Measuring Gendered Values of Time for Married Couples by Life Stage based on an Intertemporal Household Utility-Maximization Model

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ABSTRACT

We investigate the value of time as a resource (VOTR) and the value of childcare time saving (VOCTS) for a married couple with children by life cycle stage. Extending the framework of DeSerpa (1971), we develop a novel intertemporal utility-maximization model that can represent trade-offs within an individual and within a couple between different activities in their life stages based on a household lifetime equilibrium, and we derive wives' and husbands' time values when their first child is of pre-school age and after their first child reaches school age. Applying the model to the 2004-2018 Japan Household Panel Survey, we analyze couples in two life stages to empirically find the value of time by gender. The results show that the wives' average VOTR is greater than 4,400 yen/hour with statistical significance when their first child is of pre-school age; the value, however, drastically drops to around 400 yen/hour with statistical insignificance after their first child reaches school age. Conversely, the magnitudes of the husbands' VOTRs do not change much in different life stages. In the background mechanisms, the wives' high and low VOTRs reflect their short and long work and commute hours, respectively, whereas the husbands reduce their work and commute hours only slightly over time. For the dual-income households that only spend the minimum required time on childcare, VOCTS is statistically insignificant when their first child is of pre-school age but is greater than 28,000 yen/hour after their first child reaches school age. Using the estimated time values for urban and transport policy simulations, we find that enabling work flexibility could help households increase welfare more compared to transportation improvement and childcare support services.

Keywords:
Gender difference, household welfare, time allocation, value of time as a resource, value of childcare time saving

1. INTRODUCTION

More and more societies nowadays seek an even division between men and women in paid work and unpaid domestic work to ensure equal education and employment opportunities toward gender-equal communities. In cities in developed countries, available evidence suggests that urban and transportation policies that aim to reduce commute time, enhance work flexibility, and support childcare, can help relax time constraints and thus encourage men's participation in household tasks, while recruiting more women back to work (Alon et al. 2020; Borghorst, Mulalic, and Van Ommeren 2021; Jacob et al. 2019; Kawabata 2014; Kawabata and Abe 2018; Carta and Philippis 2018). Without quantitatively measuring time valuation by life stage, however, we know little about the extent to which these policies can help alleviate people's time burden from the perspectives of gender and household welfare given that any changes in household life cycle could affect household members' time allocations.

To the best of our knowledge, only a few studies have directly investigated the within-household dynamics in time values for a married couple with children (Jara-Díaz and Candia, 2020), and this is the first study that examines time values associated with the unequal childcare burden at the household level. We extend the theoretical framework of DeSerpa (1971) to develop an intertemporal utility-maximization household model that can represent trade-offs within an individual and within a couple between activities in life stages based on a lifetime equilibrium for a married couple with children. Our new model derives the husband's and wife's time values in the presence of pre-school-aged (younger than six years old) and school-aged (older than six years old) children. The within-individual trade-off conceptualizes how an individual optimizes their activities over their lifetime. The within-couple trade-off describes how a married couple compromise their time use and values with each other.

Our main focuses are the gendered values of time as a resource (VOTRs) and a household's values of childcare time saving (VOCTSs) by life stage: the former defines the monetary value of one unit increase in an individual's time availability and the latter characterizes a household's willingness to pay for childcare time reduction. Applying the theoretical model to the 2004-2018 Japan Household Panel Survey, we analyze couples' time values in multiple life stages. As a result, we empirically find that the wives' average VOTR is greater than 4,400 yen/hour with statistical significance when their first child is of pre-school age; the value, however, drastically drops to around 400 yen/hour with statistical insignificance when the first child is of school age. Conversely, the magnitudes of the husbands' VOTRs do not change much in different life stages.

In the background mechanisms yielding these results, we find trade-offs within an individual as well as within a couple between their activities in the same and different life stages. The wives' high and low VOTRs reflect their short and long work and commute hours, respectively. In contrast, the within-individual trade-offs are not found for the husbands. This is presumably because husbands' time arrangements are not affected by the responsibilities of childcare. From the viewpoint of the trade-offs within a couple, when their first child is of pre-school age, the wives' high VOTRs, short work and commute times compensate for the husbands' low VOTRs, long work and commute hours. After the first child reaches school age, the husbands slightly reduce their work and commute hours in response to their wives' increasing time on work and commuting.

For dual-income households with the binding minimum required time constraint on childcare, VOCTS is insignificant when their first child is of pre-school age but is greater than 28,000 yen/hour after the first child reaches school age. This further implies that these dual-income households could face imbalanced work-family lives, and perhaps having a long, exhausting workday does not allow them to allocate more time to childcare than is required. Our simple welfare analyses based on our estimates show that policies that provide better transportation, work-from-home options, and chauffeur services of childcare do not only alleviate the time stress but improve household welfare through reconciling work-life balance.

This research contributes to the existing literature in the following remarkable ways. It is one of the first studies to extend the prominent time value model of DeSerpa (1971) to directly compare the within-household gender differences in time values for married couples with young children. Compared to the existing research on household and gender time use at one single time point (Borghorst et al., 2021; Carta and Philippis, 2018; Jacob et al., 2019; Jara-Díaz and Candia, 2020; Kato, 2013; Rouwendal and Nijkamp, 2004; Small, 2012; Small and Verhoef, 2007), our model deliberately considers time allocations and the associated gendered time values by life stage based on intertemporal household decisions, which allow us to understand the trade-offs between activities across different time points.

This study is also the first to apply clustering analysis to capture the minimum required time of a certain activity (in our context, childcare) for the technological constraint in the framework of DeSerpa (1971) and to estimate the value of childcare time saving for the households with young children. More importantly, the estimation methods are readily applicable to the household time use research beyond Japan to provide insights into the gendered time values in other countries and regions, and the effects of urban and transportation policies can be immediately simulated when the estimated time values are obtained. Finally, the study could inform planners that time value is not limited to the conventional assumptions of wage rate, particularly for households with young children, and the impacts of transportation projects on different cohorts should be inclusive.

The remainder of the paper consists of six sections. Section 2 briefly reviews previous studies on gender differences in time allocations and values. Section 3 constructs an intertemporal household model and derives time values for a married couple. Section 4 describes the data and empirical approach. Section 5 reports the results. Section 6 discusses the results and interpretations. Section 7 concludes the paper.

2. LITERATURE REVIEW

2.1. Gender, life stage, childcare, and time use

People conduct various activities subject not only to monetary constraints but also to time constraints. Although all individuals are equally guaranteed 24 hours in a day, their gender roles and household life stages could induce different activities and time-use patterns. Childcare responsibility, for example, is strongly attached to the gender-role ideology and is conventionally believed to mostly affect the life-stage decisions of women rather than men (Alon et al., 2020; Golob and McNally, 1997; Kleven et al., 2019; Miyajima and Yamaguchi, 2017). This could lead to the gender differences not only in household obligations and career path but also in time allocations.

Kleven et al. (2019) use Danish administrative data to find that there are no evident gender differences in the work arrangement before the birth of their first child. Yet, the gender divergences in earning, working hours, employment, and wage rate become substantially wider after the arrival of the first child. The authors further reveal how the impact of children accounts for women's decisions to switch to a family-friendly working environment and a nonmanagerial career, while the impact imposes no changes on the male cohort.

The presence of young children, indeed, has been consistently recognized as a key factor in determining women's activity arrangement, whereas it seems to exert much less influence on men's lives. Based on the 1995 Nationwide Personal Transportation Survey, McGuckin and Murakami (1999), for instance, find that women with children tend to make more stops for childcare and family errands before reaching home/work destinations compared to men and childless women. Boarnet and Hsu (2015) analyze the 2001 Southern California Household Travel Survey to find that the number of chauffeuring trips conducted by women with young children is three times more than that of men living alone. From the 2012 California Household Travel Survey, Lo and Houston (2018) find that the presence of children is likely to lead mothers, but not fathers, to conduct activities within the local area.

The situation becomes more challenging for employed women. Compared to men, employed women contribute a significant amount of time to domestic and care tasks even after they return from work (Apps and Rees, 2005; Hochschild and Machung, 2012; Milkie et al., 2009). To better accommodate childcare tasks, women compromise by accepting the second-best jobs instead of their ideal occupations (Borghorst et al., 2021; Kawabata, 2014; Kawabata and Abe, 2018; Kleven et al., 2019; Rouwendal, 1999).

Rouwendal (1999) found that Dutch women with young children were reluctant to work far from home; instead, they preferred to accept part-time job offers, compared to those without children, using the 1985-1988 Dutch Housing Demand Survey. Similar trends are observed in Japan and Denmark. Recent studies by Kawabata and Abe (2018) and Borghorst et al. (2021) confirm that women with children are more likely to trade off the employment opportunities against commute time, compared to women without children and men. The increasing commuting time generates substantially greater costs for employed mothers, compared to all other types of workers, as employed mothers experience insufficient time due to childcare (Borghorst et al., 2021; Jacob et al., 2019; Kwan, 1999).

A common approach to understanding gender disparity in time use is to directly compare the proportion of the time that men and women allocate to their paid job and unpaid care tasks (Apps and Rees, 2005; Hochschild and Machung, 2012; Milkie et al., 2009). Economic studies provide more insights into the time use trade-off of marriage partners. Apps and Rees (1996) incorporate the domestic production as a function of the time spent on domestic tasks in a collective household setting, and they find that the presence of children under age 4 significantly increases the wife's time share of domestic production. Carta and Philipps (2018), for instance, use the 1997-2008 German Socio-Economic Panel to find that the husbands' long commutes could reduce their wives' working hours and probabilities of being employed but has no effect on the childcare time. The impact of the husbands' long commute is found to be stronger for those with children, implying that the wives remain in the role as the primary caregiver for their children regardless of their husbands' commute length. Extending DeSerpa (1971) and Jara-Díaz and Guevara (2003), a more recent study by Jara-Díaz and Candia (2020) analyzes the gendered differences in the value of leisure time in dual-worker households. Jara-Díaz and Candia (2020) find that women have a larger time value than men when a unitary household model is considered, while the results are reversed when an individual utility model is applied.

Another research stream in gender time use stems from activity-based studies, which focus on household members' joint activity engagement and the influences of other household members on an individual's activity decisions (Timmermans and Zhang, 2009). Based on a structural model that captures the activity interactions between married couples, Golob and McNally (1997), for instance, use the 1994 Portland Activity and Travel Survey to find that the husbands' work duration changes their wives' time spent on maintenance and discretionary activities and travel but similar impacts from the wives on the husbands' time allocations are not revealed. Srinivasan and Bhat (2005) show that women's work duration has greater negative influences on their maintenance activities compared to men. Kato and Matsumoto (2009) refine Zhang and Fujiwara (2006) by incorporating children's utility and household's income budget and estimate the influences of sociodemographic factors on individual and joint out-of-home leisure activities and household welfare. Consistent with available evidence from economic and travel behavior analyses, the activity-based studies also find that the presence of young children affects the wives' time and activity arrangement more than the husbands' (Golob and McNally, 1997; Srinivasan and Bhat, 2005; Wang and Li, 2009).

Although previous studies indicate that childcare is the primary factor associated with gendered time-use and activity patterns, none of these methods examine how the presence of children accounts for the within-household gender differences in time valuation derived from household utility maximization. As individuals have a trade-off between time use in work, travel and other activities, this mechanism can be used for measuring the value of time (VOT) in order to understand how gender roles imply the differences in time burden for men and women.

2.2. Gender and value of time

Ever since Becker (1965) introduced the pioneering time theory, VOT has long been utilized to evaluate how people use their time depending on the time available (Becker, 1965; Jara-Díaz and Rosales-Salas, 2017; Small, 2012). In Becker (1965), the allowance of a free transfer between the time spent on working and other activities imposes an exogenous VOT on the household utility (Becker, 1965; Small, 2012). VOT in this setting is defined as an individual's opportunity cost of working; that is, wage rate. Ironmonger (2000) reviews another two methods that imputes VOT, including the costs of hiring a specialist and a generalist.

Nevertheless, limitations remain if we evaluate gendered VOT using fixed values. For instance, VOT could be different from market wage due to exogenous work hours and (dis)utility of certain activities (DeSerpa, 1971; Jara-Díaz, 2008; Oort, 1969). Kono et al. (2018) confirm that the constancy assumption of VOT could lead to a significant bias in policy evaluation, as any change in budget and time constraints would simultaneously change the time values.

While the gender pay gap substantially persists, particularly because of the gender division in childcare responsibilities (Kleven et al., 2019), results could be misleading if we approximate VOT at wage rate rather than an endogenous value derived from utility maximization. Rouwendal and Nijkamp (2004) comprehensively review previous studies on commute behaviors, and conclude that women could value their time higher than men due to the burden of household responsibilities, even if women have lower pay than men.

