 (6.9%)
75 - 79	1,539 (0.2%)	11,097 (1.5%)	3,299 (0.4%)	673 (0.1%)	841 (0.1%)	4,685 (0.6%)	8,618 (1.2%)	2,215 (0.3%)	674 (0.1%)	1,210 (0.2%)	34,851 (4.7%)
80 - 84	1,141 (0.2%)	6,051 (0.8%)	1,485 (0.2%)	395 (0.1%)	720 (0.1%)	3,686 (0.5%)	4,074 (0.6%)	1,334 (0.2%)	784 (0.1%)	1,014 (0.1%)	20,684 (2.8%)
Over 85	785 (0.1%)	2,391 (0.3%)	642 (0.1%)	323 (0.0%)	463 (0.1%)	3,313 (0.5%)	2,127 (0.3%)	1,911 (0.3%)	1,108 (0.2%)	972 (0.1%)	14,035 (1.9%)
Total	39,459 (5.4%)	99,761 (13.6%)	87,601 (11.9%)	87,230 (11.9%)	40,257 (5.5%)	50,344 (6.9%)	107,611 (14.7%)	91,842 (12.5%)	88,427 (12.0%)	41,341 (5.6%)	733,873 (100.0%)

4. Method of Analysis and Results

4.1. Method of Analysis

The analyzing procedure was shown below. Firstly, the study aggregate the individual data of Tokyo PT by not only gender and age group but also household size. Secondly, some graphs and tables are illustrated based on the aggregated results. Thirdly, the study identifies some characteristics such as trip pattern difference between their attributes in the graphs and tables. Finally, the considerations for the partial application are summarized on the basis of the characteristics.

4.2. Percentage of samples for each number of trips by gender and age group

Percentage of samples for each number of trips by gender and age group is show in Figure 2. Zero trip samples increase with age for both males and females. The category of two trips is the largest among samples with one trip or more. Between genders in the same age group, the percentage of female samples having zero trips is larger than for males. On the other hand, for samples with one trip or more, females show a higher number of trips than males.

4.3. Average number of trips by gender, age group, and household size

Figure 4 gives a breakdown of Figure 3 showing the average number of trips by gender, age group, and household size. In order to maintain sample sizes above 1,000, only ages 25-69 and households with 1-4 people were used in the graphs.

For men, samples from single-person households have more trips than those from multi-person households and the number of trips is inversely related to household size for each age group. However for women, four-person households have more trips than single-person households for ages 30-44, and three-person households have more trips than single-person households for ages 35-44. There is a high likelihood that for women between ages 35-44 belonging to three-person households, family and domestic responsibilities (e.g., shopping for family, trips to and from nursery school, etc.) have an impact on travel behavior.

This is one of the important findings in the Tokyo metropolitan area where the number of singles and working women is expected to increase. These results suggest it is necessary to consider not only gender and age, but also household composition when analyzing travel behavior and demand forecast.
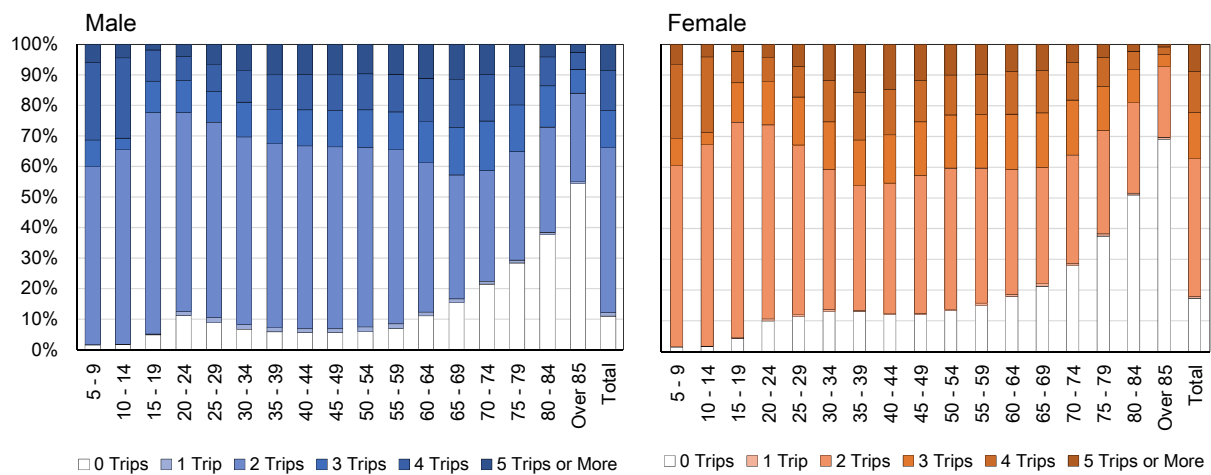

