

Understanding Activity Pattern by Household Composition in Tokyo Metropolitan Area Focusing on Future Changes in Travel Behavior Cause by Work Style Reform

Naoki OKUNOBO ^{a*}, Naohiko HIBINO ^b

^{a,b} *National Graduate Institute for Policy Studies, 7-22-1 Roppongi, Minato-ku, Tokyo 106-8677, Japan*

^a *E-mail: mjd18402@grips.ac.jp*

^b *E-mail: hibino@grips.ac.jp*

Abstract: Recently household composition in the Tokyo Metropolitan Area is changing rapidly, largely due to increasing single and dual-income households. It is necessary to consider such social change in long-term transportation planning, however, current demand forecast models used in transportation planning are not able to take these changes into account. It is important to illustrate the change in activity patterns for each household composition type. The objectives of this study are to understand current situation on the activity patterns for each household composition type using the data of national census and the Tokyo Person-Trip Survey and to identify the important characteristics of the activity patterns in order to calibrate future demand forecast models. In conclusions, the study indicates the importance of focusing on the drop-off and pick-up trips by dual-income households with young children, as well as personal trips for single households (specifically errands during return commutes) for the modelling.

Keywords: Activity pattern, Household composition, Person trip, Dual income household

1. INTRODUCTION

Recently household composition in the Tokyo Metropolitan Area is changing rapidly, largely due to increasing single and dual-income households. In addition, work-style reform is being promoted by the Japanese government in order to fight population decline and aging, and to improve work environments. When considering future long-term urban railway planning for Tokyo Metropolitan Area, there is an urgent need to address changes such as return-commute behaviors of single-person households, drop-off and pick-up trips by dual-income households with children, telework, as well as other changes in travel behavior likely to occur in the future. Although some past research on activity-based modeling which takes into account household composition exists, it does not take into account rapid changes in household composition and diversification of travel behaviors occurring in recent years. Current urban railway planning for Tokyo Metropolitan Area employs a four step method and although the latest travel demand forecast models are able to account for variation in behavior characteristics resulting from differences in gender and age group, they cannot account for the influences on behavior between trips.

One issue for long-term urban railway planning is overcrowding of trains and perpetual delays. While railway companies are making efforts to solve such issues, residents along railway lines are a necessary source of revenue. In order to satisfy both sides, railway

* Corresponding author.

companies will need to promote telework and other more diverse movement. In order to evaluate changes in how time is used throughout the day as a result of work-style reform, it is necessary to apply an activity-based model structure that can take into account time of day. In order to do so, it is necessary to identify the characteristics of activity patterns by household composition.

Figure 1 shows the change in the number of households by household composition in the Tokyo Metropolitan Area. Since 2000, the number of single households increased by approximately 50 percent from 4.3 million to 6.3 million, comprising 40 percent of total households. Japan’s lifelong single rate, which is the percentage of people still single at age 50, is shown in Figure 2. It has increased dramatically and is expected to further increase in the future. Figure 3 shows the change in the number of single households per sq. km. (from 2000 to 2010). In central Tokyo area, the number of single households has increased by 2000 per 1 square kilometer in 10 years.

