Asymmetric Fertility Elasticities

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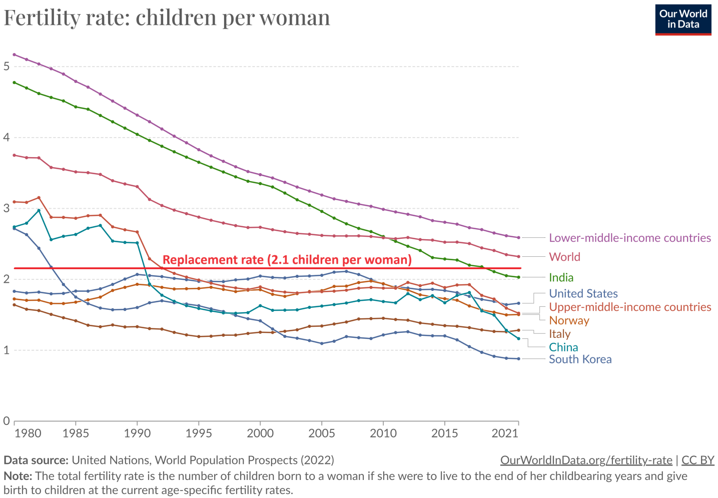
The emergence of below-replacement fertility



- Major implications for pension system, international relations, economic growth (Jones 2022), civilizational risk (Elon Musk)

Raising fertility seems to be extremely difficult

Vox

EXPLAINERS CROSSWORD VIDEO PODCASTS MORE

SOCIAL POLICY WORLD POLITICS LIFE

You can't even pay people to have more kids

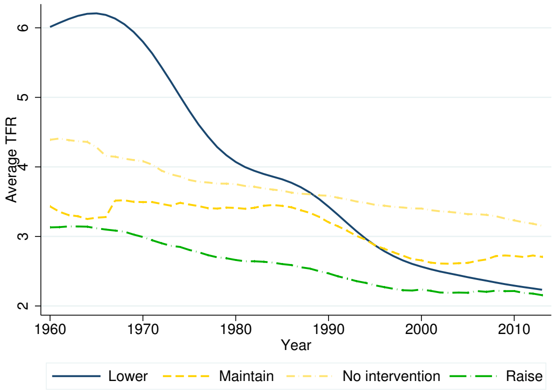
These countries tried everything from cash to patriotic calls to duty to reverse drastically declining birth rates. It didn't work.

By Anna North | Nov 27, 2023, 8:00am EST

- "There are 27 countries in the Human Fertility Database where, since the 1950 birth cohort, 'completed cohort fertility' has ever fallen below a lifetime average of 1.9 children per woman. Never, in any one of these countries, has the average ever again risen above 2." (Spears 2023)

Reducing fertility feels easier

Interestingly, many countries with low fertility problems now were reducing fertility not so long ago (e.g., China, Thailand, Singapore, . . .) background



Fertility trends by country groups based on policy stance in 1976

Research question

- At first glance, the performance of pro- versus anti-fertility policies looks drastically different
- Research questions:
  1. Is it systematically more difficult to raise fertility than to reduce it?
  2. If so, what are the macro implications and micro-foundations?
- This paper: new fact + new model + new policy implications

This paper

1. Establish a new fact
   - → Collect historical data on fertility policy stance and funding
   - → Compare fertility responses at the aggregate and the individual levels
   - → Discuss robustness to a variety of checks
2. Why does the fact matter?
   - → Present a dynamic stochastic model of cost minimization by the government
   - → New policy implications
     - i Rethink the global campaign towards the replacement rate
     - ii Re-examine the cost-benefit analysis of fertility policies
3. What explains the fact?
   - → Asymmetry challenges existing fertility theories
   - → Propose a new model of fertility choice under loss aversion

Literature

- Empirical evaluations of fertility policies

  McElroy and Yang (2000), Liu and Raftery (2020), Schultz (2007), Milligan (2005), Laroque and Salanié (2014), Raute (2019), González and Trommlerová (2023)

  Contribution: first to systematically compare +ve and -ve policies
- Structural models of fertility

  Barro and Becker (1989), de la Croix and Doepke (2004), Córdoba and Ripoll (2019), Kim, Tertilt, and Yum (2024)

  Contribution: first to incorporate loss aversion into fertility choice
- Long-run fertility trajectory

  Malthus (1872), Becker (1960), Easterlin (1968), Galor and Weil (2000), Feyrer et al. (2008), Lutz et al. (2007), Ibbitson (2019)

  Contribution: a “slippery slope” perspective and new policy insights

Outline

- Empirical results
- Simple model and policy implications
- Behavioral theory (if time permits)
- Conclusion

