

# Do Husband And Wife Value Their Time Differently? A Microeconomic Study on Childcare, Gender Equality, and Household Welfare

Ashley Wan-Tzu LO<sup>1</sup> and Tatsuhito KONO<sup>2</sup>

<sup>1</sup>Specially Appointed Assistant Professor, Graduate School of Information Sciences, Tohoku University  
(Aoba 6-6-06 Aramaki Aobaku, Sendai City, Miyagi 980-8579, Japan)  
E-mail:wantzu.lo.e1@tohoku.ac.jp

<sup>2</sup>Member of JSCE, Professor, Graduate School of Information Sciences, Tohoku University  
(Aoba 6-6-06 Aramaki Aobaku, Sendai City, Miyagi 980-8579, Japan)  
E-mail:kono@tohoku.ac.jp

Recognizing the value of household tasks in addition to economic activities has become a key to achieving a gender-equal society. Yet, little is known about how men and women evaluate their time as they devote to childcare and work. Focusing on the welfare for the households with a married couple and their young children, we first theoretically derive the value of time as a resource (VOTR) and the value of childcare time saving (VOCTS) by constructing an intertemporal behavior model. Using the 2004-2018 Japan Household Panel Survey, we empirically find that (i) the married couples, particularly the wives, have high VOTRs when their children are young, and (ii) VOCTS increases as children grow up for some dual-income households. Our results suggest that policies that aim to alleviate the burden of commute and childcare do not only improve household welfare but help reconcile the work and family life.

*Key Words* : Gender equality, household welfare, time allocation, value of time as a resource (VOTR), value of childcare time saving (VOCTS)

## 1. INTRODUCTION

We investigate the value of time (VOT) for wives and husbands in different life stages, using Japanese panel data of married couples. Our main focuses are the gender differences in values of time in terms of different life courses. Our results reveal that the VOTs of wives with young children are very high, whereas the values drastically drop when the children become older. Conversely, the VOTs of husbands do not change much in different life stages.

People conduct various activities subject not only to money budget but to time availability. Although all individuals are equally guaranteed with a 24-hour of time use in a day, they may utilize their time differently in terms of their gender roles and household life stages<sup>1,2</sup>. Indeed, the gender division of family obligations have been found to explain the gender differences in performing home and work tasks<sup>1,3-9</sup>.

The presence of young children, in particular, has been consistently found to be a key factor to women's out-of-home activities, short commute, and career choice whereas childcare seems to be less

prominent to men. Boarnet and Hsu (2015), for instance, 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 men living alone<sup>3</sup>. Based on the 1995 National Person Transportation Survey, McGuckin and Murakami (1997) find that women with children tend to make more stops for childcare and family errands before reaching home/work compared to men and childless women<sup>7</sup>.

The situation becomes more challenging for employed women. Compared to their male counterparts, employed women contribute significant amount of time to domestic and care tasks even after they return from work<sup>1,10,11</sup>. To better accommodate childcare tasks, women compromise themselves by accepting the second-best jobs instead of the ideal jobs<sup>4,6,9,11,12</sup>.

From the 1985-1988 Dutch Housing Demand Survey, Rouwendal and Rietveld (1994) find that female employees without children have the same commute length as males<sup>8</sup>. Rouwendal (1999) later uses the same data to find that Dutch women with young children are reluctant to work far from home and prefer to accept part-time job offer compared to

those without children<sup>9</sup>. Similar trends are found in Japan and Denmark<sup>4,12</sup>. Kawabata and Abe (2018) and Borghorst et al. (2021) confirm that women with children are likely to trade off the full-time employment opportunities against short commute<sup>4,12</sup>.

Increasing commuting time substantially yields greater marginal cost for employed women with children compared to all other workers<sup>4</sup>. This is primarily because employed mothers demand excessively flexible time and space in order to address their childcare responsibilities<sup>4,13</sup>. The limited time availability due to women's childcare obligations not only makes it difficult for them to participate in the labor market but prevents them from accumulating marketable human capital, thus perpetuating the gender gap in wage and career advancement<sup>4,13-16</sup>.

A common approach to understanding gender disparity in time use is to evaluate the proportion of time that men and women allocate to their paid job and unpaid care tasks<sup>1,11</sup>. Transportation studies further adopt the time-geographic concept to investigate the gender differences in temporal and spatial rigidity. For example, Kwan (1999, 2000) finds that women are more likely to have a limited activity space than men because of the temporal fixity characteristics of the childcare and household-serving activities<sup>13,14</sup>. Economic studies on gendered commute patterns reveal that the wellbeing of women with children decreases with increasing commute time whereas this does not hold for men<sup>1,9,17</sup>.

Carta and Philipps (2018) show that the longer commute of husbands could reduce wives' probabilities of employment and working hours but has no impacts on the amount of childcare time. This influence is found stronger for those with children. Their results imply that the wives remain their roles as the primary care giver for their children regardless of their husbands' commute. However, the reducing working hours of women could reveal their burden of running between work and chauffeur of children when the husbands are occupied by long work trips.

Although policymakers have been calling for alleviating women's time stress for a more gender-equal society, none of the previous studies reflect the within-household gender differences in time valuation derived from household utility maximization and the associated budget/time constraints. As individuals have a trade-off between the time use in travel and other activities, we use this mechanism to measure the value of time (VOT) in order to understand how gender roles imply the differences in time burden for men and women.

### Gender and time value

Ever since Becker (1965) introduces the time theory, VOT has long been utilized to evaluate how

people use their time depending on the money and time available<sup>18-20</sup>. In Becker (1965), the allowance of a free transfer between the time on working and other activities imposes an exogenous VOT on household's utility<sup>18-20</sup>. VOT is defined as an individual's opportunity cost, for example, wage rate<sup>18</sup>.

Nevertheless, limitations remain if we evaluate gendered VOT using a fixed value. For instance, VOT could be different from market wage due to exogenous work hours and (dis)utility of certain activities<sup>19-22</sup>. While the substantial gender pay gap persists, results could be misleading if we treat VOT as a given wage rate rather than an endogenous value. Moreover, women could value their time more than their incomes as they are the primary care givers who run between work and family responsibilities<sup>9,17</sup>.

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<sup>18,21</sup>. That is, an individual can choose to spend exactly or more than the minimum required time on consuming the good<sup>21</sup>.

DeSerpa's model thus 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<sup>23,24</sup>, to the best of our knowledge, it has not been used to compare gender disparity in time use.

Understanding the gender VOTs based on 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 activities<sup>19</sup>. In this study, we will focus on the changes in VOTs before and after household children grow up using an intertemporal household utility model given that childcare responsibility is strongly attached to gender-role ideology and gender difference in time use in different life stages<sup>1,13,14,25,26</sup>. We believe that this is the first study that directly investigates the within-household dynamics in gender VOTs for married couples in different life stages.

The remainder of the paper consists of four sections. Section 2 constructs an intertemporal household behavior model. Section 3 describes the data and analytical approach. Section 4 reports the results of our empirical analysis. Section 5 concludes policy implications and the paper.