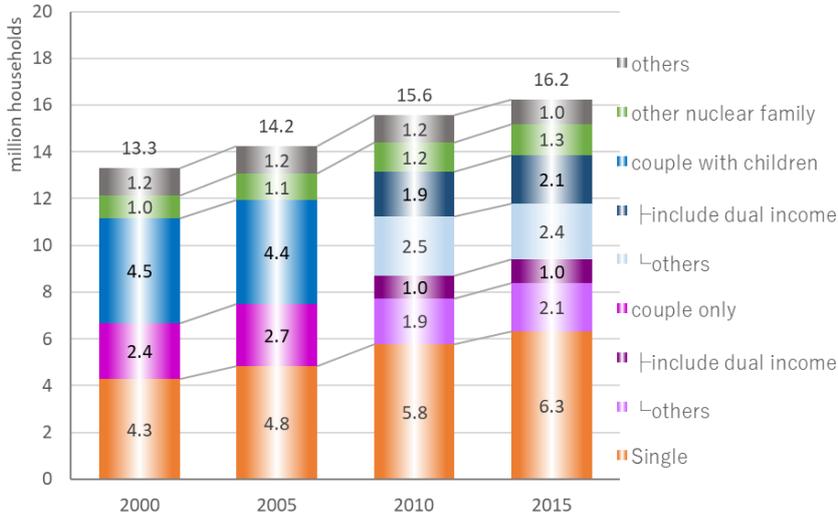


Figure 1. Changes in the number of households by household composition in TMA

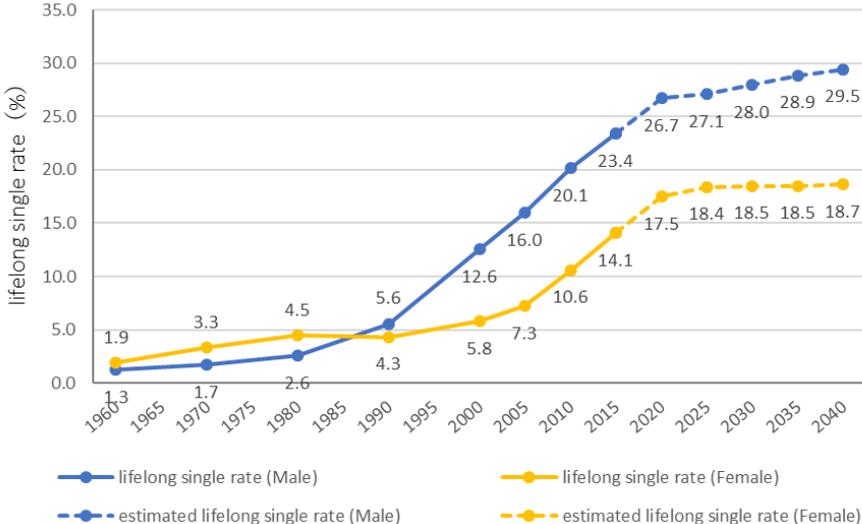


Figure 2. Changes in the lifelong single rate in Japan

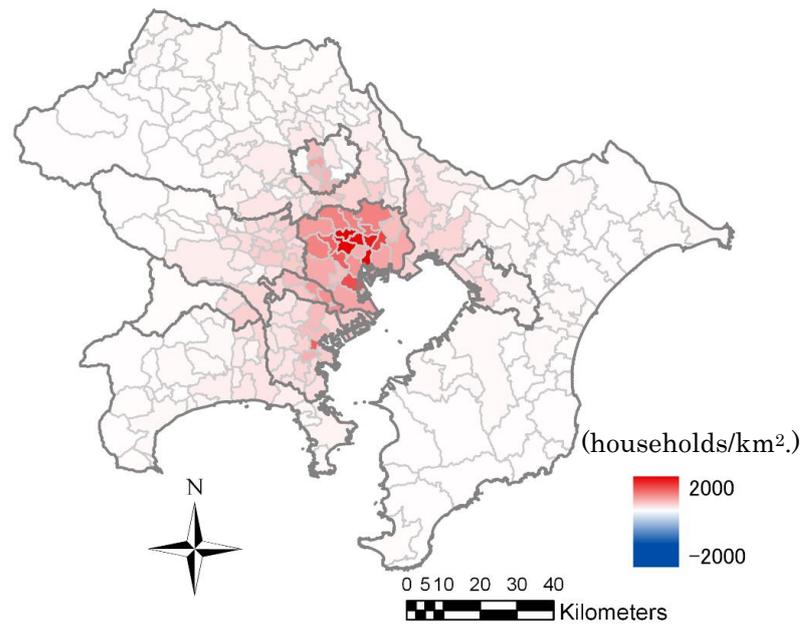


Figure 3. Changes in the number of single households per sq. km. (from 2000 to 2010)

Figure 4 shows the change in the number of dual-income couples, the percentage of dual-income couples versus the total number of couples, and the percentage of dual-income couples with children in Japan. Since 2010, the ratio and total number of dual-income households have been rapidly increasing. With improvements to the work environment in preparation for an expected decline in the working-age population, the Japanese government is encouraging more women to enter the workforce. As a result, dual-income households are expected to continue to increase in the future.