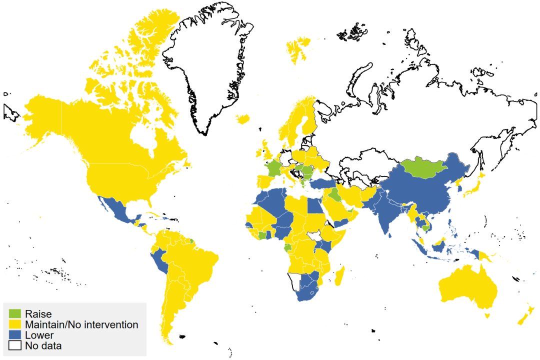
Establish a new fact

Empirical findings

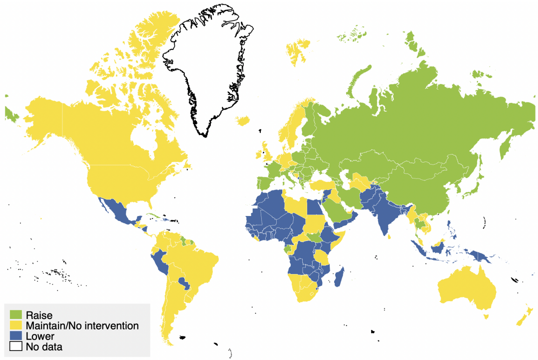
Data

- Fertility level and policy data from the United Nations
  - → Policy stance dummy assigned by the UN Population Division since 1976 - lower, raise, maintain, no intervention
- Aggregate variables from PWT and WDI: GDP per capita, urbanization, infant mortality, female labor force participation
- Family planning funding from de Silva and Tenreyro (2017)
- Individual-level data on fertility, education, and income from the World Value Survey (WVS) Database

Fertility policy in 1986 and 2021



Source: United Nations Population Division



Source: United Nations Population Division

distribution

1. Panel regressions

- We estimate the following specification

$$\begin{aligned}\Delta \text{TFR}_{it}/\text{TFR}_{it-1} = \alpha + \beta_1 \text{Policy\_Lower}_{it} + \beta_2 \text{Policy\_Raise}_{it} \\ + \beta_3 \text{Control}_{it} + \sigma_i + \eta_t + \epsilon\end{aligned} \tag{1}$$

- Control_{it} includes the level and growth rate of GDP per capita, urbanization, infant mortality, and female labor force participation
- Explanatory variables constructed by

$$\text{Policy\_Lower}_{it} = \frac{1}{N}\sum_{T=t-N}^{t-1} \mathbb{I}(\text{Policy}_{iT} = \text{Lower})$$

$$\text{Policy\_Raise}_{it} = \frac{1}{N}\sum_{T=t-N}^{t-1} \mathbb{I}(\text{Policy}_{iT} = \text{Raise})$$

Results

Table 1: Population Policy and TFR

Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate					
Policy Variables	Last Year		Average in the Last Five Years		Average in the Last Ten Years	
	(1)	(2)	(3)	(4)	(5)	(6)
Lower fertility	-0.0118***	-0.0071***	-0.0129***	-0.0076***	-0.0102***	-0.0042*
	(0.0013)	(0.0055)	(0.0015)	(0.0016)	(0.0020)	(0.0022)
Raise fertility	0.0013	0.0016	0.0034	0.0013	0.0023	0.0002
	(0.0034)	(0.0030)	(0.0039)	(0.0034)	(0.0040)	(0.0039)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes	No	Yes
Observations	10726	9146	10726	9146	9937	8462
R^2	0.133	0.174	0.133	0.173	0.123	0.170

comparison

2. Cohort exposure

- Using individual-level data, we estimate the following specification

$$\begin{aligned}\text{Child}_{icbt} = \alpha + \beta_1 \text{Policy\_Lower}_{cb} + &\beta_2 \text{Policy\_Raise}_{cb} \\ &+ \eta \text{Age}_i \times \text{Gender}_i + \gamma_{ct} + \delta_b + \epsilon\end{aligned} \tag{2}$$

- Construct individual's exposure to policies in a 10-year fertile window around mean age of childbirth MAC_{cb}:

$$\text{Policy\_Lower}_{cb} = \frac{1}{11} \sum_{t \in [b+\text{MAC}_{cb}-5, b+\text{MAC}_{cb}+5]} \mathbb{I}(\text{Policy}_{ct} = \text{Lower})$$

$$\text{Policy\_Raise}_{cb} = \frac{1}{11} \sum_{t \in [b+\text{MAC}_{cb}-5, b+\text{MAC}_{cb}+5]} \mathbb{I}(\text{Policy}_{ct} = \text{Raise})$$

Results

Table 2: Population Policy and the Number of Children

Dependent Variable	Number of Children								
Interpolation of MAC	Country-Specific Year Polynomial			Nearest Neighbor			Socioeconomic Variables		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Target: Lower fertility	-0.776***	-0.762***	-0.624***	-0.844***	-0.655***	-0.875***	-0.831***	-0.821***	-0.631***
	(0.220)	(0.210)	(0.185)	(0.201)	(0.188)	(0.208)	(0.243)	(0.232)	(0.215)
Target: Raise fertility	0.278	0.304*	0.131	0.168	-0.007	0.141	0.259	0.262	0.046
	(0.181)	(0.162)	(0.186)	(0.167)	(0.185)	(0.189)	(0.221)	(0.191)	(0.202)
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Income Level-Age-Gender FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Education Level-Age-Gender FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Macroeconomic Controls	No	No	Yes	No	No	Yes	No	No	Yes
Observations	205324	183738	163768	231257	205288	182719	210785	186911	170841
R^2	0.281	0.294	0.301	0.285	0.297	0.303	0.279	0.295	0.298

