MODELING TIME ALLOCATION IN COUPLE HOUSEHOLDS WITH YOUNG CHILDREN

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Abstract: Women work patterns and unpaid work hours undergo significant changes across life stages. This paper develops an activity time allocation model integrated interaction between spouses based on the Nested Logit model. Furthermore, it examines whether telework adoption and the mutual respect for individual activities between spouses contribute to increased women's paid work hours.

The model reveals that key factors reducing women's paid work hours include the number of children, the extent of the wife's unpaid workload, and her contributions to household members, such as supporting her husband's paid work activities. Simulation results indicate that when husband place less emphasize on his own individual activities, joint activity hours with their wives and children increases. Furthermore, the study highlights the potential benefits of integrating shared office spaces with pick-up and drop-off services to childcare facilities, which are expected to alleviate commuting burdens and promote a more balanced time allocation within households.

Keywords: Joint activity, Activity Time Allocation Model, Intra-household Interactions, Shared Office with Childcare Facilities

1. INTRODUCTION

The Japanese government has implemented various initiatives, including the Gender Equality Plan, to promote gender equality. Despite these efforts, Japan ranks 118th out of 146 countries in the 2024 Global Gender Gap Index Ranking, reflecting a significant lag in women's societal participation.

Data from the Ministry of Health, Labour and Welfare (MHLW) in 2020 indicate that Japanese women dedicate over six times as many hours to unpaid housework and childcare as men, while their hours devote to paid work are less than half (Table. 1). Additionally, the labor force participation rate of married women is significantly lower than that of unmarried women. These patterns highlight that time allocation for paid and unpaid work, as well as labor force participation, is influenced not only by individual attributes such as gender but are also by household characteristics, including marital status. Therefore, it is essential to consider intra-household interactions when analyzing the distribution of activity time.

The outbreak of COVID-19 at the end of 2019 drastically transformed the telework situation in Japan, leading substantial changes in time-use patterns. According to data released by the Ministry of Land, Infrastructure, Transport and Tourism, the percentage of people who had ever worked remotely by 2019 was 19.1% in the Tokyo metropolitan area and 14.8% nationwide. However, when focusing on the rate of remote work in Japan over the past year, in 2021, the rate was 36.2% in the Tokyo metropolitan area and 21.4% nationwide. In 2023, the rate was 28.0% in the Tokyo metropolitan area and 16.1% nationwide. Compared to pre-pandemic levels, particularly in the Tokyo metropolitan area, remote work has been continued to be implemented even after the peak of the COVID-19 pandemic.

Table 1. Paid and Unpaid Work Time by Gender (Unit: hours/day)
(Paid Work Time + Unpaid Work Time = Total Work Time)

	Paid work time	Unpaid work time	Total work time
Men	7.53	0.68	8.21
Women	3.73	4.53	8.26

Furthermore, the benefits of teleworking such as “reducing commuting and travel time” and “enhancing family interaction and work-life balance”, have been widely acknowledged and are particularly effective in promoting women’s continued employment. Therefore, it is important to quantitatively evaluate commuting time itself and its impact on commuting time and time allocation for other activities.

On the other hand, telework also presents significant challenges related to physical work environment, including “inadequate office equipment “, “lack of desks or chairs suitable for work at home “and “difficulty concentrating on work due to the presence of family members“. To further facilitate women’s sustained employment through telework, it will be essential to provide more flexible work arrangements that are not constrained by time or location, such as the introduction of shared office spaces.

The objective of this study is to develop an activity time allocation model that incorporates spousal interactions within households with children to better understand the distribution of daily activity time. Using the proposed activity time allocation model, this study examines whether the telework adoption and the mutual respect for individual activities between spouses contribute to an increase in women’s paid working hours.

2. POSITIONING OF THIS STUDY IN RELATION TO PREVIOUS RESEARCH

In Japan, the number of dual-income households surpassed that of households with full-time housewives in the 1990s, and by 2023, the number of dual-income households more than doubled that of full-time housewife households. Women’s working style has diversified, and societal participation has progressed. However, the current distribution of paid and unpaid work time and women’s employment types reveal that the traditional notion of “men as breadwinners “remains deeply entrenched. While a new gender role division system has emerged, where wives increasingly engage in social participation while retaining housewife roles, it still reflects a family structure centered on the husband. As such, women's freedom of choice has not significantly expanded (Higuchi, 1985). Ito (2010) further suggested that the traditional gender role norms, such as “men prioritizing work and women prioritizing family “serves as a career barrier for women and their spouses. Through interviews, Ito concluded that women influenced by this deeply rooted mindset tend to prioritize relationships with “important others “, such as parents, husbands, and children, when making decisions during life events such as marriage and childbirth. These findings indicate that women’s lifestyle decisions are profoundly shaped by the household dynamics.

This section organizes previous research to clarify the positioning of this study. Previous research can be classified into five key areas. First, the factors influencing household work and childcare time are examined, includes 1) factors affecting household and childcare time and 2) the relationship between husbands and wives regarding unpaid housework. Next, previous studies that evaluate household and childcare time from the perspective of commuting time related to paid work activities were thoroughly reviewed in 3) time-constraint effects of commuting time. The new workstyle of reducing commuting time is discussed in 4) the impact

of telework on household and childcare time. Finally, studies employing quantitative models to evaluate daily activity time allocation are shown in 5) activity time allocation model considering household interactions.

By addressing these research areas, this study aims to contribute to the literature by offering an integrated activity time allocation model that considers intra-household interactions, with a particular focus on households with children.

1) Factors Affecting Household Work and Childcare Time

The factors that determine the allocation of women's household and childcare time have been studied extensively over several decades. Walker and Woods (1976) conducted a survey targeting married households with children to identify the explanatory variables influencing household work allocation. Their results revealed that the primary factors affecting household work time allocation were the number of children, household composition, the wife's employment status, and the age of the youngest child. Additional factors such as the husband's working hours, social class, the educational levels of both spouses, housing type, and the residential location were also significant.

Shinoda (1996) further examined the relationship between married women's household work time allocation with lifestyle. This studied identified employment status, family composition, the distribution of household responsibilities, and the number of children as the most influential factors, in descending order of impact. These four variables could largely explain the amount of household work allocated on weekdays. Moreover, the fact that women continue to perform household work on weekends underscores the demanding nature of married women's lives.

