

Asymmetric Fertility Elasticities

Sam Engle Chong Pang Anson Zhou

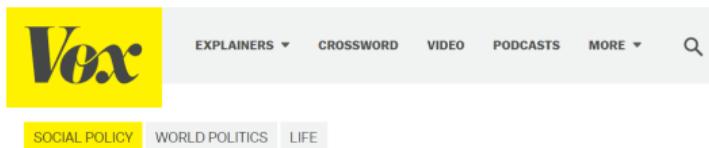
December 12, 2024

The emergence of below-replacement fertility



- Major implications for the pension system, international relations, firm dynamics, economic growth...

Boosting fertility seems to be extremely 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 the following menu items: EXPLAINERS ▾, CROSSWORD, VIDEO, PODCASTS, MORE ▾, and a magnifying glass icon for search. Below the main navigation, there are three smaller, semi-transparent buttons: SOCIAL POLICY (yellow), WORLD POLITICS (light blue), and LIFE (light green).

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

Worldwide Efforts to Reverse the Baby Shortage Are Falling Flat

Subsidized minivans, no income taxes: Countries have rolled out a range of benefits to encourage bigger families, with no luck.

34 40 min ago 9 min read

Reducing fertility seems to be easier

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

background



Did South Korea's Population Policy Work Too Well?

Romancing Singapore: When yesterday's success becomes today's challenge

Khamenei on Population Control: 'May God and History Forgive Us'

Research question

- Research questions:
 1. Is it systematically more difficult to raise fertility than to reduce it?
 2. If so, what are the micro foundation and the macro implications?
- This paper: new fact + new theory + new policy implications

This paper

1. Establish a new fact – asymmetric fertility elasticities

- Collect historical data on fertility policy stance and funding
- Compare fertility responses at the aggregate and the individual levels

2. What explains the asymmetry?

- Asymmetry challenges existing fertility theories
- **Loss aversion** explains the asymmetry and other puzzling empirical facts

3. Why does the asymmetry matter?

- A “**slippery slope**” perspective: downward pressure on fertility w/ constant economic fundamentals ⇒ new rationale for global fertility decline
- Precautionary motive to set a higher fertility rate target

4. Discuss alternative explanations

- (1) propagation, (2) technological asymmetry, (3) liquidity constraints

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

- Long-run fertility and population trajectories

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

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

- 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

Outline

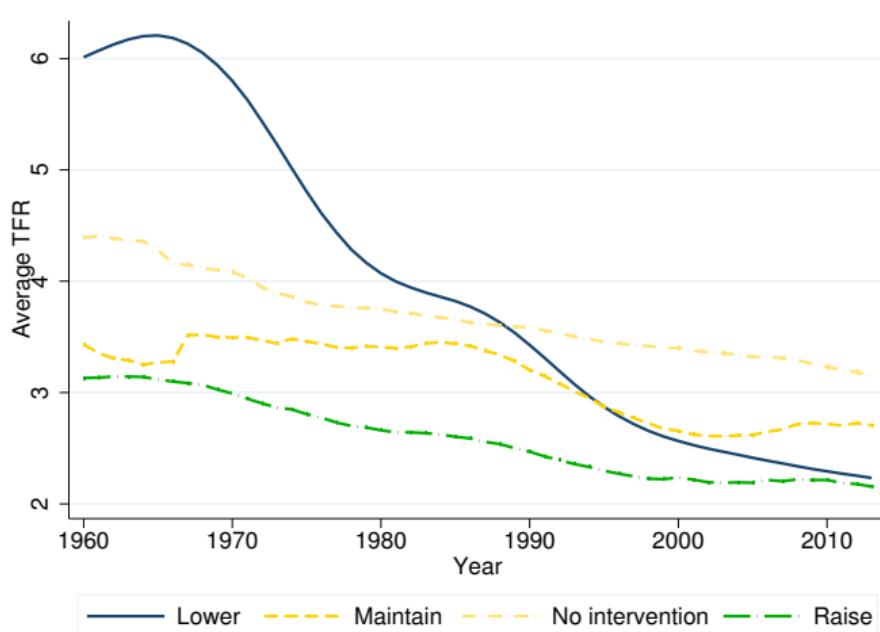
- Empirical results using
 - Aggregate & individual-level data
 - Policy direction & intensities
- A model of fertility choice under loss aversion
- The “slippery slope” perspective and its implications
- Other potential explanations
- Conclusion

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 map
- Aggregate variables from PWT, WDI, Barro and Lee (2013): GDP per capita, urbanization, infant mortality, female labor force participation, education
- 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 trends by policy stance in 1976



Fertility trends by policy stance in 1976

Panel regressions

- We estimate the following specification

$$\begin{aligned}\Delta \text{TFR}_{it}/\text{TFR}_{it-1} = & \alpha + \beta_1 \text{Policy_Lower}_{it} + \beta_2 \text{Policy_Raise}_{it} \\ & + \beta_3 \text{Control}_{it} + \sigma_i + \eta_t + \epsilon\end{aligned}\quad (1)$$

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

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

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

Fact 1: Asymmetries in panel regression coefficients

Table 1: Population Policy and TFR

Dependent Variable Construction of Policy Variables	Δ Total Fertility Rate/Lagged Fertility Rate			
	Last Year		Average in the Last Five Years	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0118*** (0.0013)	-0.0055*** (0.0016)	-0.0133*** (0.0015)	-0.0062*** (0.0021)
Raise fertility	0.0032 (0.0034)	0.0006 (0.0030)	0.0027 (0.0041)	-0.0005 (0.0036)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes
Observations	10301	7373	9545	6821
R^2	0.132	0.170	0.129	0.171

compare

Policy Implementation and Reversal

- Motivated by González and Trommlerová (2023) on Spanish child benefits
- We estimate policy effects conditional the policy stance in the last period

$$\begin{aligned}\Delta \text{TFR}_{it}/\text{TFR}_{it-1} = & \alpha + \sum_{P_1} \sum_{P_2} \beta_{P_1, P_2} \mathbb{1}(\text{Policy}_{it} = P_1) \times \mathbb{1}(\text{Policy}_{i,t-1} = P_2) \\ & + \sigma_i + \eta_t + \epsilon\end{aligned}\tag{2}$$

$P_1, P_2 \in \{\text{raise, lower, maintain/no intervention}\}$

- Compare β_{P_1, P_2} with β_{P_2, P_1} for $P_1 \neq P_2$

Fact 2: Asymmetries in policy reversal coefficients

Table 2: Asymmetric Response of Policy Implementation and Reversion

		Last Period	No Intervention/ Maintain	Lower	Raise
		This Period			
		No Intervention/ Maintain	NA	0.0028 (0.0039)	0.0006 (0.0048)
	No Intervention/ Maintain				
	Lower		-0.0094*** (0.0020)	-0.0123*** (0.0014)	-0.0105*** (0.0030)
	Raise		0.0046 (0.0057)	0.0090*** (0.0023)	0.0035 (0.0035)

Cohort exposure design

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

$$\text{Child}_{icbt} = \alpha + \beta_1 \text{Policy_Lower}_{cb} + \beta_2 \text{Policy_Raise}_{cb} + \eta \text{Age}_i \times \text{Gender}_i + \gamma_{ct} + \delta_b + \epsilon \quad (3)$$