## 2. THE INTERTEMPORAL MODEL OF HOUSEHOLD BEHAVIOR

Focusing on the households with a married couple with children, we develop a behavioral model that considers the intertemporal decisions from the first year of the couple's marriage ( $t=1$ ) to the end of their lives ( $t=\bar{t}$ ). The household's utility in period  $t$  consists of the composite goods ( $z_t$ ), children's wellbeing ( $v_t$ ), 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,  $v_t$ , measures the state of children's happiness, which is defined by the amount of money spent on a child in period  $t$ ,  $I_t$ , and the parents' childcare time. This is defined as  $v_t = v_t(I_t, l_t^h, l_t^w)$ . The birth of a child is assumed to be a random event<sup>16</sup>; that is, the number of children ( $K_t$ ) is exogenously given but influences the household behavior in  $t$ . Household in different categories (e.g., income level) could have different indifference curves. The utility function of household in category  $\phi$  in  $t$  is

$$U_t^\phi(z_t, v_t, q_t, l_t^h, l_t^w, t_{K,t}^h, t_{K,t}^w; K_t) \quad (1)$$

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 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 ( $I_t$ ), 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  $r$ . Replacing  $s_t$ , we obtain the following intertemporal budget constraint :

$$\begin{aligned} & \sum_{t=1}^{\bar{t}} \frac{(z_t + p_{q,t}q_t + (I_t + c^0 - a)K_t)}{(1+r)^{t-1}} \\ &= \sum_{t=1}^{\bar{t}} \frac{(w_t^h T_{W,t}^h + w_t^w T_{W,t}^w + y_t)}{(1+r)^{t-1}} \end{aligned} \quad (2a)$$

In Equation (2a), The price of  $z_t$  is normalized to one.  $c^0$  and  $a$  are the minimum cost 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,  $c^0$  and  $a$  are assumed 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 ( $n_t^m T_{C,t}^m$ ), leisure ( $l_t^m$ ), and childcare ( $t_{K,t}^m$ ). The mathematical formulation of  $m$ 's time constraint in  $t$  is

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

where  $\bar{T}_t^m$  is  $m$ 's available time in  $t$  after the time for sleep and meals is deducted;  $n_t^m$  and  $T_{C,t}^m$  are the count of  $m$ 's one-way commute trips and the one-way commute time per trip in  $t$ , respectively. The commuting cost is not reflected in the budget constraint because it is assumed to be reimbursed by  $m$ 's employer in Japan.

The third constraint is the minimum required time for the married couple to spend on childcare in  $t$ . Given that the married couple are free to allocate more than the required childcare time, this technical constraint describes whether the married couple together dedicate their time only to addressing the basic daily needs of their children (e.g., bathing and feeding children) or they enjoy the time with their children. This is conceptually built based on DeSerpa (1971), which firstly introduces time allocation to the consumption of market goods<sup>19,21</sup>. Mathematically, the constraint is expressed as

$$\bar{t}_{K,t} \leq t_{K,t}^h + t_{K,t}^w, \quad (2c)$$

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

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

$$V^\phi = \max_{\substack{z_t, v_t, q_t, \\ l_t^h, l_t^w, \\ t_{K,t}^h, t_{K,t}^w}} \sum_{t=1}^{\bar{t}} \frac{U_t^\phi(z_t, v_t, q_t, l_t^h, l_t^w, t_{K,t}^h, t_{K,t}^w; K_t)}{\tau^{t-1}}, \quad (3)$$

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

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

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

where  $\lambda^\phi$ ,  $\mu_t^{\phi,m}$ , and  $\kappa_t^\phi$  are the Lagrangian multipliers of the budget, time, and technical constraints for

households in category  $\phi$ , respectively. The first-order conditions of Equation (4) are documented in Appendix A.

Using the envelope theorem, we obtain the marginal 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  $K_t$ , as shown below:

$$\frac{\partial V^\phi}{\partial w_t^m} = \frac{\lambda^{\phi*} T_{W,t}^m}{(1+r)^{t-1}} \quad (5a)$$

$$\frac{\partial V^\phi}{\partial T_{W,t}^m} = \frac{\lambda^{\phi*} w_t^m}{(1+r)^{t-1}} - \mu_t^{\phi,m*} \quad (5b)$$

$$\frac{\partial V^\phi}{\partial T_{C,t}^m} = -n_t^m \mu_t^{\phi,m*} \quad (5c)$$

$$\frac{\partial V^\phi}{\partial p_{q,t}} = -\frac{\lambda^{\phi*}}{(1+r)^{t-1}} q_t^\phi \quad (5d)$$

$$\frac{\partial V^\phi}{\partial y_t} = \frac{\lambda^{\phi*}}{(1+r)^{t-1}} \quad (5e)$$

$$\frac{\partial V^\phi}{\partial \bar{t}_{K,t}} = -\kappa_t^{\phi*} \quad (5f)$$

$$\frac{\partial V^\phi}{\partial K_t} = \frac{1}{\tau^{t-1}} \frac{\partial U_t^\phi}{\partial K_t} - \frac{\lambda^{\phi*}}{(1+r)^{t-1}} I_t^\phi \quad (5g)$$

Following the derivation, we additionally make two key assumptions for the model.

<Assumption 1. Linearity> We assume that household's life-span utility is linear. It is approximated by the first-order Taylor expansion, imposing no restriction on the shape of the utility function<sup>27</sup>.

<Assumption 2. Homogeneity> Households in the same category,  $\phi$ , are assumed homogeneous before they enter  $tb=1$  and will achieve the same life-time utility level toward the end of their lives.

In this study, we use  $ta$ ,  $tb$ ,  $tc$ , and  $td$  to denote different life stages for a household.

$ta$ : beginning of marriage but no children,

$tb$ : when the first child < aged 6,

$tc$ : when the first child  $\geq$  aged 6, and

$td$ : retirement and all children leaving home.

We specifically define  $tb$  as the period before the first child turns 6 year-old ( $tb=1-6$  from aged 0 to 5) and  $tc$  as the period after the first child turns age 6 but before the married couple retire ( $tc=7-35$ ). We consider these two periods since we aim to understand the gender difference in the married couple's  $VOTRs$  in the presence of household children. We use aged 6 of the first child to differentiate  $tb$  and  $tc$  because children under 6 demand more attention from their parents compared to those who are six and over given that older children show more independence from

their parents as they reach school age<sup>28</sup>.

We further assume that all the married couples in the same category in  $ta$  are employed, receive the same wage rates, have the same working hours, and live close to their workplaces. In this context, the utility of  $w_t^m$ ,  $T_{W,t}^m$ , and  $T_{C,t}^m$  is identical. The nonlabor incomes in  $ta$  and  $td$  are assumed constant. The utility of housing is also assumed identical in  $ta$  and  $td$  since the married couples do not need to pay any attention to the accommodation given the absence of children. We denote the utility associated with wage rate, working and commute time, housing, and nonlabor income in  $ta$  and  $td$ , as  $\bar{v}^\phi$ .