Furthermore, studies on the determinants of household and childcare division of labor between spouses, such as studies by Nagai (1999) and Matsuda (2004), have pointed out factors such as the quantity of household work and childcare required, time availability, relative resources, and gender ideologies, as discussed in various papers.

2) The Relationship Between Husbands and Wives Regarding Unpaid Work

Matsuda and Suzuki (2001) pointed out that empirical studies on the factors determining the division of household and childcare duties have been limited due to data constraints. They emphasized the importance of integrating results obtained from data analyses that capture different aspects of household work to clarify the factors influencing household time allocation. Their research measured the relationship between the household work hours of husband and wives on a time-based scale. Their findings were as follows:

1) Both husbands and wives reduce their household work hours as their own paid work hours increase.

2) When one spouse's paid work hours increase, the other spouse's household work hours also increase.

3) There is no evidence of a trade-off relationship, where an increase in one spouse's results in a corresponding decrease in the other's.

These results reflect a modern household labor division structure, where the wives primarily handle household duties, while husbands support when their wives cannot manage all of the tasks.

Similarly, Fukuda (2007) found that the reduction in a wife's household and childcare time due to paid work is often offset by alternative arrangements, such as a decrease in total household and childcare time when children begin attending school, rather than by increased participation from husbands. The study concluded that such conditions are often prerequisites for wives to enter the workforce.

3) Time-Constraint Effects of Commuting Time

Many studies have examined the impact of commuting on daily activities. Izumi *et al.* (2012) focused on working mothers in nuclear families, comparing their transportation characteristics with other household types and analyzing the relationship between transportation service levels and daily activity patterns. According to the results it was confirmed that working women with children engaged in commuting, pick-up/drop-off, and returning home during the morning and evening hours. These time-constrained movements imposed a substantial burden on their daily lives. Additionally, in central urban areas and along railway lines, where train, walking, and cycling travel modes dominate, commuting time were found to be longer compared to suburban areas, where car commuting is more prevalent.

Furthermore, Kubo (2017) investigated the "time constraint hypothesis ", which suggests that individuals with fewer time constraints tend to perform more household and childcare tasks. Using "husband's frequency of participation in household work and childcare "as the dependent variable and "husband's weekly commuting time and paid work hours" as independent variables, the analysis revealed that when the husbands faced longer commuting time and paid work hours with significant time constraints, their frequency of participation in household and childcare tasks significantly decreased.

4) The Impact of Telework on Household and Childcare Time

Analyses focusing on the relationship between telework and household/childcare time were conducted by Ikeda (2021), Takami and Yamamoto (2021), and Takami (2022). Ikeda (2021) pointed out that during the early stages of the COVID-19 pandemic (based on surveys conducted in April-May 2020), women spent more time on household and childcare activities than men, reinforcing gender role divisions. However, in the subsequent period (comparing surveys from April-May 2020 and December 2020), the gender gap in household and childcare time appeared to narrow, suggesting that prolonged telework adoption may contribute to a more balanced division of household labor between spouses.

5) Activity Time Allocation Model Considering Household Interactions

As an activity time allocation model that incorporates household members' interactions, Gliebe and Koppelman (2002) proposed a Nested Logit model, which integrates the individual utility into each household member's activity time choices. This model is widely recognized and is regarded as a pioneering model for household activity time allocation. While this model considers household interactions, decision-making itself is based on individual choices. In contrast, Zhang *et al.* (2002) and Zhang *et al.* (2005) explicitly modeled household-level decision-making using a collective utility function estimated through the Seemingly Unrelated Regression (SUR) model. Later, Gliebe and Koppelman (2005) estimated the PCCL (Parallel Choice Constrained Logit) model to maximize collective utility for the entire household, incorporating the weighted sum of household members' utilities, along with their interactions.

This study applies the model proposed by Gliebe and Koppelman (2002) with a specific focus on estimating women's paid work hours, to the estimate of household activity time allocation, which can reflect both the individual decisions and interactions between spouses. Furthermore, while the model proposed by Gliebe and Koppelman (2002) randomly selects two household members (aged 18 and older) from each household and estimates their interactions, this study defines these two household members explicitly as the husband and wife, aiming to clarify their relationship from the perspective of activity time allocation.

Building upon previous studies, this research focuses on the daily activity time allocation in households with children, incorporating the interactions between spouses. An estimation model

is developed and applied to two case studies. The model evaluated key activities, including “unpaid labor (housework and childcare)” which is directly affects paid labor, and “commuting “which is expected to be reduced through telework, potentially increasing women's paid working hours. The distinctive feature of this study lies in its quantitative evaluation of both “household factors “such as spousal interactions and individual or household attributes, and “societal factors“ such as telework adoption. The study aims to identify the factors that hinder women's long-term and sustainable workforce participation, and proposes urban planning solutions to address these challenges.

3. DATA USED AND PARTICIPATION IN THE STUDY

This study utilizes two datasets. The first dataset, the Basic Survey on Social Life, serves two purposes. First, it is employed to analyze the allocation of various types of labor time in relation to wives' current and desired paid working hours (Section 4). Second, it is used to construct a daily activity time allocation model that incorporates spousal interactions (Section 5). The second dataset, obtained from a web survey, is used for one purpose. It is employed to demonstrate improvements in household activity time through telework adoption using the developed activity time allocation model, as well as exploring its implications for urban design strategies that support women's continuous workforce participation (Section 6.3). Notably, this dataset is not used in the model construction process.

a) Basic Survey on Social Life

The data used in this analysis is the anonymized data from the 2016 Basic Survey on Social Life (Survey Form B, Time Use Section), conducted by Japan's Ministry of Internal Affairs and Communications (Note 1). This survey aims to clarify citizens’ actual social life, including the time allocation of daily activity. The dataset consists of 15,521 samples collected form all 47 prefectures, with data recorded over two consecutive designated days including weekends. The survey respondents are household members aged 10 and older. Specific survey items include personal attributes such as gender and employment status, household attributes such as household income, the presence of children, and the age of the youngest child, as well as activity records for 24 hours a day broken down into 15-minute intervals. The activity records include information about activity types, companions, and activity locations. Respondents are also asked to indicate if the survey day involved any of the following: “travel/leisure”, “wedding or funeral”, “business trip/training”, “telework”, “medical care”, “day off”, “childcare leave”, “nursing care leave” or “none of the above” (Multiple answers are allowed.).