3. Intensive margin

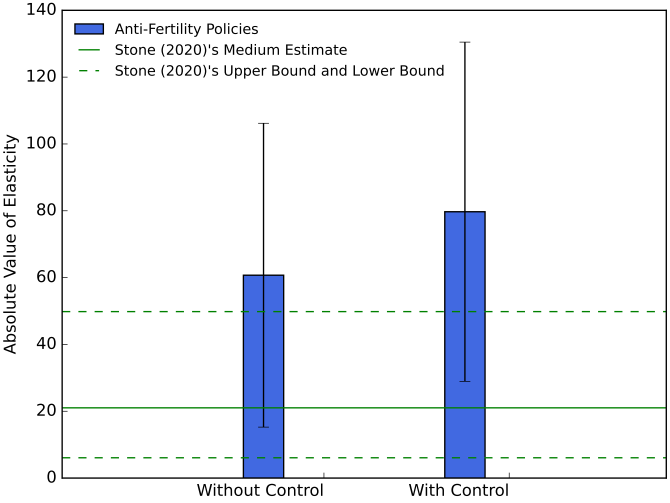
- Using data on family planning funding (de Silva and Tenreyro 2017)

Table 3: Elasticity Estimation for Anti-Fertility Policy

Dependent Variable	ΔTotal Fertility Rate/ Lagged Total Fertility Rate	
Construction of Policy Variables	Average in the Last Five Years	
	(1)	(2)
Family planning funding-GDP Ratio	-60.72***	-79.71***
	(22.65)	(25.29)
Country Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Control Variables	No	Yes
Observations	2754	2648
R^2	0.220	0.278

Results

- Combine with harmonized estimates of pro-fertility policies (Stone (2020))



Robustness

- Empirical finding is robust to
  1. Use levels instead of percentage changes in fertility
  2. Policy effects at different horizons
  3. Country-specific trends
  4. Controlling for past fertility to mitigate reverse causality
  5. Split sample by initial fertility and GDP per capita
  6. Evaluate the cumulative contributions of policies to fertility changes for specific countries and compare with existing studies (in progress)

The object we care about is the ratio between coefficients

Why does the fact matter?

A simple quantitative model

Model setup

- Government takes the status quo fertility n_t^r as given and chooses realized fertility n_t to maximize the present value:

$$\underbrace{\mathcal{W}(n_t^r)}_{\text{positional value}} = \max_{n_t} \; - \underbrace{\mathcal{P}(n_t, n_t^r)}_{\text{policy expenditure}} - \underbrace{\mathcal{S}(n_t, \overline{n})}_{\text{social cost}} + \beta \cdot \mathbb{E}_\epsilon \mathcal{W}(n_{t+1}^r)$$

$$\mathcal{P}(n_t, n_t^r) = \begin{cases} \pi^+ \cdot (\log(n_t) - \log(n_t^r)) & \text{if } n_t \geq n_t^r \\ \pi^- \cdot (\log(n_t^r) - \log(n_t)) & \text{if } n_t < n_t^r \end{cases} \qquad \underbrace{\pi^+ > \pi^- > 0}_{\text{asymmetry}}$$

$$\mathcal{S}(n_t, \overline{n}) = \lambda \cdot (\log(n_t) - \log(\overline{n}))^2$$

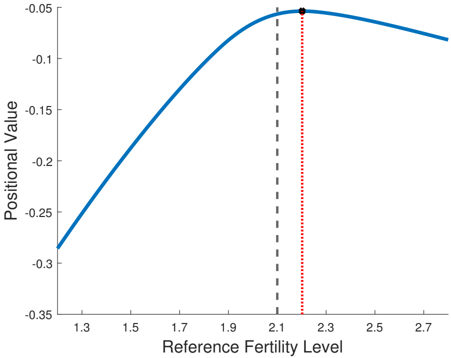
- Adaptive reference updating subject to shocks (Thakral and Tô 2021)

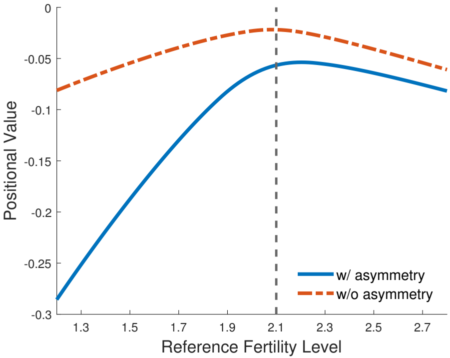
$$\log(n_{t+1}^r) = \phi \cdot \log(n_t) + (1-\phi) \cdot \log(n_t^r) + \epsilon, \qquad \epsilon \sim \mathcal{N}(0, \sigma_\epsilon^2)$$