Household life cycle is another important factor in determining value of time. For example, Gronau (1973) and Jacob et al. (2019) find that the presence of young children is associated with high time values and opportunity costs of commute time for the mothers, whereas the effect diminishes as the children grow older. This is because young children demand more of the mother's time and attention than do older children.

Extending the seminal formulation of Becker (1965), DeSerpa (1971) introduces that household utility is composed of not only the amount of good consumed but the time spent on the good. In addition to the money and time budgets, each good is associated with a technological constraint. That is, an individual can freely choose to spend exactly or more than the minimum required time on consuming the good. DeSerpa's model consists of value of time as a commodity (VOTC, from the utility function), value of time as a resource (VOTR, from the time constraint), and value of time saving (VOTS, from the technological constraint). Although this framework has been widely applied in transportation economics and project evaluation (Kato, 2013; Small and Verhoef, 2007), to the best of our knowledge, it has not been used to analyze gender disparities in time values.

Understanding the gendered VOTs based on the framework of DeSerpa (1971) can help quantitatively assess the burden of time for men and women as well as their differences in welfare since these endogenous values are derived from an individual's enjoyment and the relative importance of various activities (Jara-Díaz and Rosales-Salas, 2017). In this study, we will particularly focus on the changes in VOTs as children grow up using an intertemporal household utility model given that childcare responsibility is strongly attached to gender ideology and gender difference in time use by life stage (Apps and Rees, 2005; Golob and McNally, 1997; Kleven et al., 2019; Kwan, 2000, 1999; Miyajima and Yamaguchi, 2017; Rehel, 2014).

3. MODEL: INTERTEMPORAL HOUSEHOLD BEHAVIOR

Individuals trade off their time spent on work and commuting against childcare, leisure, and other activities/consumption given their time budgets. This concept is also applicable when household members negotiate their time use with each other. For instance, the trade-off could occur when a wife takes a part-time job close to home for its shorter working and commute time while her husband works and commutes for a longer time. In addition, such a trade-off can occur over their life stages. Indeed, as Section 2 reviews, women compromise by accepting the second-best jobs instead of their ideal occupations to better accommodate childcare tasks. Their choices of occupations further determine the future household incomes.

We utilize these trade-off mechanisms to measure the couples' VOTs derived from utility maximization, assuming that the households in the same category reach the same lifetime utility. Although households choose their own bundles regarding time use and employment, the same lifetime utility is achieved if households are homogeneous ex-ante. As our study aims to understand the within-individual and within-household trade-offs, individual utilities and the resource allocations in terms of income and time should be taken into account, as suggested by the collective household framework of Chiappori (1992, 1988). In this respect, our model development begins with the concept of a household model that incorporates individual utilities, income budget, and time constraints (Kato and Matsumoto, 2009; Zhang and Fujiwara, 2006).

Focusing on households comprising a married couple with children, we develop an intertemporal model that takes account of the decisions from the first year of a couple's marriage ($t=1$) to the end of their lives ($t=\bar{t}$). The household's utility in period *t*, HU_t, consists of the utilities of the husband and wife, U_t^h and U_t^w. For each household member *m*, where *m* ∈ {*h* (husband), *w* (wife)}, the individual utility is a function of member *m*'s consumption of composite goods (z_t^m), children's wellbeing (υ_t)[1],housing size (q_t), member *m*'s time on leisure (l_t^m), individual childcare ($t_{K,t}^m$), and joint childcare ($t_{K,t}^{hw}$). Children's wellbeing, υ_t, measures the state of children's happiness, which is defined as a function of the amount of money spent on a child in period *t*, I_t, and the parents' individual and joint childcare time. The birth of a child is assumed to be a random event (Cigno, 1991); that is, the number of children (K_t) is exogenously given but influences individual behavior in *t*. Households in different categories (e.g., income level) could have different indifference curves. The household utility in category ϕ in *t*, which includes children's wellbeing (υ_t), is[2]

$$HU_t^{\phi}\left(U_t^{\phi,h}\left(z_t^h,\upsilon_t,q_t,l_t^h,t_{K,t}^h,t_{K,t}^{hw};K_t\right),U_t^{\phi,w}\left(z_t^w,\upsilon_t,q_t,l_t^w,t_{K,t}^w,t_{K,t}^{hw};K_t\right)\right), \tag{1}$$

where $\upsilon_t=\upsilon_t\left(I_t,t_{K,t}^h,t_{K,t}^w,t_{K,t}^{hw}\right)$.

Equation (1) implies that each parent accounts for children's wellbeing (υ_t) to make their household's choices.

The household has three constraints. First, it faces a budget constraint from marriage period $t=1$ to the end period of life $\bar{t}$. The income revenue in *t* is the sum of the married couple's labor incomes and household nonlabor incomes (y_t). The labor income of member *m* in *t* is the multiplication of *m*'s wage rate (w_t^m) and working hours ($T_{W,t}^m$), where *m* ∈ {*h* (husband), *w* (wife)}. The total income budget in *t* is allocated to member *m*'s composite good consumption (z_t^m), housing expenses ($p_{q,t}q_t$), the investment in children (I_tK_t), and saving (s_t), where $p_{q,t}$ is the housing price per unit of floor area in time *t*. Households can save or borrow money at interest rate r_t. Eliminating s_t, we obtain the following intertemporal budget constraint:

$$\sum_{t=1}^{\bar{t}}\left[\left(z_t^h+z_t^w+p_{q,t}q_t+\left(I_t+e^0-\bar{e}\right)K_t\right)\Big/\prod_{t=1}^{t}\left(1+r_{t-1}\right)\right]=\sum_{t=1}^{\bar{t}}\left[\left(w_t^hT_{W,t}^h+w_t^hT_{W,t}^w+y_t\right)\Big/\prod_{t=1}^{t}\left(1+r_{t-1}\right)\right]. \tag{2a}$$

In Equation (2a), the price of z_t^m is normalized to one. r_0 is equal to 0 for the present value in *t*=1. e^0 and $\bar{e}$ are the minimum costs for raising a child and the child benefit, respectively. The child benefit is the social security payment provided by the government, which helps with the cost of rearing children. For simplicity, e^0 and $\overline{e}$ are assumed to be equal and constant.

Second, each member has his/her own time constraint in period *t*. Member *m* allocates his/her total available time in *t*, $\overline{T}_t^m$, to work ($T_{W,t}^m$), commute ($T_{C,t}^m$), leisure (l_t^m), individual childcare ($t_{K,t}^m$), and joint childcare ($t_{K,t}^{hw}$). Mathematically, *m*'s time constraint in *t* is

$$l_t^m + t_{K,t}^m + t_{K,t}^{hw} = \overline{T}_t^m - T_{W,t}^m - T_{C,t}^m, \tag{2b}$$

where $\overline{T}_t^m$ is *m*'s available time in *t* after the time for sleep and meals is deducted; $T_{C,t}^m$ is the total commute time in *t*. The commuting cost is not reflected in the budget constraint because it is reimbursed by *m*'s employer.

Our study assumes exogenous market work hours in paid jobs because individuals do not control their working times in most such jobs. In the real world, most workers depend strongly on their colleagues' workflows; therefore, they cannot change their working time continuously to suit their preferences. In the first place, the working hours in many jobs are determined institutionally. Workers are only able to choose working time discontinuously, at best (e.g., quitting their job). In the case of a full-time homemaker, their working time is fixed at zero, while they receive financial support from another source (typically their spouse's salary). Correspondingly, to reflect this situation, many papers discussing value of time assume exogenous working times, for example, the original setting in DeSerpa (1971), Jara-Díaz and Farah (1987), Jara-Díaz and Ortúzar (1989), Bianchi et al. (1998), Small and Verhoef (2007), and Blenky (2011). These previous studies provide similar reasons why people do not have free choice of work time when assuming exogenous work hours[3].

The third constraint is a technological constraint that describes the minimum required time, $\overline{t}_{K,t}$, depending on the number of young children aged 0-5, K_t^{young}. Compared to older children, most children in this age group need help from their parents to meet their physical needs (e.g., bathing, eating, dressing, etc.), and they focus primarily on family members and require more attention from their parents to develop their emotional, social, regulatory, and moral capacities (Shonkoff and Phillips, 2000; U.S. CDC, 2021). Since the married couple are free to allocate more than the required childcare time, this constraint describes whether the married couple together dedicate their time only to meeting the basic needs of their young children or enjoy the time with all of their children. This is conceptually built on DeSerpa (1971) that first introduced time allocation to good consumption. Mathematically, the constraint is

$$\overline{t}_{K,t}\left(K_t^{young}\right) \le t_{K,t}^h + t_{K,t}^w + t_{K,t}^{hw}, \tag{2c}$$

where $\overline{t}_{K,t}\left(K_t^{young}\right)$ is the minimum required childcare time in t depending on the number of young children aged 0-5 (K_t^{young}) in t.

Households choose all the endogenous variables including their residential locations. However, the following procedures set their residential locations as explanatory variables of the indirect utility function because we apply our model to the real data, which have attained the equilibrium utility. In the real data, the commuting times are observed after all the households chose their residential locations at equilibrium. Accordingly, we set the indirect utility function, which incorporates commuting times into the model as explanatory variables, and apply the equilibrium condition to them. At each location, the households maximize their utilities given their residential locations[4]. A similar treatment of commuting times has been widely used for various analyses (e.g., bid rent functions and the Muth conditions) of the Alonso-Muth-Mills model. From Equations (1) to (2c), the household's life-span utility maximization is

$$V^{\phi} = \max_{\substack{z_t^h, z_t^w, \upsilon_t, q_t,\\ l_t^h, l_t^w, t_{K,t}^h, t_{K,t}^w, t_{K,t}^{hw}}} \sum_{t=1}^{\overline{t}} \frac{HU_t^{\phi}\left(U_t^{\phi,h}\left(z_t^h, \upsilon_t, q_t, l_t^h, t_{K,t}^h, t_{K,t}^{hw}; K_t\right), U_t^{\phi,w}\left(z_t^w, \upsilon_t, q_t, l_t^w, t_{K,t}^w, t_{K,t}^{hw}; K_t\right)\right)}{\tau^{t-1}}, \quad (3)$$

subject to its intertemporal income constraint, Equation (2a), member m's time constraint in t, Equation (2b), and the technological constraint in t, Equation (2c). In Equation (3), the future household utility in t, U_t^{ϕ}, is discounted by τ^{t-1}, where τ is the time-discounted factor.

The monetary Lagrangian corresponding to Equations (2a) to (3) is

$$\begin{aligned}
\mathcal{L}^{\phi} = & \max_{\substack{z_t^h, z_t^w, \upsilon_t, q_t,\\ l_t^h, l_t^w, t_{K,t}^h, t_{K,t}^w, t_{K,t}^{hw}}} \sum_{t=1}^{\overline{t}} \frac{HU_t^{\phi}\left(U_t^{\phi,h}\left(z_t^h, \upsilon_t, q_t, l_t^h, t_{K,t}^h, t_{K,t}^{hw}; K_t\right), U_t^{\phi,w}\left(z_t^w, \upsilon_t, q_t, l_t^w, t_{K,t}^w, t_{K,t}^{hw}; K_t\right)\right)}{\lambda^{\phi}\tau^{t-1}} \\
& + \sum_t \left(\left(\left(w_t^h T_{W,t}^h + w_t^w T_{W,t}^w + y_t \right) - \left(z_t^h + z_t^w + p_{q,t} q_t + I_t K_t \right) \right) \Big/ \prod_{t=1}^{t} \left(1 + r_{t-1}\right) \right) \\
& + \sum_t \sum_{m=h,w} \left(\mu_t^{\phi,m} / \lambda^{\phi} \right) \left(\overline{T}_t^m - l_t^m - t_{K,t}^m - t_{K,t}^{hw} - T_{W,t}^m - T_{C,t}^m \right) + \sum_t \left(\kappa_t^{\phi} / \lambda^{\phi} \right) \left(t_{K,t}^h + t_{K,t}^w + t_{K,t}^{hw} - \overline{t}_{K,t} \right), \quad (4)
\end{aligned}$$

where λ^{ϕ}, $\mu_t^{\phi,m}$, and κ_t^{ϕ} are the Lagrangian multipliers of the budget, time, and technological constraints for households in category ϕ, respectively. Based on the life-time household utility maximization in Equation (4), $\mu_t^{\phi,m}/\lambda^{\phi}$ describes the value of time as a resource (*VOTR*) for member m in t and $\kappa_t^{\phi}/\lambda^{\phi}$ characterizes the value of childcare time saving (*VOCTS*) for a household in t. The first-order Karush-Kuhn-Tucker (KKT) conditions of Equation (4) are documented in Appendix A[5].