The subjects of analysis in this study are “husbands and wives in couple only households” and “husbands and wives in couple and children households”. This study excludes households with extended families, single-parent households, and households with expatriates. Additionally, the sample is limited to households where the wife is under 60 years old, and the children are under 15 years old. Each household (husband and wife) is treated as one sample, with 888 samples being used. The geographic distribution of the subjects' residences is as follows: 452 samples from the three major metropolitan areas and 436 samples from other areas. Furthermore, to classify survey days, responses marked only as “day off” are categorized as “holiday”, while days marked only as “none of the above” are categorized as “typical day”.

b) Web Survey

This survey, conducted in 2023 by Rakuten Insight, targeted child-rearing families who use shared office spaces. In addition to the 24-hour activity records in 15-minute intervals, the

survey included questions on the allocation ratio of unpaid work hours between spouses, satisfaction with this allocation, commuting transportation methods, and the use of shared office spaces, a topic not covered in the Basic Survey on Social Life. The subjects of this survey are individuals living in the Tokyo metropolitan area (Tokyo and the surrounding three prefectures), who use shared office spaces at least once a month. Additionally, the survey targeted dual-income households with a spouse and children (elementary school age or younger) living together, while the household with co-residing parents, part-time or temporary workers were excluded. The reason for limiting respondents to shared office users was to examine the potential for enhancing the value of shared office spaces, which are expected to reduce commuting time for households with children. Unlike the Basic Survey on Social Life, which collects data from all household members aged 10 and older, enabling the analysis of spousal interactions, the web survey collects data from only one household member, preventing a direct examination of spousal interactions in activity time allocation. The total sample size is 400.

4. CURRENT SITUATION AND DESIRED PAID WORK AND UNPAID WORK TIME

Before developing a time allocation model for households with children to support women's long-term workforce participation, this study first investigates whether wives prefer to increase their current paid work hours or maintain the current situation, where unpaid work hours remain long and paid work hours are short.

This study utilizes data from the Basic Survey on Social Life. Figure 1 and Figure 2 illustrate these preferences. The horizontal axis categorizes wives' desired paid work hours into three groups: "desiring fewer hours than the current situation", "wishing to maintain the current situation", and "desiring more hours than the current situation". The vertical axis of Figure 1 and Figure 2 show wives' current paid work hours and current unpaid work hours in each category, respectively. The blue lines in both figures indicate the average paid and unpaid work hours of husbands for each category of wives. The cases aggregated are couples reside in one of the three major metropolitan areas and both spouses have a regular day.

Based on Figure 1, the current paid work hours of wives who wish to work longer than their current situation is 231 minutes, which is the shortest among all categories. Figure 2 shows that the unpaid work hours of wives who wish to increase their paid work hours are 322 minutes, which is the longest among all categories.

These findings suggest that many women who wish to work longer are constrained by various factors, often compelling them to take on part-time employment or withdraw from the workforce entirely. In other words, a large number of women are unable to pursue their desired working hour due to various limitations. This highlights the importance of focusing on increasing women's paid working hours and demonstrates the significance of this study, which quantitatively addresses this issue.

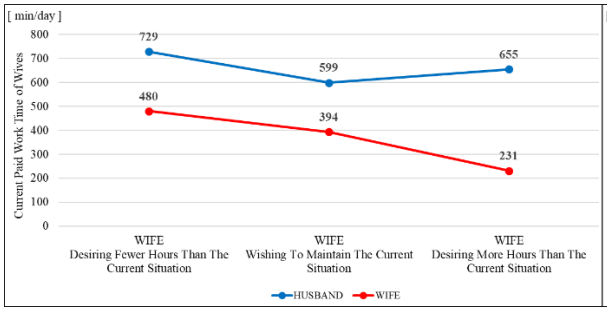

Figure 1. Current Paid Work Time of Wives

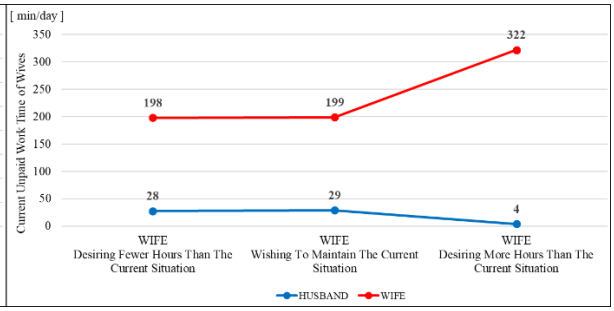

Figure 2. Current Unpaid Work Time of Wives

5. CONSTRUCTION OF AN ACTIVITY TIME ALLOCATION MODEL

5.1 Data description

As described in Section 3, the Basic Survey on Social Life is used to develop the activity time allocation model, which considers the interactions between household members (husband and wife). This section provides an overview of the activity categories in the Survey on Time Use and Leisure Activities, the activity classifications used in the model construction and descriptive statistics.

First, the Basic Survey on Social Life contains 108 activity categories, classified as: 6 categories related to paid labor; 1 category for commuting; 26 categories for unpaid labor, including 19 for housework, 14 for childcare, and 3 for volunteer activities; 6 categories related to learning, self-development, and training; 13 categories for self-care; 39 categories for free time; 7 categories classified as others. The activities are thus classified into five categories: “paid work” “commuting” “unpaid work” “self-care” and “free time”. The activity classifications for model construction are organized as follows: categories related to learning, self-development, and training, as well as other categories, are consolidated into the “free time” category.

The activity classifications used for model construction are defined as follows. Activities performed with a spouse or with a spouse and children are classified as “joint activities”. The first is “joint activity 1” included unpaid work performed together. The second is “joint activity 2” included paid work, self-care, and leisure time, but exclude unpaid work. Activities performed alone or with individual other than a spouse or spouse and children are categorized as “individual activities”. The types of activities include paid work, commuting, unpaid work, self-care, and leisure time (Figure 3). An exception is that the activity type “commuting”, even if performed with a spouse or a spouse and children, is considered an individual activity at the lower level. The reason for this is that commuting is a necessary activity for paid work, and the presence or type of companion is irrelevant.

The descriptive statistics based on the classified activity types are shown in Table 2. This shows the mean weighted averages, standard deviation, maximum value and minimum value for each member's activity time allocation. Since the data used are anonymized, scaling factors were applied to calculate the weighted averages.

5.2 Model Formulation

Based on Gliebe and Koppelman (2002), an activity time allocation model that incorporates household interactions between spouse is developed. This model is an aggregate logit model that explains the time allocation of each activity and parameter estimation is performed simultaneously.

