Career Choices, Timing of Childbirth, and Perceptions of Fecundity

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General Background

- The decrease in fertility rate is significant problem in many advanced country, such as Japan or South Korea.
- In Japan, one of the sources of the problem is derived from the postpone of the timing of childbirth.
- Unlike other animals, humans work, earn, and accumulate human capital.
- But at the same time, fecundity, the biological reproductive ability decreases over time.

General Background

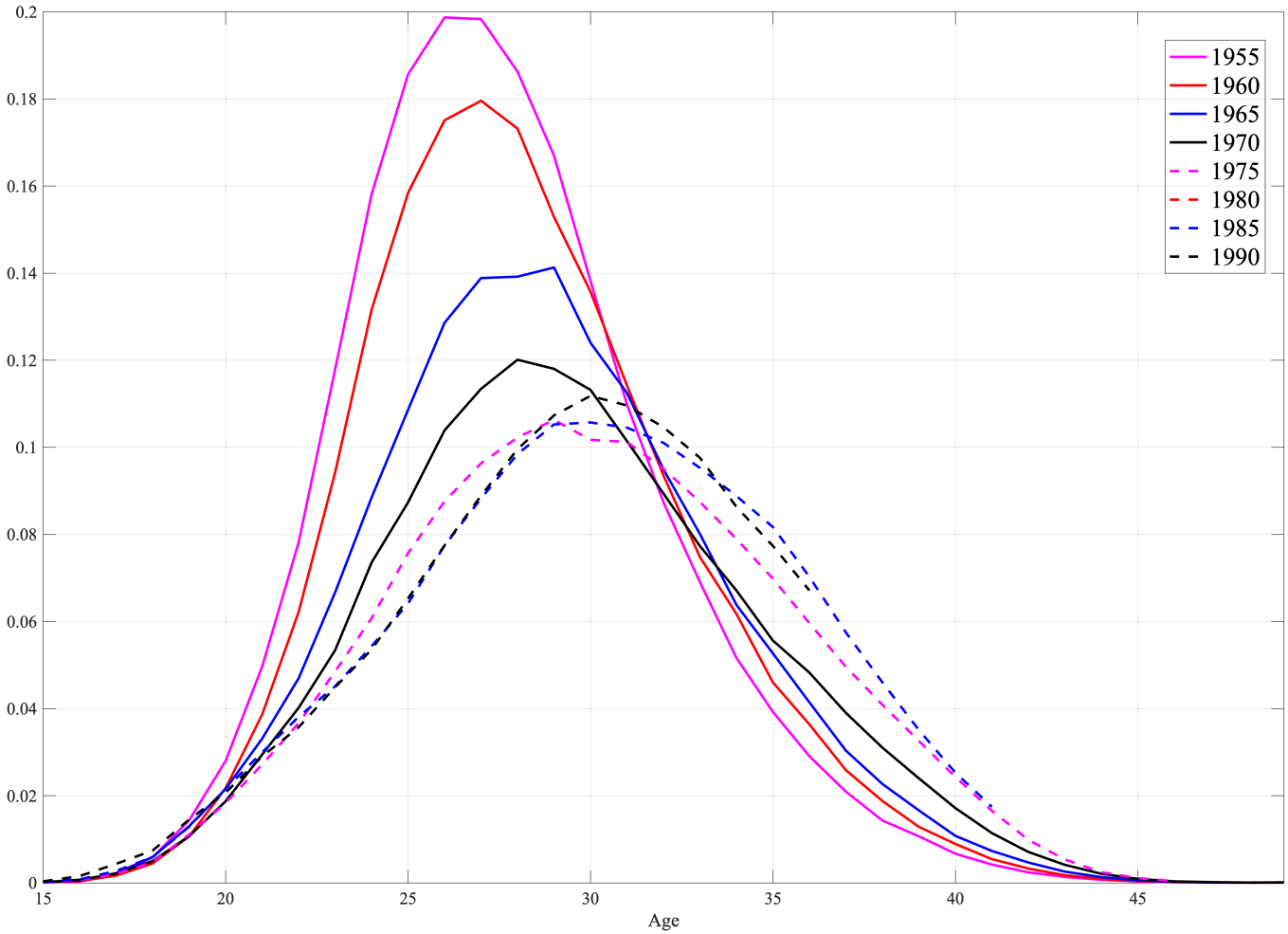

Figure: Fertility Rate

Research Question

Research Question

To what extent can improvements in fertility rates be contributed to through policies related to sex education and infertility treatments, and how do employment decisions change?

- Novel points of this analysis:

1. building a macroeconomic models with age specific fecundity, endogenizing marriage and childbirth,
2. analyzing with respect to subjective fecundity and medical fecundity, and
3. analyzing the effects of policies related to infertility treatment

Overview

- Develop a macroeconomic model endogenizing marriage and fertility decisions.
- Calibrate to match the 1960 and 1985 cohorts in Japan using JPSC data.
- Conducts the following three series of experiments:

1. Update of the belief on fecundity from subjective one to medical one,
2. Introduction of free infertility treatment, and
3. Combination of the above two.

Age Specific Fecundity

- Konishi et al. (2018) analyzed "time to pregnancy" (TTP) for various age groups to determine the probability of pregnancy within months after discontinuation contraception.

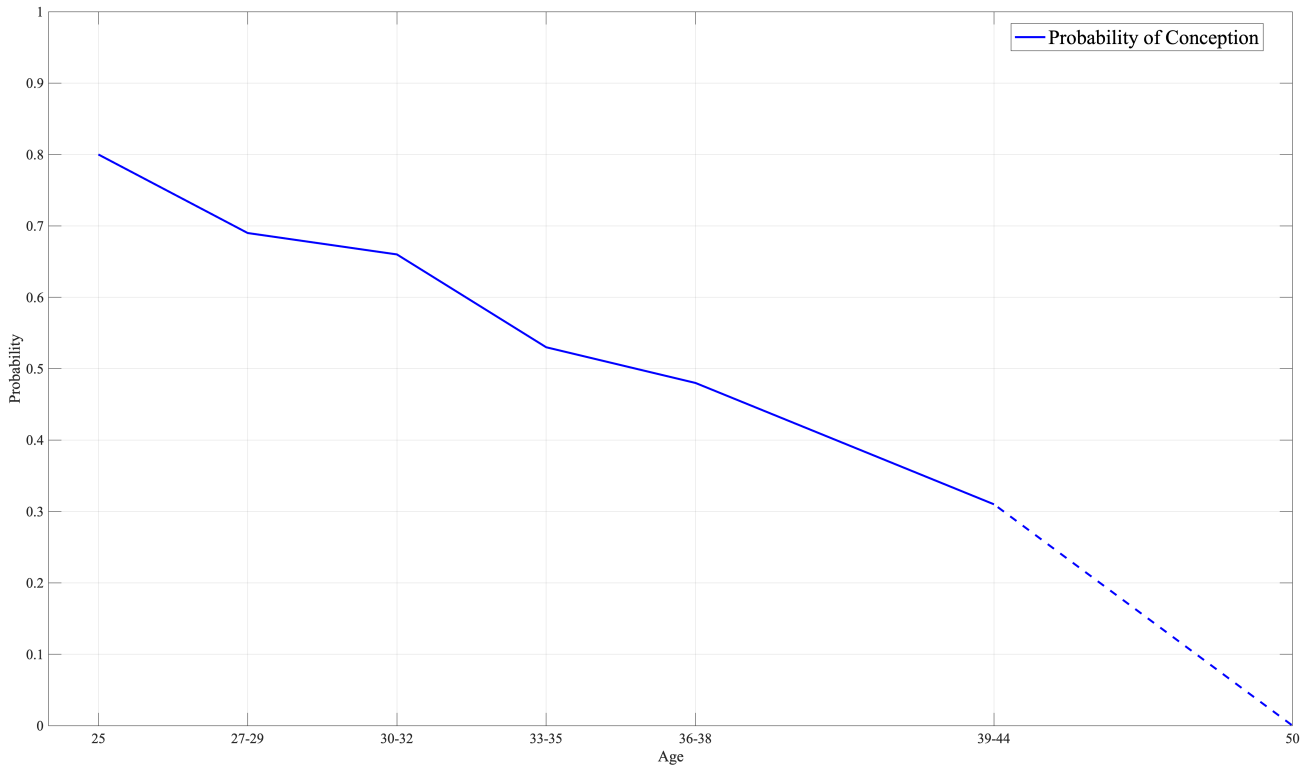

Figure: Probability of Conception by Age

Subjective Fecundity

- Survey conducted by the Health and Global Policy Institute (HGPI) represents the subjective fecundity.