Using the envelope theorem, we obtain the marginal monetary utility of the exogenous variables, w_t^m, $T_{W,t}^m$, $T_{C,t}^m$, $p_{q,t}$, y_t, r_{t-1}, K_t, and K_t^{young} (see Appendix B for more details), where the married couple's choice variables are optimized at the given levels of the exogenous variables. For the empirical analyses, we make two assumptions for the model.

Assumption 1. Linearity. — A household's life-span utility is linearly approximated.

For the empirical step, the household utility at the equilibrium is linearly approximated by the first-order Taylor expansion without imposing any restrictions on the shape of the utility function, which is also adopted by the empirical estimations in MVA Consultancy (1987), Viscusi and Evans (1990), and Blayac and Causse (2001). In the logit framework studies exploring the value of time, the first-order approximation to the indirect utility is often used as well (e.g., Bates, 1987; Jiang and Morikawa, 2007).

Assumption 2. Homogeneity. — Households in the same category, ϕ, are assumed to be homogeneous before they enter the marriage.

With Assumption 2, households in the same category have similar characteristics and will achieve the same level of life-span monetary utility toward the end of their lives, $\bar{V}^{\phi}/\lambda^{\phi}$, at equilibrium.

As we have reviewed in Section 2, existing studies (e.g., Apps and Rees, 2005; Kleven et al., 2019) have shown that the presence of young children is one of the primary factors that influences the life-cycle arrangements and perspectives of a household. We define the following four periods that differentiate the key life stages of a household.

Definition 1. Four life stages. —
ta: the early marriage period without children,
tb: when the first child is of pre-school age (younger than six years old),
tc: when the first child is six years old or over, and
td: retirement and all children having left home.

In *ta*, all the married couples in the same category are assumed to work, receive the same wage rates, have the same working hours, and live close to their workplaces. In this context, the utility of working hours, commute time, and wage are identical. Periods *tb* and *tc* are our study focuses. The presence of children affects the married couples' trade-off between different activities and therefore accounts for the dynamics of the gender differences in VOTs.

We define *tb* as the period when the first child is of pre-school age (i.e., younger than six years old) and *tc* as the period after the first child reaches school age (i.e., older than six years old and before the married couple retire). We use the first child's reaching age 6 to differentiate *tb* and *tc* for two reasons. First, as explained in the setting for the technological constraint (Equation (2c)), children under age 6 demand more attention from their parents compared to those who are six and older due to their different developmental stages. Second, parents could accumulate childcare experiences as they bring up their first child so they become experienced when nursing their younger children. Lastly, *td* is the period when the couple retire and their children have all left home.

Since the time arrangements of men and women without children are not very different (Apps and Rees, 2005; Kleven et al., 2019; McGuckin and Murakami, 1999; Rouwendal and Rietveld, 1994), we assume the trade-off between the time spent on various activities is not distinct between men and women and thus gender differences in VOTs do not appear in *ta* and *td* given the absence of children. We thereby focus on the household utility and the dynamics of gender VOTs in *tb* and *tc* when children are present. Based on these settings, we denote the monetary utility for a household in category ϕ in *ta* and *td*, as $\overline{v}^{\phi}/\lambda^{\phi}$, leaving the analysis of the remaining monetary utility, $\left(\overline{V}^{\phi}-\overline{v}^{\phi}\right)/\lambda^{\phi*}$, to our focal study periods, *tb* and *tc*. Together with marginal monetary utility, we obtain

$$\begin{aligned}\left(\overline{V}^{\phi}-\overline{v}^{\phi}\right)/\lambda^{\phi*} = &\sum_{t=tb,tc}\left(\left(\partial V^{\phi}/\partial w_{w,t}^{h}\right)/\lambda^{\phi*}\right)w_t^h + \sum_{t=tb,tc}\left(\left(\partial V^{\phi}/\partial w_t^{w}\right)/\lambda^{\phi*}\right)w_t^w + \\ &\sum_{t=tb,tc}\left(\left(\partial V^{\phi}/\partial T_{W,t}^{h}\right)/\lambda^{\phi*}\right)T_{W,t}^h + \sum_{t=tb,tc}\left(\left(\partial V^{\phi}/\partial T_{W,t}^{w}\right)/\lambda^{\phi*}\right)T_{W,t}^w + \\ &\sum_{t=tb,tc}\left(\left(\partial V^{\phi}/\partial T_{C,t}^{h}\right)/\lambda^{\phi*}\right)T_{C,t}^h + \sum_{t=tb,tc}\left(\left(\partial V^{\phi}/\partial T_{C,t}^{w}\right)/\lambda^{\phi*}\right)T_{C,t}^w + \\ &\sum_{t=tb,tc}\left(\left(\partial V^{\phi}/\partial y_t\right)/\lambda^{\phi*}\right)y_t + \sum_{t=tb,tc}\left(\left(\partial V^{\phi}/\partial p_{q,t}\right)/\lambda^{\phi*}\right)p_{q,t} + \\ &\sum_{t=tb,tc}\left(\left(\partial V^{\phi}/\partial r_{t-1}\right)/\lambda^{\phi*}\right)r_{t-1} + \sum_{t=tb,tc}\left(\left(\partial V^{\phi}/\partial K_t\right)/\lambda^{\phi*}\right)K_t + \\ &\sum_{t=tb,tc}\left(\left(\partial V^{\phi}/\partial K_t^{young}\right)/\lambda^{\phi*}\right)K_t^{young}.\end{aligned} \tag{5}$$

In contrast to the conventional static approach, Equation (5) can account for the trade-off between time use in different life stages. For instance, a wife might have a *VOTR* higher in *tb* than in *tc* since childcare in *tb* could make her days long. To reach the equilibrium condition, her commute time in *tb* is lower than in *tc*, ceteris paribus. However, the mechanism might be less apparent for her husband due to the lesser role of childcare provider in the family.

Another example is the trade-off between the married couple. A wife in *tb* may have a *VOTR* higher than her husband due to their different levels of childcare responsibilities. The equilibrium holds when her short trip to work offsets her husband's long commute, ceteris paribus. Note that the amount of time on the same activity could be different among households even though they follow the same trade-off mechanism. This situation thus enables us to estimate the time values based on regression models.

Substituting marginal monetary utility into Equation (5) allows us to estimate *VOTR* and *VOCTS* by regressing the household's available money budget on working and commute time ($T_{W,t}^{m}$ and $T_{C,t}^{m}$, where *m*=*h*, *w* and *t*=*tb*, *tc*), the minimum required childcare time ($\overline{t}_{K,t}$) depending on the number of young children aged 0-5 (K_t^{young}), and the number of children (K_t) over *tb* and *tc*. We further put forward Definitions 2 and 3 to specify the characteristics of the values of time in the study periods.

Definition 2. Value of time as a resource[6] *in t. — For a household in category ϕ, member m's values of time as a resource in tb ($VOTR_{tb}^{\phi,m}$) and tc ($VOTR_{tc}^{\phi,m}$) are constant and defined by $\overline{\mu}_{b}^{\phi,m}/\lambda^{\phi}$ and $\overline{\mu}_{c}^{\phi,m}/\lambda^{\phi}$, respectively, where $\mu_{tb}^{\phi,m}=\overline{\mu}_{b}^{\phi,m}$ and $\mu_{tc}^{\phi,m}=\overline{\mu}_{c}^{\phi,m}$.*

This, indeed, states the *VOTRs* for one household only. The magnitudes of *VOTRs* among different households in the same category could be different in terms of location[7]. Given that our goal is to examine gender differences in *VOTRs* rather than the influences of spatial distributions, we regard our estimated *VOTRs* in the current study as the mean values in each income group regardless of residential location. We assume $\mu_{tc}^{\phi,m}=\overline{\mu}_{c}^{\phi,m}$ holds because we focus on the time values during the most difficult time of the couple's life (i.e., period *tb*) versus the time values in other periods (Apps and Rees, 2005). In fact, $\mu_{tc}^{\phi,m}$ could decrease, particularly for wives, when the married couples approach their retirement age because their time use could become less restrictive as their children grow older (Gronau, 1973; Jacob et al., 2019).

Definition 3. Value of childcare time saving in t. — For households in category ϕ, the values of childcare time saving in tb ($VOCTS_{tb}^{\phi}$) and tc ($VOCTS_{tc}^{\phi}$) are constant and are measured by $\overline{\kappa}_{b}^{\phi}/\lambda^{\phi}$ and $\overline{\kappa}_{c}^{\phi}/\lambda^{\phi}$, respectively, where $\kappa_{tb}^{\phi}=\overline{\kappa}_{b}^{\phi}$ and, $\kappa_{tc}^{\phi}=\overline{\kappa}_{c}^{\phi}$ respectively.

Following Equation (5) and the definitions, the equation to be estimated is

$$
\begin{aligned}
&Y^{\phi}=\beta_0^{\phi}+\sum_{t=tb,tc}\beta_t^{\phi}K_t+\sum_{ta,tb,tc,td}\left(\partial V^{\phi}/\partial r_{t-1}\right)\left(r_{t-1}/\lambda^{\phi*}\right)\\
&VOTR_{tb}^{\phi,h}\sum_{tb}\left(T_{W,tb}^{h}+T_{C,tb}^{h}\right)+VOTR_{tb}^{\phi,w}\sum_{tb}\left(T_{W,tb}^{w}+T_{C,tb}^{w}\right)+VOCTS_{tb}^{\phi}\sum_{tb}\left(d\overline{t}_{K,tb}/dK_{tb}^{young}\right)K_{tb}^{young}\\
&VOTR_{tc}^{\phi,h}\sum_{tc}\left(T_{W,tc}^{h}+T_{C,tc}^{h}\right)+VOTR_{tc}^{\phi,w}\sum_{tc}\left(T_{W,tc}^{w}+T_{C,tc}^{w}\right)+VOCTS_{tc}^{\phi}\sum_{tc}\left(d\overline{t}_{K,tc}/dK_{tc}^{young}\right)K_{tc}^{young}+\varepsilon, \quad (6)
\end{aligned}
$$

where $Y^{\phi}=\sum_{t=tb,tc}\left[\left(2\times\left(w_t^{h}T_{W,t}^{h}+w_t^{w}T_{W,t}^{w}\right)+y_t-p_{q,t}q_t^{\phi*}\right)/\prod\left(1+r_{t-1}\right)\right]$, $\beta_0^{\phi}=\left(\overline{V}^{\phi}-\overline{v}^{\phi}\right)/\lambda^{\phi}$,

$\beta_t^{\phi}=\dfrac{1}{\lambda^{\phi*}\tau^{t-1}}\left(\sum_{m=h,w}\dfrac{\partial HU_t^{\phi}}{\partial U_t^{\phi,m}}\dfrac{\partial U_t^{\phi,m}}{\partial K_t}\right)-\dfrac{I_t^{\phi}}{\prod\left(1+r_{t-1}\right)}$, and ε is the error term following a normal distribution.

For a household in category ϕ, Y^{ϕ} characterizes the household's remaining budget by subtracting housing expenditure from labor and nonlabor incomes. The total labor income is multiplied by two because of the marginal monetary utilities of working hours and wage rates. Substituting the marginal utilities (specifically (B1) and (B2) in the Appendix) into the first two lines in equation (5) yields this part. β_0^{ϕ} represents the monetary utility in *tb* and *tc*. β_t^{ϕ} is the marginal monetary utility of children in *t*.

For our empirical analyses, we can suppose three hypotheses which are to be checked empirically in Section 5. First, according to the available evidence that a married couple could have tight schedules in the presence of young children and that wives are primarily responsible for childcare (Apps and Rees, 2005; Kawabata, 2014; Milkie et al., 2009; NHK, 2011), we make Hypotheses 1 and 2 regarding the married couple's time use and values in *tb* and *tc*.

> *Hypothesis 1.* $VOTR_{tb}^{\phi,m} \geq VOTR_{tc}^{\phi,m}$.*— Member m could have a tighter time constraint in tb than in tc since (s)he contributes a significant amount of time to childcare when the children are very young.*

> *Hypothesis 2.— % change in wife's VOTR ≥ % change in husband's VOTR.*

This is because the extent to which a wife's time constraint relaxes from *tb* to *tc* is greater than that of her husband given her role as the primary childcare giver (Milkie et al., 2009).

As previously described, the attention demanded by children and the parental experiences of nursing children are different in *tb* and in *tc*. The married couple could dedicate a significant amount of time more than necessary to childcare in *tb* but the childcare time could decrease down to the minimum required childcare time in *tc* as they become experienced. Households may tend to have a nonbinding technological constraint in *tb*, yielding $VOCTS_{tb}^{\phi} = 0$, whereas they are likely to hold a binding technological constraint in *tc*, leaving $VOCTS_{tc}^{\phi} > 0$ (see Equation (A7) for more details). These together imply Hypothesis 3.

