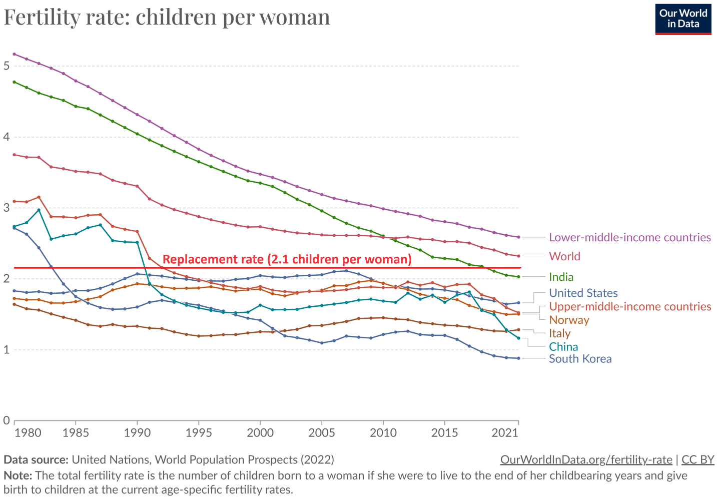
Asymmetric Fertility Elasticities

Sam Engle   Chong Pang   Anson Zhou

March 2024

The emergence of below-replacement fertility



- Public pension, economic growth (Jones 2022), “civilizational risk”

Raising fertility seems to be extremely difficult

Vox

EXPLAINERS ▾ CROSSWORD VIDEO PODCASTS MORE ▾

SOCIAL POLICY WORLD POLITICS LIFE

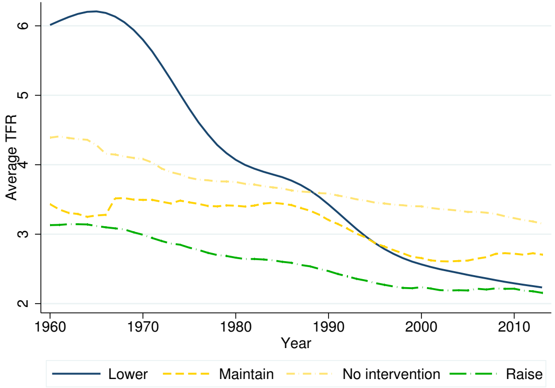
You can't even pay people to have more kids

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

- "Pro-natal policies work, but they come with a hefty price tag" (Stone 2020)
- Interestingly, many countries with low fertility problems now were reducing fertility not so long ago (e.g., China, Thailand, Singapore, . . .)

Reducing fertility feels easier



- Fertility trends by country groups based on policy stance in 1976

background

Research question

- At first glance, the performance of pro- versus anti-fertility policies looks quite 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?
- Given the magnitude of fertility decline (both China and U.S. fertility are at a historical low), these questions are important and urgent
- This paper: new fact + new theory + new policy implications

This paper

1. Empirically
   → Collect historical data on fertility policy stance and expenditures
   → Compare fertility responses at the aggregate and individual levels
   → Establish a new fact: asymmetric fertility elasticities
2. Theoretically
   → Propose a new model of fertility choice under loss aversion to interpret the empirical results
3. Quantitatively
   → A dynamic 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

Literature

- Empirical evaluations of fertility policies

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

  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

Plan of the talk

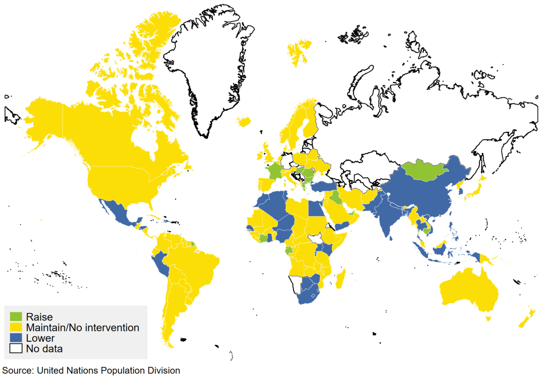
- Empirical results
- Behavioral theory to provide micro-foundation and interpretations
- Simple quantitative model for macro implications
- Conclusion

