Misreading the Biological Clock: Beliefs, Career and Fertility Decisions

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June 2026

Motivation

- Worldwide ↓ **Total fertility rate (TFR)** & ↑ **Age at first birth (AFB)**
  - Below the replacement level (2.1)
  - **Widening gap between desired and observed fertility rates**
  - Increasing share of births using Artificial Reproductive Techniques (ART)
- **Career–fertility trade-off**:
  - Large child penalty in earnings (Kleven et al., 2019)
  - Delaying childbirth increases experience and wages (Miller, 2011; Bailey et al., 2012; Gallen et al., 2024)
- Government response: **pro-natalist policies**
  - Tax credits, parental leave, childcare subsidies, cash transfers, ...
  - Limited effects on fertility

Motivation

- **Misperceptions may contribute** to ↑ AFB and ↓ TFR
  - If individuals *overestimate* their fecundity ⇒ delay childbearing ⇒ begin trying later ⇒ end up with fewer children than desired or childlessness
- **Evidence of overestimation:**
  - Average ∼30 pp overestimation (Hashiloni-Dolev et al., 2011) (Swift and Liu, 2014)
  - Ongoing representative U.S. survey measuring fecundity beliefs
- **Fecundity is heterogeneous**
  - Heterogeneity in time-to-pregnancy across and **within age** (Leridon, 2004; Dunson et al., 2002) ▸ Figure
  - Individual risk can be assessed ▸ Counseling
- **Medical counseling** might reduce misperceptions ▸ Initiatives

What We Do

1. We use a two-period **toy model** to illustrate the mechanisms
2. We build a **quantitative life-cycle model** of fertility and female labor supply decisions
   - Career-fertility trade-off: **higher future wages** vs **risk of fertility below desired**
   - **Heterogeneous fecundity**
   - Homogeneous **subjective** beliefs
3. We use the model as a lab to conduct counterfactual experiments
   - **What are the effects of subjective fecundity beliefs on women's career and childbearing decisions?**
   - **Does providing information about fecundity alter these outcomes?**

Related Literature & Contributions

- **Structural models of fertility & career decisions**

  Takeda (2024); Adda et al. (2017); de la Croix and Pommeret (2021); Sommer (2016); Guner et al. (2024); Cruces (2024); Jakobsen et al. (2024) (...)

  ⇒ Extend standard models w/ subjective fecundity beliefs and types

- **Subjective expectations & economic decisions**
  - Income (Rozsypal and Schlafmann, 2023)
  - Survival (Grevenbrock et al., 2021)
  - Returns to education (Attanasio and Kaufmann, 2014)
  - Major choice (Wiswall and Zafar, 2021)
  - Work and childcare after childbirth (Caplin et al., 2025)
  - Labor market expectations (Balleer et al., 2025)
  - Housing and house prices (Ludwig et al., 2025) (...)

  ⇒ How *biased fecundity expectations* shape women's career and family decisions

Toy Model

Main Ingredients

- Two-period life-cycle model : $j \in \{1, 2\}$
- Preference heterogeneity for children: $\psi_i \sim U(0, \bar{\psi})$
- Homogeneous fecundity and homogeneous beliefs
- Objective fecundity probability: p
- Subjective fecundity belief: $p^s > p \implies$ overestimation
- Decisions:
  - Consumption: c_{ij}
  - Fertility trial: $b_{ij} \in \{0, 1\}$

Fertility Decisions

- **Assumption 1:** At most one child

$$b_{i2} = 0 \quad \text{if } s_{i1} = 1$$

- **Assumption 2:** Probability of birth conditional on trying is one in the first period

$$s_{i1} = 1 \quad \text{if } b_{i1} = 1$$

- Let's denote the history of fertility outcomes:

$$S_i^j = \{s_{i1}, s_{ij}\}, \quad s_{ij} \in \{0, 1\}$$

where at period 2 there are three cases:

$$S_i^2 = \{ \underbrace{(0,0)}_{\text{No Motherhood}} , \underbrace{(1,0)}_{\text{Early Mother}} , \underbrace{(0,1)}_{\text{Late Mother}} \}$$

Income & Human Capital

- **First-period income:**

$$y_{i1}(b_{i1}) = 1 - \phi b_{i1}, \qquad \underbrace{\phi \in (0,1)}_{\text{childbearing time cost}}$$

- **Second-period income:**

$$y_{i2}(S_i^2) = \underbrace{h_{i2}(b_{i1})}_{\text{Human capital}} (1 - \phi s_{i2})$$

  - Human capital at $j = 2$:

$$h_{i2}(b_{i1}) = \kappa(1 - \phi b_{i1}), \qquad \underbrace{\kappa > 1}_{\text{returns to experience}}$$

- **Budget constraint:**

$$c_{ij}(S_i^j) = y_{ij}(S_i^j)$$

Preferences

- **Life-time utility:**

$$\max_{\{c_{ij}(S_i^j)>0, b_{ij}\in\{0,1\}\}_{j\in\{1,2\}}} \mathbb{E}\Big[\sum_{j=1}^{2} \beta^{j-1} u(c_{ij}(S_i^j), s_{ij})\Big], \quad \beta \in (0,1)$$

- **Per-period utility:**

$$u(c_{ij}, s_{ij}) = \ln(c_{ij}) + \psi_i s_{ij}$$

- Heterogeneity in preferences for children:

$$\psi_i \sim U(0, \bar{\psi})$$

- Subjective expectations use p^s instead of p

Expected utility in period 2

Motherhood Strategies

1. **No Motherhood (NM)** ($b_{i1} = b_{i2} = 0$):

$$U_i(0,0) = \beta \ln(\kappa)$$

2. **Late Seeker (LS)** ($b_{i1} = 0, b_{i2} = 1$):

$$EU_i(0,1) = U_i(0,0) + \beta p^s \left[\ln(1-\phi) + \psi_i\right]$$

3. **Early Mother (EM)** ($s_{i1} = b_{i1} = 1, b_{i2} = 0$):

