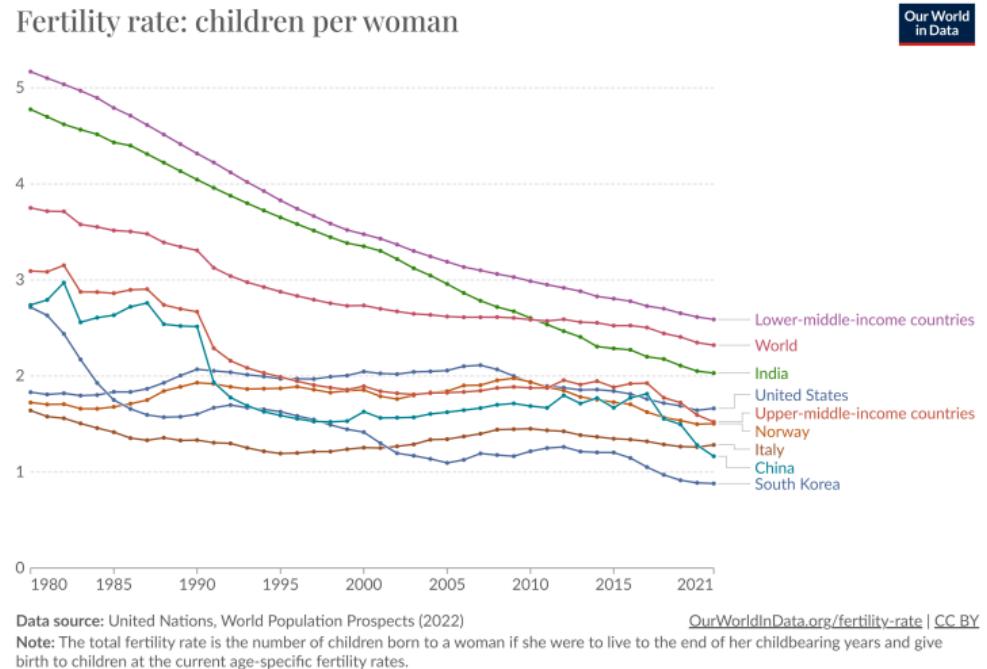


# Asymmetric Fertility Elasticities

Sam Engle    Chong Pang    Anson Zhou

March 2024

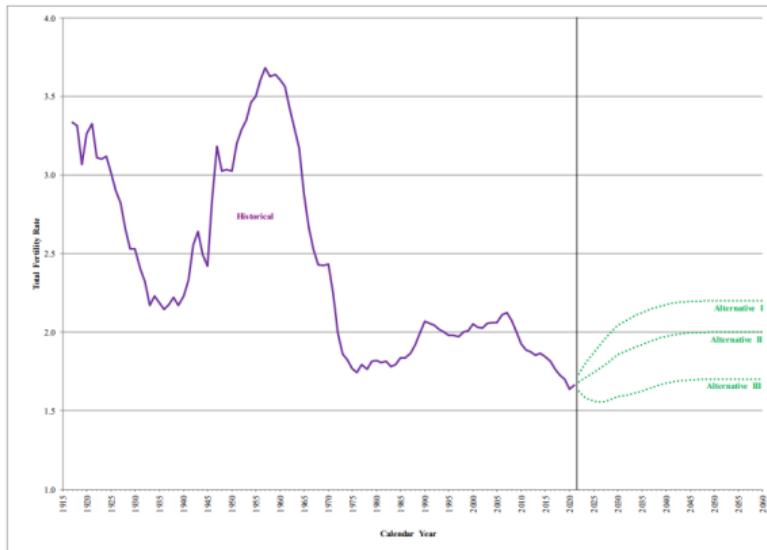
# The emergence of below-replacement fertility



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

# SSA projections

Chart 1.3: Historical and Projected Total Fertility Rates



Social Security Administration  
Office of the Chief Actuary  
March 31, 2023

- What are the policy costs of these fertility recoveries?