> *Hypothesis 3.* $VOCTS_{tb}^{\phi} < VOCTS_{tc}^{\phi}$.*— Households tend to have a nonbinding constraint in tb but a binding constraint in tc so* $VOCTS_{tb}^{\phi} < VOCTS_{tc}^{\phi}$.

Table 1 provides a list of variables for the model formulation in this study.

[Insert Table 1 Here]

4. EMPIRICAL SETTING, DATA, AND METHODS

4.1. Empirical model specification

Since our empirical analysis focuses on Japanese households (see Section 4.2 for more details), we specify our model based on the local context in Japan. First, the interest rate r_{t-1} ($\forall t \geq 2$) is assumed to be the same during our study period given the relatively constant low internal rate of return of Japanese Government Bonds[8] in the target period. Accordingly, we can set a constant interest rate. Specifically, we set the 2% interest rate using the average values of the 20-year and 30-year Japanese national bonds from 1992 to 2022 to compute the present value of wage and housing expenditure (i.e., Y^{ϕ}). In addition, we set the total length of the study periods *tb* and *tc* in Equation (6) as 35 years in order to capture the average number of working years after a couple has their first child but before they reach the retirement age of 65 in Japan[9]. More specifically, *tb*=1-6 when the first child is aged 0-5 and *tc*=7-35 when the first child is ≥ age 6 but before the married couple retire.

4.2. Survey and study sample

This study examines the behavior of households comprising a married couple and at least one child in Japan, using the 2004-2018 Japan Household Panel Survey (KHPS/JHPS) conducted by the Panel Data Research Center (PDRC) at Keio University (PDRC, 2018). We extract our study sample from a subset of 10,400 households in Japan that provide at least one year of data in *tb* and in *tc*, respectively. These households were recruited at the beginning of the surveys in 2004 (KHPS) and 2009 (JHPS) and as newly added cohorts in 2007 and 2012 (for KHPS only). The recovery rate for the panel, on average, is 91% each year. Households with a married couple account for 75% of the sample for the panel, but these households include couples without children, middle-age couples with only adolescent children, or older and retired couples whose grown-up children have left home, in addition to our focal households with a married couple and young children[10] (for more details, see https://www.pdrc.keio.ac.jp/en/paneldata/datasets/jhpskhps/).

We retain households that include a married heterosexual couple with young children and that report their income, housing expenditure, employment status, and working and commuting time. Households with the wife's commute time above the 90th or below 10th percentiles of the sample are discarded to avoid distorted results. Households with a positive Y^{ϕ} are retained since the households should have some budget allocated to other expenditures in addition to housing. These criteria together result in 249 households for the empirical estimations.

Given the data limitation that we are not able to observe all the $T_{W,t}^{m}$ and $T_{C,t}^{m}$ throughout *tb* and *tc*, we regard member *m* to be employed in *t* (=*tb*, *tc*) if *m* is mostly employed in the observed periods of *t*. We use $\overline{T}_{W,t}^{m}$ and $\overline{T}_{C,t}^{m}$ to represent *m*'s average working and commute time in *t* based on the mean observed values. Similarly, we use the total number of children observed to represent K_t.

We calculate the household's housing expenditure over *tb* and *tc* by averaging out the observed rents. For the households who own their home, we calculate the attributable rents[11] (= $P\left(1+avgmr\right)^{\Delta t} / 50$) using the purchased price of their home (P) and the average mortgage rate ($avgmr$) based on Flat 35 (www.sumai-info.com)[12] , and the difference in the years observed and purchased (Δt).

To obtain the household's total income in the study period, we first calculate the annual wage growth rate by age using the data of salaries in the private sector provided by the National Tax Agency in Japan. Based on the wage growth rates, the household's income of the observed periods, and the married couple's age in *tb*=1, we approximate the household's total income over *tb* and *tc*. In this study, we categorize households using the present value of the husband's average income since the husbands in our data are the primary breadwinners of their families. Moreover, empirical evidence has found that *VOTRs* are likely to increase with household income (Small and Verhoef, 2007). For the households with a husband's annual salary lower than the median household income (JPY 4,370,000) in Japan[13], we define ϕ=1; 0, otherwise.

Table 2 summarizes the variables of interest in the study. As expected, the housing expenditure and husband's hourly wage of the high-income households (ϕ=0) are greater than those of the low-income households (ϕ=1). More than 98% of the husbands in our sample are employed in the study period and work more than 9 hours daily. The high-income husbands spend nearly 1 hour and 20 minutes commuting per day, whereas the low-income husbands spend less than an hour. The working time of the husbands in both the income groups are comparable with the results of the 2010 Japanese Time Use Survey (JTUS), but the low-income husbands' commute is shorter than the average in Japan (NHK, 2011).

Wives in the high-income households earn less than their counterparts in the low-income households. Their hourly wages, however, are not significantly different. Most of the wives in our sample tend to stay home in *tb* but are likely to work as their children grow up in *tc*. The employment rates of the wives in the high-income households are lower than those of the wives in the low-income group. Their average working time is comparable with the 2010 JTUS for women whose youngest child is of pre-school age (NHK, 2011). The employed wives' average working time and one-way commute are less than 6 hours per day and 10 minutes per trip, respectively. Results of t-test suggest that most of our focal variables in the two groups show statistically significant differences.

[Insert Table 2 Here]

4.3. Measuring the household's minimum childcare time required, $\overline{t}_{K,t}$

As indicated in our theoretical section, a household's minimum required childcare time depends on the number of young children aged 0-5. To characterize the minimum required time on childcare, $\overline{t}_{K,t}$, for the sample households, we utilize the k-means algorithm to group households into clusters of households with more similar characteristics. The k-means clustering is an iterative algorithm that minimizes the Euclidean distances between the data points and the centroid[14] of each cluster to which the data points belong (Gan et al., 2007).

As the dependency of infants, toddlers, and preschoolers could also be different[15], we partition the sample households based on two clustering variables: (i) the number of infants and toddlers (≤ age 2) and (ii) the number of preschoolers (ages 3 to 5). Our clustering analysis is built on two matrices that enumerate all the years when at least one child in the sample household was < age 6 in *tb* and in *tc*, respectively. Each matrix includes the number of infants and toddlers and the number of preschoolers in a household by year. We partition the data in each matrix by the clustering variables into five clusters[16] and obtain the 5th percentile of the clustered households' childcare time in the observed years during *t* (denoted as $t_K^{j(t),5th}$, where *j(t),5th*=the 5th percentile of household childcare time in the cluster *j* to which the household belongs in *t*). Based on these results, we define a household's total minimum time in *t*, $\sum_t \overline{t}_{K,t}$ and $\overline{\delta}_t$ using the following conditional statement:

$$\left(\sum_t \overline{t}_{K,t}, \overline{\delta}_t\right) = \begin{cases} \left(Non-binding, 0\right) & \text{if } n_t\left(\overline{t}_{K,\tilde{t}}^h + \overline{t}_{K,\tilde{t}}^w\right) > \sum_t t_K^{j(t),5th}, \\ \left(\min\left\{n_t\left(\overline{t}_{K,\tilde{t}}^h + \overline{t}_{K,\tilde{t}}^w\right), \sum_t t_K^{j(t),5th}\right\}, 1\right) & \text{if } n_t\left(\overline{t}_{K,\tilde{t}}^h + \overline{t}_{K,\tilde{t}}^w\right) \le \sum_t t_K^{j(t),5th}. \end{cases} \tag{7}$$

The first and second conditional statements in Equation (7) yield a non-binding condition and a binding condition of childcare time, respectively. We use $\overline{\delta}_t$ to indicate whether a household holds a binding ($\overline{\delta}_t$= 0) or a nonbinding constraint ($\overline{\delta}_t$= 1) in *t* in the regressions. n_t is the number of years when the household had children younger than six years old in *t* (i.e., n_{tb}= 6 and n_{tc}= the year difference between the first and the youngest children), and $\overline{t}_{K,\tilde{t}}^m$ is m's average childcare time over $\tilde{t}$, the years observed by the survey data in *t* (=*tb*, *tc*). Note that the amount of childcare time in the KHPS/JHPS data are not broken down by type (i.e., individual vs. joint). Accordingly, member *m*'s childcare time in *t* from the data could include both the individual and joint childcare time (e.g., $t_{K,t}^m + t_{K,t}^{hw}$). In this context, the total amount of childcare time from the data (i.e., $t_{K,t}^h + t_{K,t}^w + 2t_{K,t}^{hw}$) used for the clustering analysis could be larger than their actual childcare time (i.e., $t_{K,t}^h + t_{K,t}^w + t_{K,t}^{hw}$).

4.4. Empirical approach: two-stage instrumental variable (IV) analysis

This study conducts a two-stage instrumental variable (IV) analysis that first predicts the married couple's commute time, and then substitutes the observed commute time in the second stage analysis of the available household budget in order to cope with endogeneity bias. The endogeneity issue could occur when the commute time in the regression of household available budget is correlated with possible unobserved characteristics.

In transportation literature, IV estimation is a long-established and widely applied method that controls for the correlations between the independent variables and the error term, ε (Cao et al., 2009; Houston et al., 2015; Mokhtarian and Cao, 2008; Niebuhr et al., 2012; Russo et al., 2014). An ideal IV is uncorrelated with ε but correlated with the endogenous variable (Wooldridge, 2012). That is to say, the IV should be exogenous to the outcome variable (in our study, household available budget) but also influence the endogenous variable (i.e., commute).

In this study, we use the regional ratio of waitlisted children (RWC), the regional road density (RRD), and the prefectural car density (PCD) as the instrumental variables for our analysis. Our RWC measures the regional ratio of children on the childcare waitlist, which is based on the 2000-2018 data of children waitlisted for childcare obtained from the Ministry of Health, Labour, and Welfare. RRD is defined as the regional road extent per 1,000 people based on the 2002-2010 road network mesh data of the Ministry of Land, Infrastructure, Transport and Tourism and the 2000-2015 population census data in Japan. PCD represents the number of cars per 1,000 people in the prefecture based on the 2000-2015 Automobile Inspection and Registration Information Association statistics and the 2000-2015 population census data in Japan.

We consider PCD, RRD, and RWC as the IVs for this study because they depend on the transportation and childcare provided by the government. These variables, indeed, do not directly influence a household's available budget; rather, they are associated with commute length (Niebuhr et al., 2012; StGeorge and Fletcher, 2012; Wachs et al., 1993). The first stage of the two-stage IV analysis separately predicts the commute time of the sample husbands and wives in *t* based on the Tobit model that regresses the individual's one way commute time in *t* on the IVs in *t*. Using the OLS model for the second stage estimation, we then regress the total predicted commute time in *t* as well as other independent variables on the household remaining budget, Y. Mathematically, the two-step model is

$$\overline{t}_{C,t}^{m} = Tobit\left(IV_t\right)$$

$$Y = OLS\left(\sum_t \widehat{\overline{t}_{C,t}^{m}}, \text{other independent variables}\right).$$

Based on the p-value of the likelihood ratio test that examines the overall effects of the IVs[17], the results suggest that the models produce a good fitness with the IVs (see Appendix Table C1 for more details).

5. EMPIRICAL RESULTS

5.1. Results of clustering analysis

Table 3 summarizes the clustering results based on the k-means algorithm with five clusters for our sample households in *tb* and *tc*, respectively. Within the same study period, the Kruskal-Wallis nonparametric test suggests that the median household childcare time differs significantly among the clusters. In *tb*, the 5th percentile of the childcare time of households with the average number of 2.02 infants and toddlers and 0.21 preschoolers (i.e., $t_{K,tb}^{1,5th}$) is 3.04 hours/day, which is larger than the value of households with 0.25 infants and toddlers and 2.02 preschoolers (i.e., $t_{K,tb}^{3,5th}$). In terms of the median childcare time, the households with only one preschooler but no toddlers in tb spend the least amount of time on childcare, that is, 7.14 hours/day (results not shown). By contrast, the median childcare time of the households in other clusters ranges from 8.50 to 12.14 hours/day (results not shown).

In *tc*, households with an average number of 2.15 or more children (i.e., $t_{K,tc}^{3,5th}$) have a greater 5th percentile of childcare time compared to households in the other clusters with fewer children under age 6. Indeed, the median childcare time for the households with more infants and toddlers is greater than the value of the households with less young children. For example, $t_{K,tc}^{2,5th}$ (with 1.03 infants and toddlers and zero preschoolers) and $t_{K,tc}^{4,5th}$ (with 1.03 infants and toddlers and one preschooler) are 2.45 and 3 hours/day, respectively. Cluster 5 in *tc* represents the periods when the households only have children who are aged 6 and above. This is possible because the youngest child in a family could be born a few years after the first child turns 6. The median test for the clusters with the exact same centroid values but in different study periods (i.e., Cluster 4 in *tb* vs. Cluster 1 in *tc*) indicates a moderately significant difference in childcare time (p-value=0.07, not shown). Using the results from Table 3 and Equation (7), we obtain $\sum_t \overline{t}_{K,t}$ for our sample households.