Calibration

- $\beta = 0.96$ for an annual model
- Policy expenditures needed to change fertility $\pi^+ = 0.05$ and $\pi^- = 0.014$ (% of GDP) from empirical estimates
- Social costs of fertility $\mathcal{S}(n_t, \overline{n}) = \lambda \cdot (\log(n_t) - \log(\overline{n}))^2$
  - $\rightarrow$ $\overline{n} = 2.1$: a commonly stated policy goal
  - $\rightarrow$ $\lambda \in \{0.02, 0.2, 2\}$: TFR=1.64 (USA 2022) results in a social cost of 0.65% of GDP annually
- Law of motion $\log(n^r_{t+1}) = \phi \cdot \log(n_t) + (1 - \phi) \cdot \log(n^r_t) + \epsilon$, $\epsilon \sim \mathcal{N}(0, \sigma^2_\epsilon)$
  - $\rightarrow$ $\phi \in \{0.05, 0.13, 0.25\}$: the expected half-life of the n^r_t is five years
  - $\rightarrow$ $\sigma_\epsilon \in \{0.01, 0.05, 0.1\}$ - a one s.t.d. shock in fertility is 5%

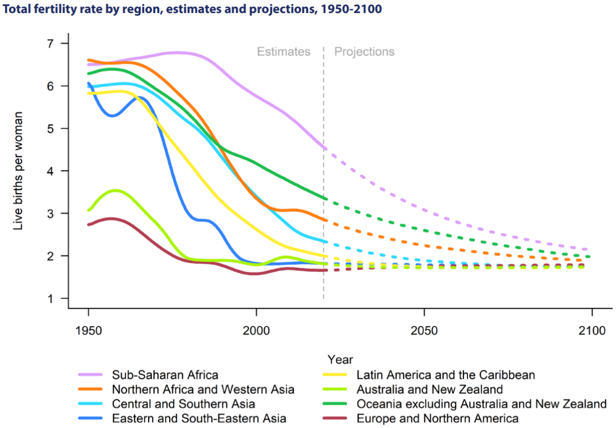
Positional value of fertility level





- Key observation: $\pi^+ > \pi^- \implies \text{argmax}_n \mathcal{W}(n) > \overline{n}$
- Countries ignoring asymmetric fertility elasticities might go "too far" when they reduce fertility, landing in the steep part of $\mathcal{W}(n)$

1. Rethink the global campaign towards $\overline{n} = 2.1$



Source: United Nations Department of Economic and Social Affairs, Population Division (2019a). *World Population Prospects 2019.*

- This paper: $\overline{n}$ is not a good target in the presence of asymmetry

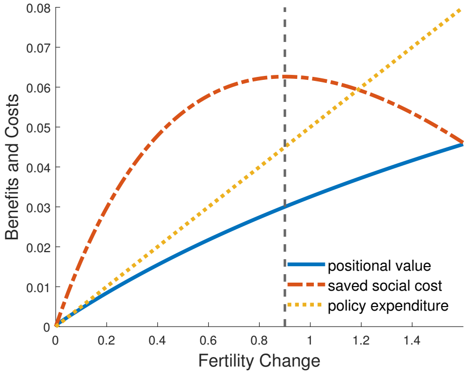
If not $\overline{n}$, then what?

- Following the buffer-stock intuition, we find that the cost-minimizing reference fertility $n^* = \text{argmax}_n \mathcal{W}(n)$:
  - $\rightarrow$ is greater than $\overline{n}$ as long as $\pi^+ > \pi^-$
  - $\rightarrow$ increases with the social cost of fertility deviations from $\overline{n}$
  - $\rightarrow$ increases with the magnitude of reference level shocks
- n^* does not depend much on the speed of reference updating

cost shock speed

2. A missing part in static cost-benefit analysis

$$\mathcal{W}(n_t^r) = \max_{n_t} \; -\mathcal{P}(n_t, n_t^r) - \mathcal{S}(n_t, \overline{n}) + \beta \cdot \mathbb{E}_\epsilon \mathcal{W}(n_{t+1}^r)$$



- Start with $n_t^r = 1.2$ and simulate different pro-fertility policies
- Gains in positional value due to changing future state variable n_{t+1}^r
- Such gains are large in the presence of asymmetry

To recap, we have

- Established asymmetric fertility responses to policies
- Before micro-founding $\pi^+ > \pi^-$, we show that
  1. cost-minimizing government should set $n^* > \overline{n}$ for precaution
  2. changes in positional value should be considered in the cost-benefit analysis of fertility policies

What explains the fact?

A behavioral model of fertility

Asymmetry challenges existing models

- Existing models of fertility choice typically look like

$$\max_{c,n,(e,\dots)} \quad U(c,n,e,\dots) \qquad \text{subject to} \qquad c + \chi n + \dots = I$$

$\Longrightarrow$ smooth aggregate Marshallian demand $n(\chi, \dots)$

- The smoothness result holds uniformly in this class of models
  - $\rightarrow$ Static and dynamic problems
  - $\rightarrow$ Altruistic and warm glow preferences
  - $\rightarrow$ Continuous and discrete fertility choices
  - $\rightarrow$ Representative and heterogeneous agents
  - $\rightarrow$ With and without quantity-quality trade-off or status competition
- Inconsistent with asymmetric elasticities $\frac{\partial n}{\partial \chi}\Big|_{+} > \frac{\partial n}{\partial \chi}\Big|_{-}$

Why loss aversion?