The activity choices are represented using a two-level hierarchical structure based on the Nested Logit model (Figure 4). Specifically, based on the activity classifications defined in Section 5.1, the upper level consists of three alternatives: “Joint Activity 1”, “Joint Activity 2”, and “Total Individual Activities” while the lower level comprises five alternatives: “Paid Work”, “Commuting”, “Unpaid Work”, “Self-Care” and “Leisure”. The blue lines in Figure 4 represent the choice hierarchy for the husband’s activity options, while the red lines represent that of the wife’s. In this model, the dependent variable represents the share of a 24-hour day (1,440 minutes) as a proportional allocation for each activity, separately set for husbands and wives. The time allocation ratios for each activity are shown in Equations (1) and (7), the utility functions are shown in Equations (2) to (6) and (8) to (10), and the log-sum equation is shown in Equation (11). The key feature of this model is that the utility function for the upper level

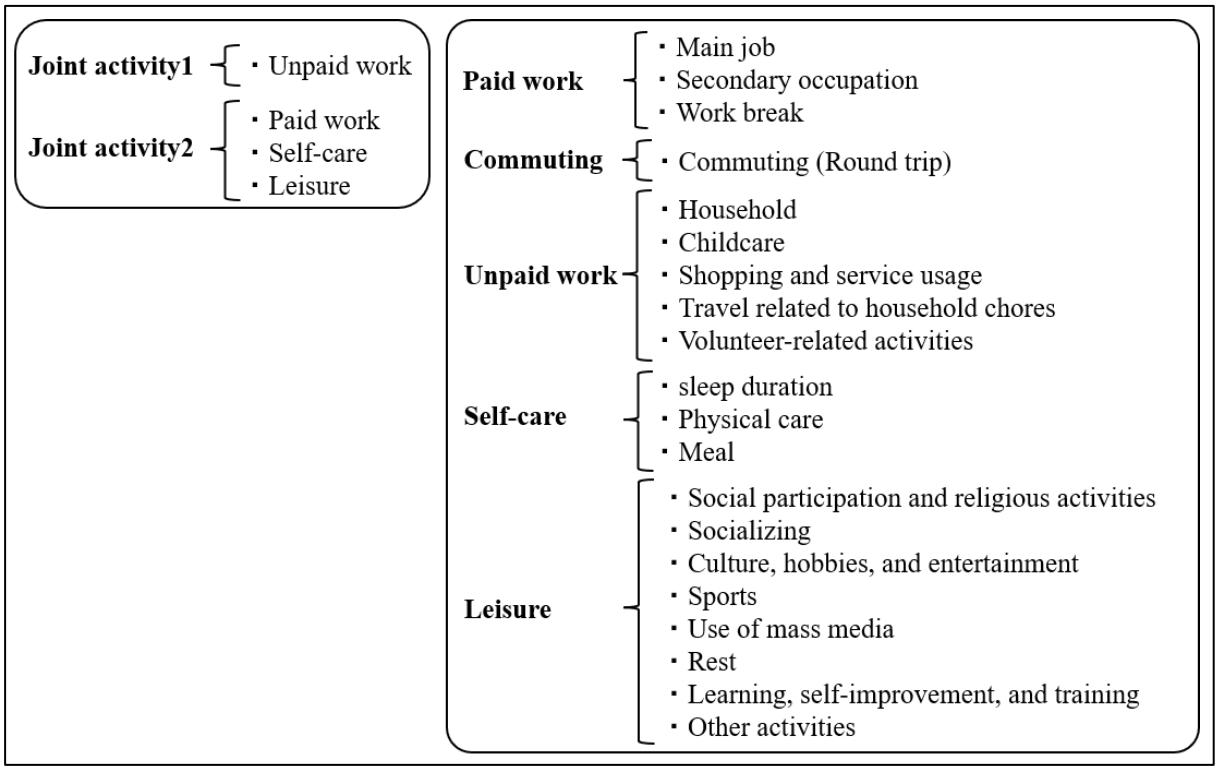

Figure 3. Types of activities

Table 2. The Description Statistics of the Data (Unit: minutes/day)

		Joint activity1	Joint activity2	Paid work	Commuting	Unpaid work	Self-care	Leisure
Husband	Weighted averages	63.5	227.5	324.3	42.0	63.0	563.0	156.7
	Standard deviation	119.2	205.7	313.4	57.9	119.0	134.6	195.9
	Maximum	780.0	1170.0	1140.0	285.0	840.0	1440.0	1155.0
	Minimum	0.0	0.0	0.0	0.0	0.0	120.0	0.0
Wife	Weighted averages	119.3	180.3	122.5	17.3	260.2	580.5	159.9
	Standard deviation	147.3	174.2	201.9	34.7	206.5	125.3	165.4
	Maximum	750.0	1155.0	930.0	210.0	945.0	1320.0	825.0
	Minimum	0.0	0.0	0.0	0.0	0.0	225.0	0.0

alternative “total individual activities” of the husband (or wife) incorporates not only the inclusive value of the individual’s own lower-level individual activities, but also that of the spouse’s lower-level individual activities (Equation (10)). This structure formalizes the links shown in Figure 4, where each lower-level individual activity of both the husband and wife is connected not only to their own upper-level “total individual activities” node, but also to that of their spouse.

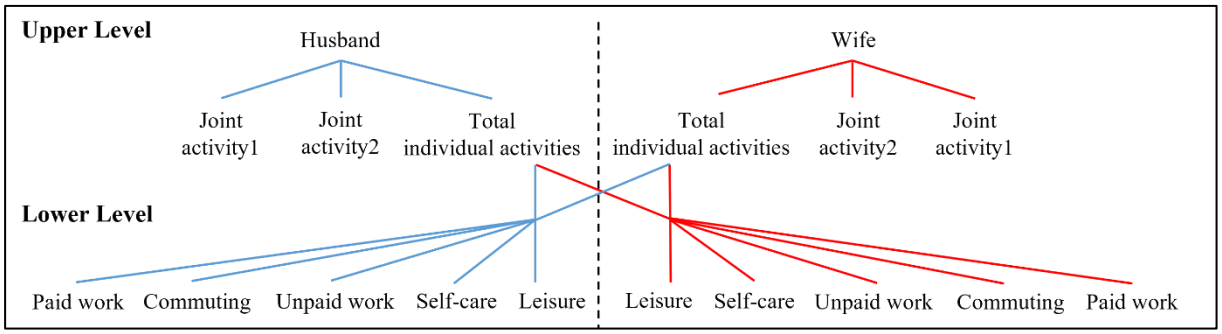

Figure 4. Types of activities

Lower Level

$$S_{pn}(i|C_p) = \frac{exp(V_{ipn})}{\sum_{j \in C} exp(V_{jpn})}, \forall j \in C_p \quad (1)$$

