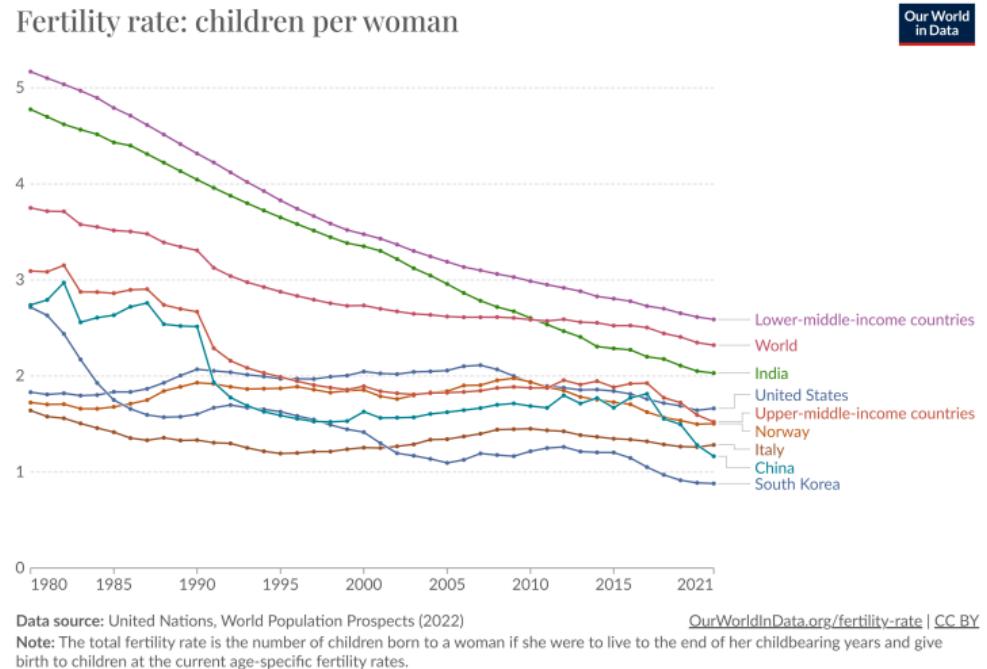


Asymmetric Fertility Elasticities

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 difficult

The image shows the header of the Vox website. It features a yellow square logo with the word "Vox" in black lowercase letters. To the right of the logo is a grey navigation bar with links for "EXPLAINERS", "CROSSWORD", "VIDEO", "PODCASTS", "MORE", and a search icon. Below the navigation bar are three tabs: "SOCIAL POLICY" (highlighted in yellow), "WORLD POLITICS", and "LIFE".

SOCIAL POLICY WORLD POLITICS LIFE

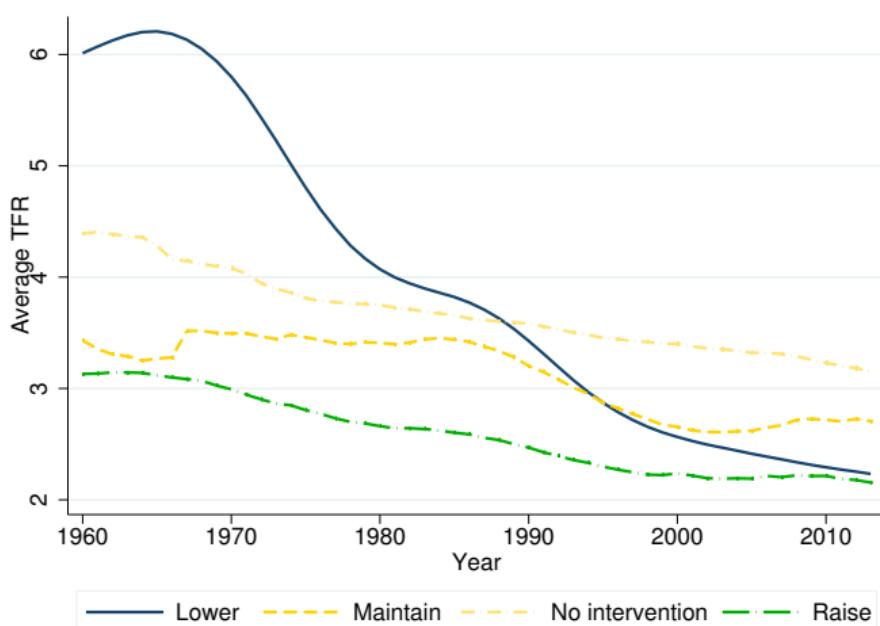
You can't even pay people to have more kids

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

- In light of the different observed performances of policies,
 1. Is it inherently more difficult to raise fertility than to reduce it?
 2. If so, what are the macro implications and micro-foundations?
- Addressing this question is “now or never” (Kishida 2023)
- This paper: new facts + new theory + new policy implications

This paper

1. Empirically

- Collect data on fertility policy stance and expenditures
- Use panel regression and cohort exposure methods
- Establish a new fact: **asymmetric fertility elasticities**

2. Quantitatively

- A dynamic model of cost minimization by the government
- **New policy implications**
 - i The cost-minimizing fertility is higher than the replacement level
 - ii Fertility level has large **buffer-stock value**

3. Theoretically

- Show that the asymmetry presents a puzzle to existing models
- Propose a new theory 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)

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), Ibbotson (2019)

