A Quantitative Model of Non-Marriage and Fertility

Bargaining over Leisure

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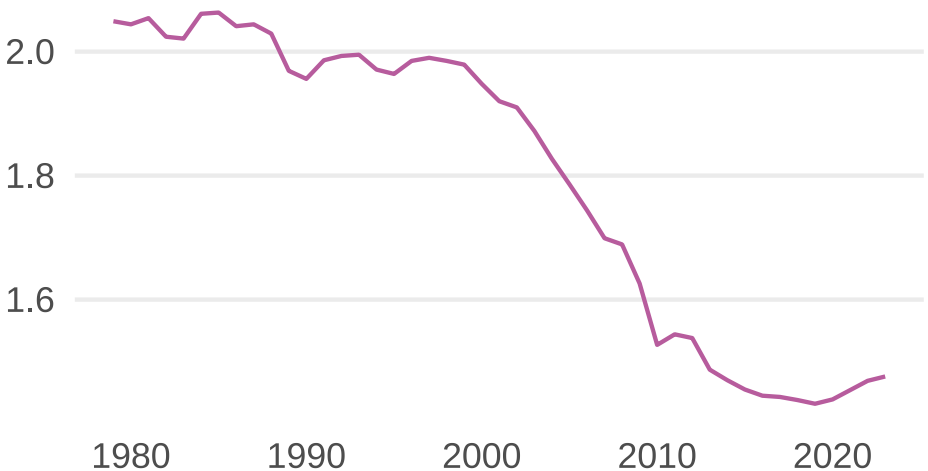
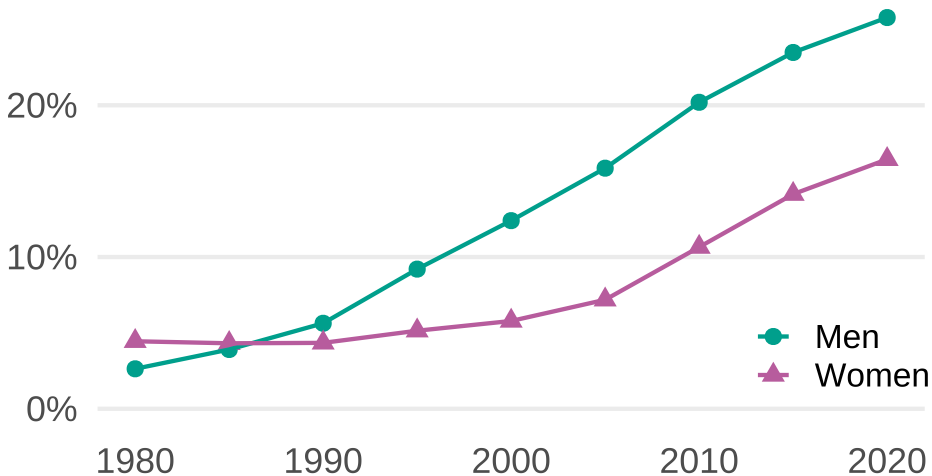
Fertility and Marriage Decline in Japan

Fertility Rate of Women at Age 45

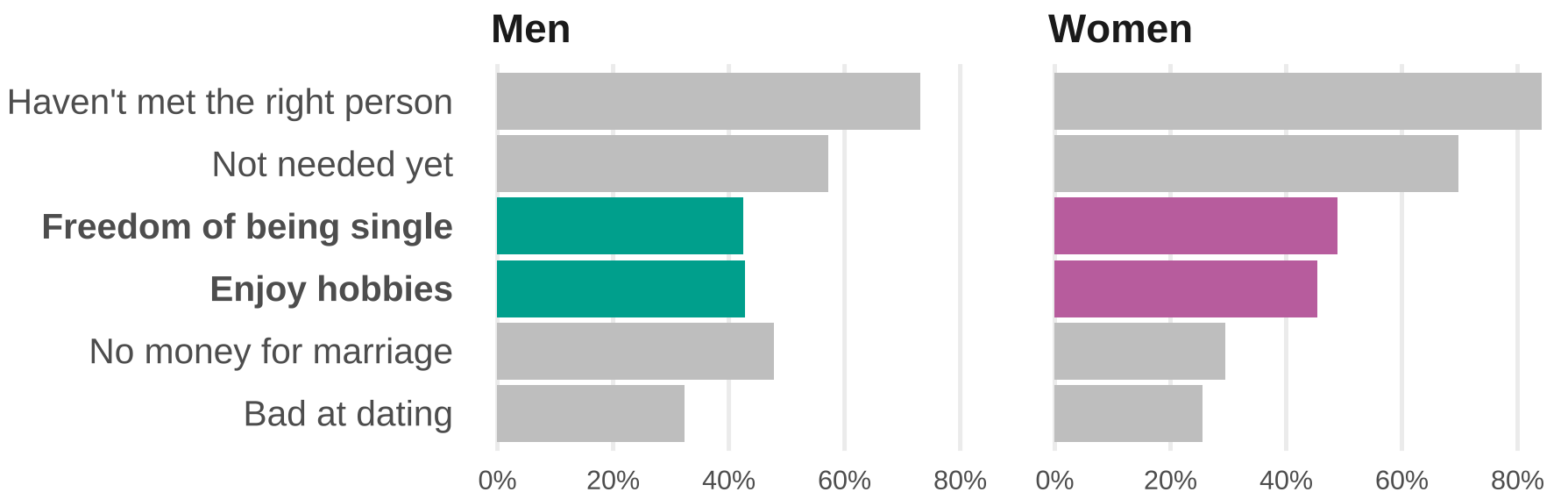


Share of Never-married at Age 45-54



- Cohort fertility started to decline in the 2000s
- Never-married increased since 1990s for men and 2000s for women
- Childbirth outside marriage is rare in Japan (2.4% in 2020)

Main Reasons for Being Single



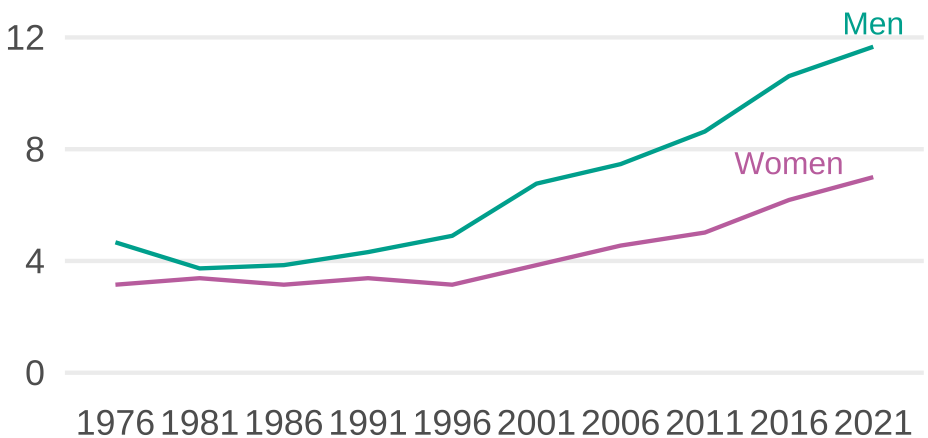
Data: NFS 2021, singles aged 25-34

- Marriage restricts the time for **leisure** and reduces the **freedom**

▸ 1992-2021

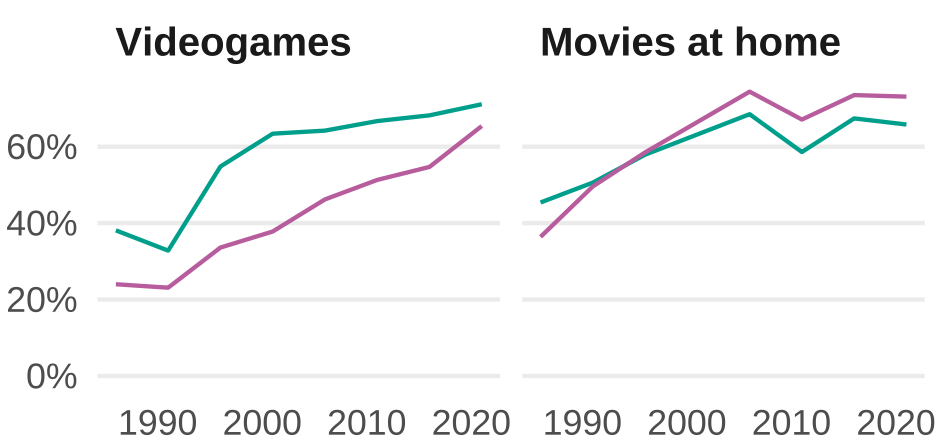
New Perspective: Leisure Technology Growth

Hours for Hobby Activities per Week



Data: Survey on time use and leisure activities. Age 25-29.