$$V_{\text{Paid work}} = \theta_4 * A_{typicalL} + \theta_8 * A_{arr1} + \theta_9 * A_{arr2} + C_1 \quad (2)$$

$$V_{\text{Commuting}} = \theta_8 * A_{commuting} \quad (3)$$

$$V_{\text{Unpaid work}} = \theta_1 * A_{child1} + \theta_5 * A_{holidayL} + C_2 \quad (4)$$

$$V_{\text{Self-care}} = \theta_3 * A_{income} + C_3 \quad (5)$$

$$V_{\text{Leisure}} = \theta_2 * A_{old6} + \theta_5 * A_{holidayL} + C_4 \quad (6)$$

Upper Level

$$S_n(i|C_n^{Jnt}) = \frac{exp(V_{in})}{exp(\mu_{husband} * \Gamma_1 + \mu_{wife} * \Gamma_2) + \sum_{j \in C_n^{Jnt}} exp(V_{in})}, \forall j \in C_n^{Jnt} \quad (7)$$

$$V_{\text{Joint activity 1}} = \theta_9 * A_{home} + \theta_{11} * A_{typicalU} + C_4 \quad (8)$$

$$V_{\text{Joint activity 2}} = \theta_{10} * A_{child2} + \theta_{12} * A_{holidayU} + C_5 \quad (9)$$

$$V_{\text{Total individual activities}} = \mu_{\text{husband}} * \Gamma_1 + \mu_{\text{wife}} * \Gamma_2 \quad (10)$$

$$\Gamma_p = \ln(\sum_{j \in C_p^{Indp}} exp(V_{ipn})). \quad (11)$$

where,

p : individual (husband or wife),
n : household,
i : the chosen alternative from the choice set for individual p,
j : an alternative in the choice set C_p for individual p.

A_{child1} : Number of children,
A_{old6} : Whether childcare support is used for children under 6 years old,
A_{income} : The ratio of individual income between husband and wife,
$A_{typicalL}, A_{typicalU}$: Typical day,
$A_{holidayL}, A_{holidayU}$ Holiday,
A_{arr1} : Full-time employment,
A_{arr2} : Part-time employment,
$A_{commuting}$: Commuting time,
A_{home} : Home and outside home in individual activities,
A_{child2} : Presence or absence of children,
μ_{husband} : Husband's scale parameter,
μ_{wife} : Wife's scale parameter,
$C_1 \sim C_6$: Constant term.

Table 3 summarized the details of key explanatory variables in the model.

For lower-level activity types, the explanatory variables are set as below:

- "Paid work": the explanatory variables full-time employment ", "part-time employment "are classified based on work types given in the dataset.
- "Commuting": the explanatory variable is "commuting time (round trip)", as the Basic Survey on Social Life data provides information on commuting time, but lacks data on transportation methods or geographic information related to residence and workplace, making it impossible to estimate the commute time from commuting distance.
- "Unpaid Work": the explanatory variable "number of children" is set as the actual number of children given in the dataset. The analysis only includes households with 0, 1, 2, or 3 children.
- "Self-care ": the explanatory variable "husband and wife's individual income ratio" is defined as the ratio of the husband's income to the total household income (sum of the husband's and wife's individual incomes), with its value ranged between 0 and 1. For example, a 1:1 income ratio corresponds to 0.5, while 3:2 ratio corresponds to 0.6.
- "Leisure ": the explanatory variable "use of childcare support for children under 6 years old" is treated as a dummy variable. If a household has children under 6 years old but does not use childcare support, it is coded as 1; if they use childcare support or have no children under 6 years old, it is coded as 0.

For upper-level activity types, the explanatory variables are set as below:

- "Joint activity 1": the explanatory variable "home dummy in individual activities" is set as 1 when no outing occurs in the lower-level individual activities and as 0 when an outing occurs.
- "Joint activity 2": the explanatory variable "presence of children" is set as 1 when no children are present and as 0 when children are present.

5.3 Parameter Estimation

The parameter estimation results are presented in Table 4. The likelihood ratio of 0.376 indicates a reasonable level of model accuracy. Many of the parameters are statistically significant, with serval meet the 1% significance level, many at the 5% level and some at the 10% level.

However, certain parameters show significance for one spouse, but not the other. Specifically, for parameters significant for husbands but not wives, examples include "holiday" at the lower level and "typical day" and "holiday" at the upper level. In contrast, significant for

Table 3. Details of some explanatory variables for each activity type

Explanatory variable	Details
Full-time	= 1 if Full-time; else 0
Part-time	= 1 if Part-time; else 0
Number of children	= 0 if none, =1 if a child, =2 if two children, =3 if three children
Husband and wife's individual income ratio	Numerical, the ratio of the husband's income to the total household income
Use of childcare support for children under 6 years old	= 1 if a household has children under 6 years old but does not use childcare support; else 0
Home dummy in individual activities	= 1 if no outing occurs in the lower-level individual activities; else 0
Presence of children	= 1 if no children are present; else 0

wives but not husbands, examples include “number of children”, “whether childcare support is used for children under 6 years old “, “The ratio of individual income between husband and wife “ and “part-time work” at the lower level. These findings suggest that the husband’s allocation of paid work hours, unpaid work hours, and leisure time varies between typical days or holidays, whereas the wife’s allocation of unpaid work hours and leisure time remains relatively stable between holidays and other days. Additionally, compared to the husband, wife’s allocation of unpaid work hours and leisure time are strongly influenced by child-related factors. The result that the number of children increases the allocation of unpaid work time (housework and childcare) is consistent with the findings by Walker and Woods (1976) and Shinoda (1996). Furthermore, the results indicate that as the number of children increases, both individual unpaid work time and leisure time increase. Notably, leisure time decreases when households with children under 6 years old do not childcare support. Additionally, in both husband’s and wife’s estimates, the variable “commuting time (round trip)” is statistically significant at 1% level.

Next, focusing on the upper-level activity type “joint activity 1”, the explanatory variable “home and outside home in individual activities “ meets the 1% significance level for both the husband and wife. Moreover, the positive parameter indicates that when individual activities are carried out only at home, joint unpaid work time between spouses increases. On the other hand, the negative parameter sign for “typical day” in the husband's estimate suggests that the allocation of joint unpaid work time decreases on typical days.