$$U_i(1,0) = U_i(0,0) + (1+\beta)\ln(1-\phi) + \psi_i$$

Proposition: Preference & Probability Thresholds

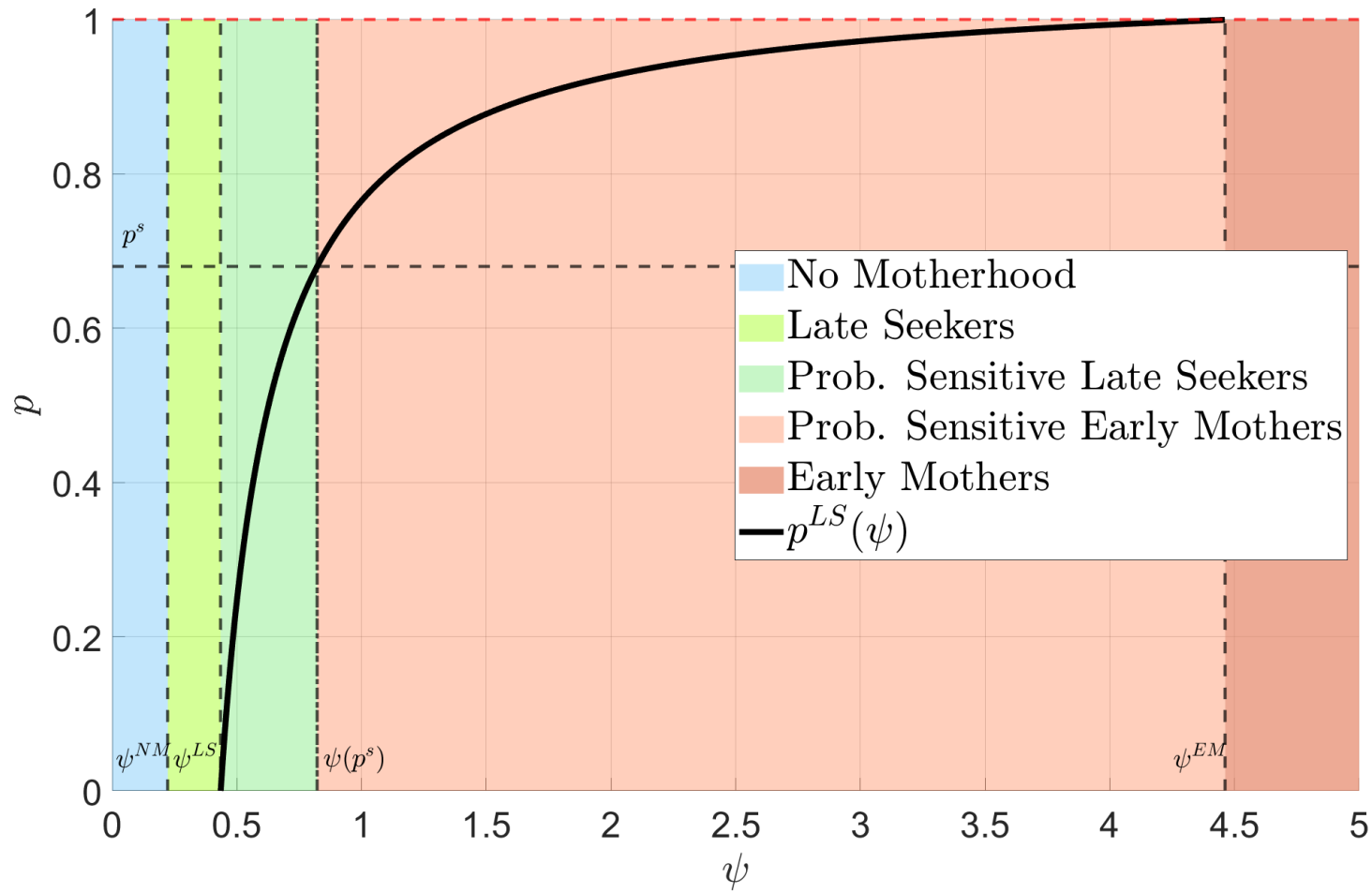
- **Classification of women by preference parameter ψ_i** ▸ Show thresholds
  1. *Not a mother* if $\psi_i < \psi^{NM}$
  2. *Late seeking* if $\psi_i \in (\psi^{NM}, \psi^{LS}]$
  3. ***Probability-sensitive late seeker*** if $\psi_i \in (\psi^{LS}, \psi(p^s)]$
  4. ***Probability-sensitive early mother*** if $\psi_i \in (\psi(p^s), \psi^{EM}]$
  5. *Early mother* if $\psi_i > \psi^{EM}$

- **Comparative statics with respect to beliefs p^s**

$$\frac{\partial \psi(p^s)}{\partial p^s} > 0 \quad \Longrightarrow \quad \uparrow p^s \Rightarrow \textbf{larger region of (3)}$$

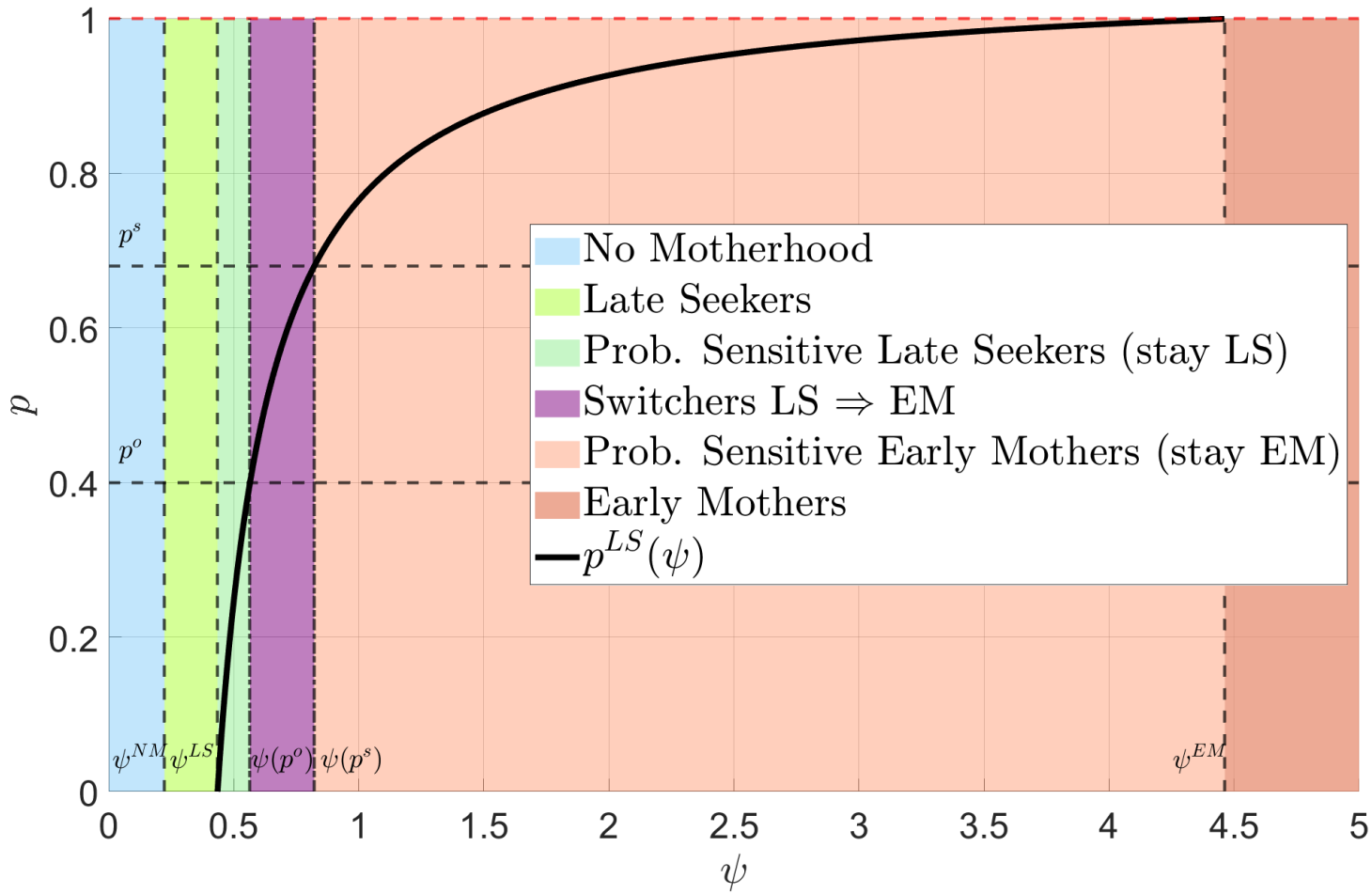
- We define a **probability threshold** $p^{LS}(\psi_i)$ such that:
  - If $p^s > p^{LS}(\psi_i)$, the woman behaves as a *late seeker*