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

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

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

Fact 3: Asymmetries in cohort exposure design

Table 3: 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 ²	0.281	0.294	0.301	0.285	0.297	0.303	0.279	0.295	0.298

- Furthermore, the degree of asymmetry increases in education/income

result

Intensive margin

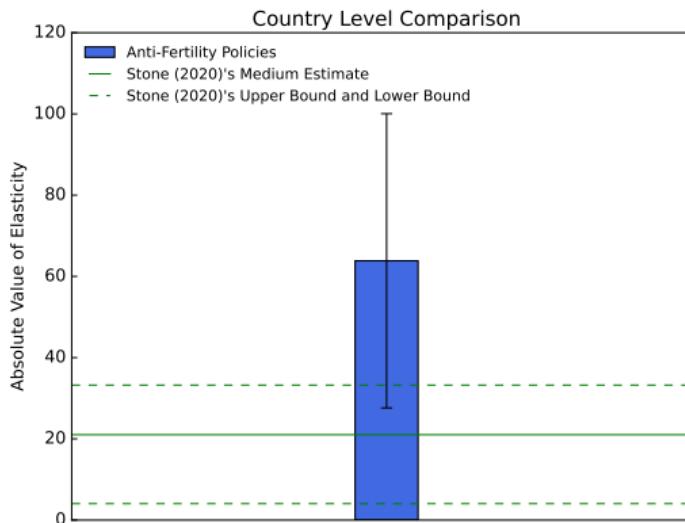
- Using data on family planning funding (de Silva and Tenreyro 2017)

Table 4: 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)
Family planning 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

Fact 4: Asymmetries in the intensive margin

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



- The median estimate of pro-fertility elasticities lies outside of the 95% confidence interval of anti-fertility elasticities

Summary of Empirical Patterns

1. Aggregate-level fertility is more responsive to anti-fertility policy stances and expenditures, including in policy implementation and reversals
2. Individual-level fertility is more responsive to anti-fertility policy stances and expenditures during the fertile window, with asymmetry being stronger for individuals with higher SES

Additionally:

- Chatterjee and Vogl (2019 AER): Fertility falls sharply in deep recessions but does not rise in rapid expansions

robust

What explains asymmetric fertility elasticities?

A behavioral model of fertility

Asymmetry challenges existing models

- Existing models of fertility choice typically look like

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

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

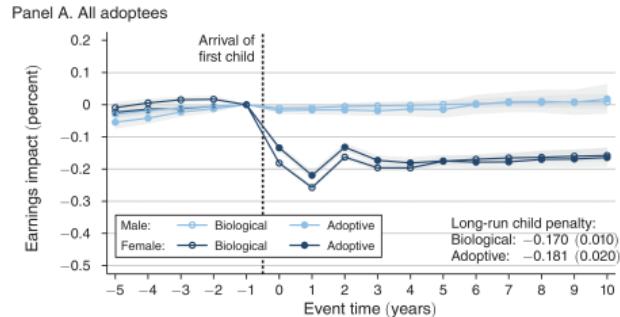
- The smoothness result holds uniformly in this class of models

- Static and dynamic problems
- Altruistic and warm glow preferences
- Continuous and discrete fertility choices
- Representative and heterogeneous agents
- With and without 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?

- Having a child often implies sacrificing some other aspects of life (e.g., lifestyle of DINK, the child penalty)



- WSJ: "In New Orleans, 42-year-old Beth Davis epitomizes some millennials' new views. 'I wouldn't mess up the dynamic in my life right now for anything, especially someone that is 100% dependent on me,' she says."

A Behavioral Theory of Fertility Choice

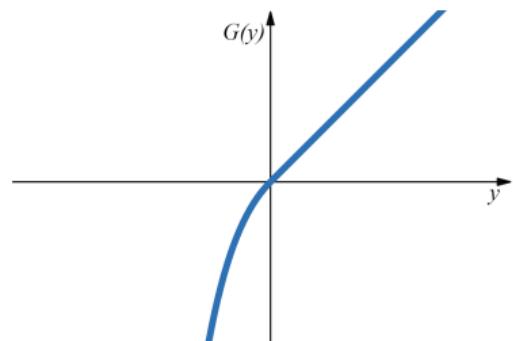
- Conditional on r , households solve

$$\max_{c,n} \quad \frac{1}{2}[u(c) + \beta u(n)] + \frac{1}{2}[G(u(c) - u(r)) + u(r)]$$

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

- Loss aversion when $\alpha > 0$

$$G(y) = \begin{cases} y & y \geq 0 \\ y - \alpha y^2 & y < 0 \end{cases}$$



- Consistency: $r = c$ in equilibrium with RA
- Results robust to c being a composite good

Result

- **Proposition 1:** When $\alpha > 0$, the optimal fertility response to an increase in χ is larger than the optimal response to a decrease in χ

$$\frac{\partial \log n^*}{\partial \log \chi} \Big|_{+, \alpha > 0} < \frac{\partial \log n^*}{\partial \log \chi} \Big|_{-, \alpha > 0} < 0 \quad (4)$$

which explains our empirical findings

- **Proposition 2:** When $\alpha > 0$, the optimal fertility response to an increase in r is larger than the optimal response to a decrease in r

$$\frac{\partial \log n^*}{\partial \log r} \Big|_{+, \alpha > 0} < \frac{\partial \log n^*}{\partial \log r} \Big|_{-, \alpha > 0} = 0 \quad (5)$$

Result

- **Proposition 3:** When $\alpha > 0$, the optimal fertility response to a decrease in I is larger than the optimal response to a increase in I

$$\frac{\partial \log n^*}{\partial \log I} \Big|_{-, \alpha > 0} < \frac{\partial \log n^*}{\partial \log I} \Big|_{+, \alpha > 0} < 0 \quad (6)$$

which explains the finding in Chatterjee and Vogl (2019 AER)

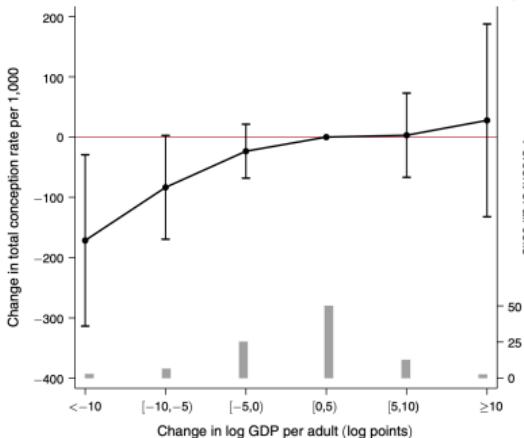


FIGURE 5. NON LINEAR SHORT-RUN ESTIMATES

Why do asymmetry fertility elasticities matter?

