

A Quantitative Model of Non-Marriage and Fertility*

Bargaining over Leisure

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ABSTRACT This paper introduces a new factor contributing to the decline in marriage and fertility: the growth of leisure technology. Over recent decades, high-income countries have experienced two notable shifts in household and family dynamics. First, there has been a significant decline in marriage rates and fertility. Second, time has increasingly been allocated to leisure activities. This paper presents a unified model of marriage and fertility, incorporating intra-household bargaining dynamics. The model, calibrated using data from Japan between 2018 and 2022, is employed to assess the impact of leisure technology growth on marriage and fertility during 2005-2009. The findings highlight that leisure technology growth makes single life relatively more appealing compared to marriage and parenthood. The model explains nearly the entire decline in fertility and accounts for 25% of the decline in marriage in Japan during this period.

1 Introduction

Most of the developed countries have been facing a decline in marriage (or partnerships) and fertility rates. The decline in fertility is often viewed as a major policy concern and many governments implement family-friendly policies to encourage childbearing. A substantial body of labor and macroeconomics literature investigates the mechanism behind fertility decline and the design of optimal policies. However, the connection between household formation and fertility, as well as the factors driving the decline in marriage rates and their potential influence on fertility decisions, are not yet fully understood.

This paper proposes a new driver of the marriage and fertility decline: the improvements in leisure technology. Leisure technology, such as video games and social media, has been dramatically

*I am grateful to my advisor Nezih Guner for his continued guidance and support. I thank Pedro Mira, Tom Zohar, and seminar participants at CEMFI Macro Reading Group, for their useful suggestions. I acknowledge financial support from the Maria de Maeztu Unit of Excellence CEMFI MDM-2016-0684, funded by MCIN/AEI/10.13039/501100011033, and CEMFI.

improved in the last decade, and the value of leisure has increased. One potential impact of the leisure technology growth could be the increase in the value of being single. Singles can enjoy their hobbies and leisure time without any constraints, while married couples have to compromise their leisure time with their partners and children, lowering incentives for marriage and partnerships.

In this paper, I study the impact of leisure technology growth on the marriage and fertility decline in Japan. Several factors make Japan an ideal case to study low fertility. First, marriage and childbirth are still strongly associated in Japan. According to the OECD data, the share of births outside of marriage in Japan was 2.4% in 2020, which is the lowest among the OECD countries. Hence, to understand low fertility in Japan, studying the entry into marriage and how married couples choose the number of children is crucial. Second, the fertility rate in Japan has been declining since 2000. Panel (a) of Figure 1 shows the fertility rate of women at age 45. The fertility rate started to decline from 2000 and reached 1.47 in 2022. During the same period, the share of never-married has dramatically increased in the past decades in Japan. Panel (a) of Figure 1 shows the share of never-married at age 45-54. For men, the share of never-married has gradually increased from 1980 and reached 27.1% in 2020. For women, the share started to increase from 2000 when the fertility rate started to decline and reached 17.2% in 2020. Since childbirth outside of marriage is very uncommon in Japan, the increase in the share of never-married is likely to be a significant contributor to the decline in fertility.

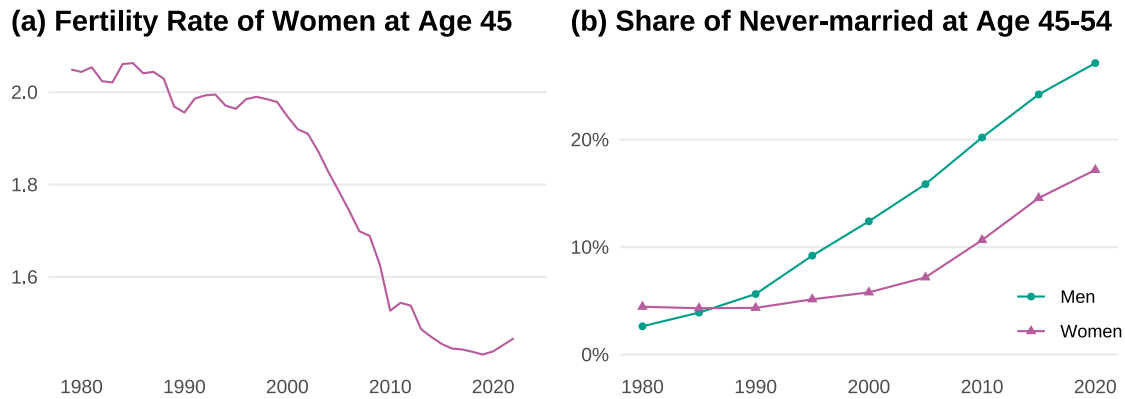


Figure 1: Marriage and Fertility in the Past Decades in Japan. Panel (a) shows the fertility rate of women at age 45. The data is from the Human Fertility Database. Panel (b) shows the share of never-married at age 45-54. The data is from the Japanese Censuses.

To explore the impact of leisure technology on the decline in marriage and fertility in Japan, I begin by documenting key patterns, including the reasons for remaining single, the time allocation differences between singles and married couples, and the trends in marriage and fertility rates. First, survey data reveals that 22 % of men and 24 % of women choose to remain single to pursue hobbies, while 27 % of men and 31 % of women prefer the freedom of being single. This indicates that the desire and opportunity to enjoy more leisure time as a single person can discourage marriage, as singles believe their leisure time will decrease after marriage. I refer to this as the “marriage penalty on leisure.” Second, panel data analysis shows that wives experience a

significantly more significant decline in leisure time compared to their husbands, which I term the “child penalty on leisure.” Finally, I document that the distribution of leisure time between married couples is influenced by their relative wages, with the lower-wage partner having less leisure time. This finding aligns with household bargaining, where the higher-earning partner enjoys more leisure time, contributing to the marriage penalty on leisure.

To quantify the impact of leisure technology on the decline in marriage and fertility, I develop a model of time allocation and household formation. This model includes single and married individuals, each with a stochastic life cycle. Individuals differ in their labor market productivity. In each period, singles are randomly matched with other singles, and marriage occurs if both parties agree. Married individuals must decide how to allocate their time among work, household work, and leisure, as well as when and where to have children. While children bring utility, they also increase the household workload for parents. Household work is modeled as a time requirement that has to be met by aggregating time inputs by husbands and wives. The parameters of this aggregation are allowed to change over time to reflect changes in the social norms, which become more egalitarian.

Marriage has economic value due to resource pooling, and a random utility value that reflects the match quality between partners. Although married couples have more resources, their time allocation is more constrained. A couple jointly decides how to allocate time and how many children to have, with bargaining power determined by their relative wages. Individuals with lower wages have less leisure time and experience a more significant reduction in leisure time when they have children. Households get utility from consumption, children and leisure. The utility weight of leisure is allowed to change over time to capture changes in the leisure technology. When deciding whether to marry, an individual considers the value of remaining single, including potential opportunities to meet other partners. The distribution of potential partners is endogenous and is determined by the decisions of all individuals.

I estimate the parameters of the structural model using data for the 2018-2022 period. The model generates the observed pattern of household time allocation, marriage, and fertility rates. It also captures the heterogeneous marriage rate by earnings and the child penalty on leisure, which are not targeted in the calibration.

I then apply the model to examine the factors driving the decline in marriage and fertility in Japan over recent decades, with a particular focus on the impact of leisure technology growth. In addition to leisure technology, I also consider the effects of rising female wages and changes in gender roles within households—two factors that have also undergone significant shifts in the past decade and have been extensively studied in the literature regarding their influence on marriage and fertility rates.

The model successfully accounts for a substantial portion of the observed decline in marriage and fertility over the last decade, explaining 25% of the decline in marriage and 137% of the decline in fertility. Decomposition analysis reveals that the growth of leisure technology has been the most significant factor contributing to the decline in fertility, as it increases the relative value of leisure compared to having children.

Related Literature My first contribution is to introduce the leisure technology growth as a new driver of the marriage and fertility decline. The impact of leisure technology growth on the labor supply and the value of leisure has been studied by others. Kopecky (2011) builds a model of endogenous retirement with leisure production and show that the decline in the price of leisure goods makes retirement more attractive. Aguiar et al. (2021) show that the leisure technology growth in computer games can explain the 2% decline in the labor supply of young men in the US in the last decade. Kopytov, Roussanov, and Taschereau-Dumouchel (2023) also show the decline in in prices of recreational activities can explain a large proportion of the decline in the labor working hours in some OECD countries.² However, little is known about the impact of leisure technology growth on the marriage and fertility decline. By incorporating the leisure technology growth into the model, I show that the leisure technology growth can explain a significant proportion of the marriage and fertility decline in the last decade.

This paper also contributes to the labor and macroeconomics literature that studies changes in marriage and fertility in high-income countries.³ As an early work Ahn and Mira (2002) points out the negative correlation between fertility and female labor force participation in high-income countries. Female earnings and labor market arrangements that affect female labor supply have been studied as a key factor in the recent marriage and fertility decline (Santos and Weiss (2016); Adda, Dustmann, and Stevens (2017); Blasutto (2023); Guner, Kaya, and Marcos (2023); Cruces (2024)). Within this literature Greenwood et al. (2016), which builds a dynamic marriage model with home production technology growth. While their model explains the decline in marriage rates in the US by the decrease in the price of home production inputs, the model does not include an endogenous fertility decision or leisure choice. Baudin, De La Croix, and Gobbi (2015) build a model of endogenous marriage and fertility, however, their model is static and does not consider a dynamic household formation.⁴

Another related literature focuses on the importance of the bargaining power and intra-household decision-making.⁵ Knowles (2013) studies intra-household bargaining and labor supply and show that the gender asymmetry in bargaining power explains the time trends of female labor supply in 1970-2001 in the US. Burda, Hamermesh, and Weil (2013) document a negative relationship between GDP per-capita and gender differences in total work, and emphasize the role of social norms and intra-family bargaining. To study the relationship between the bargaining power and fertility, Doepke and Kindermann (2019) build a Nash-bargaining model of fertility. While these models highlight the importance of the relative bargaining power to explain the intra-household decision-making, it is absent that the partnership formation with the bargaining after the marriage. The current model endogenizes the marriage given the expectation of household decision-making after the marriage.

²For the United States, the negative impact of the decline in the price of recreational goods on hours in the labor market has been studied by González-Chapela (2007) for the period 1976–93 and Vandenbroucke (2009) for the period 1900-1950s.

³See Greenwood, Guner, and Marto (2023) and Doepke et al. (2023) for comprehensive reviews of this literature.