Toy Model: Decisions With Subjective Beliefs



- Since $\psi_i \sim U(0, \bar{\psi})$
- shaded areas represent respective mass of households

Toy Model: Decisions Under Information Treatment



- Reducing optimistic bias such that $p^s = p^o$:
  - $LS \rightarrow EM$
  - AF $\uparrow$, AFB $\downarrow \Rightarrow$ aggregate human capital $H \downarrow$

Extension: Heterogeneous Fecundity

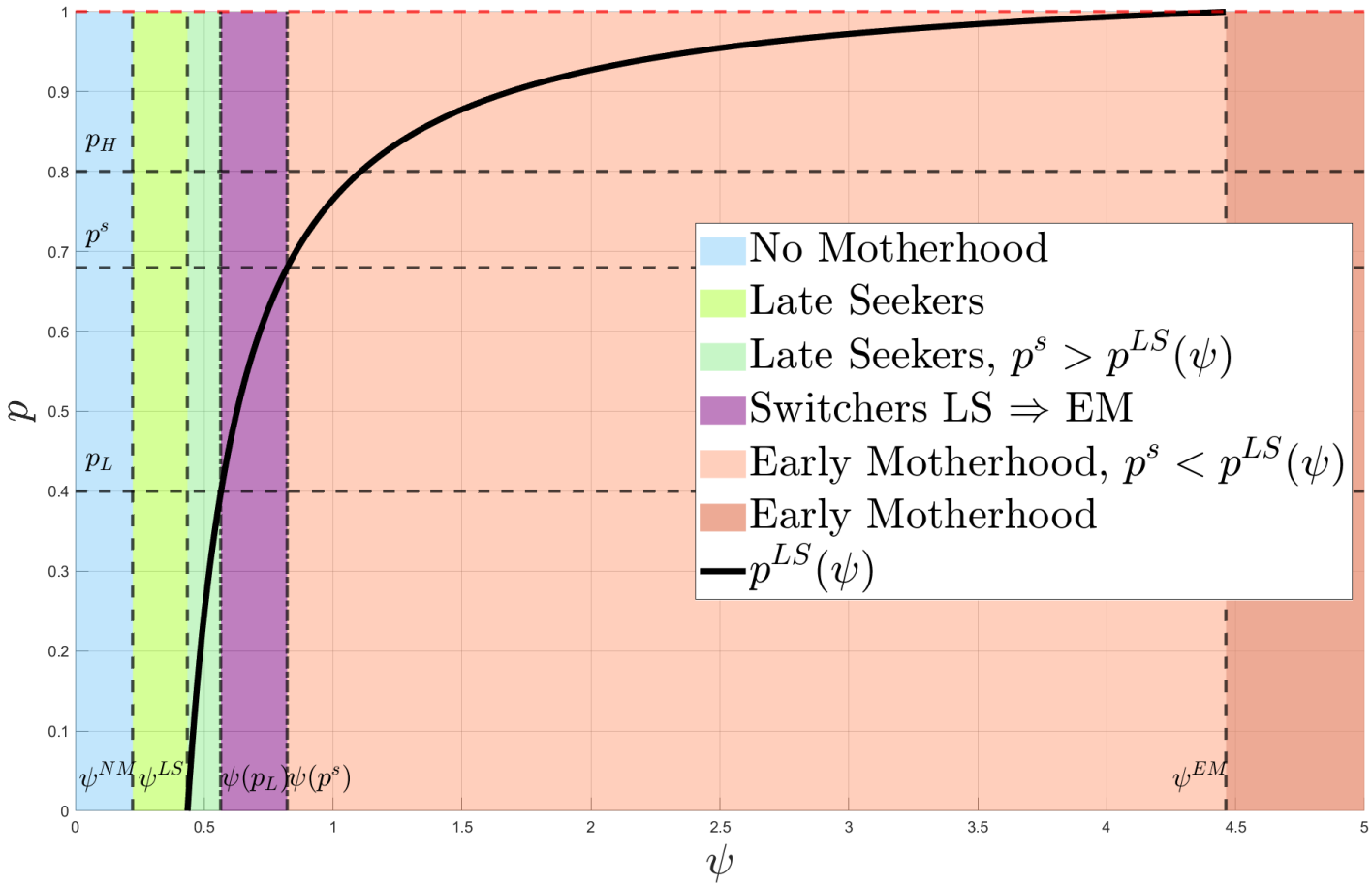
- **Heterogeneous fecundity**, homogeneous beliefs
- Two fecundity types: $p_i \in \{p_L, p_H\}$, $1 > p_H > p_L > 0$
- Objective probability for high fecundity: $\pi_i^o \in \{0, 1\}$
- Subjective high fecundity probability $\pi^s \in [0, 1]$
- Subjective probability of birth in period 2:

  $p^s = (1 - \pi^s)p_L + \pi^s p_H \in (p_L, p_H)$

- Information treatment: $p_i^{s'} \mid I(p_i) = p_i$ for $i \in L, H$

Decisions Under Information Treatment:

Low Fecundity Women

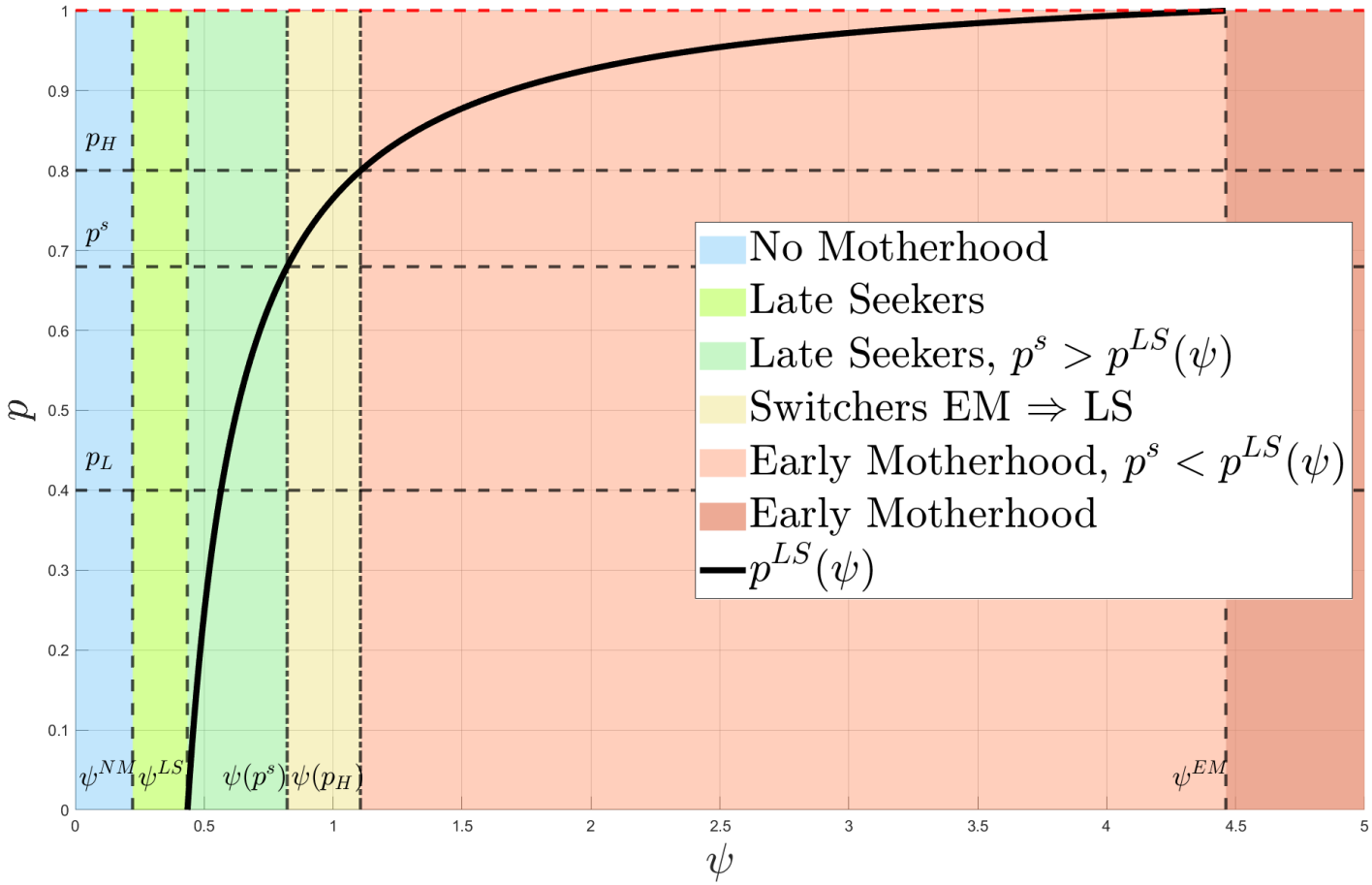


- Low fecundity women: $\Phi(EM) \uparrow$

Zoom

Decisions Under Information Treatment:

High Fecundity Women



- High fecundity women $\Phi(LS) \uparrow$

Zoom

We Need a Quantitative Model

- The net effects of the information treatment on **TFR** and **AFB** are **ambiguous**
- **Key question:** Can TFR ↑ even when AFB ↑ (and H ↑)?
  - Yes — we can derive analytical conditions, but . . .
- . . . it is ultimately a **quantitative question**:
- Where do we end up in a calibrated model?

Quantitative Model

Quantitative Model

- Life-cycle model with unitary households
- Only married individuals
- College-educated women
- Husbands always work
- Decisions: consumption, fertility, labor supply $l = \{0, 0.5, 1\}$
- Human capital formation through experience
- Monetary costs of childbearing
- Probability of conceiving decreases with age
- Ex-ante heterogeneity in: fecundity and child preferences

Fecundity and Beliefs

- Each period j, women make **pregnancy decision** $b_{j+1} \in \{0, 1\}$
- We consider heterogeneity in fecundity, two types:
  - **Low fecundity**: p_j^L
  - **High fecundity**: p_j^H
- Then children born with objective probability $p_j = 0.5\,(p_j^L + p_j^H)$
- They all have same **subjective probability beliefs**: p_j^s, where $p_j^s \neq p_j$

Children

- Children age stochastically:
  - **Newborn** (0-1) , **Baby** (1-4), **School-age child** (5-14),**Teenager** (+15)
  - Vector of children: $\mathbf{n} = \{n_0, n_1, n_2, n_3\}$, where $n_0 \leq 1$
  - Total number $N = n_0 + n_1 + n_2 + n_3$, $N \leq 3$
- **Time cost for mothers**, $\zeta_1 > \zeta_2$:

$$\tau(\mathbf{n}) = \begin{cases} \zeta_1(n_0 + n_1) & \text{if } (n_0 + n_1) > 0, \\ \zeta_2 n_2 & \text{if } (n_0 + n_1) = 0 \text{ and } n_2 > 0 \end{cases}$$

- **Monetary costs:**
  - Consumption equivalence
  - Childcare cost if mother works

$$s(\mathbf{n}, l) = l\left(\kappa_1(n_0 + n_1) + \kappa_2 n_2\right)\bar{Y}$$

Preferences

- Leisure $\mathcal{L} = 1 - l - \tau(\mathbf{n})$
- Age-based taste for children:

$$g(j;\psi) = \frac{e^{j-\psi}}{1+e^{j-\psi}} \in (0,1)$$

- Per-period utility, $u(c, \mathcal{L}, N, j)$:

$$\ln\left(\frac{c}{\iota(\mathbf{n})}\right) + \alpha_l \mathcal{L}^{\gamma_l} + g(j;\psi)\sum_{k=1}^{3}\alpha_{nk}\mathbb{1}(N \geq k) - \nu\,\mathbb{1}\{n_o = 1 \ \wedge \ (n_2 + n_3 > 0)\}$$

  - Equivalence scale: $\iota(\mathbf{n})$
  - Heterogeneity in desire for children: ψ
  - Penalty for overlapping children (Newborn + School-age or older)

Income

- **Human capital accumulation:**

$$h^f_{j+1} = \begin{cases} h^f_j(1 + l^f(\eta^f_1 + \eta^f_1 j)) & \text{if } l > 0 \\ \\ h^f_j(1-\delta) & \text{if } l = 0 \end{cases}$$

