

Asymmetric Fertility Elasticities

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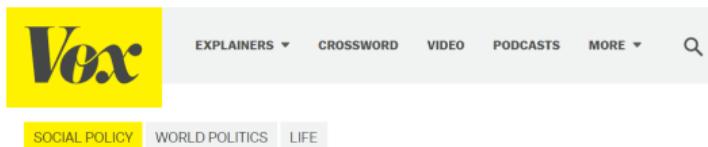
UC San Diego

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



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

Research Questions:

- Do fertility responds more to anti-fertility policies than pro-fertility ones?
- What could be the micro-foundation and what are the macro implications?

This paper

1. Motivating facts:
 - Stronger fertility responses to anti-fertility policy regimes and expenditures
 - Asymmetry challenges existing models ⇒ need a kink in fertility demand
2. A theory of fertility choice with reference-dependent preferences:
 - Explains the asymmetry and other important empirical regularities
 - Generates a “slippery slope” perspective: fertility could decline without changing economic fundamentals
 - Policy implications: precautionary motives to set a higher fertility rate target
3. Examine 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)
- Structural models of fertility
Barro and Becker (1989), de la Croix and Doepke (2004), Córdoba and Ripoll (2019), Kim, Tertilt, and Yum (2024)
- 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)

Motivating Facts

Data

- Fertility level and policy regime data from the United Nations
 - Policy regime dummy assigned by the UN Population Division since 1976 - lower, raise, maintain, no intervention
- Family planning funding from de Silva and Tenreyro (2017)
- Aggregate variables from PWT, WDI, Barro and Lee (2013): GDP per capita, urbanization, infant mortality, female labor force participation, education
⇒ panel regression for aggregate-level responses
- Individual-level data on fertility, education, and income from the World Value Survey (WVS) Database
⇒ cohort exposure design for individual-level responses

trend map

Panel regression

- 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

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

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

Asymmetries at the aggregate level

Table 1: Population Policy and TFR

Dependent Variable Construction of Policy Variables	ΔTotal 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

Cohort exposure design

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

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

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

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

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

Asymmetries at the individual level

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 ²	0.281	0.294	0.301	0.285	0.297	0.303	0.279	0.295	0.298

- Results mostly explained by changes in high-order births
- The degree of asymmetry increases in education/income

Intensive margin: -ve elasticity

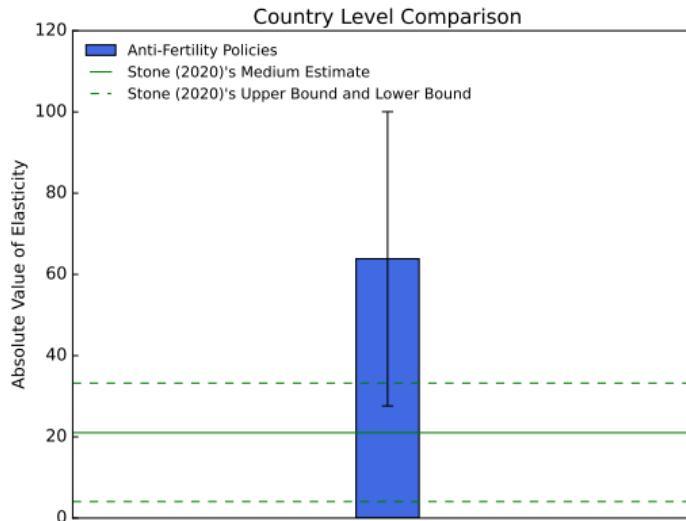
- Using data on family planning funding (de Silva and Tenreyro 2017)

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)
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

Asymmetries to expenditures

- 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

Taking Stock

1. Aggregate fertility responds more to anti-fertility policy regimes and expenditure/GDP ratios
2. Individual fertility responds more to anti-fertility policy regimes during the fertile window + stronger asymmetry for individuals with higher SES

Interpret together with three other findings in the literature:

1. Chatterjee and Vogl (2019): Fertility falls sharply in deep recessions but does not rise in rapid expansions, i.e., short-run asymmetries
2. González and Trommlerová (2023): When a pro-fertility policy was reversed, fertility fell below the level when the policy was implemented
3. Kearney et al. (2022): Puzzling decline in fertility w/o corresponding changes in economic fundamentals

Asymmetry challenges canonical models

- Most 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 $n(\chi, I, \dots)$

- The smoothness result holds uniformly in a 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 w/ asymmetric elasticities $\underbrace{\frac{\partial n}{\partial \chi}}_+ > \underbrace{\frac{\partial n}{\partial \chi}}_-$, $\underbrace{\frac{\partial n}{\partial I}}_- > \underbrace{\frac{\partial n}{\partial I}}_+$

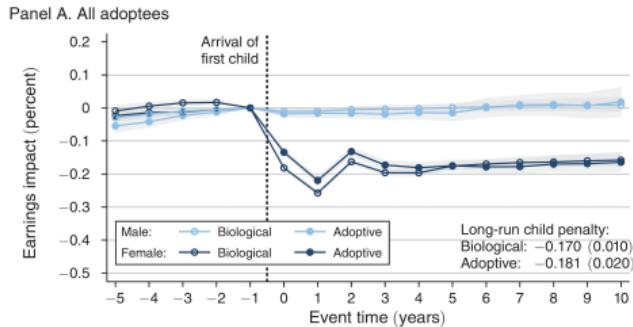
this paper

Chatterjee and Vogl (2019)

A new model of fertility choice

Why reference dependence?

- **Intuition:** having a child often implies sacrificing some other aspects of life upon which people could anchor their preferences



- 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."

Model

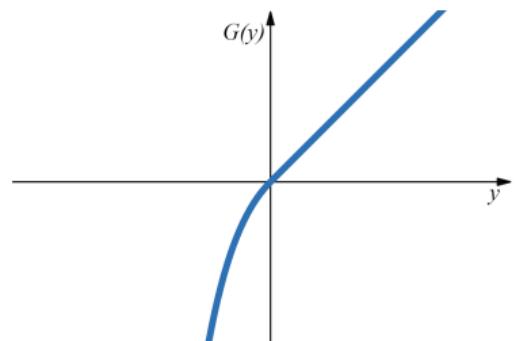
- Conditional on reference r , solve

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

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

- 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 static model with RA
- c is interpreted as composite good

Result

- **Proposition 1:** Holding r unchanged, the optimal fertility response to an increase in χ is larger than the optimal response to a decrease in χ

$$\frac{\partial \log n^*}{\partial \log \chi} \Big|_{+, \alpha > 0} < \frac{\partial \log n^*}{\partial \log \chi} \Big|_{-, \alpha > 0} < 0 \quad (3)$$

which explains our empirical findings

- **Proposition 2:** Holding r unchanged, the optimal fertility response to a decrease in I is larger than the optimal response to an increase in I