Fig. 2. Percentage of samples each number of trips by gender and age group.
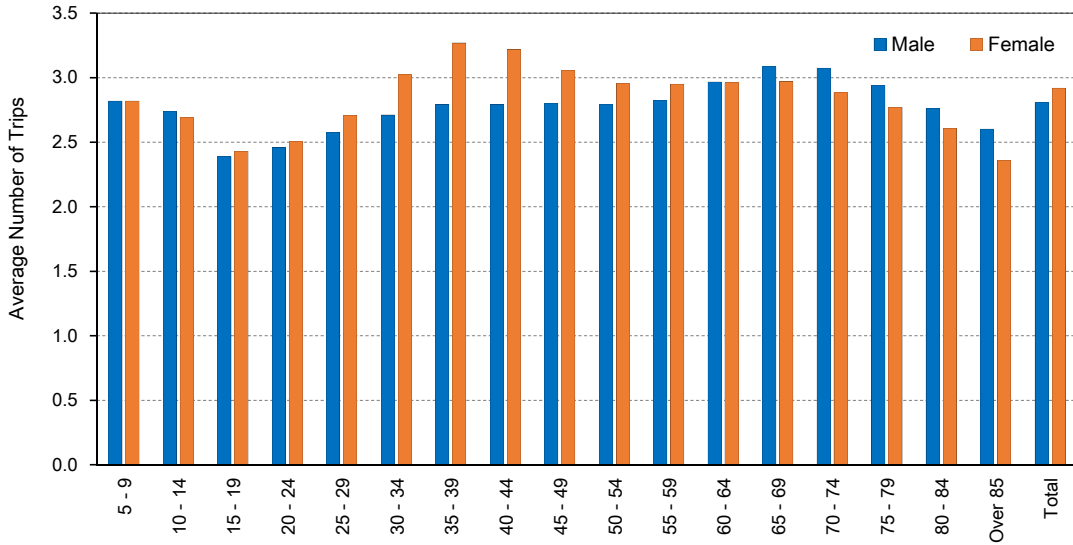
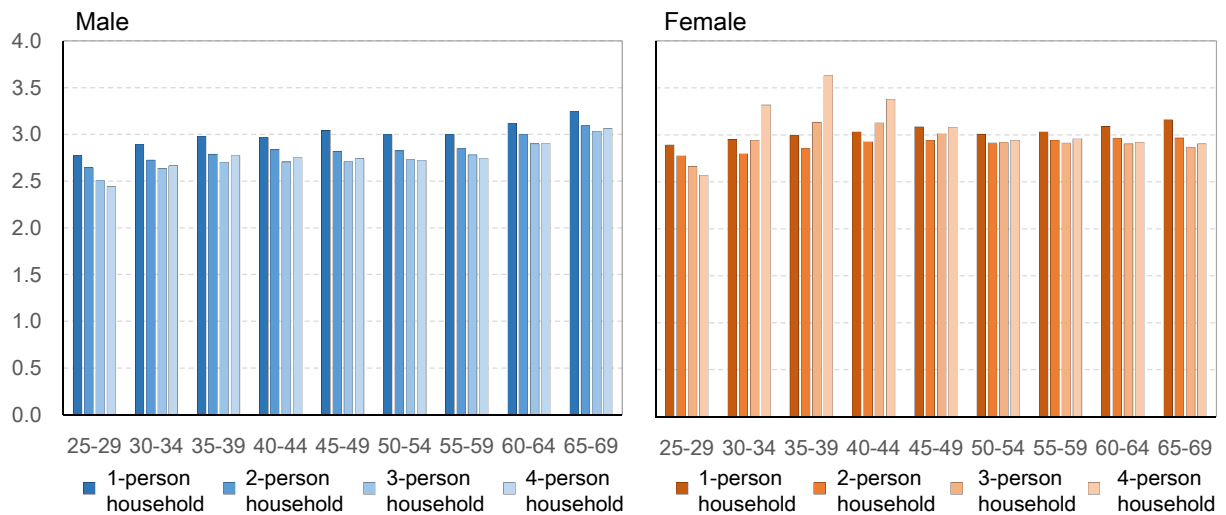Fig. 3. Average number of trips by gender and age group.