- A large theoretical and empirical literature on loss aversion w/ applications to labor supply, portfolio choice, voting, tax filing, . . .
- "The sweet, sweet life of America's DINKs" (Business Insider)

- Loss aversion as a potential explanation for the asymmetry

alternatives

A Behavioral Theory of Fertility Choice

- Households solve

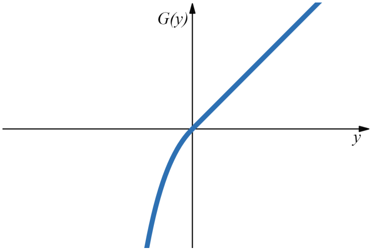
$$\max_{c,n} (1-\alpha)(u(c)+v(n)) + \alpha G(u(c)-u(x))$$

$$c + \chi n = I \qquad v(n) = \frac{n^{1-\gamma}-1}{1-\gamma} \quad \gamma > 1$$

- Loss aversion à la Santoro et al. (2014)

$$G(y) = \begin{cases} y & y \geq 0 \\ 1-\exp(-y) & y < 0 \end{cases}$$

- Consistency: $x = c$ in equilibrium with RA



Result

- *Proposition*: In the comparative statics of this economy,

$$\left.\frac{\partial n}{\partial \chi}\right|_{+} > \left.\frac{\partial n}{\partial \chi}\right|_{-}$$

- Intuition of the proof:
  - $\rightarrow$ Loss aversion creates a kink in the marginal benefit of c around the reference level x
  - $\rightarrow$ When changes in the cost of fertility χ affects the marginal cost of c
    - consumption responses are different depending on $\chi \uparrow$ or $\chi \downarrow$
    - Due to the budget constraint, fertility responses are different
- Future: integrate loss aversion into a dynamic quantitative model of demographic transition and study policy impacts

details

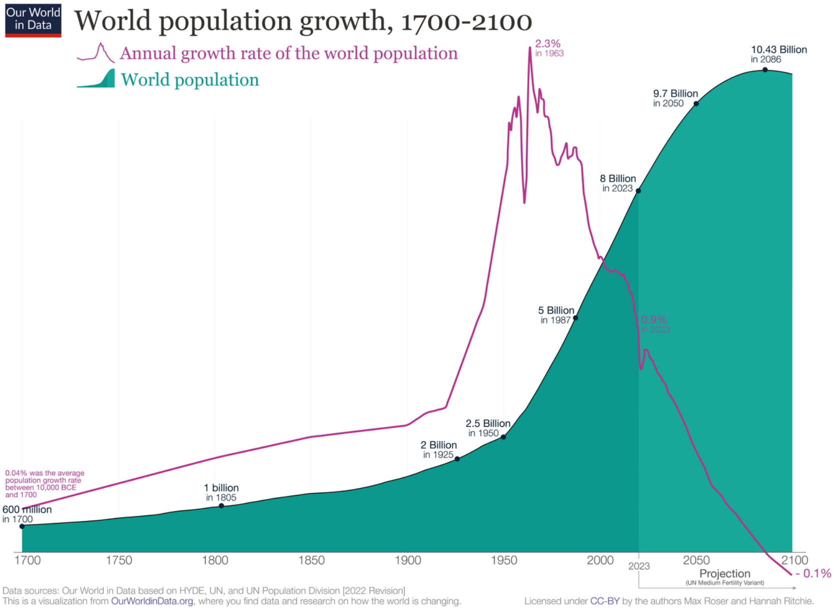
Conclusion

1. Document a new fact: asymmetric fertility elasticities
2. Build a dynamic cost-minimization model of the government
   - → The cost-minimizing fertility is higher than the commonly-targeted replacement level
   - → Fertility level has large buffer-stock value
3. Provide a micro-foundation using a behavioral theory of fertility choice under loss aversion

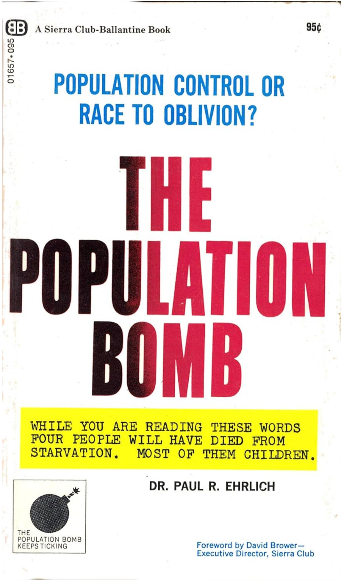
"Demographics determine the destiny of a people." –Lee Kuan Yew