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

which explains the finding in Chatterjee and Vogl (2019)

Dynamic extension

- In period t , fertile households takes r_t as given and choose $\{c_t(r_t), n_t(r_t)\}$
- Endogenous formation of the reference point

$$r_t = \phi \cdot r_{t-1} + (1 - \phi) \cdot c_{t-1} + \epsilon_t \quad \epsilon_t \sim \mathcal{N}(0, \sigma^2) \quad (5)$$

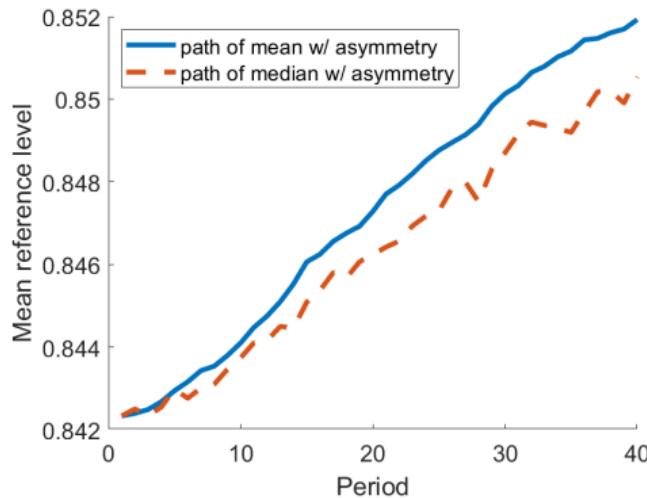
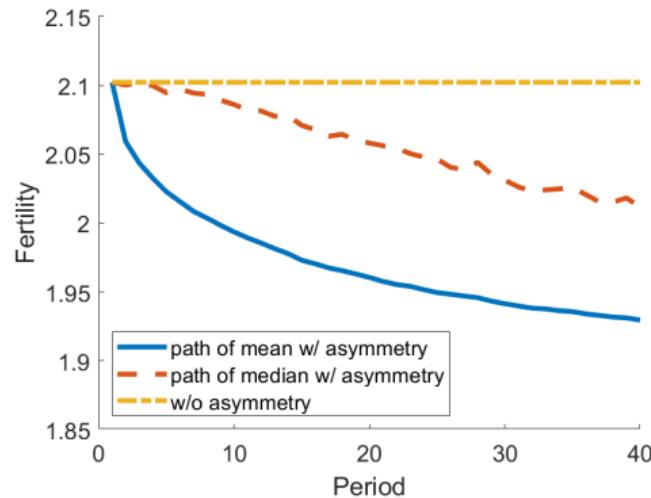
that formalizes the “relative status” in the Easterlin hypothesis

- 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 $r_0 = c_0$, 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 in the paper
- Illustration based on calibration:
 - Child costs $\chi = 0.075$ from Greenwood and Seshadri (2002)
 - Child preference $\beta = 34$ to generate $n_0 = 2.1$
 - Curvature $\gamma = 5.9$ and loss aversion $\alpha = 98$ to generate pro-fertility elasticity and the degree of asymmetry in the data
 - Updating parameters $\phi = 0.95$ and $\sigma = 0.01$ for annual frequency
- Simulate 10,000 paths for 40 years

The “slippery slope”



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

Policy Implications

Government problem

- The policymaker faces social costs from population externalities

$$\mathcal{S}(n_t | \bar{n}) = \lambda \cdot (\log(n_t) - \log(\bar{n}))^2 \quad (6)$$

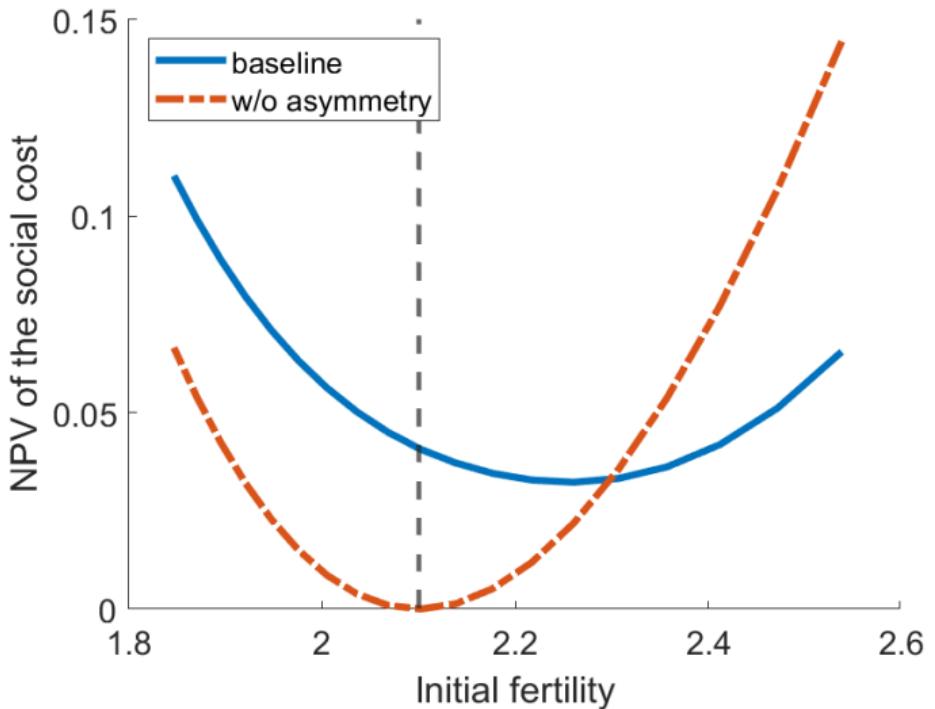
- Suppose the policymaker chooses n_0 (w/ consistent r_0) by permanently changing χ and solves

$$\min_{n_0} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \rho^t \mathcal{S}(n_t | \bar{n}) \quad (7)$$