- **Female Wages:** $\ln z^f_j = \eta^f_0 + \ln h^f_j + v^f_j$
- **Exogenous Husband Earnings:** $\ln z^m_j = \eta^m_0 + \eta^m_1 j + \eta^m_2 j^2 + v^m_j$
- **Budget Constraint:**

$$c + s(\mathbf{n}, l) = \underbrace{z^f \cdot l + z^m \cdot 1}_{Y} - T(Y)$$

where $T(Y) = (1 - \lambda Y^{-\tau})Y$ are taxes

Shocks

Calibration

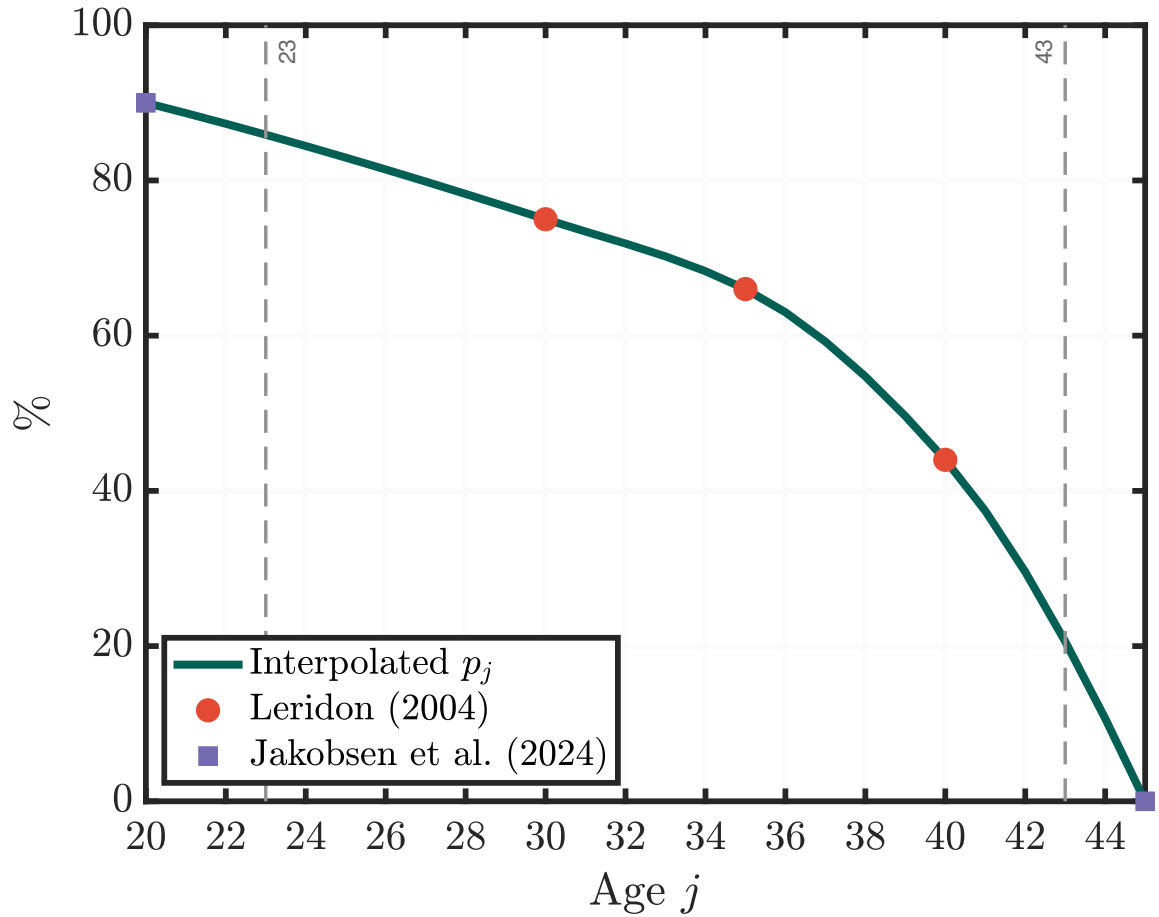
- US data (PSID, CPS)
- College-educated married women born between 1958 and 1978.
- Standard first stage (outside the model) and second stage parameters

Parameter Values: Stage I

Parameter	Value	Description	Source
Demographics			
J_f	21	Last Fertile Period	
J	37	Last Model Period	
Λ_1	0.2	Transition Probability From Baby to School-age Children	
Λ_2	0.1	Transition Probability From School-age Children to Teenager	
β	0.96	Discount Factor	
$\iota(\mathbf{n})$	$1.5 + 0.3N$	Equivalence scale	OECD
Income			
η_0^m	-0.586		
η_1^m	0.127	Regression log wage on age and age2 (men)	
η_2^m	-0.001		
σ_{ξ^m}	0.156	Standard Deviation of Income Shock Men	
ρ^m	0.955	Persistence of Income Shock Men	PSID
σ_{ξ^f}	0.156	Standard Deviation of Income Shock Women	
ρ^f	0.955	Persistence of Income Shock Women	
σ_{u^m}	0.110	Standard Deviation of Fixed Effect for Men	
σ_{u^f}	0.110	Standard Deviation of Fixed Effect for Women	
λ	2.915	Average Tax Rate	Borella et al. (2023)
τ	0.107	Index of Progressivity	
δ	0.100	Human Capital Depreciation	

