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Measuring the Gender Differences in Value of Time by Household Life Stage: An Intertemporal Analysis based on Japan Household Panel Survey

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We investigate the time values for married couples by life stage based on an intertemporal model that represents within-individual and within-couple trade-offs between different activities. Using Japan Household Panel Survey, we find that wives value their time greater than 4,400 yen/hour when their first child is of pre-school age; the value, however, decreases after their first child reaches school age. These changes reflect their time on work and commute. Conversely, the husbands' time values are not very different in magnitude. We find that some dual-income households have time burden as they highly value their time saving on childcare. (*JEL* D15, J13, J16, J22, R41)

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More and more societies nowadays call for 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. This is also targeted by the sustainable development goals (SDGs) of the United Nations. In developed countries, available evidence suggests that 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, however, we know little about the extent to which these policies can help alleviate people's time burden from the perspectives of welfare and gender equality.

To the best of our knowledge, this is the first study that directly investigates the within-household dynamics in time values for wives and husbands. We develop an intertemporal household model that can represent trade-offs within an individual as well as within a couple between activities in life stages based on a lifetime equilibrium for a married couple with children, and derive their time values in the presence of pre-school-aged and school-aged 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 uses and values with each other. Our main focuses are the gender differences in values of time as a resource (*VOTRs*) and a household's values of childcare time saving (*VOCTSs*) by life stage. Applying the model to the 2004-2018 Japan Household Panel Survey, 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.

The remainder of the paper consists of six sections. Section I provides the study background. Section II constructs an intertemporal household model. Section III describes the data and empirical approach. Section IV reports the results. Section V discusses the results and interpretations. Section VI concludes the paper.

I. Study Background

A. 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; Kleven, Landais, and Søgaard 2019; Miyajima and Yamaguchi 2017). This could lead to the gender differences in household obligations as well as in career choice.

Kleven, Landais, and Søgaard (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 path, 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 out-of-home activities and career choice based on the need for a short commute time, 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; ILO 2016; Hochschild and Machung 2012). To better accommodate childcare tasks, women compromise by accepting the second-best jobs instead of their ideal occupations (Borghorst, Mulalic, and Van Ommeren 2021; ILO 2016; Kawabata 2014; Kawabata and Abe 2018; Kleven, Landais, and Søgaard 2019; Rouwendal 1999).

Rouwendal and Rietveld (1994) concluded that female employees without children had the same commute length as males, using the 1985-1988 Dutch

Housing Demand Survey. 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 same data. Similar trends are observed in Japan and Denmark. Recent studies by Kawabata and Abe (2018) and Borghorst, Mulalic, and Van Ommeren (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 the employed mothers experience insufficient time due to childcare (Borghorst, Mulalic, and Van Ommeren 2021; Jacob et al. 2019; Kwan 1999; McGuckin and Murakami 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; ILO 2016). Economic studies provide more insights into the time use trade-off between a married couple. 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.

Although previous studies indicate that childcare is the primary factor associated with gendered activity patterns and time uses, none of these methods examine how the presence of children account 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.

B. 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; Oort 1969). While the gender pay gap substantially persists, particularly because of the gender division in childcare responsibilities (Kleven, Landais, and Søgaard 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. (2018) find that the presence of young children is associated with high time values and opportunity costs of commute for mothers, whereas the effect diminishes as the children grow older. This is because young children demand more of mothers' 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*), value of time as a resource (*VOTR*), and value of time saving (*VOTS*). Although this framework has been widely applied in transportation economics (Kato 2013; Small and Verhoef 2007), to the best of our knowledge, it has not been used to analyze gender disparities in time use.

Understanding the gender 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; Kwan 1999; Miyajima and Yamaguchi 2017; Rehel 2014; Kleven, Landais, and Søgaard 2019).

II. 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 I 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 consider 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. 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 ($t = \overline{t}$).

The household's utility in period t consists of the composite goods (z_t), children's wellbeing (υ_t), housing size (q_t), husband's and wife's leisure time (l_t^h, l_t^w), and their childcare time ($t_{K,t}^h$, $t_{K,t}^w$). 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' childcare time. This is defined as $\upsilon_t = \upsilon_t\left(I_t, t_{K,t}^h, t_{K,t}^w\right)$. 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 the household behavior in t. Households in different categories (e.g., income level) could have different indifference curves. The household utility category ϕ in t is

