Asymmetric Fertility Elasticities*

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Abstract

Exploiting rich historical data, this paper documents that the cost-effectiveness of anti-fertility policies is systematically larger than pro-fertility ones – a new fact that challenges existing theories with smooth aggregate Marshallian fertility demand. We develop a model of fertility choice under loss aversion to explain this fact and discuss potential alternatives. The model leads to a novel "slippery slope" perspective: fertility rates face sustained downward pressure even without any changes in the underlying economic fundamentals. This perspective suggests that governments concerned with population externalities have a precautionary motive to set a higher fertility rate target than previously thought.

JEL classification: J11, J13, J18

Keywords: fertility elasticity, loss aversion, precautionary motive

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1. Introduction

Governments struggling with low fertility rates feel powerless and puzzled. Recent attempts to increase birth rates have yielded disappointing results (Sobotka et al. 2019). With fertility rates far below the replacement level for major civilizations (see Figure 1), these trends indicate that the once-discounted "empty planet" future now seems altogether a plausible outcome (Bricker and Ibbitson 2019, Jones 2022).

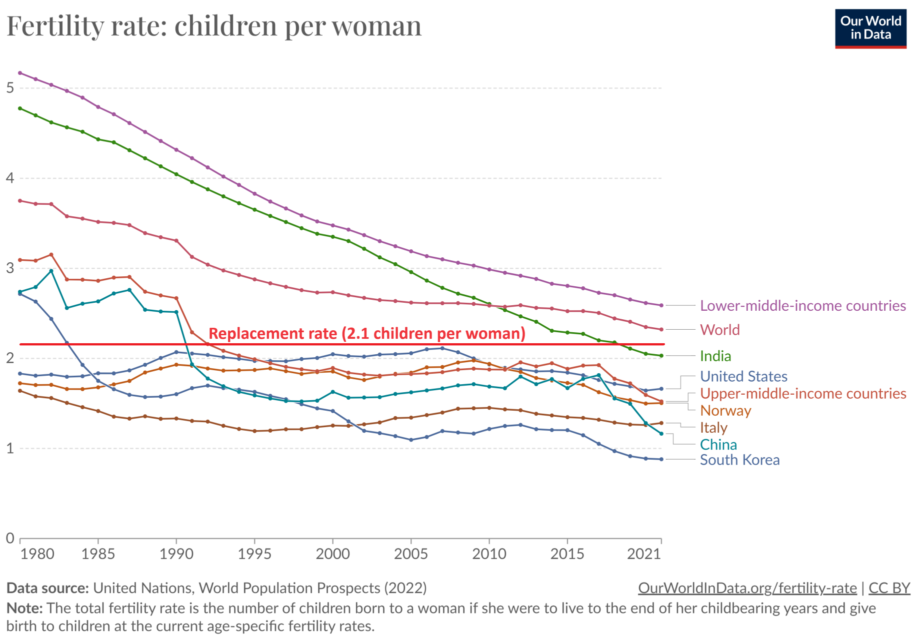


Figure 1: Total Fertility Rate Across Countries

The failures of pro-fertility policies stand in sharp contrast with the perceived success that anti-fertility policies have achieved since the "population bomb" narrative (Ehrlich 1978) gained popularity and resulted in a continuing global wave of policy interventions.[1] Past studies have shown that these policies played a key role in accounting for the rapid fertility decline in many economies (Zhang 2017, De Silva and Tenreyro 2017).

Recently, some governments that have employed anti-fertility policies in the past are now adopting pro-fertility measures to counter below-replacement fertility rates, but with limited success (e.g., China, Singapore, etc). In retrospect, anti-fertility policies might have, ironically,

[1]Briefly speaking, the "population bomb" is a reincarnation of the Malthusian idea that a growing population inevitably leads to catastrophes.

worked too well, so that "yesterday's success becomes today's challenge" (Leong and Sriramesh 2006).

These anecdotal observations of pro- and anti-fertility policies raise several intriguing empirical and theoretical questions: Is there systematic evidence in the data showing that it is more difficult for policymakers to raise fertility than to reduce it? If so, is this phenomenon–we call it asymmetric fertility elasticities–consistent with existing theories? If standard models cannot generate this asymmetry, what extra modeling ingredient is needed? Lastly, what are the implications of asymmetric fertility elasticities for economists, demographers, and policymakers? We address these questions in several steps.

First, in a range of data sources and econometric specifications, we document a new empirical fact that anti-fertility policies have much larger impacts relative to pro-fertility ones. To begin with, we estimate fertility responses to policy stances using (1) panel regression and policy reversal specifications on aggregate-level data from the United Nations and (2) cohort exposure design on individual-level data from the World Value Survey (WVS). In both cases, we examine whether the coefficients differ by policy direction. Furthermore, we collect data on the funding of anti-fertility policies, estimate the elasticity of fertility to policy funding, and juxtapose the results with the pro-fertility elasticities found in the literature. In both analyses, we find that the coefficients of the anti-fertility policies are much larger than the coefficients of the pro-fertility policies.

We conduct a battery of checks to ensure that the asymmetry is a robust empirical regularity. In particular, we (1) use levels instead of percentage changes in fertility as the dependent variable, (2) examine policy effects at different horizons, (3) add country-specific time trends, (4) control for past fertility, (5) split sample using initial fertility or GDP per capita, and (6) evaluate the cumulative contributions of notable fertility policies and cross-check with other studies in the literature. The asymmetry holds in all these specifications.

Second, we present a novel theory of fertility choice that nests standard models but allows for the possibility of asymmetric fertility elasticities. Such extension is needed because existing models uniformly predict a smooth Marshallian demand for fertility. We also argue that other approaches to reconciling the asymmetry with existing models, such as resorting to propagation mechanisms or technological irreversibility, have their limitations.

Then, we present a model of fertility choice with loss aversion over living standards. The idea is simple: due to the trade-off between fertility and non-fertility spending, households with loss aversion over current living standards are more reluctant to increase fertility than to reduce it upon symmetric incremental changes in the shadow price of children. In the model's first-order conditions, loss aversion generates a kink in the marginal benefit of consumption around the reference point. As a result, symmetric shifts in the marginal cost of consumption or reference levels have distinct effects depending on the direction of the shift.