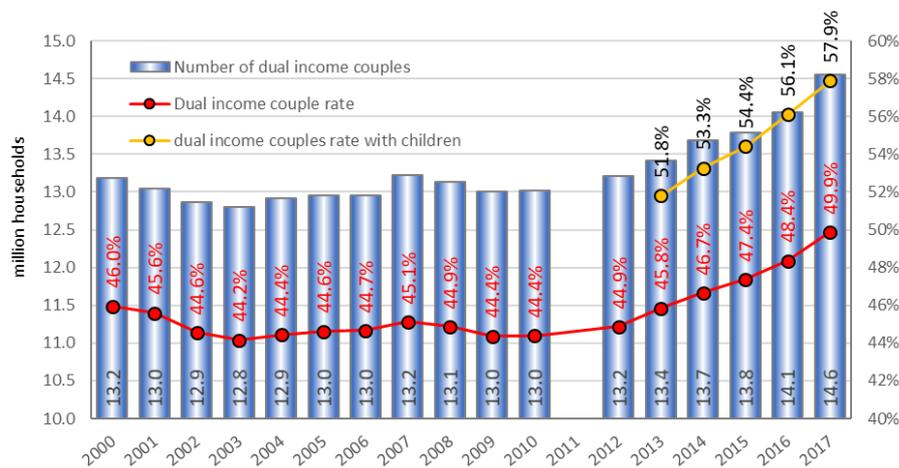


Figure 4. Changes in the number of dual income couples in Japan

In this study, the change in activity patterns for each household composition type is illustrated using person-trip survey data in order to propose a new long-term activity-based model as a fundamental analysis. This study uses Tokyo Person-Trip Survey data from the two most recent surveys and national census data from the same period. Because data from the Tokyo Person-Trip Survey conducted in 2018 was not released at the time of this study,

we use data from 2008 and 1998 surveys. National census data is from 2000, 2005, 2010, and 2015.

To understand future travel behavior by household composition, it is essential to conduct analysis which takes into account not only the most recent travel behavior, but also past trends. The objective of this research is to gain a better understanding of the most recent travel behavior by household composition, particularly dual-income households with children and single-person households.

This paper consists of 5 chapters. In the first chapter, background, objectives of the study, and our targets are described. In the next chapter, some existing papers related to the study are summarized as a literature review. Based on the review, the scope of the study is defined. Target area and data are shown in the third chapter. The detail of Tokyo Metropolitan Area and Data of Population Census and Tokyo Person Trip Survey are explained here. The fourth chapter is main chapter in the study. The chapter consists of 3 sections. In the first section of the chapter shows a comparison of activity patterns with the aim of clarifying the importance of the analysis by household composition in addition to the conventional analysis by gender and age group. After confirming the significance of the analysis by household composition, the second section analyzes the average number of trips by household composition and the third section analyzes the activity pattern of the characteristic household composition. Finally, the fifth chapter is the conclusion of the study.

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-worker and dual-income households. It has become important to consider such household composition when analyzing travel behavior and demand forecast. In Kato et al. (2017) and Yai (2016), on the latest urban railway demand forecast method in the Tokyo metropolitan area, improvement from the four-step estimation method to an activity-based approach is mentioned as a future issue. 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., Bowman and Ben-Akiva (1998), Shiftan (2008), Bhat et al. (2013), 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. Thus, although there are studies on travel behavior focusing on household composition, differences in household composition are expressed by individual variables. From this background, Hibino et al. (2019) initiated fundamental study on activity patterns focusing on household composition. This paper aims to develop their study.

3. TARGET AREA AND DATA

Target area of this study is the Tokyo Metropolitan Area in Japan. Figure 5 shows the Tokyo Metropolitan Area. It is the area of about 13,000 km², with a population of over 35 million

people. It accounts for about 30% of the population of Japan.

The study uses the Population Census and the Tokyo Person Trip Survey data (herein after, Tokyo PT data). The Population Census is conducted every five years in order to understand the population in Japan and the actual condition of households etc. The Tokyo PT is conducted every 10 years in order to understand the actual situation of trip in Tokyo metropolitan area, and this study uses two data of 1998 and 2008. The total number of samples in the 2008 data is 733,873. This is approximately 2% of the population in TMA. In samples, there are 354,308 males and 379,565 females. The sample includes 340,619 households, with an average number of 2.15 people per household. 89,803 households, or 26.4% of all households, are single households.

