Intra-household Bargaining, Endogenous Divorce, and Female Labor Supply

By Tianzhou Yao*

This paper discusses the interactions between education levels, marital preferences, family composition transitions, and female labor force participation, that are bonded by cross-sectional variations of women's bargaining powers within households. The structural model I build combines a heterogeneous agent life-cycle model with two-earners collective model of labor supply. Allowing for endogenous divorce, I examine the profile of female labor force participation through the lens of asymmetric marital preference shocks that depend on gender and education level. Calibrated to Japanese Panel Data, results show significant variation of divorce probabilities, consumption, asset accumulation, and female labor force participation patterns across different types of households. This implies the importance of marital sorting by education level to female labor supply decision through intra-household bargaining process. Macroeconomic trends observed could be caused by changing composition of household types rather than changing behavior of every household as the representative agent model suggests.

This paper examines the effect of intra-household bargaining on extensive female labor supply decisions. Allowing for asymmetric marital preference shocks within a married couple, their "tastes for marriage" depend on their gender and education level. Divorce is an outside option that will be chosen endogenously when the expected life-time value of a divorcee is larger than the expected life-time value of remaining in the marriage. Relaxing the unitary model assumption in most life-cycle dynamic models, I construct a structural model that controls for all the well-established determinants of increasing female labor supply, and focus on particularly the role of cross-sectional variation of female bargaining power within a household.

To understand why does intra-household bargaining matter for female labor force participation decisions, I start from analyzing a simple non-unitary model with only two periods young vs. old. The analytical results suggest that private consumption allocation is proportional to the Pareto weight. The "working premium" in terms of expected life time value is inversely proportional to the wife's bargaining power. However, if I allow for elastic working hours decision, female will choose to work if only they are given a high enough bargaining power inside the household.

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Starting from here, I am particularly interested in under both earnings shock and marital preference shock, how will different types of households by education levels and their asset levels affect consumption decision and female labor force participation decision. The model indicates that life-cycle profile of asset accumulation for married couples increases with their age until retirement. Households with non-college educated husbands tend to accumulate more asset at earlier stage but the trend is reversed when they get older. Related to the life-cycle profile of asset is the life-cycle profile of consumption, the model result shows inverse-u shaped consumption pattern where married couples consume the most in the middle of their working age. There is significant difference in consumption levels by the types of husband. A main focus of this paper is the female labor force participation pattern. Married females have approximately u-shaped participation patterns throughout their life-cycles, while non-college educated married females experience more prominent decreasing participation as they age leading to lower rate of participation than their college-educated counterparts in their mid 50s. Controlling for the education levels of married females, households with college-educated husbands have lower female labor force participation than households with non-college-educated husbands.

To uncover the parameters of the life-cycle structural model with four household types by education levels, I match the simulated model results with empirical targets derived from Japanese Panel Survey of Consumption (JPSC). The wage processes match corresponding average hourly wages for four types of individuals by gender and education levels. Another exogenously calibrated key parameter would be the Pareto weight for each type of household and for each asset level. To be consistent with the estimated result from Lise and Yamada (2019), I normalize the distribution of the Pareto weight so that the mean Pareto weight on wife is 0.44, with a maximum of 0.70 and a minimum of 0.20. Fixed utility cost of male is normalized to be zero since the model assumes full participation of married male, consistent with the data. Fixed utility costs of female participation are endogenously calibrated to match the mean female participation rates in 4 types of households respectively. A group of marital preferences parameters in the model including standard deviation of match quality shocks by genders and marital compatibility by combination of education levels are calibrated endogenously to match the probability of getting divorced. These estimates are embedded in the hypothesis of mutual consent divorce combining with community property regimes in which marital assets and debts are divided equally between the spouses upon divorce.

The importance of marital sorting by education to female labor force participation can be explained by the intra-household bargaining process. Positive assortative matching is most common in the sample, however, females in those households also have lowest bargaining powers, leading to lower participation. Negative assortative matching consists only 1.5% of the sample, has significantly higher female labor force participation because females have the highest bargain-

ing power. Female participation rates are negatively correlated with asset levels for all types of households, indicating negative "income effect". The model also shows that the probability of divorce relies largely on the education level of wives, meaning households with college-educated females see significantly larger chances of divorce compared with their non-college-educated counterparts.

The contribution of this paper is threefold. First, I develop and estimate a dynamic model that explicitly incorporates varying Pareto weights at the time of the marriage. Voena (2015) recognizes the fact that under unilateral divorce, favorable intra-household bargaining position for wives provides a straightforward explanation for the reduction in their likelihood of employment that is observed in survey data. However, her paper lacks the heterogeneous agent dimension by assuming identical households at the time of marriage.

Second, I allow for endogenous marital transition and apply it to estimating life-cycle moments. Lise and Yamada (2019) interpret the Japanese Panel Survey of Consumption data using a dynamic collective model of household with potentially limited commitment. Taking into account the cross-sectional differences at the time of marriage in expected wage profiles between a husband and wife, they find that it strongly affects the allocation of private consumption by households. Their paper not only lacks the life cycle profiles critical for analysis of asset accumulation, consumption, and female labor force participation, but also lacks the endogenous family composition transition. Krueger and Wu (2021) show that a calibrated life-cycle two-earner household model with endogenous labor supply can rationalize the extent of consumption insurance against shocks to male and female wages. They find that most of the consumption insurance against permanent male wage shocks is provided through the presence and labor supply response of the female earner. Since they base their analysis on the unitary model, the relative bargaining power inside a household and its cross-sectional variation are missing from the factors that would possibly affect the insurance channel against income shocks.

Third, I generate asymmetric marital preferences within a couple. Divorce is either modeled as an outside option of intra-household bargaining in homogeneous households (Mazzocco 2007; Mazzocco, Ruiz, and Yamaguchi 2007; Voena 2015), or it is modeled as an exogenous shock generated by a stochastic process (Borella et al. 2023; Cubeddu and Rios-Rull 2003; Sander 1985). Empirical observations indicate that fraction of ever married men age 35-39 increases with education level, while fraction of ever married women age 35-39 decreases with education level. Rather than leaving it to the residual, my paper explicitly models the taste for marriage and assumes that it varies with gender and education level. Aside from income shocks, the risk of divorce followed by decreasing assets and consumption would be another channel unique to my paper that affects the female labor force participation decision. Calibrated to Japanese panel survey data, it is important to account for the background empirical trends including increasing divorce rates and decreasing marriage rates that change the demographic composition of the

population.

I. Literature Review

Rising female labor force participation rate starting in the twentieth century in the US was named "Quiet revolution" by Goldin 2006. A contentious literature has attempted to establish its driving forces and implications. This important trend is accompanied by increasing family composition shocks including rising divorce rate and declining marriage rates, especially prominent in East Asian countries. The literature suggests positive correlation between this demographic change and rising female labor force participation, though less from an intra-household bargaining point of view. To address the issue, a small but growing literature focus on macro-implications of intra-household bargaining that brings new light to measuring income inequality and wealth inequality.

A. Rising Female Labor Force Participation

Women's increased involvement in the economy was the most significant change in labor markets in the past century. An important strand of literatures studies the determinants of rising female labor force participation in the 20th century.

Heathcote et al. (2009) features all the key forces behind the increase in female participation: 1) the decline in marriage rates, 2) the narrowing gender wage gap, 3) the preference (or cultural) shift towards market work, and 4) the change in women's bargaining power within the household. They find that preference shifts and the rise in relative wages of women were the most important driving forces behind rising women's participation. Attanasio et al. (2008) focus on the increase in labor supply of mothers between 1940s and 1950s cohorts in the US. They construct a life-cycle model of female participation and savings and investigate which changes in the determinants of labor supply account for the increases in participation early in the life cycle. They find that a combination of a reduction in the cost of children alongside a reduction in the wage-gender gap is needed. Albanesi and Olivetti (2016) argue in their paper that medical progress played a critical role in the process of married women entering the labor force. They construct economic measures of improved maternal health and introduction of infant formula as two dimensions of medical progress and find that these advances indeed help women to reconcile work and motherhood.