To obtain the regression equation, we divide the utility function by  $\lambda^{\phi*}$ , denote the life-span utility as  $\bar{V}^\phi$ , and substitute the marginal utility by Equations (5a) to (5g). We move the terms associated with income and housing to the left hand side (LHS) of the equation when the remaining is on the right hand side (RHS), and multiply the equation by -1. We formulate the equation to be estimated as

$$\begin{aligned} & \sum_{t=tb,tc} \left( \frac{2 \times (w_t^h T_{W,t}^h + w_t^w T_{W,t}^w) + y_t - p_{q,t} q_t^\phi}{(1+r)^{t-1}} \right) = \\ & \left( \frac{\bar{V}^\phi - \bar{v}^\phi}{\lambda^{\phi*}} \right) + \\ & \sum_{tb} \frac{\mu_{tb}^{\phi,h*}}{\lambda^{\phi*}} (T_{W,tb}^h + n_{tb}^h T_{C,tb}^h) + \sum_{tb} \frac{\mu_{tb}^{\phi,w*}}{\lambda^{\phi*}} (T_{W,tb}^w + n_{tb}^w T_{C,tb}^w), \quad (6) \\ & + \sum_{tc} \frac{\mu_{tc}^{\phi,h*}}{\lambda^{\phi*}} (T_{W,tc}^h + n_{tc}^h T_{C,tc}^h) + \sum_{tc} \frac{\mu_{tc}^{\phi,w*}}{\lambda^{\phi*}} (T_{W,tc}^w + n_{tc}^w T_{C,tc}^w) \\ & + \sum_{tb} \left( \frac{\kappa_{tb}^{\phi*}}{\lambda^{\phi*}} \right) \bar{t}_{K,tb} + \sum_{tc} \left( \frac{\kappa_{tc}^{\phi*}}{\lambda^{\phi*}} \right) \bar{t}_{K,tc} \\ & - \sum_t \left( \frac{1}{\lambda^{\phi*} \tau^{t-1}} \frac{\partial U_t^\phi}{\partial K_t} - \frac{I_t^\phi}{(1+r)^{t-1}} \right) K_t \end{aligned}$$

where  $n_t^m$  is the commute trip number of member  $m$  ( $=h,w$ ) in  $t$  ( $=tb, tc$ ).

We further put forward Propositions 1 and 2, which define two types of values of time and assume that each of them is constant in the same period.

<Proposition 1: Value of time as a resource>

For households in category  $\phi$ , member  $m$ 's value of time as a resource in  $t$  ( $VOTR_t^{\phi,m}$ ) is defined by  $\bar{\mu}_t^{\phi,m} / \lambda^{\phi*}$ .

<Proposition 2: Value of Childcare Time Saving>

For households in category  $\phi$ , the value of childcare time saving in  $t$  ( $VOCTS_t^\phi$ ) is measured by  $\bar{\kappa}_t^\phi / \lambda^{\phi*}$ .

Following the propositions, we hypothesize the married couple's time uses and values.

<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  $m$  contributes a significant amount of time to childcare when the children are very young.

<Hypothesis 2: % change of wife's  $VOTR \geq$  % change of husband's  $VOTR$ >

Available evidence has shown that wife is primarily responsible for childcare<sup>1,3,10,11,25,26</sup>, so the extent to which her time constraint is relaxed from  $tb$  to  $tc$  is possibly greater than her husband's time budget.

<Hypothesis 3:  $VOCTS_{tb}^{\phi} \leq VOCTS_{tc}^{\phi}$ >

First-time parents are not familiar with childcare and could dedicate a significant amount of time to childcare in  $tb$ . Their childcare time could decrease as they become experienced and as their children become more independent in  $tc$ . Therefore, households are more likely to have a nonbinding constraint in  $tb$  compared to in  $tc$  (i.e., Appendix A for binding/nonbinding constraints).

For the empirical analysis in this study, we use the average working hours, commute time, housing price, and housing size in each study period. The number of children in  $t$  will be replaced by the total number of children born to the household,  $K$ . Households in category  $\phi$  is specified using the interactions between  $\phi$  and the independent variables.

Moreover, we use a binary variable,  $\bar{\delta}_t$  to describe the non-binding conditions when the married couple spend more than the minimum required time,  $\bar{t}_{K,t}$ , and the binding conditions when the married couple spend exactly the minimum required time,  $\bar{t}_{K,t}$ .

$$\bar{\delta}_t = \begin{cases} 0 \text{ (non-binding)} & \text{if } n_t (\bar{t}_{K,t}^h + \bar{t}_{K,t}^w) > \sum_t \bar{t}_{K,t} \\ 1 \text{ (binding)} & \text{if } n_t (\bar{t}_{K,t}^h + \bar{t}_{K,t}^w) = \sum_t \bar{t}_{K,t}, \end{cases} \quad (7)$$

where  $n_t$  is the number of years when the household had children < aged 6 in  $t$  (i.e.,  $n_{tb}=6$  and  $n_{tc}$  is the year difference between the first and the youngest children) and  $\bar{t}_{K,t}^m$  is member  $m$ 's average childcare time over  $\tilde{t}$ , the years observed by the survey data. We rewrite Equation (6) and obtain the equation to be estimated

$$Y = \beta_0 + \beta_0^{\phi} \phi + \beta_1 K + \beta_1^{\phi} (K \phi) + \beta_4 \left( 6\bar{n}_b \bar{t}_{C,b}^h + 6\bar{T}_{W,b}^h \right) + \beta_4^{\phi} \left( 6\bar{n}_b \bar{t}_{C,b}^h + 6\bar{T}_{W,b}^h \right) \phi + \beta_5 \left( 6\bar{n}_b \bar{t}_{C,b}^w + 6\bar{T}_{W,b}^w \right)$$

$$+ \beta_5^{\phi} \left( 6\bar{n}_b \bar{t}_{C,b}^w + 6\bar{T}_{W,b}^w \right) \phi + \beta_6 \left( \bar{\delta}_{tb} \sum_{tb} \bar{t}_{K,tb} \right) + \beta_6^{\phi} \left( \bar{\delta}_{tb} \sum_{tb} \bar{t}_{K,tb} \right) \phi + \beta_7 \left( 29\bar{n}_c \bar{t}_{C,c}^h + 29\bar{T}_{W,c}^h \right) + \beta_7^{\phi} \left( 29\bar{n}_c \bar{t}_{C,c}^h + 29\bar{T}_{W,c}^h \right) \phi + \beta_8 \left( 29\bar{n}_c \bar{t}_{C,c}^w + 29\bar{T}_{W,c}^w \right) + \beta_8^{\phi} \left( 29\bar{n}_c \bar{t}_{C,c}^w + 29\bar{T}_{W,c}^w \right) \phi + \beta_9 \bar{\delta}_{tc} \sum_{tc} \bar{t}_{K,tc} + \beta_9^{\phi} \bar{\delta}_{tc} \left( \sum_{tc} \bar{t}_{K,tc} \right) \phi + \varepsilon \quad (8)$$

where  $Y$  is the sum of twice of household's labor income and nonlabor income minus its housing expense (the LHS of Equation (6)). For households in the default category,  $\beta_4$  to  $\beta_9$  are  $VOTR_{tb}^h$ ,  $VOTR_{tb}^w$ ,  $VOCTS_{tb}$ ,  $VOTR_{tc}^h$ ,  $VOTR_{tc}^w$ , and  $VOCTS_{tc}$ , respectively. For households in category  $\phi$ ,  $\beta_4^{\phi}$  to  $\beta_9^{\phi}$  are the differences in the time values between the default category and category  $\phi$ . In Equation (8), the numbers of years in  $tb$  and  $tc$  are 6 ( $tb=1-6$  when the first child is aged 0-5) and 29 ( $tc=7-35$ ), respectively.