[Insert Table 3 Here]

Table 4 describes the married couple's mean daily childcare time, the number of households that have a binding constraint, and the minimum required childcare time for those with a binding constraint. In *tb*, wives spend more than 9 hours per day on childcare while their husbands spend around one hour. In *tc*, the results indicate that the wives' daily childcare time is more than 7 hours while their husbands' is less than an hour a day. Moreover, our results of wives' childcare time are longer than the average in the 2010 JTUS for women whose youngest child is a preschooler (NHK, 2011). Although employed wives are associated with less childcare time, they still spend more than 5 hours per day on childcare, which is greater than the amount of time their husbands spend. Results of the paired t-tests show that the difference in childcare time between the married couples is statistically significant.

Based on our definition of the minimum required time for childcare, the results further show that less than 2% of the households in the study have a binding constraint. All the households in the high-income group have a nonbinding technological constraint in *tb*, whereas only one household possesses a binding constraint in *tc*. For the low-income group, there are two and three households with a binding constraint in *tb* and *tc*, respectively. For those with a binding constraint, their minimum required childcare time is less than 2 hours/day. In order to avoid the multicollinearity problem (i.e., the interaction term of minimum required time and ϕ), the estimated $VOCTS_{tb}$ is only for the low-income group (see Section 5.2 for the results in detail). For more information on the households with the binding and nonbinding conditions, Appendix Table C2 compares the employment rate and daily working time over the study periods: the households with a binding constraint for childcare time are dual-income couples and their employment rate and working time are higher than those with a nonbinding constraint.

[Insert Table 4 Here]

5.2. Results of the two-stage instrumental variable (IV) analysis

Using the models that account for the income level (ϕ), the technological constraints for childcare, and IV methods, we directly examine the factors associated with the household available budget[18]. The estimated coefficients for *m*'s total commute and working hours and the household minimum required childcare time in *t* correspond to $VOTR_t^m$ and $VOCTS_t$, respectively. Note that $VOTR_t^w$ captures the average *VOTR* for both employed and unemployed wives in our sample. Results of the adjusted R^2 and the F-test suggest that our estimations have a good fitness with the data. For the models found to have heteroskedasticity by the Breusch-Pegan test, robust t-statistics and F-test are used instead.

In order to substantially obtain the statistical inferences for our results, we further the the boot package in R to calculate the bootstrap standard errors and the associated 90% confidence intervals with 1,000 replicates (Canty, 2002; Efron and Tibshirani, 1993; James et al., 2013). The method relaxes the parametric assumption of the conventional statistical tests and provides more robust inferences, especially for multistage regression and small samples (Efron and Tibshirani, 1993; Fox and Weisberg, 2018; Freedman and Peters, 1984).

Table 5 presents the estimated results that only consider the effect of ϕ without differentiating the time values by income level. The low-income households are associated with around 181 million yen less in remaining household budget than the high-income households. The number of household children, however, does not show any statistical significance. $VOTR_{tb}^{h}$ is 1,227 yen/hour in the OLS estimation and 1,728 yen/hour in the IV-OLS model. These time values represent about 64-90% of the husbands' average wage rates. $VOTR_{tb}^{w}$ is found to be 4,619 yen/hour, which is more than 10 times the average wage rates of the wives.

As the household's children grow up in *tc*, $VOTR_{tc}^{h}$ and $VOTR_{tc}^{w}$ drop to around 1,100 yen/hour and 400 yen/hour in both models, which are about 58-59% and 93-97% of their wage rates, respectively. Results of the t-statistics and bootstrapped confidence intervals (CIs), however, suggest that only $VOTR_{tb}^{w}$ and $VOTR_{tc}^{h}$ are statistically significant. For the households with a binding constraint for childcare time, the $VOCTS_{tb}$ is 7,481 yen/hour in the OLS model and 6,309 yen/hour in the IV-OLS estimation, whereas the estimated $VOCTS_{tc}$ increases to more than 28,300 yen/hour in both models. $VOCTS_{tc}$ remains statistically significant within 90% of the bootstrapped CIs.

[Insert Table 5 Here]

Table 6 describes the results that incorporate the interactions of ϕ and other explanatory variables which differentiate the values of time by income level. Consistent with the results in Table 6, the low-income households have lower remaining budgets, yielding 150 to 174 million yen less than the high-income households. Although the estimated results show that the husbands and wives in the high-income households have higher *VOTRs* than those in the low-income households, results of the t-statistics and the bootstrapped CIs indicate that $VOTR_{tc}^{0,h}$ (around 1,600 to 1,700 yen/hour for the high-income husbands) is the only significant one among the four types of *VOTRs* we estimate. These results suggest that there is no significant difference between the *VOTRs* of the household members in the two income levels. In addition, *VOCTSs* are statistically insignificant.

[Insert Table 6 Here]

Moreover, we find that the relative change between *VOTRs* in *tb* and *tc* for the married couples are different based on the results of Table 5. Compared to $VOTR_{tb}^{h}$, the OLS estimations find a 9-13% decrease in $VOTR_{tc}^{h}$, whereas the IV-OLS results show that husbands' *VOTR* in tc drop by more than 30%. Both OLS and IV-OLS regressions consistently indicate that $VOTR_{tc}^{w}$ is around 91% smaller than $VOTR_{tb}^{w}$.

6. DICUSSION

Our empirical analyses suggest that the findings deserve further interpretations as well as discussion. We also examine the household welfare improvement with respect to three transportation and childcare policies which are the common strategies to alleviate time burden.

6.1. Key results and interpretations

We summarize the main empirical findings in this subsection.

Main finding 1.— Our results substantiate Hypothesis 1 that the wives' average VOTR in tb is statistically significant and greater than 4,400 yen/hour; however, the value in tc drastically drops to around 400 yen/hour and becomes insignificant.

Note that *tb* is the period when the first child is of pre-school age, and *tc* is the period when the first child is six years old or over. *Main finding 1* is consistent with the findings of Gronau (1973) and Jacob et al. (2019), which reveal that the presence of young children could increase a mother's VOT but the effect diminishes in the presence of older children.

Main finding 2. — The husbands' average VOTR in tb is around 1,200 to 1,700 yen/hour but insignificant. The value slightly decreases to nearly 1,100 yen/hour in tc and remains significant.

The results, together with the average times on work, commute, and childcare for the husbands in Tables 1 and 3, indicate that husbands' time uses are merely affected by the presence of children, unlike their wives.

Main finding 3. — Hypothesis 2 is supported.

This finding reveals that the presence of young children has greater influences on the wives' time allocations than on the husbands'. This finding, along with the average daily childcare time in Table 4, confirms that the wives take the primary roles of childcare giver in their families. This finding corresponds to the available evidence that wives who are responsible for childcare are stressed out because they need to run between work and family tasks (Borghorst et al., 2021; Carta and Philippis, 2018; Hochschild and Machung, 2012; Kawabata and Abe, 2018; McGuckin and Murakami, 1999; Rouwendal and Rietveld, 1994). Their male counterparts, in contrast, are not influenced by these responsibilities very much.

Main finding 4. — The trade-off mechanism for the life-time equilibrium peeps out from the estimated VOTRs and the average work and commute times.

The wives' increasing *VOTR*, for example, responds to their decreasing work and commute times in Table 2 over the study periods. This mechanism is not evident for the husbands presumably because their time arrangements are not affected by the responsibilities for childcare. The trade-offs between the married couples are also revealed. In response to the different levels of childcare responsibilities in *tb*, the wives' high *VOTRs* and short work and commute times compensate the husbands' low *VOTRs* and long work and commute hours. In *tc*, the husbands slightly reduce their work and commute hours in a way to respond to their wives' increasing time on work and commute.

Main finding 5. — $VOCTS_{tc} > VOCTS_{tb}$, supporting Hypothesis 3.

The estimated *VOCTS* in the study periods also implies how much the households enjoy individual and joint childcare time. Recall that the household's value of time as a commodity (*VOTC*) for member *m*'s individual childcare in *t* is the difference between $VOTR_t^m$ and $VOCTS_t$ and that the household's *VOTC* for joint childcare in *t* is the difference between $\sum_{m=h,w} VOTR_t^m$ and $VOCTS_t$ (see Appendix Equations (A5) and (A6) for more details). Regardless of the binding/nonbinding condition of the household's technological constraint on childcare time in *tb*, the household's *VOTC* of the husband's childcare time could range widely across people, and could possibly be zero during this period, given that the husbands' estimated *VOTR* and the households' estimated *VOCTS* are statistically insignificant. The positive *VOTCs* for the wives' individual childcare time and for the married couples' joint childcare time suggest that the households could gain utility from the wives' time spent on childcare.

In *tc*, the households with a binding technological constraint on childcare time are likely to have disutility of childcare given that the married couples' *VOTCs* for the individual and joint childcare times are negative. We further find that the household's disutility of wives' childcare time is even greater than that of husbands'. These results show that the households with a binding constraint do not enjoy their childcare time in *tc*. As shown in Table 5, the married couples with a binding constraint on childcare time in *tc* and thereby with disutility of childcare are all employed, implying that these dual-income households could not reconcile work-family lives since their long, exhausting workdays do not allow them to allocate more than the required time to childcare. Note that these dual-income households only account for around 2% of the study sample based on our definition of minimum required time on childcare.

Main finding 6. — The high-income husbands, on average, have greater VOTRs than their low-income counterparts over the study periods. Compared to the VOTRs of the low-income wives, the time values of the high-income wives are larger in tb but become smaller in tc.

The results of the differences in the *VOTRs* between the high- and low-income husbands are consistent with Small and Verhoef (2007) which summarize that *VOTR* is likely to increase with wage rate. In line with Table 2, the low-income wives' higher *VOTRs* in *tc* reflect their higher employment rate when their children grow older, compared to the high-income wives. Yet, the results of the bootstrap CIs suggest these values are insignificant to the household's available income and that the statistical significances of the difference between the high- and low-income households are not revealed. Possible explanations include having the individuals with heterogenous characteristics in the same income group in the sample, using a small sample, averaging the time variables for work and commute with limited observations, and failing to account for *VOTCs* of work and commute.

Main finding 7. — The husbands' estimated time values fall within a reasonable range in comparison with their wage rates and existing research.

Consistent with previous studies on the value of time (Kato, 2013; Small and Verhoef, 2007), we find that the husbands' *VOTR* in *tc*, for example, is around 58-60% of their wage rates. Compared to the meta-analysis of value of time in Japan (Kato, 2013), our estimations for the husbands' *VOTR* in *tc* is smaller (i.e., 19 yen/min in our study vs. 25-42 yen/min by Kato's estimation). These differences could be because we only consider the value of time as a resource while Kato (2013) investigates the value of travel time saving.

6.2. Effects of Transportation and Childcare Policies on Welfare

Urban policies that help lessen travel burden, facilitate flexible work option, and support childcare, have long been suggested to time use relaxation and welfare improvement for the households with children (Alon et al., 2020; Borghorst et al., 2021; Carta and Philippis, 2018; Jacob et al., 2019; Kawabata, 2014; Kawabata and Abe, 2018). Our Main finding 1 shows that the wives running between different tasks in addition to their responsibilities for childcare face limited time available and thus experience a high *VOTR*. Improving transport service by reducing travel time, for instance, is one doable strategy that help the wives alleviate their constrained time use. In Main finding 4, the equilibrium condition is realized when the married couple trade off the time on commute and work with each other. For example, we see that the slight reduction in the work and commute time of the husbands corresponds to their wives' increasing time spent on work and commute. Work from home[19], a common practice for easing long commute as well as a way for encouraging the husbands' participation in childcare, can be examined to understand its influences on household welfare when the wives increase labor participation as their children become older.

Main finding 5 explains that around 2% of the sample dual-income couples have a binding minimum required time constraint on childcare. These households do not allocate more than the minimum required time to childcare perhaps due to their long and exhausting workdays. The Family Support Program launched in Japan in 2015, for instance, gives parents a break by providing them a child-chauffeur service when schedule conflicts, such as an early morning meeting or overtime work, occur [20]. To understand the effects of improved transport and childcare services, we simulate the welfare gain of a household based on the *VOTRs* and *VOCTS* of the IV-OLS in Table 5 (with at least 10% significance) for three policy scenarios. We calculate the average welfare gain based on the multiplication of the target time value and the amount of time saved. Results are shown in Table 7.