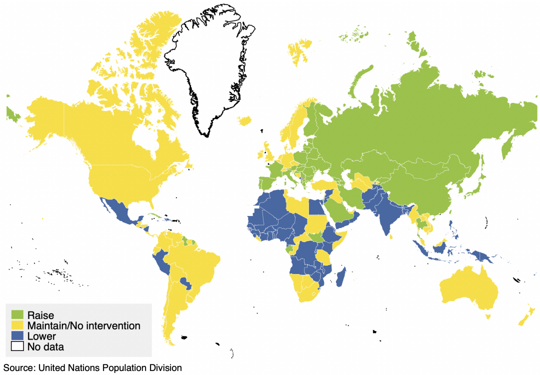
Empirical Analyses

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 expenditures from a variety of sources following 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





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

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

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

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

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

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

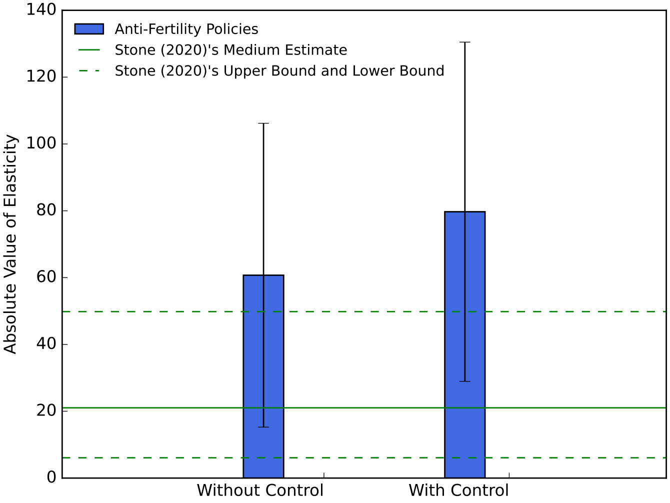
- Using data on expenditures, we estimate the effects of anti-fertility policies

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)
Anti-fertility policy 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. Restrict obs to fertility levels with both pro-a and anti-fertility adopted
  7. Evaluate the cumulative contributions of policies to fertility changes for specific countries and compare with existing studies

Importantly, the object we care about is the ratio between coefficients

A Behavioral Model of Fertility Choice

Asymmetry challenges existing models

- Existing models of fertility choice typically look like

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

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

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

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)

- This paper: loss aversion is a potential explanation of the asymmetry

Competing explanations

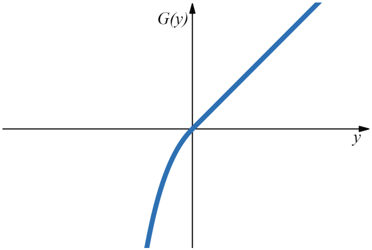
- Propagation mechanisms (e.g., peer pressure, human capital complementarities, . . .) make elasticities larger but not asymmetric
- Fertility policies are technologically feasible in either direction
  - → Propaganda/norms: "It's better to make a family disappear than to make a second new birth appear" (China) & "have one for mum, one for dad and one for the country" (Australia) & "Do it for Denmark"
  - → Family policies: childlessness tax (Soviet) & maternity capital (Russia)
  - → Access to tech.: planned parenthood (global) & Decree 770 (Romania)
  - → Reproductive coercion: forced sterilization (Bangladesh) & monthly gynecological exam w/ plant-level birth target (Romania)
- The choice of methods is affected by the preference of constituents

A Behavioral Theory of Fertility Choice

- Households solve

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

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



- 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:

  → Loss aversion creates a kink in MU_c around reference level x

  → When changes in χ perturbs the shadow price of c

  - consumption responses are different depending on $\chi\uparrow$ or $\chi\downarrow$
  - Due to the budget constraint, fertility responses are different

details

Quantitative Model

Model setup (1)

- Government takes reference fertility n_t^r as given
- Chooses realized fertility n_t to minimize the discounted stream of costs

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

$$\mathcal{P}(n_t, n_t^r) = \begin{cases} \pi^+ \cdot (\log(n_t) - \log(n_t^r)) & \text{if } \; n_t \geq n_t^r \\ \pi^- \cdot (\log(n_t^r) - \log(n_t)) & \text{if } \; n_t < n_t^r \end{cases}$$