⁴Myong, Park, and Yi (2021) extend the model of Baudin, De La Croix, and Gobbi (2015) by incorporating the social norms and explain the marriage and fertility decline in South Korea.

⁵Basu (2006) and Iyigun and Walsh (2007) provide theoretical models of endogenous bargaining power.

Finally, this paper deepens the economic understanding of the decline in marriage and fertility in Japan. Kitao and Nakakuni (2024) build a static model of marriage and fertility and show that one of the main drivers of the marriage and fertility decline in Japan from 1970 to 2020 is the change in home production technology and the increase in time and financial costs of childcare. While this paper captures the trends in marriage and fertility rates in the past decades, it does not consider the impact of leisure technology growth and gender asymmetries in bargaining power. Lise and Yamada (2019) study the collective model of intra-household allocation and welfare analysis in Japan, and Guo and Xie (2024) extend it by incorporating the arrival of the first child. While these papers focus on the intra-household decision-making, the current paper investigates the marriage market and family formation given the expectation of intra-household bargaining.

The rest of the paper is organized as follows. Section 2 documents the stylized facts of the marriage and fertility decline. Section 3 presents the model of time allocation and household formation. Section 4 describes the calibration strategy. Section 5 estimates the parameters of the model using the census and the household survey. Section 6 shows the model’s ability to reproduce the observed pattern of the marriage and fertility rates. Section 7 concludes the paper.

2 Facts

This section investigates the reasons why people do not get married and provides stylized facts to help the model construction. The results point out the importance of leisure time in the marriage decision and suggest that the intra-household bargaining power might be a mechanism of disincentivizing people from marriage and childbirth.

2.1 Data and Samples

The main data source for the empirical analysis is the Japanese Household Panel Survey (JHPS). JHPS is a panel data that started in 2004, with the most recent data wave from 2022. The original sample in 2004 was nationwide and contained 4000 households and 7000 individuals older than 20, and additional samples were added in 2007 (1400 individuals), 2009 (4000 individuals), and 2012 (1000 individuals). The survey has information on earnings, working hours, and other labor market outcomes, as well as on family structure, fertility, and other demographic variables. For the details of the data, see Appendix B.1.

The survey also has information on hours spent on housework and childcare, and I define the hours spent on leisure as the residuals of the total time budget. For the following discussion, I will use the terms “working hours” and “hours worked” to refer to the sum of hours spent on the market. The term “domestic labor” will refer to the sum of hours spent on housework and childcare. The term “leisure” will refer to the residual. I assume the total time budget is 16 hours per day and $16 \times 7 = 112$ hours per week. Hence, the weekly leisure hours are calculated as the total time budget (112 hours) minus the sum of working hours and domestic labor per week.

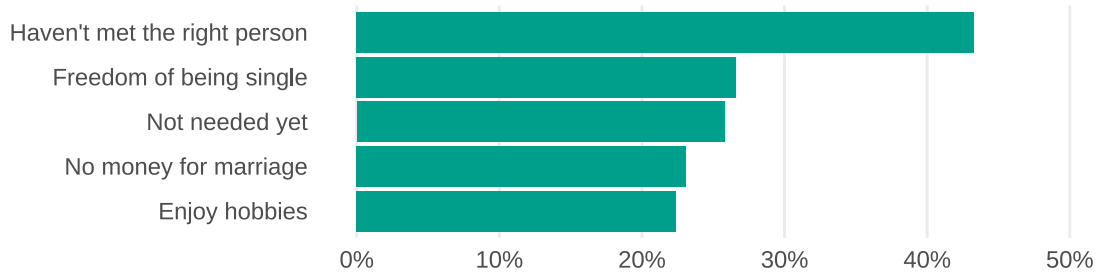
The sample is restricted to people aged 25-54 in the period 2005-2022. The data in 2004 is not used because the domestic labor data is not available. The sample of singles is restricted to those who have a job, a positive leisure time, and no children. The sample of married couples is also restricted to those who have a positive leisure time, however, it includes non-working individuals.

As a supplemental data source, I use aggregated statistics from the National Fertility Survey (NFS), which investigates the situation and issues regarding marriage, childbirth and child-rearing every five years. I mainly use the questions about the reasons why people do not get married.

2.2 Why People Do Not Marry

What is the main reason why people do not get married? The NFS provides the information on the main reasons people do not get married. Figure 2 shows the top 5 reasons in 2021.⁶ The sample is restricted to singles aged 25-34.

Men



Women

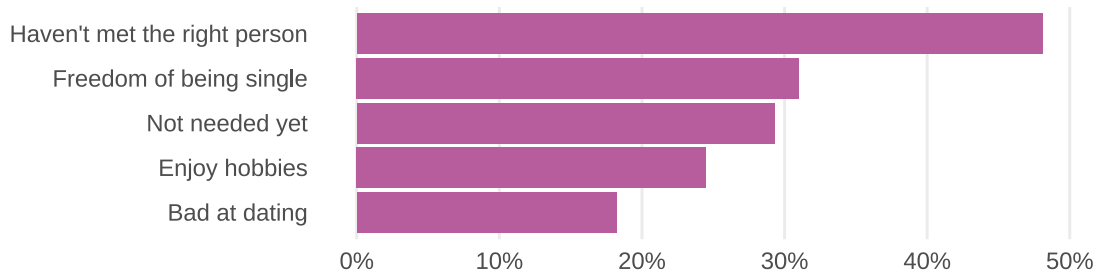


Figure 2: Top 5 Reasons Why Do not Get Married. The share of the top 5 reasons why do not get married. The data is from the National Fertility Survey and the sample is restricted to the age group 25-34 in 2021.

For both men and women, the top reason is “I haven’t met the right person”, which implies their difficulty in finding a partner with whom they spend a better time than being single. The third reason for both, “Not needed yet”, can also be interpreted in this context. They might expect that their life will not be improved with their potential partner. These elements will be represented in the model as a matching process with a potential partner and their marriage decision based on their expected value of being single and married.

“Freedom of being single” and “Enjoy hobbies” are also important reasons for both men and women. It implies that they expect that marriage will restrict their life and will not allow them

⁶I plot the time trends of these reasons from 1992 to 2021 in Figure 11. It seems that the share of the top reasons does not change much over time. However, given the fact that the share of never-married people is increasing and the survey sample is limited to singles, the number of people who agree with these reasons might be increasing.

to enjoy their hobbies enough. In other words, once they get married, they cannot live as well as they did when they were single. In the model, this will be represented as a couple's joint decision of time allocation and the bargaining power between them. If they get married, especially with a partner with a higher bargaining power, they may have less leisure time and their utility could be lower than being single.

2.3 Child Penalty on Leisure

Another important motivation for the marriage is to have children. On the other hand, raising a child is time-consuming and reduces the leisure time of parents. Hence, the reasons why people do not get married, "Freedom of being single" and "Enjoy hobbies", might be related to childbearing and its implications for time allocations within marriage.

To investigate the impact of childbirth on leisure time, I conduct an event study analysis. The specification is given by

$$y_{it} = \alpha_i + \lambda_t + \sum_{k \neq -1, -\infty} \beta_k \mathbb{1}\{E_i + k = t\} + \varepsilon_{it}. \quad (1)$$

The y_{it} is the time allocation of individual i at time t , α_i is the individual fixed effect, λ_t is the time fixed effect, and ε_{it} is the error term. The E_i is the time of the first childbirth of individual i , so the k represents the years to the first childbirth. The sample consists of the individuals who had their first childbirth during the sample period and the individuals who did not have a child in the sample period. For the individuals who did not have a child, the E_i is set to ∞ and the k is set to $-\infty$. While this is in the line with "child penalty" literature starting from Kleven, Landais, and Sogaard (2019), this specification includes the individual fixed effect to do a unit comparison. The importance of the individual fixed effect for the child penalty is discussed in Arkhangelsky, Yanagimoto, and Zohar (2024).

Figure 3 shows the coefficient β_k of the event study (1). For women, we can see a huge negative impact of childbirth on working hours (-17 hours at $k = 1$) and a positive impact on domestic labor (79 hours). The impact on men is relatively small (1 hours for working hours and 10 hours for domestic labor). Interestingly, the impact on women's leisure is negative and larger (-66 hours at $k = -1$) than men's leisure (-11 hours). This implies that a pure specialization is not held. If the reason why husbands work more in the market and wives work more in the house is the difference in their wages, the decline of leisure after childbirth should be similar for men and women. This child penalty on leisure might discourage women from having children.⁷

⁷Guo and Xie (2024) also show the child penalty on leisure in Japan by the specification of Kleven, Landais, and Sogaard (2019).

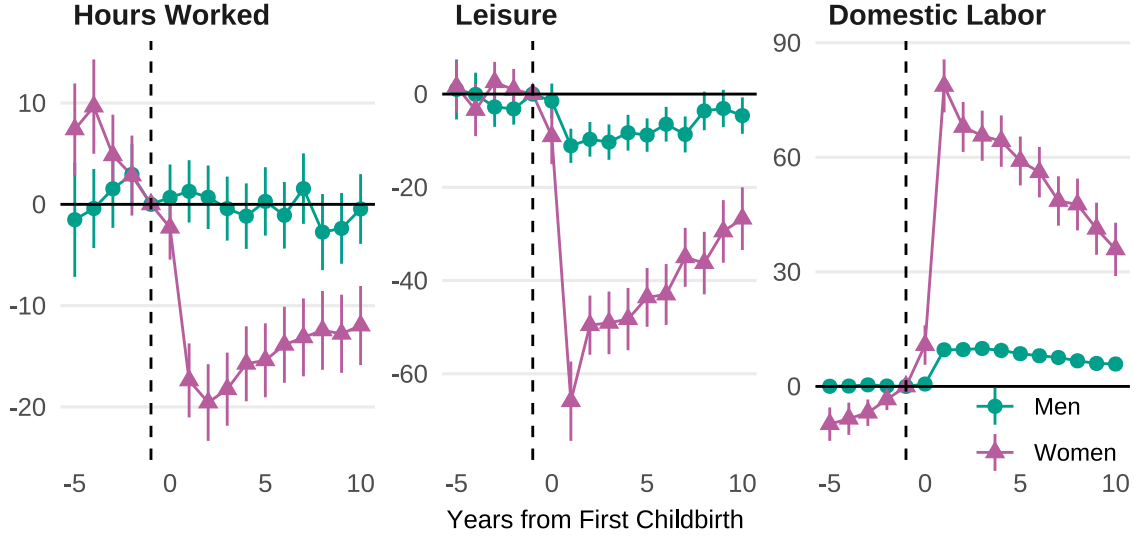


Figure 3: Event Study of Time Allocation by Childbirth. The child penalty on leisure for singles and married couples. The data is from the JHPS and the sample is restricted to the age group 25-54 in 2005-2022.