My research contributes to the existing literature by 1) relaxing the unitary theoretical framework that allows bargaining power to vary cross-sectionally with distribution factors such as household wealth and spousal wage gap, 2) relaxing the full commitment assumption and model bargaining power as an endogenous variable that characterize renegotiation inside the household after new information regarding earnings (or preferences) are realized.

B. Increasing Family Composition Shocks

In the US, the introduction of unilateral divorce law in states that imposed an equal division of property is associated with higher household savings and lower female employment, implying a distortion in household assets accumulation and a transfer toward wives whose share in household resources is smaller than the one of their husbands. As discovered by Voena (2015), how divorce laws affect couples' intertemporal choices and well-being can be uncovered through explicit modelling of intra-household bargaining process that captures the relationship between higher risk of divorce and household behavior.

In Spain, over the past twenty years there has been an 87% increase of married women's employment rate and a 48% decrease of the fertility rate. Sanchez-Marcos (2002) focus on the increase of the probability of divorce from 0.5% to 2.1% following the introduction of the Divorce Law, as a possible explanation. The paper finds that the increase in marital dissolution rate can explain up to 44% of the change in married women's full-time employment rate, depending on women's education. The model on the economics of the family, in which labor market and fertility decisions are made, provides a good framework for the evaluation of certain social policies that target the reconciliation of family and labor life.

Cubeddu and Rios-Rull (2003) show in their paper the quantitative importance of the process that determines changes in family composition to the main macroeconomics magnitudes. They model family type as a stochastic process that affects households in a way like shocks to earnings. Agents respond to these processes by optimally choosing savings. They show that the size of savings differs dramatically depending on the details of the stochastic process.

My research contributes to the existing literature by 1) constructing gender-education-specific probability of divorce induced by heterogeneous distribution of marital preference shocks, 2) allowing for endogenous marital transition when the participation constraint under limited commitment framework binds, meaning divorce is an outside option when the expected lifetime utility of marriage is smaller than that of divorce.

C. Modeling the Inter-temporal Behavior of Households

There is a small, but growing, literature that opens the family black box within macro models. Over the last few decades the literature on intra-household allocations has moved away from the unitary approach of Becker (1973, 1974, 1981) to models of strategic interaction between household members. Cooperative (Manser and Brown, 1980; McElroy and Horney, 1981) and non-cooperative bargaining solutions (Lundberg and Pollak, 1993; Del Boca and Flinn, 2012; Doepke and Tertilt, 2017) are common among models of intra-household interactions. However, the need to clearly specify the outside option, or threat point, of a marriage in these models poses difficulty for empirical analysis.

The collective model of household labor supply is an approach developed to circumvent this threat point issue (Chiappori, 1988, 1992; Apps and Rees, 1988). Without identifying the exact bargaining process within a household and the outside option of spouses, they assume households naturally arrive at Pareto efficient allocations. The important finding concludes that based on observant (leisure, private consumption or labor force participation), we can assign different individual bargaining power characterized by Pareto weight to the husband and wife that shows the sharing rule of total household resources.

Substantial cross-sectional empirical studies demonstrate that allocations within households are related to factors such as types of income, marriage market attributes like sex ratio and legislation that determines division of property upon divorce. Attanasio and Lechene (2014) provide compelling evidence rejecting the unitary model of the household in favour of a collective model. They use the exogenous variation in the wife's share of household income induced by a cash transfer programme in Mexico to implement the test of the collective model. Mazzocco (2007), on the other hand, highlights the substantial issues raised by the degree of commitment. He proposes a test for full commitment (ex ante efficiency), against no commitment (a series of static interactions) or limited commitment (limited only by participation constraints). However, the data used does not allow measuring separately the private consumption of the husband and the wife and does not contain a panel dimension. As a result, it is not possible to estimate the relative importance of cross-sectional dispersion in weights from changes accruing during marriage.

We see a lot of potential for using tools that are widely used in macroeconomics to build improved models of family. In particular, almost all macroeconomic models are dynamic, whereas in family economics static modeling is still common. There is a small literature that documents the importance of dynamics for the family. In particular, Mazzocco (2008) shows empirically that Euler equations hold at the individual but not the household level, Lise and Yamada (2015) provide evidence suggesting that bargaining power within the household evolves over time. To capture such phenomena and to better understand the link between family decisions and aggregate outcomes, more dynamic family bargaining models are needed.

Recently, Voena (2015) studied the effect of changes in divorce laws across the U.S. states (from mutual consent to unilateral), combined with different rules as to how assets are allocated at divorce (title based or equal division), on the savings and labor supply behavior of households. She finds that the observed responses of household asset accumulation and the labour supply response of the wife support a model of limited commitment in households. This analysis, however, assumes that the household weight at time of marriage is identical for all households.

My research contributes to the existing literature by focusing on life-cycle profiles of asset accumulation, consumption, and female labor force participation.

II. The Model

To identify the channels through which intra-household bargaining process affect consumption and female labor force participation decision, I first develop a simple non-unitary two-period dynamic model in which spouses jointly decide how to allocate consumption, and whether or not to work for the wife.

I then extend the simple model to a life-cycle model combined with the collective model of labor supply, in which spouses make the same decisions as in the simple two-period model in addition to the decision to get divorced. Both models take household formation as given, and hence is meant to examine the behaviors of couples that are already married.

A. A Simple Non-unitary Model

Two individuals, husband h and wife w, are married at time 0 and live until time 2. In each of the two periods, they jointly choose how much to save, how to allocate private consumption between one another. The household also makes decisions about the wife's labor market participation. Husbands always work until they die. From time 1 to 2, spouses are retired. The working hours of spouses are set to be inelastic and normalized to one.

A.1 Preferences

Both husband and wife derive utility from own consumption c_{jt} and the wife derive disutility from own labor force participation p_w for $j = h, w$ and $t = 1, 2$. θ is the Pareto weight on the husband.

Expected life time utility takes the form

$$\begin{aligned}&\theta \ln c_{h1} + (1-\theta)\left(\ln c_{w1} - p_w \cdot \psi\right)\\&+ \beta\left[\theta \ln c_{h2} + (1-\theta)\ln c_{w2}\right]\end{aligned}$$

A.2 Budget Constraint

The general form of the budget constraint is

$$c_{h1} + c_{w1} + \frac{c_{h2}}{1+r} + \frac{c_{w2}}{1+r} = w_{h1} + w_{w1} + \frac{w_{h2}}{1+r} + \frac{w_{w2}}{1+r}$$

A.3 Optimal Consumption

Private consumption allocation chosen to maximize expected life time utility to the husband and the wife are, respectively

$$\begin{aligned}c^*_{h1} &= \frac{\theta\left((1+r)\left(w_{h1}+w_{w1}\right) + w_{h2} + w_{w2}\right)}{(1+\beta)(1+r)}\\c^*_{w1} &= \frac{(1-\theta)\left((1+r)\left(w_{h1}+w_{w1}\right) + w_{h2} + w_{w2}\right)}{(1+\beta)(1+r)}\end{aligned}$$

It can be shown from the result that private consumption allocated to each spouse is proportional to their bargaining power inside the household. The spouse would consume the corresponding share of discounted total resources in their life time, represented by the Pareto weight θ for the husband and 1-θ for the wife.