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

- Asymmetric fertility elasticities reflected in $\pi^+ > \pi^- > 0$

Model setup (2)

- Adaptive reference updating process subject to idiosyncratic shocks (Thakral and Tô 2021) motivated by the new theory

$$\log(n_{t+1}^r) = \phi \cdot \log(n_t) + (1 - \phi) \cdot \log(n_t^r) + \epsilon$$

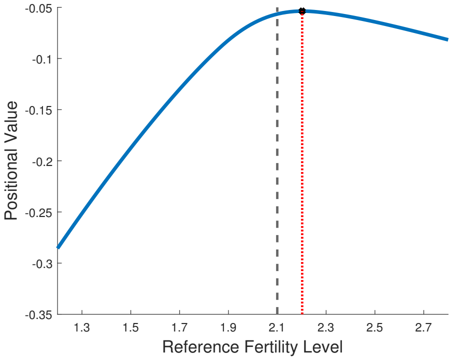
$$\epsilon \sim \mathcal{N}(0, \sigma_\epsilon^2)$$

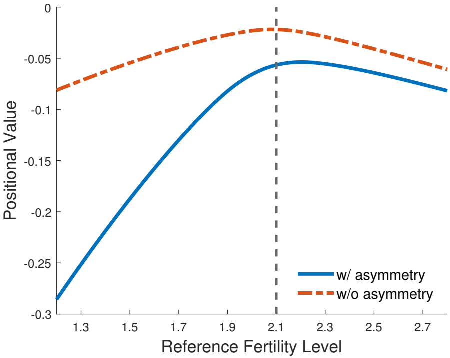
- ϵ could be preference, technology, or income shocks
- $\phi \in [0, 1]$ determines how long the government needs to spend to change people's reference point
- $\mathcal{W}(n_t^r)$ is the positional value of fertility level that captures the (expected) discount value of policy expenditures and social costs

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 0.065%, 0.65%, or 6.5% 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%

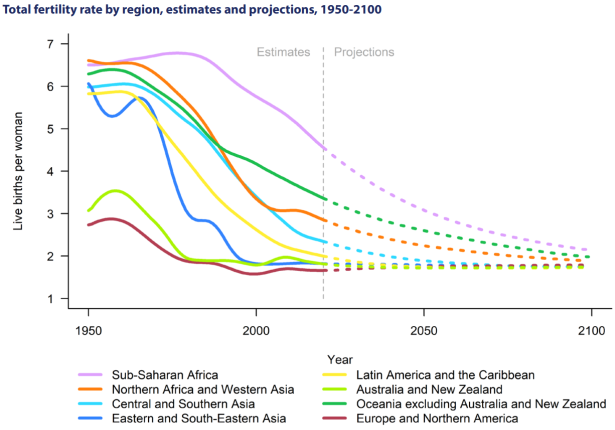
Positional value of fertility Level





- 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 $\mathcal{W}(n)$

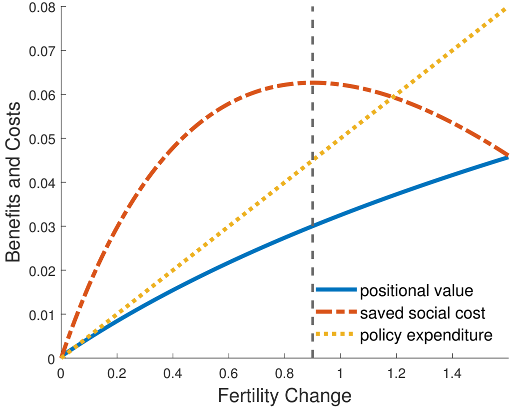
1. Rethink the global campaign towards $\overline{n} = 2.1$



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

- Few mechanisms suggest that this convergence will happen on its own
- This paper: $\overline{n}$ is not a good target in the presence of asymmetry

2. Re-examine the cost-benefit analysis of fertility policies



- 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, almost 1/3 to 1/2 of the saved social cost in baseline