### 3. DATA AND METHODS

#### (1) Survey and study sample

This study examines the behaviors of the households with a married couple and their children in Japan using the 2004-2018 Japan Household Panel Survey (KHPS/JHPS) conducted by the Panel Data Research Center (PDRC) at Keio University<sup>29</sup>. We extract our study sample from a subset of 10,400 households in Japan that provide at least one-year 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 commute time. Households with the wife's commute time above or below the 90th or 10th percentiles of the sample are discarded to avoid distorted results. Households with a positive  $Y$  (see Equation (8)) 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 that member  $m$  is employed in  $t$  ( $=tb, tc$ ) if  $m$  is mostly employed in the observed periods of  $t$ . We use  $\bar{T}_{W,t}^m$  and  $\bar{T}_{C,t}^m$  to represent  $m$ 's average working and commute time in  $t$  based on the mean observed values.

**Table 1.** Descriptive statistics

Variables of interest	Full sample	High-income households (Default, $\phi=0$ ) <sup>a</sup>	Low-income households ( $\phi=1$ ) <sup>a</sup>	Sig. <sup>b</sup>
Sample size	249	92	157	
<b>Household characteristics</b>				
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	
<b>Husband's characteristics</b>				
Annual labor income (yen/year)	4,215,576	5,943,901	3,202,799	***
Hourly wage (yen/hr)	1,922	2,734	1,446	***
<i>Period tb</i>				
Employed (1, if yes, else 0)	0.98	0.98	0.99	
Daily working time (hour)	9.53	9.40	9.61	
One-way commute (minute)	31.45	39.54	26.71	***
<i>Period tc</i>				
Employed (1, if yes, else 0)	0.99	1.00	0.99	
Daily working time (hour)	9.21	9.23	9.20	
One-way commute (minute)	31.20	39.20	26.51	***
<b>Wife's characteristics</b>				
Annual labor income (yen/year)	384,153	265,679	453,577	**
Hourly wage (yen/hour)	411	334	456	
<i>Period tb</i>				
Employed (1, if yes, else 0)	0.19	0.10	0.24	***
Daily working time (hour): All/employed	0.97/5.14	0.30/3.05	1.36/5.63	***/**
One-way commute (minute): All/employed	1.53/8.10	0.42/4.31	2.18/9.00	***/**
<i>Period tc</i>				
Employed (1, if yes, else 0)	0.40	0.28	0.47	***
Daily working time (hour): All/employed	2.02/5.03	1.17/4.14	2.52/5.34	***/*
One-way commute (minute): All/employed	3.58/8.92	2.58/9.11	4.17/8.85	**/*

<sup>a</sup>Husband's annual salary  $\leq$  the median household income in Japan,  $\phi=1$ ; 0, otherwise. <sup>b</sup>\* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

Similarly, we calculate the household's housing expenditure over  $tb$  and  $tc$  by averaging out the observed rents. For the households who owned their home, we calculate the attributable rents ( $=P(1+avgmr)^{\Delta t}/50$ ) using the purchased price of their home ( $P$ ) and the average mortgage rate ( $avgmr$ ) based on Flat 35 ([www.sumai-info.com](http://www.sumai-info.com)), and the difference between the years observed and purchased ( $\Delta t$ ). The durability of housing is assumed 50 years.

The present value of housing expenditure is computed using the household's average rent and 2% as the interest rate. We set the 2% interest rates using the average values of the 20-year and 30-year Japanese national bonds between 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 the salary in the private sector provided by the National Tax Agency in Japan. Using the wage growth rates, the household's income of the observed periods, and the married couple's age in  $tb=1$ , we approximate to 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 bread winners of their families. Moreover, empirical evidence has concluded that  $VOTR$ s are likely to increase with household income<sup>23</sup>. For households with a hus-

band's annual salary lower than the median household income (JPY 4,370,000) in Japan<sup>30</sup>, we define  $\phi=1$ ; 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 ( $\phi=0$ ) are greater than of the low-income households ( $\phi=1$ ). Almost all the husbands in our sample are employed in the study period and work more than 9 hours on a daily basis. 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 the both 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<sup>2</sup>.

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. The employment rates of the wives in the high-income households are nearly 15% and 20% lower than those of the wives in the low-income group in  $tb$  and  $tc$ , respectively. Their average working time is comparable with women whose youngest child is a preschooler the 2010 JTUS<sup>2</sup>.

For the wives participating in labor market, their average working time and one-way commute are less than 6 hours per day and 10 minutes per trip. Results of t-test suggest that most of our focal variables in the two groups are significantly different.

## (2) Measuring the households's minimum childcare time required ( $\bar{t}_{K,t}$ )

To characterize  $\bar{t}_{K,t}$  for the sample households, we utilize the k-means algorithm, an efficient and common clustering approach, to group the households with similar characteristics into clusters. The k-means clustering is an iterative algorithm that minimizes the Euclidean distances between the data points and the centroid of each cluster.

The algorithm first randomly selects  $J$  (for  $j=1,2,\dots,J$ ) distinct locations as the initial centroids, where  $J$  is arbitrarily given. The algorithm computes the distance between data point  $d$  (for  $d=1,2,\dots,D$ ) and the centroid of cluster  $j$ . Next, the algorithm assigns  $d$  to the nearest cluster and updates the new centroid of any changed clusters. The iterative process of distance computation, reassignment, and centroid update are complete when no data point needs to be reassigned<sup>31</sup>.

Given that younger children demand more attention from their parents compared to those aged 6 and over<sup>28</sup>, parents need to dedicate at least some parental time to children aged  $\leq 5$ . As children's dependency could be different as they grow up<sup>28</sup>, we consider two clustering variables: (i) the number of infants and toddlers ( $\leq$  aged 2) and (ii) the number of preschoolers (aged 3 to 5).

We build two matrices that enumerate all the years when at least one child in the sample household was aged 5 or under in  $t$  ( $=tb, tc$ ). Each matrix includes the number of infants and toddlers and the number of preschoolers in a household by year. Based on Davies-Bouldin index and Silhouette method that evaluate the optimal number of clusters, we partition the data in each matrix by the clustering variables into five groups 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  $j(t),5th$  is the 5th percentile of household childcare time in the cluster  $j$  to which the household belongs in  $t$ ).