Table: Survey on Subjective Fecundity

		30	35	40	45	50
Natural Intercourse	Female	14.1%	39.1%	27.5%	9.3%	3.6%
	Male	10.2%	31.5%	36.8%	10.8%	4.6%
Infertility Treatment	Female	4.0%	16.5%	44.8%	23.2%	7.4%
	Male	4.3%	13.3%	41.4%	24.6%	10.4%

Source: "The Public Opinion Survey on Child-Rearing in Modern Japan (Final Report)", Health and Global Policy Institute, March 4, 2022.

Infertility Treatment

- In the following context, infertility treatment refers to assisted reproductive technology (ART), such as intracytoplasmic sperm injection (ICSI)

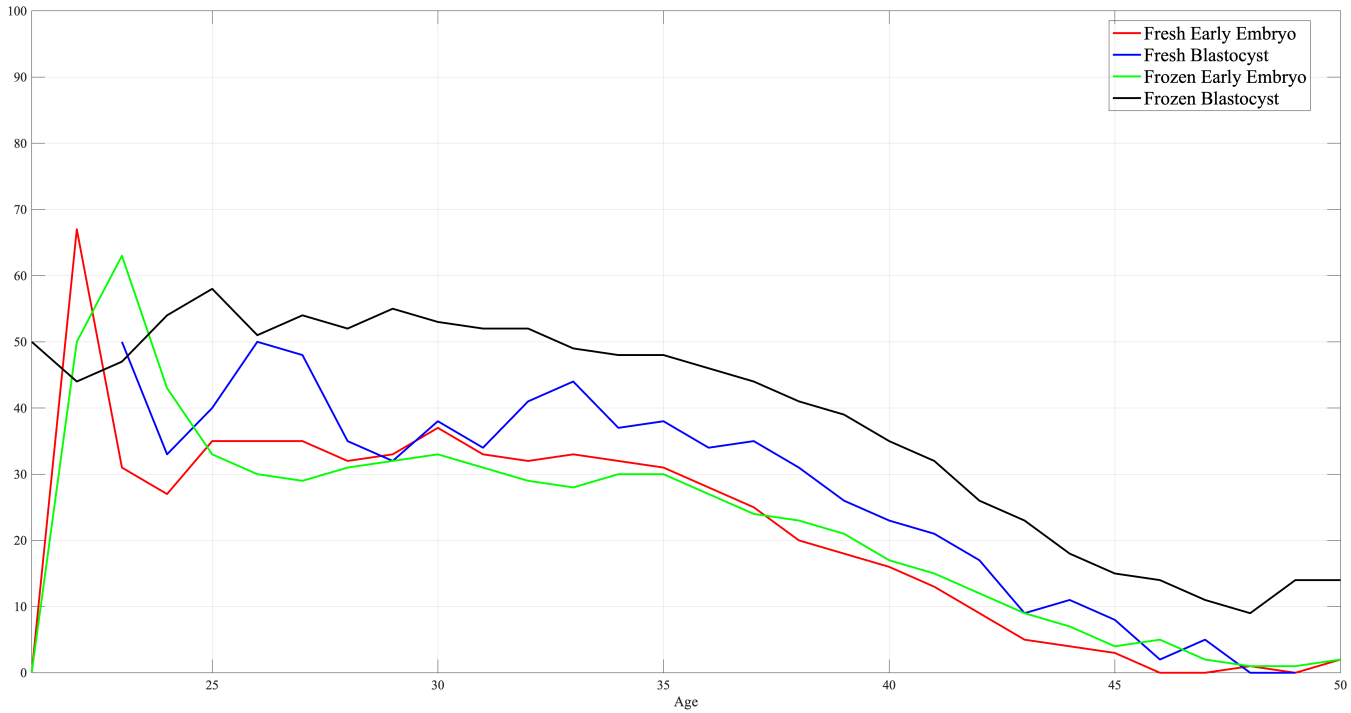

Figure: Pregnancy Rate by Age with Infertility Treatment

Infertility Treatment

- The following table summarizes the transition of subsidy/insurance for infertility treatment in Japan.

Table: Transition subsidy/insurance for infertility treatment in Japan

Year	Limit Income	Age	Number of times per year	In total	Amount
2004	6.5 mil yen	NA	Each year for two years	NA	100,000yen
2006	6.5 mil yen	NA	Each year for five years	NA	100,000yen
2007	7.3 mil yen	NA	2, for five years	NA	100,000yen
2009	7.3 mil yen	NA	2, for five years	NA	150,000yen
2011	7.3 mil yen	NA	3, for the first year	10	150,000yen
			2, for second year onwards		
2015	7.3 mil yen	NA		10	300,000yen (first)
					150,000yen (onwards)
2016	7.3 mil yen	-40	NA	6	
		40-43		3	
2019	9.05 mil yen				
2022	NA		NA		30% of cost

Literature

- Endogenous Decision on Childbirth
  - Doepke and Kindermann (2019), Barro and Becker (1989), Becker et al. (1990)
- Infertility Treatment in Macroeconomic Model
  - Sommer (2016), Doepke et al. (2023), de la Croix and Pommeret (2021)
- Female Career
  - Kitao and Mikoshiba (2022), Adda et al. (2017), Eckstein et al. (2019)
- Fecundity
  - Broekmans et al. (2007), Dunson et al. (2002), Eijkemans et al. (2014), Habbema et al. (2015), Taylor et al. (2020)
  - Bunting and Boivin (2008), Hammarberg et al. (2017), Lampic et al. (2005)

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Overview of Model

- Life-cycle partial equilibrium model.
- Three types of agents, single male, single female, and married couple.

Endogenous Variables

- Consumption (c), employment type (e), marriage (m), intention to have a child (i), and decision on infertility treatment (ι).

State Variables

- Ex-ante skill (s), asset (a), human capital (ϕ), previous period employment (e_{-1}), infertile indicator (ξ), child-birth history (k), and existence of child in the household (χ)

Life Cycle Flow

- The life cycle in this model is described in the following figure:

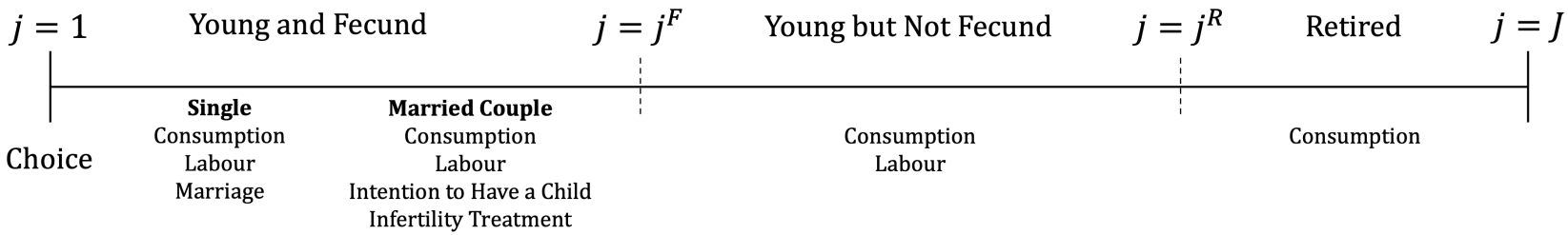

Figure: Life Cycle

- The decision flow in the young and fecund period is given in the next figure:

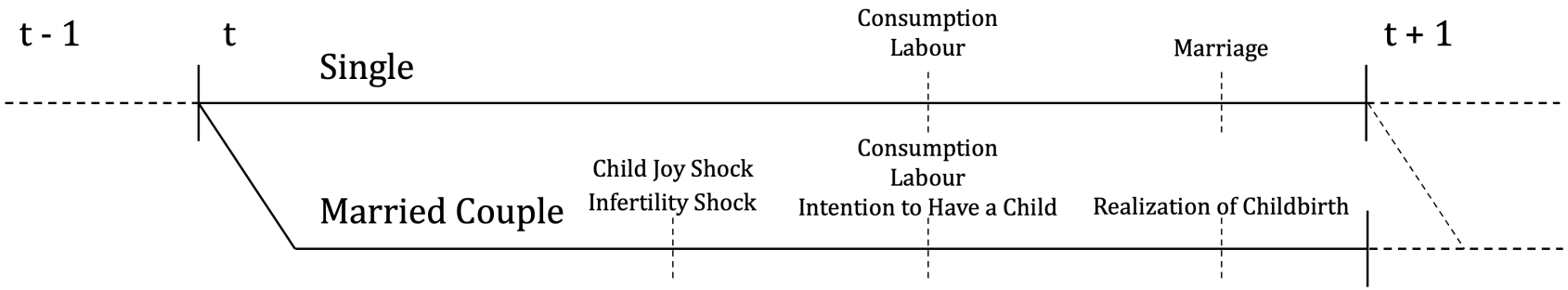

Figure: Young and Fecund Period

Endowment

- Men's income (y_m) is determined by age and the given skills deterministically.
- Following Guner et al. (2020), the process of human capital accumulation is as follows:

$$\phi' = \mathcal{H}(\phi, s, e).$$

  - e: employment type $e \in \{R, C, N\}$.
  - ϕ: human capital
  - s: skill

- The women's income is

$$y_f = \phi \cdot l_e$$

Preference

- The utility for each single agent is given by

$$u^S(c, l_g) = \frac{\left(\left(\frac{c}{\eta}\right)^{\omega} l_g^{1-\omega}\right)^{1-\sigma}}{1-\sigma}$$

  - η: equivalence scale
  - ω: weight parameter
  - σ: risk aversion parameter

Preference

- The utility for a married couple is given by

$$u^M(c, l_m, l_f, b, v) = \frac{\left(\left(\frac{c}{\eta}\right)^{\omega} l_m^{1-\omega}\right)^{1-\sigma}}{1-\sigma} + \frac{\left(\left(\frac{c}{\eta}\right)^{\omega} l_f^{1-\omega}\right)^{1-\sigma}}{1-\sigma} + b \cdot \nu_{(j,k)}$$

  - b: indicator of the realization of child birth
  - $\nu_{(j,k)}$: joy shock on childbirth

Preference

- The leisure time for a single female is defined as:

$$l_f = L - \varpi_{S,e} - \kappa_{e_{-1},e}$$

  - L: total available leisure time
  - $\varpi_{S,e}$: disutility of labor participation for a single female
  - $\kappa_{e_{-1},e}$: cost of switching employment status

- For married females, leisure time is determined by:

$$l_f = L - \varpi_{M,e} - \kappa_{e_{-1},e} - \chi\psi \tag{1}$$

  - ψ: additional cost of participation when there is a young child

Decision of Marriage

- The joy shock for marriage is denoted by ζ_j that follows Gumbel distribution $F(\zeta_j)$ with two parameters, scale parameter a_j and location parameter d_j.

$$F(\zeta_j) = \exp\left[-\exp\left\{-\left(\frac{\zeta_j - a_j}{d_j}\right)\right\}\right]$$

Let S and M represent the utility values of remaining single and getting married in the next period, respectively. An individual decides to marry if the following condition is met:

$$M + \zeta \geq S$$

where ζ represents the joy shock experienced in the current period.

Decision of Childbirth

- The joy shock for a child is denoted by $\nu_{(j,k)}$.
- $\nu_{(j,k)}$ follows Gumbel distribution $G(\nu_{(j,k)})$ with two parameters, scale parameter $\varsigma_{(j,k)}$ and location parameter $\varrho_{(j,k)}$.
- Given a shock, parents determine whether they intend to have a child or not. They do at t if

$$u^M(c/\eta, h_m, h_f, 1, \nu) + \beta M^{t+1}[\mathbf{x} \mid b = 1] \geq u^M(c/\eta, h_m, h_f, 0, \nu) + \beta M^{t+1}[\mathbf{x} \mid b = 0]$$

where M and $\mathbf{x}$ are, for convenience, defined as the future value function and state space in the next period, respectively.

Transition of Child in Household

- Given the intention of having child, the transition matrices of the state of child change.
- If the household already has a child, the child is gone from the household with probability o_j.
- When household do not intend to have a child, the transition matrix of the state of child is given by

$$\pi_j^n(\chi, \chi') = \begin{pmatrix} 1 & 0 \\ o_j & 1 - o_j \end{pmatrix}$$

- When they intend, it is realized with probability q_j, so that the transition matrix is

$$\pi_j^i(\chi, \chi') = \begin{pmatrix} 1 - q(j) & q(j) \\ o_j & 1 - o_j \end{pmatrix}$$

Transition of Child in Household

- In this model, agents base their decisions not on actual medical probability of conception, but rather on a subjective perception of fecundity, which they overestimate.

$$\pi^{s}_{j,k}(\chi,\chi') = \begin{pmatrix} 1-\varphi_j q(j) & \varphi_j q(j) \\ o_j & 1-o_j \end{pmatrix}$$

- In each period, agents are subject to a shock that may result in infertility and the state is denoted by ξ.

$$\pi^{f}_{j}(\chi,\chi') = \begin{pmatrix} 1-\rho(j) & \rho(j) \\ o_j & 1-o_j \end{pmatrix}.$$

where $\rho(j)$ is the probability that one can get pregnant when they take infertility treatment.

Government

Tax: The government imposes tax on consumption, asset income, and labour income, denoted by τ_c, τ_a, and τ^l, respectively

Public Pension: Public pension p_g is provided for retired agents.

Infertility Treatment: Cost of infertility treatment is denoted by Ω and the government provides subsidy/insuranceThe co-payment rate for infertility treatment is denoted by λ_j, so that net cost for infertility (Δ_j) treatment is described as

$$\Delta_j = \iota \cdot \lambda_j \cdot \Omega \tag{2}$$

where ι is the indicator of taking infertility treatment.

Recursive Formulation

- There are 3 stages of life in this economy.
- Each value is described as follows:

  Young and Fecund: The value of single female, single male, and married couple in this period are denoted as $S^f_{\mathcal{F}}$, $S^m_{\mathcal{F}}$, and $M_{\mathcal{F}}$, respectively.
  Young but not Fecund: The value of single female, single male, and married couple in this period are given as $S^f_{\mathcal{N}}$, $S^m_{\mathcal{N}}$, and $M_{\mathcal{N}}$, respectively.
  Retired: The value of single female, single male, and married couple in this period are given as $S^f_{\mathcal{R}}$, $S^m_{\mathcal{R}}$, and $M_{\mathcal{R}}$, respectively.

Recursive Formulation

Young Fecund Married Couple:

$$M_{\mathcal{F}}(j, s_m, s_f, a, \phi, e_{-1}, \xi, h, \chi, \nu) = \max_{c,a',e,i,\iota} \{u^m(c, l_m, l_f, b,') + \beta[(1 - b(i,j))\mathbb{E}M_{\mathcal{F}}(j+1, s_m, s_f, a', \phi', e, \xi, h, \chi', \nu) + b(i,j)\mathbb{E}M_{\mathcal{F}}(j+1, s_m, s_f, a', \phi', e, \xi, h+1, \chi', \nu')]\}$$

subject to

$$(1 + \tau_c)c + a' + \Delta_j = Ra + \sum_g y_g - \tau_M^l(y_m, y_f)$$

$$a' \geq 0$$

$$\Delta_j = \iota \cdot \lambda_j \cdot \Omega$$

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Calibration

- The model is calibrated to match the 1960 and 1985 cohorts in Japan.
- Parameters related to the disutility of labor are set to match female labor participation rates in Japan.
- Parameters for the joy shock on the childbirth are set to match medical fertility rates and observed fertility rates.