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

Plan of the talk

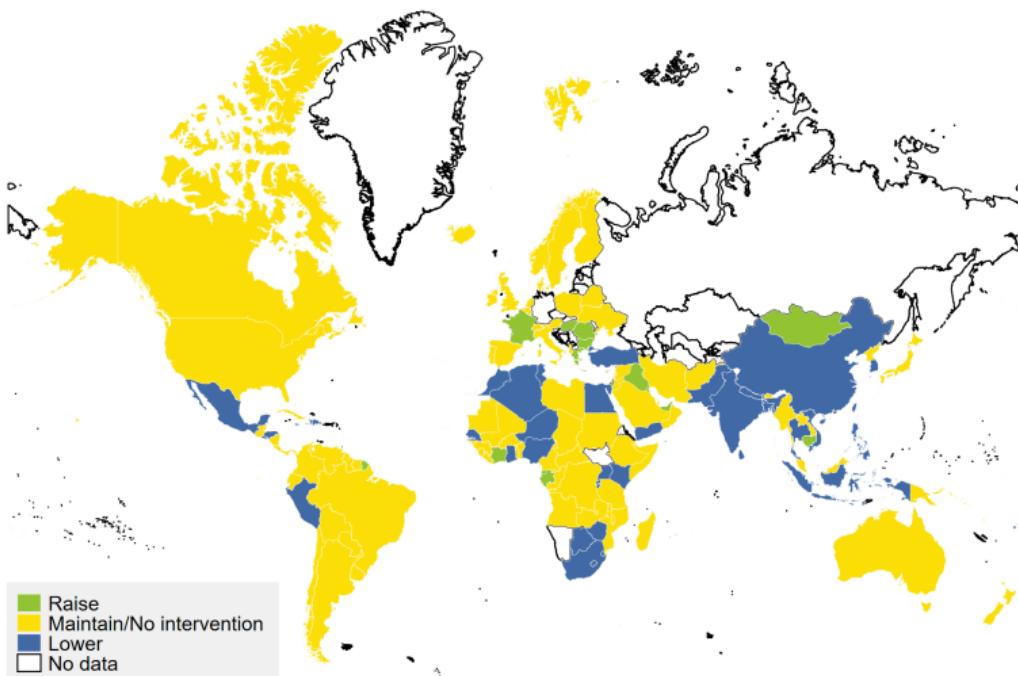
- Empirical results
- Quantitative model for macro implications
- Behavioral theory to provide micro-foundation
- Conclusion

Empirical Analyses

Data

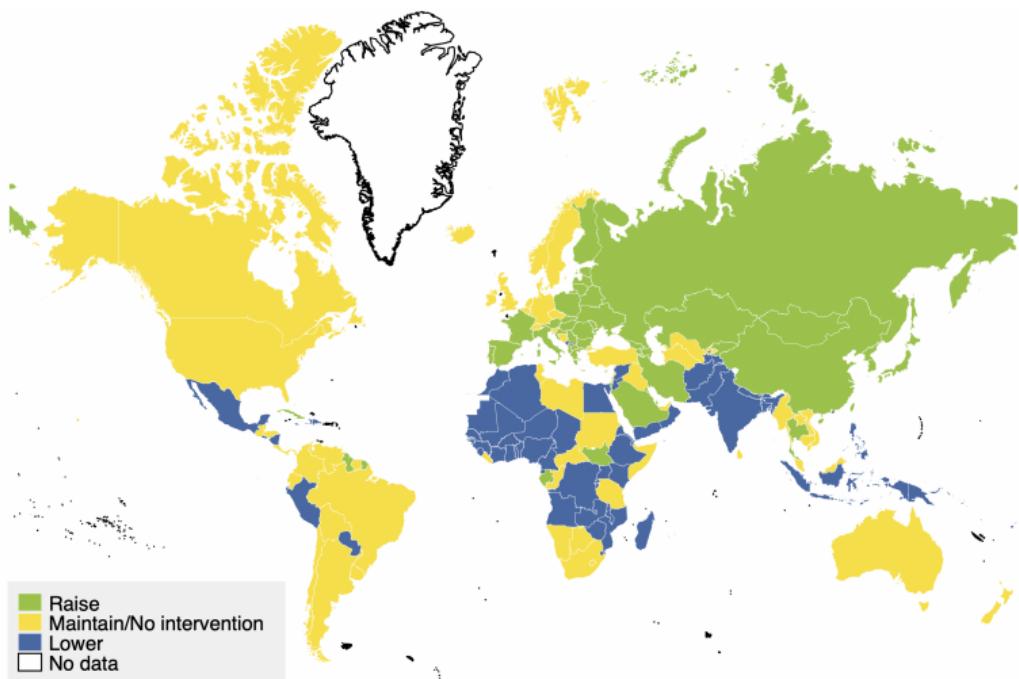
- Fertility level and policy data from the United Nations
 - Policy stance dummy assigned by the UN Population Division since 1976 - lower, raise, maintain, no intervention
- Aggregate variables from PWT and WDI: GDP per capita, urbanization, infant mortality, female labor force participation
- Family 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



Source: United Nations Population Division

Fertility policy in 2021



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

Policy Variables	ΔTotal Fertility Rate/Lagged Fertility Rate					
	Last Year		Average in the Last Five Years		Average in the Last Ten Years	
	(1)	(2)	(3)	(4)	(5)	(6)
Lower fertility	-0.0118*** (0.0013)	-0.0071*** (0.0055)	-0.0129*** (0.0015)	-0.0076*** (0.0016)	-0.0102*** (0.0020)	-0.0042* (0.0022)
Raise fertility	0.0013 (0.0034)	0.0016 (0.0030)	0.0034 (0.0039)	0.0013 (0.0034)	0.0023 (0.0040)	0.0002 (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

$$\text{Child}_{icbt} = \alpha + \beta_1 \text{Policy_Lower}_{icb} + \beta_2 \text{Policy_Raise}_{icb} + \eta \text{Age}_i \times \text{Gender}_i + \gamma_{ct} + \delta_b + \epsilon \quad (2)$$