The “slippery slope” perspective

Dynamic environment

- In period t , fertile households takes r_t as given and choose $\{c_t(r_t), n_t(r_t)\}$
- Adaptive reference updating process

$$r_t = \phi \cdot r_{t-1} + (1 - \phi) \cdot c_{t-1} + \epsilon_t \quad \epsilon_t \sim \mathcal{N}(0, \sigma^2) \quad (7)$$

- Formalizes the “relative status” in the Easterlin hypothesis
- ϕ is the persistence of past reference:
 - $\phi = 1$: random walk of r_t
 - $\phi = 0$: immediate updating $r_t = c_{t-1}$
- **The “slippery slope” perspective:** Starting from any consistent reference level r_0 , the expected fertility $\mathbb{E}_0(n_t)$ declines with time while the expected consumption $\mathbb{E}_0(c_t)$ and reference level $\mathbb{E}_0(r_t)$ rises with time.

Calibration

- Proof is simple for

1. $\phi = 1$: r_t is a random walk $\implies \mathbb{E}(x_t) = x_0$ for $x \in \{r, c, n\}$
2. $\phi = 0$: due to the asymmetric responses to r in Proposition 2

$$\begin{cases} c_t > c_{t-1} & \text{when } \epsilon_t > 0 \\ c_t = c_{t-1} & \text{when } \epsilon_t \leq 0 \end{cases}$$

- $\phi \in (0, 1)$: proof in paper. Illustration based on calibration:

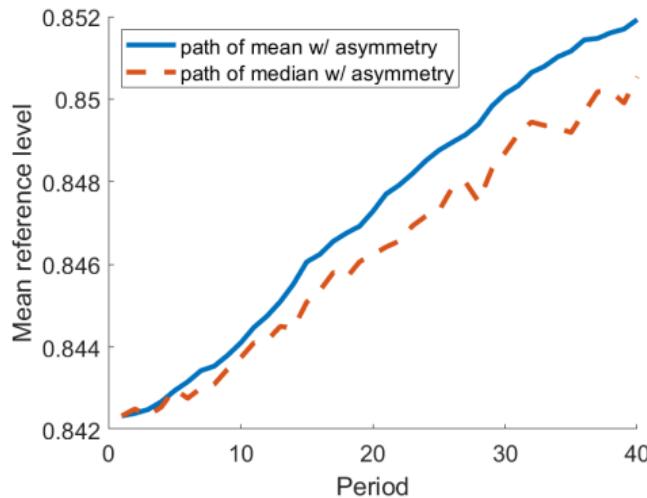
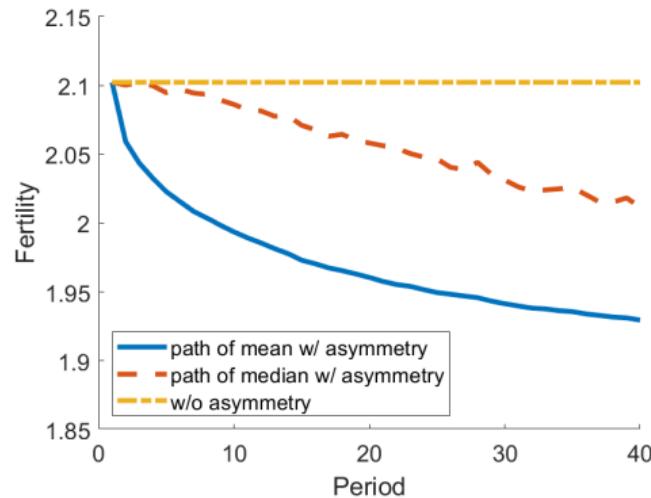
→ $\chi = 0.075$ from Greenwood and Seshadri (2002)

→ $\beta = 34$ to generate $n^* = 2.1$

→ $\gamma = 5.9$ and $\alpha = 98$ to generate pro-fertility elasticity and the degree of asymmetry in the data

→ $\phi = 0.95$ and $\sigma = 0.01$ to illustrate the idea

The “slippery slope”



- Fertility rate slides without changes in the underlying economic fundamentals \Rightarrow different mechanism from existing theories
- Explanation for the puzzling fall in fertility since 2010 (Kearney et al. 2022)

Government problem

- Present a simple case to highlight the policy implications
- The policymaker faces social costs from population externalities

$$\mathcal{S}(n_t | \bar{n}) = \lambda \cdot (\log(n_t) - \log(\bar{n}))^2 \quad (8)$$

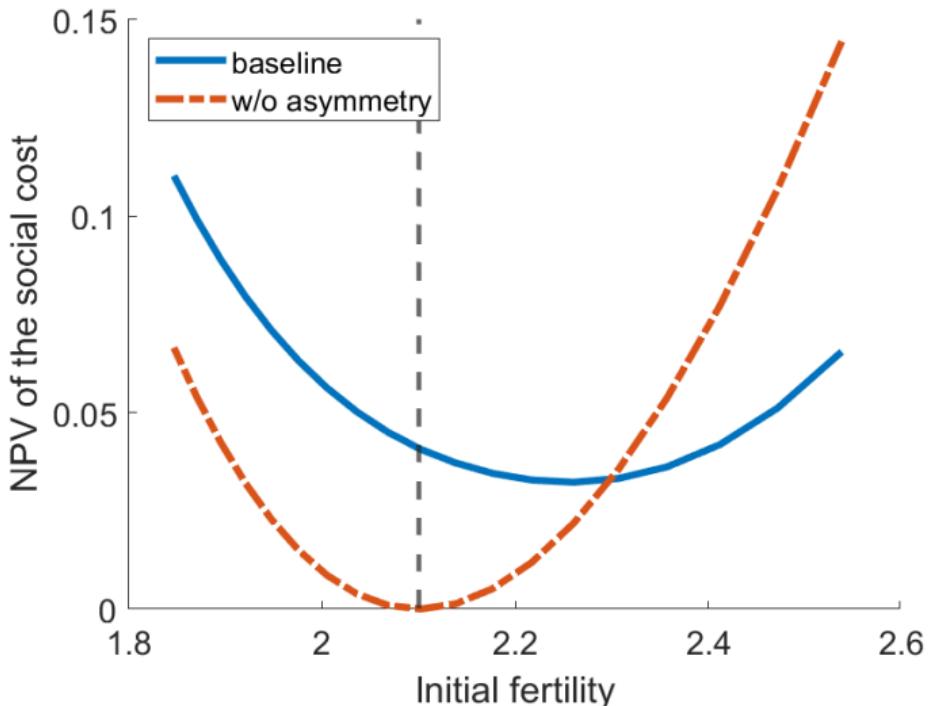
- Suppose the policymaker chooses n_0 (w/ consistent r_0) by permanently changing χ and solves

$$\min_{n_0} \mathbb{E}_0 \sum_{t=0}^{\infty} \rho^t \mathcal{S}(n_t | \bar{n}) \quad (9)$$