Calibration: Fecundity

- $q(j)$ and ϕ_j are calibrated using data Konishi et al. (2018) and survey by HGPI.

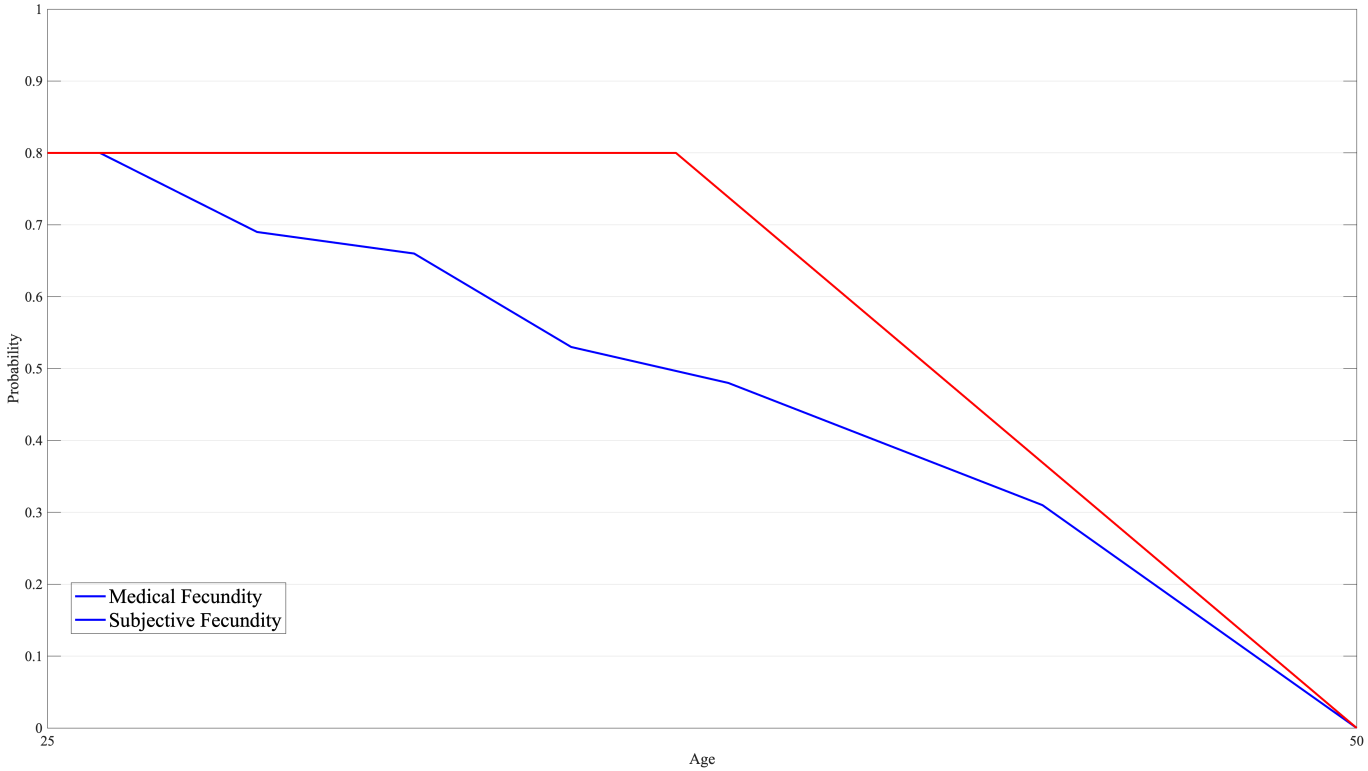

Figure: Medical and Subjective Fecundity

Calibration Results

Parameter	Description	Value/Source
j^f	Last fecund age	26 (50 years old)
j^R	Retirement age	41 (65 years old)
J	Maximum age	61 (85 years old)
$\pi_g(s, s')$	Degree of assortative mating	JPSC data
y_m	Men's earning	JPSC data
β	Subjective discount factor	0.98
σ	Risk aversion parameter	3.0
ω	Leisure/consumption weight	0.5
η	Equivalence scale	OECD
q	Medical fecundity	Konishi et al. (2018)
φ	Subjective fecundity parameter	See text and Appendix
ρ	Success rate of infertility treatment	See text
Ω	Infertility treatment cost	500,000 yen
$\tau_q^l(y_g)$	Labor income tax	Progressive (see text)
τ^c	Consumption tax rate	3-10%
τ^a	Capital income tax rate	35%
r	Interest rate	2%
λ	Infertility treatment co-payment rate	See text

Calibration Results

Parameter	Description	Value
1960 cohort		
$\varpi_{q,e}$	Participation cost	0.382($\varpi_{S,R}$), 0.014($\varpi_{S,C}$)
		0.176($\varpi_{M,R}$), 0.160($\varpi_{M,C}$)
ψ_k	Time cost (a small child)	0.260
$\kappa_{e-1,e}$	Switching cost	0.291($\kappa_{N,R}$), 0.171($\kappa_{N,C}$), 0.293($\kappa_{C,R}$)
δ_s	Human capital depreciation rate	0.021(δ_L), 0.043(δ_H)
1985 cohort		
$\varpi_{q,e}$	Participation cost	0.293($\varpi_{S,R}$), 0.006($\varpi_{S,C}$)
		0.144($\varpi_{M,R}$), 0.092($\varpi_{M,C}$)
ψ_k	Time cost (a small child)	0.302
$\kappa_{e-1,e}$	Switching cost	0.252($\kappa_{N,R}$), 0.150($\kappa_{N,C}$), 0.259($\kappa_{C,R}$)
δ_s	Human capital depreciation rate	0.016(δ_L), 0.044(δ_H)
a_j	Scale parameters (marriage)	Appendix
d_j	Location parameters (marriage)	Appendix
$\varrho_{(j,k)}$	Scale parameters (childbirth)	Appendix
$\varsigma_{(j,k)}$	Location parameters (childbirth)	Appendix
$\alpha_{j,e,s}$	Human capital accumulation rate	Appendix

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Overview

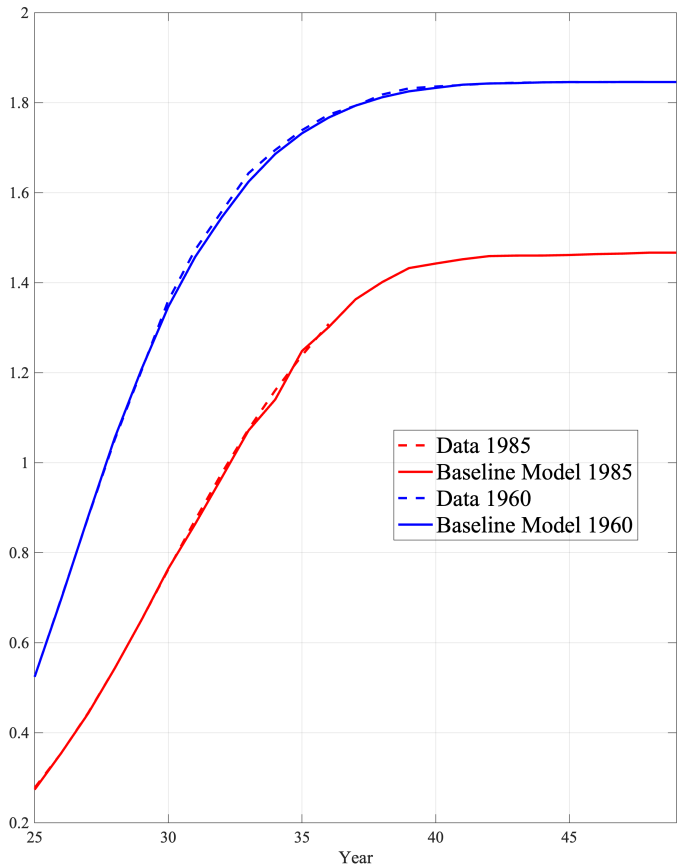
- We conducted the following three series of experiments:

Experiment 1: Update of the belief on fecundity from subjective one to medical one

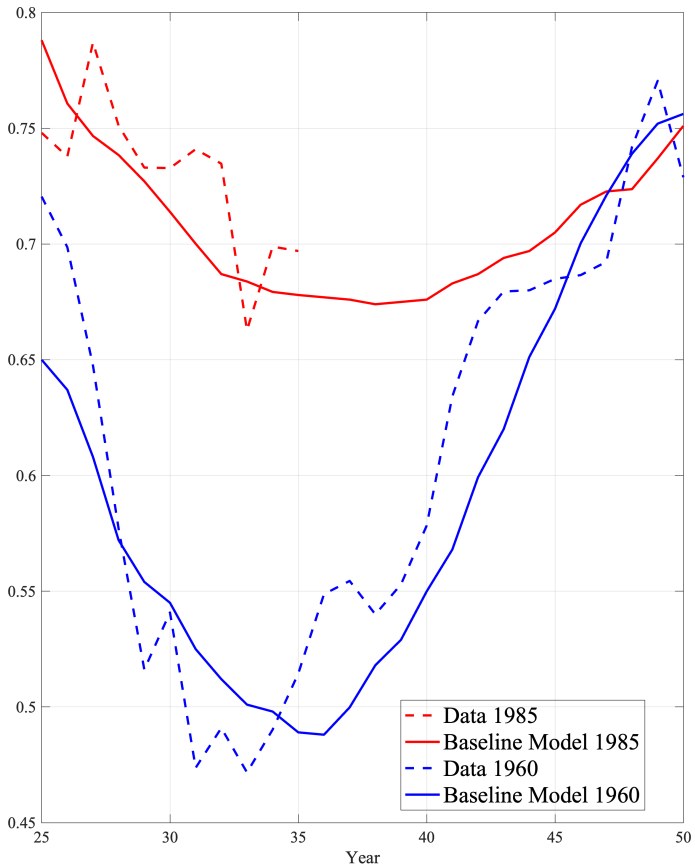
Experiment 2: Introduction of free infertility treatment

Experiment 3: Combination of the above two

Baseline Model

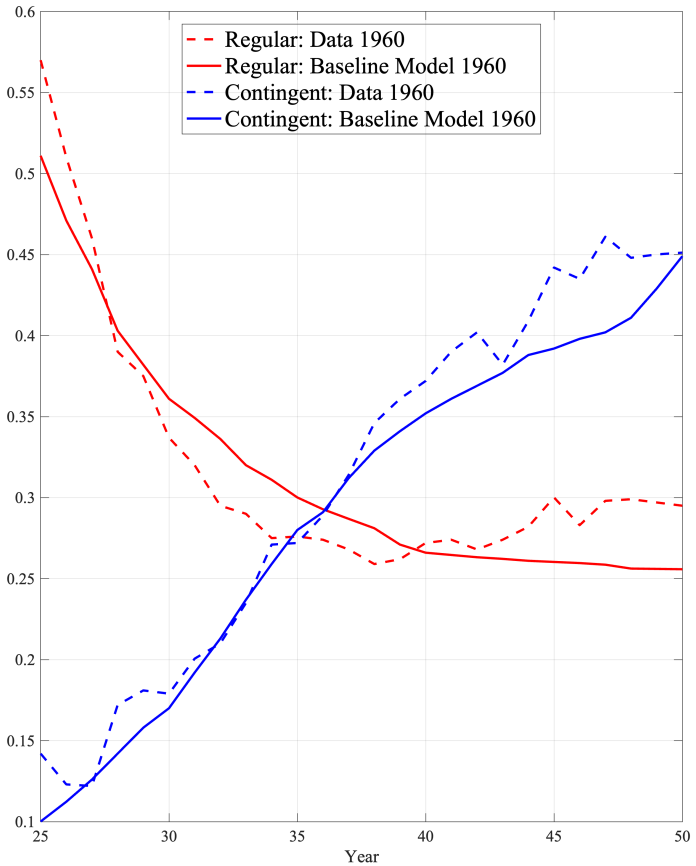


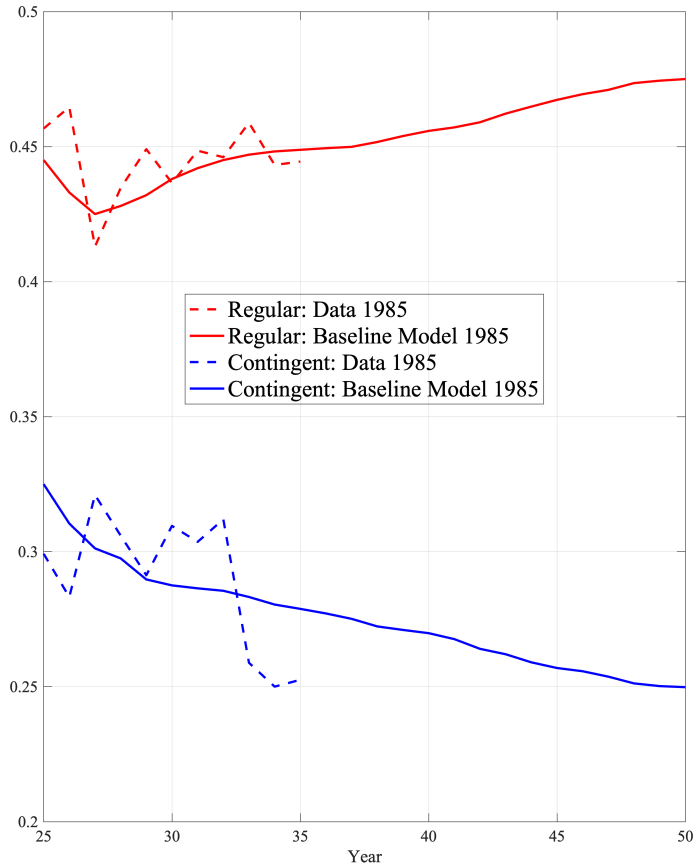
(a) Fertility Rate



(b) Employment Rate

Baseline Model





(a) Employment Share for Cohort 1960 (b) Employment Share for Cohort 1985

Cohort Effect

- The results for the 1960 cohort showed that, although there were minor changes, there was almost no significant change.
  - It can be considered that the 1960 cohort did not delay the decision to give birth as much as today, and therefore, the impact of changing beliefs was smaller.
  - It can also be believed that the need for infertility treatments was less due to the completion of childbirth at an early stage.
- The results of 1985 cohort are summarized in the following table.

Table: Result of experiments for cohort 1985

	Fertility	Employment	Regular	Contingent	AVG Income
EX1	+0.049	−0.16%	−0.87%	+0.62%	- 2.2%
EX2	+0.021	−0.08%	−0.70%	+0.03%	- 1.1%
EX3	+0.051	−0.20%	−0.91%	+0.78%	- 2.4%

Experiment 1: Belief Update (Fertility Rate)