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

The household has three constraints. First, it faces a budget constraint from marriage period $t = 1$ to the end period of life $\overline{t}$. The income revenue in t is the sum of the household's labor and 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 $m \in \{h \text{ (husband)}, w \text{ (wife)}\}$. The household allocates its expenditure in t to the composite good (z_t), housing expenses ($p_{q,t}q_t$), the investment in children ($I_t K_t$), 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 with interest rate r. Eliminating s_t, we obtain the following intertemporal budget constraint:

$$\text{(2a)}\quad \sum_{t=1}^{\bar{t}}\left(z_t + p_{q,t}q_t + \left(I_t + e^0 - \bar{e}\right)K_t\right)\Big/\left(1+r\right)^{t-1} = \sum_{t=1}^{\bar{t}}\left(w_t^h T_{W,t}^h + w_t^h T_{W,t}^w + y_t\right)\Big/\left(1+r\right)^{t-1}.$$

In Equation (2a), the price of z_t is normalized to one. 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 $\bar{e}$ 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*, $\bar{T}_t^m$, to work ($T_{W,t}^m$), commute ($T_{C,t}^m$), leisure (l_t^m), and childcare ($t_{K,t}^m$). Mathematically, *m*'s time constraint in *t* is

$$\text{(2b)}\qquad l_t^m + t_{K,t}^m = \bar{T}_t^m - T_{W,t}^m - T_{C,t}^m,$$

where $\bar{T}_t^m$ 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 in Japan.

The third constraint is a technological constraint that describes the minimum required time for the married couple to spend on childcare in *t*. 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 addressing the basic needs of their children (e.g., bathing and feeding) or they enjoy the time with their children. This is conceptually built on DeSerpa (1971) that first introduced time allocation to good consumption. Mathematically, the constraint is

$$\text{(2c)}\qquad \bar{t}_{K,t} \le t_{K,t}^h + t_{K,t}^w,$$

where $\bar{t}_{K,t}$ is the minimum required childcare time.

From Equations (1) to (2c), the household's life-span utility maximization is

$$\text{(3)}\qquad V^{\phi} = \max_{z_t,\upsilon_t,q_t,l_t^h,l_t^w,t_{K,t}^h,t_{K,t}^w} \sum_{t=1}^{\bar{t}} U_t^{\phi}\left(z_t,\upsilon_t,q_t,l_t^h,l_t^w,t_{K,t}^h,t_{K,t}^w;K_t\right)\Big/\tau^{t-1},$$

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

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

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. 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.

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, $\bar{t}_{K,t}$, and K_t (see Appendix B for more details). For the empirical analyses, we make two assumptions for the model.

Assumption 1. Linearity. — A household's life-span utility is linear.
This utility is approximated by the first-order Taylor expansion without imposing any restrictions on the shape of the utility function (Viscusi and Evans, 1990).

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 will achieve the same level of the life-time monetary utility toward the end of their lives, $\bar{V}^{\phi}/\lambda^{\phi}$, at equilibrium.

As we have reviewed in Section I, existing studies (e.g., Apps and Rees, 2005) 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. More specifically, we set the total length of periods *tb* and *tc* as 35 years in order to capture the average number of working years after a couple have their first child but before they reach the retirement age of 65[1].

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 as a cutoff to differentiate tb and tc for two reasons. First,

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

children under age 6 demand more attention from their parents compared to those who are six and over because older children show more independence from their parents as they reach school age[2]. Second, parents could accumulate childcare experiences as they bring up their first child so they become experienced when nursing their younger children. Lastly, *td* defines 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; McGuckin and Murakami 1999; Rouwendal and Rietveld 1994; Kleven, Landais, and Søgaard 2019), 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

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

[2] The U.S. Centers for Disease Control and Prevention (CDC) Positive Parenting Tips: https://www.cdc.gov/ncbddd/childdevelopment/index.html.

In Equation (5), *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.

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 ($T^m_{W,t}$ and $T^m_{C,t}$, where *m*=*h*, *w* and *t*=*tb*, *tc*), the minimum required childcare time ($\overline{t}_{K,t}$), 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 in t. — For a household in category ϕ, member m's values of time as a resource in tb ($VOTR^{\phi,m}_{tb}$) and tc ($VOTR^{\phi,m}_{tc}$) are constant and defined by $\overline{\mu}^{\phi,m}_b / \lambda^\phi$ and $\overline{\mu}^{\phi,m}_c / \lambda^\phi$, respectively, where $\mu^{\phi,m}_{tb} = \overline{\mu}^{\phi,m}_b \; \forall$ tb=1-6 and $\mu^{\phi,m}_{tc} = \overline{\mu}^{\phi,m}_c \; \forall$ tc=7-35.

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[3]. 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 $\mu_{tc}^{\phi,m} = \overline{\mu}_{c}^{\phi,m}$ $\forall$ *tc*=7-35 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, $\mu_{tc}^{\phi,m}$ $\forall$ *tc*=7-35 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.