Third, we embed the static theory into a dynamic environment where the reference point follows an adaptive updating process (Thakral and Tô 2021) with random shocks. Due to asymmetric elasticities, this model implies that fertility rates face sustained downward pressure even without any changes in the underlying economic fundamentals – a "slippery slope" perspective. This perspective is distinct from traditional theories where variations in fertility necessarily reflect changes in factors such as the returns to education, the opportunity cost of children, etc. Thus, the "slippery slope" perspective provides a potential explanation for the puzzle of falling U.S. birth rates since the Great Recession documented by Kearney et al. (2022).

Lastly, we study the policy implications of asymmetric fertility elasticities. We assume that the economy faces a quadratic loss function due to population externalities if its fertility rate deviates from a certain level – commonly assumed to be the replacement rate in real-life policy settings. We then calculate the net present value of the expected social cost along the transition path for different initial fertility levels.

This exercise offers three main policy insights. First, anti-fertility campaigns are likely to overshoot because loss aversion exerts downward pressure on fertility, and hence fertility tends to slide down on its own even without policy interventions. Therefore, governments have precautionary motives to set a higher fertility target than the replacement rate – previously thought to be the cost-minimizing level by many policymakers (Striessnig and Lutz 2013). Second, unless the social discount factor is zero, starting from the replacement rate is never cost-minimizing because in that case, the expected social cost is monotonically increasing over time. Third, the cost-minimizing initial fertility depends on a range of factors, including the magnitude of population externalities, the variance of shocks, the speed of reference updating, and the social discount factor. Hence, the government's long-term planning problem is more nuanced than the traditional rule of thumb of “getting it close to the replacement rate.”

Related Literature

This paper builds on the large body of empirical literature that analyzes the effectiveness of fertility policies. For example, McElroy and Yang (2000), De Silva and Tenreyro (2017), Liu and Raftery (2020), and Yin (2023) study anti-fertility policies while Schultz (2007), Milligan (2005), Laroque and Salanié (2014), and Raute (2019), among many others, investigate pro-fertility policies. This line of research generally evaluates the impacts of different policies in isolation and does not attempt to compare pro- versus anti-fertility policies. We contribute to the literature by systematically documenting the asymmetric effectiveness across policies, utilizing both policy stance and elasticity estimates. In addition, we provide a theoretical explanation for this novel observation and embed the asymmetry into a dynamic quantitative model.

This paper is closely related to the literature that studies the long-run trajectories of fertility and population, dating back to the groundbreaking work by Malthus (1872), Becker (1960), Easterlin (1968), and Galor and Weil (2000) on the economic determinants of fertility, Albanesi and Olivetti (2016) on the role of maternal morbidity, Myrskylä et al. (2009) and Feyrer et al. (2008) on the “J-curve” hypothesis, and Bricker and Ibbitson (2019) on the empty planet prediction. We contribute to the literature a new perspective: fertility rates face sustained downward pressure even without changes in the underlying economic fundamentals. Compared with traditional theories, the “slippery slope” perspective has distinct predictions and generates a new precautionary motive for governments to maintain a higher fertility rate.

In this literature, the most relevant paper is Lutz et al. (2006). They argue that due to demographic, sociological, and economic mechanisms, fertility reductions are self-perpetuating.[2] Moreover, they propose that there exists a no-come-back threshold of fertility from which countries are unlikely to recover – a low fertility trap. This paper differs from Lutz et al. (2006) in two important ways. First, we document and explain asymmetric fertility elasticities – a channel that is fundamentally different from the self-perpetuating channels they propose because the latter works equally well in either direction, whether it is to increase or to decrease fertility. Sec-

[2] For example, Rossi and Xiao (2024) present empirical evidence of social spillovers in the context of the one-child policy in China.

ond, we differ in policy suggestions: Lutz et al. (2006) focus on the time aspect, urging governments to act as soon as possible to avoid falling into the low fertility trap. This paper, however, focuses on the level aspect, urging governments to maintain a higher fertility rate to counter-act the "slippery slope" nature of fertility evolution.

Lastly, this paper connects the literature on fertility to behavioral economics. On the one hand, systematic behavioral patterns, in particular loss aversion, have been extensively documented in the experimental setting (Kahneman et al. 1991) and applied to analyzing individual decisions such as labor supply (Farber 2008, Crawford and Meng 2011, Thakral and Tô 2021), voting (Alesina and Passarelli 2019), tax filing (Rees-Jones 2018), and portfolio choice (Berkelaar et al. 2004). On the other hand, economists have traditionally analyzed fertility choices in models populated by neoclassical agents, such as Barro and Becker (1989), De La Croix and Doepke (2003), and Carlos Córdoba and Ripoll (2019) among many others.[3]

Two notable exceptions have considered household preferences that depend on societal factors in the fertility choice context. De Silva and Tenreyro (2020) build a model where households face disutility costs if their fertility choice deviates from the social norm. Kim et al. (2021) studies status externality in children's education where parents derive utility from children's human capital after comparing it to (a fraction of) the average human capital in the economy. This paper differs by considering loss aversion and how it leads to asymmetric fertility elasticities.

The rest of the paper is organized as follows. In Section 2, we present our main empirical results, the challenge of these results to existing theories, and alternative explanations. We then develop the theoretical framework and the "slippery slope" perspective in Section 3. We discuss the policy implications of this new theory in Section 4. Section 5 concludes.

2. Empirical Analyses

This section presents several data facts and our main empirical results.

[3] Jones et al. (2008), Greenwood et al. (2017), and Doepke et al. (2023) provide excellent summaries of the literature.

2.1 Changing Landscape of Fertility Policies

We collect the main variable of interest, policy stances on fertility level, from the World Population Policies Database operated by the United Nations. For a large number of countries between 1976 and 2019, the database provides information on national policy stances on the prevailing fertility level, categorized into "lower", "raise", "maintain", and "no intervention." The entry values were assigned by the United Nations based on a detailed country-by-country review of national plans and strategies, program reports, legislative documents, official statements, and various international, inter-governmental, and non-governmental sources. The review also takes into account the official responses to the United Nations Inquiry among Governments on Population and Development. Between 1976 and 1996, the database was updated once every ten years. Since 2001, the database has been updated biennially.