# 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

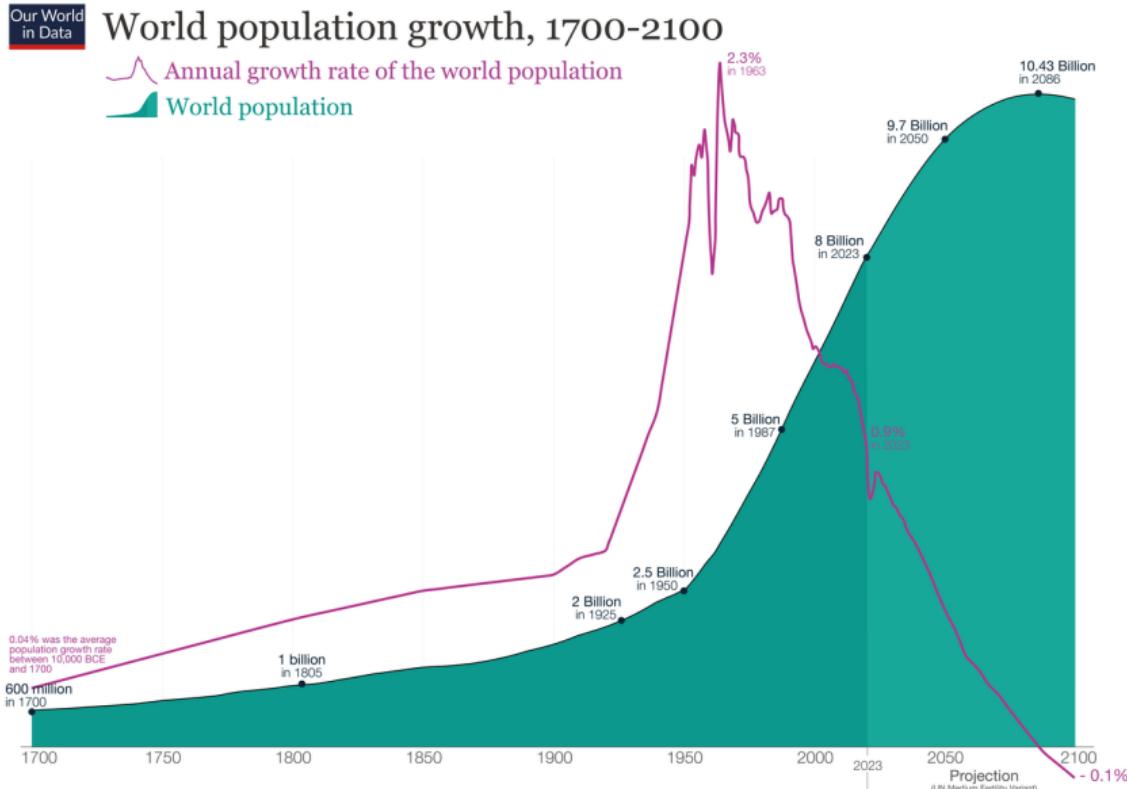
## You can't even pay people to have more kids

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)

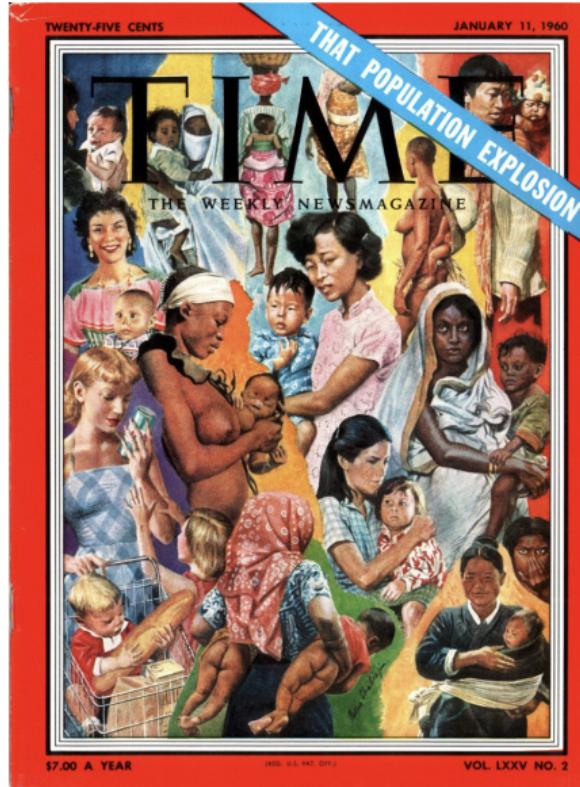
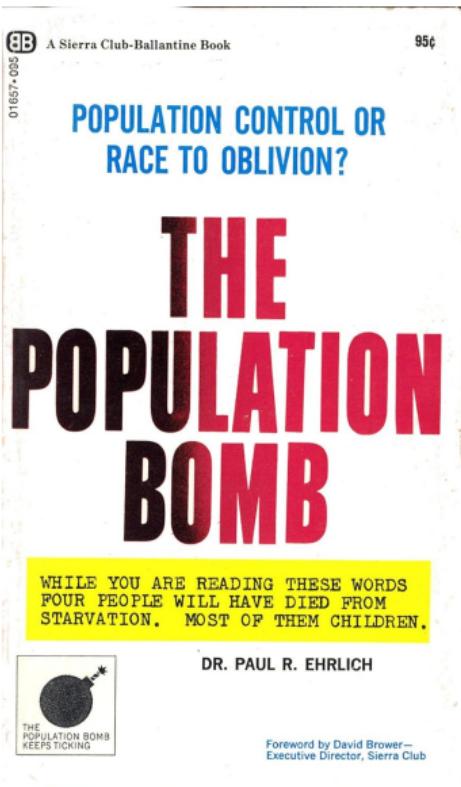
# The specter of Malthus in the 1960s