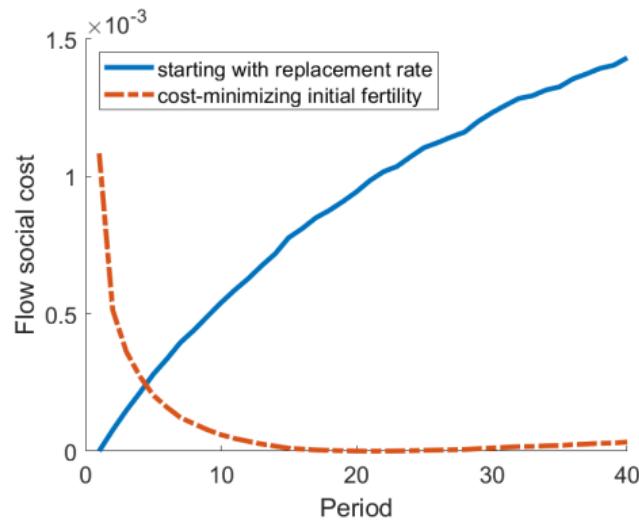
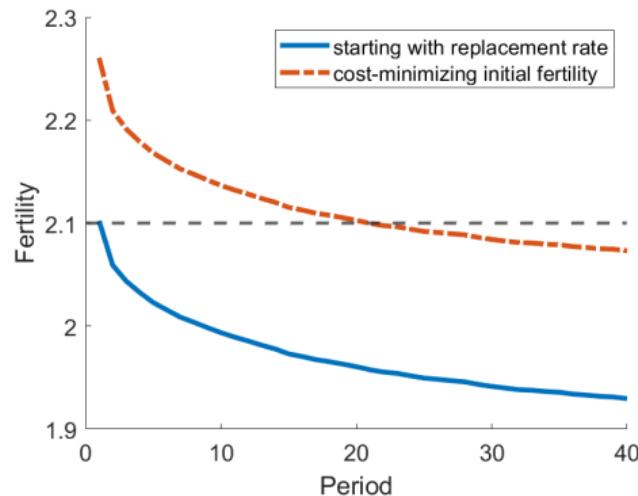
where n_t are optimizing choices by households

- **Question:** What is the level of n_0 that minimizes the expected social cost?
- Set $\bar{n} = 2.1, \lambda = 0.2 \implies n_{\text{U.S. 2022}} = 1.62$ generates $\mathcal{S} = 0.62\%$ of GDP

Cost-minimizing initial fertility



Evolution of fertility and social cost



- When $\rho > 0$, there is an **intertemporal tradeoff** of social costs

Policy implications

- **Implication 1:** Unless the discount factor is zero, choosing the replacement rate as the initial level of fertility is never cost-minimizing
 - ⇒ One can always find a path that dominates $n_0 = \bar{n}$ in expectation
 - ⇒ a **precautionary motive** of higher fertility rate target
- **Implication 2:** To maintain n_0 , policy effort needs to increase in time
- **Implication 3:** The cost-minimizing initial fertility level depends on the degree of asymmetry, the reference updating process, and the social discount factor
 - ⇒ More intricate than the traditional approach of “getting it close to \bar{n} ”

Alternatives

	Loss Aversion	Propagation	Tech. asym.	Constraints
Empirical findings				
Asym. responses to policies	Yes	No	Yes	Yes
Asym. responses to policy reversal	Yes	No	No	No
Asym. responses to income shocks	Yes	No	No	Yes
Implications				
“Slippery slope” perspective	Yes	No	No	Yes
Precautionary high fertility	Yes	Yes	Yes	Yes

more

Conclusion

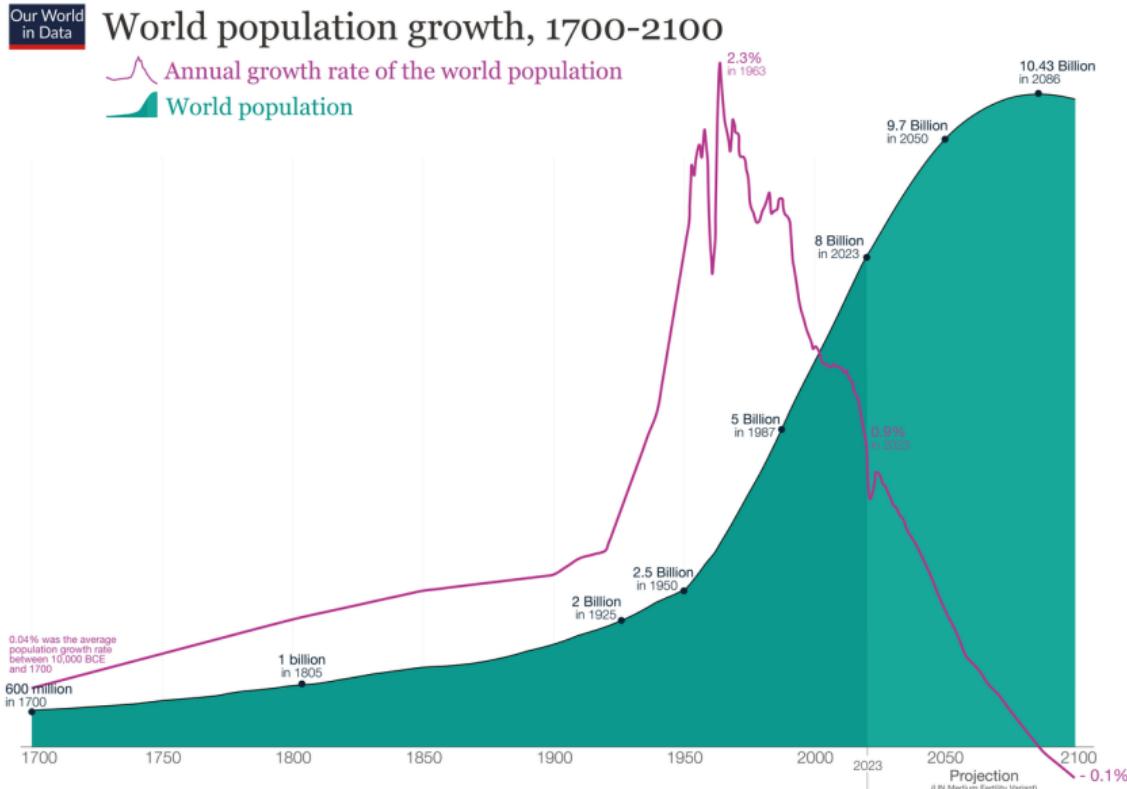
1. Document asymmetric fertility responses to fertility policies
2. Fertility choice under loss aversion explains this fact, and it *additionally* matches empirical findings by other papers:
 - Asymmetric responses to income shocks
 - Fertility decline in the absence of changing fundamentals
3. The “slippery slope” perspective offers new implications

“Demographics determine the destiny of a people.”