Cost-minimizing fertility level

- 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

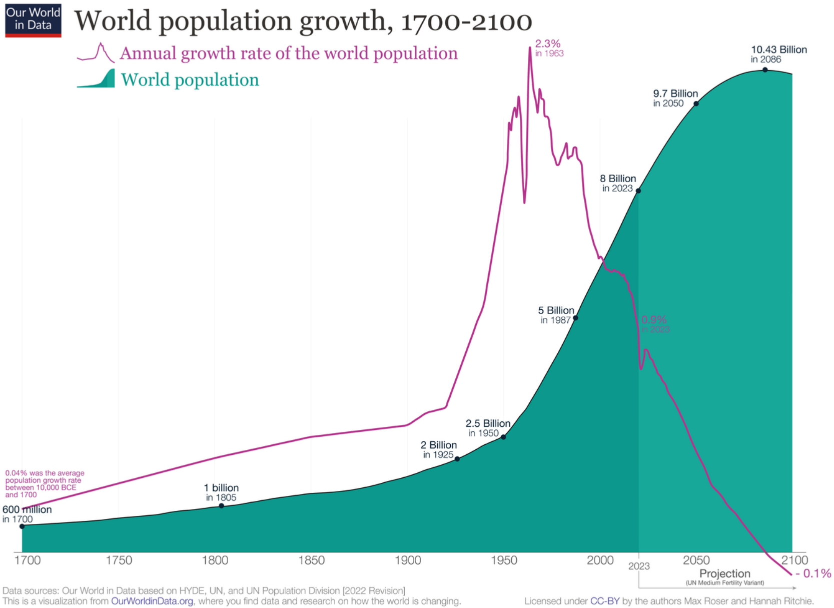
Conclusion

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
4. (Future work) embed the micro-foundation explicitly into a full-blown quantitative model w/ transition path

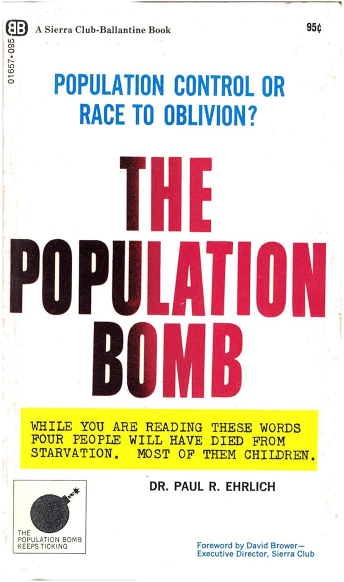
"Demographics determine the destiny of a people." –Lee Kuan Yew

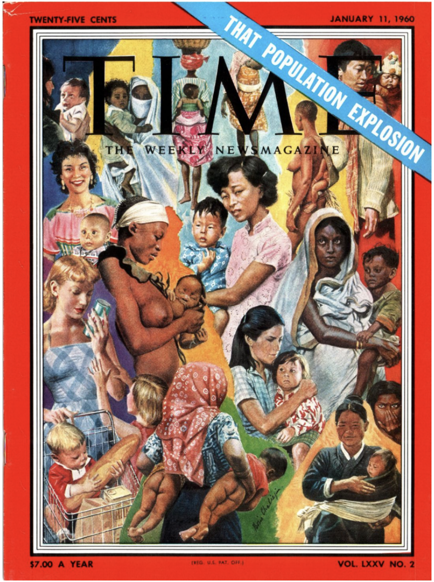
Appendix

The specter of Malthus in the 1960s



The population bomb



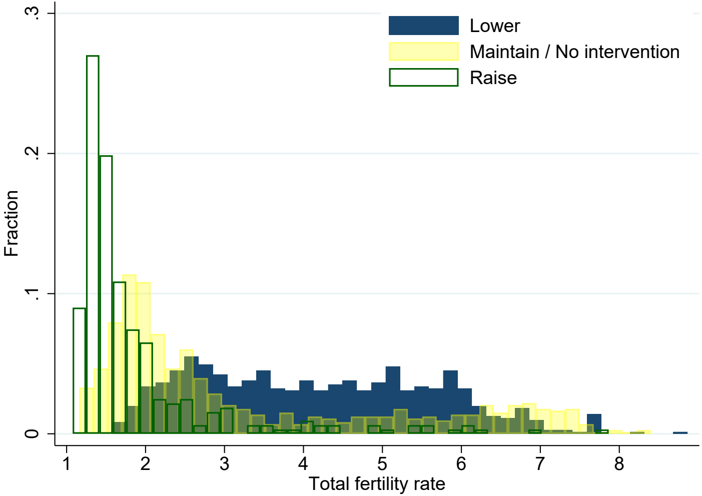


The global family planning movement

- 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)