2.4 Intra-Household Time Allocation and Bargaining Power

Where does the child penalty on leisure come from? One possible explanation is the intra-household bargaining. If a husband has a higher wage than his wife, he might have more bargaining power on household time allocations. As a result, the wife might have less leisure time than the husband.

To highlight the role of bargaining, I study how relative earnings of husband and wives affect time allocations within households. I use bin-scatter (Cattaneo et al. 2024) with a couple of fixed effects and estimate the following relation. For a couple i at time t , I relate their relative time allocations to their relative earnings:

$$\log y_{it}^m - \log y_{it}^f = \phi(\log e_{it}^m - \log e_{it}^f) + \alpha_i + \varepsilon_{it} \quad (2)$$

For $g \in \{m, f\}$, m is for the husband and f is for the wife, y_{it}^g is the time allocation (hours worked, leisure, domestic labor). The e_{it}^g is their earnings, and α_i is the couple fixed effect. The $\phi(\cdot)$ is an arbitrary function of the log difference in earnings, which will be non-parametrically estimated in the bin-scatter algorithm. The sample is restricted to couples both of whom have a job to observe the bargaining power based on the earnings.

Figure 4 shows the relationship between the log difference in earnings and the time allocation. We see a positive relationship for working hours and a negative relationship for domestic labor. This is consistent with household specialization, the higher-wage husband works more in the market and his wife works more in the house. An interesting result is that the relationship for leisure is positive, i.e., the partner with higher earnings has more leisure time. This implies that

the husband has more bargaining power on leisure and might suggest that the bargaining power is a mechanism behind the child penalty on leisure.

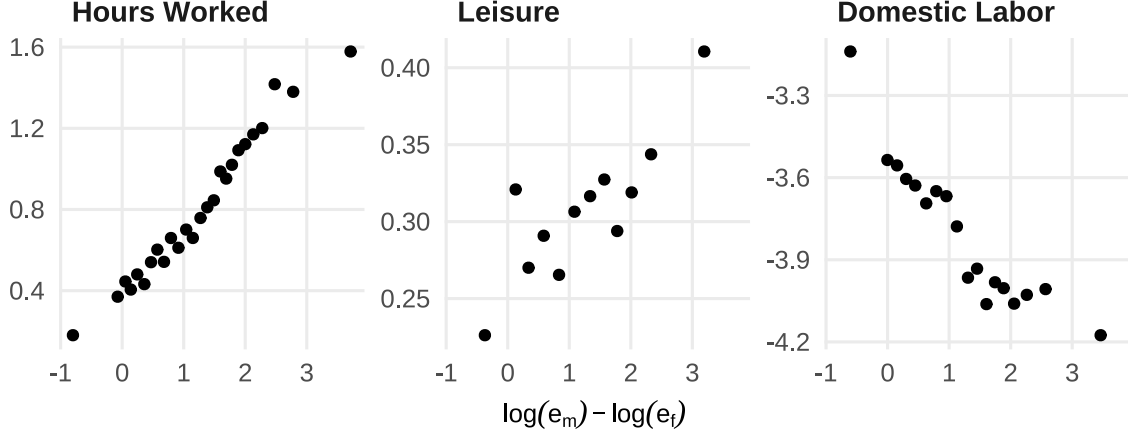


Figure 4: Intra-Household Time Allocation. A bin-scatter plot of the intra-household time allocation for dual-working married couples. The data is from the JHPS and the sample is restricted to the age group 25-54 in 2005-2022. The specification is given by equation (2) .

3 Model

3.1 Setup

The model economy consists of an equal mass continuum of men $i \in \mathcal{I}$ and women $j \in \mathcal{J}$. Individuals are distinguished by their discrete level of exogenous hourly wage, denoted w_i and w_j . It will be assumed that w_i and w_j are log-normally distributed so that $\log w_i \sim \mathcal{N}(\mu_{w_i}, \sigma_{w_i}^2)$ and $\log w_j \sim \mathcal{N}(\mu_{w_j}, \sigma_{w_j}^2)$. Some individuals of each gender will be married, the rest will be never married. Divorce is not allowed in this model. Married couples can have up to three children, while singles are not allowed to have children.

Individuals live forever but stochastically age and die. There are three states of life: young (Y), middle-aged (M), and old (O). A person faces a constant probability of aging and death. κ_0 is the probability of aging from Y to M and κ_1 is the probability of aging from M to O . From O , a person dies with probability δ . Upon death, an individual is replaced by a new single individual with the age Y and the wage $w_i \in \mathcal{W}$ or $w_j \in \mathcal{W}$.

Marriage and having a new child are allowed only for the couple with age Y or M , and they can only marry someone of the same age. Also, there are two states of the age of children, 0 and 1. Children age from 0 to 1 when their parents age from Y to M or from M to O .

Each individual is endowed with one unit of time each period. Households (single or couple) are also endowed with domestic labor requirements that depend on their marital status and the age and number of children. This requirement capture housework and childcare that have to be done by the household members. The household decides how to allocate time for the labor market, leisure, and domestic labor. Domestic labor decisions imply how time requirement is shared be-

tween the household members. A married couple with age Y or M also decides to have a new child or not if they do not have three children yet.

At the end of each period, a single person will meet someone else of the opposite gender from the set of singles of the same age. The couple will then draw a match-specific bliss shock $b \in \mathcal{B}$, taken from a distribution $G(b)$, which is assumed to be a normal distribution $\mathcal{N}(\mu_b, \sigma_b)$. In a marriage, the bliss shock stays constant over time and the couple will enjoy the same shock in each period.

Last, let all people have a common subjective discount factor β . People with age Y and M discount the future at rate β and people with age O discount the future at rate $\beta(1 - \delta)$. Suppose that for married, tastes over the consumption of market goods c , leisure hours l , and the number of children N are represented by

$$u(c, l, N) = \frac{c^{1-\gamma_c}}{1-\gamma_c} + \alpha_l \frac{l^{1-\gamma_l}}{1-\gamma_l} + \alpha_n \frac{(N+1)^{1-\gamma_n} - 1}{1-\gamma_n}. \quad (3)$$

Note that the singles do not have children in this model, so the number of children N is always zero and their utility function is simplified as

$$u(c, l) = \frac{c^{1-\gamma_c}}{1-\gamma_c} + \alpha_l \frac{l^{1-\gamma_l}}{1-\gamma_l}.$$

3.2 Singles

Consider the consumption and time allocation decision facing a single individual. This is a purely static problem and does not depend on the age of the single. For a single man of wage w_i , the problem is given by

$$v_i(w_i) = \max_{c_i, h_i, l_i, e_i, k_i} u(c_i, l_i), \quad (4)$$

subject to

$$c = w_i h_i, \quad (\text{Budget Constraint})$$

$$k_i = \psi_I^S, \quad (\text{Domestic Labor Constraint})$$

and

$$h_i + l_i + k_i = 1 \quad (\text{Time Constraint}).$$

The domestic labor requirement for singles is given as a gender-specific constant: ψ_I^S for men and ψ_J^S for women. The problem for a woman with wage w_j is similarly given by $v_j(w_j)$.

Next, consider the marriage decision facing a single. Suppose that a man of wage w_i with age $a \in \{Y, M\}$ meets a woman of wage w_j and the potential couple draws a bliss shock b . They decide to marry based on the expected lifetime utility of being single and being married. Let $W_i^a(w_i)$ and $W_j^a(w_j)$ be the expected lifetime utilities that both parties will realize if they remain single in the current period. Likewise, let $V_i(w_i, w_j, b)$ be the expected lifetime utility that is associated with a marriage in the current period. A marriage will occur if and only if

$$V_i^a(w_i, w_j, b) > W_i^a(w_i) \text{ and } V_j^a(w_j, w_i, b) > W_j^a(w_j). \quad (5)$$

Define an indicator function $\mathbb{1}^a(w_i, w_j, b)$ as taking the value of 1 if the couple marries and 0 otherwise. The value function for a single man of wage w_i with age a can be written as

$$\begin{aligned} W_i^Y(w_i) &= v(w_i) + \beta(1 - \kappa_0) \int_{\mathcal{B}} \int_{\mathcal{W}} (1 - \mathbb{1}^Y) W_i^Y(w_i) + \mathbb{1}^Y V_i^Y(w_i, w_j, 0, 0; b) d\hat{S}_j^Y(w_j) dG(b) \\ &\quad + \beta\kappa_0 \int_{\mathcal{B}} \int_{\mathcal{W}} (1 - \mathbb{1}^M) W_i^M(w_i) + \mathbb{1}^M V_i^M(w_i, w_j, 0, 0; b) d\hat{S}_j^M(w_j) dG(b), \\ W_i^M(w_i) &= v(w_i) + \beta(1 - \kappa_1) \int_{\mathcal{B}} \int_{\mathcal{W}} (1 - \mathbb{1}^M) W_i^M(w_i) + \mathbb{1}^M V_i^M(w_i, w_j, 0, 0; b) d\hat{S}_j^M(w_j) dG(b) \quad (6) \\ &\quad + \beta\kappa_1 W_i^O(w_i), \\ W_i^O(w_i) &= v(w_i) + \beta(1 - \delta) W_i^O(w_i). \end{aligned}$$

A single man at age Y enjoys $v(w_i)$ in this period. Next period, he gets aged to M with probability κ_0 or remains at age Y with probability $1 - \kappa_0$. Then he meet another single woman from the distribution $\hat{S}_j^a(w_j)$ for $a \in \{Y, M\}$. This is an endogenous object that will be determined in the equilibrium and formally defined in Section 3.4.