–Lee Kuan Yew

Appendix

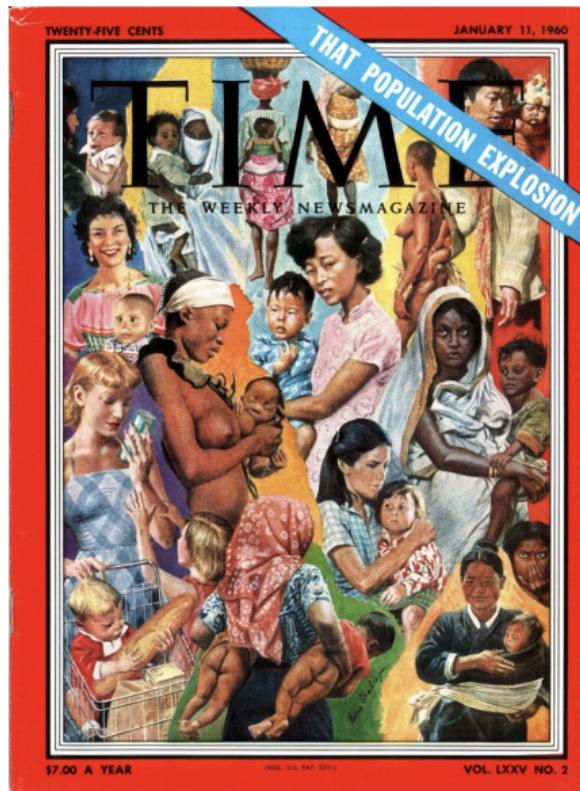
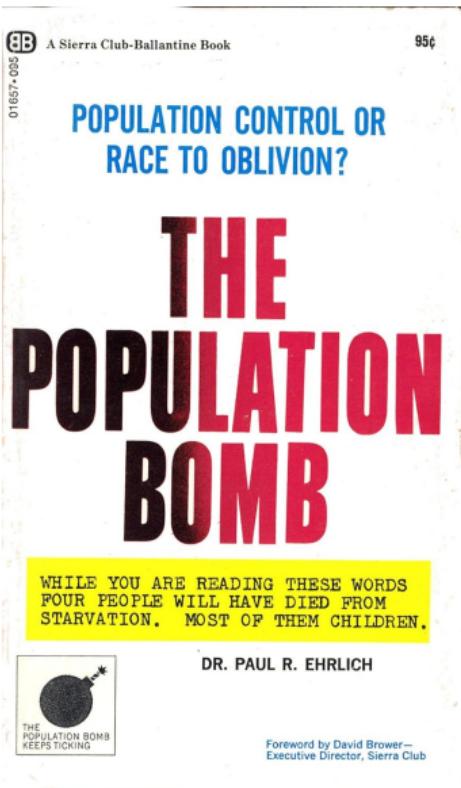
The specter of Malthus in the 1960s



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

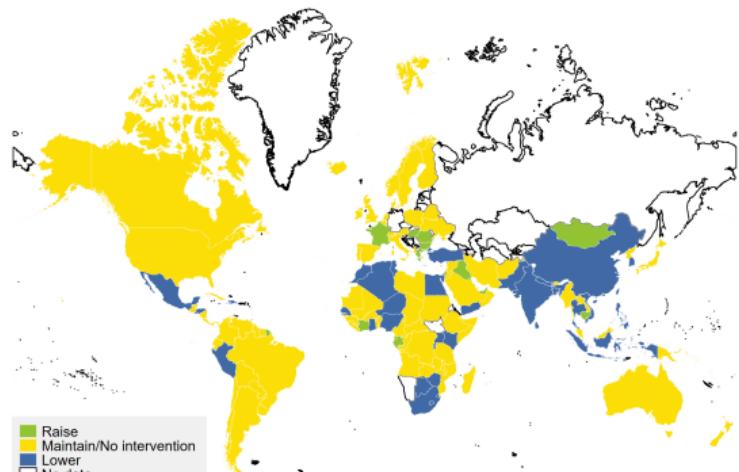


The global family planning movement

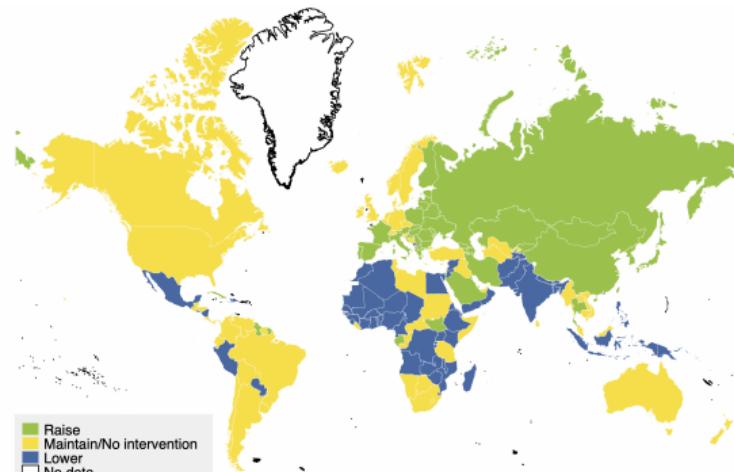
- Led by global organizations such as the United Nations, the World Bank, USAID, and Bill & Melinda Gates Foundation
- \$4.2 billion spent across low- & lower-middle-income countries in 2021
- Many country-specific policies (e.g., the one-child-policy in China)
- Gradually attaches more benefits to low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

back

Fertility policy in 1986 and 2021



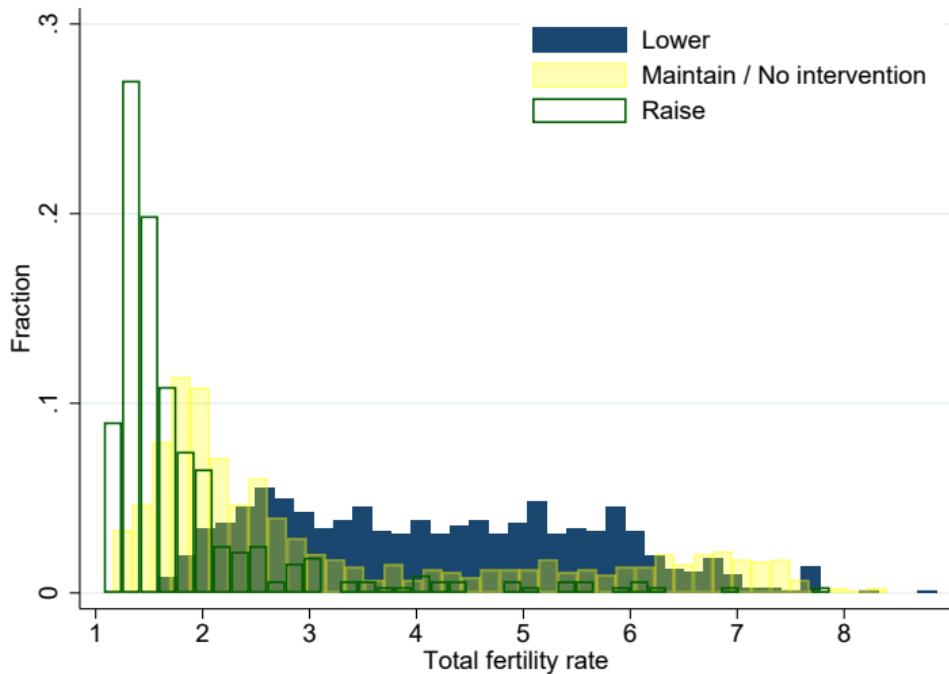
Source: United Nations Population Division