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 ($VOTR_{tb}^{\phi,m}$) are constant and are measured by $\overline{\kappa}_{b}^{\phi}/\lambda^{\phi}$ and $\overline{\kappa}_{c}^{\phi}/\lambda^{\phi}$, respectively, where $\kappa_{tb}^{\phi} = \overline{\kappa}_{b}^{\phi}$ $\forall$ tb=1-6 and $\kappa_{tc}^{\phi} = \overline{\kappa}_{c}^{\phi}$, $\forall$ tc=7-35 respectively.

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

$$
\begin{aligned}
Y^{\phi} = {} & \beta_0^{\phi} + \sum_{t=tb,tc} \beta_t^{\phi} K_t + \\
& VOTR_{tb}^{\phi,h} \sum_{tb} \left(T_{W,tb}^{h} + T_{C,tb}^{h} \right) + VOTR_{tb}^{\phi,w} \sum_{tb} \left(T_{W,tb}^{w} + T_{C,tb}^{w} \right) + VOCTS_{tb}^{\phi} \sum_{tb} \overline{t}_{K,tb} \\
& VOTR_{tc}^{\phi,h} \sum_{tc} \left(T_{W,tc}^{h} + T_{C,tc}^{h} \right) + VOTR_{tc}^{\phi,w} \sum_{tc} \left(T_{W,tc}^{w} + T_{C,tc}^{w} \right) + VOCTS_{tc}^{\phi} \sum_{tc} \overline{t}_{K,tc} + \varepsilon
\end{aligned} \tag{6}
$$

where $Y^{\phi} = \sum_{t=tb,tc} \left(2 \times \left(w_t^h T_{W,t}^h + w_t^w T_{W,t}^w \right) + y_t - p_{q,t} q_t^{\phi *} \right) \Big/ \left(1+r \right)^{t-1}$,
$\beta_0^{\phi} = \left(\overline{V}^{\phi} - \overline{v}^{\phi} \right) \Big/ \lambda^{\phi}$, $\beta_t^{\phi} = \left(\partial U_t^{\phi} / \partial K_t \right) \Big/ \lambda^{\phi *} \tau^{t-1} - I_t^{\phi} \Big/ \left(1+r \right)^{t-1}$, and ε is the error term.

[3] Based on a monocentric urban model, the working paper by Kono and Lo (2022) 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.

For households in category ϕ, Y^{ϕ} characterizes the household's remaining budget by subtracting housing expenditure from labor and nonlabor incomes. A household's total labor income is multiplied by two because of the marginal monetary utility of working hours and wage rates. 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, 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; NHK 2011), we make Hypotheses 1 and 2 regarding the married couple's time uses 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.

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 as they become experienced in *tc*. 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 (A6) 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* $VOCTS_{tb}^{\phi} < VOCTS_{tc}^{\phi}$.

III. Data and Methods

A. 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. 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 $T^{m}_{W,t}$ and $T^{m}_{C,t}$ 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 $\overline{T}^{m}_{W,t}$ and $\overline{T}^{m}_{C,t}$ 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[4] ($= P\left(1+avgmr\right)^{\Delta t} \Big/ 50$) using the purchased price of their home (P) and the average mortgage rate ($avgmr$) based on Flat 35 (www.sumai-

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

info.com)[5] , and the difference in the years observed and purchased (Δt). The present value of housing expenditure is computed using the household's average rent and 2% as the interest rate r. We set the 2% interest rate using the average values of the 20-year and 30-year Japanese national bonds from 1992 to 2022 from the Ministry of Finance, Japan.

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 households with a husband's annual salary lower than the median household income (JPY 4,370,000) in Japan[6], we define ϕ=1; 0, otherwise.

Table 1 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

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

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

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 1 Here]

B. Measuring the Household's Minimum Childcare Time Required, $\overline{t}_{K,t}$

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[7] of each cluster to which the data points belong (Gan, Ma, and Wu 2007).

Given that younger children demand more attention from their parents compared to those aged 6 and over[2], we assume that the married couples need to dedicate at least some parental time to children younger than age 6. As the dependency of

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

infants, toddlers, and preschoolers could also be different[8], 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 (age 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 *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[9] 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:

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

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 $\overline{t}^{m}_{K,\tilde{t}}$ is m's average childcare time over $\tilde{t}$, the years observed by the survey data in *t* (=*tb*, *tc*).