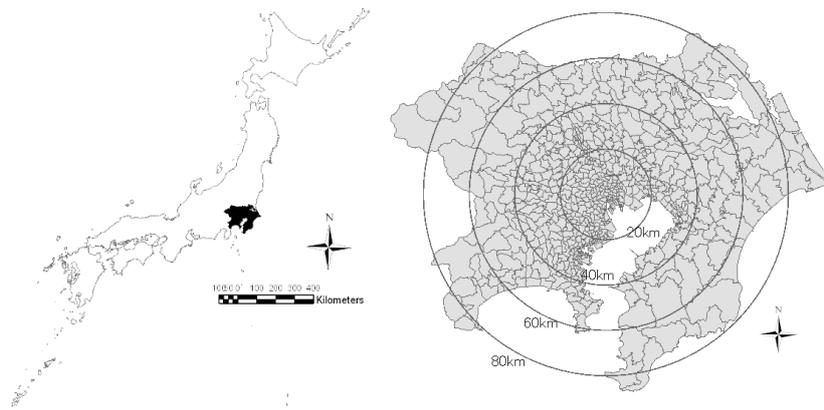


Figure 5. Target area

4. METHODOLOGY AND RESULTS

4.1 Comparison of Activity Pattern by Gender, Age and by Household Composition

Using individual data of Tokyo Person-Trip Survey, this study illustrates the activity patterns of working people applying aggregate analysis. We aggregated data focusing on Home-Work-Home trips, and activity patterns including pick-up and drop-off, return-commute shopping, and work-related trips. Figure 6 shows activity patterns for working people in the 20s to 40s age groups by gender. The highest percentage of trips were Home-Work-Home for both genders. The percentage of trips including shopping were higher for females than males in every age group, while the percentage of work-related trips was higher for males. There were no major differences by gender for the 20s age group. For the 30s and 40s age groups, we observed difference by gender, but no significant difference by age group.

Figure 7 shows activity patterns for working people by household composition and gender. Factors considered in household composition whether or not the household had small children, whether or not the household is dual income, and lastly, single-income households. Since it was not possible based on individual Person-Trip Survey data to determine whether a male and female were a couple, in this study males and females within 15 years of age living in the same household were considered couples. For households with small children, there was a large difference between males and females in the percentage of trips involving drop-off and pick-up. In addition, the percentage of return commute shopping trips was larger for single income households.

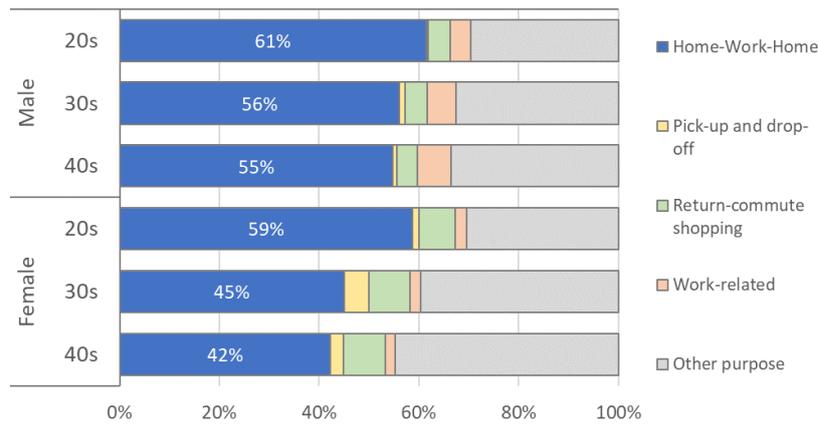


Figure 6. Activity pattern for worker by gender, age

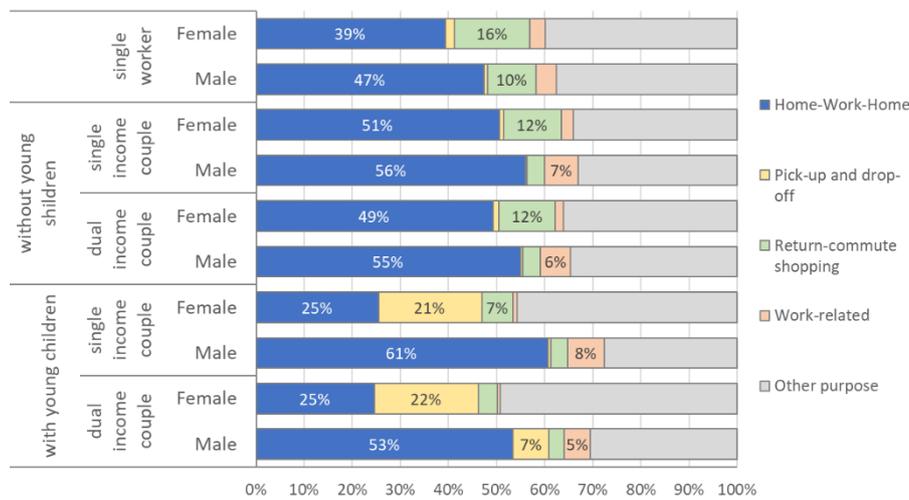


Figure 7. Activity pattern for worker by household composition, gender

Here, we conduct two t-test to determine the degree of influence age group and household composition have on activity patterns for both genders. The result of t-test for age group and household composition are shown in Table 1 and Table 2 respectively. T-test results for difference in age group were under the 20% level, indicating no significant difference. With the exception of single male and dual-income households with no children, t-test results for household composition reached a 20% level, indicating that the difference was significant.