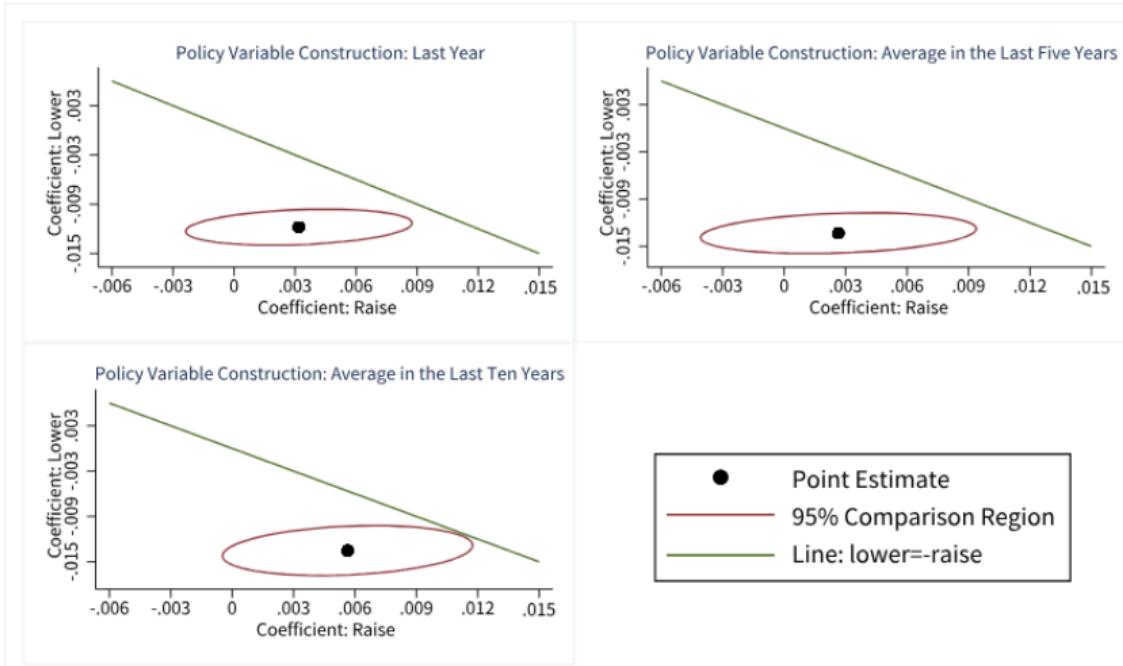
Source: United Nations Population Division

[back](#) [distribution](#)

Fertility policy distribution



The sum of coefficients is significantly negative



- Wald test-based comparison regions for simultaneous inference for two parameters (Eckert and Vach 2020)

back

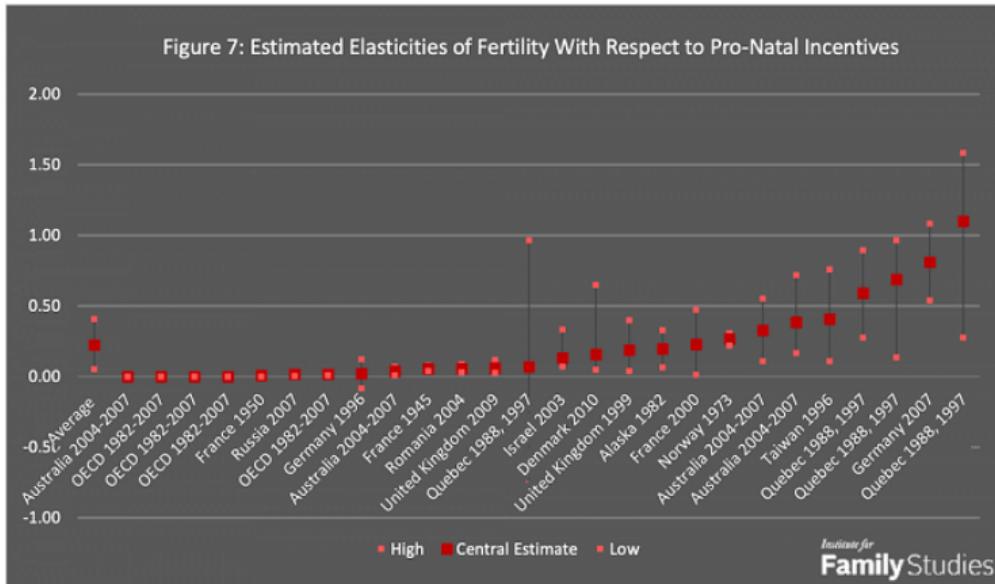
Heterogeneity by Income

Table 5: Heterogeneity by Income

Dependent Variable Interpolation of MAC	ΔTotal Fertility Rate/Lagged Fertility Rate		
	Country-Specific Year Polynomial	Nearest Neighbor	Socioeconomic Variables
	(1)	(2)	(3)
Lower fertility#Income	-0.153*** (0.0233)	-0.166*** (0.0269)	-0.166*** (0.0274)
Lower fertility	-0.0563 (0.258)	-0.0880 (0.258)	-0.0425 (0.302)
Raise fertility#Income	-0.0842** (0.0353)	-0.0877** (0.0360)	-0.0891** (0.0375)
Raise fertility	0.706*** (0.249)	0.610** (0.250)	0.734** (0.285)
Baseline Controls	Yes	Yes	Yes
Observations	192565	214856	195463
R^2	0.278	0.282	0.276

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

Robustness

- Empirical finding is robust to
 1. Policy effects at different horizons
 2. Controlling for past fertility to mitigate reverse causality
 3. Split sample by initial fertility and GDP per capita
 4. Evaluate the cumulative contributions of policies to fertility changes for specific countries and compare with existing studies

back

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

back

Control for past fertility

Table 6: Population Policy and TFR: Control Average TFR in the Last Five Years

Dependent Variable Construction of Policy Variables	Δ Total Fertility Rate/Lagged Fertility Rate			
	Last Year		Average in the Last Five Years	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0121*** (0.0014)	-0.0065*** (0.0015)	-0.0134*** (0.0016)	-0.0070*** (0.0017)
Raise fertility	0.0031 (0.0037)	0.0013 (0.0033)	0.0033 (0.0043)	0.0009 (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