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

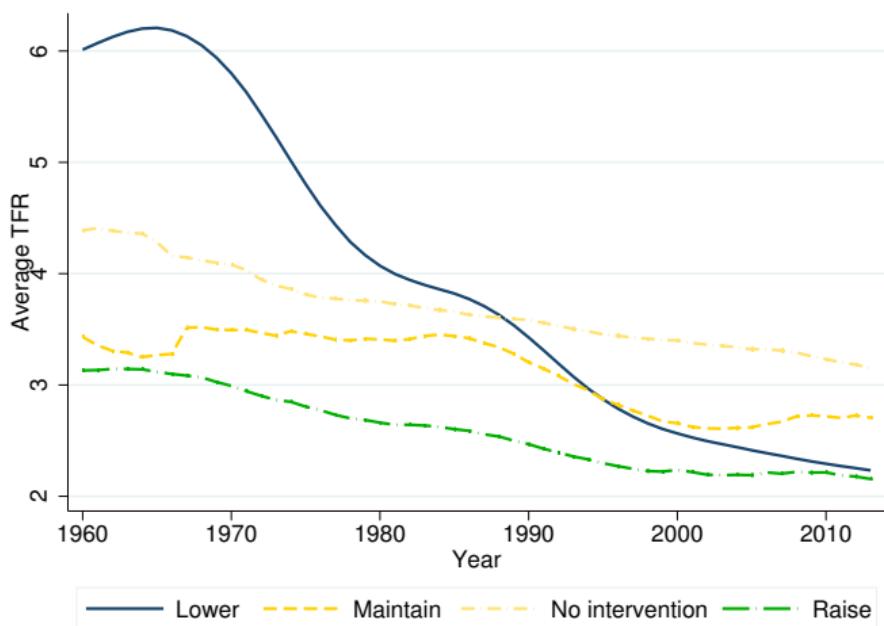
## **Population Decline Will Change the World for the Better**

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

---

By Stephanie Feldstein on May 4, 2023

# Reducing fertility feels easier



- Family planning policies played an instrumental role in explaining the rapid fertility convergence (de Silva and Tenreyro 2017)

# This paper

- Research questions
  1. Is it inherently more difficult to raise fertility than to reduce it?
  2. If so, what are the micro-foundations and macro implications?
- Addressing this question is “now or never” (Kishida 2023)
- What we do: new facts + new theory + new policy implications
  1. Empirically: establish asymmetric fertility elasticities using panel regression and cohort exposure methods
  2. Quantitatively: a dynamic model of cost minimization by the government  
⇒ under asymmetric elasticities, fertility level has large positional values
  3. Theoretically: a behavioral theory of fertility choice under loss aversion

# Literature

- 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 of fertility evolution

- Empirical evaluations of fertility policies

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

Contribution: document systematic asymmetry and its implications

- Structural models of fertility

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

Contribution: incorporate loss aversion into fertility choice

# Roadmap

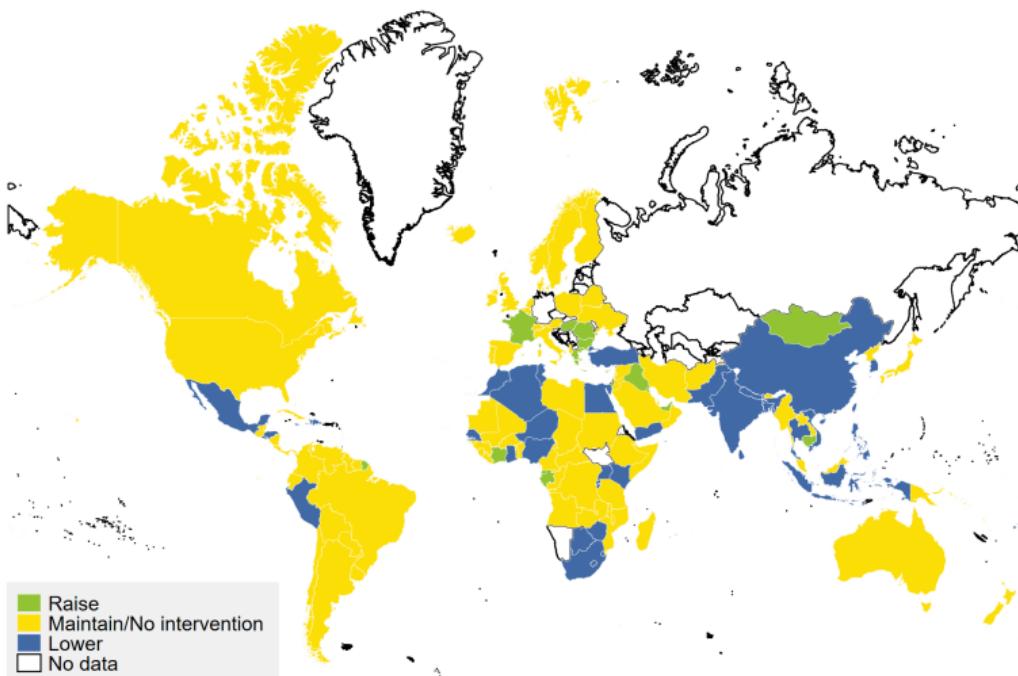
- Empirical results w/ extensive & intensive measures
- Quantitative model for macro implications
- Behavioral theory to provide micro-foundation
- Competing explanations
- Conclusion