Next, focusing on the activity type “joint activity 2”,” presence or absence of children “ is significance at 10% level for the husband and the 5% level for the wives. This shows that when there are no children, the allocation of joint paid work, self-care, and leisure time increases.

Finally, the scale parameters in the upper-level estimation reveal how much individuals prioritize their own activities versus their spouse’s activities. The husband's scale parameter μ_{husband} is significant at the 5% level, while the wife's scale parameter μ_{wife} is significant at the 10% level. In the wife's parameter estimation, the scale parameters μ_{husband} and μ_{wife} are significant at 1% and 5% levels, respectively. In this analysis, the scale parameters μ_{husband} and μ_{wife} represent the utility of individual activities for the person themselves and the degree of cooperation with the spouse’s individual activities. A larger scale parameter for the individual indicates that the person prioritizes their own individual activities over their spouse's. Conversely, a larger scale parameter for the spouse suggests that the person values the spouse's individual activities more than their own. The husband’s estimation shows that the scale parameter μ_{husband} is 0.955, and the scale parameter μ_{wife} is 0.664. Larger μ_{husband} indicates that the husband values his own individual activities more. While the wife’s estimation shows that μ_{husband} is 1.468, and μ_{wife} is 0.907. A larger μ_{husband} indicates that the wife values the husband’s individual activities more than her own and is more cooperative with his individual activities.

6. CASE STUDY OF COUPLE’S ACTIVITY TIME ALLOCATION

In Section 5, a daily activity time allocation model incorporating spousal interactions was developed, and the parameter estimation results were presented. One key objective of this study is to utilize the developed model to identify the factors that hinder women's long-term employment from both household and societal perspectives and to propose solutions to address these challenges. Therefore, in Section 6, simulations will be conducted on three key factors: the number of children, commuting time and the intrahousehold interaction between husband and wife. These simulations aim to analyze how variations in these factors affect women’s

Table 4. Model Estimation Results

	Independent variable	Husband	Wife
Lower Level	Number of children	0.123	0.215***
	Whether childcare support is used for children under 6 years old	-0.300	-0.741***
	The ratio of individual income between husband and wife	0.202	-0.692**
	Typical day	2.402***	2.879***
	Holiday	0.473***	0.163
	Full-time employment	4.945**	7.784**
	Part-time employment	4.207	6.898**
	Commuting time	0.168***	0.276***
	C_1	-3.340	-5.873*
	C_2	1.267***	3.476***
	C_3	3.706***	5.258***
	C_4	2.336***	3.373***
Upper Level	Home and outside home in individual activities	0.839***	0.808***
	Presence or absence of children	0.401**	0.461**
	Normal	-1.160***	0.009
	Holiday	0.563***	-0.003
	C_5	5.865*	8.971***
	C_6	6.730**	9.448***
	Husband's scale parameter	0.955**	1.468***
	Wife's scale parameter	0.664*	0.907**
	Observations	888	
	Initial log-likelihood	-4809.497	
	Final log-likelihood	-3000.219	
	McFadden's Rho-squared $\bar{\rho}^2$	0.376	

- Not relevant; *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

workforce participation, and to explore potential urban design policies that support long-term employment sustainability for women.

In Section 6, the difference between the estimated commuting time, calculated using parameter estimation results, and the actual commuting time is allocated according to each activity time distribution.

6.1 The Impact of the Number of Children in the Household

Using the parameter estimation results shown in Table 4, several simulation scenarios are presented to show how the daily activity time allocation of husbands and wives changes with the number of children. The simulation settings are as follows: both husband and wife have a typical day, both work full-time, the individual income ratio of husband and wife is 0.5, the home dummy in individual activities is 0, the round-trip commuting time for both husband and wife is 160 minutes, and the presence of children is set as 1 when there are no children, and 0 when there are 1, 2, or 3 children. Simulations of four scenarios based on the number of children (0, 1, 2, 3) are conducted.

Table 5 presents the daily activity time allocation for husband and wife under different

numbers of children (0, 1, 2, or 3). The values in parentheses show the increase or decrease in the time allocation for each activity relative to no children scenario. Since the Basic Survey on Social Life collects responses from household members aged 10 and older. The actual data for joint activity time allocation (Joint Activity 1 and 2) varied significantly between husbands and wives. Consequently, the estimation results also show notable variation between the husband and wife.

Focusing on joint activities 1 and 2, the time allocation for Joint Activity 1 remains relatively stable regardless of the number of children, whereas Joint Activity 2 shows distinctive changes in time allocation for both the husband and wife. Joint Activity 1 refers to unpaid work activities such as housework and childcare with spouse or children. A slight increase is observed with one child, but a small decrease occurs when there are two or three children. Joint Activity 2 refers to paid work, self-care, and leisure time with spouse or children. Both the husband and wife show a significant decrease in time allocation when children are present compared to without children scenario, and this decrease is more pronounced as the number of children increases.

Regarding paid work, a significant difference in time allocation between the husband and wife is observed regardless of the number of children, with wives consistently spending fewer hours on paid work compared to husbands. For the husband, paid work hours increase when children are present compared to no children scenario, and this time allocation remain unaffected by the number of children. For the wife, time allocation for paid work slightly increases when there is one child compared to having no children. However, as the number of children increases (2 or 3), the time allocation of paid work decreases. This decrease is particularly large with three children, showing that the number of children strongly affects the wife's paid work allocation.

For unpaid work, a significant difference between the husband and wife is observed regardless of the number of children, with the wife's unpaid work hours being overwhelmingly longer. As the number of children increases, the unpaid work hours also increase, and the increase is more pronounced for the wife. This indicates the wife's unpaid work hours are longer than the husband's regardless of the presence or number of children, and the wife is more strongly affected by household attributes such as the number of children. These findings suggest that changes in activity time allocation are influenced by life stage transitions.

For self-care, regardless of the number of children, husbands allocate more time to self-care than wives. Husbands' self-care time increase when children are present compared to no children scenario, but it is not significantly affected by the number of children. For wives, self-care time slightly increases with one child compared to having no children, but as the number of children increases (2 or 3), the self-care time decreases. The decrease is particularly large with three children, indicating that the number of children strongly affects the wife's self-care time.