Figure 2 plots the fertility policy stance around the world in 1986, eighteen years after the publication of The Population Bomb (Ehrlich 1978). As can be seen, a number of populous developing countries had already taken a policy stance aimed at lowering fertility levels at that time, most notably China and India. Only several countries had adopted the pro-fertility stances (e.g., France, Romania, Cambodia), mostly for cultural, ideological, or religious reasons.

The policy landscape looked drastically different in 2021. As shown in Figure 3, the anti-fertility policy stance has become much more prevalent in Africa, partly reflecting efforts by governments and international organizations that view family planning as a pathway to economic development. Most countries in Europe and many in Asia, on the other hand, have adopted the policy stance "raise" to address the issue of below-replacement fertility.

Figure 4 plots the histogram of policy stances by the contemporaneous fertility level in the data. Unsurprisingly, "lower" is much more common among countries with high fertility while "raise" is more prevalent among countries with below replacement fertility. Interestingly, there is a mix of policy stances for countries where the prevailing total fertility rate is between 1.8 and 2.6 children per woman.

Figure 5 plots the evolution of the average fertility rate among countries in different categories assigned by their policy stance in 1976.[4] An immediate message this figure delivers is that while countries with initial anti-fertility policy stances seem to be achieving their stated

[4] This figure is also shown in De Silva and Tenreyro (2017).

Figure 2: Fertility Policy Stance in 1986

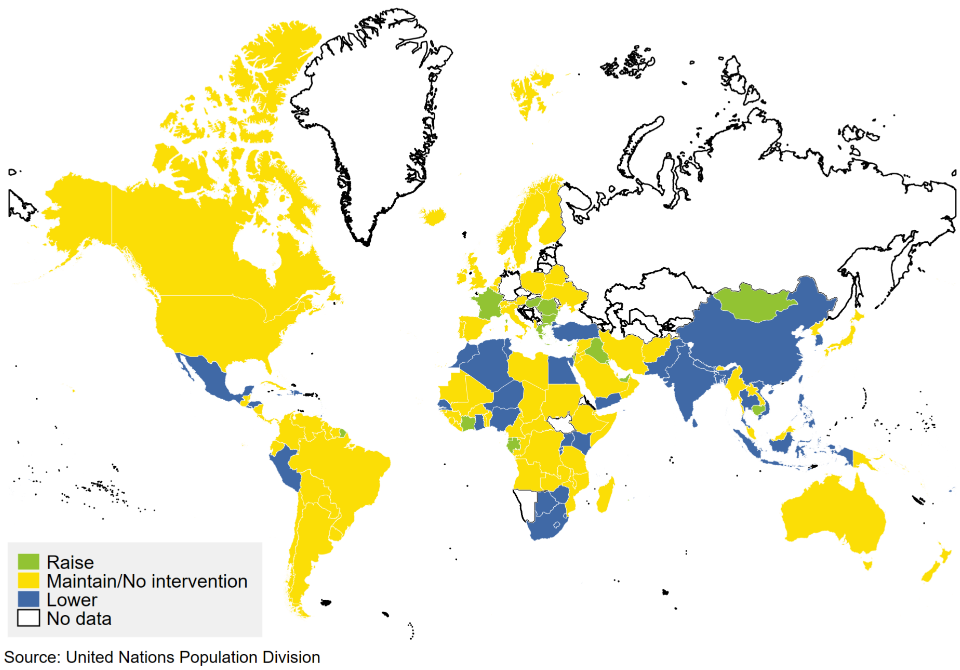


Figure 3: Fertility Policy Stance in 2021

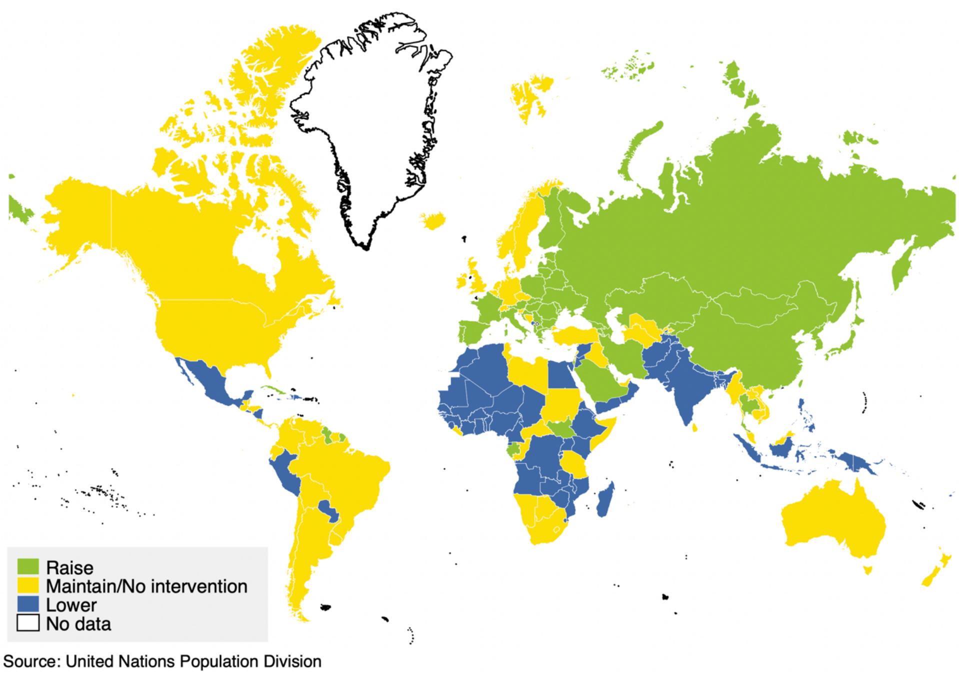
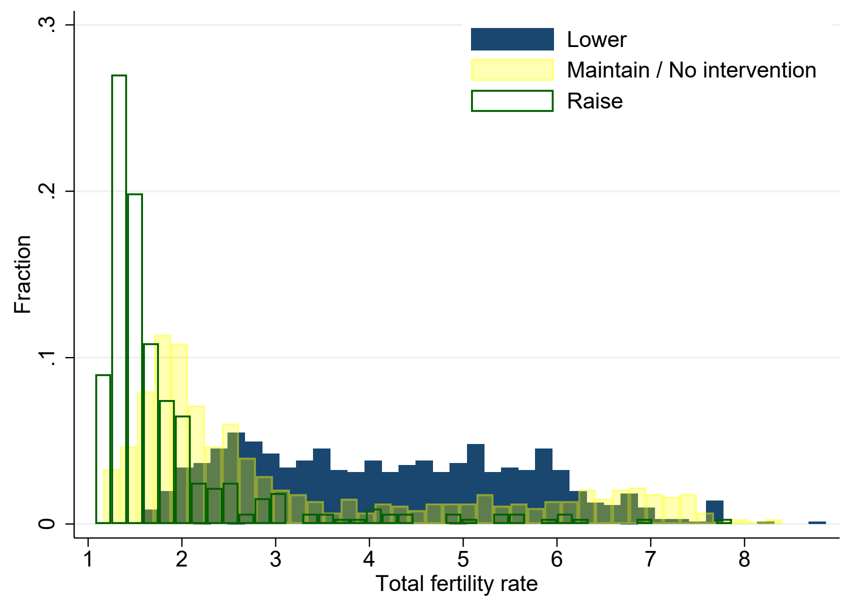