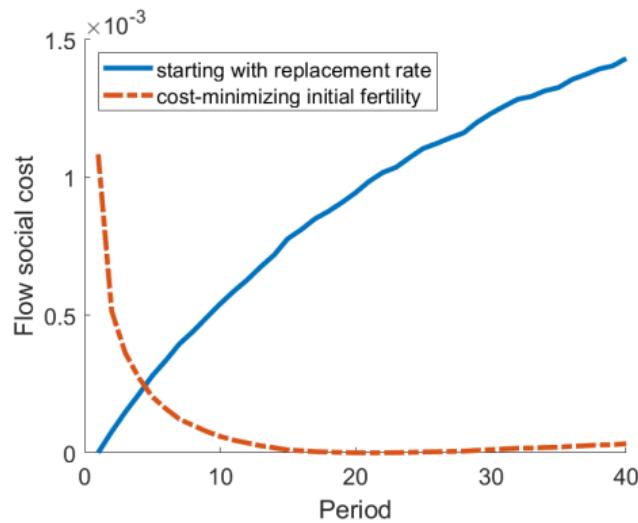
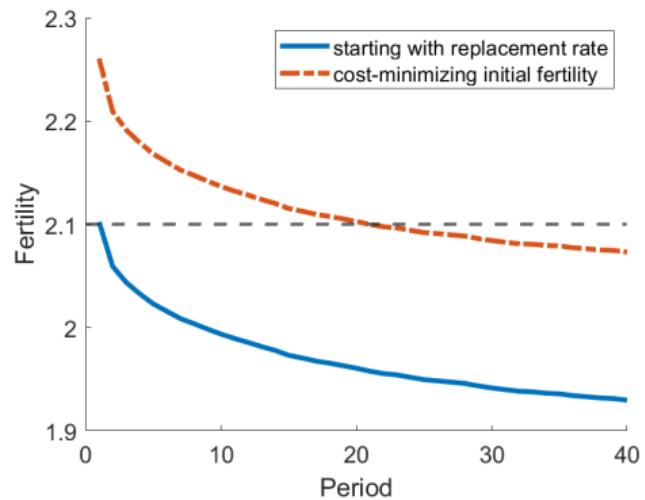
where n_t are optimizing choices by households

- **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
- One can always find a path with $n_0 > \bar{n}$ that dominates $n_0 = \bar{n}$

Policy lessons

1. Precautionary motive of higher fertility rate target
2. To maintain n_0 , policy effort needs to increase in time
3. The cost-minimizing initial fertility level depends on the degree of asymmetry, the reference updating process, and the social discount factor

Alternatives

	Propagation Mechanism	Technological Asymmetry	Liquidity Constraints	Reference Dependence
Asymmetric responses w.r.t				
Fertility policies	✓	✓	✓	✓
Implementation and reversal	✗	✗	✗	✓
Income shocks	✗	✗	✓	✓
Puzzling fertility decline	✗	✗	✗	✓
Policy implications				
Precautionary high fertility	✗	✓	✗	✓
Rising pro-fertility effort	✗	✓	✗	✓

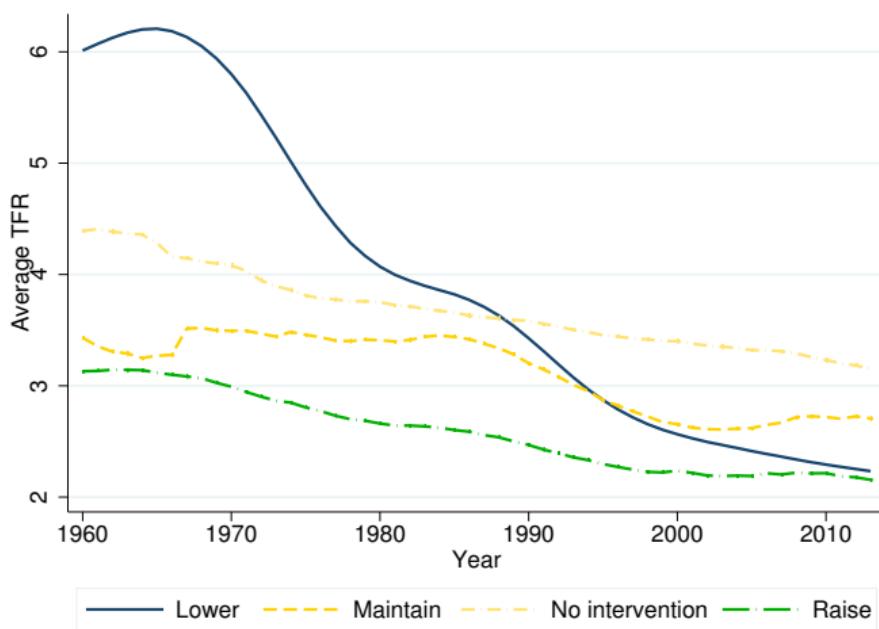
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Conclusion

- Document asymmetric fertility responses to fertility policies
- Fertility choice under reference dependence explains this fact
- The theory also generates
 - Asymmetric responses to income shocks
 - Asymmetric responses to policy implementation and reversal
 - Fertility decline in the absence of changing fundamentals
- The “slippery slope” perspective offers new implications