The clustering results enable us to define a household's total minimum time in  $t$ ,  $\sum_t \bar{t}_{K,t}$  as well as  $\bar{\delta}_t$  (see Equation (7)) using the following conditional statement:

$$\left( \sum_t \bar{t}_{K,t}, \bar{\delta}_t \right) = (Non-binding, 0)$$

$$\text{if } n_t \left( \bar{t}_{K,i}^h + \bar{t}_{K,j}^h \right) > \sum_t t_K^{j(t),5th},$$

else

$$\left( \sum_t \bar{t}_{K,t}, \bar{\delta}_t \right) = \left( \min \left\{ n_t \left( \bar{t}_{K,i}^h + \bar{t}_{K,j}^h \right), \sum_t t_K^{j(t),5th} \right\}, 1 \right). \quad (9)$$

The first and second conditional statements yield a non-binding and a binding conditions of childcare time, respectively.

## (3) Empirical approach: Two-stage instrumental variable (IV) analysis of commute and household budget

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 for Equation (8) in order to capture endogeneity bias. The endogeneity issue could occur when the commute time in Equation (8) 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<sup>32,33</sup>. An ideal IV is uncorrelated with  $\varepsilon$  but correlated with the endogenous variable<sup>34,35</sup>. Namely, the IV should be exogenous to the outcome variable (in our study, household available budget,  $Y$ ) but could influence the endogenous variable (i.e., commute).

In this study, we use the prefectural car density (PCD) and the regional ratio of waitlisted children (RWC) as the instrumental variables for our analysis. 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 in Japan.

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. We choose PCD and RWC as the IVs for this study because they depend on the transportation and childcare supplies provided by the government. These variables, indeed, do not directly influence a household's available budget (i.e.,  $Y$  in Equation (8)), rather, they are associated with commute length<sup>34,35</sup>.

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 commute time in  $t$  on the IVs in  $t$ , the number of children, education attainment, and the individual's average working time in  $t$ .

Using the ordinary least squares models for the

**Table 2.** The 5th percentile of daily childcare time (hour) by cluster

Cluster $j$	Centroid Number of infants and toddlers	Number of preschoolers	Cluster size	Size of the households with observed childcare time	$t_K^{j(t),5th}$ (hours)	Sig. <sup>a,b</sup>
<i>Period tb</i>						
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	
<i>Period tc</i>						
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	

<sup>a</sup> Kruskal-Wallis nonparametric test. <sup>b</sup> Significance: \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

second stage estimation, we then regress the predicted commute time in  $t$  as well as other independent variables (see Equation (8)) on the household available budget,  $Y$ . Based on the  $p$ -value of the likelihood ratio test that examines the overall effects of the IVs, the results suggest that the models produce a good fitness with the IVs (see Appendix B for more details).

## 4. EMPIRICAL RESULTS

### (1) 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 different 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.,  $t_K^{1(tb),5th}$ ) 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.,  $t_K^{3(tb),5th} = 2.50$  hours/day).

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). Conversely, the median childcare time of the households in other clusters ranges from 8.50 to 12.14 hours/day (results not shown). These results are compatible with the assumptions that household's childcare time increase with the number of very young children.

In  $tc$ , households with an average number of 2.15 children (i.e.,  $t_K^{3(tc),5th}$ ) have a greater 5th percentile of childcare time compared to households in the other clusters with fewer children. The median childcare time for the households with more infants and tod-

dlers, indeed, is greater than the value of the households with less young children. For example,  $t_K^{2(tc),5th}$  (with 1.03 infants and toddlers and zero preschoolers) and  $t_K^{4(tc),5th}$  (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+ but without any children  $\leq$  aged 5. 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 (9), we obtain the total minimum required children time in  $t$ ,  $\sum_t \bar{t}_{K,t}$ , for our sample households.

Table 3 describes the mean daily childcare time of the married couples, 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 on a daily basis.

Moreover, our results of wives' childcare time are longer than the average in the 2010 JTUS for women whose youngest child is a preschooler<sup>2</sup>. Although employed wives are associated with less childcare time, they still spend more than 5 hours per day on their children, which is greater than the time their husbands spend. Results of paired  $t$ -tests show that the difference in childcare time between the married couples is statistically significant.

The results further show that around 2% of the households in the study sample have a binding constraint. All of the households in the high-income

**Table 3.** Average daily childcare time (hour) and the households with a binding constraint

	High-income households (Default, $\phi=0$ ) <sup>a</sup>	Low-income households ( $\phi=1$ ) <sup>a</sup>
Sample size	92	157
<i>Period tb</i>		
Husband	1.07	1.23
Wife: All/employed	11.18/10.68	9.07/6.48
Diff. (All). sig. <sup>b</sup>	10.11***	7.83***
Number of households with a binding constraint	0	2
Minimum childcare time (hour/day)	-	1.29
<i>Period tc</i>		
Year difference between the first and the youngest children ( $n_{tc}$ )	4.00	4.08
Husband	0.80	0.94
Wife: All/employed	9.33/6.45	7.97/5.91
Diff. (All). sig. <sup>b</sup>	8.53***	7.03***
Number of households with a binding constraint	1	3
Minimum childcare time (hour/day)	1.00	1.59

<sup>a</sup>Husband's annual salary  $\leq$  the median household income in Japan,  $\phi=1$ ; 0, otherwise. <sup>b</sup>Significance: \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

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  $\phi$ ), the estimated  $VOCTS_{tb}$  is only for the low-income group (see Section 4.2 for the results in detail).

## (2) Results of the two-stage instrumental variable (IV) analysis

To substantially obtain the statistical inferences for our results, we compute the the 90% bootstrap confidence intervals for the coefficients of estimates using the bootstrapping package with 1000 replicates in R<sup>36</sup>.

Bootstrapping is a statistical method that randomly and repeatedly draws independent samples with replacement from the original data, refits the model of interest using the bootstrapped samples, and finally calculates the bootstrapped standard errors and the confidence intervals for the estimated coefficients based on the estimated coefficients of each bootstrapped sample<sup>37</sup>.

This method relaxes the parametric assumption on which the conventional statistical tests depend and provides more robust inferences, especially for multistage regression and for small samples<sup>37,38</sup>.

Tables 4 and 5 present the estimated results that only consider the effect of  $\phi$ . Households with a lower income are associated with more than 180 million yen less in remaining household budget.  $VOTR_{tb}^h$  is nearly 1,300 yen/hour in the OLS estimations and 1,700 yen/hour in the IV-OLS models, representing about 65% and 90% of the husbands'

average wage rates, respectively (see Table 6 for the ratios in detail).  $VOTR_{tb}^w$  is found to be greater than 4,000 yen/hour, which is 10 times more than the wives' average wage rate. As the household children grow up,  $VOTR_{tc}^h$  and  $VOTR_{tc}^w$  drop to 1,120 yen and 400 yen/hour, about 58% and 100% of their wage rates, respectively. Results of 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 around 7,500 yen/hour in OLS and 5,400 yen/hour in IV-OLS, whereas the estimated  $VOCTS_{tc}$  increases to nearly 30,000 yen/hour.  $VOCTS_{tc}$  remain significant within 90% of the bootstrapped CIs.