A.4 Female Participation Decision

Let $(1+r)(w_{h1}+w_{w1})+w_{h2}+w_{w2}=R$, which indicates the life time total resources earned by the couple conditioning on the wife chooses to participate in the labor force. Let $(1+r)w_{h1}+w_{h2}+w_{w2}=R'$, which shows the life time total resources earned by the couple conditioning on the wife chooses not to participate in the labor market.

Then, the maximized life time utility of the married couple conditioning on the wife chooses to work, and conditioning on she chooses not to work are, respectively

$$\begin{aligned}
V_w =& \theta \ln\left(\frac{\theta R}{(1+\beta)(1+r)}\right) + (1-\theta)\left(\ln\left(\frac{(1-\theta)R}{(1+\beta)(1+r)}\right) - \psi\right) \\
&+ \beta\left[\theta \ln\left(\frac{\beta\theta R}{1+\beta}\right) + (1-\theta)\ln\left(\frac{\beta(1-\theta)R}{1+\beta}\right)\right] \\
V_{nw} =& \theta \ln\left(\frac{\theta R'}{(1+\beta)(1+r)}\right) + (1-\theta)\ln\left(\frac{(1-\theta)R'}{(1+\beta)(1+r)}\right) \\
&+ \beta\left[\theta \ln\left(\frac{\beta\theta R'}{1+\beta}\right) + (1-\theta)\ln\left(\frac{\beta(1-\theta)R'}{1+\beta}\right)\right]
\end{aligned}$$

For the household to determine collectively whether the wife should participate in the labor market, the couple compares between V_w and V_{nw}. The difference between the two values can be expressed as

$$Diff = (1+\beta)\ln\frac{R}{R'} - (1-\theta)\psi$$

Given the wife's Pareto weight at the start of the marriage $1-\theta$, the critical value $1-\theta^*$ such that when $1-\theta < 1-\theta^*$, the expected life time value of choosing to work is larger than that of choosing not to work, can be shown as

$$1-\theta^* = \frac{(1+\beta)\ln\frac{R}{R'}}{\psi}$$

The critical value $1-\theta^*$ depends on three variables: β, $\frac{R}{R'}$, and ψ. The larger β is, the larger $1-\theta^*$ is. This shows that the more patient a household is, the more likely a wife would choose to work. The larger $\frac{R}{R'}$ is, the larger $1-\theta^*$ is. This shows that the larger the contribution of the wife's income to the total household resources, the more likely a wife would choose to work. Lastly, the smaller ψ is, the larger $1-\theta^*$ is. This shows that the less the wife dislikes working, the more likely she would choose to participate in the labor market.

B. The Life Cycle Model

Two individuals, husband A and wife B, are married at time 1 and live until time T. In every period from time 1 to T, they jointly choose how much to save, how to allocate private consumption between one another, and whether to stay together or divorce. Between time 1 and time $T - R$, the household also makes decisions about the wife's labor market participation. Husbands always work until they retire. The working hours of spouses are set to be inelastic and normalized to one. From time $T - R + 1$ to T, spouses are retired.

There are four types of household by education types (e_A, e_B). $e_j \in \{H, L\}$ for individuals with or without college degree, respectively.

B.1 Preferences

Both husband and wife derive utility from own consumption c_t^j and the wife derive disutility from own labor force participation p_t for $j = A, B$. Preferences are separable across periods of time and states of the world.

Both the husband and the wife have a subjective taste for marriage parameter $\xi_t^{j,e}$ which evolves over time and differs by gender and education level. This parameter reflects the spouses' affection for one another and their attachment to marriage based on other idiosyncratic factors (e.g., fear of the social stigma associated with divorce, concerns about the well-being of the children). Taste for marriage parameter only applies to married couples, that is, when $m_t = 1$. $s^{j,e}$ is stigma cost of divorce that only applies to divorcees, when $m_t = 0$.

Period utilities take the form

$$u_t^j = u\left(c_t^j, p_t\right) + \xi_t^{j,e} m_t - s^{j,e}\left(1 - m_t\right)$$

The taste shocks follow a random walk stochastic process, which captures the persistence in the taste for the current marriage,

$$\xi_t^{j,e} = \xi_{t-1}^{j,e} + \epsilon_t,$$

where ϵ_t is distributed as $N\left(0, \sigma^2\right)$.

At the start of the life cycle when $t = 1$, $\xi_1^{j,e}$ can take five values for the wife and the husband with or without a college degree.

$$\xi_1^{j,L} \in \left\{-2\sigma_j, -\sigma_j, 0, \sigma_j, 2\sigma_j\right\},$$

where

$$\xi_1^{A,H} = \xi_1^{A,L} + \sigma_A$$

,

$$\xi_1^{B,H} = \xi_1^{B,L} - \sigma_B$$

.

The utility function $u\left(c_t^j, p_t\right)$ is constant relative risk aversion (CRRA) and is separable in consumption and participation in the labor market:

$$u\left(c_t^j, p_t\right) = \frac{\left(c_t^j\right)^{1-\gamma}}{1-\gamma} - q_{-e}p_t$$

, with $\gamma \geq 0$ and $q_{-e} > 0$.

B.2 Income Over the Life Cycle

Each spouse's labor income ($y_t^{j,e}$ for $j = A, B$ and $e = H, L$) depends on her human capital $h_t^{j,e}$ and on her permanent income ω_t^j:

$$\ln\left(y_t^{j,e}\right) = \ln\left(h_t^{j,e}\right) + \omega_t^j$$

Spouses experience permanent income shocks, which follow a random walk process:

$$\omega_t^j = \omega_{t-1}^j + \zeta_t^j \quad \text{and} \quad \omega_1^j = \zeta_1^j,$$

in which ζ_t^j is i.i.d. as $N\left(0, \sigma_\zeta^2\right)$ and is uncorrelated between spouses.

Human capital is accumulated through age. The law of motion for each spouse's human capital $h_t^{j,e}$ is

$$\ln\left(h_t^{A,e}\right) = \alpha_{0,e} + \alpha_{1,e}t + \alpha_{2,e}t^2$$

$$\ln\left(h_t^{B,e}\right) = \kappa_{0,e} + \kappa_{1,e}t + \kappa_{2,e}t^2 + \kappa_{3,e}t^3$$

Men always work until they retire. At the end of period $T - R$, spouses retire and receive a share of their preretirement income in every subsequent period.

B.3 Budget Constraint

In marriage, the general form of the budget constraint is

$$\frac{a_{t+1}}{1+r} - a_t + c_t = y_t$$

B.4 Marital Compatibility

Each type of couple has a subjective feeling for their current marital status, which differs by the education levels of both the wife and the husband (e_A, e_B). This parameter reflects the spouses' affection for one another and their attachment to marriage based on other idiosyncratic factors (e.g., how well partners in a marriage align across various domains, such as values, communication styles, decision-making, and conflict resolution).

Marital compatibility of a couple with education levels (e_A, e_B) is

$$M(e_A, e_B) = \mu_0 (1 - e_A)(1 - e_B) + \mu_1 * e_A e_B$$

If neither attained a college degree, $M(0,0) = \mu_0$. If both attained college degrees, $M(1,1) = \mu_1$. $M = 0$ for the other two types of households.

B.5 The Pareto Weight

The husband's bargaining power at the time of the marriage, θ, is a function of the distribution factors known at $t = 1$. Information known at the start of the life cycle fixes the cross-sectional weight.