Scenario 1. — Improving transport service by reducing a 1-minute of travel time

This scenario aims to decrease people's travel burden by improving transportation. On average, a household can gain 19,145 yen/year in tb via a one-minute of reduction in the wives' travel burden over weekdays. This gain includes the welfare of children, which is altruistically considered by their parents.

Scenario 2. — Work from home

For a household with a husband who telecommutes once per week, the welfare gain is 61,652 yen/year in *tc*.

Scenario 3. — Utilizing children-chauffeur service

Suppose that a dual-income family with a binding minimum required time constraint on childcare occasionally cannot pick up/drop off their children at nursery or the afterschool program because of the schedule conflict. The family then utilizes the chauffeuring service once per week[21]. This enables our sample households, on average, obtain 11,402 yen/year of welfare gain in tc.

[Insert Table 7 Here]

The simulation results indicate that household welfare gain in Scenario 2 appears to be the largest, followed by Scenarios 1 and 3.

7. CONCLUSIONS

This research investigates different types of time values by life stage for households comprising a married couple and at least one child in Japan. We first theoretically construct an intertemporal household behavior model and then derive values of time as a resource (*VOTRs*) and values of time as childcare saving (*VOCTSs*) from household utility maximization. Based on the 2004-2018 KHPS/JHPS, we quantitively measure the married couple's *VOTRs* and household's *VOCTSs* when their first child is of pre-school age and after their first child reaches school age.

Our results show that the wives on average have a *VOTR* of more than 4,400 yen/hour when all their children are preschoolers or younger. The value, however, drops to around 400 yen when the children reach school age. This remarkable change implies the wives' busy days when their children are young. Husbands, by contrast, do not experience very different *VOTRs*, ranging from 1,100 to 1,700 yen/hour in the two life stages. In line with previous studies (Borghorst et al., 2021; Jacob et al., 2019; Kawabata and Abe, 2018; Kleven et al., 2019), our results of *VOTRs* confirm that the wives still bear the primary responsibilities for childcare.

The results of the *VOCTSs* reflect that some dual-income families do not enjoy enough quality time with their children and thus could experience imbalanced work-family lives. This is perhaps because their long and exhausting working days do not enable them to spend the childcare time more than the minimum required. Although urban strategies that facilitate travel time reduction and childcare-chauffeur service can enhance household welfare, the simulation suggests that, in the short term, the work-from-home option seems to be more effective in improving household welfare through alleviating the time and spatial constraints.

In the long term, family-friendly programs that overcome the social stress of taking paternity leave can encourage men to actively parent children and equally share childcare responsibilities with their wives (Miyajima and Yamaguchi, 2017; Rehel, 2014). More importantly, these programs could help men transition to parenting faster, and improve their mental and physical conditions by balancing work and family life, thus sustainably supporting female employment (Alon et al., 2020; Amin et al., 2016; Miyajima and Yamaguchi, 2017; Thor Arnarson and Mitra, 2010).

Our study makes various contributions to the existing research on gender, childcare, and urban planning and transportation. While previous research evaluates gender differences in the number of activities and the time use of paid work and unpaid domestic tasks (Apps and Rees, 2005; Boarnet and Hsu, 2015; Carta and Philippis, 2018; Golob and McNally, 1997; Hochschild and Machung, 2012; Kleven et al., 2019; McGuckin and Murakami, 1999; Milkie et al., 2009; Srinivasan and Bhat, 2005; Wang and Li, 2009), this study is the first to provide a rigid, advanced method to directly measure and compare the within-household gender differences in time values by life stage. Using the clustering analysis to capture the minimum required childcare time, we estimate the value of childcare time saving and understand the time burden of some dual-income households with young children. In particular, the estimation methods are not limited to Japan but can be readily applied to the gender equality research in other countries and regions and to urban policy evaluation. Beyond the conventional settings of time value as a portion of wage rate, our results could inform urban and transportation planners that project evaluations should be inclusively conducted by taking different cohorts, particularly mothers with young children, into account, as discussed by Ortúzar and Willumsen (2011).

This study has some limitations, mainly because of the current availability of data. Compared to the 2019 Comprehensive Survey of Living Conditions in Japan[22], the low employment rate of the wives in our sample could underestimate *VOTR* as well as *VOCTS*. Moreover, the commute time in this study only appears in the time constraint, leaving an open question as to how different the value of time as a commodity (*VOTC*) for travel would be for a married couple.

The lack of geographic information is another noteworthy limitation. Because of privacy concerns, the KHPS/JHPS data do not specify the home locations of the survey participants in detail. This prevents us from identifying the impacts of job accessibility and childcare services at an intercity level on the trade-off between the locational choices of home and work. In addition, future research could consider households' income sharing rules at the individual level and thus more directly address the collective household setting of Chiappori (1992, 1988). Lastly, self-selection could play a determinant role within households: could a married couple's gender ideologies account for their work-life preferences and thus lead to their distinct time use and values of time (Davis and Greenstein, 2009; Kleven et al., 2019)?

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Ashley (Wan-Tzu) Lo: Conceptualization, Methodology, Software, Validation, Formal analysis, Resources, Data curation, Writing-Original Draft, Writing-Review & Editing, Supervision, Project administration.

Tatsuhito Kono: Conceptualization, Methodology, Resources, Writing-Original Draft, Writing-Review & Editing, Supervision.

DECLARATION OF COMPETING INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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NOTES

[1] Our household utility function consists of parents' altruistic utilities by incorporating children's wellbeing into parents' utilities. As a result, our utility function HU_t^{ϕ} can represent the specified functions set in Barro and Becker (1989) and Kato and Matsumoto (2009), where parents' utilities and their children's utility are taken into account. Although Kato and Matsumoto (2009) suppose that children's utility is weakly separable from their parents' utilities, our household utility function $HU_t^{\phi}\left(U_t^{\phi,h}\left(\cdots,\upsilon_t,\cdots\right),U_t^{\phi,w}\left(\cdots,\upsilon_t,\cdots\right)\right)$ is essentially the same as their utility function when determining a household's choices because the explanatory variables are the same at the household level. See footnote 2 for a related discussion.

[2] In the current paper, we specify that the utilities of the husband and wife, U_t^h and U_t^w, are weakly separable in the household utility function (1). This specification is useful for showing a link between the model and the collective household models, but is not our current study focus. Indeed, if we set the household utility function composed of only the choices of the husband and wife, i.e., $HU_t^{\phi}\left(z_t^h,l_t^h,t_{K,t}^h,z_t^w,l_t^w,t_{K,t}^w,\upsilon_t,q_t,t_{K,t}^{hw};K_t\right)$, the following analyses hold. This setting also permits the household utility to include altruistic utilities between the husband and wife. In other words, the following analyses can hold even if the weak separability regarding the utilities of the husband and wife are not considered.

[3] Some exact quotes are "an endogenously determined working hours and an exogenously given working hours makes income endogenous. Since most individuals cannot do this, we turn to the analysis in which income and working hours are fixed." (Jara-Díaz and Farah, 1987), "People cannot always change the amount of time they spend at work, perhaps because they are locked into a particular job with fixed hours" (Small and Verhoef, 2007), and "In theory, a worker's hourly wage is equal to his marginal value of time, but with an institutionally fixed working day, this concept can be no better than an approximation." (Blenky, 2011).

[4] Although location-specific variables (e.g., education opportunities) could reflect the household utility at a given residential location, the limitation of data used in our empirical analyses does not allow us to examine the effects of location-specific variables. Accordingly, we leave the unobserved characteristics to the error term.

[5] The first-order KKT conditions show that the binding/nonbinding condition depends on the total amount of time that the married couple spend with their children. A binding technological constraint describes the condition that the couple only spend the minimum required childcare time. The binding condition yields $\kappa_t^{\phi} > 0$ and therefore a positive *VOCTS* (κ_t^{ϕ}/λ) in *t*. This further implies that, when the minimum required childcare time is binding, the marginal monetary utility of individual (joint) childcare time is smaller than the individual (joint) VOTR (e.g., see Appendix Equations (A5) and (A6)). Furthermore, when this constraint is binding at equilibrium, the marginal monetary utility of individual (joint) childcare time can be negative, indicating that childcare time generates disutility for the household. In contrast, a nonbinding technological constraint shows that the parents are willing to spend more than the minimum required time on childcare, which yields $\kappa_t^{\phi} = 0$ and thus a zero *VOCTS* in *t*. This suggests that the household's marginal monetary utility of individual (joint) childcare time is equal to individual (joint) VOTR at equilibrium.

[6] Even if the working time is not included in the direct utility function, the value of time as a resource (*VOTR*) could still be different from the wage rate when the working time is fixed. This is because the *VOTR* is the ratio of the Lagrange multiplier of the time constraint to the Lagrange multiplier of the budget constraint (i.e., μ_t^m/λ, *m=h(husband), w(wife)*), namely the ratio of the shadow price of time to the shadow price of budget.

This shows that *VOTR* varies simultaneously with the budget and time availability, rather than simply being equal to a constant wage rate. For more on this point, please see Kono et al. (2018) and Jiang and Morikawa (2004). Blenky (2011) also points out "In theory, a worker's hourly wage is equal to his marginal value of time, but with an institutionally fixed working day, this concept can be no better than an approximation.

[7] Based on a monocentric urban model, the working paper by Kono and Lo (2023) indicates that *VOTR* could vary with commute distance within a homogeneous group, which is different from the conventional constancy assumption of *VOTR* in urban economics.

[8] Ministry of Finance, Japan: https://www.mof.go.jp/jgbs/reference/interest_rate/index.htm

[9] https://www.mhlw.go.jp/toukei/saikin/hw/jinkou/tokusyu/syussyo07/dl/gaikyou.pdf

[10] We assume that the study households optimize their choices given their prior knowledge of unequal childcare burden. This implies that our estimated time values are only applicable to married couples with children.

[11] The durability of housing is assumed to be 50 years.

[12] Flat 35 is a housing finance program that provides a long-term fixed mortgage rate to home buyers in Japan.

[13] https://www.mhlw.go.jp/toukei/saikin/hw/k-tyosa/k-tyosa19/dl/03.pdf

[14] The mean value of the data points is assigned to a cluster.

[15] Preschoolers could be more independent than infants and toddlers and they can help with some simple chores (U.S., CDC, 2021). Moreover, preschoolers are likely to have completed their toilet training and stay dry (Baird et al., 2019). In this context, preschoolers are assumed to demand less parental time than infants and toddlers.

[16] Using the built-in functions in MATLAB, we evaluate the optimal number of clusters based on the Davies-Bouldin index and the Silhouette method. The results suggest that the optimal number is five.

[17] When the first-stage estimation is based on an OLS regression, it is encouraged to report the F-statistics that test the null hypothesis that at least one of the estimated coefficients for the IVs is not zero (Mokhtarian and Cao 2008; Wooldridge 2012). We report the p-value of the likelihood ratio test instead, given that we have a Tobit model for the first-stage.

[18] We also perform the analyses that include neither ϕ nor the interaction terms. The estimations yield invalid, negative time value for the wives in *tc*, and the models do not fit the data well based on the adjusted R^2 and the p-value of F-statistics.

[19] The productivity of working from home is assumed to be the same as that of working at a workplace. In reality, the two can differ.

[20] https://www.mhlw.go.jp/content/000922964.pdf

[21] We assume that the service saves the parents 30 minutes per week. We set 1,000 yen/hour as the fee based on the service price in Chiyoda City, Tokyo (https://www.city.chiyoda.lg.jp/koho/kosodate/kosodate/ichijiteki/f-s-center.html).

[22] https://www.mhlw.go.jp/toukei/saikin/hw/k-tyosa/k-tyosa19/dl/02.pdf

TABLES

Table 1 List of variables for model formulation

Variables	Definitions
z_t^m	Household member *m*'s consumption of composite goods in period *t*, where $m \in \{h, w\}$
υ_t	Children's wellbeing in period *t*, defined as a function of the amount of money spent on a child in *t*, I_t , and the parents' individual and joint childcare time, $t_{K,t}^m$ and $t_{K,t}^{hw}$), where $m \in \{h, w\}$.
q_t	Housing size in period *t*
I_t	The amount of money spent on a child in period *t*
e^0	The minimum costs for raising a child
$\overline{e}$	Child benefit
y_t	Household nonlabor income in period *t*
w_t^m	Household member *m*'s wage rate in period *t*, where $m \in \{h, w\}$
$p_{q,t}$	Housing price per unit of floor area in period *t*
s_t	Household saving in period *t*
r_t	Interest rate in period *t,* where r_0 is zero in *t*=1
K_t	The number of children in period *t*
K_t^{young}	The number of young children aged 0-5 in period *t*
l_t^m	Household member *m*'s leisure time in period *t*, where $m \in \{h, w\}$
$t_{K,t}^m$	Household member *m*'s individual childcare time in period *t*, where $m \in \{h, w\}$
$t_{K,t}^{hw}$	The married couple's joint childcare time in period *t*
$\overline{T}_t^m$	Household member *m*'s total available time in period *t*, where $m \in \{h, w\}$
$T_{W,t}^m$	Household member *m*'s working hours in period *t*, where $m \in \{h, w\}$
$T_{C,t}^m$	Household member *m*'s commuting time in period *t*, where $m \in \{h, w\}$
$\overline{t}_{K,t}$	Minimum required childcare time in period *t*
τ	Time-discounted factor
λ^ϕ	Lagrange multiplier of budget constraint in period *t* for households in category ϕ
$\mu_t^{\phi,m}$	Lagrange multiplier of member *m*'s time constraint in period *t* for households in category ϕ, where $m \in \{h, w\}$ $\mu_t^{\phi,m}/\lambda^\phi$: the value of time as a resource (*VOTR*) for *m* in *t*
κ_t^ϕ	Lagrange multiplier of technological constraint in period *t* for households in category ϕ $\kappa_t^\phi/\lambda^\phi$: the value of childcare time saving (*VOCTS*) for household in *t*

Note: *h* and *w* indicate husband and wife, respectively.