3.3 Couples

The consumption and time allocation decision facing a couple is also a static problem. A couple with age $a \in \{Y, M, O\}$, wage w_i and w_j , and N_0 children of age 0 and N_1 children of age 1 solves

$$\max_{c, h_i, h_j, l_i, l_j, k_i, k_j} (1 - \lambda(w_i, w_j)) u\left(\frac{c}{\Gamma(N_0, N_1)}, l_i, N_0 + N_1\right) + \lambda(w_i, w_j) u\left(\frac{c}{\Gamma(N_0, N_1)}, l_j, N_0 + N_1\right) \quad (7)$$

subject to

$$c = w_i h_i + w_j h_j, \quad (\text{Budget Constraint})$$

$$K(k_i, k_j) = \psi^M + \psi^N \mathbb{1}\{N_0 > 0\}, \quad (\text{Domestic Labor Constraint})$$

and

$$h_i + l_i + k_i = 1, h_j + l_j + k_j = 1 \quad (\text{Time Constraint}).$$

The bargaining power of the wife is given by

$$\lambda(w_i, w_j) = \frac{w_j^\rho}{w_i^\rho + w_j^\rho}, \text{ with } \rho \geq 0.$$

Hence, if the husband's wage is higher than the wife's wage, the husband has more bargaining power, especially for his leisure l_i since consumption of the market goods and the number of children are public goods in the household. The curvature parameter ρ captures the strength of the bargaining power by relative wage. If $\rho = 0$, the bargaining power becomes equal ($\lambda(w_i, w_j) = \frac{1}{2}$) and does not depend on wage difference. If $\rho = 1$, the bargaining power is determined by the

share of the wife's wage in the total wage. Appendix A.2 shows that if $\rho = 1$, the optimal leisure time of the married couple is equal, i.e., $l_i = l_j$. If $\rho > 1$, the bargaining power is larger than the relative wage difference, which, given observed gender wage gaps, leads to strengthening the husbands' bargaining power. Appendix A.2 also shows that the positive correlation between the intra-household gaps in wages and leisure time happens if and only if the bargaining power ρ is larger than 1.

The ψ^M represents the domestic labor requirement for married couples without children and ψ^N represents the additional domestic labor requirement for small children.⁸ The production function of domestic labor is given by a Cobb-Douglas function,

$$K(k_i, k_j) = k_i^{1-\theta} k_j^\theta. \quad (8)$$

The θ parameter represents the relative productivity of the wife in domestic labor and potentially captures the social norms of gender roles in domestic labor. This is because the higher θ incentivizes the wife to do more domestic labor and the husband to do less. I formulate the role of θ in Appendix A.3.

For ages Y or M , the couple also decides to have a new child or not. The couple decides to have a new child with the same bargaining power $\lambda_{ij} = \lambda(w_i, w_j)$ as the time allocation decision. Hence, the young couple solves

$$\begin{aligned} \max_{N_0' \in \{N_0, N_0+1\}, N_0' \leq 3} & (1 - \kappa_0) \left[(1 - \lambda_{ij}) V_i^Y(w_i, w_j, N_0', 0; b) + \lambda_{ij} V_j^Y(w_i, w_j, N_0', 0; b) \right] \\ & + \kappa_0 \left[(1 - \lambda_{ij}) V_i^M(w_i, w_j, 0, N_0'; b) + \lambda_{ij} V_j^M(w_i, w_j, 0, N_0'; b) \right] \end{aligned} \quad (9)$$

and the middle-aged couple solves

$$\begin{aligned} \max_{N_0' \in \{N_0, N_0+1\}, N_0' + N_1 \leq 3} & (1 - \kappa_1) \left[(1 - \lambda_{ij}) V_i^M(w_i, w_j, N_0', N_1; b) + \lambda_{ij} V_j^M(w_i, w_j, N_0', N_1; b) \right] \\ & + \kappa_1 \left[(1 - \lambda_{ij}) V_i^O(w_i, w_j, 0, N_0' + N_1; b) + \lambda_{ij} V_j^O(w_i, w_j, 0, N_0' + N_1; b) \right]. \end{aligned} \quad (10)$$

The first term in (9) captures the expected lifetime utility of the couple if they do not get aged to M . If they don't have three children yet, they can choose to have a new child or not, and the number of children at age 0 will be N_0' . The second term represents the expected lifetime utility of the couple if they get aged to M . When they get aged to M , their children will age from 0 to 1, and as a result, the number of children at age 0 will be zero and the number of children at age 1 will be N_0' . Note that this stochastic aging of children also applies to their newborn child, so the newborn child will be aged to 1 in the next period.⁹ The middle-aged couple's decision (10) is similar to the young couple's decision.

Let the indirect utility functions derived from the couple's time allocation problem be $v_i(w_i, w_j, N_0, N_1)$ and $v_j(w_i, w_j, N_0, N_1)$, which do not depend on the age of the couple. Given the

⁸In Appendix, Figure 12 shows that the domestic labor hours significantly increase with the existence of children but does not change much by the number of children.

⁹This assumption is made for computational reasons, to reduce the dimensions of the state space.

childbirth decision N_0^* , the value function for a married man of wage w_i and with N_0 children age 0 and N_1 children age 1 and a bliss shock b can be written as

$$\begin{aligned}
V_i^Y(w_i, w_j, N_0, 0; b) &= v_i(w_i, w_j, N_0, 0) + b \\
&\quad + \beta(1 - \kappa_0)V_i^Y(w_i, w_j, N_0^*, 0; b) + \beta\kappa_0 V_i^M(w_i, w_j, 0, N_0^*; b), \\
V_i^M(w_i, w_j, N_0, N_1; b) &= v_i(w_i, w_j, N_0, N_1) + b \\
&\quad + \beta(1 - \kappa_1)V_i^M(w_i, w_j, N_0^*, N_1; b) + \beta\kappa_1 V_i^O(w_i, w_j, 0, N_0^* + N_1; b), \\
V_i^O(w_i, w_j, 0, N_1; b) &= v_i(w_i, w_j, 0, N_1) + b + \beta(1 - \delta)V_i^O(w_i, w_j, 0, N_1; b).
\end{aligned} \tag{11}$$

The value functions for a married woman with age $a \in \{Y, M, O\}$ can be written similarly, $V_j^a(w_i, w_j, N_0, N_1; b)$.

3.4 Equilibrium

The dynamic programming problem for a single person, or equation (6), depends on the solution of the problem for a married person, as given by equation (11). In addition, solving the single's problem requires knowing the steady-state wage distribution of potential mates in the marriage market S_i^a and S_j^a for $a \in \{Y, M, O\}$. The non-normalized steady-state wage distributions for singles are given by

$$\begin{aligned}
S_i^Y(w_i) &= (1 - \kappa_0) \int_{\mathcal{B}} \int_{\mathcal{W}} \int_{\mathcal{W}}^{w_i} (1 - \mathbb{1}^Y(w'_i, w'_j, b)) dS_i^Y(w'_i) d\hat{S}_j^Y(w'_j) dG(b) \\
&\quad + \frac{\delta\kappa_0\kappa_1}{\kappa_0\kappa_1 + \delta(\kappa_0 + \kappa_1)} \int_{\mathcal{W}}^{w_i} dF_i(w'_i), \\
S_i^M(w_i) &= \kappa_0 \int_{\mathcal{B}} \int_{\mathcal{W}} \int_{\mathcal{W}}^{w_i} (1 - \mathbb{1}^Y(w'_i, w'_j, b)) dS_i^Y(w'_i) d\hat{S}_j^Y(w'_j) dG(b) \\
&\quad + (1 - \kappa_1) \int_{\mathcal{B}} \int_{\mathcal{W}} \int_{\mathcal{W}}^{w_i} (1 - \mathbb{1}^M(w'_i, w'_j, b)) dS_i^M(w'_i) d\hat{S}_j^M(w'_j) dG(b), \\
S_i^O(w_i) &= \kappa_1 \int_{\mathcal{B}} \int_{\mathcal{W}} \int_{\mathcal{W}}^{w_i} (1 - \mathbb{1}^M(w'_i, w'_j, b)) dS_i^M(w'_i) d\hat{S}_j^M(w'_j) dG(b) \\
&\quad + (1 - \delta) \int_{\mathcal{W}}^{w_i} dS_i^O(w'_i).
\end{aligned} \tag{12}$$

In the above equations, \hat{S}_j^a represents the normalized distribution of singles of the opposite gender for age $a \in \{Y, M\}$ and is given by

$$\hat{S}_j^a(w_j) = \frac{S_j^a(w_j)}{\int_{\mathcal{W}} dS_j^a(w'_j)}. \tag{13}$$

The first term of the $S_i^Y(w_i)$ in equation (12) counts those singles who did not marry in the current period and did not age to M . The second term represents the arrival of new adults. The mass of new arrivals is normalized as the total mass of singles and married couples is 1 in the steady state.

For its derivation, see Appendix A.1. $S_i^M(w_i)$ consists of the flow of singles who did not marry in the current period and aged to M and singles at age M who remained single and did not age to O . Since singles at age O do not marry, $S_i^O(w_i)$ consists of singles at age M who did not marry in the current period and aged to O and singles at age O who did not die in the current period.

Definition 3.4.1 (Stationary Matching Equilibrium): A *stationary matching equilibrium* is a set of value functions for singles $W_i^a(w_i)$ and $W_j^a(w_j)$ and couples $V_i^a(w_i, w_j, N_0, N_1; b)$ and $V_j^a(w_i, w_j, N_0, N_1; b)$; matching rules for singles $1^a(w_i, w_j, b)$; and *stationary distributions for singles* $S_i^a(w_i)$ and $S_j^a(w_j)$ such that:

1. The value function $W_i^a(w_i)$ solves the single's recursion (6), taking as given his indirect utility function $v_i(w_i)$ from problem (4), the value functions for a married person $V_i^a(w_i, w_j, N_0, N_1; b)$, the matching rule for singles $1^a(w_i, w_j, b)$ from (5), and the wage distribution of potential mates $\hat{S}_j^a(w_j)$ defined in (13).
2. The value function $V_i^a(w_i, w_j, N_0, N_1; b)$ solves the couple's recursion (11), taking as given his indirect utility function $v_i(w_i, w_j, N_0, N_1)$ from the couple's problem (7), and the child-birth decision N_0^* from the couple's problem (9) or (10).
3. The matching rule for singles $1^a(w_i, w_j, b)$ is determined by the equation (5), taking as given the value functions for $W_i^a(w_i)$, $W_j^a(w_j)$, $V_i^a(w_i, w_j, N_0, N_1; b)$, and $V_j^a(w_i, w_j, N_0, N_1; b)$.
4. The stationary distribution for singles $S_i^a(w_i)$ solves the equation (12), taking as given the matching rule for singles $1^a(w_i, w_j, b)$.

4 Calibration

The model developed will now be fit to the Japanese data for the period 2018-2022. Some parameters are exogenously determined based on a priori information or taken directly from data. Most of the parameters, however, will be estimated using a minimum distance procedure. In Section 6, the model will be simulated using female wages, social norms, and leisure technology from the period 2005-2009. It will be assumed that the model is in a steady state for each of these years. A comparison between two steady states will determine the key factors that can account for changes in marriage and fertility behavior.