As the primary distribution factors known at the time of marriage in my baseline specification, I include the difference between the log wage fixed effect for the wife and husband, and log household asset at the time of marriage:

$$z_0 = \left\{ \ln\left(h_0^{A,e}\right) - \ln\left(h_0^{B,e}\right), \ln(a_0) \right\}'.$$

Bargaining power of the husband at the time of marriage:

$$\hat{\theta}_0 = \hat{\alpha} + \hat{\vec{\beta}}' z_0.$$

In order to uncover the exogenous cross-sectional distribution of the Pareto weight $\hat{\theta}_0$, I run a Ordinary Least Squares regression using data from Japanese Panel Survey of Consumption that generates regression coefficients $\hat{\alpha}$ and $\hat{\vec{\beta}}$. I use the private consumption share of the husband as a proxy for his Pareto weight because the model does not include other possible proxies such as leisure hours share, home hours share, market hours share, or public expenditure share.

$$\theta = \hat{\alpha} + \hat{\beta}_1 \cdot \ln\left(\frac{\bar{w}_A}{\bar{w}_B}\right) + \hat{\beta}_2 \ln \bar{a}$$

Where I regress the time-series average of husband's private consumption share on the time series average of log earnings gap between spouses, and on the time series average of the amount of household assets for each household in the sample. Based on the estimated results from Lise and Yamada (2019), the main source of dispersion in the Pareto weight comes at the time of marriage. In the cross section, the relative weight ranges between 0.22 and 2.1, with a mean of 0.8. I normalize the derived Pareto weights of the wife so that they have the matched mean of 0.44, and ranges between 0.2 and 0.7.

B.6 Timeline for Shocks and Decisions

There are two types of family in the model, families of a married couple and families of divorcee. At $t = 1$, each individual draws with equal probability an education level e_j of being college educated or not. In every subsequent time

period between time t and time $t+1$, divorcees update the permanent wage shock ω_t^j, and then decide how much to save, how much to consume based on the realized shock. Female divorcees also make labor force participation decisions while male divorcees always work until retirement.

In every subsequent time period between time t and time $t+1$, married couples update the gender-education-specific marital preference shock $\xi_t^{j,e}$ and the permanent wage shock ω_t^j. Based on the realized shocks, they make divorce decisions after comparing their expected life time value of marriage with the expected life time value of the outside option. Conditioning on the divorce decision being made, each household, either remaining as married couple and make decisions collectively about savings, consumption, and female labor force participation, or make individual decisions as divorcees:

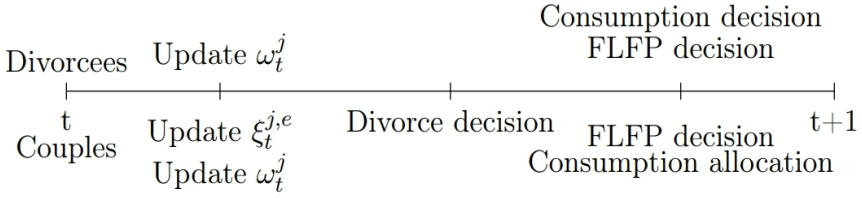


Figure 1. : Timeline for Shocks and Decisions

B.7 Problem of the Divorcee

I now characterize the value of being divorced, given state variables $W_t = \left\{H, \omega_t^j, a_t^j\right\}$, where H represents the 2 types of divorcees by education level.

In each period t, the divorcee chooses consumption, savings, and whether or not to work (if she is a woman). Thus, the value of being divorced and not remarrying at time t is

$$V_t^{jD}\left(W_t\right) = \max_{p_t, a_{t+1}^j} u\left(c_t^j, p_t\right) + \beta E\left[V_{t+1}^{jD}\left(\omega_{t+1}^j \mid \omega_t^j\right)\right]$$

s.t. budget constraint in divorce, for $j = A, B$

$$\frac{a_{t+1}^j}{1+r} - a_t^j + c_t^j = y_t^j$$

The budget constraint depends on the property division regime at the time of divorce, which is assumed to be community property regime in the model

$$\frac{a_{t+1}^j}{1+r} - \frac{a_t^j}{2} + c_t^j = y_t^j$$

B.8 Household Planning Problem

The couple's planning problem depends on the current divorce law regime. In unilateral divorce, assumed by the model, the couple divorces even if just one spouse wants to divorce. The household solves a constrained Pareto problem, in which the husband's Pareto weight is indicated by θ_0 and the wife's weight by $1-\theta_0$. The parameter θ_0 is determined exogenously.

Define $\mathrm{W}_t = \left\{H, \theta_0, q_{-e}, M\left(e, e^*\right), \xi_t^{j,e}, \omega_t^j, a_t\right\}$ the vector of variables over which the household maximizes. A couple that enters period t as married solves

$$V_t^M\left(W_t\right) = \max_{p_t, a_{t+1}} \theta_0 u^A\left(c_t^A\right) + \left(1-\theta_0\right) u^B\left(c_t^B, p_t, q_{-e}\right) + M\left(e, e^*\right)$$
$$+ \beta E\left[V_{t+1}^M\left(\omega_{t+1}^j, \xi_{t+1}^{j,e}, \mid \omega_t^j, \xi_t^{j,e}\right)\right]$$

s.t. budget constraint in marriage, for each married couple

$$\frac{a_{t+1}}{1+r} - a_t + c_t = y_t$$

B.9 Divorce Decision

In a unilateral divorce state, the couple maximizes the weighted sum of spouses' utilities in marriage under the constraint that both spouses must prefer the marriage allocation to the value of being divorced. Which is to say, the marriage allocation has to satisfy the participation constraints by comparing the expected life time value of marriage V^{jM} with the expected life time value of divorce V^{jD}, for $j = A, B$.

There are three cases that will lead to divorce in the model

case 1: only wife wants to stay together, assume no renegotiation

$$V^{AM} \leqslant V^{AD} \quad \text{and} \quad V^{BM} \geqslant V^{BD}, \theta_{t+1} = \theta_t$$

case 2: only husband wants to stay together, assume no renegotiation

$$V^{AM} \geqslant V^{AD} \quad \text{and} \quad V^{BM} \leqslant V^{BD}, \theta_{t+1} = \theta_t$$

case 3: both want to divorce, no need for renegotiation

$$V^{AM} \leqslant V^{AD} \quad \text{and} \quad V^{BM} \leqslant V^{BD}, \theta_{t+1} = \theta_t$$

To align with the fact that in Japan, the predominant ground for divorce is mutual consent under the "divorce by mutual agreement", I assume accordingly that there will be no credible threat of divorce thus no adjustment of bargaining power within a household unless both of the spouses agree to separate. This indicated that the "limited commitment" channel is shut down under this divorce regime.

There is only one case that will leave to divorce in the benchmark model

$$V^{AM} \leqslant V^{A1D} \quad \text{and} \quad V^{BM} \leqslant V^{B1D}, \theta_{t+1} = \theta_t$$

C. *Calibration*

In this section, I describe how I parameterize the model, using empirical targets derived from Japanese household data, as measured in the Japanese Panel Survey of Consumption (JPSC).

C.1 Data

I use the JPSC data covering the period from 1993 to 2013. The data include four cohorts: cohort 1 comprising 1,500 women aged 24-34 years in 1993, cohort 2 comprising 500 women aged 24-27 years in 1997, cohort 3 comprising 836 women 24-29 years in 2003, and cohort 4 comprising 636 women aged 24-28 years in 2008. In addition to rich data on demographics, education, wages and labor supply, the JPSC has a consumption expenditure module and a time use module. I choose cohort 1 as the benchmark cohort and compare female labor force participation life cycle patterns with cohort cohort 3. Figure 2 presents the comparison between cohort 1 and cohort 3 in terms of female participation and working hours. It shows higher female participation as well as higher female labor supply (conditional on working) everywhere in the life cycle for cohort 3. I keep married women and their husbands for whom I observe, for both spouses, (1) their demographic characteristics, such as current age, age at marriage, and education; (2) their expenditures and time use for at least two consecutive years; and (3) their wages for at least two consecutive years. The sample used in the baseline analysis includes 655 households (8,832 household-year observations).