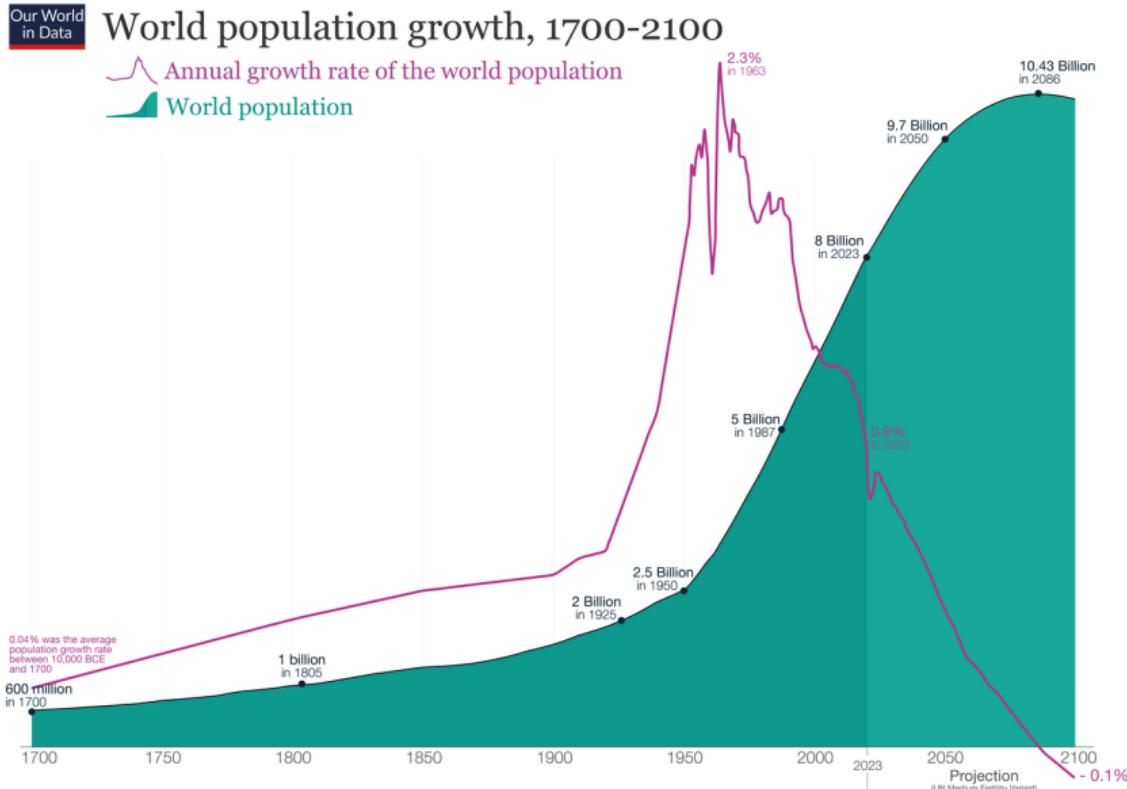
Appendix

Fertility trends by policy regime in 1976

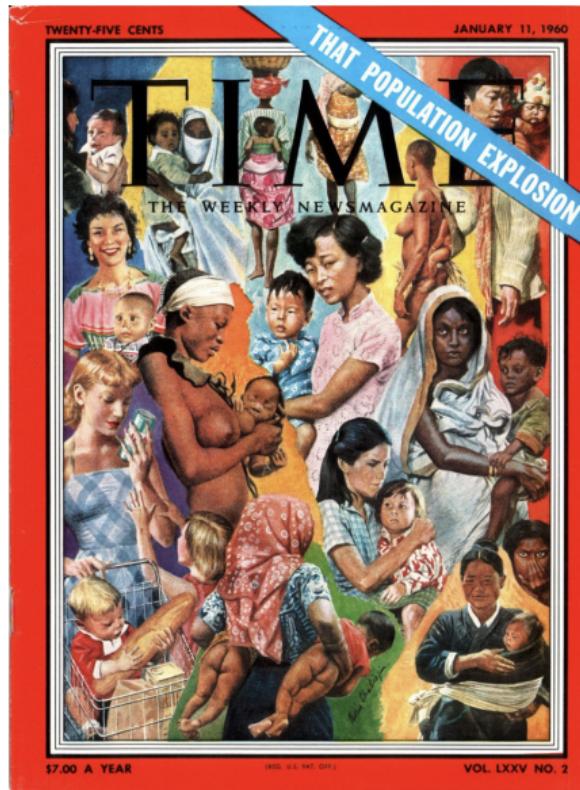
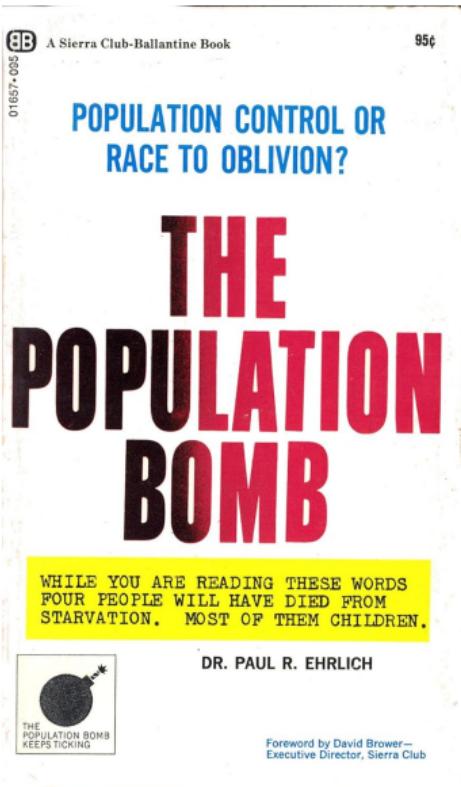


Fertility trends by policy regime in 1976

The specter of Malthus in the 1960s



The population bomb

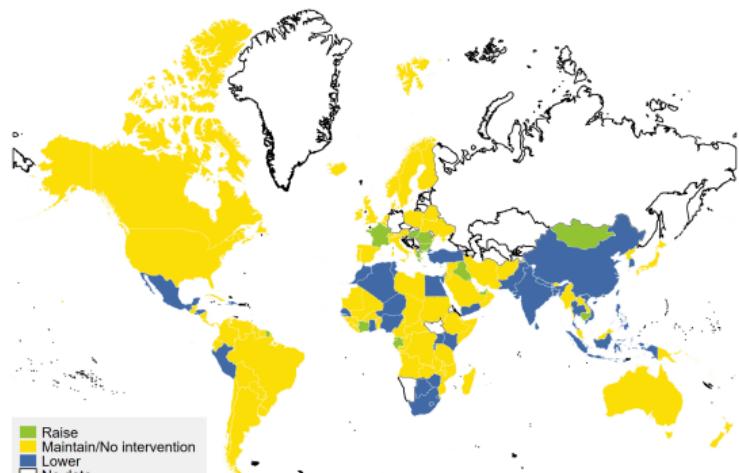


The global family planning movement

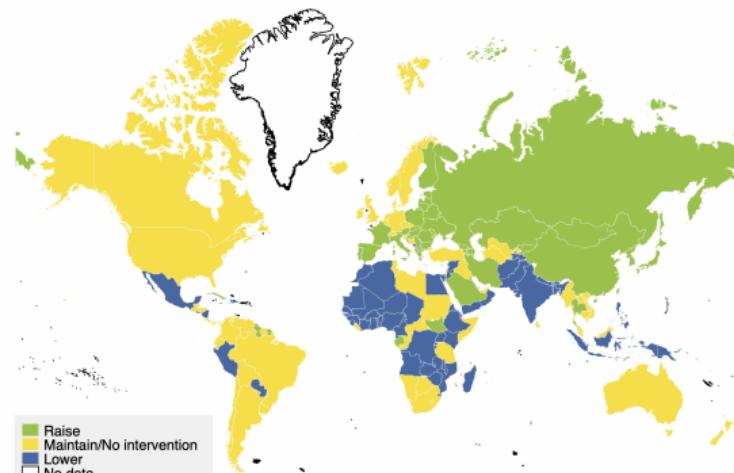
- Led by global organizations such as the United Nations, the World Bank, USAID, and Bill & Melinda Gates Foundation
- \$4.2 billion spent across low- & lower-middle-income countries in 2021
- Many country-specific policies (e.g., the one-child-policy in China)
- Gradually attaches more benefits to low 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 in 1986 and 2021