Figure 4: Policy Stance and Contemporaneous Fertility Rate



Notes: This figure plots the histogram of fertility policies over the current total fertility rate using data from the United Nations Population Division.

goals, fertility levels in countries with the initial policy stance "raise" are still falling. This figure, of course, only provides suggestive evidence as it does not take into many other factors that affect fertility. In the following sections, we evaluate the relationship between these policy stances are subsequent fertility changes more systematically using several methods.

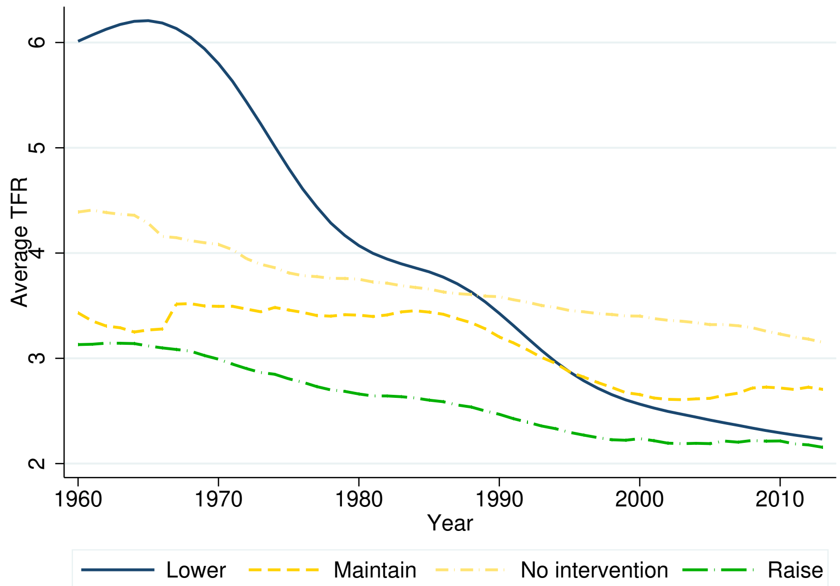
2.2 Evidence from Policy Stances

This section presents evidence on the asymmetric effects of policy stances using country- and individual-level data.

2.2.1 Panel Regressions

We first use country-level data to assess the impacts of pro- and anti-fertility policies on subsequent fertility rates. We combine policy stance and fertility data from the United Nations with several country-year level controls, such as GDP from the Penn World Table 10.0, average years of schooling from Barro and Lee (2013), as well as infant mortality rate, female labor force par-

Figure 5: Evolution of fertility



Notes: This figure plots the evolution of the average fertility rate among countries in different categories assigned by their policy stance in 1976.

ticipation, and urbanization rate from the World Development Indicator. The combined data provides broad coverage of countries at all stages of development from 1976 to 2013.[5]

To be clear, estimating the causal effects of policies on fertility is challenging due to issues such as the lack of a control group, small policy magnitude, reverse causality, external validity, and confounders (Zhou 2023). We try to mitigate these concerns by adopting a rich set of fixed effects and by controlling for a battery of variables that are known to affect fertility. Moreover, because the object we care about is not about the policy effects per se, but rather the difference (or ratio) between pro- and anti-fertility policies, some of the concerns, such as lagged effects, are less troublesome. Lastly, even when clean identification is difficult to obtain, we believe that it is important to document and discuss this salient pattern in the data due to its profound implications.

[5]Due to missing values in explanatory variables, we conduct nearest neighbor interpolation to keep as many observations as possible. In the Appendix, we examine our result's robustness to using alternative interpolation methods or not conducting interpolation.

We adopt the following empirical specification:

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

In specification (1), i stands for country, and t stands for year; $\Delta\text{TFR}_{it}/\text{TFR}_{it-1}$ is country i's percentage change in total fertility rate (TFR) between year t and $t-1$; Policy_Lower_{it} and Policy_Raise_{it} are policy variables to be discussed in more details below. For control variables, we include the absolute level and growth rates of (1) real GDP per capita, (2) urbanization rate, (3) infant mortality rate, (4) years of education, and (5) female labor participation rate.