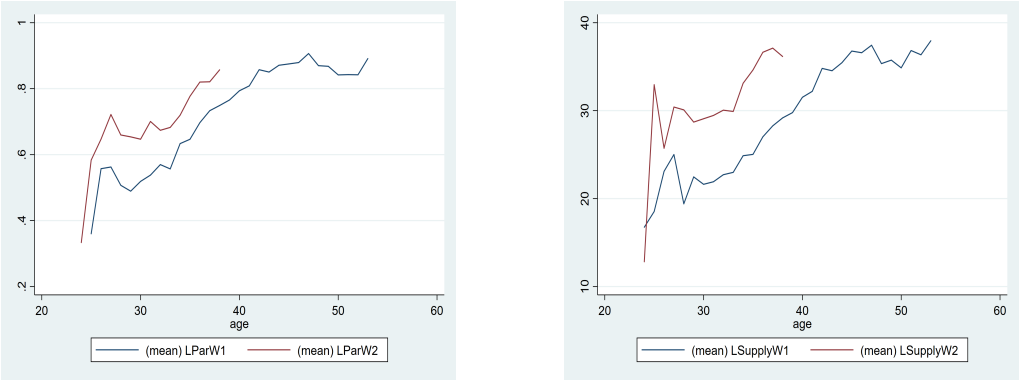


Figure 2. : Cohort Comparison of Female Labor Supply Pattern

The JPSC asks the following question about the components of household expenditures:

Please write down your household expenditure in September this year, including not only cash purchases, but also purchases with the credit loan(s), or those charged to your bank/post office account. (If there was no expenditure corresponding to the items below, put "0" for each answer.)

Importantly for my purpose, the JPSC also asks for breakdown of total household expenditures into the following five categories: (1) Expenses for all of your family, (2) Expenses for you, (3) Expenses for your husband, (4) Expenses for your child(ren), (5) Expenses for other(s).

I treat categories 1, 4, and 5 as expenditures used to produce the household public good, category 2 as private consumption of the wife c^B, and category 3 as the private consumption of the husband c^A.

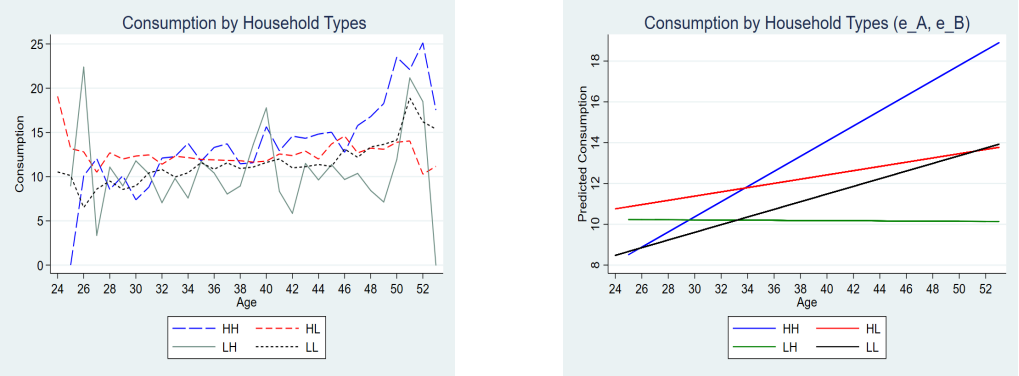


Figure 3. : Consumption by Household Types

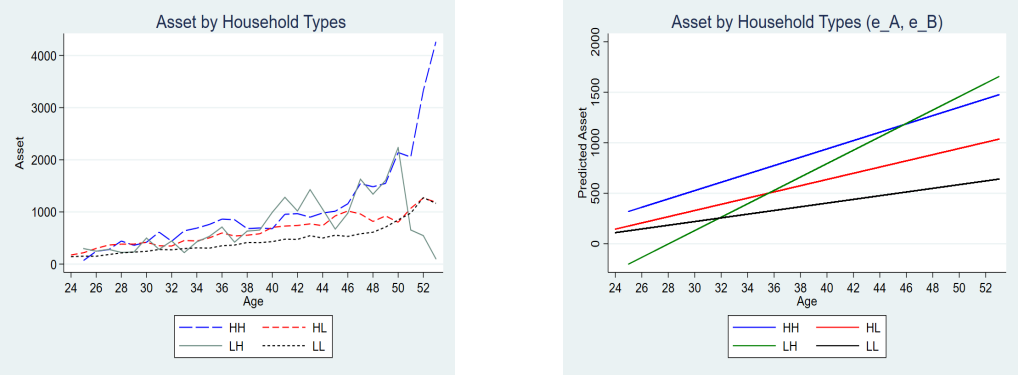


Figure 4. : Asset by Household Types

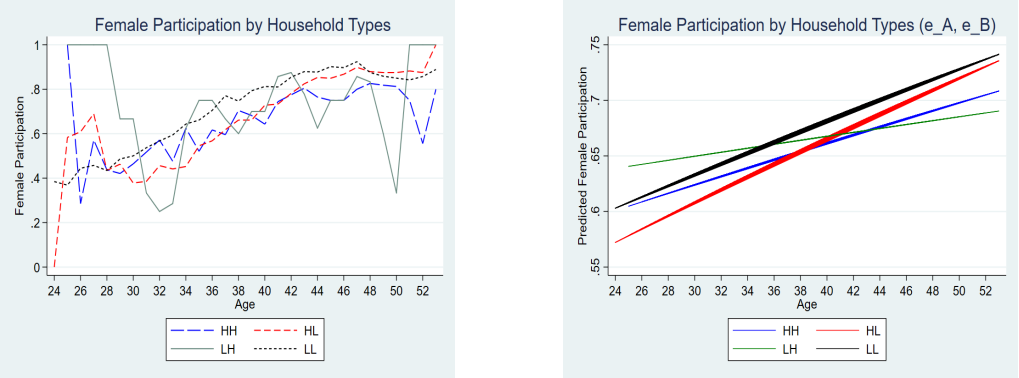


Figure 5. : Female Labor Force Participation by Household Types

Since the aim of this paper is to examine the life cycle patterns of consumption, asset accumulation, and female labor force participation, I therefore present in figure 3, 4 and 5 the life cycle patterns by household types observed in the JSPC data for the benchmark cohort. The left graphs show cross-sectional mean of consumption, asset and female labor force participation at each age generated from raw data for household types $e^A e^B$. To account for fixed effects within group and between groups, I run random effect regression to derive the predicted variables that filters out fluctuations.

C.2 Demographic and Initial Conditions

Households are born at age 21, when they start working. They retire at age 65, and die at age 80. Therefore, age 1 in the model corresponds to age 24 in the data, and consequently $t_R = 42$ and $T = 57$. Households start their life with assets ranging from 150 to 1700 that vary by household types and a permanent component of log hourly wages ranging from -2.308 to -1.821 based on individual's gender and education level. There is no transitory component for log wages.