Table 2 Summary statistics

	Full sample	High-income household (Default, ϕ=0)	Low-income household (ϕ=1)	Sig.
Sample size	249	92	157	
Household characteristics				
Housing expenditure (yen/month)	56,569	64,894	51,690	***
Nonlabor income (yen/year)	81,077	59,122	93,942	
Number of children	2.33	2.34	2.33	
Husband's characteristics				
Annual labor income (yen/year)	4,215,576	5,943,901	3,202,799	***
Hourly wage (yen/hour)	1,922	2,734	1,446	***
Period tb				
Employed (1, if yes, else 0)	0.98	0.98	0.99	
Daily working time (hours)	9.53	9.40	9.61	
One-way commute (minutes)	31.45	39.54	26.71	***
Period tc				
Employed (1, if yes, else 0)	0.99	1.00	0.99	
Daily working time (hours)	9.21	9.23	9.20	
One-way commute (minutes)	31.20	39.20	26.51	***
Wife's characteristics				
Annual labor income (yen/year)	384,153	265,679	453,577	**
Hourly wage (yen/hour)	411	334	456	
Period tb				
Employed (1, if yes, else 0)	0.19	0.10	0.24	***
Daily working time (hours): All/employed	0.97/5.14	0.30/3.05	1.36/5.63	***/**
One-way commute (minutes): All/employed	1.53/8.10	0.42/4.31	2.18/9.00	***/**
Period tc				
Employed (1, if yes, else 0)	0.40	0.28	0.47	***
Daily working time (hours): All/employed	2.02/5.03	1.17/4.14	2.52/5.34	***/*
One-way commute (minutes): All/employed	3.58/8.92	2.58/9.11	4.17/8.85	**/

Notes: 1. The present value of monetary variables in *tb*=1 is calculated based on r =2%, using the average values of the 20-year and 30-year Japanese national bonds from 1992 to 2022 from the Ministry of Finance, Japan.
2. Husband's annual salary ≤ the median household income in Japan, ϕ=1; 0, otherwise.
3. Significance of a two-sample t-test: *p < 0.1, **p < 0.05, ***p < 0.01.

Table 3 The 5th percentile of daily childcare time (hours) by cluster

Cluster j	Centroid: Number of infants and toddlers	Centroid: Number of preschoolers	Cluster size	Size of the households with observed childcare time	$t_{K,t}^{j,5th}$ (hours)	Sig.
Period tb						
1	2.02	0.21	239	89	3.04	
2	1.00	0.00	977	196	2.59	
3	0.25	2.02	193	165	2.50	***
4	0.00	1.00	209	121	2.50	
5	1.00	1.00	722	505	3.00	
Period tc						
1	0.00	1.00	1044	763	2.00	
2	1.03	0.00	278	208	2.45	
3	0.15	2.00	60	46	3.03	***
4	1.03	1.00	180	156	3.00	
5	0.00	0.00	46	0	0.00	

Notes: Significance of a Kruskal-Wallis nonparametric test: *p < 0.1, **p < 0.05, ***p < 0.01

Table 4 Average daily childcare time (hours) and the households with a binding constraint

	Full sample	High-income households (ϕ=0)	Low-income households (ϕ=1)
Sample size	249	92	157
Period tb			
Husband	1.17	1.07	1.23
Wife: All/employed	9.85/7.29	11.18/10.68	9.07/6.48
Difference (All). sig.	8.68***	10.11***	7.83***
Number of households with a binding constraint	2	0	2
Minimum childcare time (hours/day)	1.29	-	1.29
Period tc			
Year difference between the first and the youngest children (n_{tc})	4.05	4.00	4.08
Husband	0.89	0.80	0.94
Wife: All/employed	8.47/6.05	9.33/6.45	7.97/5.91
Difference (All). sig.	7.59***	8.53***	7.03***
Number of households with a binding constraint	4	1	3
Minimum childcare time (hours/day)	1.44	1.00	1.59

Notes: 1. Husband's annual salary ≤ the median household income in Japan, ϕ=1; 0, otherwise.
2. Significance of a paired t-test: *p < 0.1, **p < 0.05, ***p < 0.01

Table 5 Two-stage analysis considering ϕ only

	With the technology constraints		Without the technology constraints	
	OLS	IV	OLS	IV
	Coef. sig. (Bootstrap SE)	Coef. sig. (Bootstrap SE)	Coef. sig. (Bootstrap SE)	Coef. sig. (Bootstrap SE)
Intercept	**3.04E+08*** (3.73E+07)**	**3.01E+08*** (3.88E+07)**	**3.03E+08*** (3.68E+07)**	**3.01E+08*** (3.83E+07)**
Household characteristics				
Low-income: ϕ=1, if yes, else 0	**-1.81E+08*** (1.59E+07)**	**-1.84E+08*** (1.66E+07)**	**-1.80E+08*** (1.59E+07)**	**-1.83E+08*** (1.66E+07)**
Number of children	-3.89E+06 (1.06E+07)	-4.59E+06 (1.07E+07)	-4.21E+06 (1.05E+07)	-4.92E+06 (1.06E+07)
Period tb				
Husband's total commute and working time	1227 (2.58E+03)	1728 (2.69E+03)	1290 (2.57E+03)	1788 (2.69E+03)
Wife's total commute and working time	**4459** (2.06E+03)**	**4418** (2.08E+03)**	**4619** (1.87E+03)**	**4548** (1.88E+03)**
Minimum required childcare time	7481 (4.91E+04)	6309 (4.79E+04)		
Period tc				
Husband's total commute and working time	**1112*** (4.33E+02)**	**1140*** (4.61E+02)**	**1117*** (4.31E+02)**	**1149*** (4.58E+02)**
Wife's total commute and working time	381 (2.84E+02)	398 (2.94E+02)	399 (2.82E+02)	415 (2.92E+02)
Minimum required childcare time	**29680 (9.74E+03)**	**28300 9.39E+03**		
Sample size	249	249	249	249
Adjusted R^2	0.3971	0.3957	0.4004	0.3992
P-value of F-test	<2.2E-16	<2.2E-16	<2.2E-16	<2.2E-16
P-value of Breusch-Pegan test	0.4225	0.4358	0.2433	0.2555

Notes: 1. Husband's annual salary ≤ the median household income in Japan, ϕ=1, else 0.
2. The significance level of the t-statistics: *p < 0.1, **p < 0.05, ***p < 0.01.
3. We obtain the bootstrap standard errors (SEs) and the bootstrap bias-corrected and accelerated confidence intervals (BCa CIs, Appendix Table C3) with 1000 replicates. Bold text indicates significance at 90% BCa CI.

Table 6 Two-stage analysis considering the interaction terms with ϕ

	With the technology constraints		Without the technology constraints	
	OLS	IV	OLS	IV
	Coef. sig. (Bootstrap SE)	Coef. sig. (Bootstrap SE)	Coef. sig. (Bootstrap SE)	Coef. sig. (Bootstrap SE)
Intercept	**2.96E+08***** **(7.69E+07)**	**2.80E+08***** **(9.48E+07)**	**2.96E+08***** **(7.70E+07)**	**2.80E+08***** **(9.49E+07)**
Household characteristics				
Low-income: ϕ=1, if yes, else 0	**-1.72E+08**** **(8.52E+07)**	-1.50E+08* (1.02E+08)	**-1.74E+08**** **(8.49E+07)**	-1.53E+08 (1.01E+08)
Number of children	-1.92E+07 (2.13E+07)	-2.05E+07 (2.06E+07)	-1.94E+07 (2.12E+07)	-2.07E+07 (2.05E+07)
Number of children∗ϕ	2.57E+07 (2.50E+07)	2.61E+07 (2.44E+07)	2.58E+07 (2.46E+07)	2.62E+07 (2.41E+07)
Period tb				
Husband's total commute and working time	1174 (5.95E+03)	2692 (6.49E+03)	1206 (5.92E+03)	2713 (6.47E+03)
Husband's total commute and working time∗ϕ	-58 (6.27E+03)	-1587 (6.81E+03)	9 (6.25E+03)	-1500 (6.80E+03)
Wife's total commute and working time	10320 (1.04E+04)	10080 (1.23E+04)	10270 (1.03E+04)	10040 (1.22E+04)
Wife's total commute and working time∗ϕ	-6756 (1.06E+04)	-6599 (1.24E+04)	-6448 (1.05E+04)	-6301 (1.23E+04)
Minimum required childcare time	10,900 (4.90E+04)	10860 (4.78E+04)		
Period tc				
Husband's total commute and working time	**1635**** **(1.03E+03)**	**1720***** **(1.13E+03)**	**1634***** **(1.03E+03)**	**1720** **(1.13E+03)**
Husband's total commute and working time∗ϕ	-807 (1.10E+03)	-903 (1.19E+03)	-790 (1.10E+03)	-878 (1.19E+03)
Wife's total commute and working time	388 (7.99E+02)	378 (8.73E+02)	397 (7.99E+02)	385 (8.72E+02)
Wife's total commute and working time∗ϕ	-6 (8.48E+02)	17 (9.23E+02)	10 (8.48E+02)	34 (9.22E+02)
Minimum required childcare time	35310 (3.15E+04)	29090 (3.02E+04)		
Minimum required childcare time∗ϕ	-3563 (4.02E+04)	2175 (3.89E+04)		
Sample size	249	249	249	249
Adjusted R^2	0.3916	0.3923	0.3971	0.3979
P-value of F-test	<2.2E-16	<2.2E-16	<2.2E-16	<2.2E-16
P-value of Breusch-Pegan test	0.1460	0.0939	0.0568	0.0332

Notes: 1. Husband's annual salary ≤ the median household income in Japan, ϕ=1, else 0.
2. The significance level of the t-statistics: *p < 0.1, **p < 0.05, ***p < 0.01.
3. We obtain the bootstrap standard errors (SEs) and the bootstrap bias-corrected and accelerated confidence intervals (BCa CIs, Appendix Table C4) with 1000 replicates. Bold text indicates significance at 90% BCa CI.
4. Since the null hypothesis of homoskedasticity is rejected at 5%, we use the robust t- and F-statistics: *p < 0.1, **p < 0.05, ***p < 0.01.