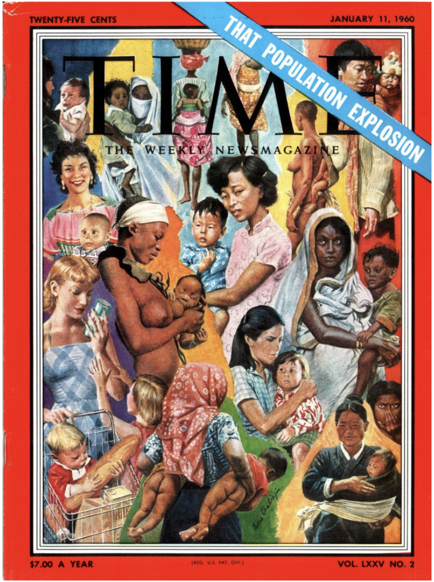
Appendix

The specter of Malthus in the 1960s



The population bomb





The global family planning movement

- Led by global organizations such as the United Nations, the World Bank, USAID, and Bill & Melinda Gates Foundation
- $4.2 billion spent across low- & lower-middle-income countries in 2021
- Many country-specific policies (e.g., the one-child-policy in China)
- Gradually attaches more benefits to low fertility: economic development, health, gender equity, environment. . .
- Evidence that fertility policies played an important role in the rapid fertility decline (de Silva and Tenreyro 2020)

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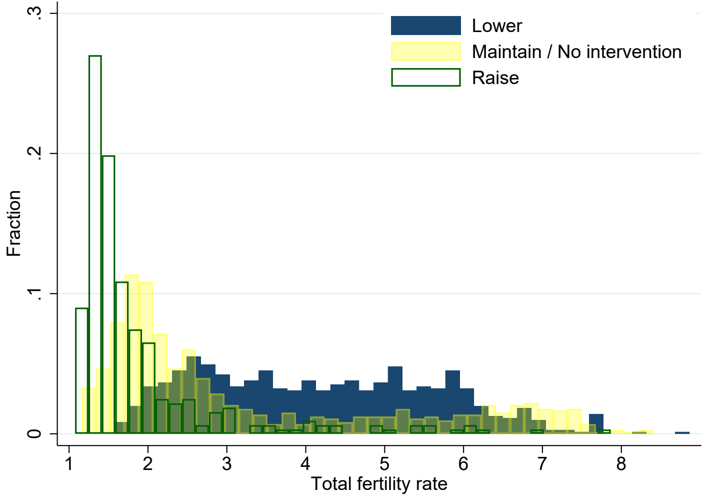
Fertility policy distribution



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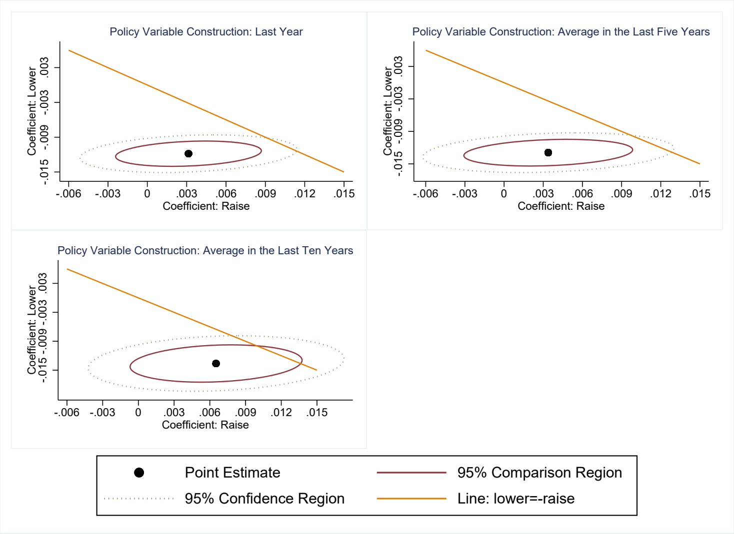
Confidence region of coefficients



- Wald test-based comparison regions (Eckert and Vach 2020)

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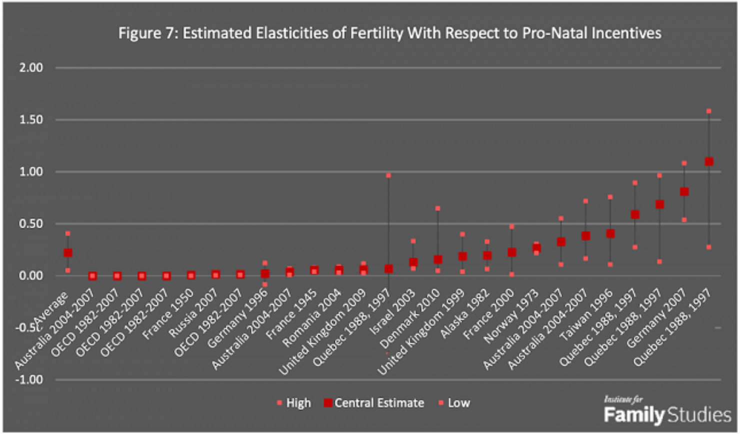
Responses to pro-fertility policies



- "An increase in the present value of child benefits equal to 10% of a household's income can be expected to produce between 0.5% and 4.1% higher birth rates." (Stone 2020)

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Alternatives

- Propagating mechanisms?
  - → E.g., peer pressure, human capital complementarities . . .
  - → They make elasticities larger, but not asymmetric
- Asymmetric technological feasibility?
  - → Insight: The toolbox of policymakers is diverse but symmetric more
  - → Within the toolbox, the observed choices could be different depending on policy direction. But what explains this pattern?