- Individual's exposure to policy constructed as

$$\text{Policy_Lower}_{icb} = \frac{1}{11} \sum_{t \in [b + \text{MAC}_{cb+18} - 5, b + \text{MAC}_{cb+18} + 5]} \mathbb{I}(\text{Policy}_{ct} = \text{Lower})$$

$$\text{Policy_Raise}_{icb} = \frac{1}{11} \sum_{t \in [b + \text{MAC}_{cb+18} - 5, b + \text{MAC}_{cb+18} + 5]} \mathbb{I}(\text{Policy}_{ct} = \text{Raise})$$

Results

Table 2: Population Policy and the Number of Children

Interpolation of MAC	Number of Children								
	Country-Specific Year Polynomial				Nearest Neighbor			Socioeconomic Variables	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Target: Lower fertility	-0.776*** (0.220)	-0.762*** (0.210)	-0.624*** (0.185)	-0.844*** (0.201)	-0.655*** (0.188)	-0.875*** (0.208)	-0.831*** (0.243)	-0.821*** (0.232)	-0.631*** (0.215)
Target: Raise fertility	0.278 (0.181)	0.304* (0.162)	0.131 (0.186)	0.168 (0.167)	-0.007 (0.185)	0.141 (0.189)	0.259 (0.221)	0.262 (0.191)	0.046 (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

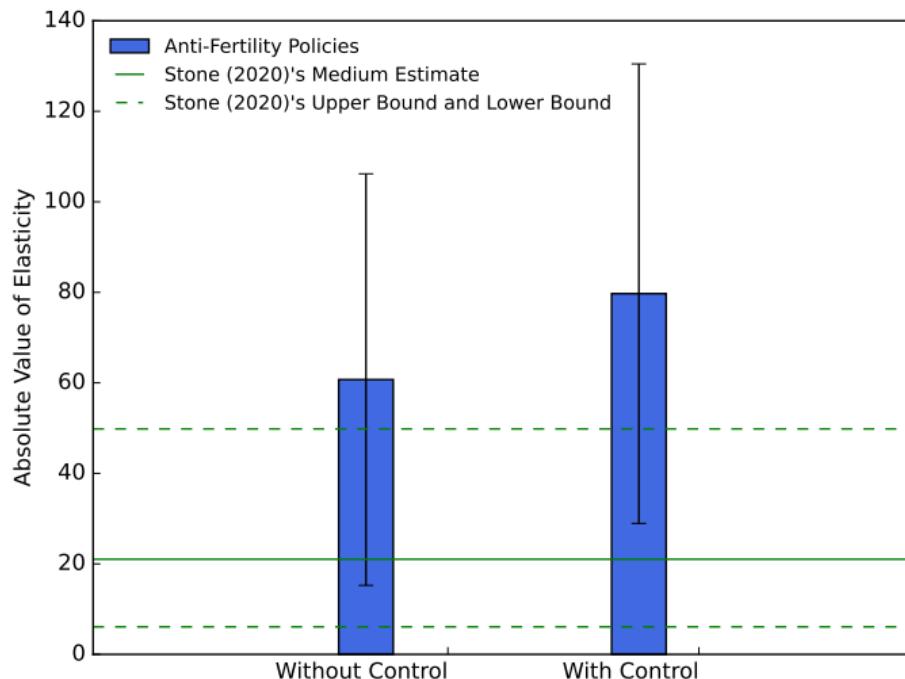
- Using data on expenditures, we estimate the effects of anti-fertility policies

Table 3: Elasticity Estimation for Anti-Fertility Policy

Dependent Variable	Δ Total 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*** (22.65)	-79.71*** (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

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



Robustness

- Use levels instead of percentage changes in fertility
- Policy effects at different horizons
- Country-specific trends
- Controlling for past fertility to mitigate reverse causality
- Split sample by initial fertility and GDP per capita

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

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

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

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

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

- Asymmetric fertility elasticities reflected in $\pi^+ > \pi^- > 0$
- Not considering household welfare due to population ethics and the diversity of policy instruments

Model setup (2)

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

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

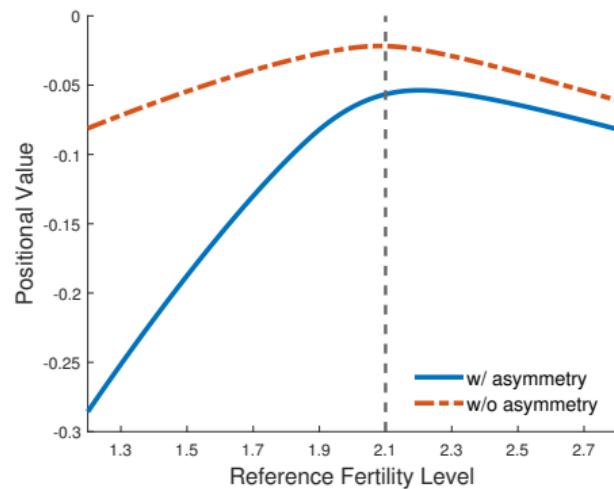
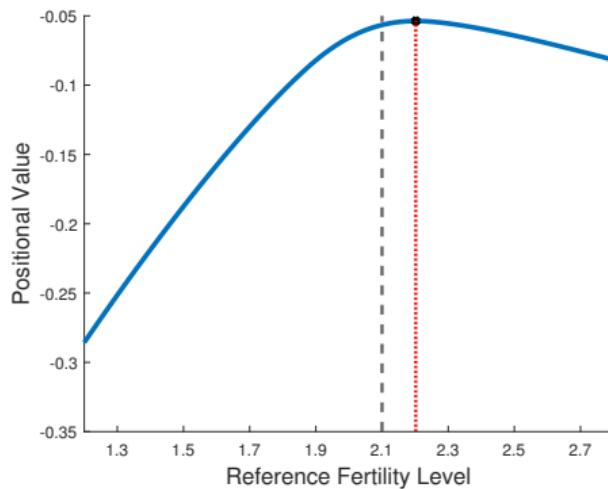
$$\epsilon \sim \mathcal{N}(0, \sigma_\epsilon^2)$$