back

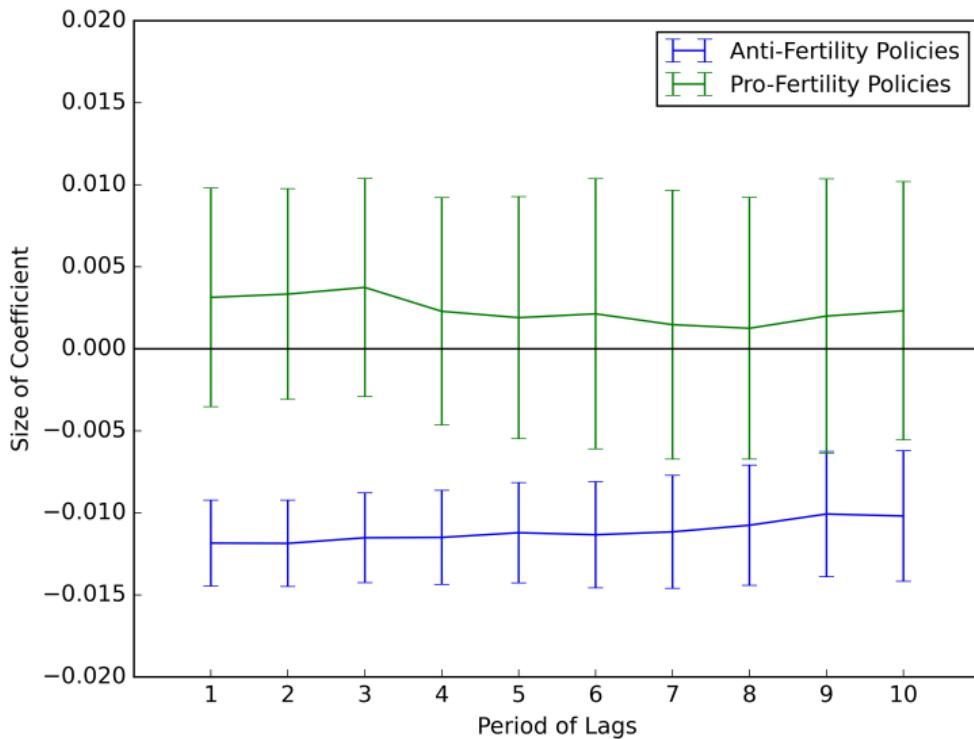
Split samples

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*** (0.0014)	-0.0056*** (0.0014)	-0.0080*** (0.0018)	-0.0057*** (0.0018)
Raise fertility	0.0003 (0.0034)	0.0005 (0.0055)	0.0009 (0.0062)	0.0007 (0.0056)
Observations	5936	5247	5936	5247
R ²	0.339	0.390	0.337	0.388

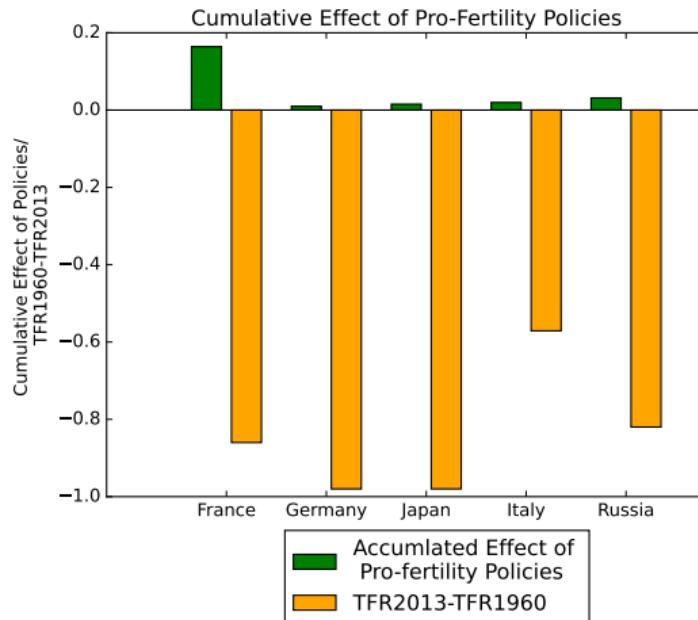
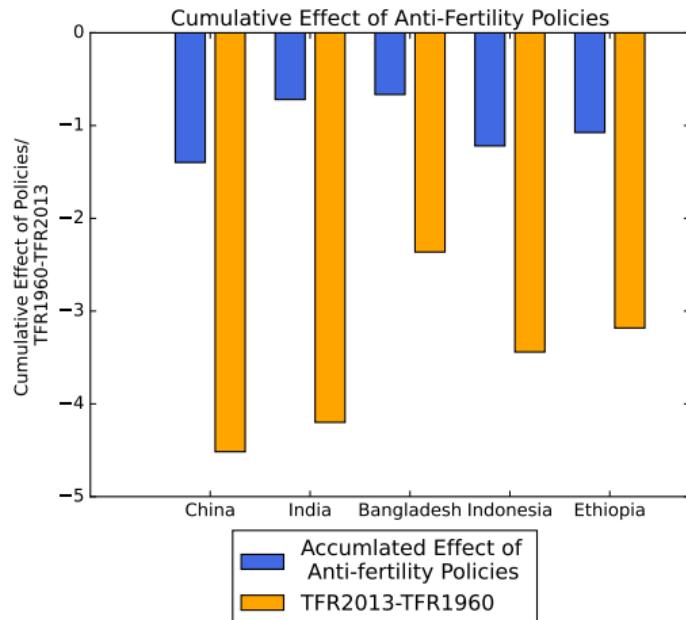
Panel B: Subsample with Low TFR in 1960				
Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate			
Construction of Policy Variables	Last Year		Average in the Last Five Years	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0150** (0.0028)	-0.0117** (0.0049)	-0.0151*** (0.0023)	-0.0117** (0.0047)
Raise fertility	0.0016 (0.0038)	0.0030 (0.0037)	0.0024 (0.0044)	0.0038 (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