4.1 Exogenous Parameters

The length of a model period is one year. Let β (the subjective discount factor) be 0.96, as the standard value in macroeconomics studies, such as in Prescott (1986). All the targets for the estimation are calculated for individuals between the ages of 25 and 54, which corresponds to an operational lifespan of 30 years. Let the aging and death probability $\kappa_0 = \kappa_1 = \delta = 1/10 = 0.1$, so that individuals in the model also live 30 years on average. Finally, following the Organization for Economic Co-operation and Development (OECD) equivalence scale, set $\chi_0 = 0.5$ and $\chi_1 = 0.3$.

Next, some parameters are directly computed from the data. Given the time constraint of the single's problem (4), domestic labor requirements for singles, ψ_I^S and ψ_J^S , are equal to their time

spent on domestic labor, k_i and k_j . Using the mean value of singles' k_i and k_j from the JHPS in the period 2018-2022, set $\psi_I^S = 0.031$ and $\psi_J^S = 0.058$. The domestic labor productivity parameter θ from (8) is fully characterized by the first-order condition for the maximization problem in (7)¹⁰:

$$\theta = \frac{w_j k_j}{w_i k_i + w_j k_j}. \quad (14)$$

Using the mean values $\frac{w_j k_j}{w_i k_i + w_j k_j}$ from the married couple from JHPS in the period 2018-2022, set $\theta = 0.677$. To sum up, the parameter values exogenously determined are summarized in Table 1.

Table 1: Exogenous Parameters

Parameter values	Source
$\chi_0 = 0.5, \chi_1 = 0.3$	OECD scale
$\beta = 0.96$	Prescott (1986)
$\kappa_0 = \kappa_1 = \delta = \frac{1}{10}$	30-year Lifespan
$\psi_I^S = 0.031, \psi_J^S = 0.058$	JHPS 2018-2022
$\theta = 0.677$	JHPS 2018-2022

4.2 Estimated Parameters

Now, 14 parameters will be estimated using a minimum distance procedure. There are five preference parameters, $\{\gamma_c, \gamma_l, \gamma_n, \alpha_l, \alpha_n\}$; two domestic labor requirements, $\{\psi^M, \psi^N\}$; three wage distribution parameters, $\{\mu_{w_i}, \mu_{w_j}, \sigma_{w_i}, \sigma_{w_j}\}$; two parameter for bliss shock, $\{\mu_b, \sigma_b\}$; and one parameter for the bargaining power ρ . As a normalization, the mean of log wage is set to zero, $\mu_{w_i} = 0$. The remaining 13 parameters are estimated so that the model matches a set of 13 data moments for the period 2018-2022.

Table 2 shows the selected targeted moments and their corresponding values computed from the data in the fourth column. Although all parameters in the model have an impact on all the targets, the table highlights the target that is most influenced by each specific parameter.

The curvature parameters of the utility function, γ_c , γ_l , and γ_n , directly affect the time allocation. As a result, the mean of leisure time of singles and married women are targeted. The preference strength for leisure, α_l , and the one of children, α_n , relate to the marriage and fertility decisions, and I choose the cohort fertility rate and the share of the women without children as the targets. The domestic labor requirements, ψ^M and ψ^N bind the domestic labor time of married women with and without children. The wage distribution parameters, μ_{w_i} , μ_{w_j} , σ_{w_i} , and σ_{w_j} , are chosen to match the female relative wage and the wage dispersion of singles. The bliss shock parameters, μ_b and σ_b , are related to the share of never-married women and also the wage gap between singles and married. Finally, the correlation between husband and wife's wages reflects the bargaining power ρ in the model because the bargaining power penalizes the singles to marry with a higher-wage partner.

¹⁰See Appendix A.3 for its derivation.

Table 2: Parameters Estimated (Minimum Distance)

	Value	Target	Source	Data	Model
γ_c	1.578	Mean of single l_i	JHPS 2018-2022	0.598	0.610
γ_l	1.187	Mean of single l_j	JHPS 2018-2022	0.616	0.580
γ_n	1.470	Mean of married l_j	JHPS 2018-2022	0.487	0.509
α_l	3.386	Cohort fertility rate	HFD 2018-2022	1.446	1.445
α_n	1.397	Share of women without children	HFD 2018-2022	0.279	0.259
ψ^M	0.116	Mean of married k_j without children	JHPS 2018-2022	0.155	0.153
ψ^N	0.117	Mean of married k_j with children	JHPS 2018-2022	0.337	0.232
μ_{w_j}	-0.293	Single's log $w_i - \log w_j$	JHPS 2018-2022	0.117	0.117
σ_{w_i}	0.679	S.D. of single log w_i	JHPS 2018-2022	0.744	0.703
σ_{w_j}	0.714	S.D. of single log w_j	JHPS 2018-2022	0.842	0.758
μ_b	-0.308	Share of never-married women	Census 2020	0.172	0.172
σ_b	0.330	Married's log w_i - single's log w_i	JHPS 2018-2022	0.474	0.424
ρ	1.420	Correlation of log w_i and log w_j	JHPS 2018-2022	0.175	0.181

Note: The first and second columns show the estimated value of the model parameters. The third column is the calibration targets and the fourth column is its source. The fifth and sixth columns are their moment values in the data and the baseline model. The distance between these columns is minimized by the method of simulated moments.

While most of the targets are from the JHPS 2018-2022, there are two targets from the Human Fertility Database (HFD) 2018-2022 and one from the 2020 Japanese Census. I choose the cohort fertility rate and the share of women without children in a cohort as the targets. I use the mean of the values of 1974-1978 cohorts, who reached age 44 in 2018-2022. For the model economy, I use the number of children for women with age O . The share of never-married is reported by each 5-year age group in the 2020 Japanese Census. I use the mean of the share of the never-married aged 45-54 as the target. The model moment is also computed for women with age O .

5 Baseline Economy

5.1 Estimated Parameters

The second column in Table 2 shows the estimated parameter values. By comparing the fourth and the fifth columns, which are the moments in the data and the model, we can see that the model matches all the targets reasonably well.

The estimate of the degree of curvature in the utility function for market goods ($\gamma_c = 1.58$) is in line with the macroeconomics literature, which typically uses a coefficient of relative risk aversion of either 1 or 2. The other curvatures, the one for leisure time ($\gamma_l = 1.19$) and for number of children ($\gamma_n = 1.47$), are also in the range between 1 and 2. The preference strength of leisure ($\alpha_l = 3.39$) is

significantly higher than the one for market goods (since it is normalized to 1), which may reflect the high value of leisure time these days.

The $\psi^M = 0.116$ represents the domestic labor requirement for married couples without children, and it takes a larger value than the aggregation of the domestic labor requirements for singles $K(\psi_I^S, \psi_J^S) = 0.047$. It reflects the fact that married couples spend more time on domestic labor than singles even without children.¹¹ The existence of small children nearly doubles the domestic labor requirement for married couples ($\psi^N = 0.117$).

While the variance of the log wage ($\sigma_{w_i} = 0.68$ for men and $\sigma_{w_j} = 0.71$ for women) takes close values to the observed log wage dispersion of the singles (0.74 for men and 0.84 for women), the gender gap in the mean of the log wage ($\mu_{w_i} - \mu_{w_j} = 0.29$) is significantly larger than the gaps in singles data (0.12). It suggests that the marriage rate gaps between people with high and low wages, and it will be shown in Figure 5 in Section 5.2.

The bliss shock parameters, $\mu_b = -0.31$ and $\sigma_b = 0.33$, suggest that the bliss shock is negative in the most of the matching (82%). This is a downforce for the singles to marry while marriage could improve their utility by the economy of scale ($\chi_0 = 0.5$) and the possibility of having children.

Finally, the fact that bargaining parameter $\rho = 1.42$ is larger than 1 is consistent with the positive correlation between intra-household gaps in wages and the leisure time shown in Figure 4.¹²

5.2 Marriage Rate by Earnings

Next, I show how the model economy performs along dimensions that are not targeted in the calibration. Figure 5 shows the marriage rate by earnings deciles, i.e., the first decile contains 0-10% of the population by earnings, and so on. The bars show the share of married individuals with age O in each decile of earnings in the baseline model. For the data moments, I use the Employment Status Survey 2022, which reports the number of people by earnings, age, and marital status. Since the data reports categorical earnings, I compute the cumulative density function of the earnings distribution and calibrate the marriage rate by earnings deciles by linear interpolation. For the details, see Appendix B.2.

¹¹One possible explanation is that married couples have different preferences on household chores. Married couples may prefer to cook by themselves, while singles prefer to eat out or buy ready-made meals.

¹²See Appendix A.2 for the proof.

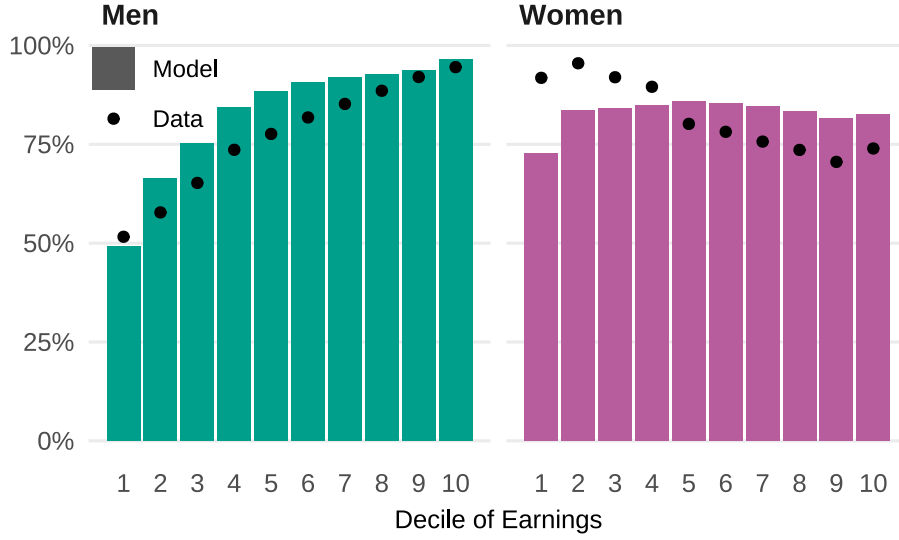


Figure 5: Marriage Rate by Earnings Decile. The bars show the share of married individuals in each decile of earnings in the baseline model. The points show the marriage rate estimated from the Employment Status Survey 2022.