- $\phi \in [0, 1]$ 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

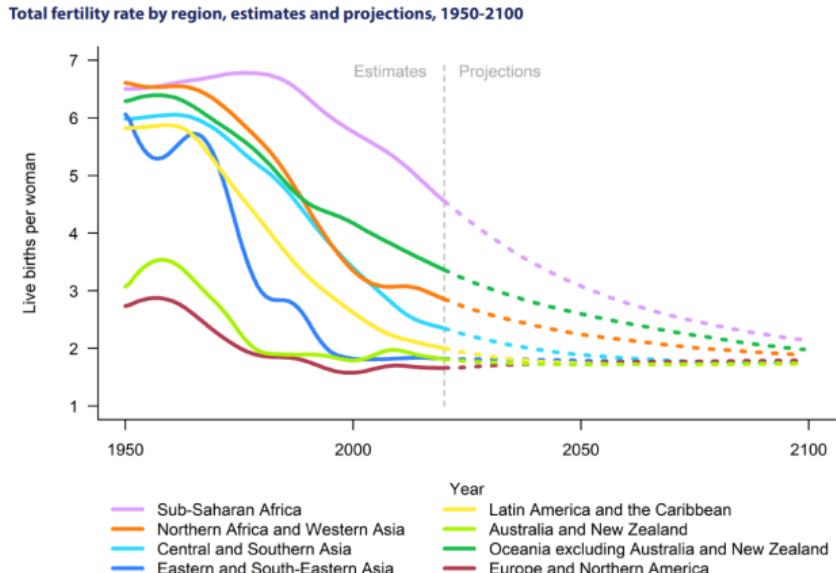
- $\beta = 0.96$ for an annual model
- $\pi^+ = 0.05$ and $\pi^- = 0.014$ (% of GDP) from empirical estimates
- $\bar{n} = 2.1$: a commonly stated policy goal
- $\lambda \in \{0.02, 0.2, 2\}$: TFR=1.64 (USA 2022) results in a social cost of 0.065%, 0.65%, or 6.5% of GDP annually
- $\phi = 0.13$: the expected half-life of the original reference n_t^r is five years
- $\sigma_\epsilon \in \{0.01, 0.05, 0.1\}$

Positional value of fertility Level



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

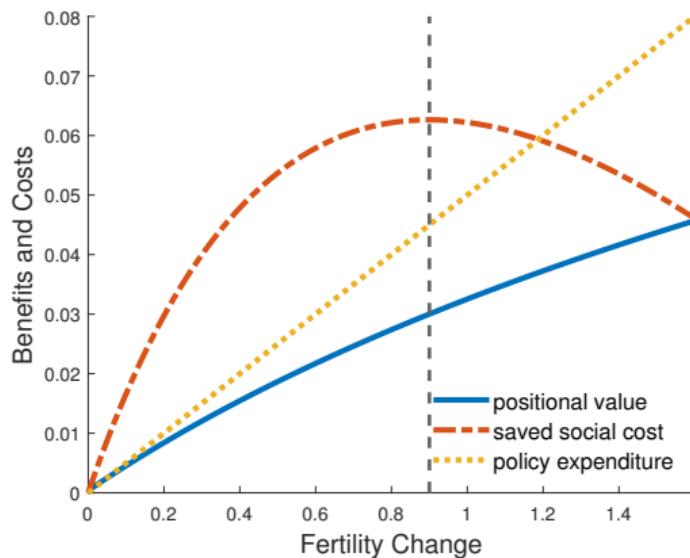
1. Re-examine the global campaign towards $\bar{n} = 2.1$



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: \bar{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 $n^* = \operatorname{argmax}_n \mathcal{W}(n)$:
 - is greater than \bar{n} as long as $\pi^+ > \pi^-$
 - increases with the social cost of fertility deviations from \bar{n}
 - increases with the magnitude of reference level shocks
- n^* does not depend much on the speed of reference updating

cost shock speed

A Behavioral Theory of Fertility Choice

Challenges to existing models

- Existing models of fertility choice typically look like

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

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

- The smoothness result holds uniformly in this class of models
 - Static and dynamic problems
 - Altruistic and warm glow preferences
 - Continuous and discrete fertility choices
 - Representative and heterogeneous agents
 - With and without 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 (Berkellar et al. 2004, Crawford and Meng 2011, Rees-Jones 2019, Alesina and Passareli 2019, ...)
- “The sweet, sweet life of America’s DINKs” (Business Insider)



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

A Behavioral of Fertility Choice

- A theory to provide micro-foundation of why $\pi^+ > \pi^-$
- Key ingredient: individuals have loss aversion over consumption
- Households solve

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

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

- Loss aversion exists as long as $\alpha > 0$
- c can be interpreted broadly to capture other aspects of living standard
- $\gamma > 1$ is a sufficient condition such that a rise in the cost of children χ raises the marginal cost of consumption c

Loss aversion over consumption

- Individuals have loss aversion à la Santoro et al. (2014)