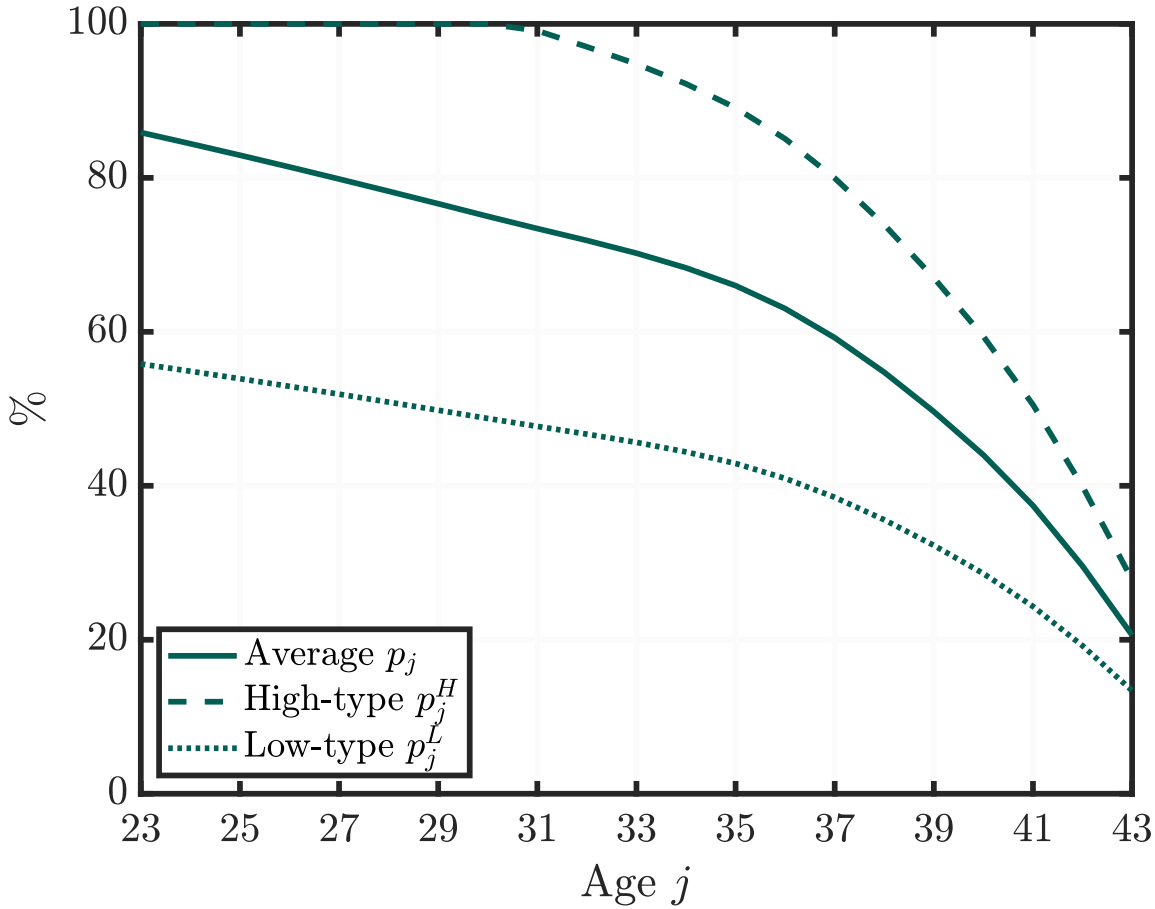
Guess

Biological Fecundity Probability by Age



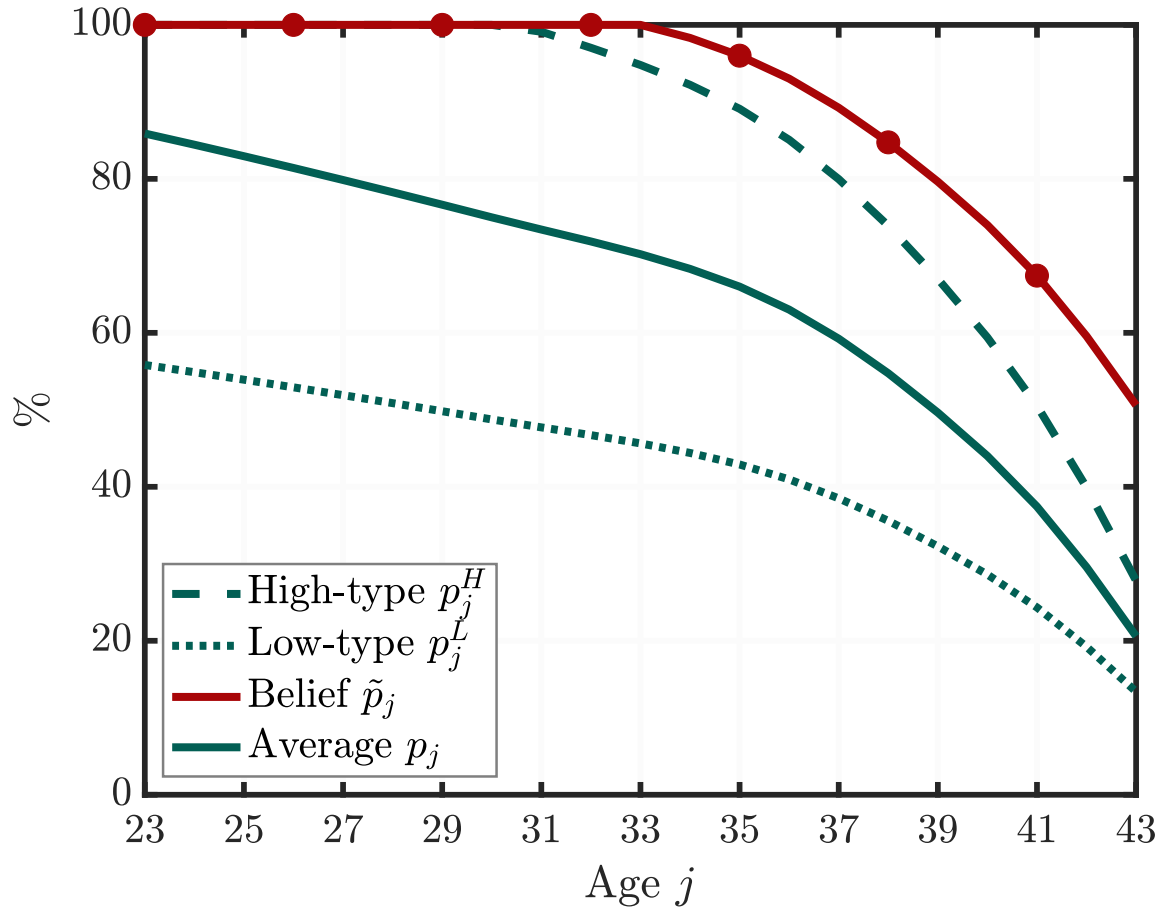
- Probability that a couple conceives and has a live birth within 12 months of trying (Leridon, 2004)

Heterogeneity in Biological Fecundity Probability by Age



- Distribution of fecundability estimated by Leridon (2004)