One concern in evaluating fertility policies is the presence of persistent effects. First, because there is a 10-month gap between conception and childbirth, it takes at least one year for the policy effects on the total fertility rate to appear unless the policy is anticipated in advance. Second, if fertility policies take the form of improved access to contraceptive technologies or propaganda instead of direct economic incentives, their effect may be long-lasting and growing with time. To address these issues, we consider the following definitions of policy treatment variables: one-year lagged policy stance and exposure to population policies in the last several years. The latter one is constructed with the following formula:

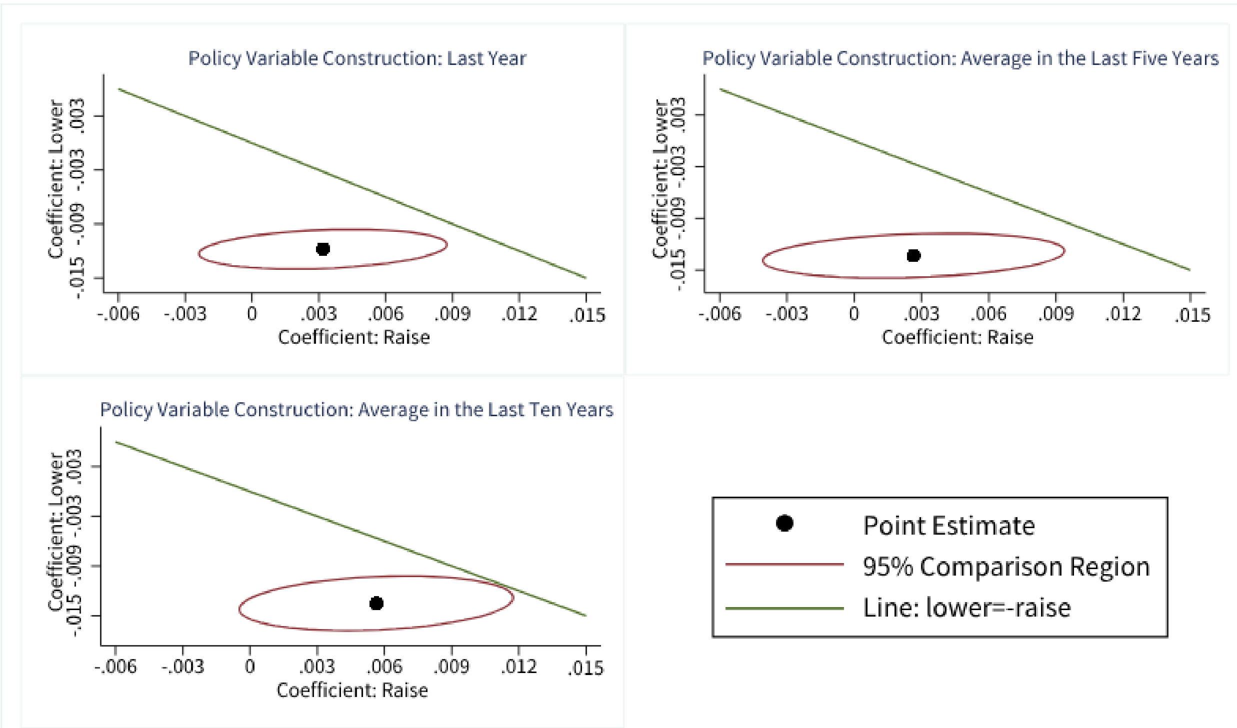
$$\text{Policy\_Lower}_{it} = \frac{1}{N}\sum_{T=t-N}^{t-1}\mathbb{I}(\text{Policy}_{iT} = \text{Lower})$$

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

We evaluate regression specification (1) where the omitted category is "maintain" or "no intervention." Table 1 presents the results. Columns (1) and (3) contain the coefficients of interest after controlling for two-way fixed effects. Column (1) indicates that a one-year (additional) exposure to anti-fertility policies is associated with a 1.2% reduction of TFR, an economically significant size given that many fertility policies can last for decades. For pro-fertility policies, however, we cannot reject the null hypothesis of no treatment effect, and the size of the coefficients is also much smaller than that of anti-fertility policy. The pattern is similar for results using policy exposure in the last five years as dependent variables in column (3). In columns

(2) and (4), we present the results after controlling for confounding variables. The size of the coefficients becomes smaller compared to columns (1) and (3), but the main conclusion about the asymmetric effect of fertility policies holds in all specifications. In Figure 6, we follow Eckert and Vach (2020)'s method to draw the 95% joint comparison region of $\hat{\beta}_1$ and $\hat{\beta}_2$. The result again suggests that anti-fertility policies are more effective than pro-fertility policies.

Figure 6: Comparison Region of Coefficients: Country-Level Results



Notes: This figure plots the 95% comparison region (Eckert and Vach 2020) of the coefficients of lower fertility policy and raise fertility policy in columns (1), (3), (5) of Table 1. The green reference line indicates the boundary of the area where the absolute value of the anti-fertility policies' coefficient is larger than the absolute value of the pro-fertility policies.

2.2.2 Policy Implementation and Reversals

Besides responding differently to pro- versus anti-fertility policies, asymmetric fertility elasticities may arise in the differential responses to the implementation and the reversal of the same policy.

Table 1: Population Policy and TFR

Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate					
Construction of 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***	-0.0055***	-0.0133***	-0.0062***	-0.0135***	-0.0060**
	(0.0013)	(0.0016)	(0.0015)	(0.0021)	(0.0020)	(0.0027)
Raise fertility	0.0032	0.0006	0.0027	-0.0005	0.0056	0.0018
	(0.0034)	(0.0030)	(0.0041)	(0.0036)	(0.0037)	(0.0034)
	95% Confidence Intervals of Coefficients' Ratios					
Raise / Lower	[-0.849, 0.308]	[-1.198, 0.984]	[-0.812, 0.414]	[-1.059, 1.207]	[-0.994, -0.159]	[-1.494, 0.890]
Raise / Lower (Bootstrap)	[-0.865, 0.324]	[-0.988, 0.396]	[-0.834, 0.436]	[-1.042, 0.487]	[-1.034, 0.200]	[-1.481, 0.295]
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	10301	7373	9545	6821	8595	6126
R^2	0.132	0.170	0.129	0.171	0.155	0.205

[1] Source: Policy variables are collected from the UN World Population Policies Database; TFR and control variables are collected from the Penn World Table 10.0, Barro and Lee (2013), and the World Bank's World Development Indicators. For missing values, we conduct nearest neighbor interpolation.

[2] Note: The table reports the result of regressions of the change rate of TFR on fertility policy variables. In columns (1) and (2), fertility policy stance in the last year is used as the independent variable; in columns (3) and (4), the fraction of years exposed to corresponding fertility policies in the last five years is used as the independent variable; in columns (5) and (6), the fraction of years exposed to corresponding fertility policies in the last ten years is used as the independent variable. Columns (1), (3), and (5) only control for two-way fixed effects; columns (2), (4), and (6) add additional control variables. Control variables include both the absolute level and growth rate of real GDP per capita, urbanization rate, infant mortality rate, female labor participation rate, and average years of schooling for women. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively. 95% confidence intervals of the ratio of coefficients estimated are also presented. The bootstrap intervals are percentile intervals calculated from country-cluster bootstraps with 5000 draws.