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Technological Reversibility

1. Propaganda: “It’s better to make a family disappear than to make a second new birth appear” (China) & “have one for mum, one for dad and one for the country” (Australia) & “Do it for Denmark”
2. Family policies: childlessness tax (Soviet) & maternity capital (Russia)
3. Access to tech.: planned parenthood (global) & Decree 770 (Romania)
4. Reproductive coercion: forced sterilization (Bangladesh) & monthly gynecological exam w/ plant-level birth target (Romania)

Fertility policies have different combinations of cost-effectiveness and repugnancy. But each of them is technologically feasible in either direction

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Control for past fertility

Table 4: Population Policy and TFR: Control Average TFR in the Last Five Years

Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate			
Construction of Policy Variables	Last Year		Average in the Last Five Years	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0121***	-0.0065***	-0.0134***	-0.0070***
	(0.0014)	(0.0015)	(0.0016)	(0.0017)
Raise fertility	0.0031	0.0013	0.0033	0.0009
	(0.0037)	(0.0033)	(0.0043)	(0.0038)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes
Average TFR in the Last Five Years	Yes	Yes	Yes	Yes
Observations	9881	8446	9881	8446
R^2	0.134	0.182	0.133	0.182

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Country-specific trends

Table 5: Population Policy and TFR: Control Country-Specific Linear Trend

Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate			
Construction of Policy Variables	Last Year		Average in the Last Five Years	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0040**	-0.0050**	-0.0038	-0.0054**
	(0.0018)	(0.0019)	(0.0026)	(0.0026)
Raise fertility	-0.0006	-0.0001	-0.0004	0.0009
	(0.0039)	(0.0037)	(0.0047)	(0.0045)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Country-Specific Linear Trend	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes
Observations	10726	9146	10726	9146
R^2	0.204	0.220	0.203	0.220

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Split samples

Panel A: Subsample with High TFR in 1960				
Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate			
Construction of Policy Variables	Last Year		Average in the Last Five Years	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0076***	-0.0056***	-0.0080***	-0.0057***
	(0.0014)	(0.0014)	(0.0018)	(0.0018)
Raise fertility	0.0003	0.0005	0.0009	0.0007
	(0.0034)	(0.0055)	(0.0062)	(0.0056)
Observations	5936	5247	5936	5247
R^2	0.339	0.390	0.337	0.388
Panel B: Subsample with Low TFR in 1960				
Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate			
Construction of Policy Variables	Last Year		Average in the Last Five Years	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0150**	-0.0117**	-0.0151***	-0.0117**
	(0.0028)	(0.0049)	(0.0023)	(0.0047)
Raise fertility	0.0016	0.0030	0.0024	0.0038
	(0.0038)	(0.0037)	(0.0044)	(0.0043)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes
Observations	4789	3899	4789	3899
R^2	0.128	0.147	0.128	0.147

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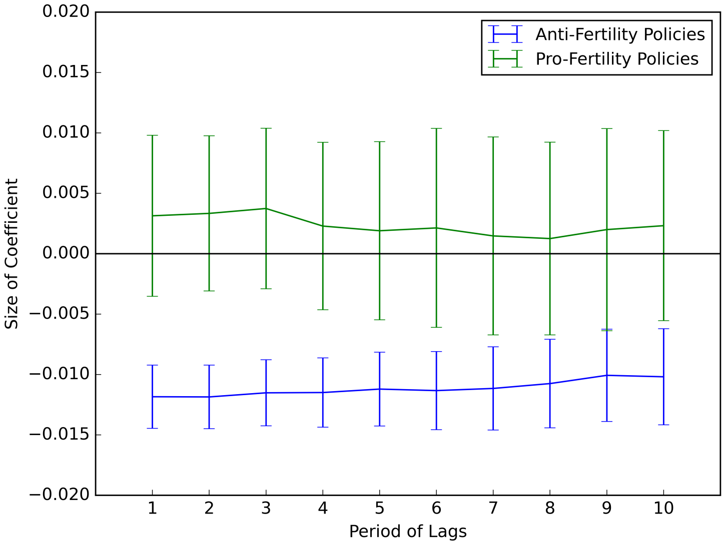
Different horizons



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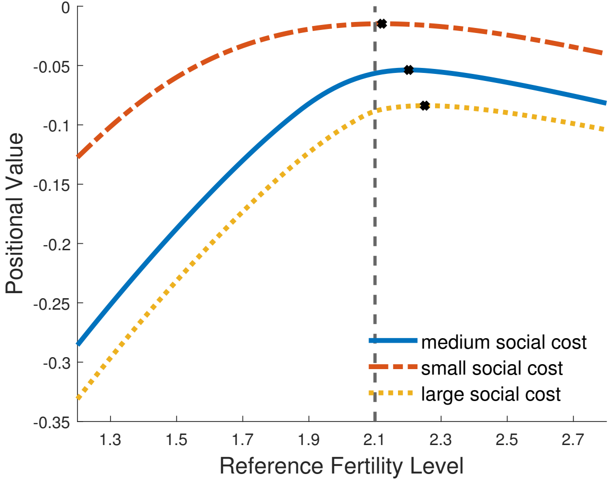
The role of social cost λ