C.3 Wage Process

The deterministic life cycle profile of male hourly wages is taken directly from the paper by Lise and Yamada (2019). They estimate this wage profile on JPSC data from 1993 to 2013. The age profile starts from age 24 and ends at age 53 for the benchmark cohort. However, Lise and Yamada (2019) report only a pooled wage profile for males and females. Because the life cycle earnings profile by human capital accumulation for females have different shapes compared to their male counterparts observed from the data as shown in figure 6 and figure 7, in the model I assume that deterministic life cycle wage profiles of female follow cubic spline. For example, in the JPSC data, average hourly wages of working college

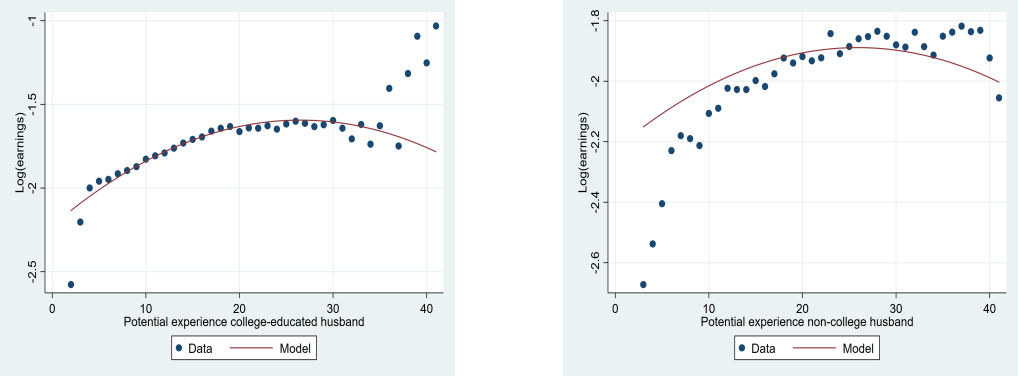


Figure 6. : Earnings Profile of Males

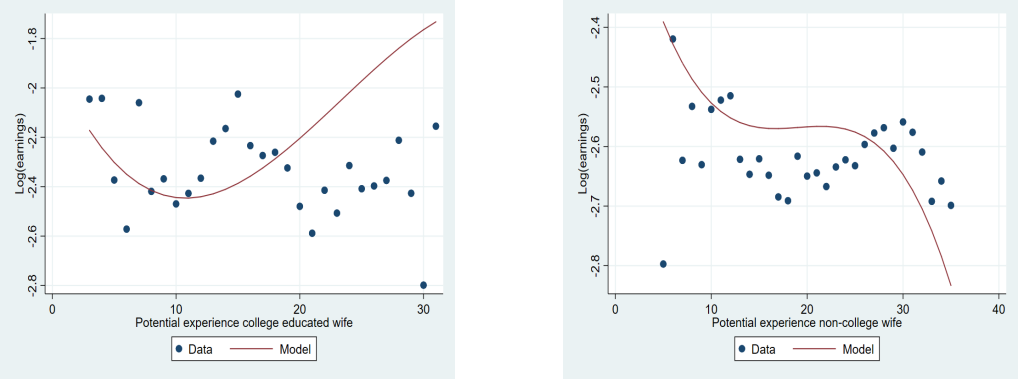


Figure 7. : Earnings Profile of Females

educated females is 0.507 times that of college educated males; I calibrate the level of female wages to match this earnings ratio.

Turning to the stochastic component of wages, the covariances matrix of permanent wage shocks is taken from Voena (2015), and modified in the calibration process so that it matches the life cycle mean of asset levels for the four household types, respectively. As in her work, the permanent wage shocks are assumed to be i.i.d. across time and uncorrelated between the two earners of a household:

$$\begin{bmatrix} \sigma^2_{\zeta_A} & \sigma_{\zeta_B,\zeta_A} \\ \sigma_{\zeta_A,\zeta_B} & \sigma^2_{\zeta_B} \end{bmatrix} = \begin{bmatrix} 0.15 & 0 \\ 0 & 0.1 \end{bmatrix}$$

2003 National Income Tax Brackets (Japan)

Taxable Income Range (JPY)	Tax Rate	Deduction (JPY)
0 – 3,300,000	10%	0
3,300,001 – 9,000,000	20%	330,000
9,000,001 – 18,000,000	30%	1,230,000
Over 18,000,000	37%	2,700,000

Figure 8. : Income Tax Rates by Annual Earnings

C.4 Discount Factor and Interest Rate

I adopt the Voena (2015) choice of real risk-free interest rate of $r = 2$ percent per year. The discount factor, a key determinant of household precautionary (and life cycle) saving, is calibrated such that the average asset level for households aged 24 to 53 in the model ranges from 368.7 to 890.5 by household types, as measured in the JPSC dataset. This delivers a time discount factor of 0.99.

C.5 Income Tax

I refer to the 2003 income tax rates in Japan since the sample spans from 1993 to 2013. In Japan, each earner in the household is taxed individually based on which bracket their income level lies within. The tax regime follows a progressive system shown in figure 8.

To determine the income tax rate for each of the four types of individuals, I calculate the average of their life cycle annual earnings in 10,000 Japanese yen. The average annual earnings for college educated male, non-college educated male, college educated female, and non-college educated female are as follows: 1004.4, 666.5, 321.1, 238.0. As a result, the respective income tax rates they face are: 30%, 20%, 10%, 10%.

C.6 Retirement Replacement Rate

The retirement replacement rate in Japan in 2003 refers to the ratio of an individual's pension benefits to their pre-retirement income. This measure is used to evaluate how effectively pensions replace earnings after retirement. According to OECD data on replacement rates in Japan (2003), the gross replacement rate is approximately 34-42% for an average worker. The model assumes each individual earns 40% of the pre-retirement income for each period during retirement.

C.7 Fix Utility Cost of Female Participation

In the data, only female workers have significant labor market nonparticipation rates. Since the JPSC sample is based on households of married wife with male members, I do not include an extensive margin of male labor supply decisions in the model. Based on empirical observation, the married female labor force participation depends more on the husband's education level than the education level of oneself. To generate empirically plausible female labor supply decisions along the extensive margin in the model, the fixed utility cost of married female labor market participation $q_{-e,m}$ is chosen such that the average female nonparticipation rate of households aged 24 to 53 is 34%, as in the JPSC dataset. Also observed in the data is the fact that all divorced females with a college degree choose to participate, at the same time, divorced females without college degrees have a nonparticipation rate of 13%. There are reflected in the choice of $q_{e,d}$.

C.8 Preference Parameters

With my preference specification, the parameter γ is the inverse of consumption Frisch elasticity, and set to be equal to 2. The number is adopted from Voena (2015) then adjusted upward to match the life cycle patterns of consumption and asset accumulation. I also directly adopted the parameter for economies of scale ρ in the household to capture the benefit of marriage compared with divorce to match the low divorce rate in the JPSC dataset.

Table 1 summarizes the calibration of the model, and Table 2 panel A reports the exogenously calibrated empirical targets as well as the (near-perfect) fit of the model along these dimensions. Table 2 panel B reports endogenously calibrated empirical targets for both married couple and divorcee, along with fit of the model along these dimensions.

D. Life Cycle Profiles in the Benchmark Economy

I now report, in Section D, the model-implied mean profiles over the life cycle of consumption, asset, and female labor force participation for married couple and divorcee by education level.