Participation in Hobby Activities

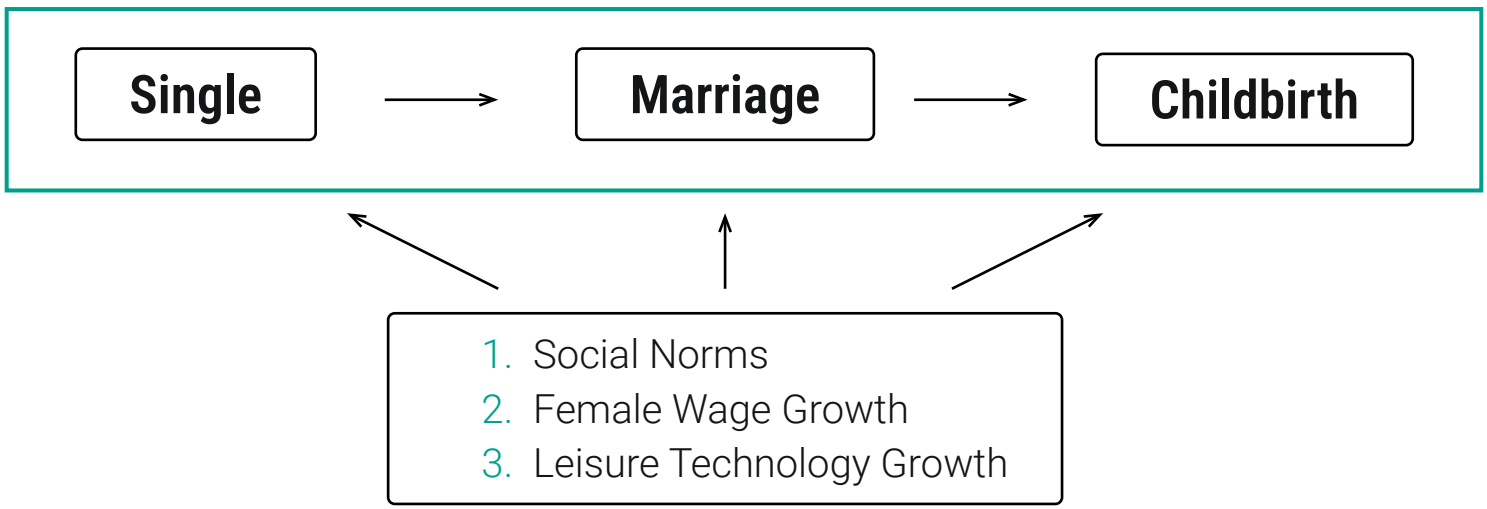


Data: Survey on time use and leisure activities. Age 25-29.

- Increase in hobby activities for both men and women
- Leisure technlogy growth (e.g., video games) ⇒ decline in working hours

  → Kopecky (2011); Kopytov, Roussanov, and Taschereau-Dumouchel (2023); Aguiar et al. (2021)

Question: Why Are Marriage and Fertility Declining?



Build an Unified Model of Marriage and Fertility

- Dynamic model with **endogenous** marriage and childbirth decision
- Interaction with changes in female wage, social norms, and leisure

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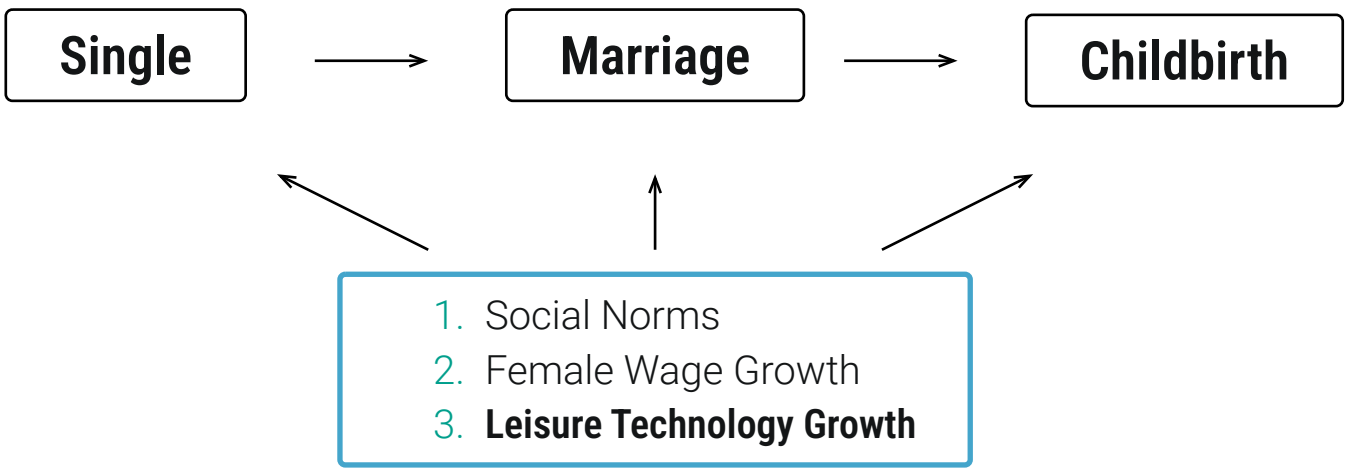

Potential Driving Forces

- Female Wage Increase & Social Norms Change
- **Leisure Technology Growth**

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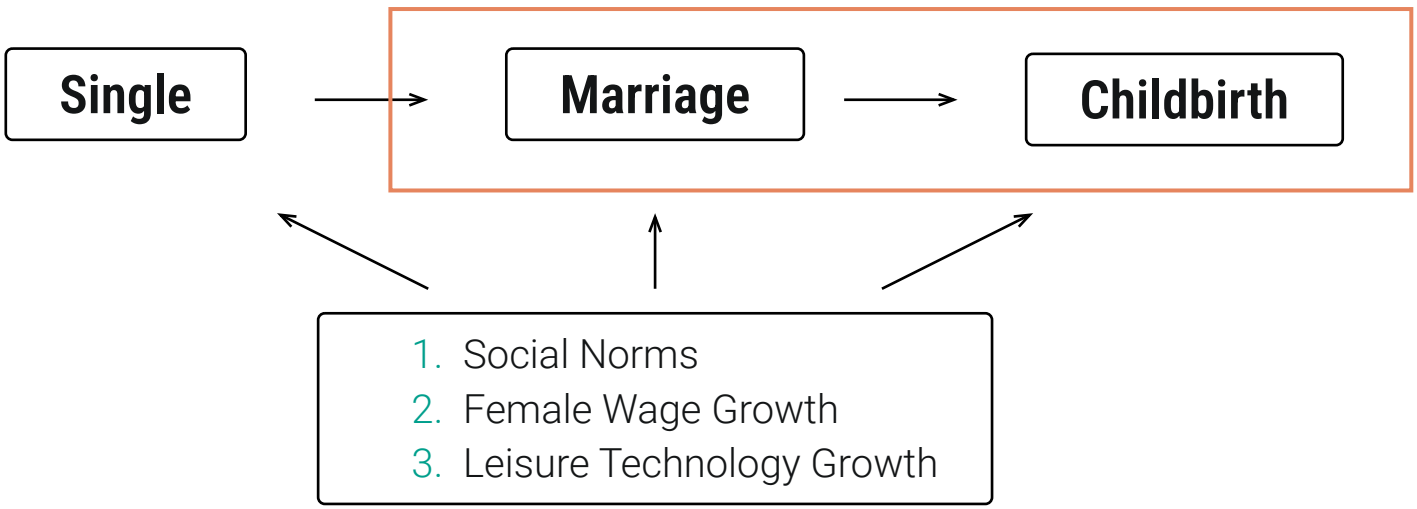

Labor/Macroeconomic Literature

- Many models with endogenous fertility start with married couples
  → e.g., Ahn and Mira (2002); Erosa, Fuster, and Restuccia (2016); Doepke and Kindermann (2019)
- Little is known about the dynamic decision of marriage and childbirth

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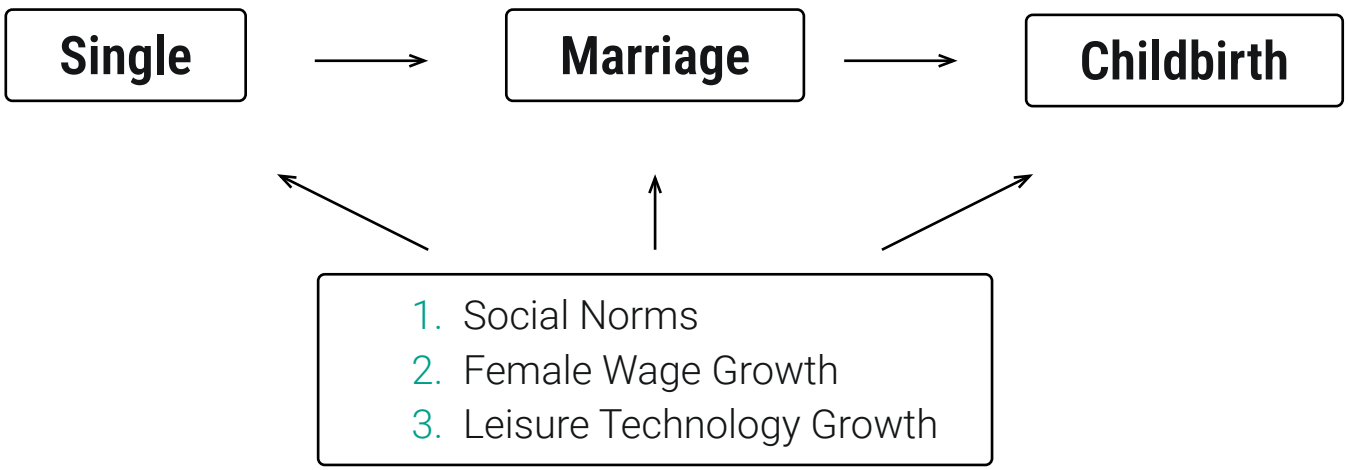