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

which is differentiable at $y = 0$ and $G'(y) < G'(-y)$ for all $y > 0$

- A consistency condition in equilibrium is

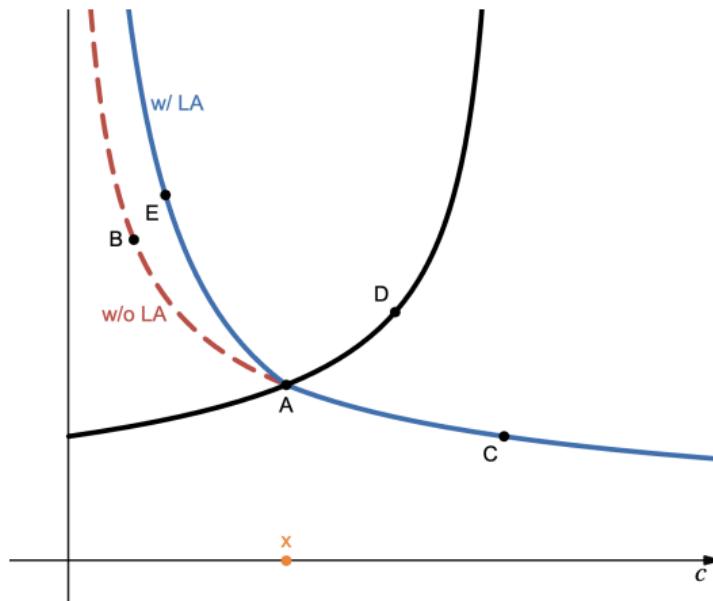
$$x = c$$

so that individual's expectation of the reference coincides with the actual consumption of their peers in this economy with representative agents

Optimal choice

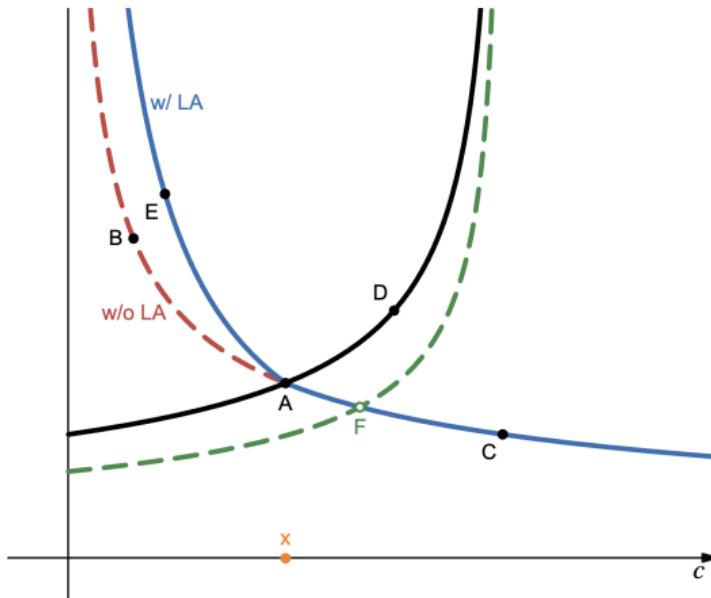
- The first-order condition of optimal consumption satisfies

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



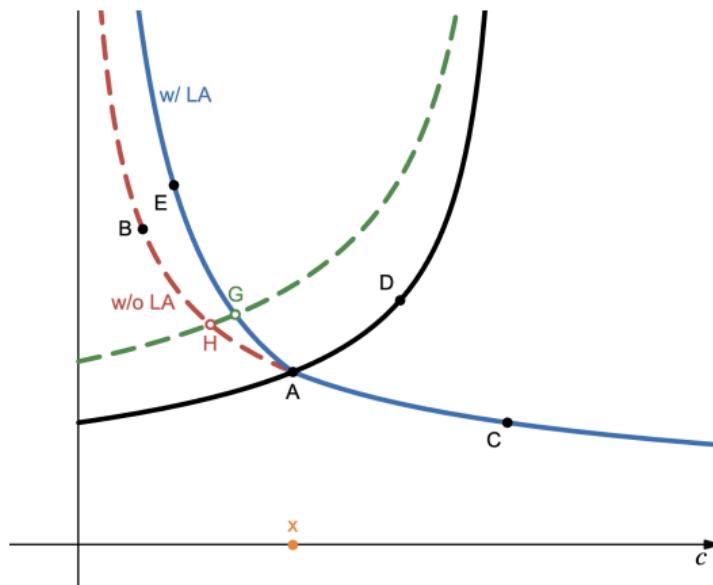
Falling price of fertility χ

- 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 \Rightarrow fertility needs to reduce by *more* due to the budget constraint



Conclusion

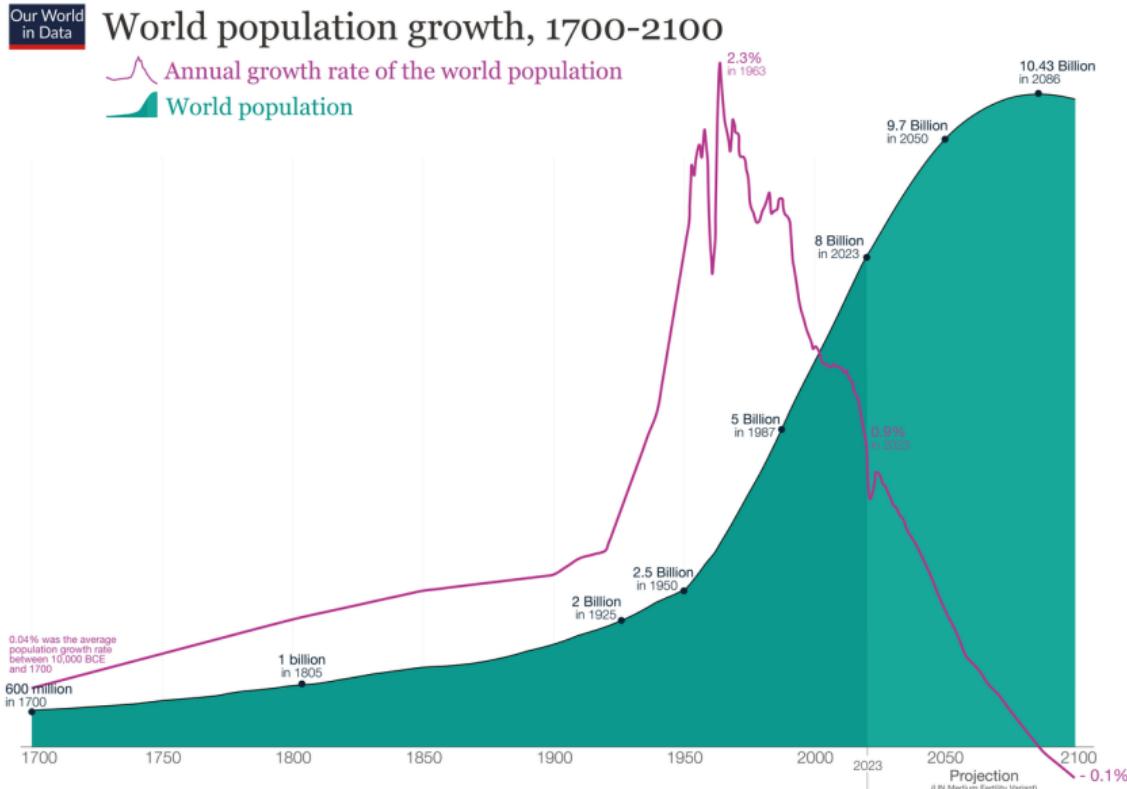
1. Document **asymmetric fertility elasticities** in the data
2. Build a dynamic cost-minimization model of the government \Rightarrow fertility level has **positional values**
3. Provide a micro-foundation using a behavioral theory of fertility choice under loss aversion
4. (Future work) embed the micro-foundation into a full-blown quantitative model w/ transition path