Figure 9 displays average consumption, asset, and labor supply profiles from age 24 to 80, for model generated results. As is common in life cycle models,

Table 1—: Calibrated Model Parameters

Parameter	Governing	Value
Panel A: Consumption Preferences		
β	Discount factor	0.99
$q_{-L,m}$	Disutility of participation	0.0028
$q_{-H,m}$	Disutility of participation	0.0023
$q_{L,d}$	Disutility of participation	0.013
$q_{H,d}$	Disutility of participation	0
γ	Inverse Frisch elasticity	2
ρ	Economies of scale	0.3
Panel B: Marital Preferences		
σ_{ϵ_A}	Match quality shock	0.85
σ_{ϵ_B}	Match quality shock	1.05
μ_0	Marital compatibility	0.5
μ_1	Marital compatibility	1
$s^{A,e}$	Stigma cost of divorce	10, 30
$s^{B,e}$	Stigma cost of divorce	100, 300
Panel C: Financial Market		
r	Risk-free interest rate	0.02
$\tau^{j,e}$	Income tax rates	0.3, 0.2, 0.1, 0.1
Panel D: Wage Process		
$\frac{h_0^{B.e}}{h_0^{A,e}}$	Fixed-effect wage ratio	0.81, 0.79, 1, 0.97
$\sigma^2_{\zeta_A}$	Permanent shock	0.15
$\sigma^2_{\zeta_B}$	Permanent shock	0.1
$\sigma^2_{t_1,A}$	Initial dispersion	0.74
$\sigma^2_{t_1,B}$	Initial dispersion	0.32

assets rise over the life cycle as households accumulate wealth to fund retirement consumption (and because $r > \frac{1}{\beta} - 1$), but also for precautionary reasons to hedge against stochastic wage fluctuations. Assets in the model peak at retirement (age 65 in the model) and are then drawn down to fund retirement consumption. Note that in the model, by the start of the life cycle, households on average have accumulated considerable amount of assets (see panel b of Figure 9).

Consumption in the model rises over the life cycle until around age 50 in the model before starting to decline. In the earlier stage, wage and earnings risk, and the associated precautionary saving, as well as fairly high degree of patience ($r - (\frac{1}{\beta} - 1) \approx 1\%$) lead to low consumption early in life and subsequent positive consumption growth. Overall, the model captures well the growth of consumption

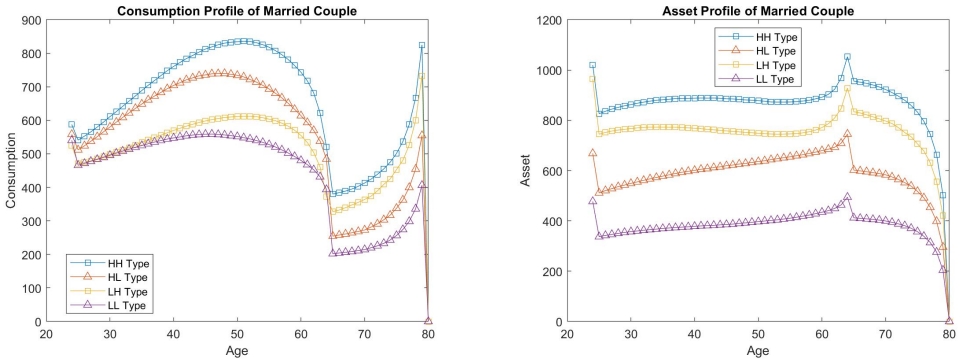
Table 2—: Empirical Targets Matched

Empirical targets	Data	Model
Panel A: Exogenously Calibrated		
College male labor income	-1.66	-1.66
Non-college male labor income	-2.06	-2.06
College female labor income	-2.34	-2.34
Non-college female labor income	-2.62	-2.62
Mean Pareto weight on wife	0.44	0.44
Panel B: Endogenously Calibrated		
Married couple consumption	13.6, 12.3	13.8, 12.7
	10.2, 11.1	10.6, 10.2
Married couple asset	890.5, 596.0	879.3, 593.0
	773.4, 368.7	767.9, 378.2
Married female participation	64.8%, 65.0%	64.5%, 64.6%
	66.2%, 66.4%	67.6%, 67.7%
Female divorcee participation	1, 86.6%	1, 87.3%
Divorce rate	0.23%	0.38%

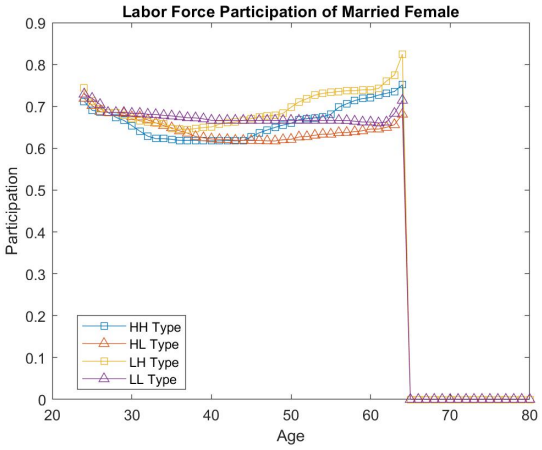
and assets over the life cycle in the data. Panel (c) of Figure 9 shows average married female labor force participation rates throughout the life cycle. There is considerable non-participation with the lowest rate at 20%. An U-shaped pattern is observed, meaning that female participation decreases with age until 40, before increasing with age.

Now I analyze the life cycle patterns of married couples by their types for consumption, asset accumulation, and female labor force participation rate. Panel (a) shows the consumption profiles of married couple. HH type consumes the most, followed by HL type, LH type, and LL type. The ranking remains until retirement, and there are considerable consumption gaps between types. In Japan, husband is the primary earner, the type of the husband largely determines the consumption level of the household. However, the education type of wife determines when will the consumption level peak within a life cycle. For instance, household with college-educated wife continues to increase consumption until a later stage in life, while household with non-college educated wife decrease their consumption well before retirement. After retirement, the consumption level rankings change in terms of the second and the third place. LH type surpasses HL type after age 65.

Panel (b) shows the asset accumulation profiles of married couple. HH type consumes the most, followed by LH type, HL type, and LL type. The ranking remains until age 80, and there are considerable asset gaps between types. The



(a) (b)



(c)

Figure 9. : Life Cycles of Cross-Sectional Means

Note: This figure shows the life cycles of cross-sectional means in the benchmark model with additively separable preferences for married couples age 24-80. There are four types of household in each panel by the couples education level: HH type for college educated husband with college educated wife, HL type for college educated husband with non-college educated wife, LH type for non-college educated husband with college-educated wife, LL type for non-college educated husband with non-college educated wife.

household type that consumes the most also has the highest asset level, and the household type that consumes least also has the lowest asset level. While at the same time, HL type consumes more but accumulates less asset, LH type consumes less but accumulates more asset.

Panel (c) shows the female labor force participation profiles of married couple. Although unlike consumption or asset, there is no constant participation ranking throughout the working age, there are two pair of relationships that can be

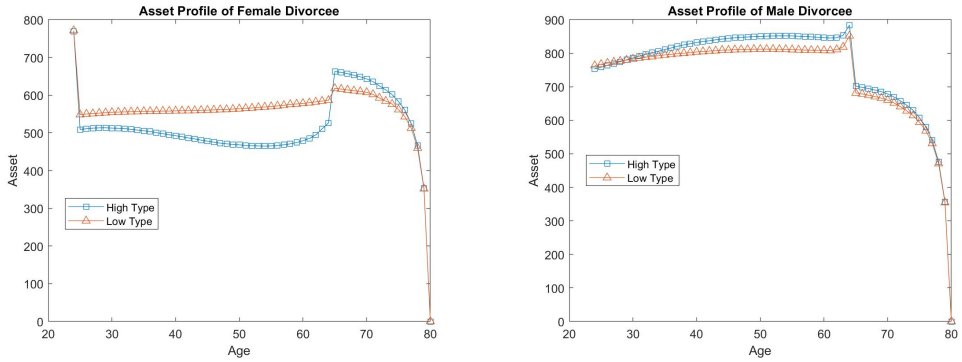
observed. If a college-educated female marries a non-college educated male, she will always have a higher probability of working compared to her counterpart who marries a college-educated male. At the same time, if a non-college educated female marries a non-college educated male, she will always have a higher probability of working compared to her counterpart who marries a college-educated male. Which means that married female labor force participation rate depends on the husband's education/income level, marrying a high type husband lowers the participation rate of married female controlling for the wife's type. Especially at the later stage of the life cycle (past 50), it becomes significant that college educated females have a higher probability of working compared with their non-college educated counterparts. The ranking in participation rate after 50 years old is: $LH > HH > LL > HL$.