Contributions

1. **Leisure technology** as a new driver of marriage and fertility decline
2. **Dynamic** model with endogenous **marriage** and **childbirth** decision

Roadmap

1. Model

- Dynamic model with endogenous marriage and childbirth decision
- **Bargaining power** are key elements

2. Calibration for 2018-2022

- Calibrate model parameters with data from 2018-2022
- Replicate marriage and fertility behavior

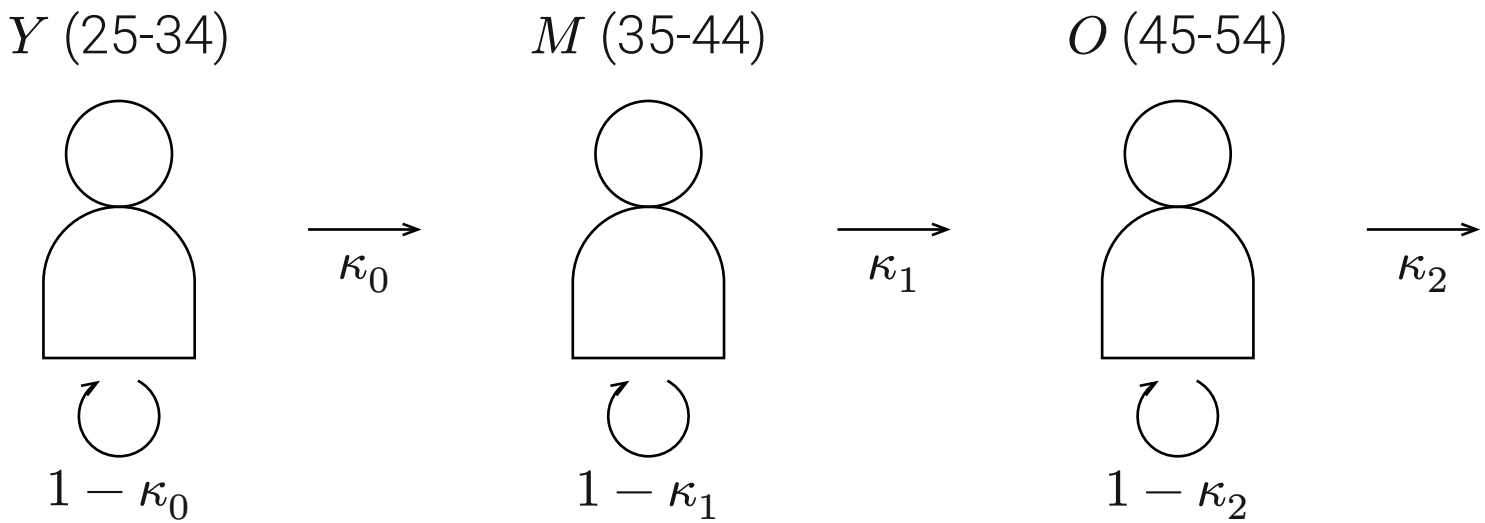
3. Simulation for 2005-2009

- Parameters for **female wage**, **social norms**, and **leisure technology**
- Simulate with parameters, fix other parameters

Model

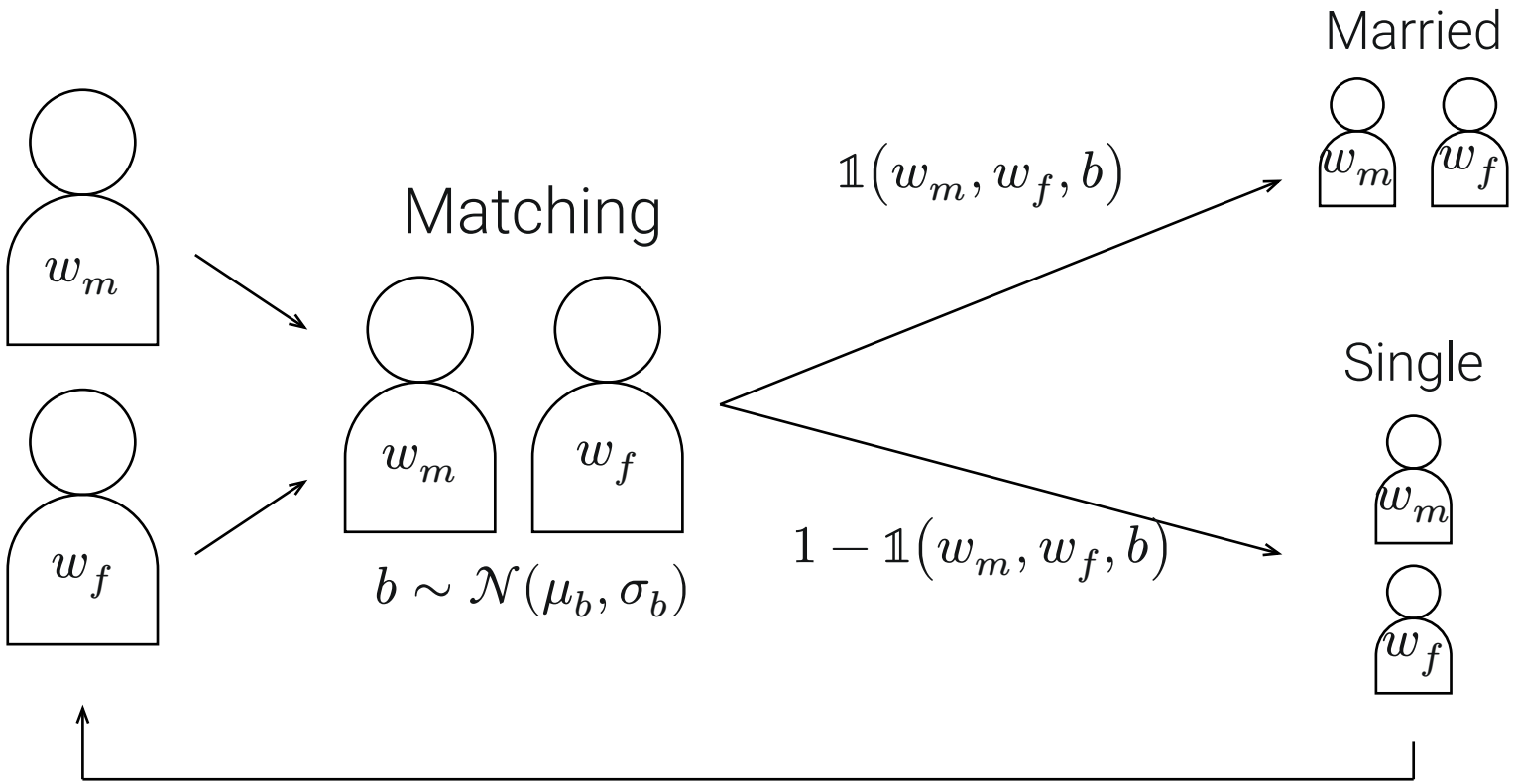
Settings

Infinite Horizon with Stochastic Aging



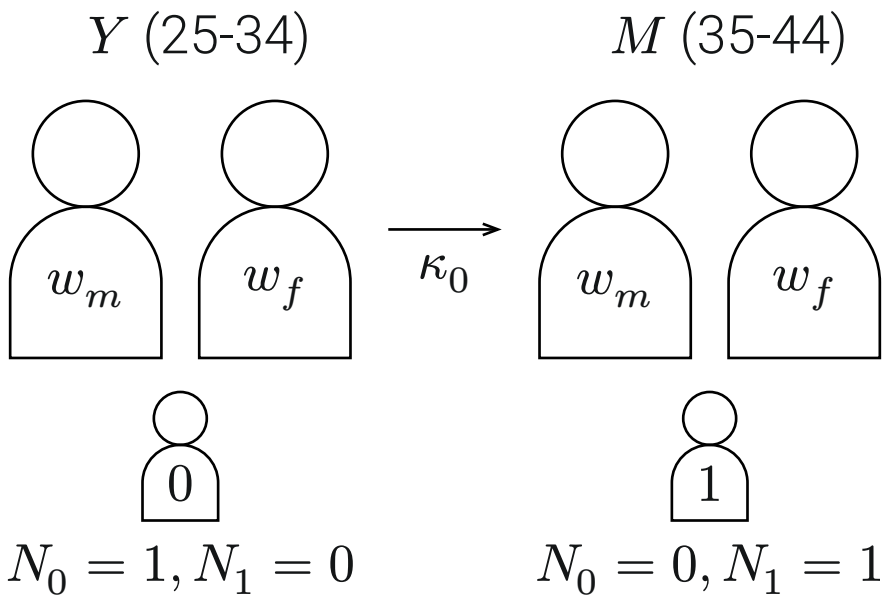
- Individuals with gender $g \in \{m, f\}$
- One model period is **one year**. 3 stages of life (Y, M, O) and death
- In the period end, agents get aged with probability $\kappa_0 = \kappa_1 = \kappa_2 = 1/10$
- Individuals born at Y with wage $w_g \sim \log -\mathcal{N}\left(\mu_{w_g}, \sigma_{w_g}\right)$. Fixed for life