Source: United Nations Population Division



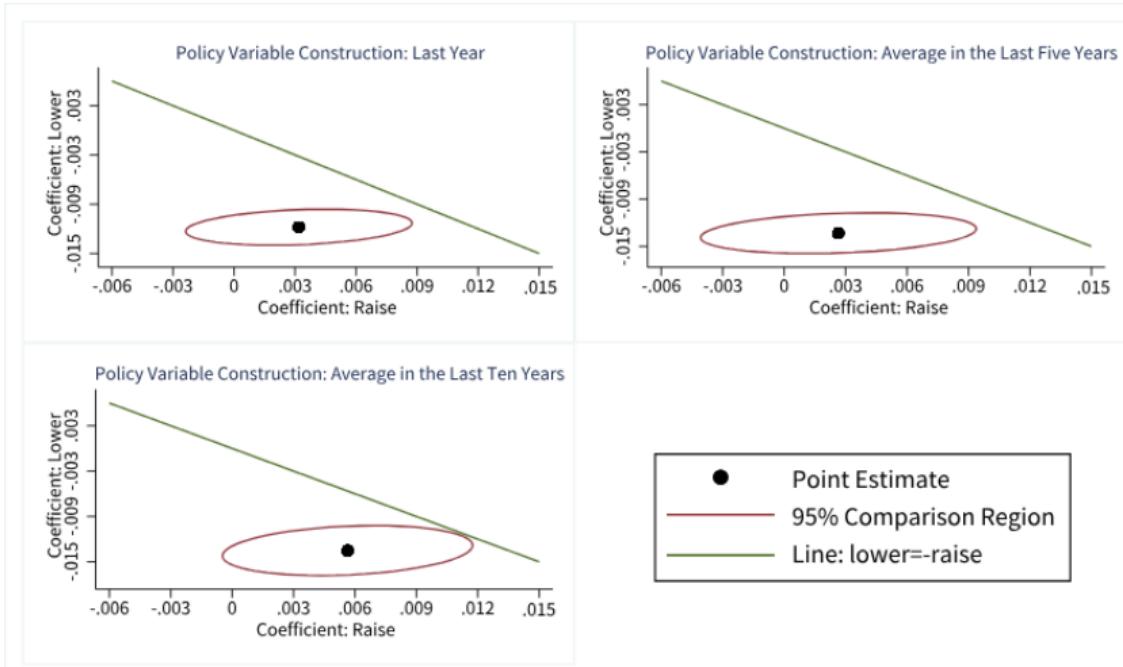
Source: United Nations Population Division

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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)

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Decomposition of Policy Effect

Table 4: Decomposition of Fertility Policy's Effect on Children Number

Dependent Variable	Number of Children			I(NChild<0)		
	Whole Sample		NChild<0			
Sample	OLS	PPML	OLS	PPML	OLS	Probit
	(1)	(2)	(3)	(4)	(5)	(6)
Lower fertility	-0.844*** (0.073)	-0.070** (0.030)	-0.834*** (0.060)	-0.153*** (0.022)	0.053*** (0.016)	0.058 (0.081)
Lower fertility (Average Marginal Effect)						-0.027 (0.075)
Raise fertility	0.168** (0.066)	0.057 (0.036)	0.436*** (0.060)	0.153*** (0.025)	-0.089*** (0.019)	-0.269*** (0.075)
Raise fertility (Average Marginal Effect)						-0.063*** (0.018)
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes
Income Level-Age-Gender FE	No	No	No	No	No	No
Education Level-Age-Gender FE	No	No	No	No	No	No
Macroeconomic Controls	No	No	No	No	No	No
Observations	205288	200307	174638	174638	205288	200307
R^2	0.297	0.067	0.305	0.053	0.217	0.103

Decomposition of Policy Effect

Table 5: Calculation of Intensive Margin Effect

Effect	All	Intensive Margin
Anti-fertility Policy's Effect on Children Number (OLS)	-0.844	-0.704
Pro-fertility Policy's Effect on Children Number (OLS)	0.168	0.368
Anti-fertility Policy's Effect on Children Number (Discrete Choice Model)	-0.070	-0.129
Pro-fertility Policy's Effect on Children Number (Discrete Choice Model)	0.057	-0.129

Decomposition of Policy Effect

Table 6: Fertility Policies' Effect Conditional on Children Number

Dependent Variable Sample	Number of Children				
	Whole Sample (1)	NChild \geq 0 (2)	NChild \geq 1 (3)	NChild \geq 2 (4)	NChild \geq 3 (5)
Lower fertility	-0.844*** (0.073)	-0.834*** (0.060)	-0.887*** (0.056)	-0.518*** (0.051)	-0.184*** (0.039)
Raise fertility	0.168** (0.066)	0.436*** (0.060)	0.500*** (0.062)	0.479*** (0.073)	0.192** (0.076)
Baseline Controls	Yes	Yes	Yes	Yes	Yes
Income Level-Age-Gender FE	No	No	No	No	No
Education Level-Age-Gender FE	No	No	No	No	No
Macroeconomic Controls	No	No	No	No	No
Observations	205288	174638	144116	80964	43193
R^2	0.297	0.305	0.317	0.232	0.129

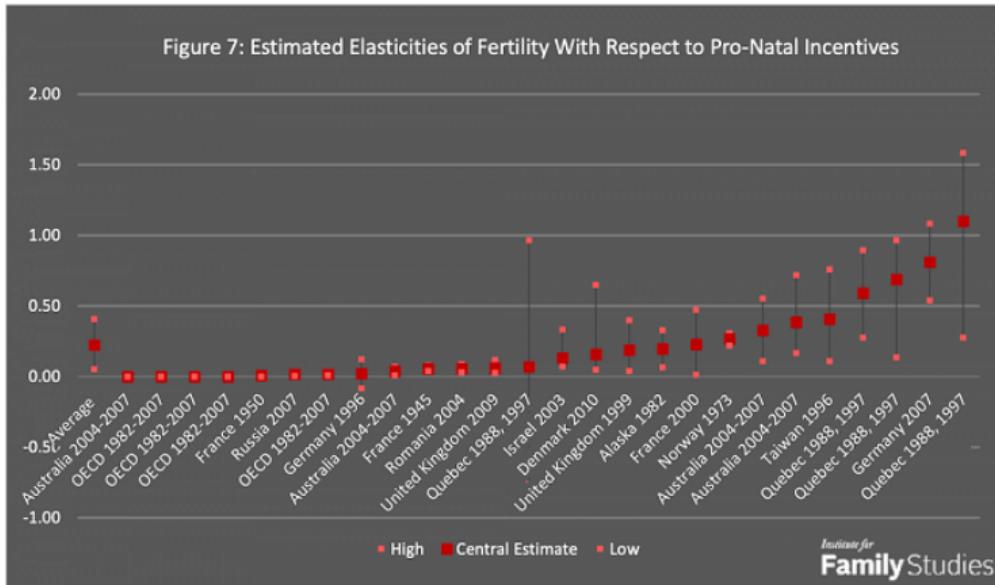
Heterogeneity by Income

Table 7: Heterogeneity by Income

Dependent Variable	Number of Children		
	Interpolation of MAC	Country-Specific Year Polynomial	Nearest Neighbor
	(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

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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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Policy Implementation and Reversal

- We estimate policy effects conditional the policy regime in the last period

$$\begin{aligned}\Delta \text{TFR}_{it}/\text{TFR}_{it-1} = & \alpha + \sum_{P_1} \sum_{P_2} \beta_{P_1, P_2} \mathbb{1}(\text{Policy}_{it} = P_1) \times \mathbb{1}(\text{Policy}_{i,t-1} = P_2) \\ & + \sigma_i + \eta_t + \epsilon\end{aligned}\tag{8}$$