Table 7 Effects of transportation and childcare services on the average household's welfare

	Average household welfare gain (yen/year)
Scenario 1: When the upgraded transportation system reduces wife's travel time by one minute	19,145
Scenario 2: When a husband works from home once per week	61,652
Scenario 3: When a married couple utilizes the chauffeuring service supported by the local government once per week	11,402

Appendix A. The First-Order Conditions

The first-order Karush-Kuhn-Tucker conditions of Equation (4) (i.e., $\partial\mathcal{L}^{\phi}/\partial z_t^m = 0$, $\partial\mathcal{L}^{\phi}/\partial q_t = 0$, $\partial\mathcal{L}^{\phi}/\partial l_t^m = 0$, $\partial\mathcal{L}^{\phi}/\partial I_t = 0$, $\partial\mathcal{L}^{\phi}/\partial t_{K,t}^m = 0$, and $\partial\mathcal{L}^{\phi}/\partial t_{K,t}^{hw} = 0$) are described as following equations.

$$\frac{1}{\lambda^{\phi *}}\frac{\partial HU_t^{\phi}}{\partial U_t^{\phi,m}}\frac{\partial U_t^{\phi,m}}{\partial z_t^m} = \frac{\tau^{t-1}}{\prod_{t=1}^{t}\left(1+r_{t-1}\right)} \tag{A1}$$

$$\frac{1}{\lambda^{\phi *}}\left(\frac{\partial HU_t^{\phi}}{\partial U_t^{\phi,h}}\frac{\partial U_t^{\phi,h}}{\partial q_t} + \frac{\partial HU_t^{\phi}}{\partial U_t^{\phi,w}}\frac{\partial U_t^{\phi,w}}{\partial q_t}\right) = p_{q,t}\frac{\tau^{t-1}}{\prod_{t=1}^{t}\left(1+r_{t-1}\right)} \tag{A2}$$

$$\frac{1}{\lambda^{\phi *}}\left(\frac{\partial HU_t^{\phi}}{\partial U_t^{\phi,m}}\right)\left(\frac{\partial U_t^{\phi,m}}{\partial l_t^m}\right) = \tau^{t-1}\frac{\mu_t^{\phi,m*}}{\lambda^{\phi *}} \tag{A3}$$

$$\frac{1}{\lambda^{\phi *}}\left(\frac{\partial HU_t^{\phi}}{\partial U_t^{\phi,h}}\frac{\partial U_t^{\phi,h}}{\partial \upsilon_t}\frac{\partial \upsilon_t}{\partial I_t} + \frac{\partial HU_t^{\phi}}{\partial U_t^{\phi,w}}\frac{\partial U_t^{\phi,w}}{\partial \upsilon_t}\frac{\partial \upsilon_t}{\partial I_t}\right) = \frac{\tau^{t-1}}{\prod_{t=1}^{t}\left(1+r_{t-1}\right)}K_t \tag{A4}$$

$$\frac{1}{\lambda^{\phi *}}\left(\frac{\partial HU_t^{\phi}}{\partial U_t^{\phi,m}}\frac{\partial U_t^{\phi,m}}{\partial t_K^m} + \frac{\partial HU_t^{\phi}}{\partial U_t^{\phi,m}}\frac{\partial U_t^{\phi,m}}{\partial \upsilon_t}\frac{\partial \upsilon_t}{\partial t_K^m}\right) = \tau^{t-1}\frac{\left(\mu_t^{\phi,m*} - \kappa_t^{\phi *}\right)}{\lambda^{\phi *}} \tag{A5}$$

$$\frac{1}{\lambda^{\phi *}}\left(\sum_{m=h,w}\frac{\partial HU_t^{\phi}}{\partial U_t^{\phi,m}}\left(\frac{\partial U_t^{\phi,m}}{\partial t_K^{hw}} + \frac{\partial U_t^{\phi,m}}{\partial \upsilon_t}\frac{\partial \upsilon_t}{\partial t_K^{hw}}\right)\right) = \tau^{t-1}\frac{\left(\mu_t^{\phi,h*} + \mu_t^{\phi,w*} - \kappa_t^{\phi *}\right)}{\lambda^{\phi *}} \tag{A6}$$

$$\frac{\kappa_t^{\phi *}}{\lambda^{\phi *}}\left(t_{K,t}^h + t_{K,t}^w + t_{K,t}^{hw} - \overline{t}_{K,t}\right) \geq 0 \tag{A7}$$

For Equation (A7), either $\kappa_t^{\phi} > 0$ and $t_{K,t}^h + t_{K,t}^w + t_{K,t}^{hw} - \overline{t}_{K,t} = 0$ (a binding constraint), or $\kappa_t^{\phi} = 0$ and $t_{K,t}^h + t_{K,t}^w + t_{K,t}^{hw} - \overline{t}_{K,t} > 0$ (a non-binding constraint).

Appendix B. The Marginal Monetary Utility of the Exogenous Variables

$$\frac{1}{\lambda^{\phi*}}\frac{\partial V^{\phi}}{\partial w_t^m}=\frac{T_{W,t}^m}{\prod_{t=1}^{t}\left(1+r_{t-1}\right)} \tag{B1}$$

$$\frac{1}{\lambda^{\phi*}}\frac{\partial V^{\phi}}{\partial T_{W,t}^m}=\frac{w_t^m}{\prod_{t=1}^{t}\left(1+r_{t-1}\right)}-\frac{\mu_t^{\phi,m*}}{\lambda^{\phi*}} \tag{B2}$$

$$\frac{1}{\lambda^{\phi*}}\frac{\partial V^{\phi}}{\partial T_{C,t}^m}=-\frac{\mu_t^{\phi,m*}}{\lambda^{\phi*}} \tag{B3}$$

$$\frac{1}{\lambda^{\phi*}}\frac{\partial V^{\phi}}{\partial p_{q,t}}=-\frac{q_t^{\phi*}}{\prod_{t=1}^{t}\left(1+r_{t-1}\right)} \tag{B4}$$

$$\frac{1}{\lambda^{\phi*}}\frac{\partial V^{\phi}}{\partial y_t}=\prod_{t=1}^{t}\left(1+r_{t-1}\right) \tag{B5}$$

$$\frac{1}{\lambda^{\phi*}}\frac{\partial V^{\phi}}{\partial K_t^{young}}=-\frac{\kappa_t^{\phi*}}{\lambda^{\phi*}}\frac{d\overline{t}_{K,t}}{dK_t^{young}} \tag{B6}$$

$$\frac{1}{\lambda^{\phi*}}\frac{\partial V^{\phi}}{\partial K_t}=\frac{1}{\lambda^{\phi*}\tau^{t-1}}\left(\frac{\partial HU_t^{\phi}}{\partial U_t^{\phi,h}}\frac{\partial U_t^{\phi,h}}{\partial K_t}+\frac{\partial HU_t^{\phi}}{\partial U_t^{\phi,w}}\frac{\partial U_t^{\phi,w}}{\partial K_t}\right)-\frac{I_t^{\phi}}{\prod_{t=1}^{t}\left(1+r_{t-1}\right)} \tag{B7}$$

$$\frac{1}{\lambda^{\phi*}}\frac{\partial V^{\phi}}{\partial r_{t-1}}=-\sum\frac{\left(w_t^hT_{W,t}^h+w_t^wT_{W,t}^w+y_t\right)-\left(z_t^h+z_t^w+p_{q,t}q_t+I_tK_t\right)}{\left(1+r_{t-1}\right)\prod_{t=1}^{t}\left(1+r_{t-1}\right)} \tag{B8}$$

Appendix C. Supplementary Tables

Table C1 The first-stage instrumental variable (IV) estimations

Dependent variable: One-way commute time	Husband in *tb*	Wife in *tb*	Husband in *tc*	Wife in *tc*
	Coef. sig.	Coef. sig.	Coef. sig.	Coef. sig.
Intercept	1.13***	-0.78***	1.10***	-0.35***
Regional ratio of waitlisted children (RWC)	7.56**	4.83*		
Regional road density (RRD)			-0.01**	2.86.E-03
Prefectural car density (PCD)	-1.14E-03***	7.62E-04***	-7.75E-04***	4.42E-04***
Sample size	249	249	249	249
Log likelihood	-141.71	-68.25	-145.25	-64.75
P-value of likelihood ratio test	1.33E-09	0.0261	9.80E-06	4.01E-04

Notes: Significance: *p<0.1, **p<0.05, ***p<0.01

Table C2 Average working time and employment rate for the households with a binding constraint and the households with a nonbinding constraint

	Full sample		High-income households (ϕ=0)		Low-income households (ϕ=1)	
Sample size	249		92		157	
	Binding	Nonbinding	Binding	Nonbinding	Binding	Nonbinding
Period tb						
Number of households	2	247	0	92	2	155
Husband						
Employment rate	100%	98.4%	-	97.8%	100%	98.7%
Daily working time (hours)	11.6	9.5	-	9.4	11.6	9.6
Wife						
Employment rate	100%	18.2%	-	9.8%	100%	23.2%
Daily working hours	10.3	0.9	-	0.3	10.3	1.2
Period tc						
Number of households	4	245	1	91	3	154
Husband						
Employment rate	100%	99.2%	100%	100%	1	98.7%
Daily working hours	9.5	9.2	10	9.2	9.3	9.2
Wife						
Employment rate	100%	39.2%	100%	27.5%	1	46.1%
Daily working hours	3.6	2.0	2.1	1.2	4.1	2.5

Table C3 The 90% bootstrap bias-corrected and accelerated confidence intervals (BCa CIs) for the two-stage analysis considering ϕ only

	[90% Bootstrap BCa CIs]			
	With the technology constraints		Without the technology constraints	
	OLS	IV-OLS	OLS	IV-OLS
Intercept	**[2.44E+08, 3.64E+08]**	**[2.41E+08, 3.67E+08]**	**[2.44E+08, 3.60E+08]**	**[2.39E+08, 3.63E+08]**
Household's characteristics				
Low-income: ϕ=1, if yes, else 0	**[-2.13E+08, -1.58E+08]**	**[-2.19E+08, -1.61E+08]**	**[-2.14E+08, -1.58E+08]**	**[-2.18E+08, -1.61E+08]**
Number of children	[-2.16E+07,1.42E+07	[-2.19E+07, 1.31E+07]	[-2.14E+07, 1.40E+07]	[-2.20E+07, 1.26E+07]
Period tb				
Husband's total commute and working time	[-2705, 5732]	[-2314, 6408]	[-2604, 5873]	[-2216, 6516]
Wife's total commute and working time	**[1550, 8482]**	**[1457, 8465]**	**[2215, 8580]**	**[2155, 8481]**
Minimum required childcare time	[-8.67E+04, 2.54E+04]	[-8.45E+04, 2.50E+04]		
Period tc				
Husband's total commute and working time	**[449, 1826]**	**[428, 1945]**	**[452, 1819]**	**[417, 1917]**
Wife's total commute and working time	[-105, 824]	[-110, 866]	[-97.4, 842]	[-89, 883]
Minimum required childcare time	**[1.52E+04, 4.36E+04]**	**[1.36E+04, 4.22E+04]**		
Sample size	249	249	249	249

Notes: 1. Efron and Tibshirani (1993) suggest using BCa CIs in order to closely match the exact CIs. We obtain the bootstrap results with 1000 replicates. Bold text indicates that the estimated coefficient is significant at 90% BCa CI.

2. Husband's annual salary ≤ the median household income in Japan, ϕ=1, else 0.

Table C4 The 90% bootstrap bias-corrected and accelerated confidence intervals (BCa CIs) for the two-stage analysis considering the interaction terms with ϕ

	[90% Bootstrap BCa CIs]			
	With the technology constraints		Without the technology constraints	
	OLS	IV-OLS	OLS	IV-OLS
Intercept	**[1.48E+08, 4.03e+08]**	**[9.18E+07, 3.99E+08]**	**[1.49E+08, 4.04E+08]**	**[9.20E+07, 4.00E+08]**
Household characteristics				
Low-income: ϕ=1, if yes, else 0	**[-2.96E+08, -1.28E+07]**	[-2.88E+08, 4.60E+07]	**[-2.98E+08, -1.59E+07]**	[-2.93E+08, 3.78E+07]
Number of children	[-5.76E+07, 9.73e+06]	[-5.78E+07, 7.22E+06]	[-5.74E+07, 9.97E+06]	[-5.77E+07, 6.86E+06]
Number of children∗ϕ	[-9.84 E+06, 7.06 E+07]	[-8.74E+06, 7.26E+07]	[-7.75E+06, 7.06E+07]	[-7.38E+06, 7.33E+07]
Period tb				
Husband's total commute and working time	[-7508, 11584]	[-6181, 14291]	[-7388, 11530]	[-6182, 14254]
Husband's total commute and working time∗ϕ	[-12663, 8306]	[-14489, 7672]	[-11643, 8597]	[-14206, 7773]
Wife's total commute and working time	[-4581, 25666]	[-6869, 24285]	[-4610, 25545]	[-6795, 24374]
Wife's total commute and working time∗ϕ	[-22321, 8506]	[-20575, 10364]	[-21410, 8962]	[-20038, 10730]
Minimum required childcare time	[-94653, 30374]	[-89178, 31657]		
Period tc				
Husband's total commute and working time	**[268, 3786]**	**[202, 4094]**	**[259, 3785]**	**[198, 4076]**
Husband's total commute and working time∗ϕ	[-3120, 682]	[-3300, 716]	[-3099, 706]	[-3308, 748]
Wife's total commute and working time	[-812, 1728]	[-953, 1848]	[-853, 1724]	[-933, 1857]
Wife's total commute and working time∗ϕ	[-1520, 1250]	[-1581, 1362]	[-1535, 1259]	[-1633, 1340]
Minimum required childcare time	[-18377, 86321]	[-56070, 63660]		
Minimum required childcare time∗ϕ	[-51051, 1.02 E+05]	[-44480, 98430]		
Sample size	249	249	249	249

Notes: 1. Efron and Tibshirani (1993) suggest using BCa CIs in order to closely match the exact CIs. We obtain the bootstrap results with 1000 replicates. Bold text indicates that the estimated coefficient is significant at 90% BCa CI.

2. Husband's annual salary ≤ the median household income in Japan, ϕ=1, else 0.