[8] Preschoolers could be more independent than infants and toddlers and they can help with some simple chores according to CDC (see Footnote 2). Moreover, preschoolers are likely to have completed their toilet training and stay dry (Baird, Bybel, and Kowalski 2019). In this context, preschoolers are assumed to demand less parental time than infants and toddlers.

[9] 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.

C. 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, Mokhtarian, and Handy 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 (StGeorge and Fletcher 2012; Wachs et al. 1993; Niebuhr et al. 2012). 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[10], the results suggest that the models produce a good fitness with the IVs (see Appendix Table C1 for more details).

IV. Empirical Results

A. Results of Clustering Analysis

Table 2 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

[10] 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.

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 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+. 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 2 and Equation (7), we obtain $\sum_t \overline{t}_{K,t}$ for our sample households.

[Insert Table 2 Here]

Table 3 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 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 3 Here]

B. 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[11]. 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 calculate the bootstrap standard errors and the associated 90% confidence intervals with 1,000 replicates[12] (Efron and Tibshirani 1993). 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; Freedman and Peters 1984; Fox and Weisberg 2018).

Table 4 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

[11] 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.

[12] We use the boot package in R (Canty 2002; James et al. 2013).

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 4 Here]

Table 5 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 5, 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 5 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 4. 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 $VOTR_{tb}^{w}$.

V. Discussion

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.

A. Key Results and Interpretations

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; the value in tc, however, drastically drops to around 400 yen/hour and becomes insignificant.

This 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.

The 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 3, 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, Mulalic, and Van Ommeren

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 1 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 married couples enjoy childcare. Recall that member *m*'s value of time as a commodity (*VOTC*) for childcare in *t* is the difference between $VOTR_t^m$ and $VOCTS_t$ (see Appendix Equation (A5)). For the households with a binding technological constraint on childcare time in *tb*, the husbands are indifferent to childcare since their *VOTC* for childcare is zero in this period. Wives, in contrast, have a positive *VOTC* for childcare, suggesting their enjoyment. In *tc*, the households with a technological constraint on childcare time have disutility of childcare.

For the households with a binding technological constraint in *tc*, both husbands and wives have a negative *VOTC* for childcare. We find that the wives' disutility of childcare is even greater than the husbands'. These results show that both

husbands and wives in the households with a binding constraint do not enjoy their childcare time in *tc*. As shown in Table 4, 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 1, 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. — Comparisons between the husbands' time values and wage rates

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.

B. 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, Mulalic, and Van Ommeren 2021; Jacob et al. 2019; Kawabata 2014; Kawabata and Abe 2018; Carta and Philippis 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, 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[13], 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. 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 4 (with at least 10% significance) for three policy scenarios. Results are shown in Table 6.

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.

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[14]. This enables our sample households, on average, obtain 11,402 yen/year of welfare gain in tc.

[Insert Table 6 Here]

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

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

[14] 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).

VI. 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, our results reflect 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, Islam, and Sakhonchik 2016; Miyajima and Yamaguchi 2017; Thor Arnarson and Mitra 2010).

This study has some limitations, mainly because of the current availability of data. Compared to the 2019 Comprehensive Survey of Living Conditions in Japan[15], 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. Lastly, self-selection could play a determinant role within households: a married couple's gender ideologies might account for their work-life preferences and thus lead to their distinct time use and values of time (Davis and Greenstein 2009; Kleven, Landais, and Søgaard 2019).

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TABLE

TABLE 1—SUMMARY STATISTICS

	Full sample	High-income household (Default, ϕ=0) [a]	Low-income household (ϕ=1) [a]	Sig.[b]
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: 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.

[a] Husband's annual salary ≤ the median household income in Japan, ϕ=1; 0, otherwise.

[b] Significance of a two-sample t-test: *p < 0.1, **p < 0.05, ***p < 0.01.

TABLE 2— 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.[a]
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	

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

TABLE 3—AVERAGE DAILY CHILDCARE TIME (HOURS) AND THE HOUSEHOLDS WITH A BINDING CONSTRAINT

	Full sample	High-income households (ϕ=0)[a]	Low-income households (ϕ=1)[a]
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
Diff. (All). sig.[b]	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
Diff. (All). sig.[b]	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

[a] Husband's annual salary ≤ the median household income in Japan, ϕ=1; 0, otherwise.

[b] Significance of a paired t-test: *p < 0.1, **p < 0.05, ***p < 0.01.

TABLE 4—TWO-STAGE ANALYSIS CONSIDERING Φ ONLY

	With the technology constraints		Without the technology constraints	
	OLS	IV-OLS	OLS	IV-OLS
	Coef. sig.[b] (Bootstrap SE)[c]	Coef. sig.[b] (Bootstrap SE)[c]	Coef. sig.[b] (Bootstrap SE)[c]	Coef. sig.[b] (Bootstrap SE)[c]
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[a]	**-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

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

[b] The significance level of the t-statistics: *p < 0.1, **p < 0.05, ***p < 0.01.