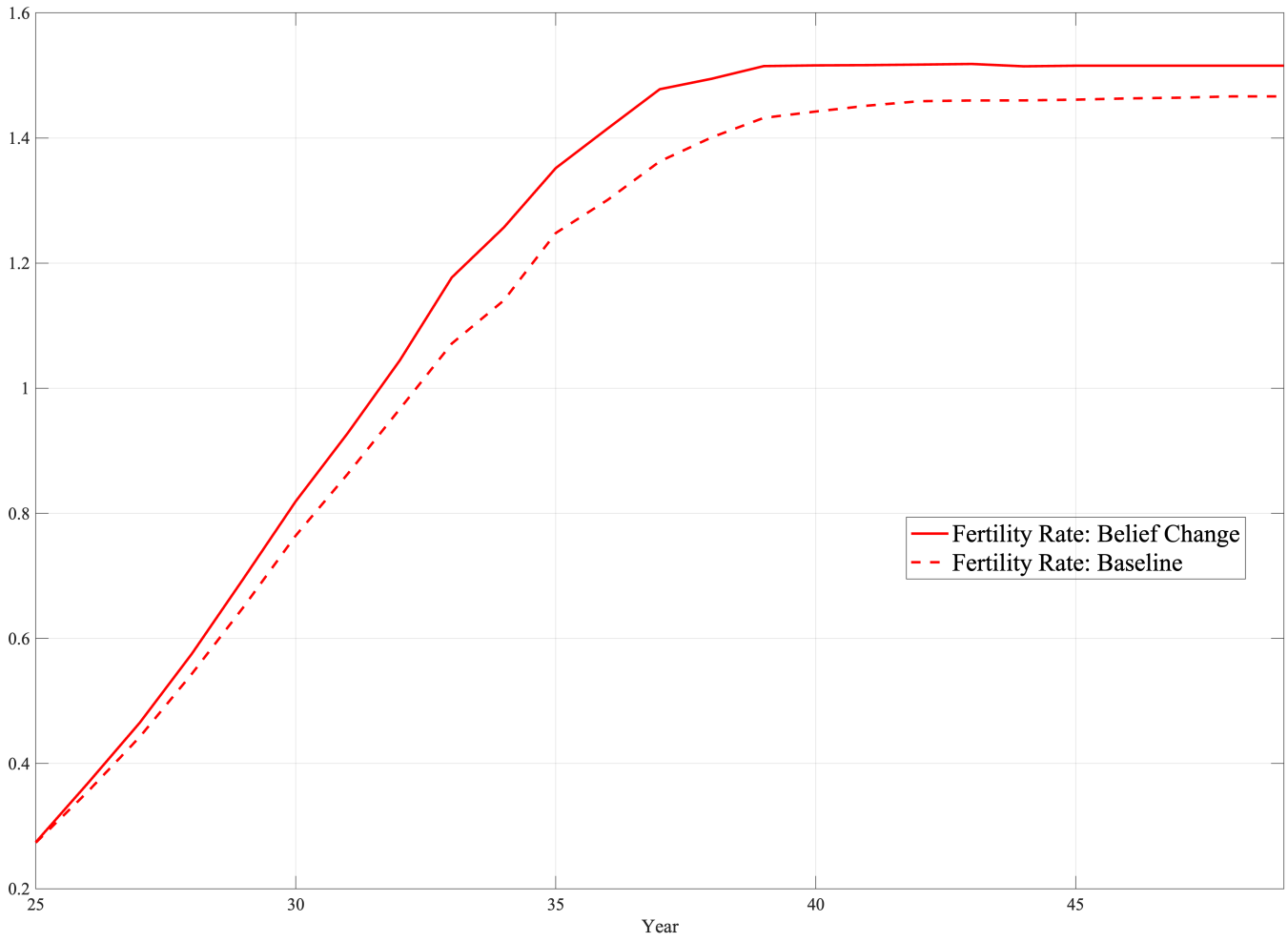
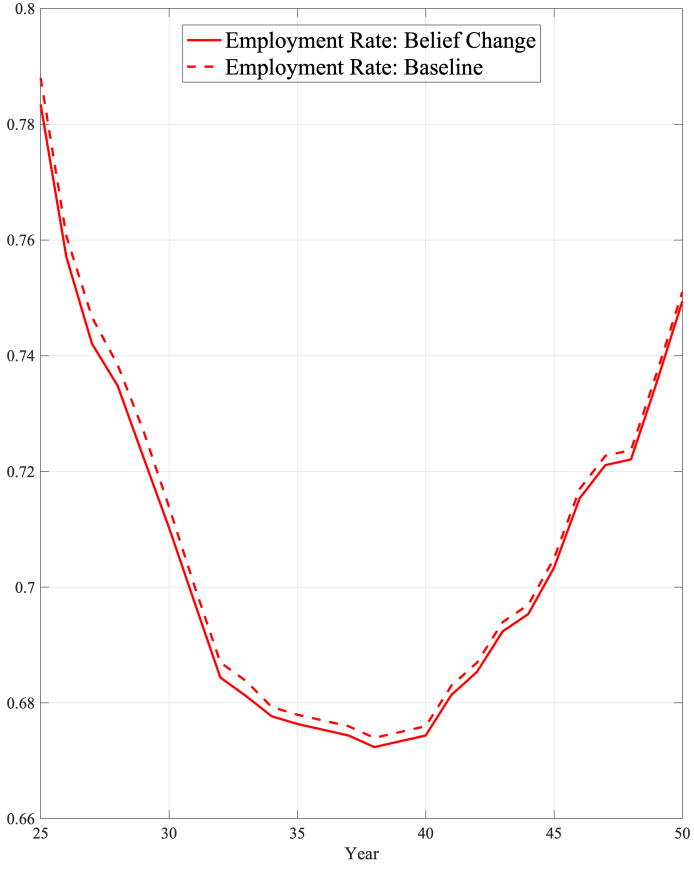
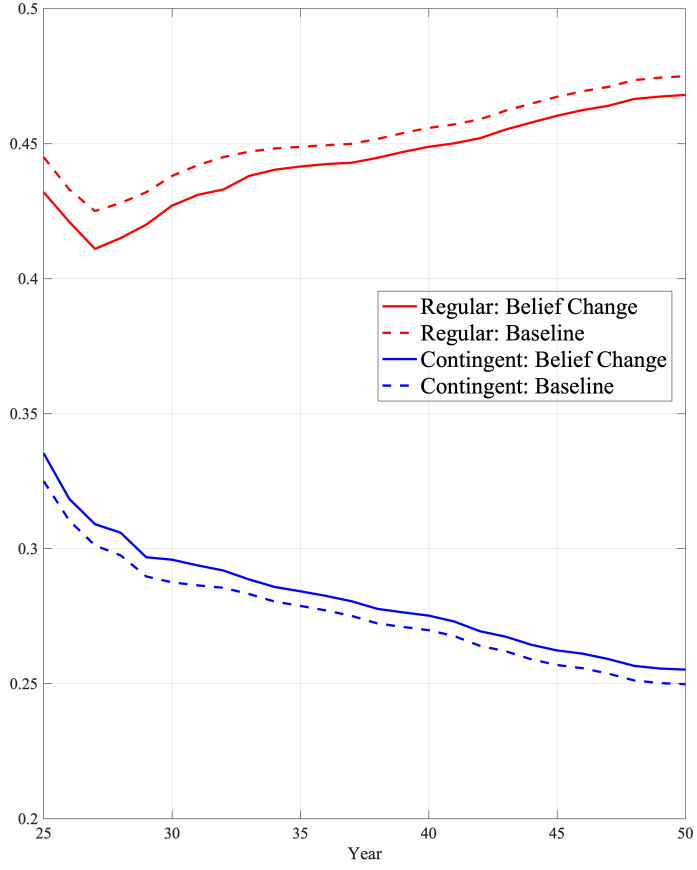


Figure: Change in Fertility Rate

Experiment 1: Belief Update (Employment)



(a) Employment Rate



(b) Employment Share

Figure: Female's Employment Status with Belief Update

Experiment 2: Free Infertility Treatment (Fertility Rate)