Marriage Decision



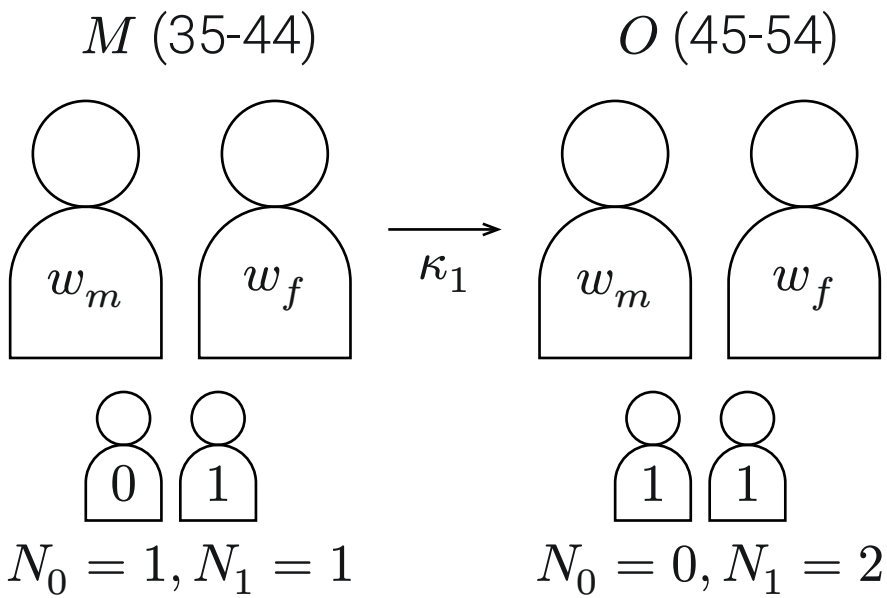
- In each period, randomly matched with singles of the **same age**
- Draw a **match quality** $b \sim \mathcal{N}(\mu_b, \sigma_b)$. Fixed for life
- If both of them agree based on (w_m, w_f, b), they get married

Children's Age



- Children has two age 0 (small kids) and 1 (teenagers)
- N_0 and N_1 are # of children at each age

Children's Age



- Children has two age 0 (small kids) and 1 (teenagers)
- N_0 and N_1 are # of children at each age
- Children got aged with their parents from 0 to 1 but not from 1 to more

Preferences

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

- c: Consumption
- l: Leisure
- $N = N_0 + N_1$: Number of children

Only married couples can have children $\Rightarrow$ Single's utility is

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

Singles

$$v_g(w_g) = \max_{c_g, h_g, l_g, k_g} u(c_g, l_g)$$

subject to

$$\begin{aligned} c &= w_g h_g && \text{(Budget Constraint)} \\ d_g &= \psi_g^S && \text{(Domestic Labor Constraint)} \\ h_g + l_g + d_g &= 1 && \text{(Time Constraint)} \end{aligned}$$

- Hours worked h_g, leisure l_g, and domestic labor d_g
- Each individual is endowed a unit of time $h_g + l_g + d_g = 1$
- Domestic labor requirement is different by gender (ψ_m^S, ψ_f^S)
- Domestic labor is not a choice for singles

Couples

$$\max_{c,h_m,h_f,l_m,l_f,d_m,d_f} (1-\lambda)u\left(\frac{c}{\Gamma(N)}, l_m, N\right) + \lambda u\left(\frac{c}{\Gamma(N)}, l_f, N\right)$$

subject to

$$c = w_m h_m + w_f h_f, \qquad \text{(Budget Constraint)}$$

$$D\big(d_m, d_f\big) = \psi_0 + \psi_1 \mathbb{1}\{N_0 > 0\} + \psi_2 \mathbb{1}\{N > 0\}, \quad \text{(Domestic Labor Constraint)}$$

where

- $\Gamma(N) < 2 + N$: Economies of scales
- $D\big(d_m, d_f\big)$: Domestic labor production function (next slides)
- $\lambda = \lambda\big(w_m, w_f, N_0\big)$: Bargaining power (next slides)

Social Norms Parameter θ

Domestic Labor Production Function

$$D(d_m, d_f) = \left((1-\theta)d_m^{\xi} + \theta d_f^{\xi}\right)^{\frac{1}{\xi}} \quad \text{where} \quad \theta \in (0,1), \xi < 1$$

From the FOCs of the couple's problem, we can derive

$$\theta = \frac{w_f d_f^{\frac{1}{1-\xi}}}{w_m d_m^{\frac{1}{1-\xi}} + w_f d_f^{\frac{1}{1-\xi}}}$$

- The higher wage earner works less domestic labor $\Rightarrow$ **Specialization**
- **Larger θ** $\Rightarrow$ more domestic labor hours for **women**
- Interpreted as the **social norms** parameter

Wife's Bargaining Power λ

Assume a parameteric form of bargaining power:

$$\lambda(w_m, w_f, N_0) = \frac{1}{1 + \exp\big(\rho_0 + \rho_1\big(\log w_m - \log w_f\big) + \rho_2 \mathbb{1}\{N_0 > 0\}\big)}$$

Relative wage and children affect bargaining power

- $\rho_0 = \rho_1 = \rho_2 = 0$: $\lambda = \frac{1}{2}$
  $\longrightarrow$ Equal bargaining power. Common assumption
- $\rho_1 = 1, \rho_0 = \rho_2 = 0$: $\lambda = \frac{w_f}{w_m + w_f}$
  $\longrightarrow$ Proportion of wage. (Baudin, De La Croix, and Gobbi 2015)
- Similar formula used in the collective models
  $\longrightarrow$ Lise and Yamada (2019); Guo and Xie (2024)

Bargaining Power λ and Leisure Allocation

$$\log l_m - \log l_f = \frac{\rho_0}{\gamma_l} + \frac{\rho_1 - 1}{\gamma_l}(\log w_m - \log w_f) + \frac{\rho_2}{\gamma_l}\mathbb{1}\{N_0 > 0\}$$

Data: JHPS2005-2022. Married couples aged 25-54.

- **Positive correlation**: $\log l_m - \log l_f \leftrightarrow \log w_m - \log w_f$ if $\rho_1 > 1$
- Marriage might constraint or reduce the leisure by bargaining power

Value Functions and Life Events

For age $a \in \{Y, M, O\}$, the value functions are

- **Single**: $W_g^a(w_g)$ ▸ Bellman Equation
- **Married**: $V_g^a(w_g, w_{g'}, N_0, N_1; b)$ ▸ Bellman Equation

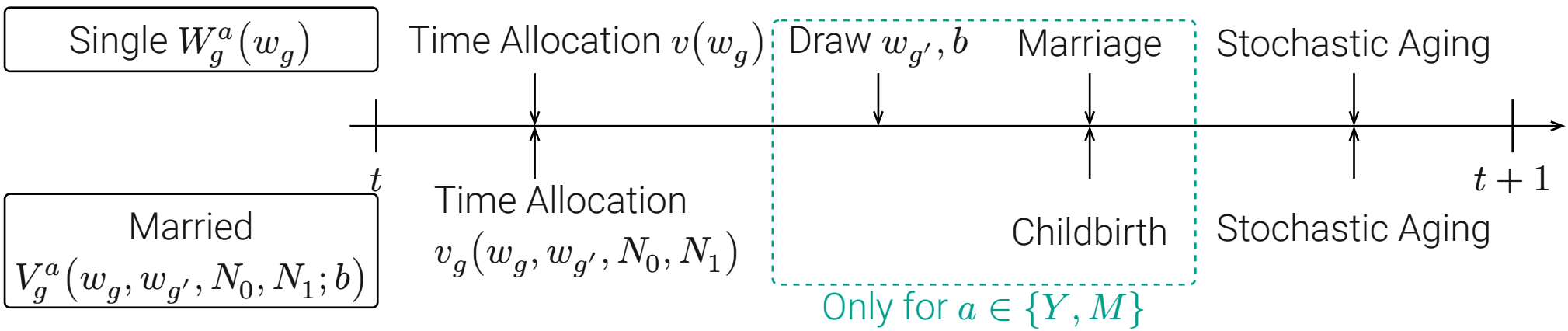
Life Events

- Marriage and Childbirth decisions can be made only at Y and M
- **Marriage**: $V_m^a(w_m, w_f, 0, 0; b) > W_m^a(w_m)$ and $V_f^a(w_f, w_m, 0, 0; b) > W_f^a(w_f)$
- **Childbirth**: Decide based on $(1-\lambda)V_m^a + \lambda V_f^a$
  - $\rightarrow$ Can have a newborn child with probability δ_0 (at Y) or δ_1 (at M)