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

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

Asymmetries in policy reversal coefficients

Table 8: 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)	
Lower	Maintain	-0.0094*** (0.0020)	-0.0123*** (0.0014)	-0.0105*** (0.0030)	
Raise	Lower	0.0046 (0.0057)	0.0090*** (0.0023)	0.0035 (0.0035)	

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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

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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 9: 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

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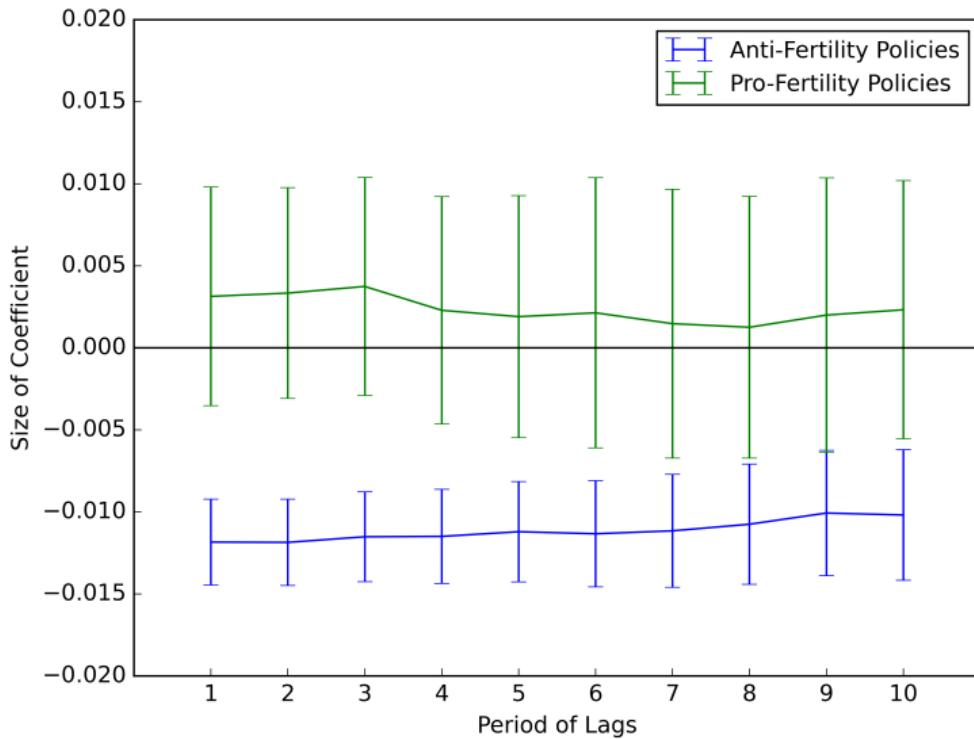
Split samples

Panel A: Subsample with High TFR in 1960				
Dependent Variable	Δ Total 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

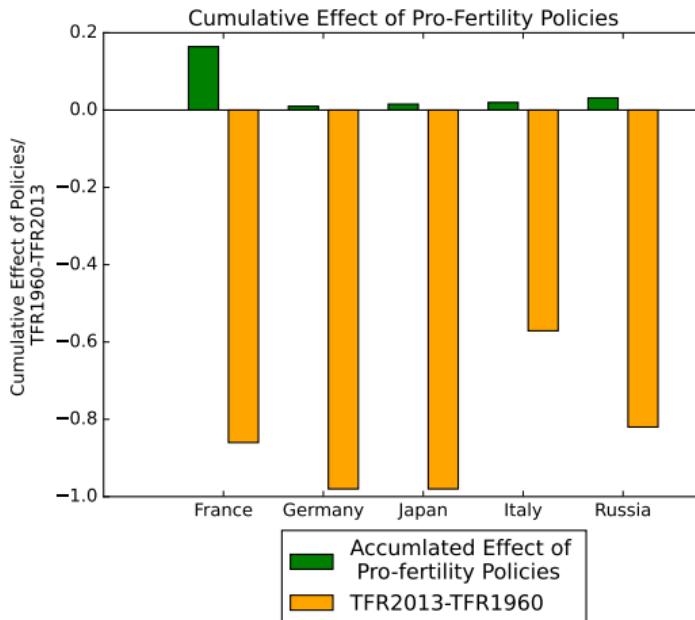
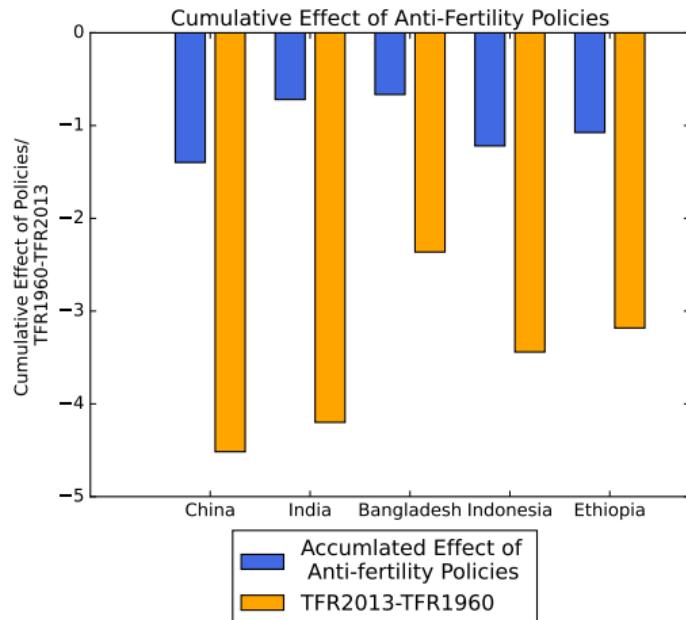
Panel B: Subsample with Low TFR in 1960				
Dependent Variable	Δ Total Fertility Rate/Lagged Fertility Rate			
Construction of Policy Variables	Last Year		Average in the Last Five Years	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0150** (0.0028)	-0.0117** (0.0049)	-0.0151*** (0.0023)	-0.0117** (0.0047)
Raise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