Tables 7 and 8 describe the results that incorporate the interactions of  $\phi$  and other explanatory variables. Consistent with Tables 4 and 5, the households with a lower income have lower remaining budget. Based on t-statistics and the bootstrapped CIs,  $VOTR_{tc}^{oh}$  (around 1,600 to 1,700 yen/hour) is the only significant variable among the six values of time we estimate. In addition, the results suggest that there is no significant difference between the  $VOTRs$  of the households in the two income levels.

Table 9 presents the relative change between  $VOTRs$  in  $tb$  and  $tc$  for the married couples when we only consider  $\phi$ . Compared to the husbands'  $VOTRs$  in  $tb$ , the OLS estimations find less than a 15% decrease in their  $VOTRs$  in  $tc$ , whereas the IV-OLS results show that husbands'  $VOTRs$  in  $tc$  drop by more than 30%. Both regression analyses consistently indicate that the wives'  $VOTRs$  in  $tc$  are more than 90% smaller than their  $VOTRs$  in  $tb$ .

The key results of the empirical analyses are shown below.

**<Main finding 1>** *Wives remain as the primary care givers of their children even when they stay in*

**Table 4.** Two-stage analysis considering  $\phi^a$  only, with the technology constraints

	OLS		IV-OLS	
	Coef. sig. <sup>b</sup>	90% Bootstrap CI.	Coef. sig. <sup>b</sup>	90% Bootstrap CI.
Intercept	3.04E+08***	<b>(2.4E+08, 3.6E+08)</b>	2.99E+08***	<b>(2.4E+08, 3.6E+08)</b>
Household's characteristics				
Low-income husband ( $\phi=1$ , if yes, else 0) <sup>a</sup>	-1.81E+08***	<b>(-2.1E+08, -1.6E+08)</b>	-1.83E+08***	<b>(-2.2E+08, -1.1E+08)</b>
Number of children	-3.89E+06	(-2.2E+07, 1.4E+07)	-4.06E+06	(-2.1E+07, 1.4E+07)
<i>Period tb</i>				
Husband's total commute and working time	1227	(-2705, 5732)	1676	(-2240, 6206)
Wife's total commute and working time	4459**	(1550, 8482)	4284**	<b>(1440, 8321)</b>
Minimum required childcare time	7481	(-8.7E+04, 2.5E+04)	5423	(-8.9E+04, 2.4E+04)
<i>Period tc</i>				
Husband's total commute and working time	1112***	<b>(449, 1826)</b>	1117***	<b>(434, 1916)</b>
Wife's total commute and working time	381	(-105, 824)	402	(-88, 839)
Minimum required childcare time	29680	<b>(1.5E+04, 4.4E+04)</b>	27890	<b>(1.3E+04, 4.1E+04)</b>
Sample size	249		249	
Adjusted R <sup>2</sup>	0.3971		0.3979	
P-value of F-test	<2.2E-16		<2.2E-16	
P-value of Breusch-Pegan test	0.4225		0.4688	

<sup>a</sup>Husband's annual salary  $\leq$  the median household income in Japan,  $\phi=1$ , else 0. <sup>b</sup>Significance of t-test: \*p < 0.1, \*\*p < 0.05, \*\*\*p < 0.01.

**Table 5.** Two-stage analysis considering  $\phi^a$  only, without the technology constraints

	OLS		IV-OLS	
	Coef. sig. <sup>b</sup>	90% Bootstrap CI.	Coef. sig. <sup>b</sup>	90% Bootstrap CI.
Intercept	3.03E+08***	<b>(2.4E+08, 3.6E+08)</b>	2.98E+08***	<b>(2.4E+08, 3.6E+08)</b>
Household's characteristics				
Low-income husband ( $\phi=1$ , if yes, else 0) <sup>a</sup>	-1.80E+08***	<b>(-2.1E+08, -1.6E+08)</b>	-1.83E+08***	<b>(-2.2E+08, -1.6E+08)</b>
Number of children	-4.21E+06	(-2.1E+07, 1.4E+07)	-4.41E+06	(-2.1E+07, 1.3E+07)
<i>Period tb</i>				
Husband's total commute and working time	1290	(-2705, 5732)	1732	(-2195, 6312)
Wife's total commute and working time	4619**	<b>(1550, 8482)</b>	4400**	<b>(2041, 8327)</b>
<i>Period tc</i>				
Husband's total commute and working time	1117***	<b>(449, 1826)</b>	1124***	<b>(426, 1890)</b>
Wife's total commute and working time	399	(-105, 824)	418	(-73, 849)
Sample size	249		249	
Adjusted R <sup>2</sup>	0.4004		0.4015	
P-value of F-test	<2.2E-16		<2.2E-16	
P-value of Breusch-Pegan test	0.2433		0.2833	

<sup>a</sup>Husband's annual salary  $\leq$  the median household income in Japan,  $\phi=1$ , else 0. <sup>b</sup>Significance of t-test: \*p < 0.1, \*\*p < 0.05, \*\*\*p < 0.01.

**Table 6.** Ratio of the estimated *VOTR* to the average wage rate, consider  $\phi^a$  only

		With technology constraints		Without technology constraints	
		OLS	IV-OLS	OLS	IV-OLS
Husband	$VOTR_{tb}^h / \bar{w}^h$	64%	87%	67%	90%
	$VOTR_{tc}^h / \bar{w}^h$	<b>58%</b>	<b>58%</b>	<b>58%</b>	<b>58%</b>
Wife	$VOTR_{tb}^w / \bar{w}^w$	<b>1,085%</b>	<b>1,042%</b>	<b>1,124%</b>	<b>1,071%</b>
	$VOTR_{tc}^w / \bar{w}^w$	93%	98%	97%	102%

<sup>a</sup>Husband's annual salary  $\leq$  the median household income in Japan,  $\phi=1$ , else 0. <sup>b</sup>**Bold** the estimated result that is at 10% of significance.

the labor market.

<Main finding 2> The Wives' *VOTR* in *tb* is statistically significant and greater than 4,000 yen/hour; the value in *tc*, however, drastically drops to around 400 yen/hour and becomes insignificant.

<Main finding 3> The husbands' *VOTR* in *tb* is around 1,300 to 1,700 yen/hour but insignificant. The value slightly decreases to nearly 1,200 yen/hour in *tc* and remains significant.

<Main finding 4> *VOCTS* is insignificant in *tb* but is

statistically significant and greater than 30,000 yen/hour in *tc*.

<Main finding 5> The *VOTRs* and *VOCTSs* of high and low income households are not significantly different.