For instance, González and Trommlerová (2023) examine a generous Spanish lump-sum maternity allowance introduced in 2007 and subsequently eliminated in 2010. While standard theories predict fertility would return to its original level upon policy repeal, González and Trommlerová (2023) find that fertility increased by 1.7% when the policy was introduced and decreased by 5.5% when it was reversed. In this section, we investigate whether the asymmetric effects between policy implementation and reversal can be extended to a broader setting.

We employ the following empirical specification:

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

In Equation (2), the variables R, L, and N represent "Raise", "Lower", and "No Intervention/Maintain", respectively. The coefficient of main interest, β_{P_1,P_2}, estimates the current policy's effect on TFR, conditional on the previous year's policy stance. The results are presented in Table 2, where $\beta_{N,N}$ serves as the baseline for comparison. We don't find any significant effect of both pro-fertility policy's implementation and reversal. However, switching from "no policy" to "anti-fertility policy" has a larger and more significant impact on TFR than reversion from anti-fertility policy to no policy. In Section B.4, we adopt an alternative strategy analogous to González and Trommlerová (2023)'s to ease concern about lagged policy effect. The results are similar to Table 2.

Table 2: Asymmetric Response of Policy Implementation and Reversion

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

2.2.3 Cohort-Exposure Design

Section 2.2.1 provides evidence of the short-run asymmetric effects of fertility policies. However, if fertility policies have lasting impacts, and it takes more time for pro-fertility policies to come into effect, then our conclusion may be overturned in the long run. This problem is especially concerning if we consider the fact that many anti-fertility policies, like China's One-Child Policy (Zhang 2017), have a certain degree of compulsion, which means that they will have a much larger impact on the fertility rate in the short run. In this section, we use a cohort exposure design to show that the asymmetry of fertility policies' effect also exists in the long run. More specifically, we find that individuals who are exposed to anti-fertility policies in their childbearing age have significantly fewer children even after decades. And for pro-fertility policy, the effects are much weaker.

In this section, we match the country-level policy stances to individual-level data from the World Value Survey (WVS), a large-scale repeated cross-sectional social survey that was conducted in seven rounds between 1981 and 2022. The WVS provides detailed individual-level information, including the number of children ever had, gender, birth year, income, and education. Thus, besides providing evidence on the long-run policy effects, another important advantage of using the WVS data is that it allows us to control a richer set of variables and explore the individual-level heterogeneity of fertility policy's effects.

To exploit the effects of policy exposure on the number of children, We adopt an empirical strategy similar to Chen et al. (2020)'s cohort exposure method. Chen et al. (2020) study how exposure to the send-down movement during adolescence affects the education level of rural-born individuals in China. Similar to education, fertility decisions are mainly affected by the policy environment during individuals' childbearing time window. Therefore, we construct a policy exposure index based on different methods to construct the childbearing window.

As the World Values Survey (WVS) does not provide information on the timing of individuals' marriage or first child, we rely on the mean age of childbirth (MAC) data from the United Nations' World Fertility Data. We consider three interpolation methods for missing values for each country-year observation: country-specific year polynomial, nearest neighbor, and regression on a set of socioeconomic variables. Subsequently, we assume that each individual's treatment window is an 11-year period centered on the MAC of her country when she is 18 years old. For example, if an individual from India was born in 1990, and the MAC of India in 2008 is 25, then the treatment window for this individual is $[20, 30]$. We then follow a similar approach as in Section 2.2.1 by constructing indicators of different fertility policies and calculating each individual's exposure to these policies during their childbearing period.

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

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

where i is individual, c is country, b is individual i's birth year, and MAC_{cb+18} is country c's MAC when individual i is 18 years old. Policy exposure of individuals younger than $\text{MAC}_{cb+18} + 5$ years old is not well defined, so they are excluded from our analysis.

After constructing the policy exposure index, we estimate the following regression specification:

$$\begin{aligned}\text{Child}_{icbt} = \alpha + \beta_1 \text{Policy\_Lower}_{icb} + &\beta_2 \text{Policy\_Raise}_{icb} \\ &+ \eta \text{Age}_i \times \text{Gender}_i + \gamma_{ct} + \delta_b + \epsilon\end{aligned} \tag{3}$$

where i indexes the individual, c is country, b is the individual's birth year, and t is the survey year. Child_{icbt} is respondent i's number of children in the household.[6] $\text{Policy\_Lower}_{icbt}$ and $\text{Policy\_Raise}_{icbt}$ are the policy exposure variables defined in the last paragraph. $\text{Age}_{tb} \times \text{Gender}_i$ is the interaction of age group indicator and gender indicator, which controls age and gender's effect on the number of children. We interact these two variables to account for the fact that males and females potentially differ in family roles and childbearing period. The term γ_{ct} is country-survey year fixed effect, which eases the concern about data comparability among countries and survey years. Lastly, δ_b is the birth year fixed effect, which controls for the global declining trend of birth rate. Since the variation of our treatment variable comes from the interaction of country and birth cohort, we cannot control for the birth year-country fixed effect. This may raise concerns about omitted variable bias caused by confounding macro shocks during individuals' childbearing time window. We thus provide empirical results after controlling

[6] The number of children may be zero. Referring to Chen and Roth (2023), we do not take logs for this variable.

for the average real GDP per capita and its growth rate during the childbearing time window in each specification. Lastly, the WVS also records respondents' relative income level and education level. Because income and education may be affected by population policy and fertility decisions, they are potentially "bad controls" and are thus not included in the baseline specifications. Nevertheless, we display results after including education and income and show that our main conclusion is robust to controlling for these variables.