Table 5. Daily Activity Time Allocation of Couples Based on the Number of Children (Unit: minutes/day)

	No children		One child		Two children		Three children	
	Husband	Wife	Husband	Wife	Husband	Wife	Husband	Wife
Joint activity1	13.2	39.0	+0.2	+0.3	±0	-0.8	-0.4	-2.2
Joint activity2	130.4	98.7	-41.5	-35.9	-43.4	-37.8	-45.6	-39.9
Paid work	549.0	432.6	+17.6	+2.9	+16.0	-8.5	+14.3	-21.8
Commuting	160.0	160.0	±0	±0	±0	±0	±0	±0
Unpaid work	35.4	116.3	+5.9	+28.8	+11.2	+58.8	+17.2	+93.9
Self-care	448.9	488.5	+14.4	+3.2	+13.1	-9.6	+11.7	-24.7
Leisure	103.1	104.9	+3.3	+0.7	+3.0	-2.1	+2.7	-5.3

Regarding leisure time, wives have more leisure time than husbands except in households without children. For husbands, leisure time increase when there are children compared to no children scenario, and it remains relatively stable regardless the number of children. For wives, leisure time slightly increases when there is one child compared to having no children, but as the number of children increases (2 or 3), the allocation of leisure time decreases.

6.2 The Effects of Telework, including Shared Offices

With the changes in working styles following the COVID-19 pandemic, the demand for telework has increased, allowing individuals to allocate commuting time to other activities. This results in changes in the daily activity time allocation among couples. To examine this impact, simulations are conducted under two commuting time conditions: round-trip commuting time of 160 minutes assuming a 30 km radius around Tokyo; a commuting time of 30 minutes round-trip, assuming the use of a shared office place near the nearest station. The simulation scenario settings are as follows: both husband and wife have a typical day, both works full-time, the individual income ratio of husband and wife is 0.5, the home dummy for individual activities is 0, the number of children is 1.

Table 6 presents three scenarios setting. Scenario 1 shows the case where both the husband and wife's commuting time (round-trip) is 160 minutes. Scenario 2 shows the case where the husband's commuting time (round-trip) is 160 minutes and the wife's commuting time (round-trip) is 30 minutes. Scenario 3 shows the case where the husband's commuting time (round-trip) is 30 minutes and the wife's commuting time (round-trip) is 160 minutes. The values in parentheses indicate the increase or decrease in the time allocation for each activity when compared to the scenario where both the husband and wife have a round-trip commuting time of 160 minutes.

First, let us examine the scenario where only the wife's commuting time is reduced to 30 minutes. With a 130-minute reduction in the wife's commuting time, the following activities show an increase of more than 10 minutes in time allocation: paid work time (44.6 minutes), unpaid work time (14.9 minutes), self-care time (40.4 minutes), and leisure time (11.8 minutes). The reduction in the wife's commuting time emerges as a key factor in increasing her paid work hours, which is expected to enhance women's long-term and continuous workforce participation.

Next, let us examine the scenario where only the husband's commuting time is reduced to 30 minutes. With a 130-minute reduction in the husband's commuting time, the following activities show an increase of more than 10 minutes in time allocation: Paid work time (57.8 minutes), self-care time (47.3 minutes), and leisure time (10.9 minutes). Unlike in the scenario where the wife's commuting time is reduced, no increase is observed in the husband's unpaid work time. Additionally, the wife's time allocation for Joint Activity 2 increases by 10.5 minutes. These findings indicate that reducing the husband's commuting time leads to an increase of time spending in his paid work, self-care, and leisure activities with the spouse or children.

The estimation results presented above quantitatively demonstrated that telework increases paid working hours by reducing commuting time. Based on these findings, we propose a new urban service: "Shared office spaces with pick-up and drop-off services to childcare facilities ". This concept integrates a shared telework space with childcare transportation services, enabling parents to reduce both commuting time and childcare drop-off/pick-up time. A conceptual diagram is shown in Figure 5. The shared office spaces with childcare drop-off and pick-up station will be located in highly accessible areas, such as near train stations, where children are transported by bus to childcare facilities. This service has already been successfully implemented in cities such as Nagareyama and Machida. The shared

Table 6. Daily Activity Time Allocation of Couples by Commuting Time (Unit: minutes/day)

	Commuting time Husband:160minWife:160min		Commuting time Husband:160minWife:30min		Commuting time Husband:30minWife:160min	
	Husband	Wife	Husband	Wife	Husband	Wife
Joint activity1	13.4	39.3	+0.9	+3.6	+1.3	+5.9
Joint activity2	89.0	62.8	+5.9	+5.7	+8.5	+9.5
Paid work	566.5	435.5	-3.2	+44.6	+57.8	-5.7
Commuting	160.0	160.0	±0	-130.0	-130.0	±0
Unpaid work	41.4	145.0	-0.2	+14.9	+4.2	-1.9
Self-care	463.3	491.8	-2.6	+40.4	+47.3	-6.4
Leisure	106.4	105.6	-0.6	+11.8	+10.9	-1.4

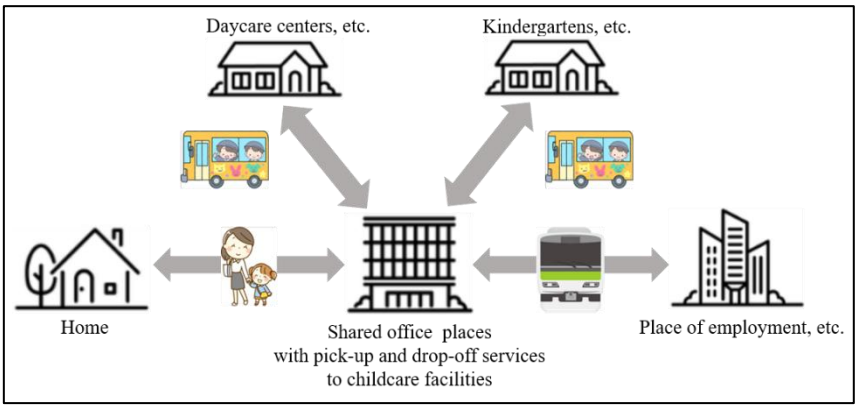

Figure 5. Conceptual Diagram of Shared Office Spaces with Pick-up and Drop-off Services to Childcare Facilities

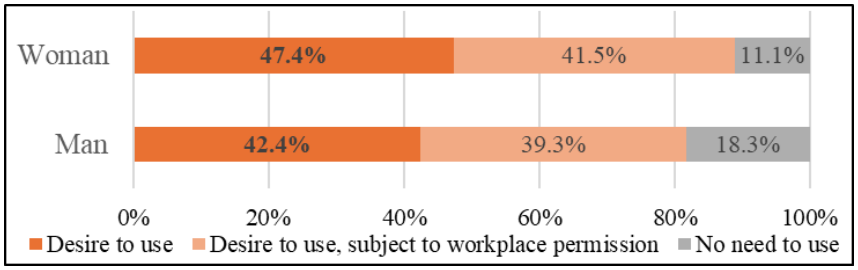

Figure 6. Interest in Using Shared Office Space with Pick-up and Drop-off Services to Childcare Facilities

office spaces with childcare pick-up and drop-off services are expected to not only reduce commuting and drop-off/pick-up times but also address the disadvantages of telework such as insufficient office equipment at home. This could further increase the paid work hours of women.