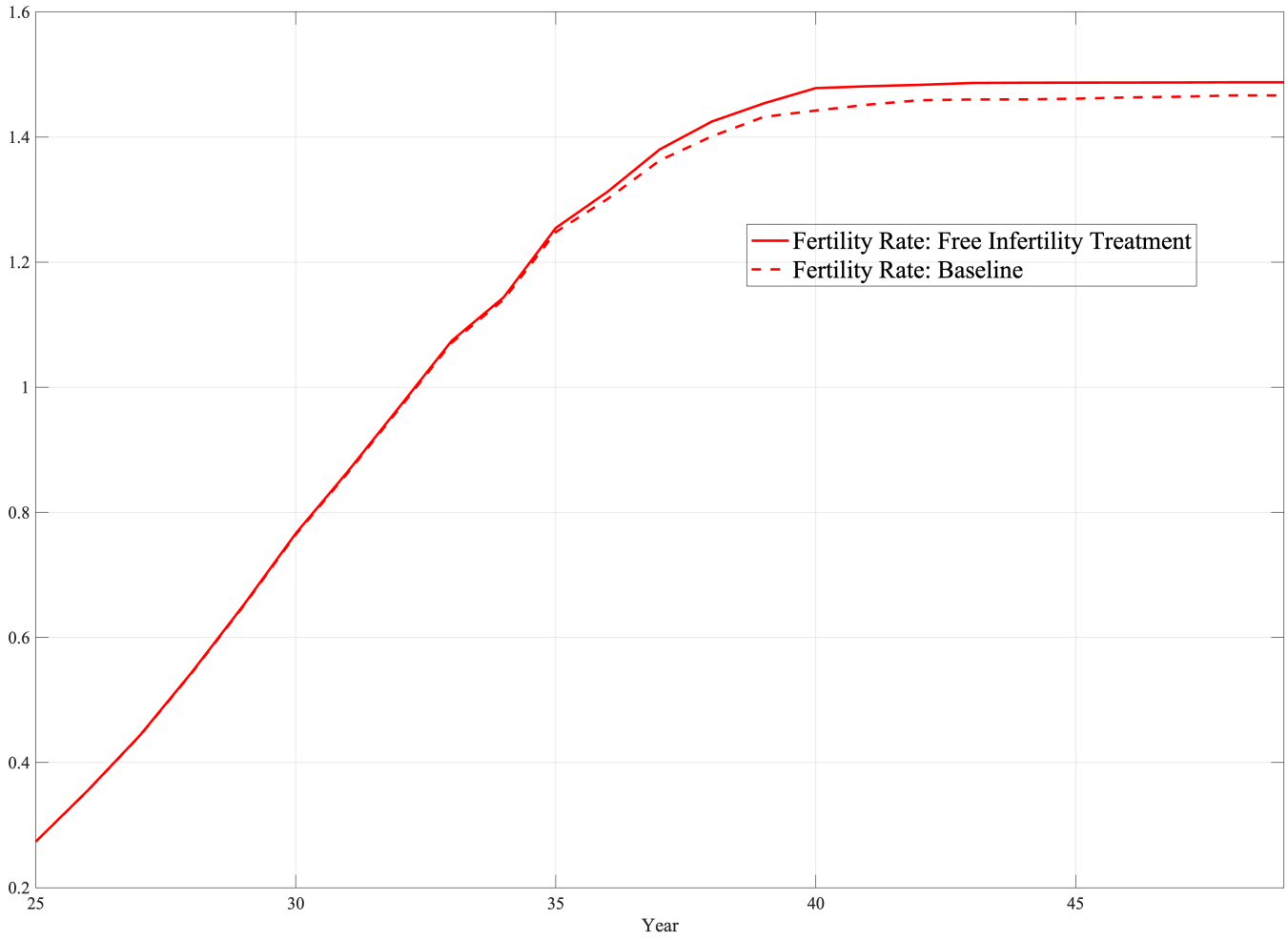
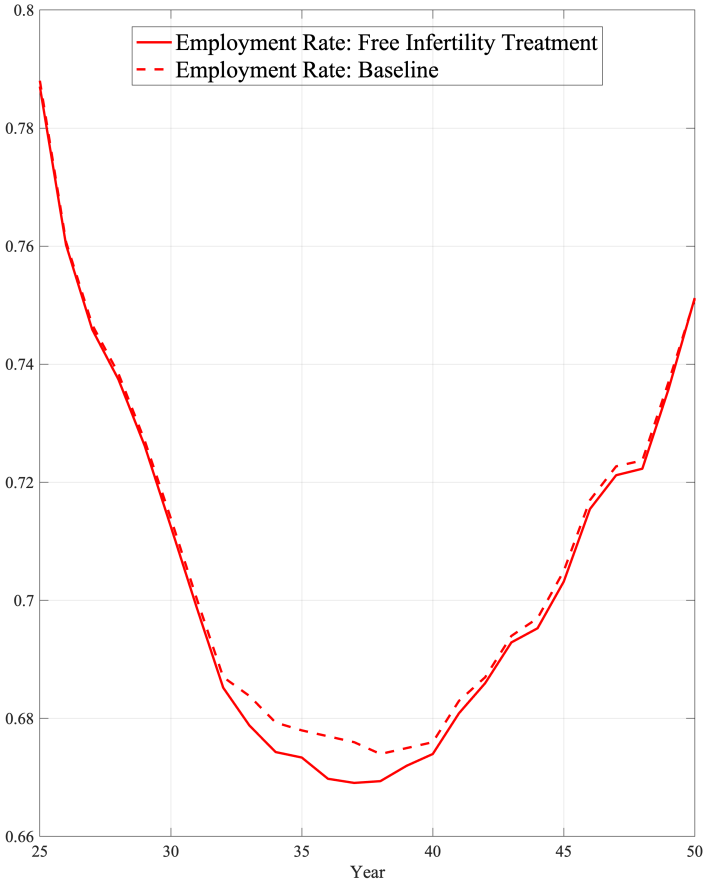
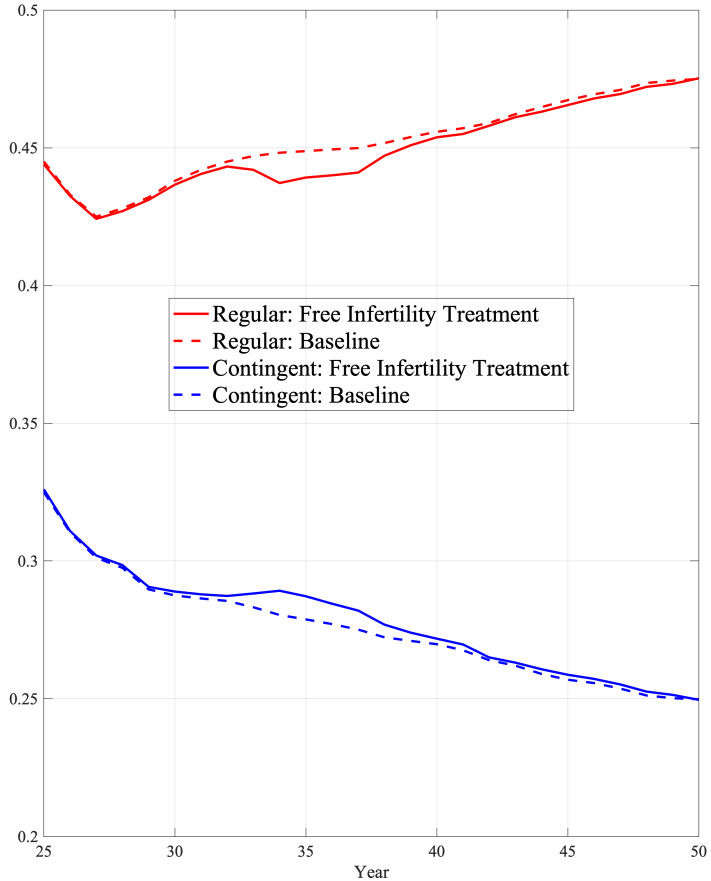


Figure: Change in Fertility Rate

Experiment 2: Free Infertility Treatment (Employment)



(a) Employment Rate



(b) Employment Share

Figure: Employment Changes by Age with Free Infertility Treatment

Experiment 3: Combination (Fertility Rate)