Table 1. Results of t-test on activity pattern by gender, age group

Gender	Male			Female		
Age group	20s	30s	40s	20s	30s	40s
<i>t</i>	1.41	1.37	0.78	1.42	1.14	1.46
<i>p</i>	0.232	0.241	0.479	0.228	0.320	0.218

*** Significant at the 0.1 level.
 ** Significant at the 0.15 level.
 * Significant at the 0.2 level.

Table 2. Results of t-test on activity pattern by gender, household composition

Gender	Male			Female		
household composition	With young children	Without young children	Single worker	With young children	Without young children	Single worker

	Dual income	Single income	Dual income	Single income		Dual income	Single income	Dual income	Single income	
<i>t</i>	1.85	1.77	1.20	1.12	1.63	2.09	2.18	0.95	1.73	1.74
<i>p</i>	0.139**	0.152*	0.297	0.327	0.179*	0.104**	0.095***	0.397	0.159*	0.157*

*** Significant at the 0.1 level.

** Significant at the 0.15 level.

* Significant at the 0.2 level.

Comparison of the aggregate results suggests that in addition to traditional analysis by gender and age group, in order to fully understand activity patterns, it is important to conduct analysis based on household composition.

4.2 Characteristics of Average Number of Trips by Household Composition

To understand the behavioral characteristics by household composition the average number of trips by household composition are analyzed in this section. Figure 8 shows the average number of trips by household composition in 2008. In the five household compositions, the average number of trips of dual-income households with young children is the maximum at 3.24 times/day. The number of trips of single households is second largest. Also, the average number of trips by gender group by household composition shows that the significant influence of young children in females from Figure 9. For male, the average number of trips for single households is the largest. Dual-income households and single households those who have high average number of trips are expected to increase in the future, and it is necessary to be able to appropriately evaluate the activity pattern of these attributes in considering future long-term transportation planning.