According to data from the Web survey, if shared office spaces with pick-up and drop-off services are introduced, 81.7% of men and 88.9% of women responded that they would like to use the service (Figure 6), indicating a high level of demand. Moreover, frequently mentioned positive changes in daily life associated with shared office spaces use include a reduction in commuting time, increased flexibility in the mornings and evenings schedules and improved work efficiency. As shown in Table 6, a reduction in commuting time for wives leads to an increase in their paid working hours. This highlights the potential impact of new urban services

such as shared office spaces with childcare pick-up and drop-off services in contributing to urban design that supports women's continuous workforce participation and work-life balance.

6.3 The Impact of Spousal Interactions on Individual Activities

From the upper-level parameter estimation results shown in Table 4, the scale parameters μ_{husband} and μ_{wife} in the husband's estimation obviously indicate that the husband values his own individual activities more than the wife's individual activities. To further analyze this dynamic, a sensitivity analysis is conducted to examine how the daily activity time allocation of the husband and wife changes when the husband places less emphasize on his individual activities.

Based on Table 4, the scale parameter μ_{husband} in thehusband's estimation is 0.955. In this analysis, it will be varied in increments of 0.005 between 0.91and 1.00 (Figure 7). The chosen range of variation has no specific attempt; expanding the range further results in no change in the scale parameter's sign, but the magnitude the variation in time allocation. The following conditions are set for the sensitivity analysis: both the husband and wife have a typical day, both work full-time, the individual income ratio of the husband and wife is 0.5, the home dummy for individual activities is 0, the round-trip commuting time for both the husband and wife is 160 minutes, the number of children is 1.

First, we analyze the scenario where the estimated scale parameter $\mu_{\text{husband}} = 0.955$ is used as a baseline, and its value is reduced. This represents a situation where the husband places less emphasis on his individual activities. The simulation results present that the activities with increased time allocation are Joint Activity 1 and Joint Activity 2, while the activities with decreased time allocation are Paid Work, Commuting, Unpaid Work, Self-Care, and Leisure. Whild the extent of these changes depends on how much μ_{wife} is varied, the analysis indicates that as the husband please less emphasis on his individual activities, the time allocation for Joint Activity 1 and Joint Activity 2 increases, resulting in greater engagement in joint activities with the spouse or children. On the other hand, when the value of the scale parameter μ_{husband} is increased beyond the estimated value of 0.955, the opposite changes are observed.

In summary, when the husband places less emphasis on his individual activities, the time allocation on unpaid labor and joint activities with the spouse or children increases. This shift creates an environment where the wife can better prioritize her own individual activities, including increasing her paid working hours, potentially contributing to the development of a society that enables women to engage in long-term and sustainable workforce participation.

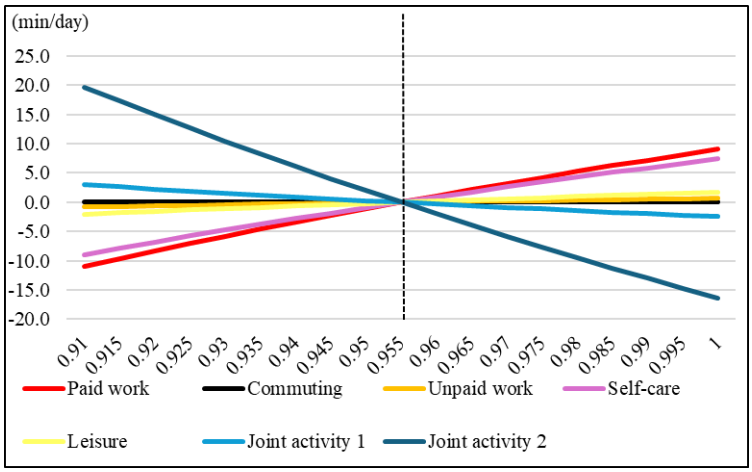

Figure 7. Differences in the Husband's Daily Activity Time Allocation When the Scale Parameter μ_{wife} is Varied in the Husband's Estimation (Unit: minutes/day)

7. Conclusion

In this study, a daily activity time allocation model incorporating spousal interactions was developed. The findings reveal key household and societal factors that influence women's paid work hours. The household factors that reduce women's paid work hours include, the number of children, the high allocation of unpaid work time by the wife regardless of whether it is a regular day or holiday, and the wife's devotion to household members, especially their cooperation with their husband's individual activities. The results suggest that when the husband place less emphasis on his own individual activities, respects more on his wife's personal activities, and becomes more cooperative, it leads to an increase in the wife's individual activity time, including paid work hours.

Beyond household dynamics, the study also examines societal factors leading to the reduction of women paid working hours. The analysis quantitatively demonstrated that the introduction of telework significantly reduces commuting time and contributes to an increase in paid working hours for both spouses. Moreover, the use of telework by both the husband and wife leads to an increase in the time allocated to unpaid work jointly undertaken by the spouse, promoting a more balanced labor division. Telework is highly likely to be an effective measure in promoting women's continuous workforce participation. Additionally, this study explores potential urban services by presenting findings from a web survey on the potential demand for shared office spaces with pick-up and drop-off services to childcare facilities. The survey results revealed that 81.7% of men and 88.9% of women expressed a desire to use such a service, with the most frequently cited benefit was the reduction in commuting time, which significantly impacts daily life. The implementation of innovative urban services, such as shared office spaces with pick-up and drop-off services, is highly likely to reduce commuting time and particularly increase paid work time for wives. This is expected to contribute to the design of a society enabling women to pursue their careers continuously.

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