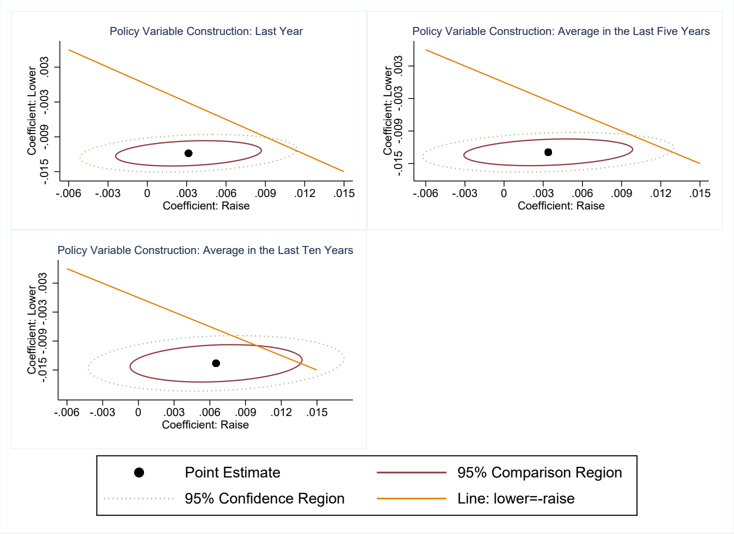
back

Fertility policy distribution



back

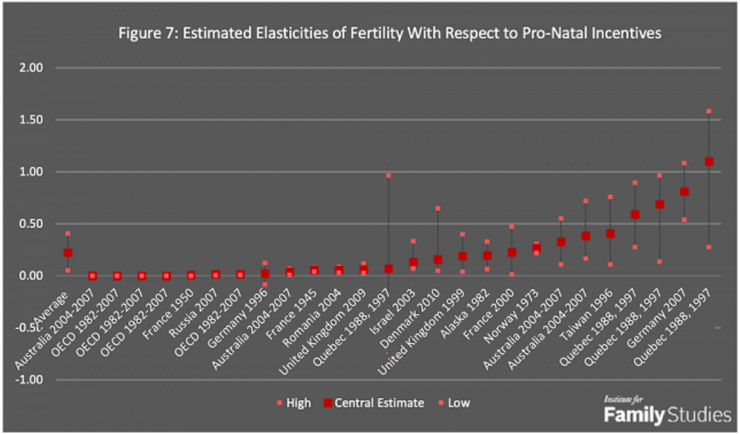
Confidence region of coefficients



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

back

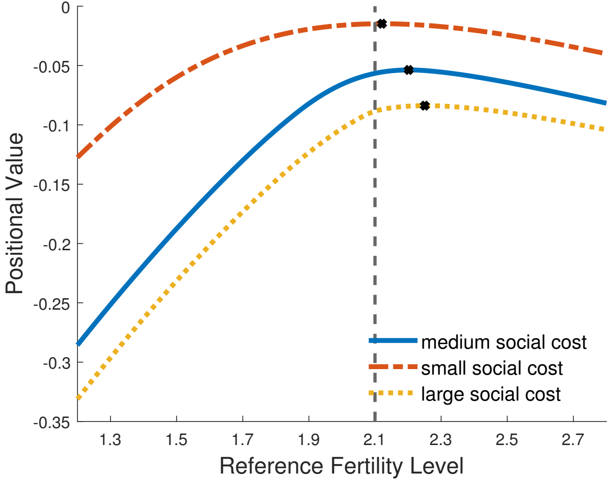
Responses to pro-fertility policies



- "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)