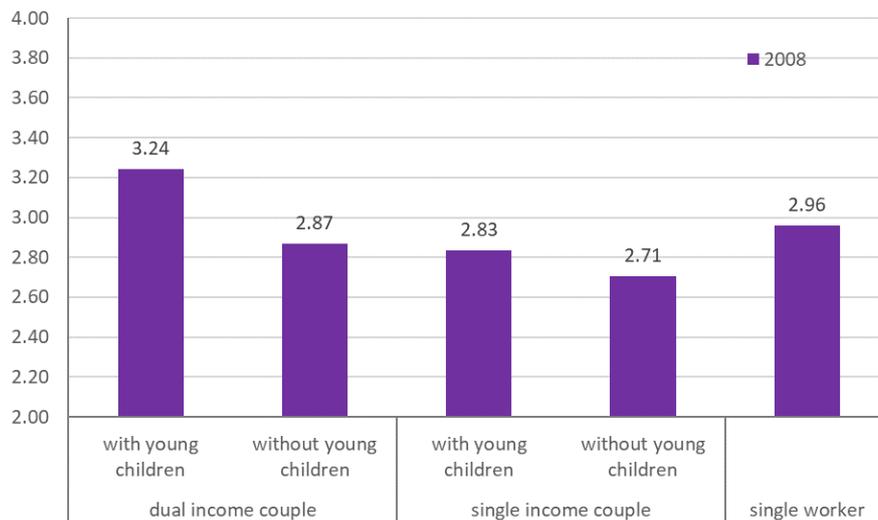


Figure 8. Average number of trips by household composition

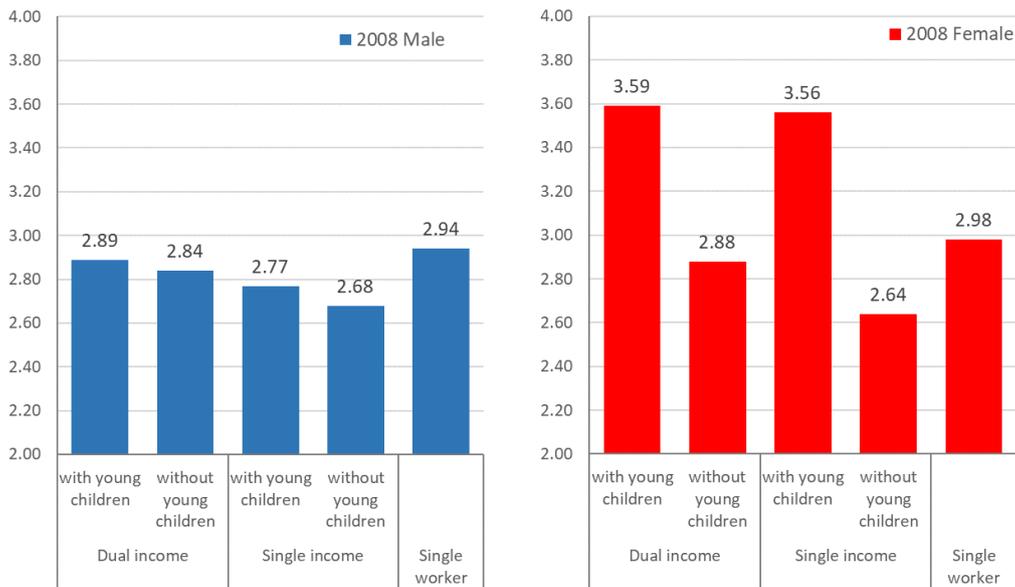


Figure 9. Average number of trips by gender, household composition

Figure 10 shows the average number of trips by household composition type and gender. Females with young children show a high number of pick-up and drop-off trips. In single households, the proportion of personal trips including shopping and dining out for both male and female are high. Therefore, in future transportation analysis in the Tokyo Metropolitan Area, it will be necessary to consider these personal purpose trips such as return commute errands. Unlike commuter purpose trips that typically take place in the morning, when considering personal trips it is necessary to consider the time of day. Here, our objective is not to-the-minute detailed modeling, but to gain a clearer picture of whole day activity patterns and how these trends may affect rush hour characteristics in the future.

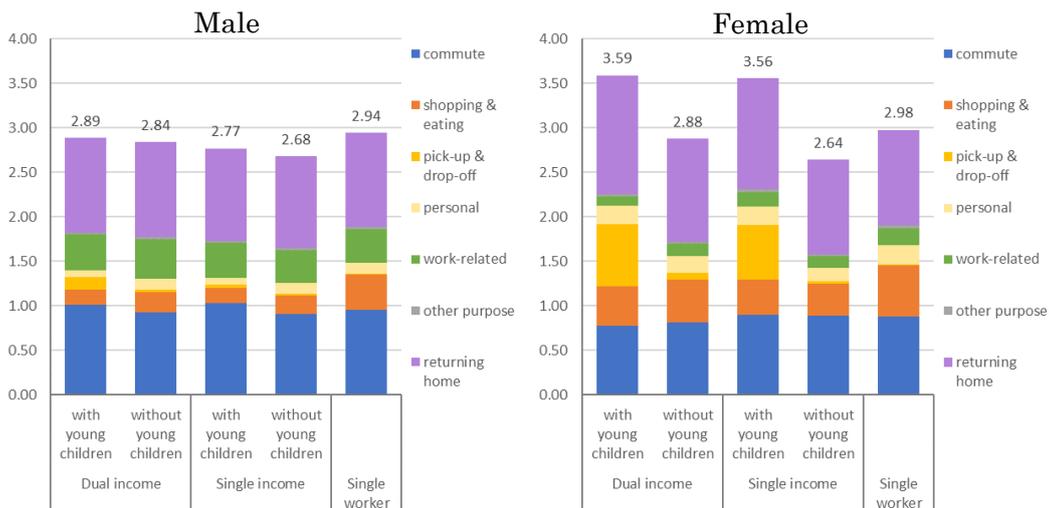


Figure 10. Average number of trips by trip purpose, gender, household composition

4.3 Characteristics of Activity Pattern of Dual-Income Households with Young Children and Single-Workers

In this section, activity patterns of both dual-income households with young children and

single-worker households are shown in detail. The activity pattern to be analyzed is a pattern having the following place as an origin and destination. Home (H), Work place (W), pick-up and drop-off (P), shopping (Sh), eating (E), other personal purpose (Ps) and work-related (B). For example, a pattern that commutes to work place and return-commute shopping is shown as "H-W-Sh-H".

Figure 11 and Figure 12 show the number of samples by activity pattern of each dual-income households with young children and single workers, respectively. However, since the HWH pattern is particularly numerous, it is excluded. In the activity pattern of the dual-income households with young children, the patterns including the pick-up and drop-off (P) are first three in the rank, these all increase in large amounts for ten years. For single worker households, there are many patterns that return-commute shopping, eating, and these patterns are more common in 2008 than in 1998.