Figure 10 displays model generated results of average asset level and labor supply profiles from age 24 to 80 for divorced individuals. As is common in life cycle models, assets rise over the life cycle as households accumulate wealth to fund retirement consumption (and because $r > \frac{1}{\beta} - 1$), but also for precautionary reasons to hedge against stochastic wage fluctuations. Assets in the model peak at retirement (age 65 in the model) and are then drawn down to fund retirement consumption. This trend of asset accumulation is commonly shared across different types of individuals except for college educated female. Their asset level first decrease relatively slowly until age 50 before rapidly increasing till retirement. Note that in the model, by the start of the life cycle, households on average have accumulated considerable amount of assets (see panel a and b of Figure 10).

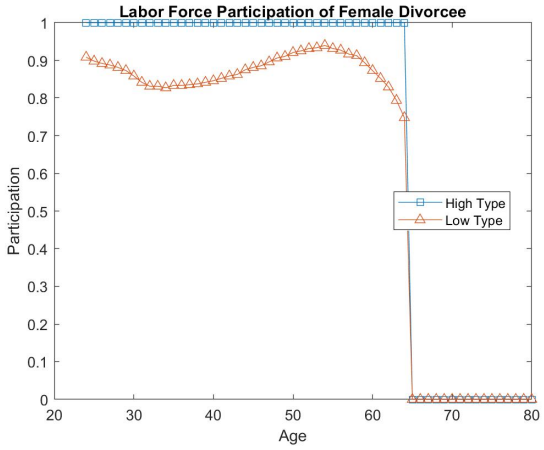
Overall, the model captures well the growth of assets over the life cycle in the data. Panel (c) of Figure 10 shows average divorced female labor force participation rates throughout the life cycle. There is considerably lower non-participation compared with their married counterparts. College educated female always works throughout their life. An U-shaped pattern is observed between age 24 and 55 for non-college educated female divorcee, meaning that female participation decreases with age until 30, before increasing with age, and decreasing again around age 50.

Now I analyze the life cycle patterns of divorced individuals by their types for asset accumulation and female labor force participation rate. Panel (a) and Panel (b) show the asset accumulation profiles of female and male divorcee, respectively. Low type female accumulated more asset compared to their college-educated peers for every period before retirement. After age 65, asset level for high type female becomes constantly larger than that of low type female. Male divorcee of both types have significantly higher level of asset comparing with female divorcees. At the same time, high type male accumulates more asset for every period of the life cycle from the start until the end. However, there is less asset gap between types for male divorcee compared with female divorcee.

Panel (c) shows the female labor force participation profiles of divorcee. College educated female divorcee has 100% participation as in the JPSC dataset. For non-



(a) (b)



(c)

Figure 10. : Life Cycles of Cross-Sectional Means

Note: This figure shows the life cycles of cross-sectional means in the benchmark model with additively separable preferences for divorced individuals age 24-80. There are two types of household in each panel by the individual's education level: High type for college educated, Low type for non-college educated.

college educated female divorcee, participation lowers to 80% at the start of age 30, then starts to increase until age 50 before decreasing again. The average participation rate for low type female divorcee is 87% in the benchmark model as in the dataset, showing a fairly well match of female labor force participation life cycle patterns between the benchmark model and the dataset.

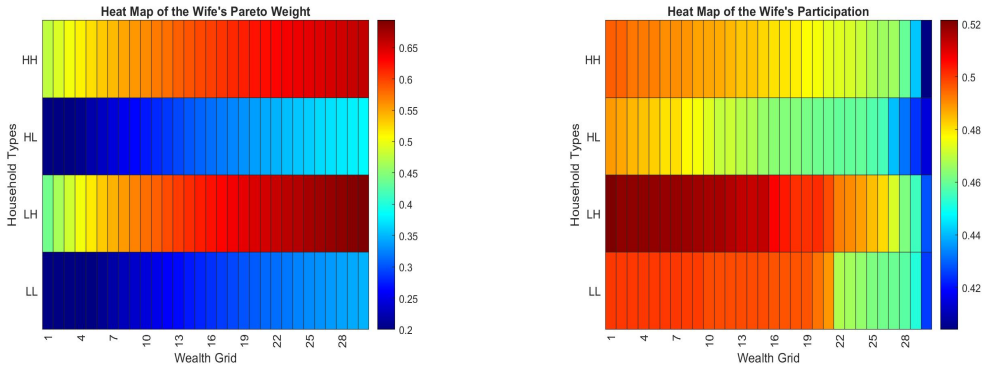


Figure 11. : The Pareto Weight and Female Participation

Note: This figure shows the cross-sectional variation of the Pareto weight and female labor force participation in the benchmark model with additively separable preferences for married couple age 24-80. There are four types of household in each panel by the combination or their education levels, there are 30 wealth grids with level of assets from low to high in each panel.

E. The Pareto Weight and Female Participation

Now I analyze the cross-sectional patterns of married couples by their types for the Pareto weight and married female labor force participation rate. The left graph shows how the Pareto weight of wife varies with the household type and household asset level. It can be concluded that college educated wife has higher bargaining power comparing to their non-college educated counterparts. Especially, if a college-educated wife marries a non-college educated husband, the Pareto weight can be as high as 70%. On the contrary, if a non-college educated wife marries a college educated husband, her Pareto weight can be as low as 20%. Another pattern to be noticed is the low bargaining power of wife for LL type household, even if the spouses have the same education level, the resource allocation inside the household could be very unequal. The higher the asset level of the household, the higher the wife's bargaining power, regardless of the household type.

The right graph shows how the wife's labor force participation rate varies with household type and asset level. College educated wife marrying non-college educated husband has a significantly higher rate of participation compared with other cases. It is partly due to their relatively higher income, and at the same time due to their ability to receive larger share of resources in the allocation stage since they have higher bargaining power. For the similar reason, but completely opposite case applies to non-college educated wife marrying college-educated husband, leading to the lowest rate of participation among the four types. It is worth noticing the high female labor force participation rate for LL type, even if the wife has the lowest bargaining power among different types of households, her probability to work is the second highest. More information is needed to discuss

why this is the case and its policy implications. It would shed light on the topic since LL type consists of the largest share of households in the JPSC dataset. The higher the asset level of the household, the lower the wife's rate of participation, regardless of the household type.

III. Concluding Remarks

In this paper, I show that intra-household bargaining matters for female labor force participation decisions. Starting from a simple non-unitary model with only two periods, the analytical results suggest that private consumption allocation is proportional to the Pareto weight. The female participation surplus in terms of additional life time value gained from working is inversely related to the bargaining power of wife. Extending this simple framework to a classical life cycle problem, I introduced heterogeneous households by education level, endogenous family composition transition, and cross-sectional variation of bargaining power. Results show that there are significant variation by types in terms of consumption and asset accumulation throughout the life cycle. There is also gender asymmetry in terms of asset accumulation patterns for divorced individuals. There is a general pattern that higher bargaining power of wife within the household leads to higher rate of participation. An exception is the household that consists of both non-college educated spouses. Despite the low bargaining power of wife, their rate of participation is the second highest.

In order to make use of the rich time use data, I plan to extend the utility function to include elastic working hours. This allows for the measurement of the second-earner effect in the intensive margin. I also plan to calibrate the model closely to the tax regime in Japan, conducting counterfactual analysis to the benchmark model that can shed light on policy responses to not only progressivity but also the collective vs. individual taxation debate. In addition to the future works mentioned above, I will do sensitivity analysis on the parametrization of the Pareto weight, and relaxing the non-renegotiation assumption to allow for dynamic adjustment of the bargaining power as new information is revealed when time evolves.

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