[c] 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 5—TWO-STAGE ANALYSIS CONSIDERING THE INTERACTION TERMS WITH Φ

	With the technology constraints		Without the technology constraints	
	OLS	IV-OLS	OLS	IV-OLS
	Coef. sig.[b] (Bootstrap SE)[c]	Coef. sig.[b] (Bootstrap SE)[c]	Coef. sig.[b] (Bootstrap SE)[c]	Coef. sig.[d] (Bootstrap SE)[c]
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[a]	**-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[d]
P-value of Breusch-Pegan test	0.1460	0.0939	0.0568	0.0332

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

[b] The significance level of the t-statistics: *p < 0.1, **p < 0.05, ***p < 0.01.

[c] 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.

[d] Given that the null hypothesis of homoskedasticity is rejected at 5%, we use the significance of the robust t-statistics and F-statistics instead: *p < 0.1, **p < 0.05, ***p < 0.01.

TABLE 6—EFFECTS OF TRANSPORTATION AND CHILDCARE SERVICES ON THE AVERAGE HOUSEHOLD'S WELFARE

	Average household welfare gain (yen/year)
Scenario 1: When the upgraded tranportation 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 chaufeurring 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., $\partial\mathcal{L}^{\phi}/\partial z_t = 0$, $\partial\mathcal{L}^{\phi}/\partial q_t = 0$, $\partial\mathcal{L}^{\phi}/\partial l_t^m = 0$, $\partial\mathcal{L}^{\phi}/\partial I_t = 0$, and $\partial\mathcal{L}^{\phi}/\partial t_K^m = 0$) yields

(A1) $$\partial U_t^{\phi}/\partial z_t = \lambda^{\phi *}\left(\tau/(1+r)\right)^{t-1},$$

(A2) $$\partial U_t^{\phi}/\partial q_t = \lambda^{\phi *} p_{q,t}\left(\tau/(1+r)\right)^{t-1},$$

(A3) $$\partial U_t^{\phi}/\partial l_t^m = \tau^{t-1}\mu_t^{\phi,m*},$$

(A4) $$\left(\partial U_t^{\phi}/\partial \upsilon_t\right)\left(\partial \upsilon_t/\partial I_t\right) = \lambda^{\phi *}\left(\tau/(1+r)\right)^{t-1} K_t,$$

(A5) $$\partial U_t^{\phi}/\partial t_K^m + \left(\partial U_t^{\phi}/\partial \upsilon_t\right)\left(\partial \upsilon_t/\partial t_K^m\right) = \tau^{t-1}\left(\mu_t^{\phi,m*} - \kappa_t^{\phi *}\right), \text{ and}$$

(A6) $$\kappa_t^{\phi *}\left(t_{K,t}^w + t_{K,t}^h - \overline{t}_{K,t}\right) \geq 0.$$

For Equation (A6), either $\kappa_t^{\phi} > 0$ and $t_{K,t}^w + t_{K,t}^h - \overline{t}_{K,t} = 0$ (a binding constraint), or $\kappa_t^{\phi} = 0$ and $t_{K,t}^w + t_{K,t}^h - \overline{t}_{K,t} > 0$ (a non-binding constraint).

B. The Marginal Monetary Utility of the Exogenous Variables

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

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

(B3) $$\left(\partial V^{\phi}/\partial T_{C,t}^m\right)/\lambda^{\phi *} = -\mu_t^{\phi,m*}/\lambda^{\phi *}$$

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

(B5) $$\left(\partial V^{\phi}/\partial y_t\right)/\lambda^{\phi *} = (1+r)^{1-t}$$

(B6) $$\left(\partial V^{\phi}/\partial \overline{t}_{K,t}\right)/\lambda^{\phi *} = -\kappa_t^{\phi *}/\lambda^{\phi *}$$

(B7) $$\left(\partial V^{\phi}/\partial K_t\right)/\lambda^{\phi *} = \left(\partial U_t^{\phi}/\partial K_t\right)/\lambda^{\phi *}\tau^{t-1} - I_t^{\phi}/(1+r)^{t-1}$$

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.[a]	Coef. sig.[a]	Coef. sig.[a]	Coef. sig.[a]
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

[a] 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—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[a]	**[-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: 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.

[a] Husband's annual salary $\leq$ the median household income in Japan, ϕ=1, else 0.

TABLE C4—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[a]	**[-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: 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.

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