Marriage Market Equilibrium

- The distribution of singles does not change ▸ Equilibrium

Model Summary



Baseline Model (2018-2022)

Data

Japan Household Panel Survey (JHPS)

- Since 2004 on 4,000 households and 7,000 individuals nationwide
- Demographic variables, labor market outcomes

3 Usage of Hours

- **Hours worked** h: Hours worked per week + Commuting time per week
- **Domestic Labor** d: Hours spent on
  → housework (prepare meal, laundry, grocery shopping, cleaning) & childcare
- **Leisure** l: Hours spent on leisure per week
  → Measured as $l = 16(\text{hours}) \times 7(\text{days}) - h - d$

Calibration Strategy

2 Types of Parameters

1. **Exogenous Parameters**: Literature, Data
2. **Endogenous Parameters**: Minimizing distance by simulation

Exegenous Parameters

Parameter	Source
$\Gamma(N) = 1 + 0.5 + 0.3N$	OECD equivalence scale
$\beta = 0.96$	Literature (Prescott 1986)
$\kappa_0 = \kappa_1 = \kappa_2 = 1/10$	30-year lifespan
$\mu_{w_m} = 0$	Male wage is normalized to 1
$\psi_m^S = 0.007, \psi_f^S = 0.058$	Singles in JHPS2018-2022
$\sigma_{w_m} = 0.519$	Single and married men in JHPS2018-2022

Simulated Method of Moments

19 parameters remained

$$\omega = \Big\{ \underbrace{\gamma_c, \gamma_l, \gamma_n, \alpha_l, \alpha_n}_{\text{Preference}}, \underbrace{\rho_0, \rho_1, \rho_2}_{\text{Bargaining}}, \underbrace{\mu_{w_f}, \sigma_{w_f}}_{\text{Wage}}, \underbrace{\mu_b, \sigma_b}_{\text{Match quality}}, \underbrace{\theta, \xi}_{\text{Home production}}, \underbrace{\psi_0, \psi_1, \psi_2}_{\text{Domestic labor}} \underbrace{\delta_1, \delta_2,}_{\text{Childbirth}} \Big\}$$

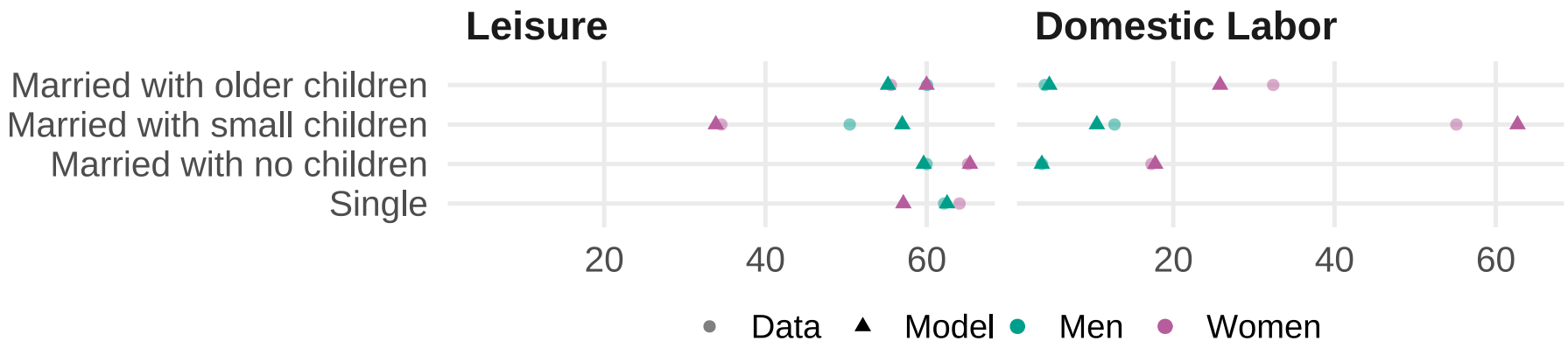
Define

- $DATA$: 20 Moments from Japanese Data 2018-2022
- $\mathcal{M}(\omega)$: 20 moments produced by the model with ω
- $G(\omega) := \mathcal{M}(\omega) - DATA$

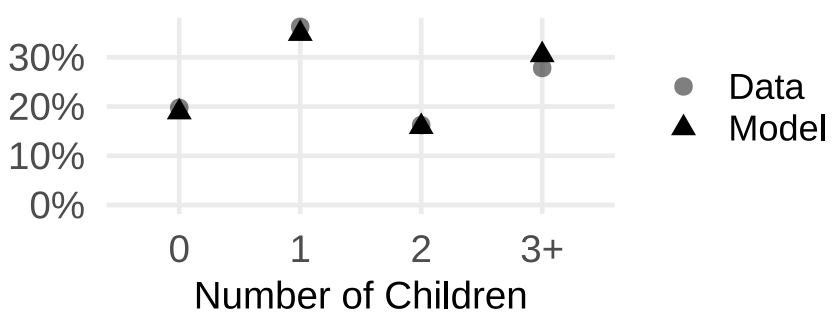
With a weighting matrix W, the parameters are estimated by

$$\hat{\omega} = \arg\min G(\omega)^\top W G(\omega)$$

Targeted Moments



	Data	Model
Single's $\log w_m - \log w_f$	0.129	0.129
S.D. of single's $\log w_f$	0.786	0.792
Share of never married	0.164	0.161



Endogenous Parameters

Category	Parameter Values
Preference	$\gamma_c = 1.572, \gamma_l = 1.316, \gamma_n = 1.319$
	$\alpha_l = 2.425, \alpha_n = 3.242$
Bargaining	$\rho_0 = -0.286, \rho_1 = 1.465, \rho_2 = 0.784$
Female wage	$\mu_{w_f} = -0.153, \sigma_{w_f} = 0.757$
Match quality	$\mu_b = -1.579, \sigma_b = 1.333$
Home prouduction	$\theta = 0.835, \xi = 0.026$
Domestic labor	$\psi_0 = 0.114, \psi_1 = 0.231, \psi_2 = 0.051$
Fertility	$\delta_1 = 0.246, \delta_2 = 0.192$

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- $\gamma_c, \gamma_l, \gamma_n \in [1, 2] \Rightarrow$ Standard values in the literature

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- $\alpha_l = 2.425 \Rightarrow$ Importance of leisure in utility

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- $\rho_1 > 1 \Rightarrow$ Positive correlation $\log l_m - \log l_f \leftrightarrow \log w_m - \log w_f$

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- $\mu_{w_f} = -0.153 \Rightarrow$ 14% gender gap in median wage

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- $\mu_b < 0 \Rightarrow$ Expected match quality is negative. Wait for the right partner

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- $\theta > 0.5 \Rightarrow$ Social norms on female domestic labor