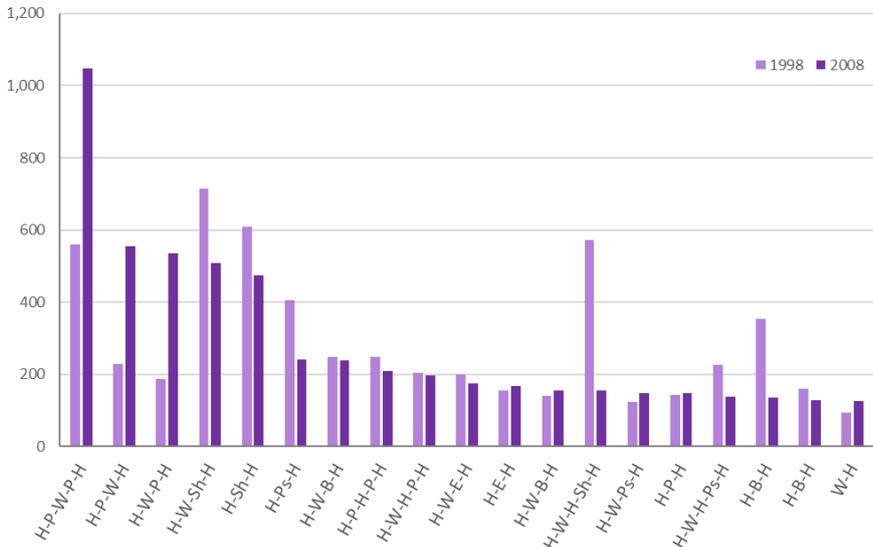


Figure 11. Number of dual-income household with young children by activity pattern

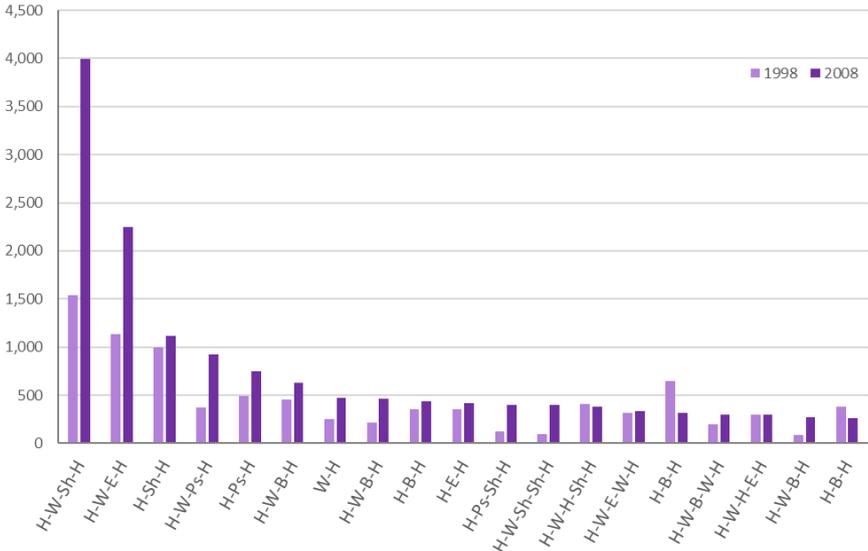


Figure 12. Number of single worker samples by activity pattern

The following shows the activity patterns of single-person households by gender and age group. Figure 13 shows the results for 1998 and Figure 14 for 2008. The figure shows the breakdown of the top 20 activity patterns in the total of all attributes for each year. Comparing the two figures, the percentage of H-W-H is lower in 2008 for all attributes, indicating that activity patterns are more diverse. Focusing particularly on those in their 60s, the proportion of H-W-H was less than 40% in 2008, indicating that the proportion of patterns not included in the top 20 patterns is much higher than in other age groups. Analyzing the pattern of single workers in their 60s, in addition to the return-commute personal purpose patterns that are seen in other age groups, there are also many patterns that include only personal trip. Future travel demand forecasting, it is important to appropriately express behaviors for personal purposes.