## Empirical Analyses

# Data

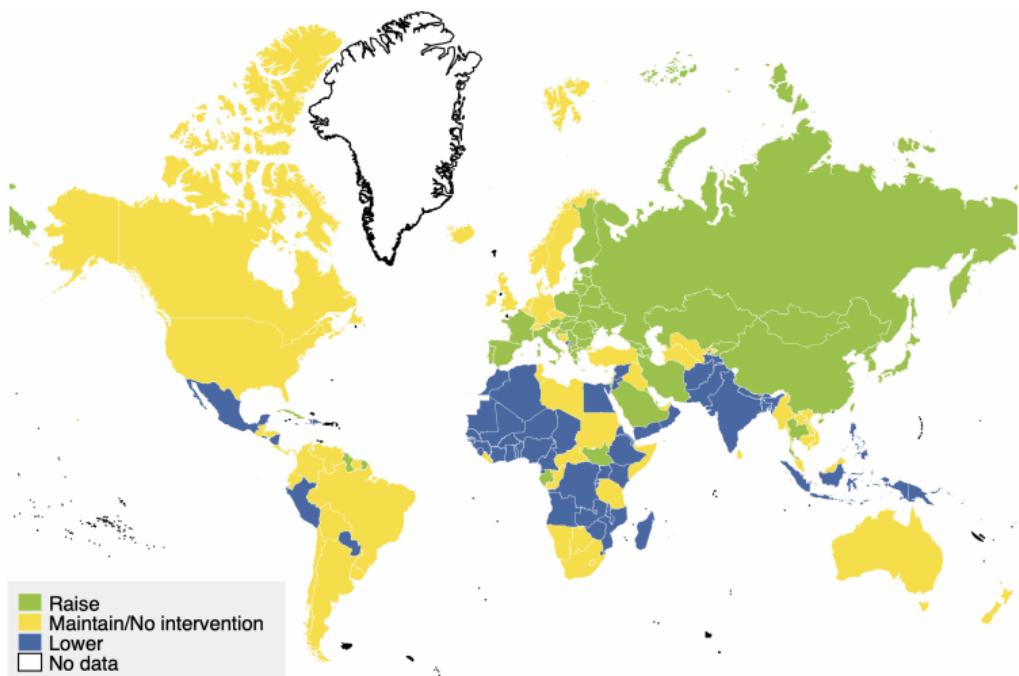
- Fertility data from the United Nations
- Policy stance dummy assigned by the UN Population Division since 1976
- Family planning expenditures from various sources following de Silva and Tenreyro (2017)
- Aggregate control variables from PWT and WDI: GDP per capita, urbanization, infant mortality, female labor force participation
- 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

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

- $\text{Control}_{it}$  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		$\Delta$ Total 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*** (0.0013)	-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

## 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*

Dependent Variable 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 <sup>2</sup>	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

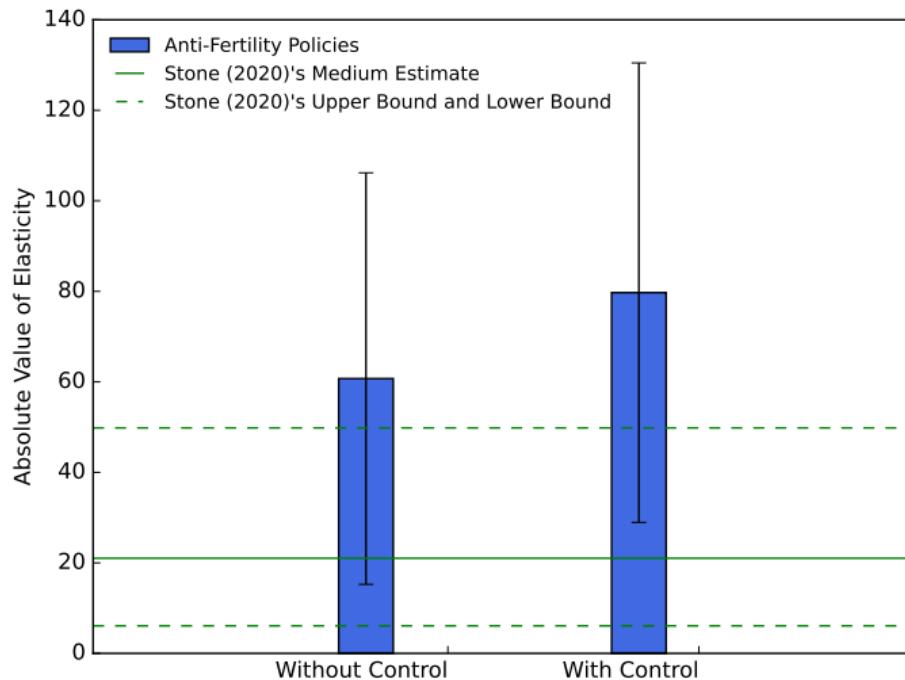
*Table 3: Elasticity Estimation for Anti-Fertility Policy*