“Demographics determine the destiny of a people.”

–Lee Kuan Yew

Appendix

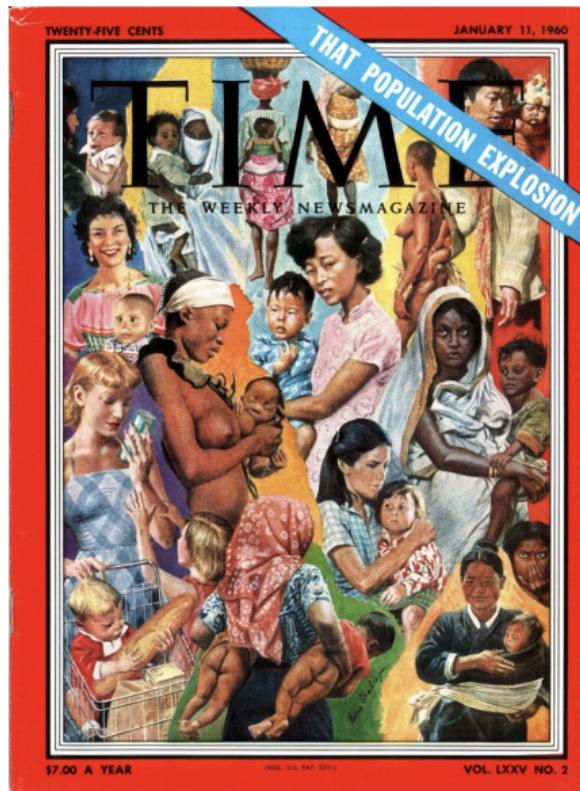
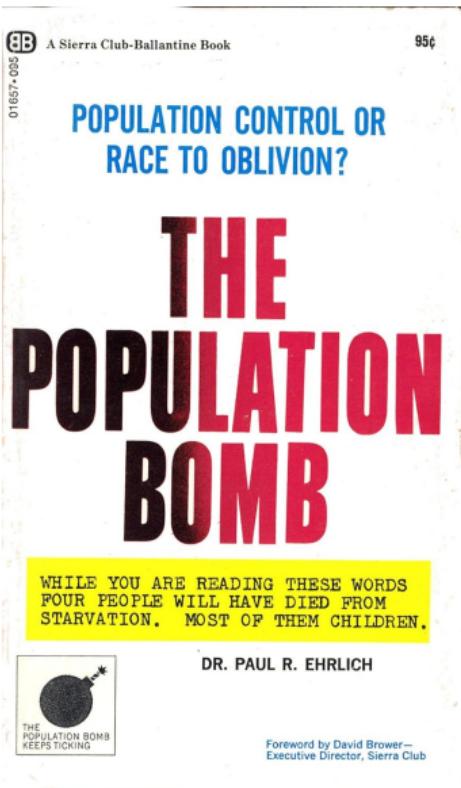
The specter of Malthus in the 1960s



Data sources: Our World in Data based on HYDE, UN, and UN Population Division [2022 Revision].
This is a visualization from [OurWorldinData.org](https://ourworldindata.org), where you find data and research on how the world is changing.

Licensed under CC-BY by the authors Max Roser and Hannah Ritchie.

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...