Table 3 presents the empirical results using individual-level data. Columns (1), (4), and (7) contain the results from estimating the specification (3) under different assumptions of the childbearing window. We find that exposure to anti-fertility policy during the whole childbearing window leads to 0.63-0.88 fewer children, which is a large number compared to the sample average child number of 1.7. The effect of pro-fertility policies, on the other hand, is approximately one-third or less than the anti-fertility policy's effect. Interestingly, the ratio of coefficient size is very similar to what we find in Table 1 using country-level data. In columns (2), (5), and (8), we further control for individual's income group and education level and allow the effects to vary among age-gender groups. In columns (3), (6), and (9), we control for the average real GDP per capita and its growth rate during individuals' childbearing time window. Including these control variables does not have a significant impact on the estimated effect of fertility policies, and the same is true for its asymmetric effect. Figure 7 plots the joint confidence region of coefficients, and the result reinforces our conclusion about fertility policy's asymmetric effect.

2.2.4 Decomposition of Fertility Changes

In this section, we compare our empirical result in Section 2.2 with existing studies by examining fertility policy's cumulative effect on TFR. For each country, we calculate the cumulative effects on TFR using the following formula:

$$\mathrm{CE}_i^{\mathrm{Lower}} = \sum_{t=1960}^{2013} \beta_1 \times \mathrm{Policy\_Lower}_{it} \times \mathrm{TFR}_{it}$$

$$\mathrm{CE}_i^{\mathrm{Raise}} = \sum_{t=1960}^{2013} \beta_2 \times \mathrm{Policy\_Raise}_{it} \times \mathrm{TFR}_{it}$$

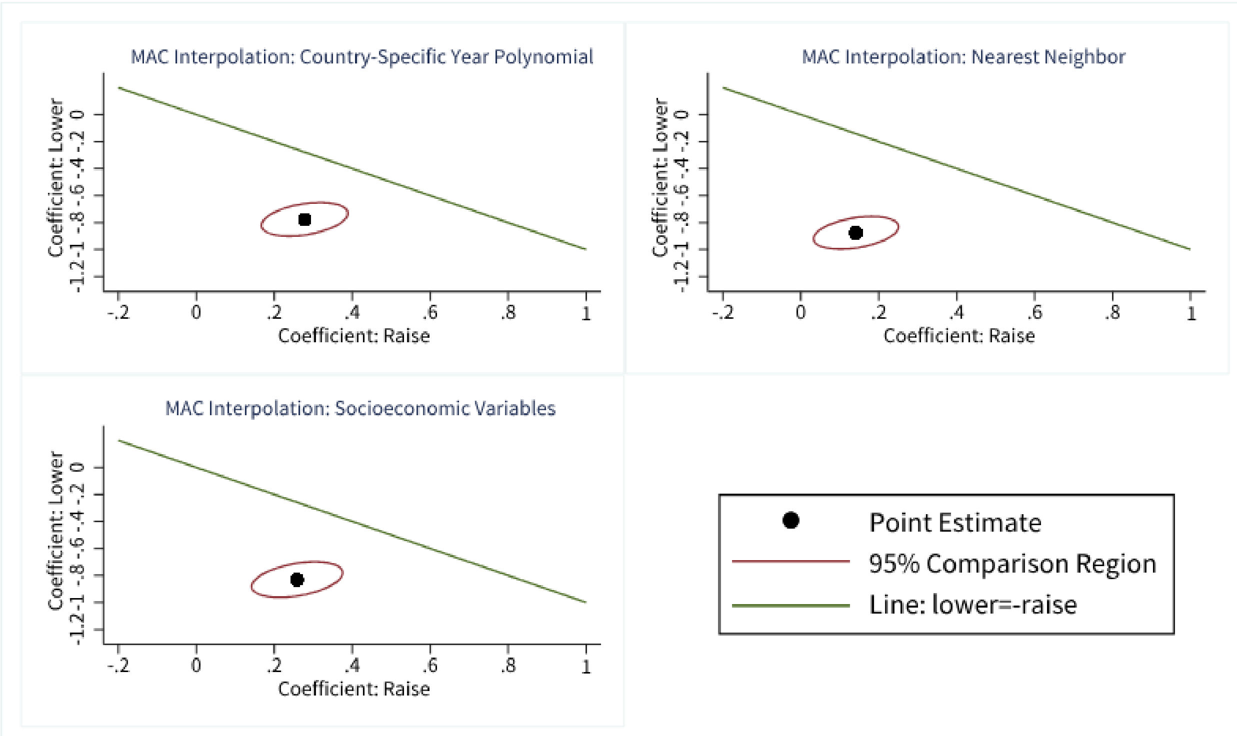
Table 3: Population Policy and the Number of Children

Dependent Variable	Number of Children								
Interpolation of MAC	Country-Specific Year Polynomial			Nearest Neighbor			Socioeconomic Variables		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Target: Lower fertility	-0.776***	-0.762***	-0.624***	-0.875***	-0.844***	-0.655***	-0.831***	-0.821***	-0.631***
	(0.076)	(0.075)	(0.076)	(0.074)	(0.073)	(0.076)	(0.080)	(0.080)	(0.082)
Target: Raise fertility	0.278***	0.304***	0.131*	0.141**	0.168**	-0.007	0.259***	0.262***	0.046
	(0.067)	(0.067)	(0.073)	(0.066)	(0.066)	(0.071)	(0.071)	(0.070)	(0.076)
	95% Confidence Intervals of Coefficients' Ratios								
Raise/Lower	[-0.563, -0.153]	[-0.609, 0.189]	[-0.460, 0.040]	[-0.322, -0.001]	[-0.367, -0.031]	[-0.202, 0.223]	[-0.509, -0.114]	[-0.516, -0.123]	[-0.315, 0.169]
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

[1] Source: Policy variables are collected from the UN World Population Policies Database; the number of children, age, gender, income group, and education are collected from the World Value Survey; real GDP per capita and its growth rate are collected from the World Bank World Development Indicators. For missing values in real GDP per capita and its growth rate, we conduct nearest neighbor interpolation.