back

Different horizons



Cumulative effects

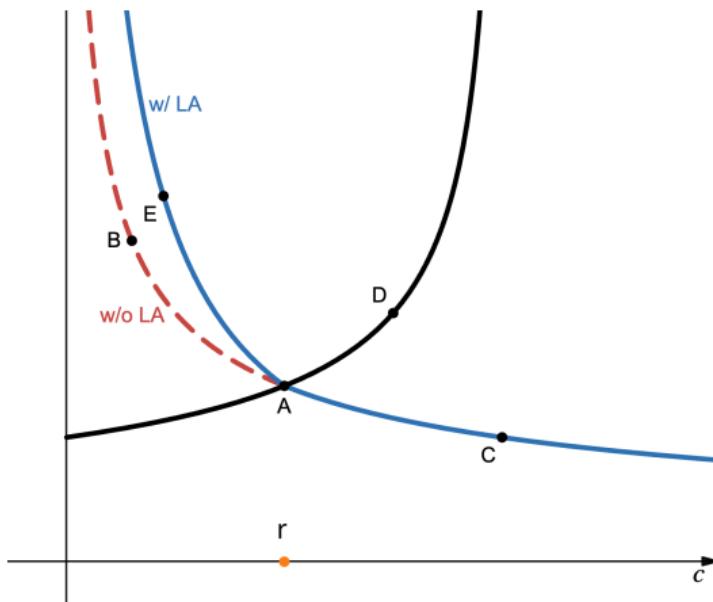


back

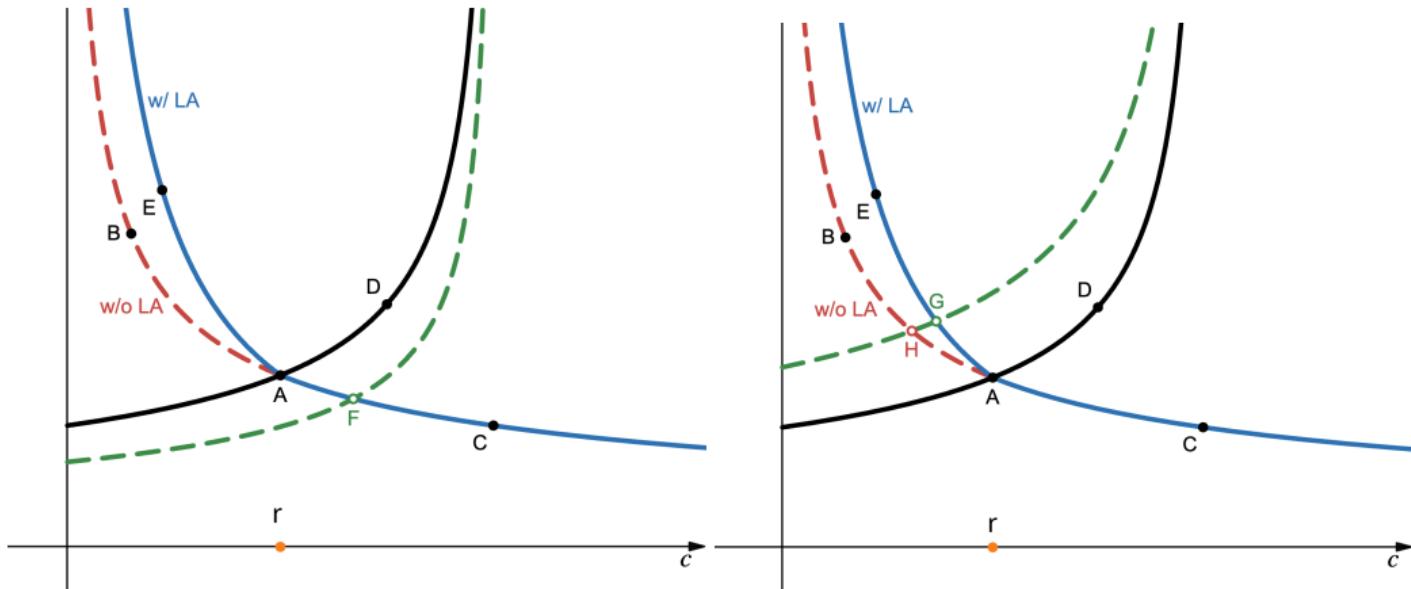
First-order condition

- The first-order condition of optimal consumption satisfies

$$u'(c) \cdot (1 + G'(u(c) - u(r))) = \frac{\beta}{\chi} \cdot u' \left(\frac{I - c}{\chi} \right)$$



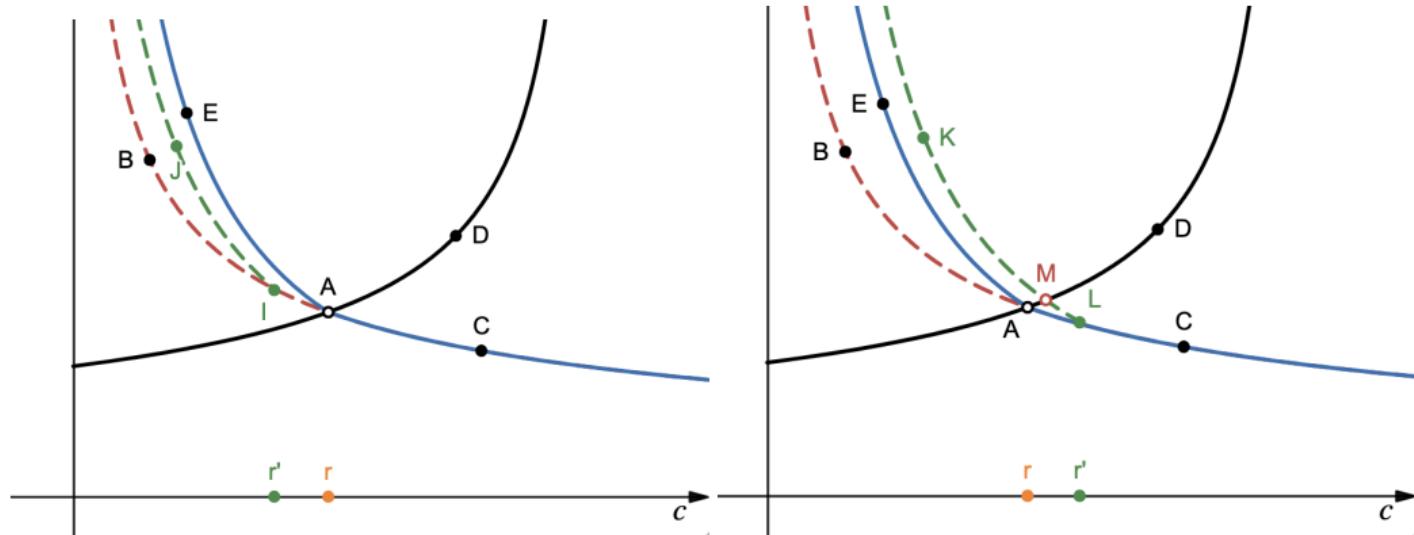
Asymmetry in χ



- Comparative static when χ falls (left) or rises (right)

back

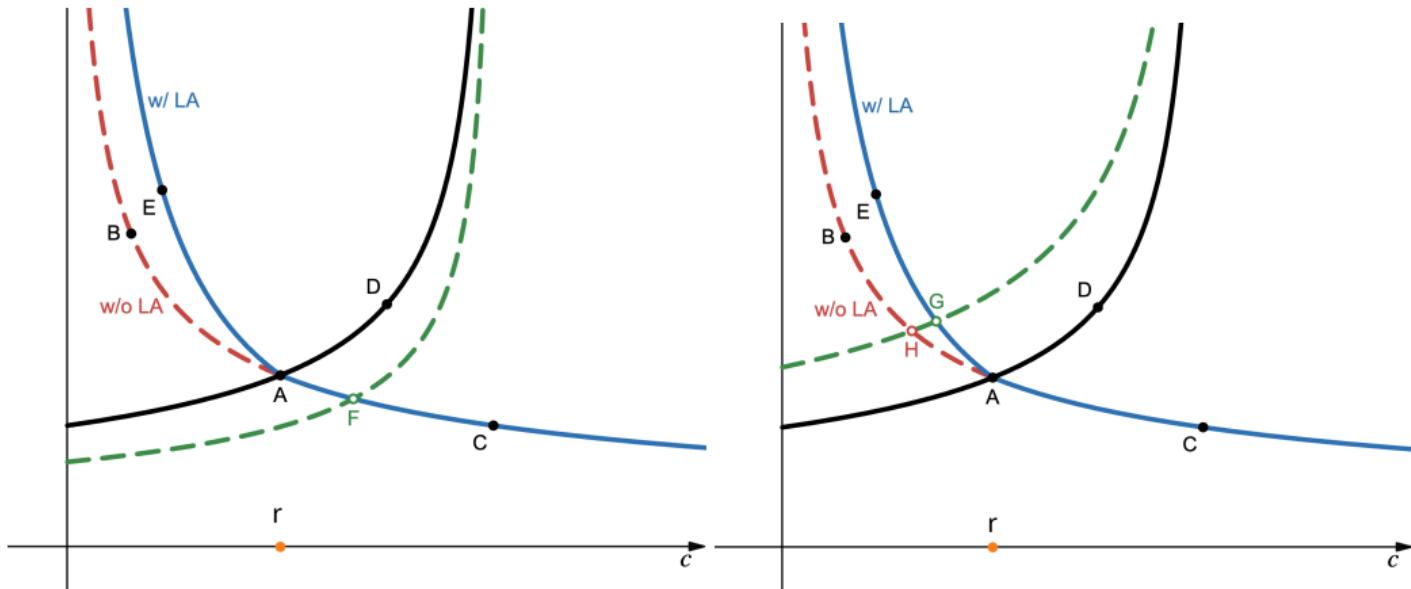
Asymmetry in r



- Comparative static when r falls (left) or rises (right)

back

Asymmetry in I



- Comparative static when I rises (left) or falls (right)

back