Biological Fecundity Probability by Age & Types vs Beliefs

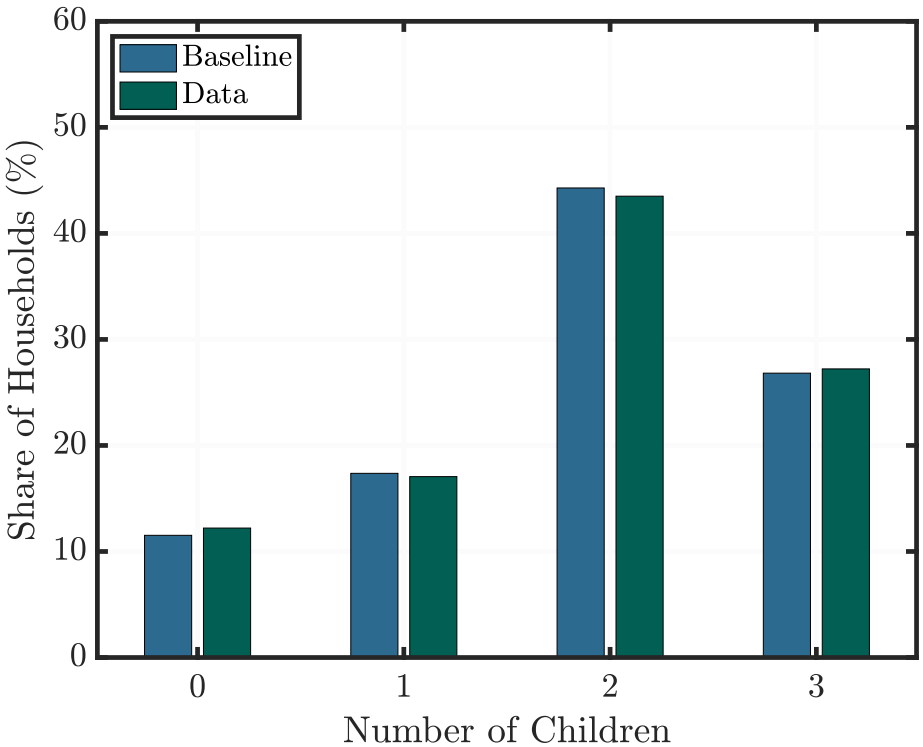


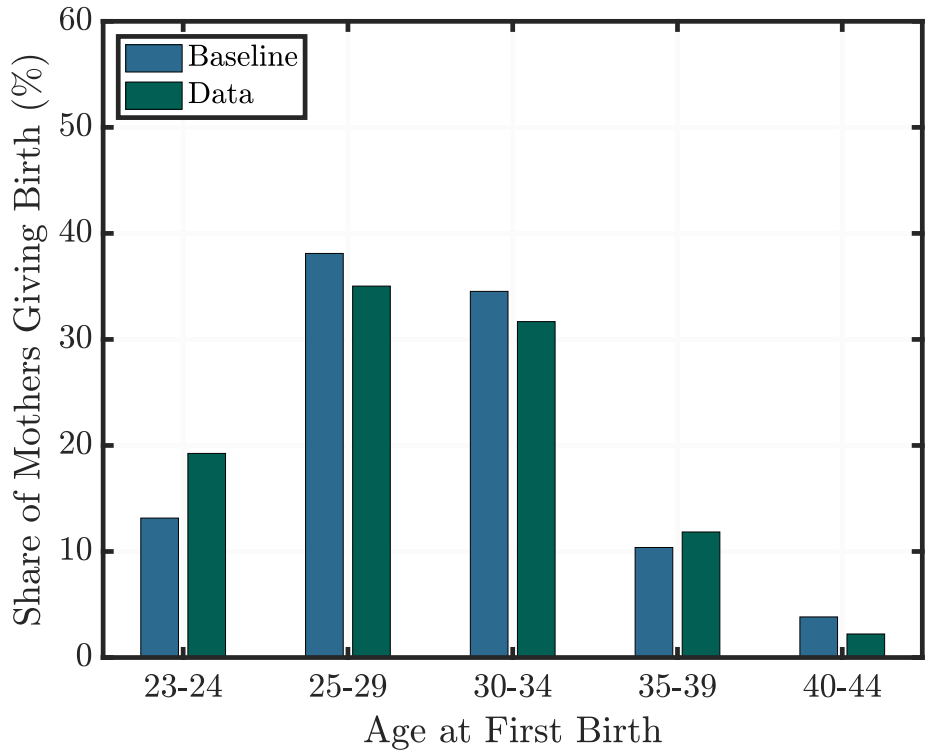
- Average gap of 30pp taken from Hashiloni-Dolev et al. (2011)

Parameter Values: Stage II

Parameter	Value	Description	Target
Preferences for Children			
α_{n1}	0.30		Share of hh with 1 kid
α_{n2}	0.25		Share of hh with 2 kids
α_{n3}	0.22		Share of hh with 3 kids
Share women with ψ_1	0.61		Share of mothers giving birth at ages 23–24
Share women with ψ_2	0.26		Share of mothers giving birth at ages 25–29
ψ_1	22.0		Share of mothers giving birth at ages 30–34
ψ_2	33.0		Share of mothers giving birth at ages 35-39
ψ_3	50.5		Share of mothers giving birth at ages +40
Preferences for Leisure			
ν	1.03		Spacing between 1st and 2nd child
α_l	1.19		Average employment
γ_l	0.20		Average full-time
Cost of children			
ζ_1	0.060	Time Cost, Newborns and Babies	Average time spent w/ children
ζ_2	0.019	Time Cost, School Age Children	Employment difference of mothers w/ old & young kids
κ_1	0.082	Childcare Cost, Newborns and Babies	Childcare expenditure 0–5
κ_2	0.055	Childcare Cost, School Age Children	Childcare expenditure 5–14
Human capital accumulation			
η_0^f	1.32		Gender wage gap at 23–24
η_1^f	0.39	Returns to work	Wage growth$<$35
η_2^f	-0.0081		Wage growth $\geq$35

Targeted Fertility Moments





- TFR: 1.85 vs 1.98
- Mother's AFB: 28.89 vs 28.88
- Spacing between children: 2.02 vs ≈ 2

Targeted Moments

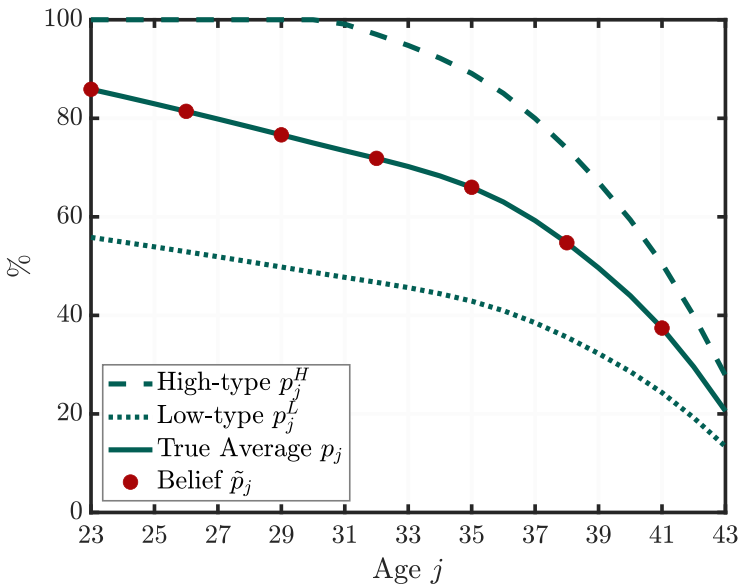
Targeted Moments	Model	Data
Childcare Cost Share Young (%)	8.50	8.00
Childcare Cost Share Old (%)	5.00	5.00
Average Employment (%)	80.61	81.00
Average Full-Time (%)	69.57	81.00
Employment Gap Between Mothers 5-14 and 0-4	0.11	0.11
Gender Wage Gap at Ages 23-24	1.37	1.37
Wage growth <35	5.47%	5.7%
Wage growth ≥ 35	-0.05%	-1.33%

Non-targeted moments (I) Non-targeted moments (II)

Counterfactuals: Correcting Fecundity Beliefs

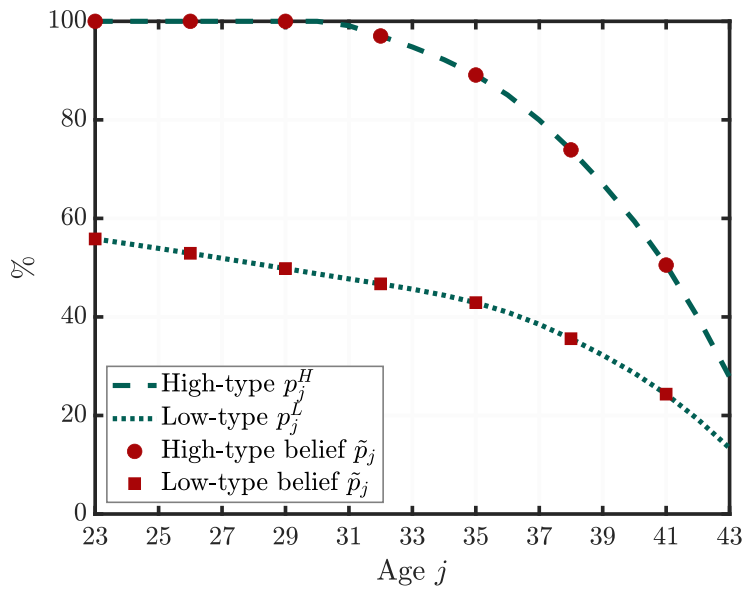
I. *Average* Fecundity Beliefs

- Approach: Provide women with **average** objective probabilities and let them re-optimize (steady-state comparison)