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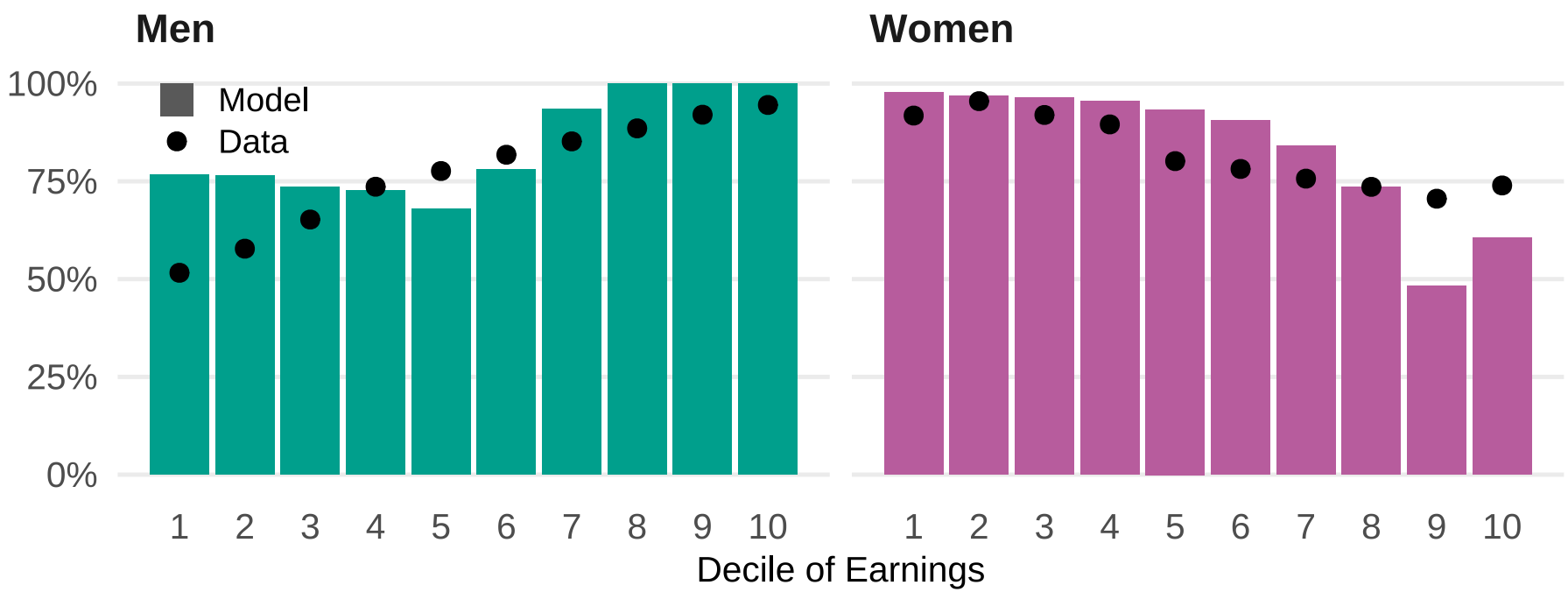
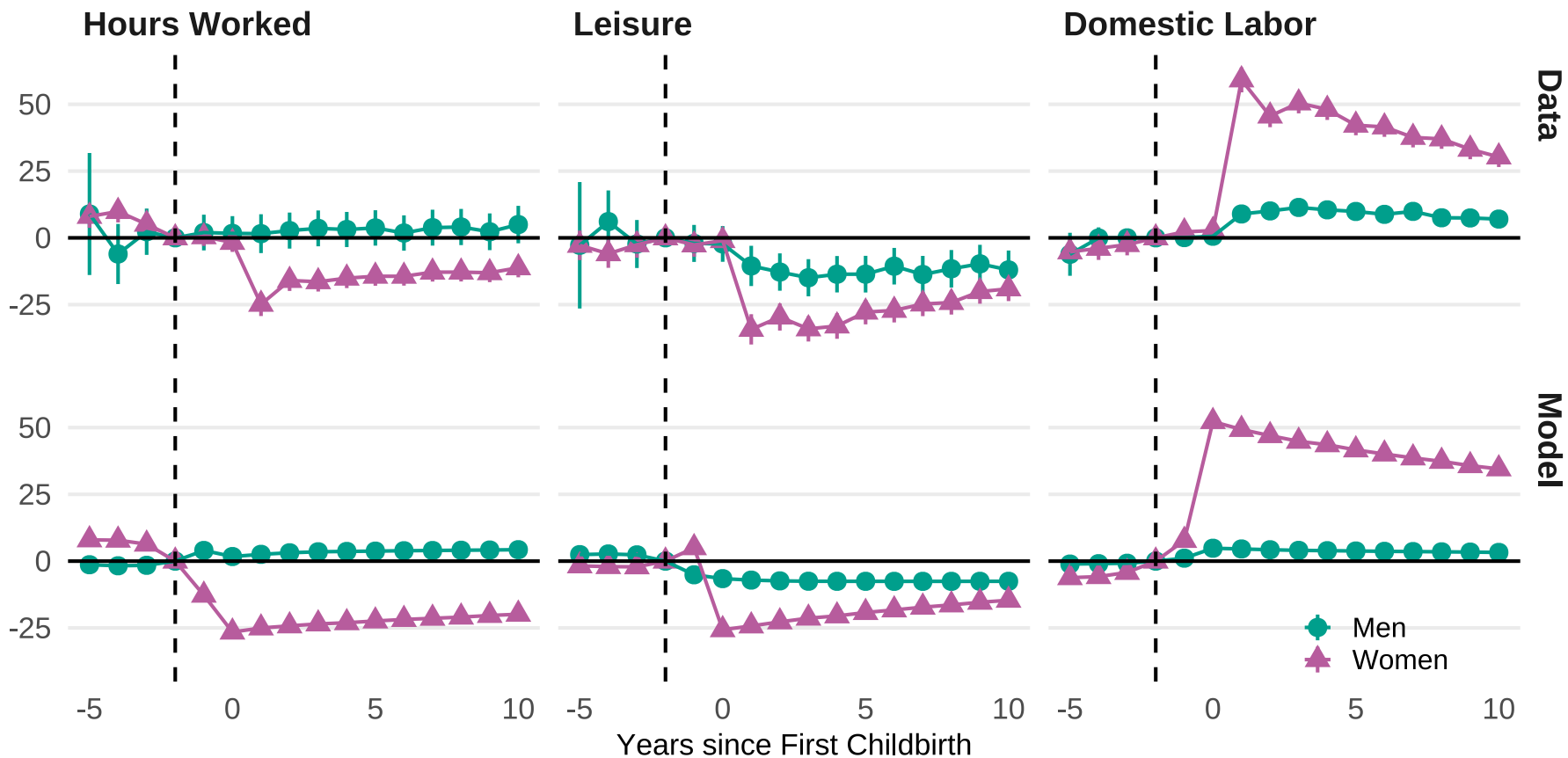
- $\delta_1 > \delta_2 \Rightarrow$ Higher fertility for younger couples

Marrige Rate by Earnings (Untargeted)



- Captures the pattern increasing for men and decreasing for women

Child Penalty (Untargeted)