Dependent Variable	$\Delta$ 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 consistent with de Silva and Tenreyro (2017)

# Results

- Compare with recent meta-study 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)

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

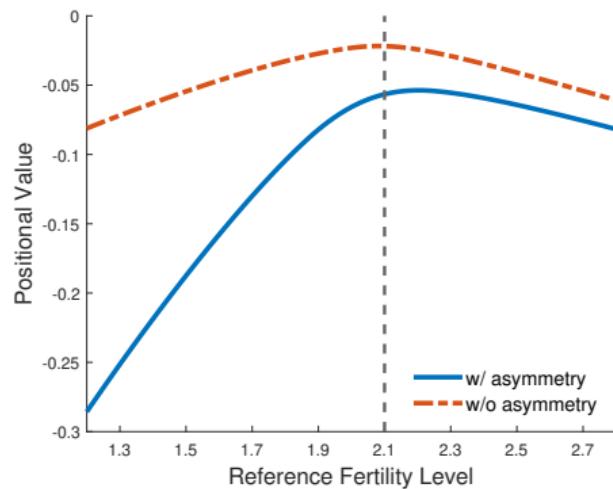
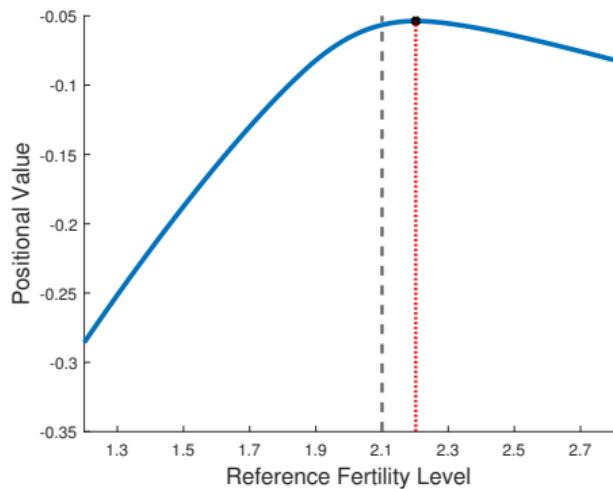
$$\epsilon \sim \mathcal{N}(0, \sigma_\epsilon^2)$$

- $\phi \in [0, 1]$  determines how long the government needs to spend to change people's reference point
- A new concept:  $\mathcal{W}(n_t^r)$  is the **positional value of fertility level** that captures the (expected) discount value of policy expenditure and social cost

# Calibration

- $\pi^+ = 0.05$  and  $\pi^- = 0.014$  (% of GDP) from empirical estimates
- $\beta = 0.96$  for an annual model
- $\bar{n} = 2.1$ : 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
- $\sigma_\epsilon \in \{0.01, 0.05, 0.1\}$