### (3) Effects of transportation and childcare service on welfare

In order to understand the effects of improved transportation and childcare services, this section

**Table 7.** IV-Tobit analysis considering the interaction terms with  $\phi^a$ , with the technology constraints

	OLS		IV-OLS	
	Coef. sig. <sup>b</sup>	90% Bootstrap CI.	Coef. sig. <sup>b</sup>	90% Bootstrap CI.
Intercept	2.96E+08***	<b>(1.5E+08, 4.0E+08)</b>	2.74E+08***	<b>(1.1E+08, 3.9E+08)</b>
Household's characteristics				
Low-income husband ( $\phi=1$ , if yes, else 0) <sup>a</sup>	-1.72E+08**	<b>(-3.0E+08, -1.3E+07)</b>	-1.45E+08*	(-2.8E+08, 3.3E+07)
Number of children	-1.92E+07	(-5.8E+07, 9.7E+06)	-2.05E+07	(-5.9E+07, 6.5E+06)
Number of children* $\phi$	2.57E+07	(-9.8E+06, 7.1E+07)	2.66E+07	(-7.7E+06, 7.5E+07)
<i>Period tb</i>				
Husband's total commute and working time	1174	(-7508, 11584)	2649	(-5922, 14312)
Husband's total commute and working time* $\phi$	-58	(-12663, 8306)	-1611	(-14440, 7329)
Wife's total commute and working time	10320	(-4581, 25666)	10540	(-4075, 23644)
Wife's total commute and working time* $\phi$	-6756	(-22321, 8506)	-7212	(-21197, 7177)
Minimum required childcare time	10,900	(-94653, 30374)	10470	(-92367, 31646)
<i>Period tc</i>				
Husband's total commute and working time	1635**	<b>(268, 3786)</b>	1685***	<b>(231, 3848)</b>
Husband's total commute and working time* $\phi$	-807	(-3120, 682)	-890	(-3139, 632)
Wife's total commute and working time	388	(-812, 1728)	408	(-848, 1796)
Wife's total commute and working time* $\phi$	-6	(-1520, 1250)	-23	(-1576, 1297)
Minimum required childcare time	35310	(-18377, 86321)	26430	(-86336, 51753)
Minimum required childcare time* $\phi$	-3563	(-51051, 1.0E+05)	4710	(-45616, 1.0E+05)
Sample size	249		249	
Adjusted R <sup>2</sup>	0.3916		0.3960	
P-value of F-test	<2.2E-16		<2.2E-16	
P-value of Breusch-Pegan test	0.146		0.1272	

<sup>a</sup>Husband's annual salary  $\leq$  the median household income in Japan,  $\phi=1$ , else 0. <sup>b</sup>Significance of t-test: \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

**Table 8.** IV-Tobit analysis considering the interaction terms with  $\phi^a$ , without the technology constraints

	OLS		IV-OLS	
	Coef. sig. <sup>b</sup>	90% Bootstrap CI.	Coef. sig. <sup>c</sup>	90% Bootstrap CI.
Intercept	2.96E+08***	<b>(1.5E+08, 4.0E+08)</b>	2.74E+08***	<b>(1.2E+08, 3.9E+08)</b>
Household's characteristics				
Low-income husband ( $\phi=1$ , if yes, else 0) <sup>a</sup>	-1.74E+08**	<b>(-3.0E+08, -1.6E+07)</b>	-1.48E+08*	(-2.8E+08, 2.4E+07)
Number of children	-1.94E+07	(-5.7E+07, 10.0E+06)	-2.06E+07	(-5.8E+07, 6.4E+06)
Number of children* $\phi$	2.58E+07	(-7.8E+06, 7.1E+07)	2.66E+07	(-6.6E+06, 7.4E+07)
<i>Period tb</i>				
Husband's total commute and working time	1206	(-7388, 11530)	2670	(-5836, 14190)
Husband's total commute and working time* $\phi$	9	(-11643, 8597)	-1533	(-14099, 7615)
Wife's total commute and working time	10270	(-4610, 25545)	10500	(-3889, 23765)
Wife's total commute and working time* $\phi$	-6448	(-21410, 8962)	-6922	(-20360, 7689)
<i>Period tc</i>				
Husband's total commute and working time	1634***	<b>(259, 3785)</b>	1686*	<b>(243, 3852)</b>
Husband's total commute and working time* $\phi$	-790	(-3099, 706)	-868	(-3169, 663)
Wife's total commute and working time	397	(-853, 1724)	414	(-846, 1804)
Wife's total commute and working time* $\phi$	10	(-1535, 1259)	-5	(-1581, 1292)
Sample size	249		249	
Adjusted R <sup>2</sup>	0.3971		0.4016	
P-value of F-test	<2.2E-16		<2.2E-16 <sup>e</sup>	
P-value of Breusch-Pegan test	0.0568		0.0487	

<sup>a</sup>Husband's annual salary  $\leq$  the median household income in Japan,  $\phi=1$ , else 0. <sup>b</sup>Significance of t-test: \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

<sup>c</sup>P-values of the robust t-statistics and F-statistics given the null hypothesis of homoskedasticity is rejected at 5% level of significance; \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

simulates the welfare gain of an individual household based on the *VOTRs* and *VOCTS* of the IV-OLS in Table 4 (with at least 10% significance) for three scenarios. Results are documented in Table 10.

<**Scenario 1: Improving transportation service by reducing a 5-minute of travel time per day**>

On average, a household can gain nearly 93,000 yen/year in *tb* and 24,000 yen/year in *tc*.

<**Scenario 2: Working from home**>

This is a common practice for reducing the stress of long commute and has been prevalently adopted during the Covid-19 pandemic. For a household with

a husband who telecommutes twice per week, the welfare gain is around 121,000 yen/year in *tc*.

<**Scenario 3: Alliviating time burden by extensive childcare support**>

This scenario is built based on the Family Support Program launched in Japan in 2015<sup>39</sup>. The program aims to support households who need a childminder when they are not able to care for or chauffeur their children due to schedule conflicts<sup>39</sup>. Suppose that a dual-income family occasionally cannot pick up/drop off their children at nursery on time due to their work schedules. For a family that utilizes the chauffeuring

**Table 9.** Estimated  $VOTRs$  and the relative changes between  $tb$  and  $tc$  for the married couple

		With technology constraints		Without technology constraints	
		OLS	IV-OLS	OLS	IV-OLS
Husband	$VOTR_{tb}^h$ (yen/hour)	1,227	1,676	1,290	1,732
	$VOTR_{tc}^h$ (yen/hour)	<b>1,112</b>	<b>1,117</b>	<b>1,117</b>	<b>1,124</b>
	Relative change	-9%	-33%	-13%	-35%
Wife	$VOTR_{tb}^w$ (yen/hour)	<b>4,459</b>	<b>4,284</b>	<b>4,619</b>	<b>4,400</b>
	$VOTR_{tc}^w$ (yen/hour)	381	402	399	418
	Relative change	-91%	-91%	-91%	-91%

<sup>a</sup>Bold text indicates that the coefficient of estimate is at least at 10% of significance.