Fig. 4. Average number of trips by gender, age group, and household size.

4.4. Sample size by gender, age group, and household size

Only trip patterns accounting for more than 5% of the total number of samples for each gender and household size among samples of age 25-69 and households with 1-4 people were used in the analysis, leaving 8 different trip patterns. Table 2 show the sample size by gender, age group, and household size. In the table, W is Work Commute, H is Back Home, P is Personal Errand, and B is Business Related. The 8 trip patterns are represented by combining these 4 trip purposes. The blank column means that the percentage is less than 5.0%. Differences in trip patterns by household composition in each age group are considered in this section.

Table 2. Sample size by gender, age group, and household size.

Age Group	Trip Pattern	Male				Female			
		1-person household	2-person household	3-person household	4-person household	1-person household	2-person household	3-person household	4-person household
25-29	W•H	51.7%	60.3%	61.8%	61.2%	43.1%	43.0%	47.1%	57.9%
	W•P•H	9.7%	5.4%			17.6%	13.2%	5.8%	6.5%
	W•P•P•H					5.5%			
	W•B•B•H								
	P•H						11.4%	14.2%	8.1%
	P•P•H						5.8%	7.0%	
	P•P•P•H								
	P•H•P•H								
30-34	W•H	49.1%	57.5%	59.8%	59.5%	40.8%	41.5%	32.4%	30.1%
	W•P•H	11.4%	5.5%			19.7%	12.4%	6.1%	5.0%
	W•P•P•H					5.0%			
	W•B•B•H		5.0%						
	P•H						13.4%	19.5%	16.0%
	P•P•H						5.4%	9.2%	6.5%
	P•P•P•H							6.4%	
	P•H•P•H								8.8%
35-39	W•H	46.8%	56.2%	58.6%	59.2%	39.0%	37.6%	29.3%	19.7%
	W•P•H	10.6%	5.3%			20.4%	12.2%	6.2%	
	W•P•P•H					5.3%			
	W•B•B•H		5.0%		5.3%				
	P•H						15.0%	18.8%	19.3%
	P•P•H						6.8%	7.9%	6.9%
	P•P•P•H							6.0%	5.1%
	P•H•P•H							5.9%	10.6%
40-44	W•H	45.2%	54.4%	58.0%	58.2%	37.2%	35.6%	31.5%	25.3%
	W•P•H	10.6%	6.0%			20.2%	12.3%	7.5%	6.8%
	W•P•P•H								
	W•B•B•H		5.5%		5.7%				
	P•H						14.1%	18.3%	19.3%
	P•P•H						7.4%	6.8%	6.1%
	P•P•P•H								
	P•H•P•H							5.5%	7.8%
45-49	W•H	43.4%	53.4%	58.2%	58.7%	37.2%	33.8%	32.2%	29.1%
	W•P•H	9.8%	5.6%			18.4%	11.8%	9.4%	9.7%
	W•P•P•H					5.1%			
	W•B•B•H				5.7%				
	P•H						15.3%	18.4%	20.3%
	P•P•H						7.8%	7.6%	6.9%
	P•P•P•H								
	P•H•P•H								
50-54	W•H	41.5%	51.2%	56.4%	58.0%	36.6%	31.6%	29.9%	28.6%
	W•P•H	8.3%				16.2%	9.3%	9.1%	8.1%
	W•P•P•H					5.0%			
	W•B•B•H				5.0%				
	P•H	5.9%				6.8%	18.7%	21.6%	22.6%
	P•P•H					5.7%	8.5%	8.3%	8.4%
	P•P•P•H								
	P•H•P•H								
55-59	W•H	38.0%	48.8%	54.3%	55.6%	35.1%	24.7%	24.2%	23.9%
	W•P•H	7.5%				12.6%	7.0%	6.9%	7.0%
	W•P•P•H								
	W•B•B•H				5.6%				
	P•H	8.2%	6.0%			9.0%	23.6%	25.9%	26.4%
	P•P•H	5.2%				8.1%	10.7%	11.4%	9.5%
	P•P•P•H								
	P•H•P•H								
60-64	W•H	27.4%	36.4%	40.2%	42.7%	22.4%	15.1%	14.7%	16.3%
	W•P•H					7.6%			
	W•P•P•H								
	W•B•B•H								
	P•H	14.6%	11.8%	12.0%	10.3%	16.3%	30.3%	34.0%	32.0%
	P•P•H	9.9%	6.2%	5.2%		14.6%	14.9%	13.6%	13.5%
	P•P•P•H						6.3%	6.2%	5.3%
	P•H•P•H						5.1%		5.2%
65-69	W•H	14.9%	19.6%	22.8%	24.7%	12.2%	6.7%	7.5%	8.5%
	W•P•H								
	W•P•P•H								
	W•B•B•H								
	P•H	21.5%	21.3%	21.0%	21.0%	23.8%	37.3%	41.2%	39.8%
	P•P•H	13.1%	11.9%	10.0%	8.8%	17.4%	17.6%	16.6%	15.6%
	P•P•P•H	7.4%	5.1%	5.0%		9.7%	7.2%	5.8%	5.5%
	P•H•P•H						6.3%	6.1%	