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Different horizons

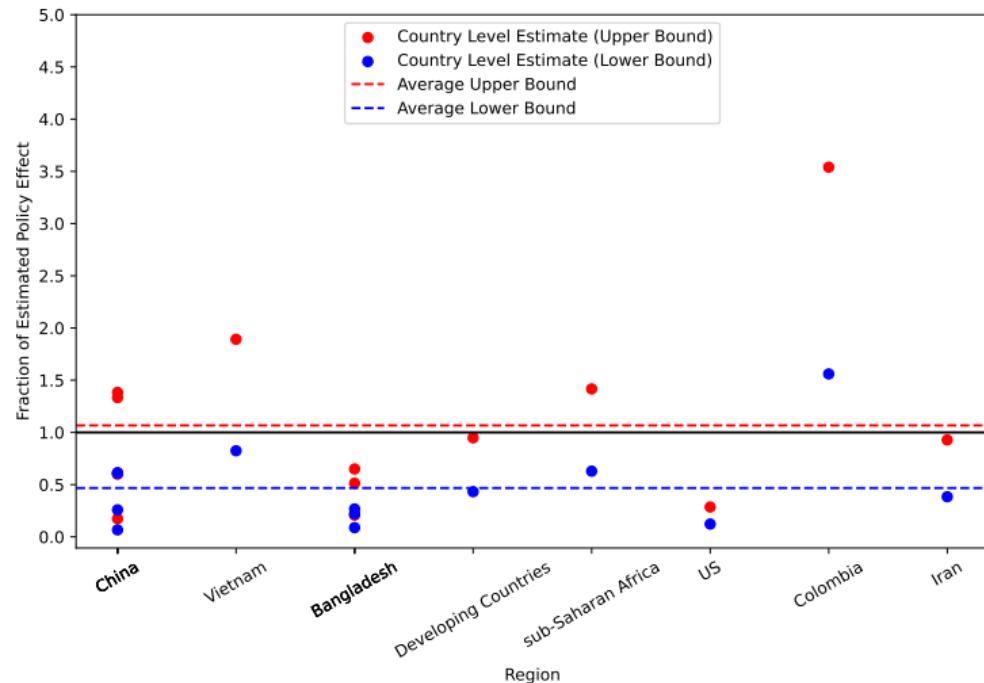


Cumulative effects



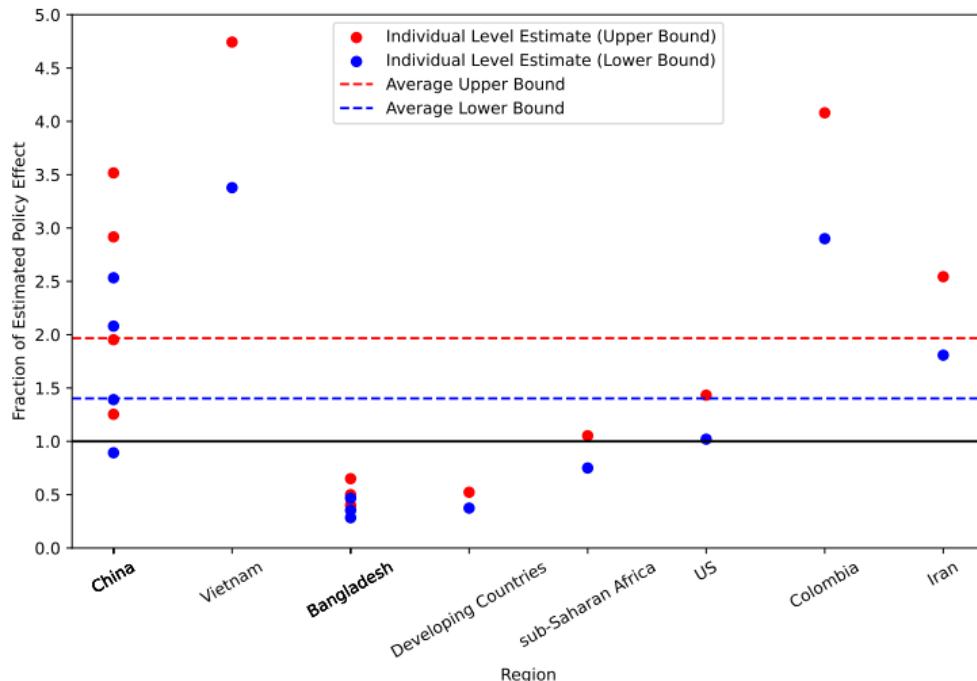
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Comparison with other existing studies



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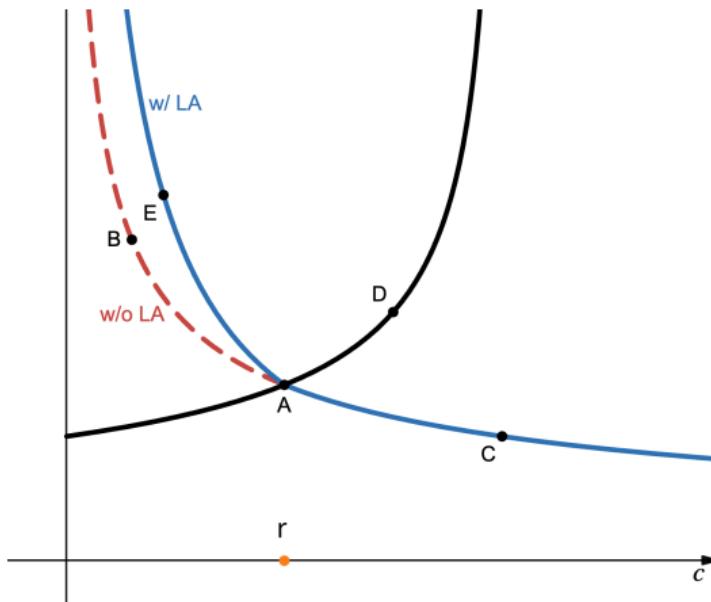
Comparison with other existing studies