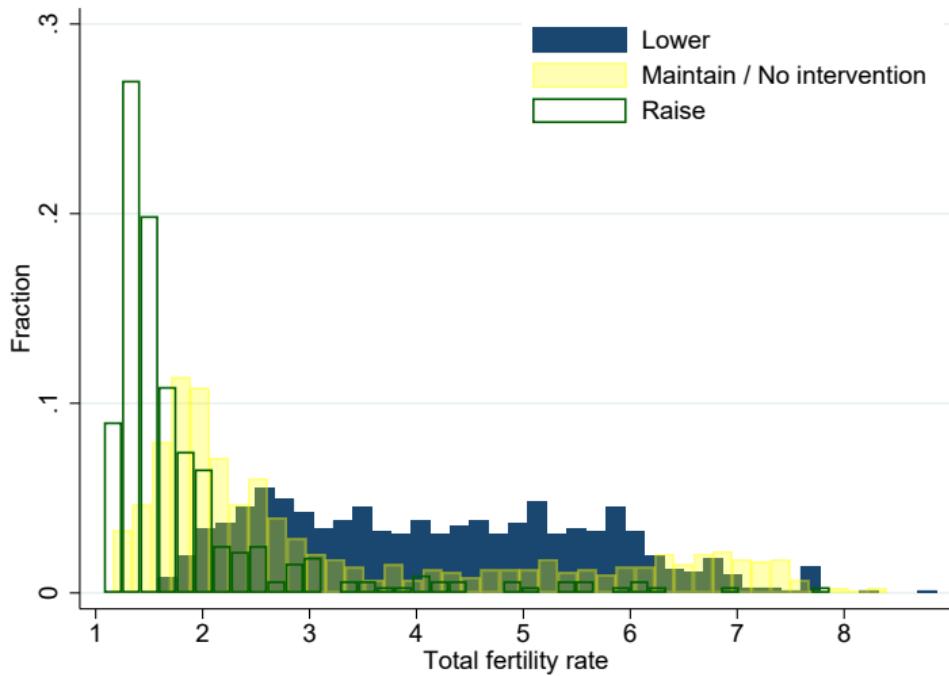
CLIMATE CHANGE | OPINION

Population Decline Will Change the World for the Better

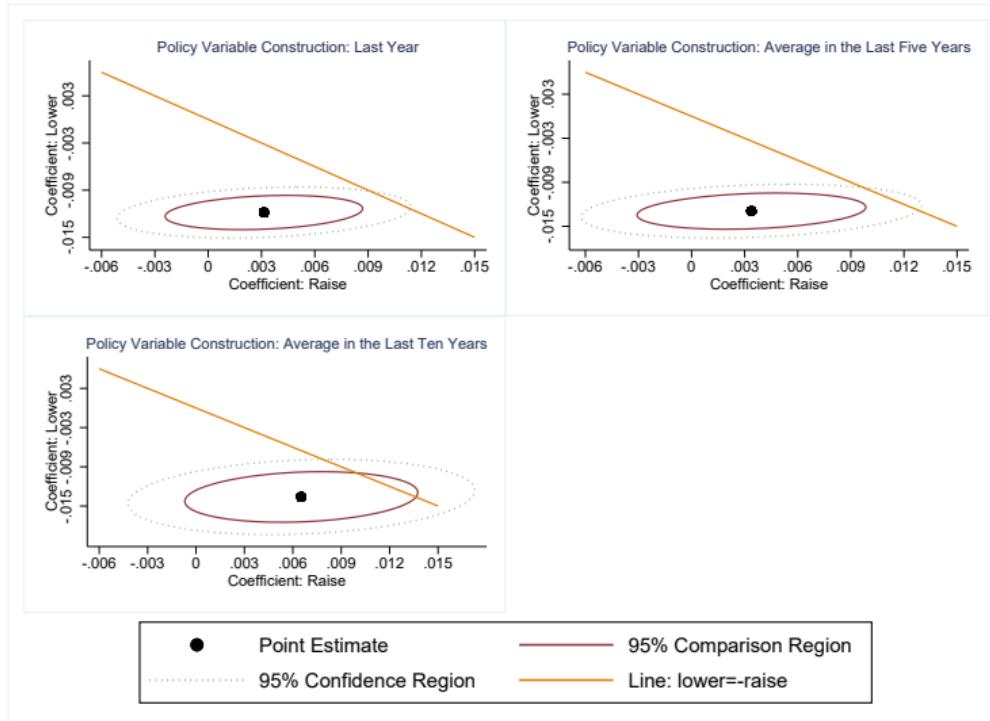
A future with fewer people offers increased opportunity and a healthier environment