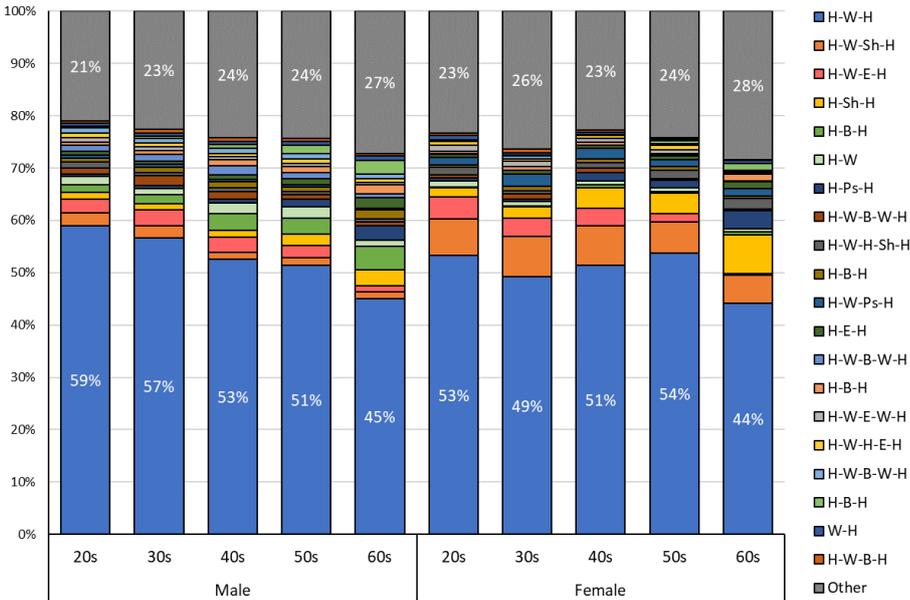


Figure 13. Top 20 activity pattern of single worker household by gender by age group in 1998

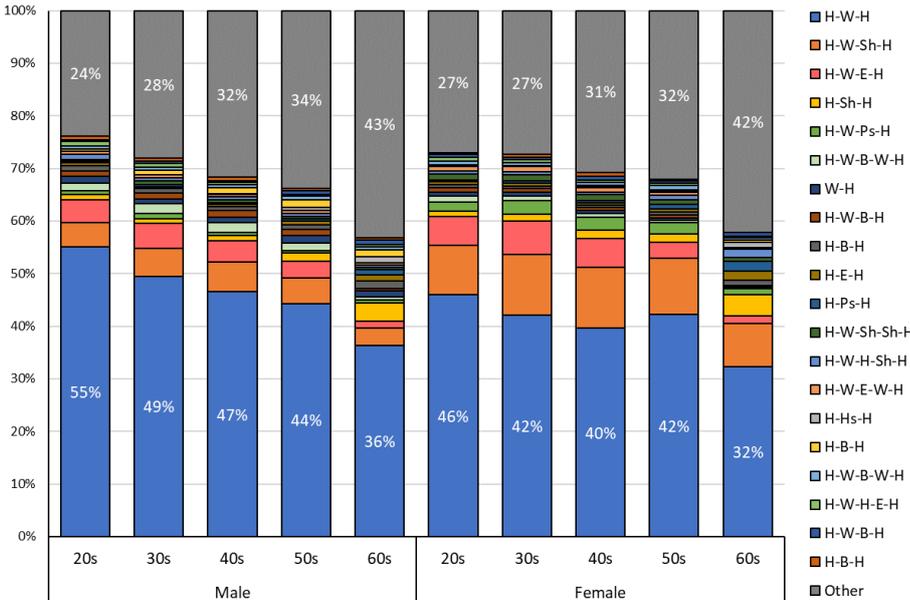


Figure 14. Top 20 activity pattern of single worker household by gender by age group in 2008

5. CONCLUSION

This study conducts a quantitative analysis using individual data of Tokyo Person-Trip Survey to illustrate the importance of considering characteristics of various type of household composition for travel demand analysis. The study suggests that it is necessary to consider not only gender and age but also household composition for more precise travel demand analysis. This is because considering that difference in household composition have a more significant influence on travel behavior than differences in gender and age group, and the diversification and complication of household composition and behavior, it is difficult to respond to such changes only taking into account gender and age group. The number of trips of dual-income households and single households is greater than the other household composition groups and is predicted to increase in the future. A method of analysis that can express such activity is required for long-term transportation planning. In addition, based on analysis of trip purpose and activity patterns by household composition, the study illustrated the need for a model that can reflect characteristics such as drop-off and pick-up trips by dual-income households with young children, as well as personal trips for single households (specifically errands during return commutes).

For future research, it is necessary to identify spatial characteristics of activity patterns for dual-income households and single households from the findings of the study. Specifically, it is important to understand which railway lines, distance bands, and household types show change in activity patterns. Furthermore, based on these spatial characteristics, it is critical to determine a more reasonable structure for activity-based models that take into consideration household composition for future travel demand analysis.

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