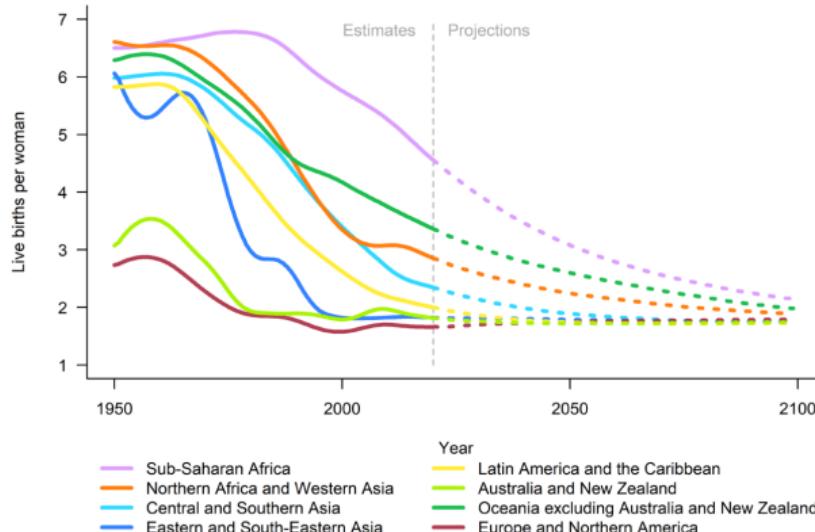
# Positional value of fertility Level



- 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  $\mathcal{W}(n)$

# U.N. projections

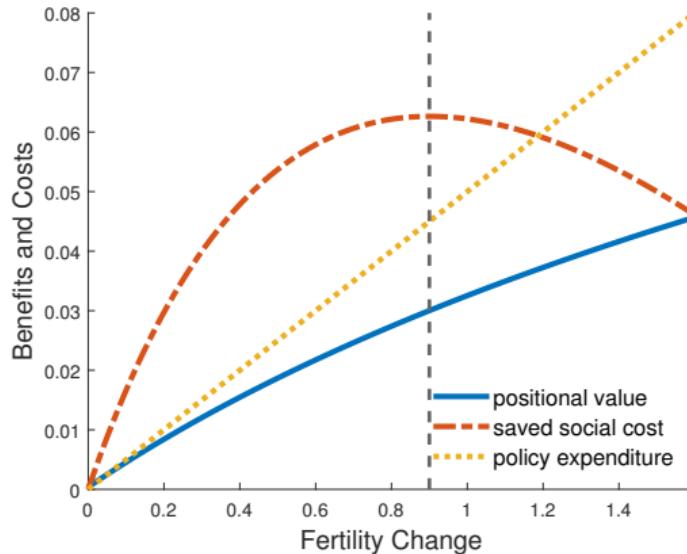
Total fertility rate by region, estimates and projections, 1950-2100



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
- The replacement rate is not a good target in the presence of asymmetry

# Benefits and costs of pro-fertility policy when $n_t^r = 1.2$



- Gains in positional value due to changing future reference  $n_{t+1}^r$
- 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
- “The sweet, sweet life of America’s DINKs” (Business Insider)



- Natural to think loss aversion would affect fertility choices

# Competing explanations

- Propagation mechanisms (e.g., peer pressure) 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

# 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

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

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

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

# 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

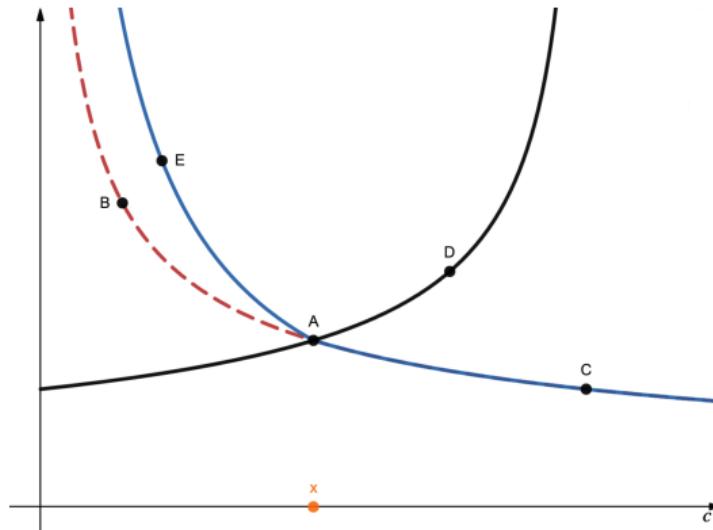
$$x = c$$

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

# Optimal choice

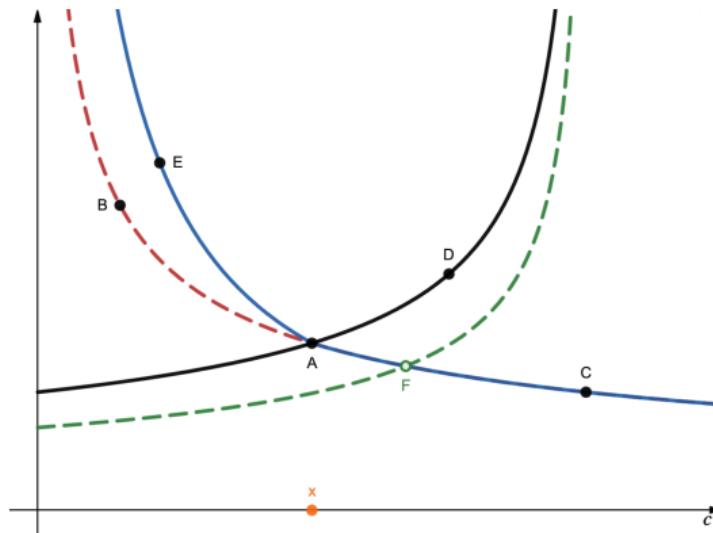
- The first-order condition of optimal consumption satisfies