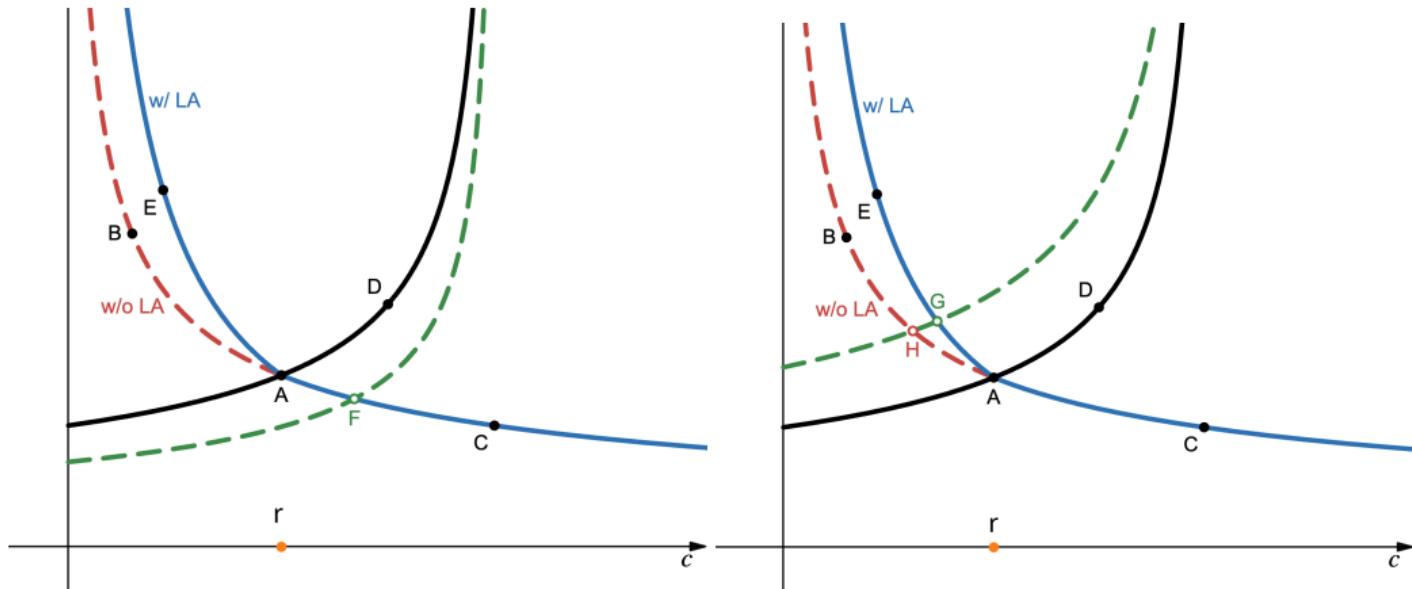
First-order condition

- The first-order condition of optimal consumption satisfies

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



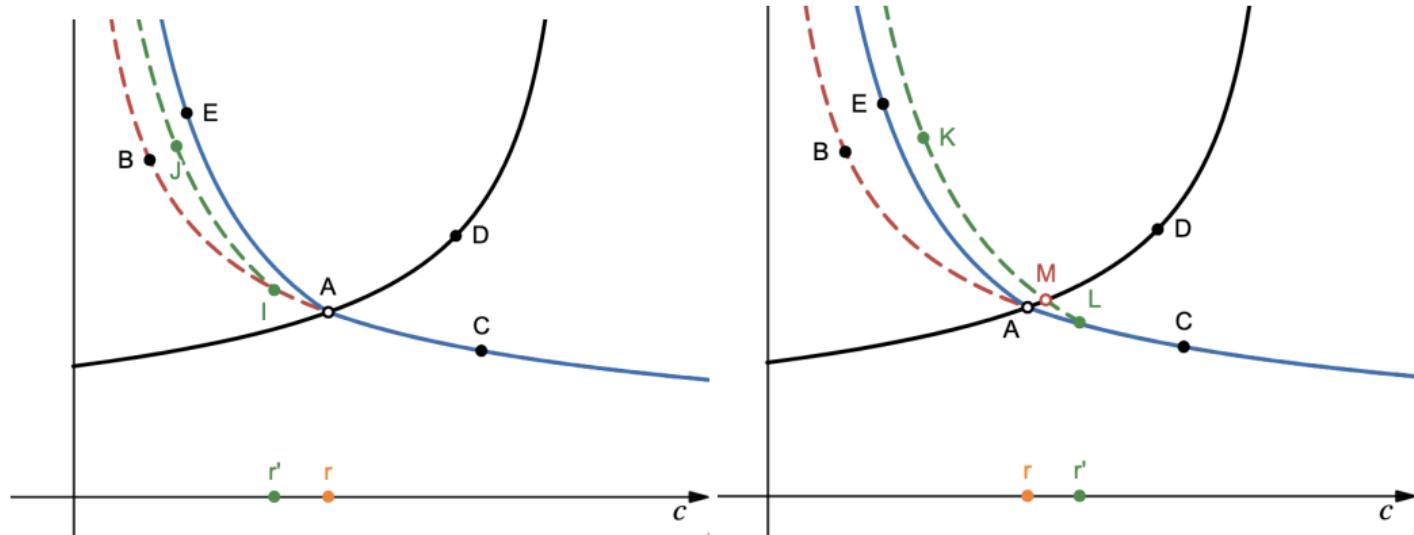
Asymmetry in χ



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

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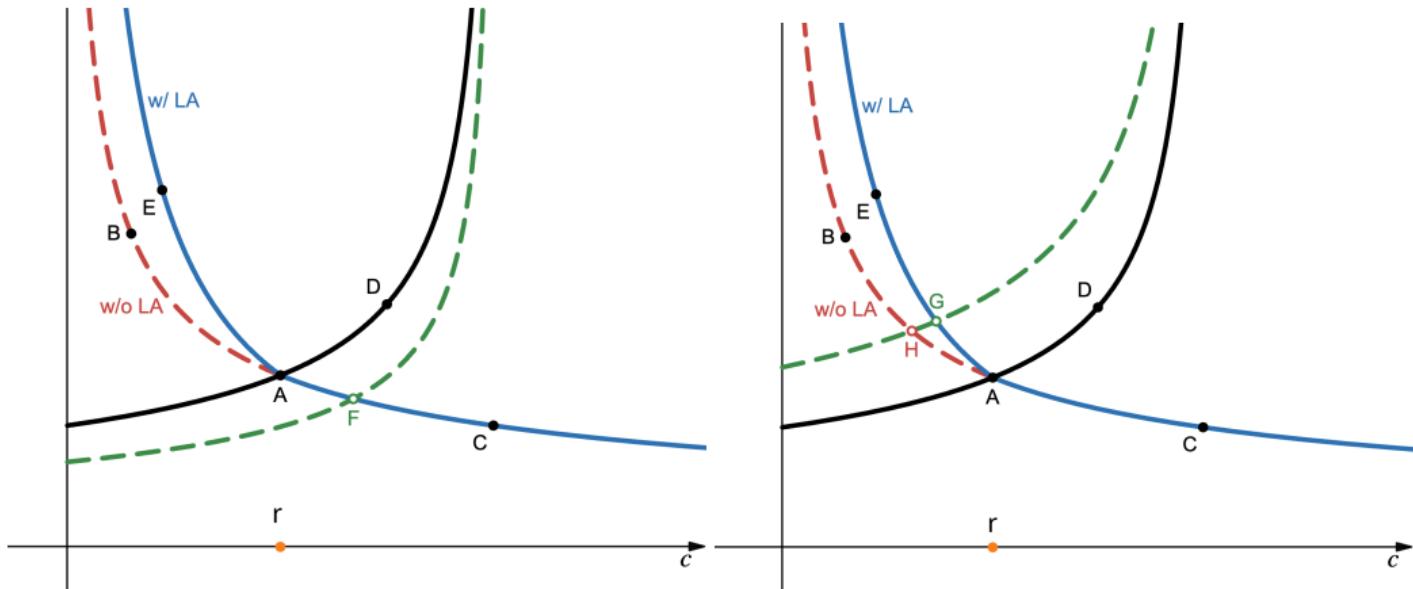
Asymmetry in r



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

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Asymmetry in I



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

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