The model economy captures the general pattern of the marriage rate by earnings. In particular, the model economy reproduces the positive correlation between the marriage rate and earnings for men. For women, the data shows that the marriage rate is higher for the lower deciles of earnings, while the model economy does not. One of the potential reasons for this discrepancy is that the model economy does not consider the exemption for low-income spouses in the income tax system.¹³ The exemption incentivizes married women to reduce working hours or to stay at home, which may lead to a higher marriage rate for the lower deciles of earnings.

5.3 Child Penalty on Leisure

In Section 2, I show that the time allocation changes around the first childbirth differ between men and women. Female leisure time decreases significantly more than male leisure time. Figure 6 shows a similar event study using the baseline model. I created a ten thousand single young men and women with wages drawn from $\mathcal{N}(\mu_{w_i}, \sigma_{w_i}^2)$ and $\mathcal{N}(\mu_{w_j}, \sigma_{w_j}^2)$, respectively. I simulate their time allocations and life events, such as marriage, childbirth, and death until 30 periods. The specification is the same as (1), however, I do not include time-fixed effects λ_t since time does not play a role in the simulation.

Figure 6 shows the results. To make a comparison with the data, the hours are re-scaled to weekly hours, i.e., $h + l + k = 16 \times 7 = 112$ hours. As in the data, the model economy shows a decline in working hours and a larger increase in domestic labor for women. The model economy also shows a decrease in leisure time for both men and women, which is consistent with the data. While it is also consistent with data that the decrease in leisure time is larger for women, the model economy

¹³Tax exemption for spouses in Japan and its effect on labor market outcomes are discussed in Kitao and Mikoshiba (2022).

shows a smaller difference in the decrease in leisure time between men and women (in one year after the first childbirth, 54.8 hours in the data and 2 hours in the model).

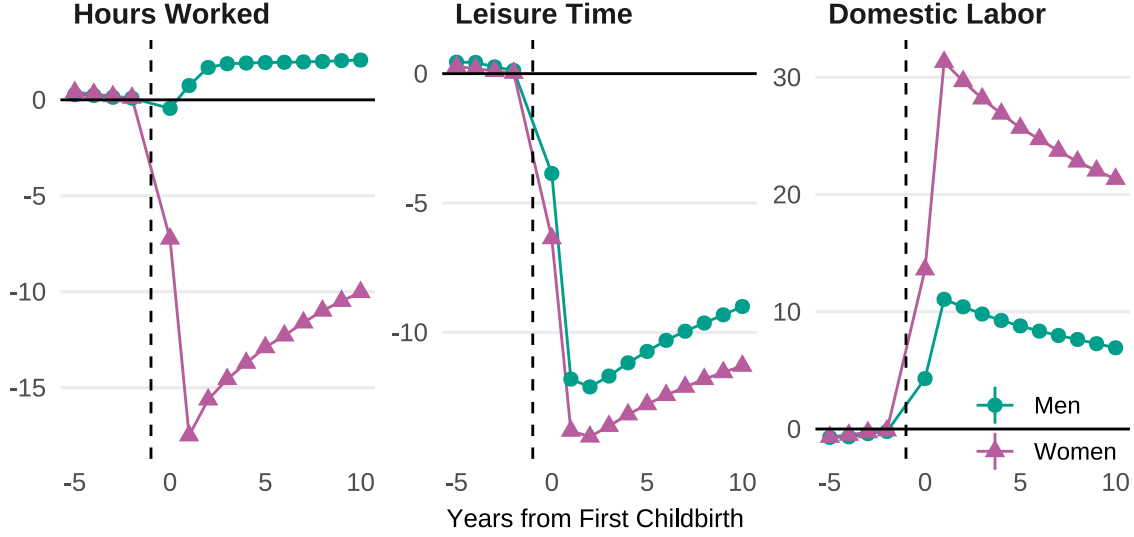


Figure 6: Child Penalty in the Baseline Model. The figure shows the event study of time allocation around the first childbirth in the baseline model.

6 Back to 2005-2009

In this section, I simulate for the 2005-2009 period. The main goal of this analysis is to disentangle the main drivers of the recent decline in the marriage rate and fertility rate in Japan. To answer the question, I show the three stylized facts that significantly changed in the past decades and may affect marriage and fertility decisions. Given the facts, I choose three model parameters that capture the three changes: female wage growth, change in social norms, and leisure technology growth. With all other parameters kept at the baseline values, I simulated the model to evaluate the impact of each factor on the marriage and fertility decisions.

6.1 What has changed since 2005-2009?

In this section, I will show the time trend of factors that may affect marriage and fertility decisions. As in the previous section, I will use the samples aged between 25-54 in the JHPS. The single sample is defined as those who work, are not married, and have no children. The married couple sample is defined as those who are married and have at most 3 children.

Panel (a) in Figure 7 shows the gender gap in the log wage of singles. Each point represents the differences in the average log wage and the linear fit is also plotted. From 2005, the female relative wage has increased by around 5%. Since this is not a small change, I will calibrate the parameter μ_{w_j} to capture this trend.

Panel (b) in Figure 7 shows the husband's share in domestic labor of married couples. The husbands' share in domestic labor has almost doubled from 2005 to 2022. I interpret this as the change

in social norms on gender roles, and I will discuss its impact on marriage and fertility decisions by calibrating the parameter θ .

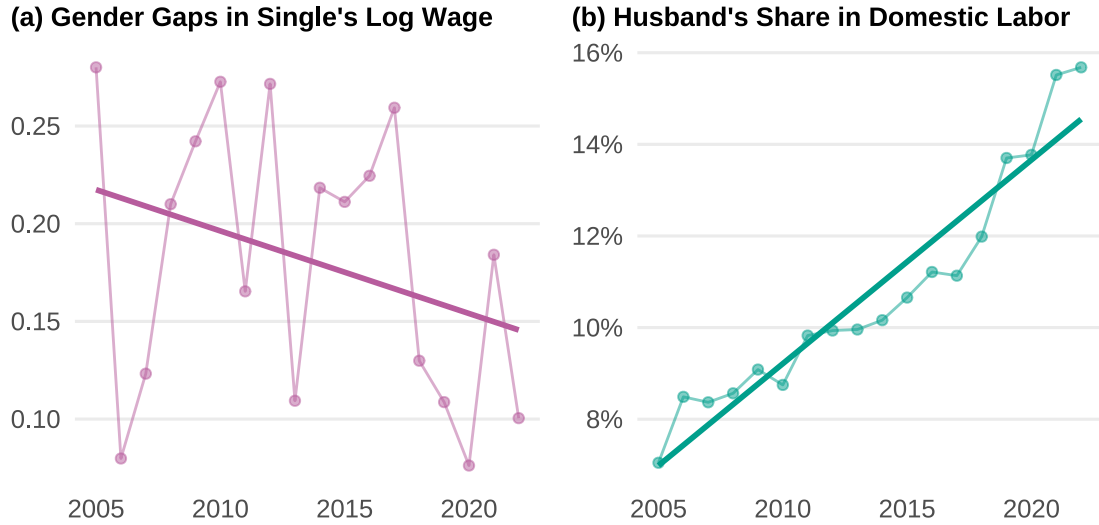


Figure 7: Female Wage Growth and Husband's Domestic Labor. Panel (a) shows the gaps in the average log wages of singles aged between 25-54. Panel (b) shows the husband's share in domestic labor of married couples aged between 25-54. In both panels, each dot represents the data point and the center line is the linear fit. The data from JHPS and see the text for the sample selection.

Finally, Figure 8 shows the average hours worked and leisure time of singles. Each point represents the average hours worked and leisure time for each year and the linear fit is also shown. The hours worked are decreasing and the leisure time is increasing over time. I interpret this as the increase in leisure technology, and I will estimate the parameter α_l to study its impact on marriage and fertility decisions.

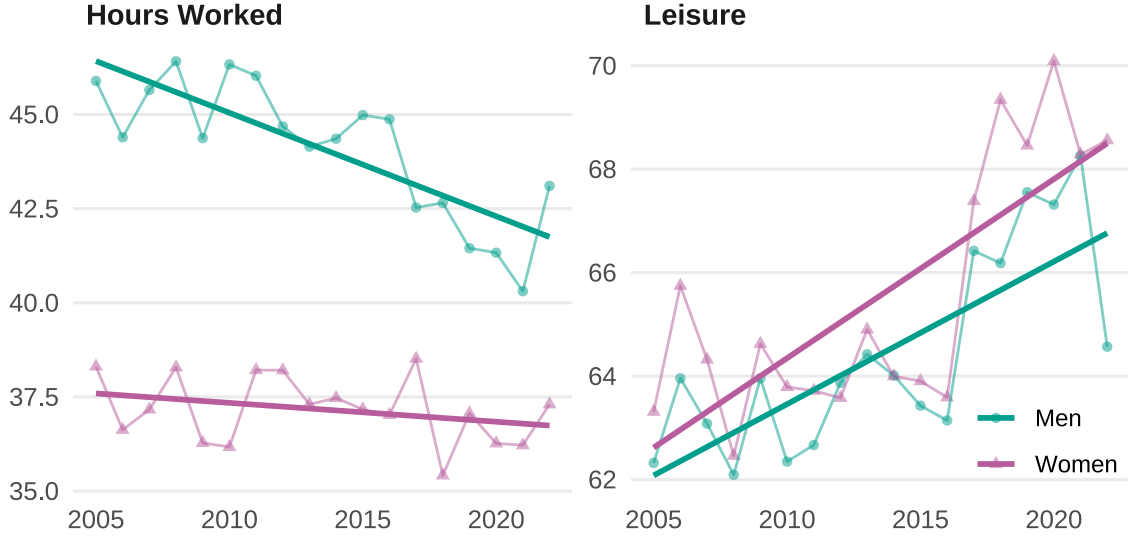


Figure 8: Single's Hours Worked and Leisure Time The figure shows the average hours worked and leisure time of singles aged between 25-54. Each dot represents the average hours worked and leisure time in a year and the center line is the linear fit. The data from JHPS and see the text for the sample selection.

6.2 Driving Forces

Section 6.1 points out the three important factors that may affect marriage and fertility decisions: female wage growth, change in social norms, and leisure technology growth. I interpret these factors as the changes in the parameters μ_{w_f} , θ , and α_l , respectively. The mean of log female wage, μ_{w_f} , is directly connected to the female relative wage. The parameter θ is related to the social norms on domestic labor because it captures the relative productivity of the husband for domestic labor. The leisure technology growth is captured by the parameter α_l because larger α_l means the higher utility given the same amount of leisure.

The parameter θ is similarly calibrated as in the baseline model. Using the mean values of (14) from the married couple data in the period 2005-2009, set $\theta = 0.746$. The larger value than the baseline model (0.677) captures the trend in the husband's share in domestic labor in Figure 7.