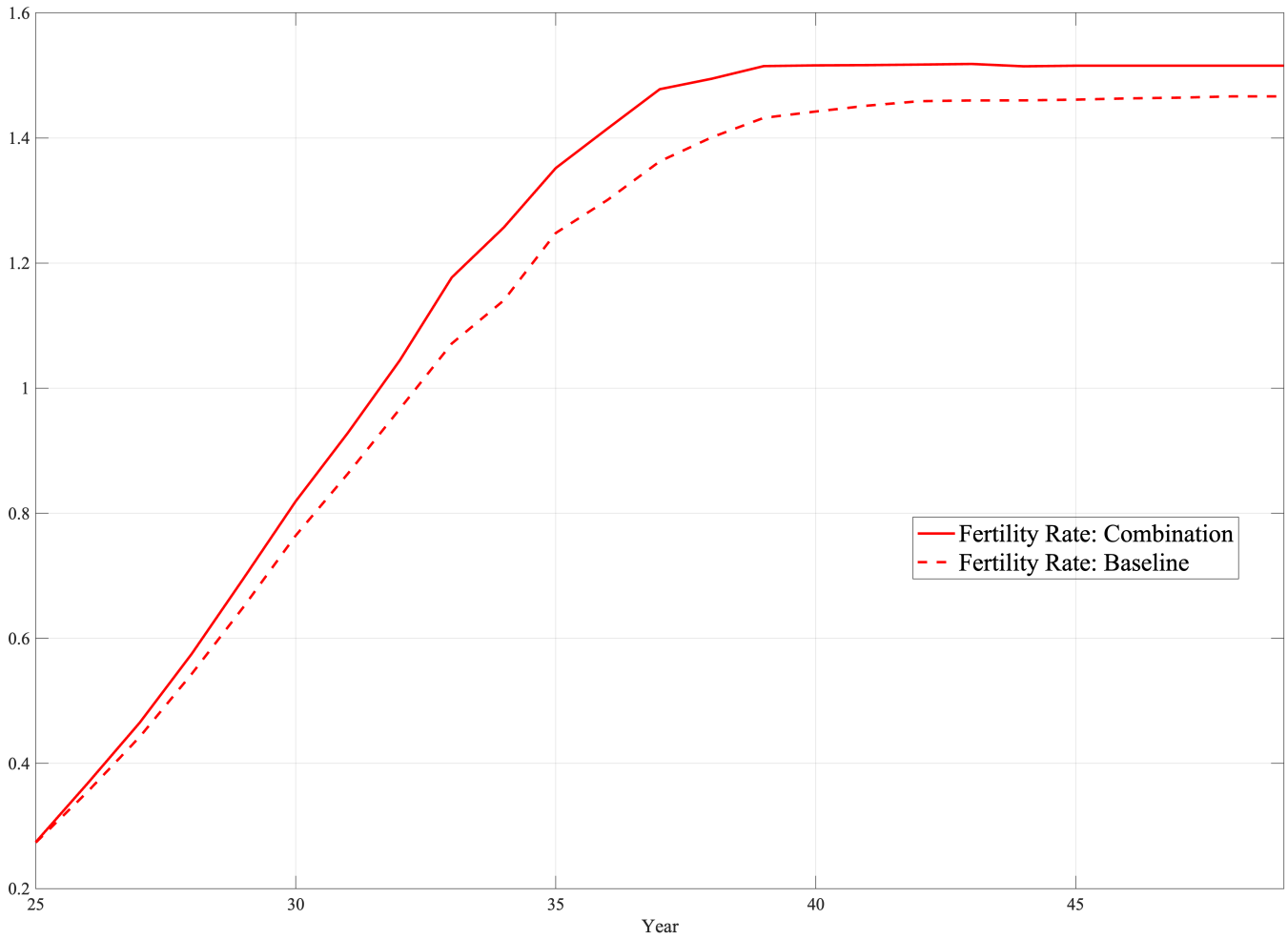
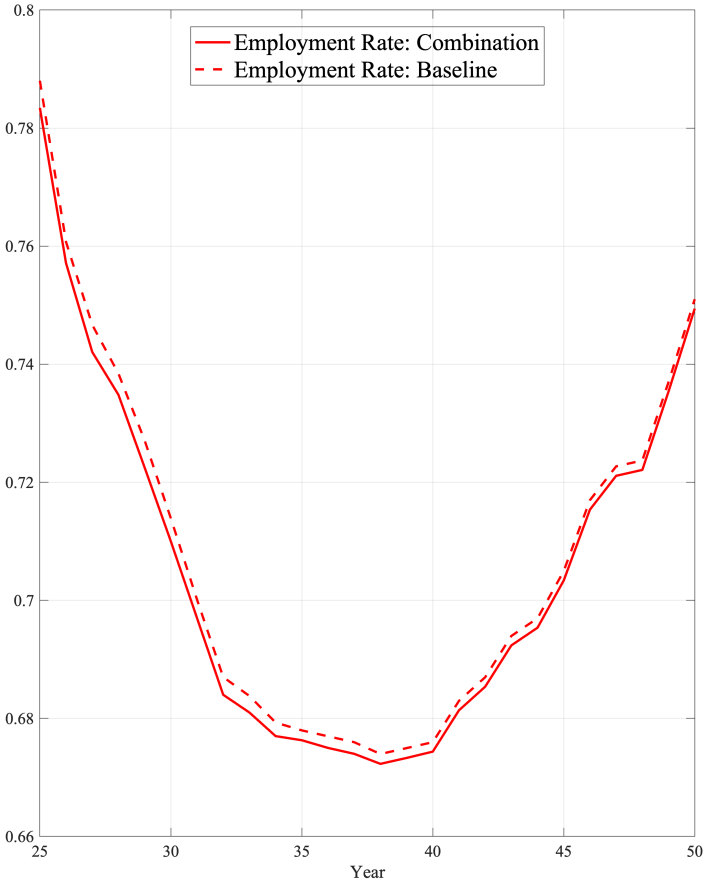
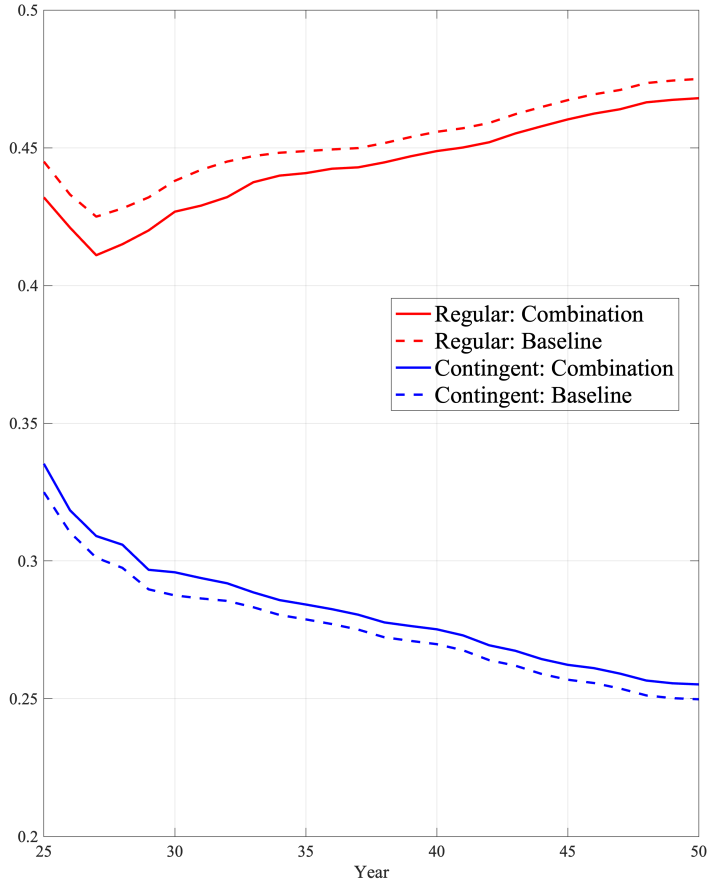


Figure: Fertility Rate

Experiment 3: Combination (Employment)



(a) Employment Rate



(b) Employment Share

Figure: Employment Changes with Combined Experiment

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Conclusion

- Uses a quantitative life-cycle model, calibrated for the Japanese economy, to evaluate impacts on fertility rates and employment choices for individuals born in 1960 and 1985.
- Updating perceptions of fecundity could increase fertility rates by 0.049, especially in the 1985 cohort.
- Subsidizing infertility treatment led to an increase of 0.021 in fertility rates for the 1985 cohort and a slight decrease in employment rates.
- Combination of updated fertility understanding and subsidized treatments yielded similar results.

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