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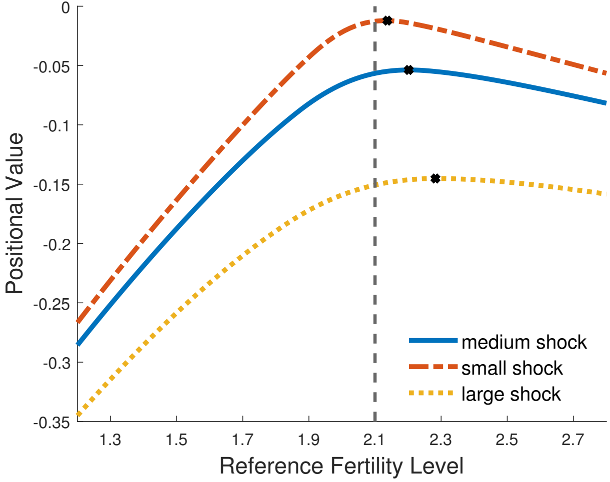
The role of reference shock σ_ϵ



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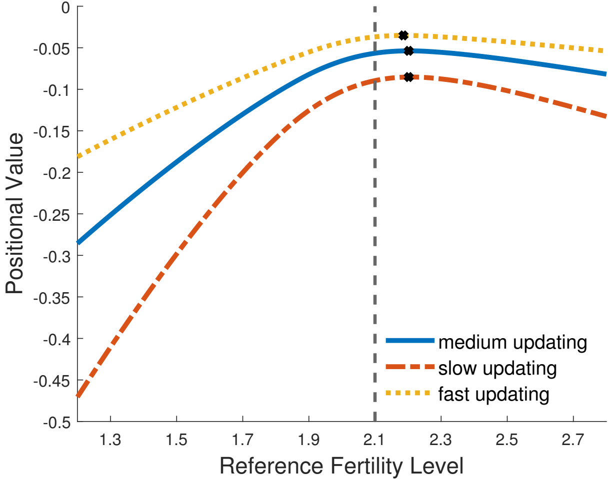
The role of reference updating speed ϕ



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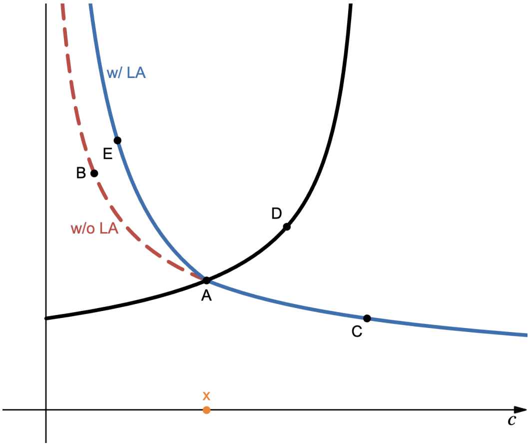
Optimal choice

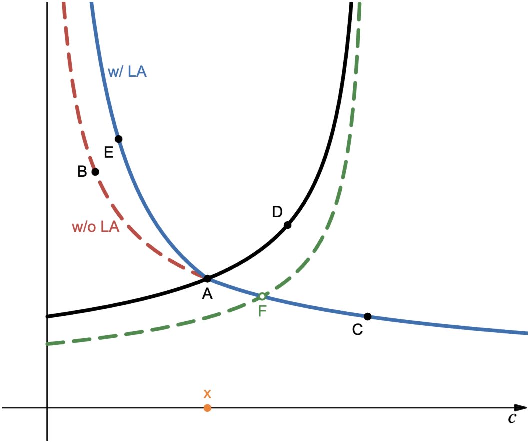
- The first-order condition of optimal consumption satisfies

$$(1-\alpha)u'(c) + \alpha u'(c)G'(u(c) - u(x)) = \frac{1}{\chi}v'\left(\frac{y-c}{\chi}\right)$$



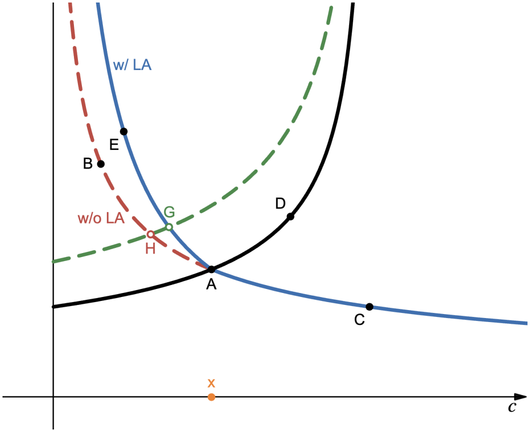
Falling price of fertility χ

- When χ falls, optimal choices coincide with and without loss aversion



Rising price of fertility χ

- When χ rises, optimal consumption falls *less* with loss aversion $\Longrightarrow$ fertility needs to reduce by *more* due to the budget constraint



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