Focusing on the difference between genders, the percentage of commuting trips by males is higher than females. For women, there are many personal trips. Women have more diverse trip patterns than men.

Regarding the household size, there are differences in whether or not both males and females are single households or not. For men, the percentage of trip pattern "W • P • H" of single household is higher than the other household compositions. This is likely because the number of opportunities for eating out and shopping for daily necessities etc. by single men before going home is larger than the other households. For single women under 50 years old, the percentage of the case in which the first trip is personal trip is particularly low because of the high number of working women.

Samples of women of 2 or more person households are roughly divided into samples in which the first trip is a commuting trip and samples in which it is a personal trip. It seems that this trend is divided according to employment status even for same household size. Among them, for women of 3-4 person households, the percentage of trip patterns that are mainly composed of personal trips is high and it seems that the difference in trip patterns is due to the presence or absence of children.

Regarding age group, for men, samples in which the first trip is a personal trip can be seen in 50s or older. From this it can be inferred that employment status is strongly related. For men who are in their 60s, the trip patterns are diversified like women.

4.5. Sample size by gender, age group, employment status, and presence of children.

For both genders under 49 years old, differences in household composition, especially focusing on differences in the presence or absence of children are analyzed in this section.

Table 3. Sample size by gender, age group, employment status, and presence of children.

Age	Employment	Child	Male P • W +	Male P • H • W +	Female P • W +	Female P • H • W +
20-24	Working	Without child	0.4%	0.4%		
	Working	With child				2.2%
	Non-Working	Without child				
	Non-Working	With child				
	Total		0.4%	0.4%		1.7%
25-29	Working	Without child	0.3%	0.2%	1.3%	
	Working	With child	2.6%		1.7%	
	Non-Working	Without child				
	Non-Working	With child				
	Total		0.3%	0.2%	1.3%	
30-34	Working	Without child	0.6%	0.2%	1.1%	0.4%
	Working	With child	0.8%		23.8%	3.8%
	Non-Working	Without child				
	Non-Working	With child				
	Total		0.6%	0.2%	1.7%	0.4%
35-39	Working	Without child	0.5%	0.1%	1.1%	0.4%
	Working	With child	2.2%	0.4%	12.4%	3.1%
	Non-Working	Without child				
	Non-Working	With child				
	Total		0.7%	0.2%	2.2%	0.6%
40-44	Working	Without child	0.8%	0.2%	2.0%	0.6%
	Working	With child	1.5%	0.4%	8.3%	2.2%
	Non-Working	Without child				
	Non-Working	With child			0.1%	
	Total		1.0%	0.2%	3.0%	0.8%
45-49	Working	Without child	0.8%	0.2%	1.8%	0.6%
	Working	With child	1.3%	0.4%	3.4%	1.3%
	Non-Working	Without child				
	Non-Working	With child				0.0%
	Total		1.1%	0.3%	1.7%	0.7%

Table 10 shows sample size by gender, age group, employment status, and presence of children. As in the previous table, W is Work Commute, H is Back Home, P is Personal Errand. In this table "+" is other trip purposes.