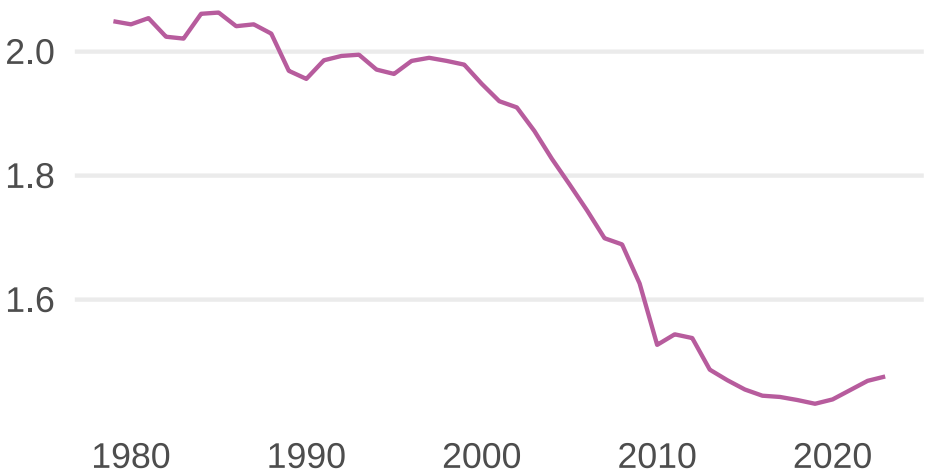


▸ Specification

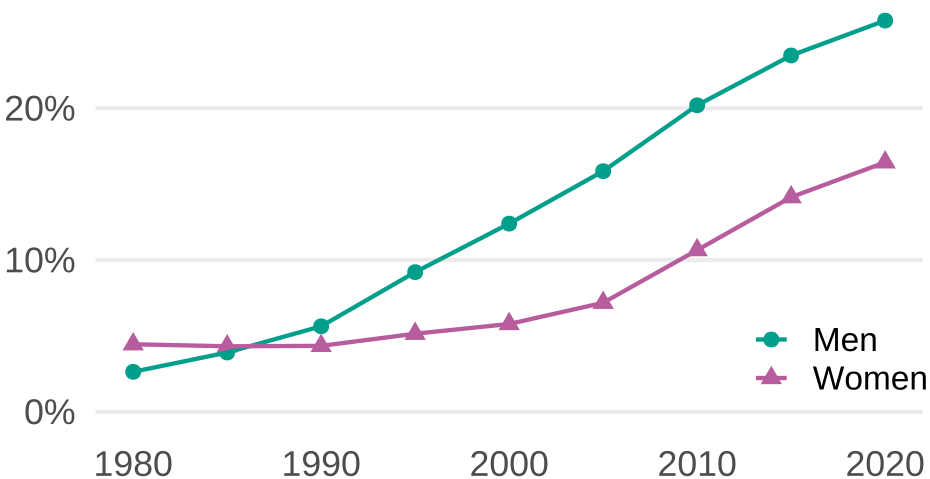
Back to 2005-2009

Driving Forces of the Marriage and Fertility Decline

Fertility Rate of Women at Age 45

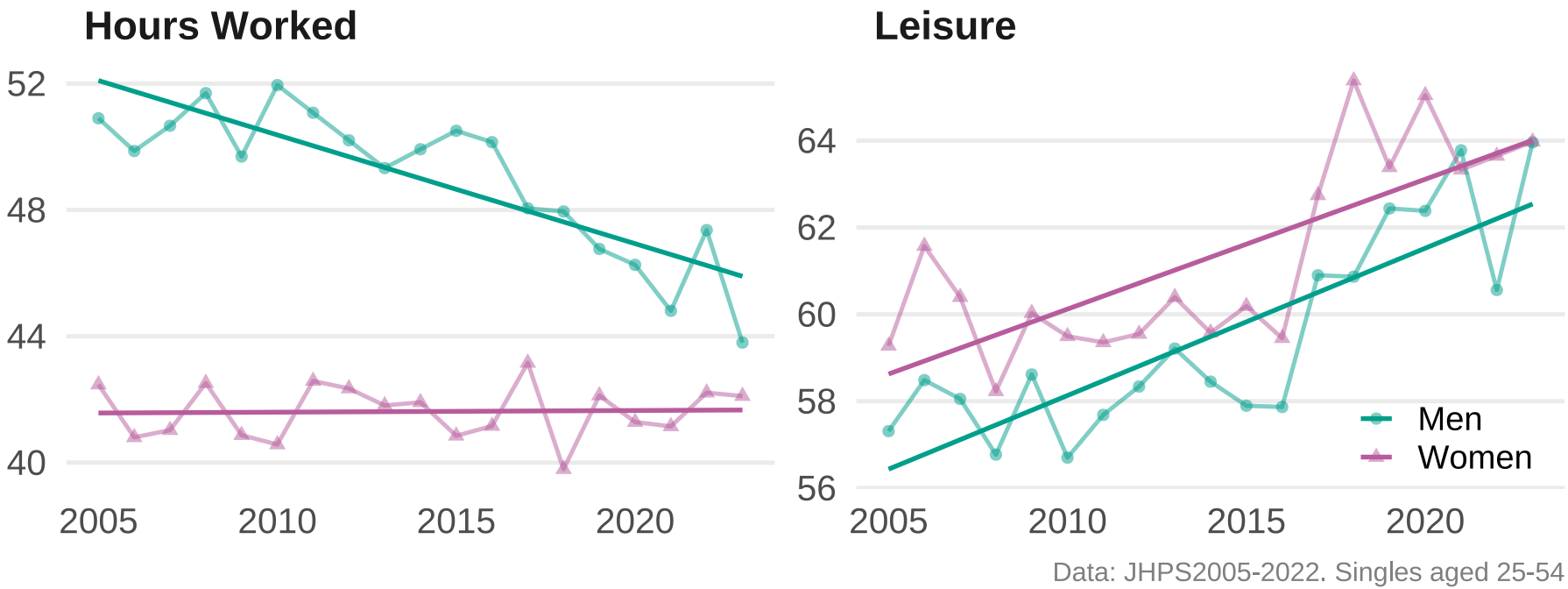


Share of Never-married at Age 45-54



1. Leisure technology growth $\Rightarrow$ Increase in α_l
2. Female wage growth $\Rightarrow$ Increase in μ_{w_f}
3. Shift in social norms $\Rightarrow$ Decline in θ

Increase in Leisure Hours

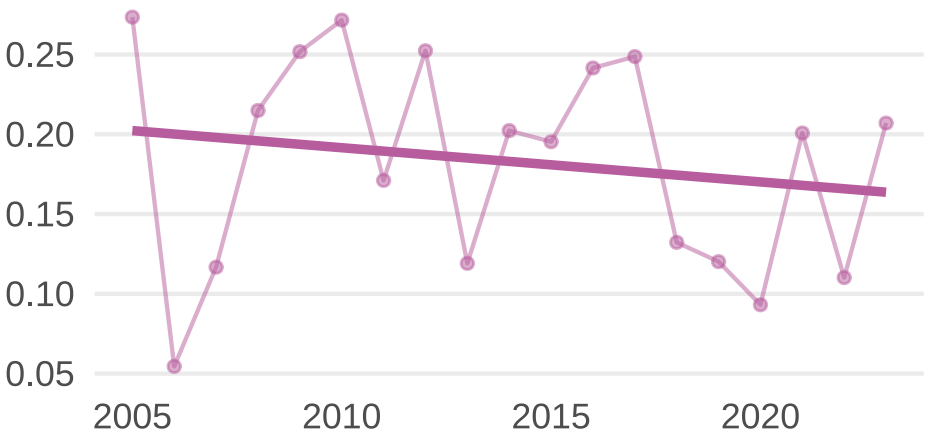


Data: JHPS2005-2022. Singles aged 25-54

- Decline in working hours & Increase in leisure hours for singles
- Consistent with leisure technology growth $\Rightarrow$ Increase in α_l

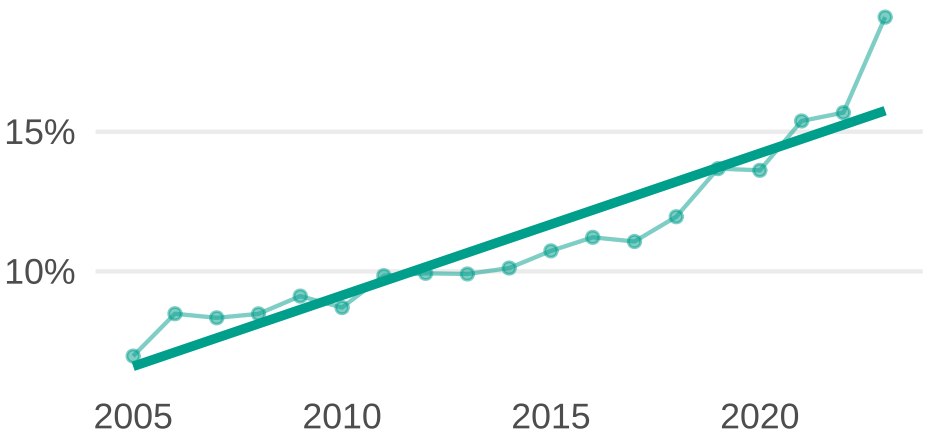
Other Potential Factors

Gender Gaps in Single's Log Wage



Data: JHPS2005-2022. Singles aged 25-54

Husband's Share in Domestic Labor



Data: JHPS2005-2022. Married couple aged 25-54

- Decline of the gender wage gap ⇒ Increase in μ_{w_f}
- Increase the husbands' domestic labor ⇒ Decrease in θ
  - → Weaker social norms on domestic labor for women

Calibration for 2005-2009

To simulate the model for 2005-2009,

- Calibrate only α_l, μ_f, θ and keep the rest of the parameters
- Target the following moments from the data in 2005-2009

	2005-2009	Target	Data	Model
α_l	**1.846**	Single's l_m	0.516	0.516
μ_f	**-0.157**	Single's $\log w_m - \log w_f$	0.181	0.181
θ	**0.913**	Couple's $d_m/(d_m + d_f)$	0.917	0.917

Estimated parameters captures

- $\alpha_l = 2.425$ in 2018-2022 $\Rightarrow$ Leisure technology growth
- $\mu_f = -0.153$ in 2018-2022 $\Rightarrow$ Female wage growth
- $\theta = 0.835$ in 2018-2022 $\Rightarrow$ Shift in social norms

Results

				Marriage Rate		Fertility Rate	
	α_l	μ_f	θ	Model	Data	Model	Data
Baseline (2018-2022)				0.839	0.836	1.622	1.446
Leisure Technology	✓			0.847		1.699	
Female Wage		✓		0.839		1.622	
Social Norms			✓	0.855		1.723	
All (2005-2009)	✓	✓	✓	0.859	0.928	1.794	1.709

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- Female wage growth does not play a role on the marriage and fertility
- Social norms does 17% for the marriage and 39% of the fertility