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



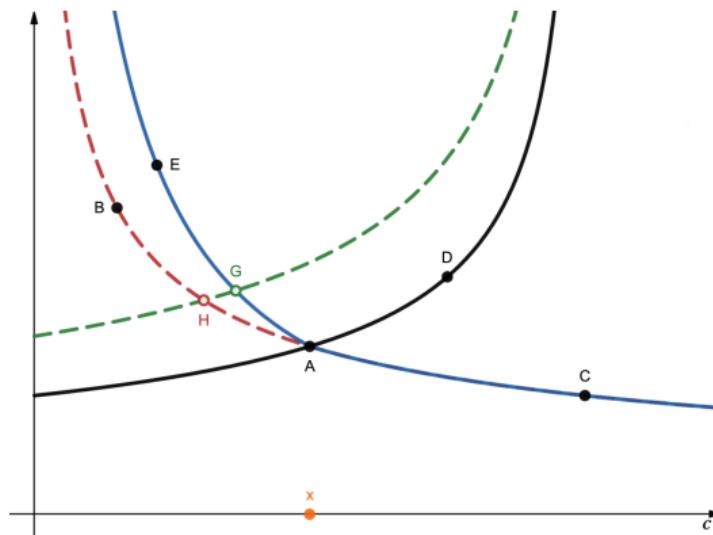
# Falling price of fertility $\chi$

- When  $\chi$  falls, optimal choices coincide with and without loss aversion



# Rising price of fertility $\chi$

- When  $\chi$  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 to study the positional value of fertility levels ⇒ a “slippery slope” perspective
3. Provide a micro-foundation using a behavioral theory of fertility choice under loss aversion

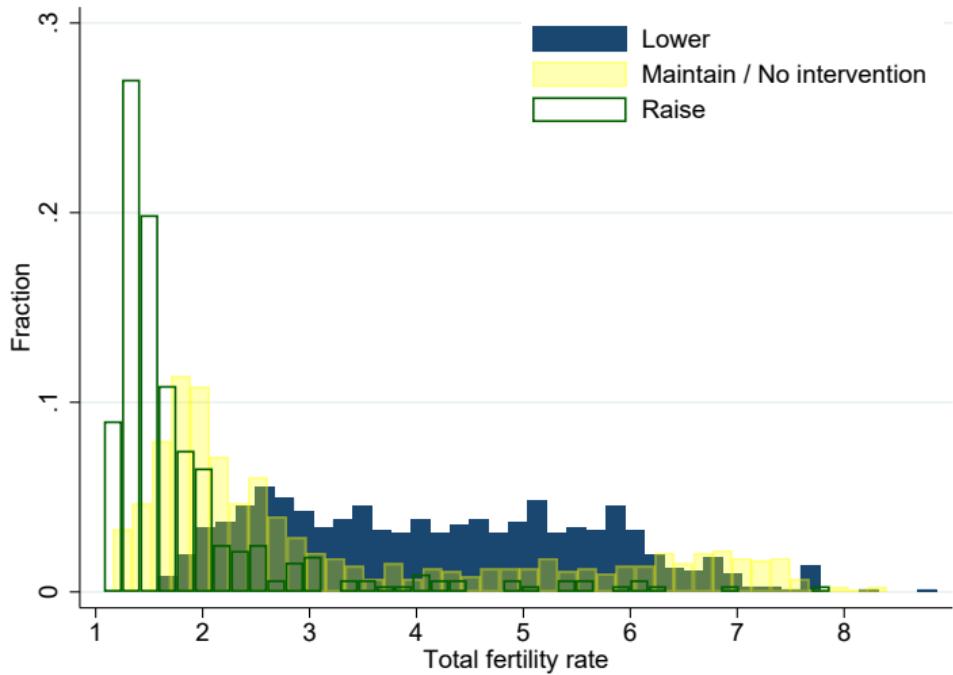
“Demographics determine the destiny of a people.”

–Lee Kuan Yew

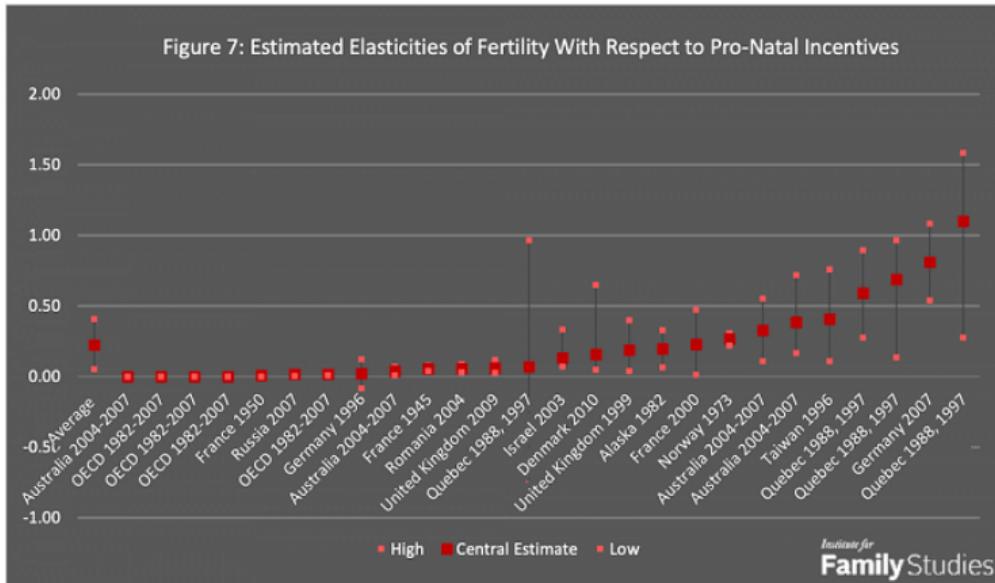
More research is needed!