As a feature, for women in their 30s, the percentage of samples who have personal trips before commuting are differ significantly depending on the presence or absence of children. It is important point that One quarter of the working mother in the early 30s has this personal trip pattern. On the other hand, for men, there is not significant difference due to the presence or absence of children.

From this result, in analyzing focusing on travel behavior, it is necessary to consider the influence by household composition as well as gender and age group. In addition, it has become more important to consider household composition because these activity patterns above mentioned will increase as more women advance into society in the future.

5. Conclusion

This study focused on individual differences in travel behavior and analyzed the differences in trip patterns by gender, age group, and household composition using the individual data of Tokyo PT with the aim of incorporating an activity-based methods into master plans in Tokyo Metropolitan Areas. Although it is a fundamental aggregate analysis, it suggested that consideration of the household composition in demand forecast is very important by identification of the difference in the trip pattern by household composition.

In the Tokyo Metropolitan Area, the number of middle-aged singles, working mothers, and seniors are expected to increase. This means that the number of trips in the future may increase due to numerous trips in these categories. Especially, identification of the increase in personal trips before singles return home, personal trips to nursery schools by working mothers, and personal trips by seniors quantitatively is an important finding with in the trend of decreasing total population of the area.

The study concludes that it is important to employ activity-based models which take into consideration household composition and that not only commuting trips but also personal trips need to be analyzed more precisely in the future. It is necessary to calibrate models for demand forecast based on the results as future research.

Acknowledgements

References

Ben-Akiva M.E., Bowman, J. L., 1998. Integration of an activity-based model system and a residential location model. Urban Studies, 35.7, 1131–1153.

Chapin, F.S., 1974. Human Activity Patterns in the City: Things People Do in Time and Space, New York, Wiley.

Council for Transport Policy, 2016. Technical report of railway demand analysis method.

Glickman, I., Ishaq, R., Katoshevski, C.R., Shiftan, Y., 2015. Integrating activity-based travel-demand models with land-use and other long-term lifestyle decisions. The Journal of Transport and Land Use 8.3, 71–93.

Hibino N., Yamashita, Y., Morita, Y., Kariyazaki, K., 2011. Policy and research issues in urban railway. The Proceedings of Infrastructure Planning 43, CD-ROM, 12pages, [in Japanese].

Jones, P.M., M.C. Dix, M.I. Clarke, I.G. Heggie, 1983. Understanding Travel Behavior. Gower, Aldershot.

Kato, H., Fukuda, D., Yamashita, Y., Iwakura, S., Yai, T., 2017. Latest urban rail demand forecast model system in the Tokyo Metropolitan Area, Japan, Journal of the Transportation Research Board 2668.

Kitamura, R., 2003. A preliminary study on variability. The Journal of Infrastructure Planning 20.1, 1–15.

Pas, E.I., 1984. The Effect of Selected Sociodemographic Characteristics on Daily Travel Activity Behavior. Environment and Planning A 16, 571–581.

Shiftan, Y., 2008. The use of activity-based modeling to analyze the effect of land-use policies on travel behavior. Annals of Regional Science 42, 79–97.

Shiftan, Y., Ben-Akiva M.E., 2011. A practical policy-sensitive, activity-based, travel-demand model. The Annals of Regional Science 47, Issue 3, 517-541.

Vovsha, P., Bradley, M., Bowman, J.L., 2004. Activity-based travel forecasting models in the United States: Progress since 1995 and Prospects for the Future. EIRASS Conference on Progress in Activity-Based Analysis, Vaeshartelt Castle, Maastricht, The Netherlands.