By Stephanie Feldstein on May 4, 2023

Fertility policy distribution



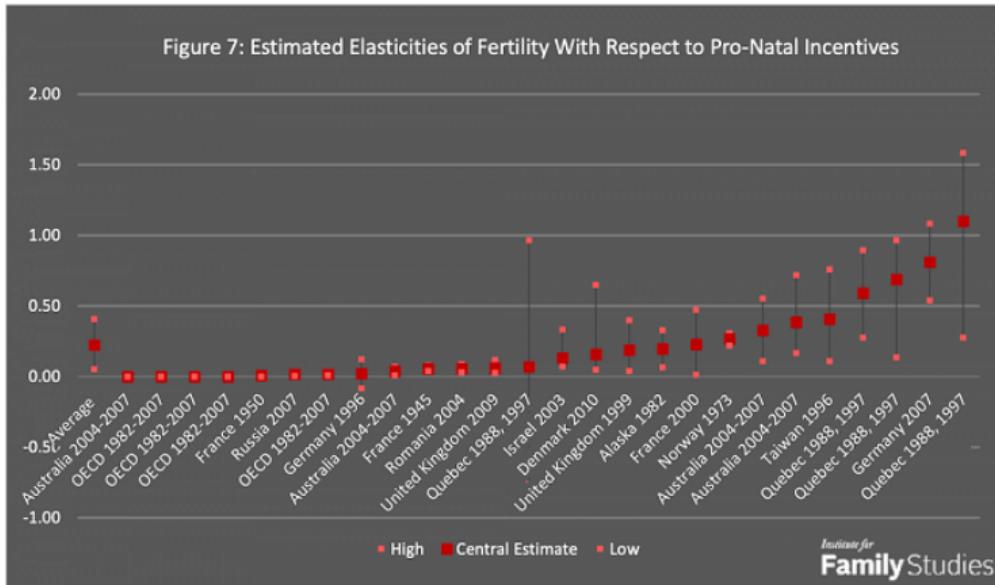
Confidence region of coefficients



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

back

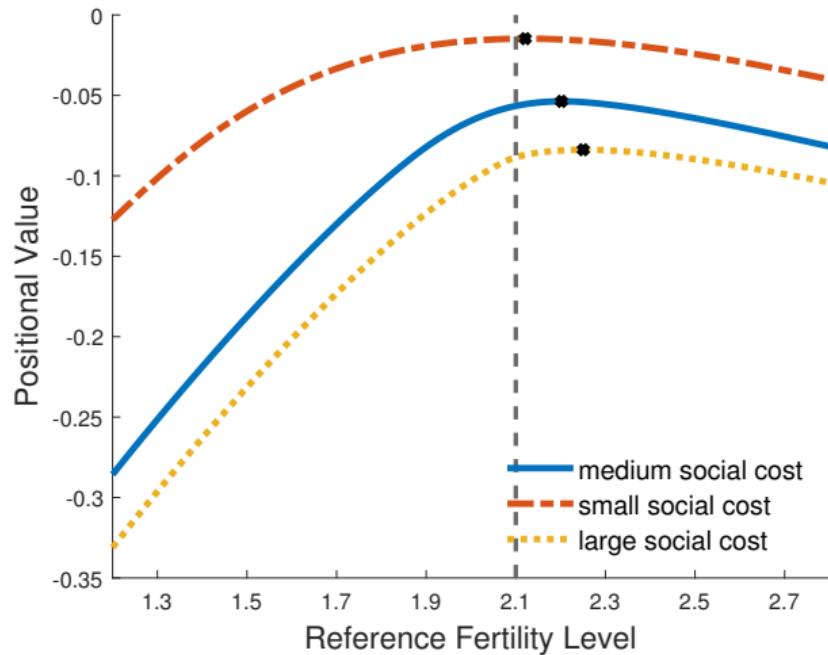
Responses to pro-fertility policies



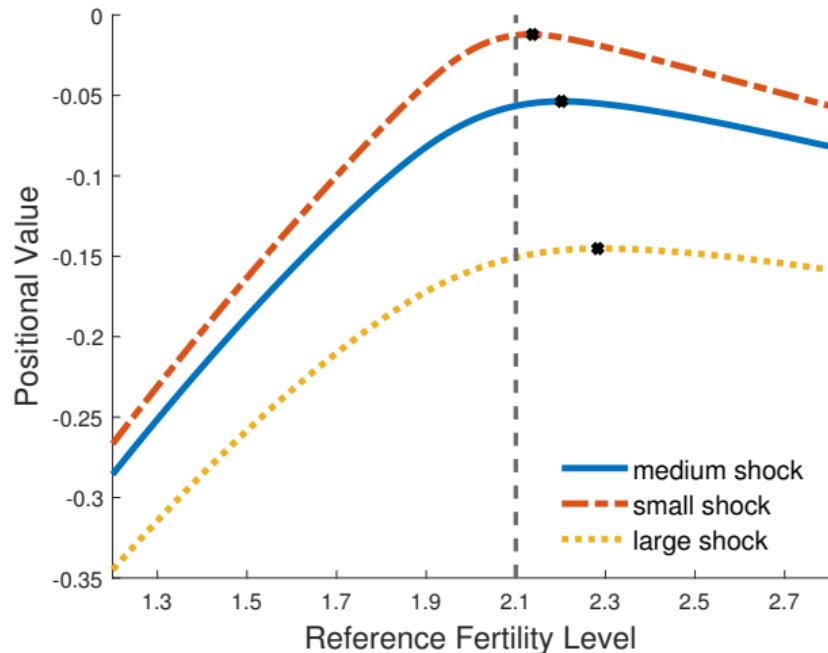
- “An increase in the present value of child benefits equal to 10% of a household’s income can be expected to produce between 0.5% and 4.1% higher birth rates.” (Stone 2020)

back

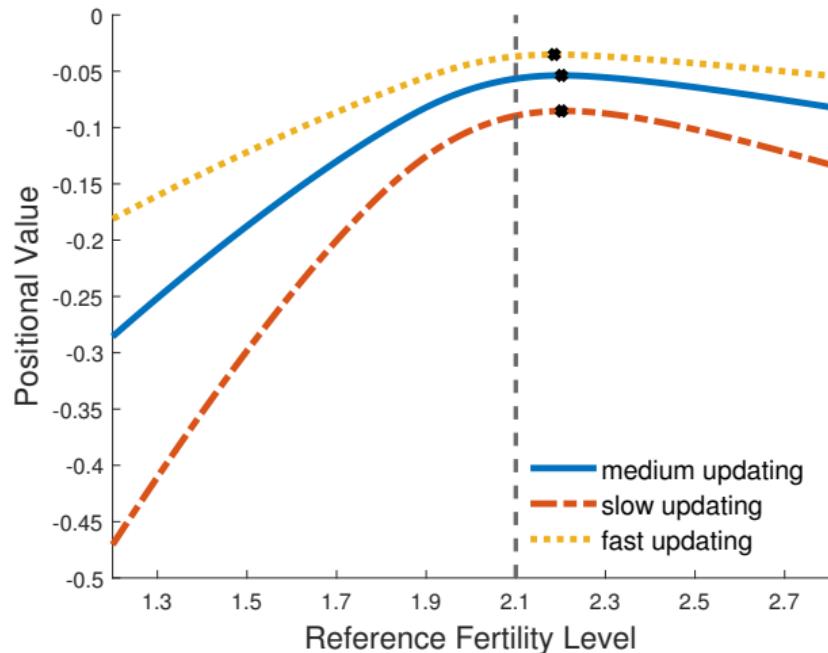
The role of social cost λ



The role of reference shock σ_ϵ



The role of reference updating speed ϕ



Competing explanations

- Propagation mechanisms (e.g., peer pressure, human capital complementarities, ...) make elasticities larger but do not induce asymmetry
- 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