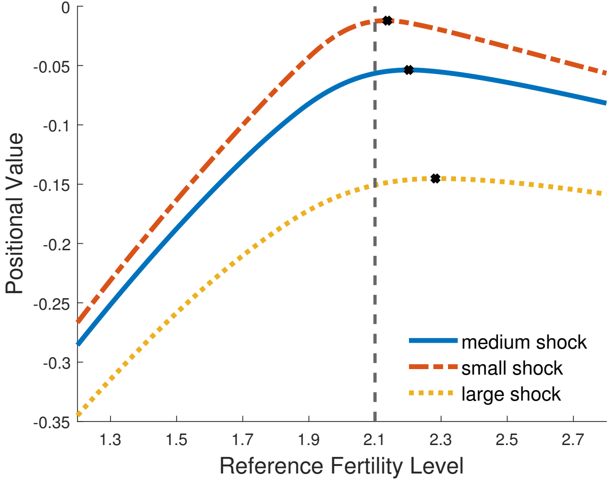
back

The role of social cost λ



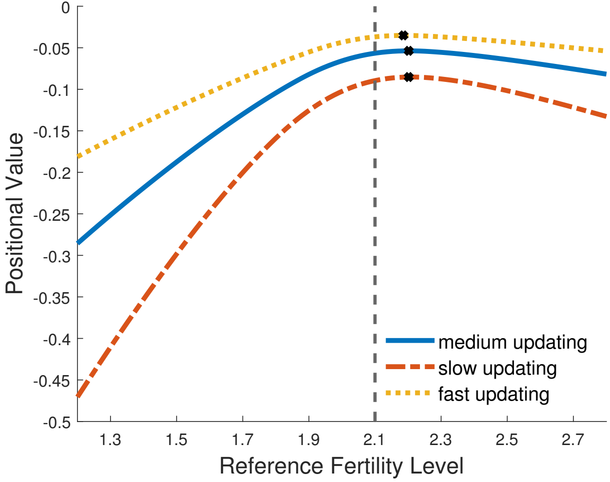
back

The role of reference shock σ_ϵ



back

The role of reference updating speed ϕ

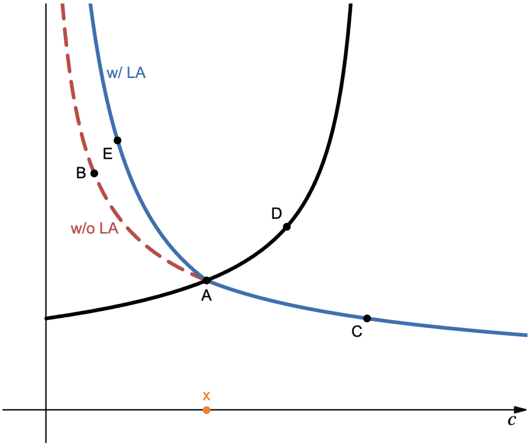


back

Optimal choice

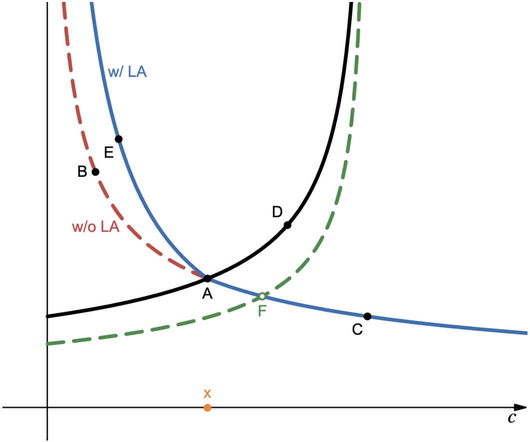
- The first-order condition of optimal consumption satisfies

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



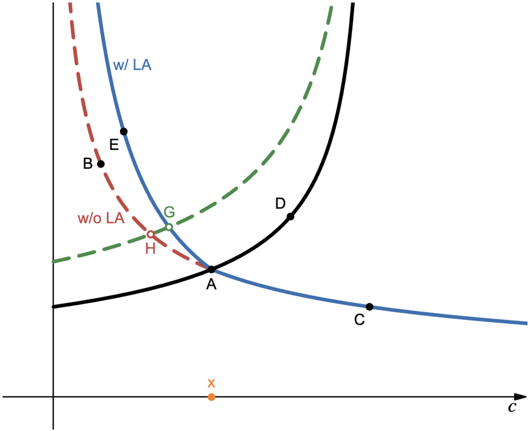
Falling price of fertility χ

- 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



back