**Table 10.** Effects of transportation and childcare services on individual household's welfare (yen/year)

	Husband	Wife	Household	Total
<b>Scenario 1: Reducing travel time by 5 minutes per day</b>				
Period $tb$	-	92,820	-	92,820
Period $tc$	24,202	-	-	24,202
<b>Scenario 2: Work-from-home husband</b>				
Period $tb$	-	-	-	-
Period $tc$	60,409	-	-	60,409
<b>Scenario 3: Chauffeur service supported by the local government<sup>a</sup></b>				
Period $tb$	-	-	-	-
Period $tc$	-	-	1,398,280	1,398,280

<sup>a</sup>We assume that the parents use the service one hour per time per week. We set 1,000 yen/hour as the service fee by referring to the service price in Chiyoda City, Tokyo

service once per week, the welfare gain is nearly 1.4 million yen/year in  $tc$ .

## 5. CONCLUSIONS

In this research, we investigate the time values for the households with a married couple and their children in Japan by constructing an intertemporal household behavior model. Based on the 2004-2018 KHPS/JHPS data, our two-stage IV analysis quantitatively measures the married couple's  $VOTRs$  and the household's  $VOCTSs$  before and after their first child reaches aged 6.

Our results substantiate Hypothesis 1 that wives have greater  $VOTRs$  in  $tb$  than in  $tc$ , indicating that they face a busy schedule when their children are young. We find that wives'  $VOTR$  is more than 4,000 yen/hour in  $tb$  but becomes statistically insignificant in  $tc$ . This is consistent with the finding of Gronau (1973), which reveals that the presence of young children could increase a mother's VOT but the presence of older children has no such effect<sup>40</sup>. Conversely, husbands'  $VOTR$  remains insignificant in  $tb$  but is around 1,100 yen/hour in  $tc$ . Our Hypothesis 2 is also supported since the wives are found to have a drastic decrease in their  $VOTRs$  in  $tc$ , where the extent of the decrease is larger than what their husbands experience. These results are in line with the available evidence that wives are primarily re-

sponsible for childcare and stressed out because they are running between work and family responsibilities. Their male counterparts, in contrast, are not influenced by these responsibilities very much<sup>4-7,9,10</sup>.

Consistent with previous studies on value of time<sup>23,24</sup>, we find that the husbands'  $VOTR$  in  $tc$  is around 58% of their wage rates. Compared to the meta analysis of value of time in Japan by Kato (2013), the husband's  $VOTR$  in  $tc$  is smaller. Our study shows that  $VOTR_{tc}^h$  is 19 yen/min whereas the average time value is around 25-42 yen/min in Kato (2013)<sup>24</sup>. These differences are possibly because we only consider the value of time as a resource while Kato (2013) additionally incorporates the value of time as a commodity<sup>24</sup>. However, our estimation results that incorporate the interactions are different from those of some previous studies<sup>23,24</sup> since we do not find any significant differences in the  $VOTRs$  and  $VOCTSs$  between high and low income households.

We find that the  $VOCTSs$  are greater in  $tc$  than in  $tb$ , yielding conclusive evidence for Hypothesis 3. This shows that both husbands and wives in the households with a binding constraint do not enjoy their childcare time in  $tc$ .

Recall that member  $m$ 's value of time as a commodity ( $VOTC$ ) for childcare in  $t$  is defined as  $VOTR_t^m$  deducted by  $VOTR_t^m$  (e.g., Equation (A5) in Appendix A). For the households with a technology constraint in  $tb$ , the husbands are indifferent to childcare since their  $VOTC$  for childcare is zero. Wives, in

contrast, have positive *VOTC* for childcare, suggesting their enjoyment of childcare. The disutility of childcare, however, arises as their children grow older. For the households with a technology constraint in *tc*, both husbands and wives have negative *VOTCs* for childcare.

We look into the data and realize that the above-mentioned married couples with a binding technology constraint are all employed. Therefore, the disutility of childcare could imply that their lives of work and childcare may not be well reconciled. Note that these households only account for 2% of our sample.

To improve the household well-being, especially for those with high *VOTRs* and large childcare burden, attention should be paid to the measures that help relieve their time use. Our study suggests that, in the short term, transportation and childcare policies that decrease commute time, incentivize telework, and provide child chauffeuring services could alleviate the time and spatial constraints that force people to run between work and family tasks.

In the long term, family-friendly programs that overcome the social stigma of paternity leave can encourage men to actively parent children and equally share childcare responsibilities with their wives<sup>25,26</sup>. More importantly, these policies could together help men transition to parenting faster, and improve their mental and physical conditions by balancing work and family life, thus sustainably supporting female employment<sup>25,26,41</sup>.

This study has some limitations, mainly due to the current data availability. Compared to the 2019 Comprehensive Survey of Living Conditions in Japan<sup>42</sup>, the low employment rate of the wives in our sample may not perfectly yield *VOTR* as well as *VOCTS*. In addition, the commute time in this study only appears in the time constraint, leaving an unanswered question of how different *VOTCs* 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 service at an intercity level on the tradeoff 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.

**ACKNOWLEDGMENT:** This research was supported by Japan Society for the Promotion of Science KAKENHI (Grant Number: 19K13673 Early-Career

Scientists). We thank the Panel Data Research Center (PDRC) at Keio University for facilitating the data access to the Japan Household Panel Survey (JHPS/KHPS).

## APPENDIX A THE FIRST-ORDER KARUSH-KUHN-TUCKER CONDITIONS

The first-order Karush-Kuhn-Tucker condition of the Lagrangian of Equation (4) yields

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

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

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

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

$$\frac{\partial U_t^\phi}{\partial t_K^m} + \frac{\partial U_t^\phi}{\partial v_t} \frac{\partial v_t}{\partial t_K^m} = \tau^{t-1} (\mu_t^{\phi,m*} - \kappa_t^{\phi*}) \quad (A5)$$

$$\kappa_t^{\phi*} (t_{K,t}^w + t_{K,t}^h - \bar{t}_{K,t}) \geq 0 \quad (A6)$$

In Equation (A6), when the constraint is binding, we have  $\kappa_t^{\phi*} > 0$  and  $t_{K,t}^w + t_{K,t}^h - \bar{t}_{K,t} = 0$ . When the constraint is non-binding,  $\kappa_t^{\phi*} = 0$  and  $t_{K,t}^w + t_{K,t}^h - \bar{t}_{K,t} > 0$ .

## APPENDIX B FIRST-STAGE IV ESTIMATIONS

Dep. var.:	Husband	Wife	Husband	Wife
One-way commute time	in <i>tb</i>	in <i>tb</i>	in <i>tc</i>	in <i>tc</i>
Intercept	0.87***	-0.56***	0.82***	-0.21**
B.S. degree	0.18***	-0.04	0.19***	-0.02
Working hours/day	0.02*	0.05***	0.01	0.04***
PCD	-1E-3***	5E-4***	-8E-4**	2E-04
RWC	6.19*	2.44	1.70	-0.73
Sample size	252	252	252	252
P-value of likelihood ratio test				
Full model	2.66E-11***	6.23E-29***	1.18E-06***	1.00E-34***
Overall effects of IVs	5.13E-08***	0.012**	1.09E-03***	0.068*

PCD: Prefectural Car Density. RWC:Regional Ratio of Wait-listed Children. Significance: \*p<0.1, \*\*p<0.05, \*\*\*p<0.001.

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