▸ cumulative results

Conclusion

Build a Model of Endogenous Marriage and Fertility

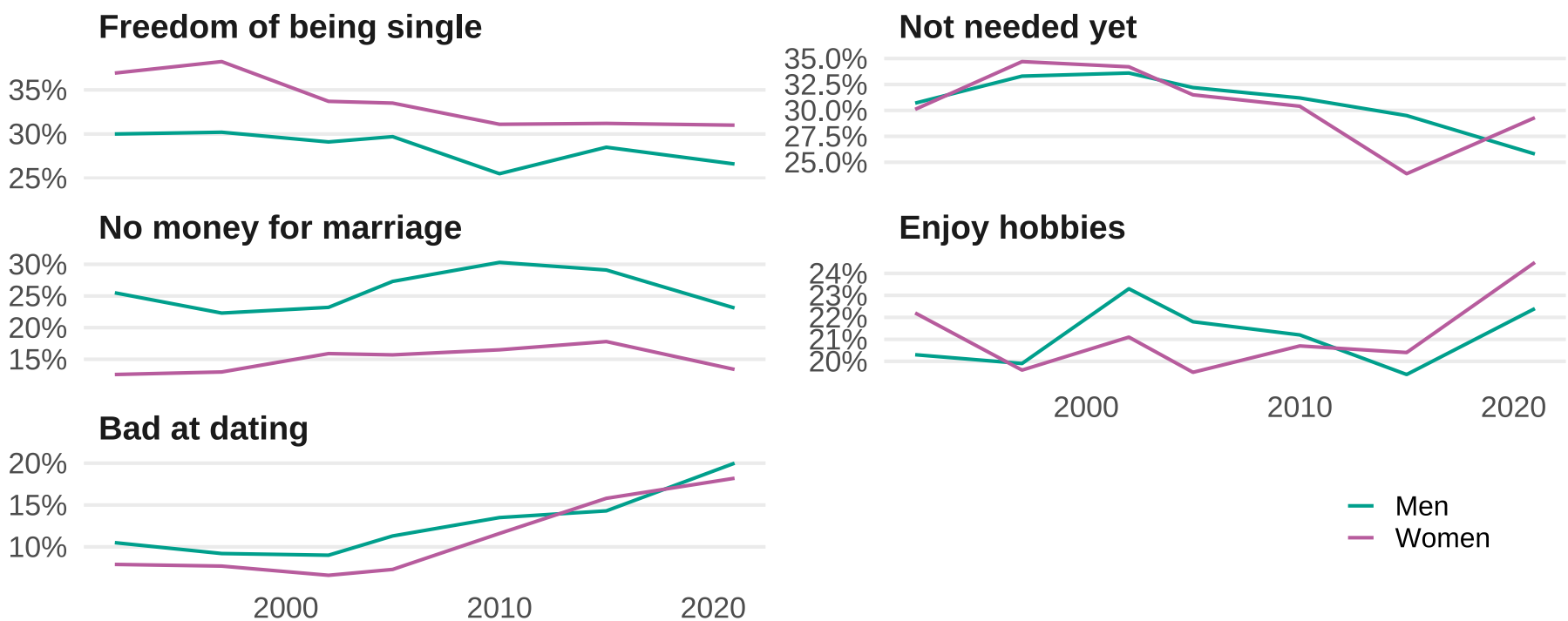
- Dynamic decision of mate selection, marriage, and childbirth
- Integrate heterogeneous wage, leisure technology, and social norms

Model explains the decline from 2005-2009 to 2018-2022:

- Leisure technology growth explains 9% for marriage and 29% for fertility
- Social norms on domestic labor explain 17% for marriage and 39% for fertility

Appendix

Reasons for Being Single Overtime



▸ back to main

Berman Equations (Single)

$$W_g^Y(w_g) = v(w_g) + \beta(1-\kappa_0)\int_{\mathcal{B}}\int_{\mathcal{W}}(1-\mathbb{1}^Y)W_g^Y(w_g) + \mathbb{1}^Y V_g^Y(w_g, w_{g'}, 0, 0; b)\, d\hat{S}_{g'}^Y(w_{g'})dG(b)$$

$$+\beta\kappa_0\int_{\mathcal{B}}\int_{\mathcal{W}}(1-\mathbb{1}^M)W_g^M(w_g) + \mathbb{1}^M V_g(w_g, w_{g'}, 0, 0; b)\, d\hat{S}_{g'}^M(w_{g'})dG(b)$$

$$W_g^M(w_g) = v(w_g) + \beta(1-\kappa_1)\int_{\mathcal{B}}\int_{\mathcal{W}}(1-\mathbb{1}^M)W_g^M(w_g) + \mathbb{1}^M V_g^M(w_g, w_{g'}, 0, 0; b)\, d\hat{S}_{g'}^M(w_{g'})dG(b)$$

$$+\beta\kappa_1 W_g^O(w_g)$$

$$W_g^O(w_g) = v(w_g) + \beta(1-\delta)W_g^O(w_g)$$

where

$$\mathbb{1}^a(w_g, w_{g'}, b) = \begin{cases} 1 \; V_m^a(w_m, w_f, b) > W_m^a(w_f) \quad \text{and} \quad V_f^a(w_f, w_m, b) > W_f^a(w_f) \\ 0 \text{ otherwise} \end{cases}$$

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Berman Equations (Married)

$$
\begin{aligned}
V_g^Y\left(w_g, w_{g'}, N_0, 0; b\right) &= v_g\left(w_g, w_{g'}, N_0, 0\right) + b \\
&+\beta(1-\kappa_0)\delta V_g^Y\left(w_g, w_{g'}, N_0^*, 0; b\right) + \beta(1-\kappa_0)(1-\delta)V_g^Y\left(w_g, w_{g'}, N_0, 0; b\right) \\
&+\beta\kappa_0\delta V_g^M\left(w_g, w_{g'}, 0, N_0^*; b\right) + \beta\kappa_0(1-\delta)V_g^M\left(w_g, w_{g'}, 0, N_0; b\right) \\
V_g^M\left(w_g, w_{g'}, N_0, N_1; b\right) &= v_g\left(w_g, w_{g'}, N_0, N_1\right) + b \\
&+\beta(1-\kappa_1)\delta V_g^M\left(w_g, w_{g'}, N_0^*, N_1; b\right) + \beta(1-\kappa_1)(1-\delta)V_g^M\left(w_g, w_{g'}, N_0, N_1; b\right) \\
&+\beta\kappa_1 V_g^O\left(w_g, w_{g'}, 0, N_0^* + N_1; b\right) + \beta\kappa_1(1-\delta)V_g^O\left(w_g, w_{g'}, 0, N_0 + N_1; b\right) \\
V_g^O\left(w_g, w_{g'}, 0, N_1; b\right) &= v_g\left(w_g, w_{g'}, 0, N_1\right) + b + \beta(1-\kappa_2)V_g^O\left(w_g, w_{g'}, 0, N_1; b\right).
\end{aligned}
$$

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Wage Distribution of Singles

$$S_g^Y(w_g) = (1-\kappa_0)\int_{\mathcal{B}}\int_{\mathcal{W}_{g'}}\int_{\mathcal{W}_g^{w_g}}\left(1-\mathbb{1}^Y(w'_g, w'_{g'}, b)\right) dS_g^Y(w'_g) d\hat{S}_{g'}^Y(w'_{g'}) dG(b) + \frac{\delta\kappa_0\kappa_1}{\kappa_0\kappa_1+\delta(\kappa_0+\kappa_1)}\int_{\mathcal{W}}^{w_g} dF_g(w'_g),$$

$$S_g^M(w_g) = \kappa_0\int_{\mathcal{B}}\int_{\mathcal{W}}\int_{\mathcal{W}}^{w_g}\left(1-\mathbb{1}^Y(w'_g, w'_{g'}, b)\right) dS_g^Y(w'_g) d\hat{S}_{g'}^Y(w'_{g'}) dG(b)$$

$$+(1-\kappa_1)\int_{\mathcal{B}}\int_{\mathcal{W}}\int_{\mathcal{W}}^{w_g}\left(1-\mathbb{1}^M(w'_g, w'_{g'}, b)\right) dS_g^M(w'_g) d\hat{S}_g^M(w'_{g'}) dG(b),$$

$$S_g^O(w_g) = \kappa_1\int_{\mathcal{B}}\int_{\mathcal{W}}\int_{\mathcal{W}}^{w_g}\left(1-\mathbb{1}^M(w'_g, w'_{g'}, b)\right) dS_g^M(w'_g) d\hat{S}_{g'}^M(w'_{g'}) dG(b) + (1-\delta)\int_{\mathcal{W}}^{w_g} dS_g^O(w'_g).$$

where $\hat{S}_{g'}^a(w_{g'})$ is the normalized wage distribution of the opposite gender

$$\hat{S}_{g'}^a(w_{g'}) = \frac{S_{g'}^a(w_{g'})}{\int_{\mathcal{W}} dS_{g'}^a(w_{g'}{}')}$$

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Specification of Child Penalty

For individual i at time t,

$$y_{it} = \alpha_i + \lambda_t + \sum_{q \neq -1, -\infty} \beta_q \{q = t - c_i\} + \varepsilon_{it}$$

- α_i: Individual fixed effect
- λ_t: Year fixed effect
- c_i: Year of first childbirth
- y_{it}: Working hours, domestic labor hours, or leisure hours

Data: JHPS 2005-2022

- **Treated**: First childbirth in 2005 or later
- **Control**: People never had a child until 2022

On the line of works of **Child Penalty** (Kleven, Landais, and Søgaard 2019)

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Cumulative Results

	α_l	μ_f	θ	Model	Data	Model	Data
Baseline (2018-2022)				0.839	0.836	1.622	1.446
	✓			0.847		1.699	
		✓		0.839		1.622	
	✓	✓		0.847		1.699	
			✓	0.855		1.723	
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