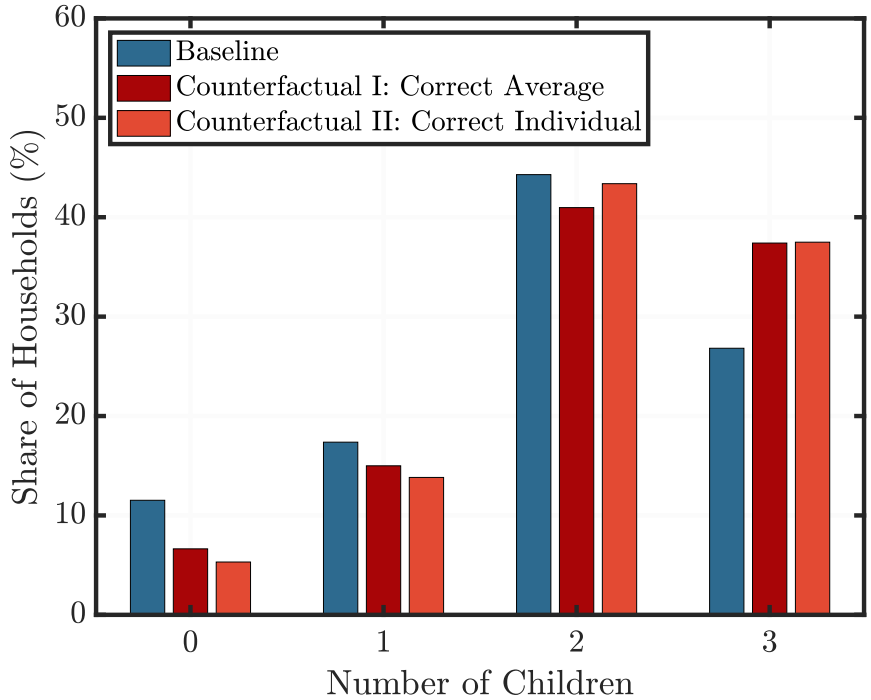


II. *Individual* Fecundity Beliefs

- Approach: Provide women with **individual** objective probabilities and let them re-optimize (steady-state comparison)

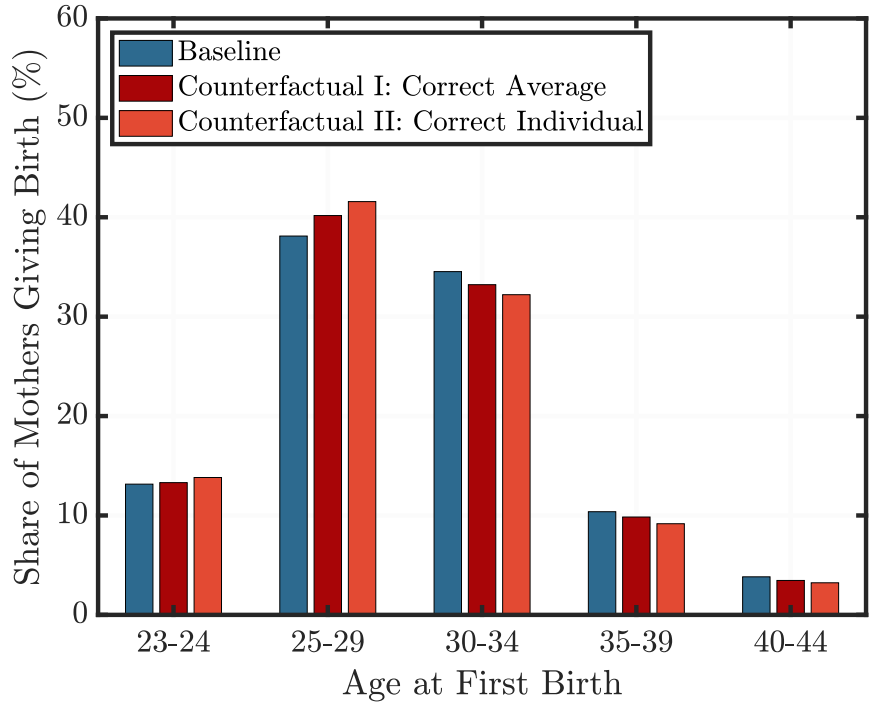


Households by Number of Children



- Providing fecundity information increases TFR
- The increase is larger with *individual* information:
  - **Baseline:** 1.846
  - **Counterfactual I:** 1.975 (Correct Average)
  - **Counterfactual II:** 1.999 (Correct Individual)

Age at First Birth Distribution



- Providing fecundity information shifts births to earlier ages
- The effect is stronger when women receive *individual* information:
  - **Baseline:** Mean AFB = 28.89
  - **Counterfactual I:** Mean AFB = 28.73 (Correct Average)
  - **Counterfactual II:** Mean AFB = 28.59 (Correct Individual)

Heterogeneity by Types

	Baseline	CF I: Δ from Baseline	CF II: Δ from Baseline
Total Fertility Rate			
Overall	1.85	+0.13	+0.15
High fecundity	2.03	+0.15	+0.05
Low fecundity	1.66	+0.11	+0.26
High preference	2.12	+0.15	+0.17
Medium-High preference	2.11	+0.10	+0.13
Medium-Low preference	2.05	+0.11	+0.11
Low preference	1.66	+0.11	+0.26
Age at First Birth			
Overall	28.89	−0.16	−0.30
High fecundity	28.23	−0.08	+0.09
Low fecundity	29.57	−0.24	−0.71
High preference	26.15	−0.23	−0.36
Medium-High preference	35.10	−0.75	−0.97
Medium-Low preference	43.31	−0.50	−0.78
Low preference	33.78	−0.76	−0.54

- Low-fecundity and low-preference women show the largest increase in fertility when beliefs are corrected
- Accurate information on average can induce overreactions among those who are already above average (high fecundity)

Plot Employment and Wages

Conclusion

Summary

- How do subjective beliefs about fecundity impact on fertility decisions?
- Information treatment about the average or individual fecundity
- Tools: Illustrative toy & quantitative model
- Main (preliminary) findings of endowing women w/ correct beliefs:
  - TFR $\uparrow$ by 7% and 8%
  - AFB $\downarrow$ by 0.15 and 0.30 years
  - Little effect on employment

Extensions

- Launching a nationally **representative survey** for the U.S
- Model assessment: **young vs old mothers**
- Incorporate **Learning**
- Allow for a decision on **Assisted Reproductive Technologies** as:
  - a partial "insurance"
  - another source of miss-perceptions: overestimation on the success probability of ARTs
- Other countries

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