## Appendix

# Fertility policy distribution



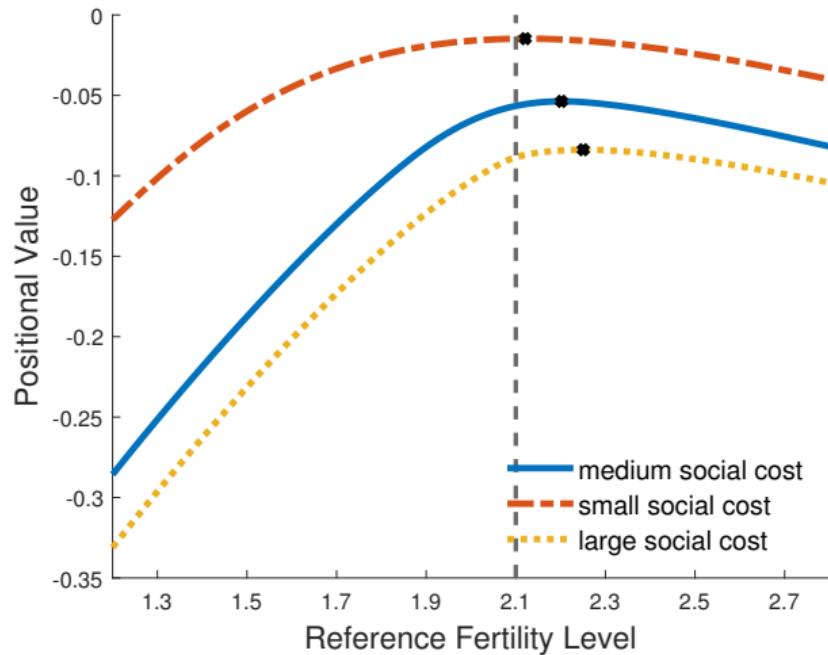
# Responses to pro-fertility policies



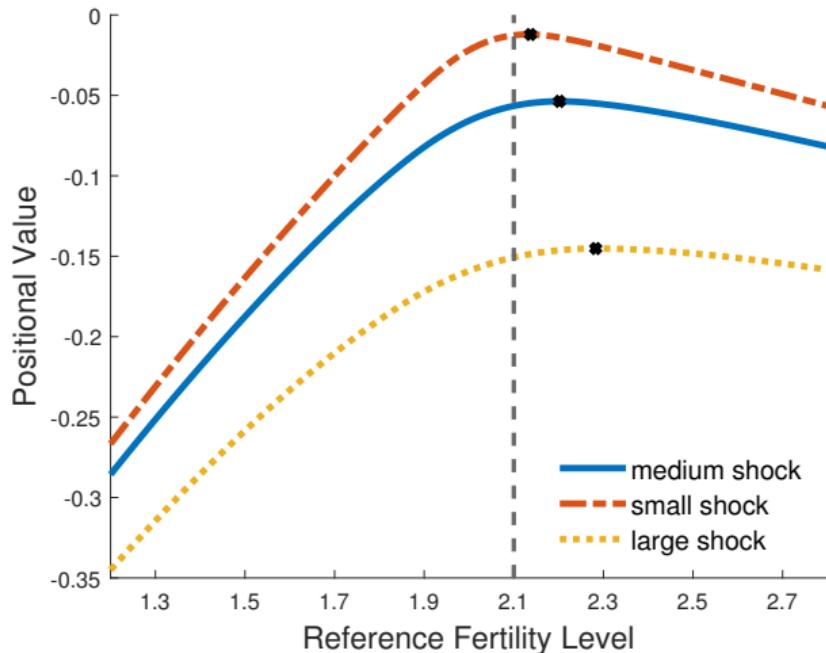
- “An increase in the present value of child benefits equal to 10% of a household’s income can be expected to produce between 0.5% and 4.1% higher birth rates.” (Stone 2020)

back

# The role of social cost $\lambda$



# The role of reference shock $\sigma_\epsilon$



# The role of reference updating speed $\phi$