The parameter α_l is estimated based on the first-order condition of the single's problem (4). Substituting $k = \psi^S$, $h = 1 - l - k$, and $c = wh$, the first order condition with respect to l is

$$w^{1-\gamma_c} (1 - l - \psi^S)^{-\gamma_c} = \alpha_l l^{-\gamma_l}.$$

Using $h = (1 - l - \psi^S)$, we have

$$\alpha_l = w^{1-\gamma_c} h^{-\gamma_c} l^{\gamma_l}. \quad (15)$$

In the model, the male median wage is normalized to one. I use the hours worked and leisure time of singles at median wage to estimate α_l . In the pooled data of single and married males in the period 2005-2009, the 45th percentile of the wage is 1333 JPY and the 55th percentile is

1515 JPY. Using the mean of the hours worked and leisure time of singles between the 45th and 55th percentiles, I calibrate \hat{h} and \hat{l} as the choice of singles at median wage. Given the estimated parameters γ_c and γ_l from the baseline model, I estimate $\alpha_l = \hat{h}^{-\gamma_c} \hat{l}^{\gamma_l} = 1.931$ from (15).

Last, the parameter μ_{w_j} is estimated by the simulated method of moments (SMM). Similarly to the baseline model, I choose the gender gaps in log wage of singles in the period 2005-2009 as the target moment, i.e., $\log w_i - \log w_j = 0.185$. I use the above-estimated parameters θ and α_l and keep the other parameters as in the baseline model. By minimizing the data and model moments, I estimate $\mu_{w_j} = -0.338$. The summarized calibrated parameters are shown in Table 3.

Table 3: Calibrated Parameters in 2005-2009 and 2018-2022

Parameter	2005-2009	2018-2022
μ_{w_j}	-0.338	-0.293
θ	0.746	0.677
α_l	1.931	3.386

6.3 Why did the Marriage and Fertility Decline?

Given the calibrated parameters in Section 6.2, I simulate the model in the period 2005-2009, and Table 4 shows the results. The first row shows the baseline model for the period 2018-2022, and the last row shows the model with all the calibrated parameters in 2005-2009. To evaluate the model, I use the marriage rate from the Japanese Census 2005 and the cohort fertility rate (CFR) from the Human Fertility Database (HFD) 2005-2009, which are the targets in the baseline calibration.

Table 4: Decomposition of the Marriage Rate and CFR in 2005-2009

	μ_{w_j}	θ	α_l	Marriage Rate		CFR	
				Model	Data	Model	Data
Baseline (2018-2022)				0.828	0.828	1.445	1.446
Female Wage	✓			0.827		1.431	
Social Norms		✓		0.841		1.493	
Leisure Technology			✓	0.842		1.783	
All (2005-2009)	✓	✓	✓	0.853	0.928	1.806	1.709

Note: The model is simulated with the calibrated parameters in 2005-2009. The mark ✓ means the values in 2005-2009 are used. The marriage rate is from the Japanese Census 2005 and 2020 and the cohort fertility rate (CFR) is from the Human Fertility Database (HFD) 2005-2009 and 2018-2022.

Overall, the model with the calibrated parameters in 2005-2009 can capture 25% marriage rate and almost all changes in the CFR. To study the role of the three factors, I simulated the model with each calibrated parameter in 2005-2009 and showed the results in the second to the fourth rows of Table 4. The second row suggests that female wage growth has almost no impact on the marriage rate and CFR (changes by -0.001 and -0.014). This might be because the female wage

growth increases both the value of being single and married. The female values of singles are improved by the income shock but the value of marriage is also increased by the income shock, rise in her bargaining power, and the affordability of children.

The third row suggests that the smaller value of θ , or weaker norms on gender roles, reduces the marriage rate (by 0.013) and CFR (by 0.048). Given the higher wages of men, the smaller θ is a negative productivity shock for domestic labor and reduces the value of marriage. The fourth row shows that the leisure technology growth has a negative impact on the marriage rate (by 0.014) and CFR (by 0.338). The impact is especially large on CFR because the leisure technology growth increases not only the value of being single but also the relative value of children to leisure.

7 Conclusion

In this paper, I build a model that can account for the marriage and fertility decline in the last decade. The key ingredients of the model are intra-household bargaining, leisure technology growth, and the social norms on gender roles. The baseline model explains almost all the fertility decline from 2005 to 2022 and 25% of the marriage decline from 2005 to 2020.

I also decompose the three drivers of the marriage and fertility decline. The simulation results show that the leisure technology growth has a significant impact on the fertility decline, which suggests that the leisure technology growth has increased the value of being single and also the child penalty on leisure for married couples.

Appendix

A Mathematical Derivations

A.1 Mass of the New Arrivals

Proposition 1.1.1 (Mass of the New Arrivals): In the equation (12), the mass of new arrivals is given by the following formula:

$$D^N = \frac{\delta \kappa_0 \kappa_1}{\kappa_0 \kappa_1 + \delta(\kappa_0 + \kappa_1)}.$$

Proof. Define the mass of each $a \in \{Y, M, O\}$ as D^a . Given the aging probability κ_0, κ_1 and the probability of dying δ , the mass of new arrivals is given by the following equation:

$$\begin{aligned} D^Y &= D^N + (1 - \kappa_0)D^Y \\ D^M &= \kappa_0 D^Y + (1 - \kappa_1)D^M \\ D^O &= \kappa_1 D^M + (1 - \delta)D^O \\ 1 &= D^Y + D^M + D^O. \end{aligned}$$

Solving the above equations, we get the mass of each group as follows:

$$\begin{aligned} D^N &= \frac{\delta \kappa_0 \kappa_1}{\kappa_0 \kappa_1 + \delta(\kappa_0 + \kappa_1)} \\ D^Y &= \frac{\delta \kappa_1}{\kappa_0 \kappa_1 + \delta(\kappa_0 + \kappa_1)} \\ D^M &= \frac{\delta \kappa_0}{\kappa_0 \kappa_1 + \delta(\kappa_0 + \kappa_1)} \\ D^O &= \frac{\kappa_0 \kappa_1}{\kappa_0 \kappa_1 + \delta(\kappa_0 + \kappa_1)}. \end{aligned}$$

A.2 Bargaining Power and Leisure Time

In Figure 4, we have shown that the intra-household gaps in earnings are positively correlated with leisure time. This is consistent with the model economy, where the bargaining power ρ is larger than 1.

Proposition 1.2.1 (Positive Correlation in Intra-Household Gaps in Wages and Leisure): In the married couple's time allocation problem, the gaps in log wages ($\log w_i - \log w_j$) and leisure time ($\log l_i - \log l_j$) are positively correlated if and only if the bargaining power curvature ρ is larger than 1.

Proof. From the first order condition of the utility function in (7) with respect to l_i and l_j , we have the following equation:

$$\begin{aligned}(1 - \lambda)\alpha l_i^{-\gamma_l} &= \eta w_i \\ \lambda\alpha l_j^{-\gamma_l} &= (1 - \eta)w_j\end{aligned}$$

where η is a Lagrange multiplier for the budget constraint. From the above equations and $\lambda = \frac{w_j^\rho}{w_i^\rho + w_j^\rho}$, we can derive the following equation:

$$\log l_i - \log l_j = \frac{\rho - 1}{\gamma_l} (\log w_i - \log w_j).$$

Since $\gamma_l > 0$, the positive correlation between the intra-household gaps in wages and leisure time happens if and only if the bargaining power ρ is larger than 1.

The last equation leads to the following proposition.

Corollary 1.2.1: If the bargaining power curvature ρ is 1, the optimal leisure time of the married couple is the same $l_i = l_j$.

A.3 Domestic Labor Productivity θ

Proposition 1.3.1 (Calibration of Domestic Labor Productivity): The domestic labor productivity parameter θ from (8) is fully characterized by the first-order condition for the maximization problem in (7) :

$$\theta = \frac{w_j k_j}{w_i k_i + w_j k_j}.$$

Proof. The cost minimization problem of joint domestic labor is given by

$$\min_{k_i, k_j} w_i k_i + w_j k_j$$

subject to

$$K(k_i, k_j) = k_i^{1-\theta} k_j^\theta = \psi^M + \psi^N \mathbb{1}\{N_0 > 0\}.$$

The first order conditions with respect to k_i and k_j are

$$\begin{aligned} w_i &= \eta(1 - \theta)k_i^{-\theta} k_j^\theta \\ w_j &= \eta\theta k_i^{1-\theta} k_j^{\theta-1} \end{aligned}$$

where η is a Lagrange multiplier for the cost minimization problem. From the above equations, we can derive the following equation

$$\frac{w_i}{w_j} = \frac{1 - \theta}{\theta} \frac{k_j}{k_i},$$

and we will get the equation of the proposition.

B Data Description

B.1 Japanese Household Panel Survey (JHPS)

The analysis is mostly based on the Japanese Household Panel Survey (JHPS). The JHPS has been implemented annually since 2004 by the Panel Data Research Center at Keio University and was originally named the Keio Household Panel Survey (KHPS). The purpose of the KHPS is to collect panel data on households and individuals reflecting the population composition of society as a whole, as in the Panel Study of Income Dynamics (PSID) in the U.S. and the European Community Household Panel (ECHP) in Europe. KHPS started in 2004 with 4000 households and 7,000 individuals nationwide and added a cohort of about 1400 households and 2500 individuals from 2007 to compensate for sample dropout. In 2009, the Panel Data Research Center at Keio University started a new survey, the JHPS, targeting 4000 male and female subjects nationwide in parallel with the KHPS. The JHPS collects data focused on education and health/healthcare in addition to economic status and employment status. In 2014, the KHPS was merged with the JHPS.

As described in Section 2.1, the sample is restricted to people aged 25-54 in the period 2005-2022. The sample of singles is restricted to those who have a job, a positive leisure time, and have no children. The sample of married couples is also restricted to those who have a positive leisure time, however, it includes the case of non-working individuals. Table 5 and Table 6 show the summary statistics of singles and married couples, respectively.

Table 5: Summary Statistics of Singles in JHPS2005-2022

	Men (N = 1020)		Women (N = 964)	
	Mean	Std. Dev.	Mean	Std. Dev.
Hours worked (per week)	44.0	16.2	37.3	15.1
Leisure (per week)	64.5	16.9	65.0	16.7
Domestic labor (per week)	3.5	5.5	9.7	10.1
Hourly wage (JPY)	1999.2	2195.1	1679.7	2797.6

Notes: The table shows the summary statistics of singles aged 25-54 in the period 2005-2022. The sample of singles is restricted to those who have a job, a positive leisure time, and have no children.

Table 6: Summary Statistics of Married Couples in JHPS2005-2022

	Men (N = 1869)		Women (N = 1932)	
	Mean	Std. Dev.	Mean	Std. Dev.
Hours worked (per week)	43.7	19.09	20	17.5
Leisure (per week)	63.9	19.90	55	22.6
Domestic labor (per week)	4.4	7.27	37	23.6
Hourly wage (JPY)	2873.0	3280.08	1460	1847.4

Notes: The table shows the summary statistics of married couples aged 25-54 in the period 2005-2022. The sample of married couples is restricted to those who have a positive leisure time and have up to three children.

B.2 Marriage Rate by Earnings Decile

In Figure 5, I show the marriage rate by earnings deciles from the Employment Status Survey 2022. In this survey, the number of people by earnings, age, and marital status is reported. Figure 9 shows the original data of the number of people aged between 45 and 54 by earnings and marital status.

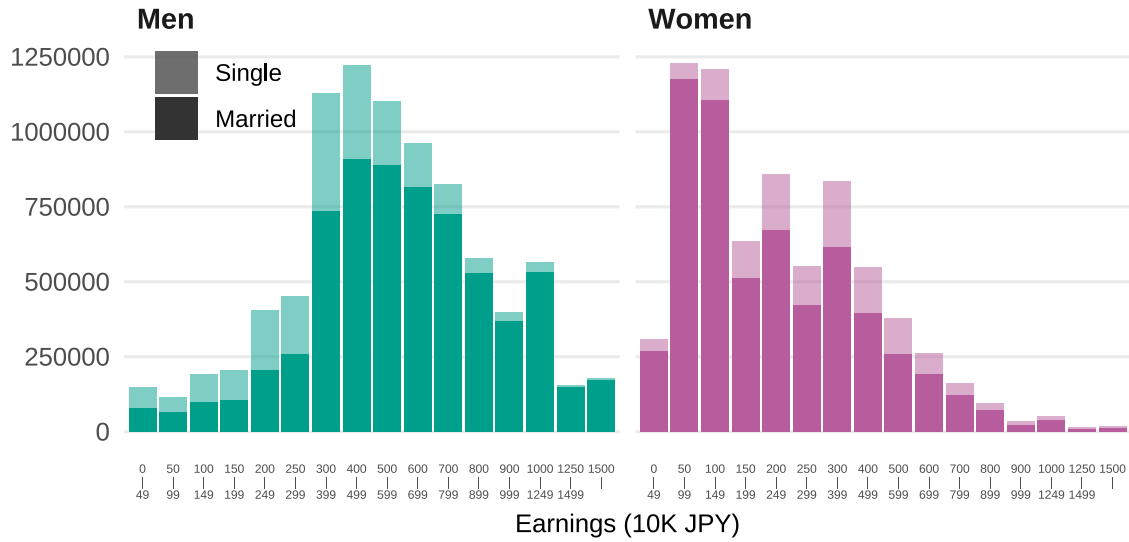


Figure 9: Number of People Aged between 45 and 54 by Earnings and Marital Status. The data is from the Employment Status Survey 2022.

To estimate the marriage rate by earnings deciles, I compute the cumulative density of the earnings distribution by marital status. Since the original data reports only the 16 categories of earnings, I estimate the cumulative density by linear interpolation. Figure 10 shows the estimated cumulative density of earnings by marital status.

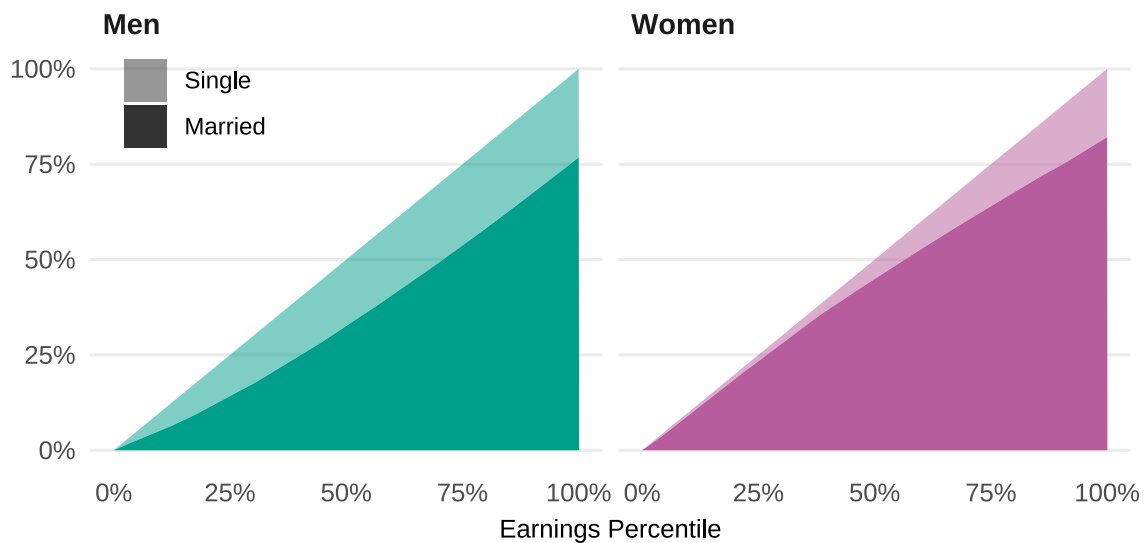


Figure 10: Cumulative Density of Earnings by Marital Status. The data is from the Employment Status Survey 2022.

The marriage rate by earnings deciles is defined as the ratio of the mass of married individuals to the cumulative density of single and married individuals. Since the denominator is 10% by definition, the marriage rate by earnings decile is given by

$$\text{Marriage Rate}_n = \frac{\hat{M}(0.1n) - \hat{M}(0.1(n-1))}{0.1},$$

where $\hat{M}(q)$ is the estimated cumulative density of married individuals at the q -th percentile of earnings.

C Supplemental Figures

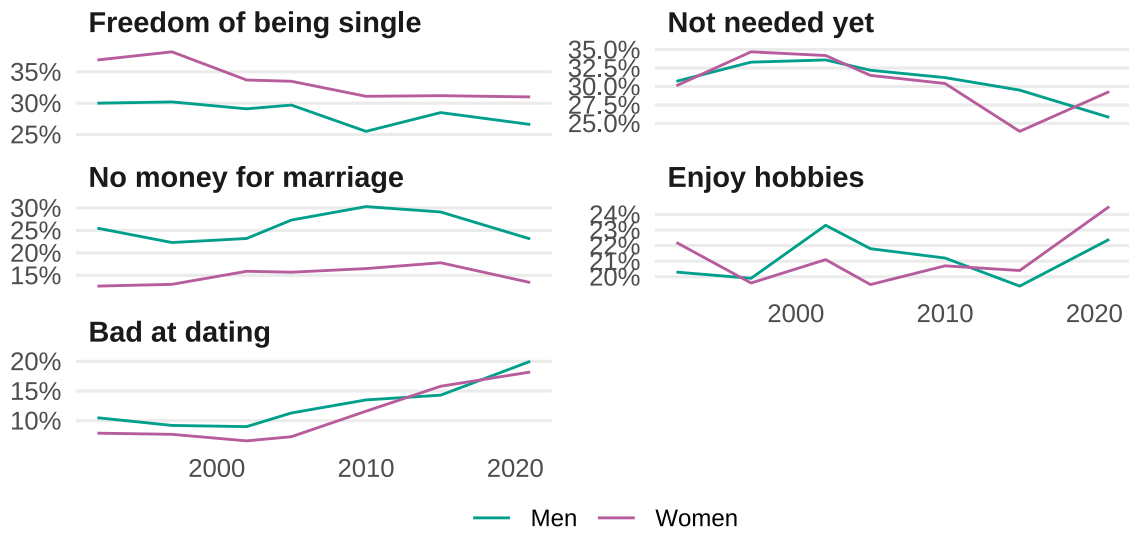


Figure 11: Time Series of Reasons Why Do not Get Married. The figure shows the time trends of the share of the main reasons why do not get married. The data is from the National Fertility Survey from 1992 to 2021 and the sample is restricted to the age group 25-34.

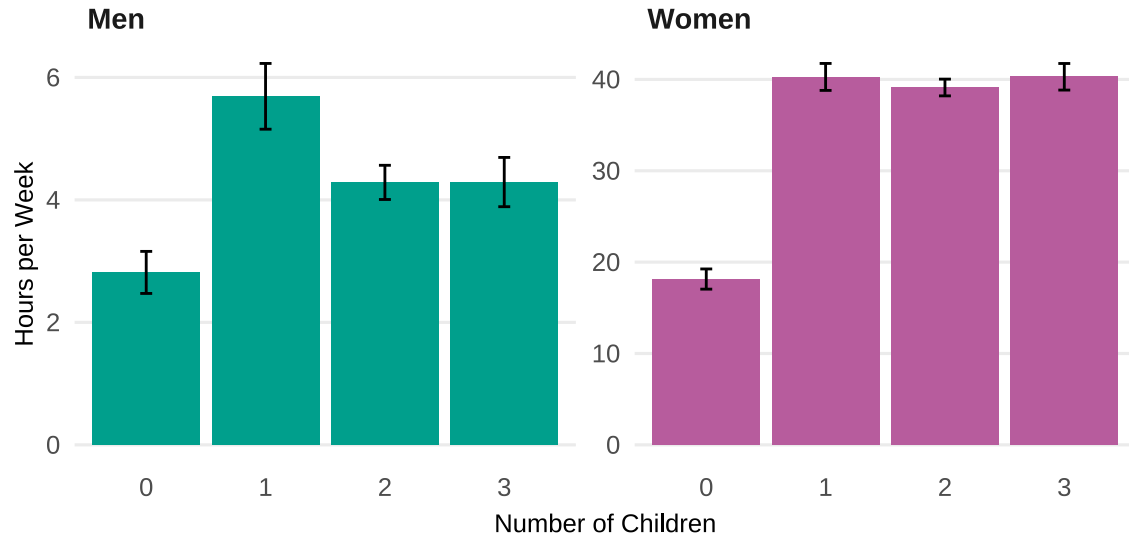


Figure 12: Domestic Labor Hours by Number of Children The figure shows the average hours of domestic labor by the number of children. The error bar shows the 95% confidence interval with the standard error clustered by household. The data is from the Japanese Household Panel Survey from 2005 to 2022 and the sample is restricted to married individuals with age 25-54.

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