[2] Note: The table reports the result of regressions of the number of children on individual's exposure to fertility policies during their assumed treatment time window. The interpolation method of MAC is third order year polynomial for each country in columns (1)-(3), nearest neighbor method in columns (4)-(6), and regression on real GDP per capita, years of schooling, urbanization rate, and female labor participation rate in columns (7)-(9), respectively. Variables used to predict MAC in columns (7) to (9) are from World Bank World Development Indicators, and we conduct nearest neighbor interpolation for these variables before using them to predict MAC. Columns (1), (4), and (7) control for age group×gender fixed effect, country×survey year fixed effect and birth year fixed effect – a set of baseline controls; columns (2), (5), and (8) additionally control for income group×age group×gender fixed effect and education group×age group×gender fixed effect; columns (3), (6), and (9) additionally control for the average real GDP per capita and its grow rate during individuals' assumed treatment time window. Standard errors are clustered at the cohort level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Figure 7: Comparison Region of Coefficients: Individual-Level Results



Notes: This figure plots the 95% comparison region (Eckert and Vach 2020) of the coefficients of lower fertility policy and raise fertility policy in columns (1), (4), (7) of Table 3. The green reference line indicates the boundary of the area where the absolute value of the anti-fertility policies' coefficient is larger than the absolute value of the pro-fertility policies.

where $\text{CE}_i^{\text{Lower}}$ and $\text{CE}_i^{\text{Raise}}$ represent the cumulative effects of anti-fertility policies and pro-fertility policies on country i's TFR, respectively. The coefficients β_1 and β_2 are derived from the empirical results in Table 1. Table 4 provides an overview of the estimated cumulative effects of fertility policies on TFR. On average, 14.1%-36.4% of the TFR decline between 1960 and 2013 can be attributed to anti-fertility policies. The cumulative effect of pro-fertility policies is much smaller. In spite of the substantial resources that countries have invested to increase fertility, the cumulative effect of these policies is only as large as, at most, 1.7% of the overall TFR decline between 1960 and 2013.

In Figure 8, we present the estimated cumulative policy effect for several countries of main interest. We find that these results are comparable with other studies that evaluate the role of policies in accounting for fertility changes in some notable settings (e.g., Zhang (2017) for

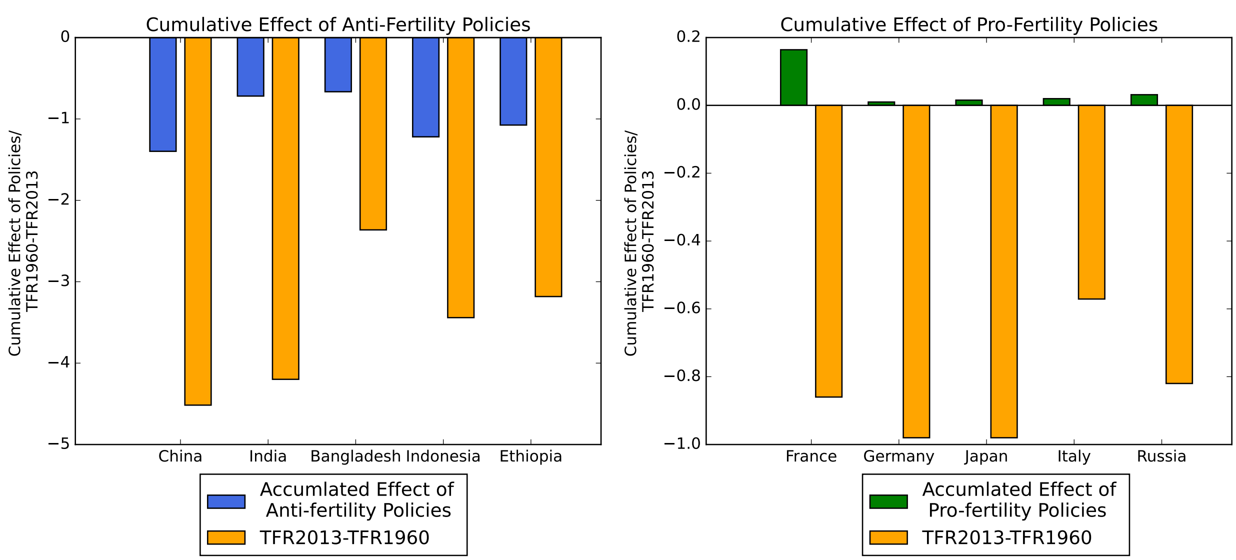
Table 4: Fertility Policies' Cumulative Effect on TFR

	Empirical Setting of Policy Effect Estimation					
Construction of Policy Variables	Last Year		Average in the Last Five Years		Average in the Last Ten Years	
Control Variables	No	Yes	No	Yes	No	Yes
Cumulative Effect of Fertility Policies 1960-2013 (Average Across Countries)						
Anti-Fertility Policies	-0.9678	-0.4511	-0.9754	-0.4547	-0.8501	-0.3778
Pro-Fertility Policies	0.0587	0.0110	0.0443	-0.0082	0.0800	0.0257
Change of TFR Between 1960 and 2013			-2.6797			

[1] Source: Coefficients of fertility policies are calculated from Table 1; Policy variables are collected from the UN World Population Policies Database; TFR is collected from the Penn World Table 10.0, Barro and Lee (2013).
[2] Note: This table presents the cumulative effect of fertility policies, using estimated coefficients from Table 1. Cumulative effect of fertility policies is calculated by summing the product of coefficients, TFR and policy variables' product over years. For the sake of comparison, the country level average cumulative policy effect presented in the table only includes countries that have TFR data in both 1960 and 2013.

China, and De Silva and Tenreyro (2017) for a wider set of countries).

Figure 8: Fertility Policies' Cumulative Effect on TFR (for Several Important Countries)



Notes: This figure plots fertility policies' cumulative effect on TFR between 1960 and 2013 for several important countries, computed from coefficients in columns (1), (3), (5) of Table 1.

2.3 Evidence from Policy Expenditures

While Section 2.2 shows that the anti-fertility policy stance has significantly larger effects on fertility than the pro-fertility policy stance, an important question is whether this is driven by systematic differences in policy intensities. In this section, we show that the asymmetric effects found in the previous section are not driven by heterogeneous policy intensities.

We use governments' monetary expenditures on fertility policies to construct a comparable measure of intensity across countries and policy stances. Following the approach by De Silva and Tenreyro (2017), we obtain the yearly country-level funding data for anti-fertility policies from Nortman (1982), Nortman and Hofstatter (1978), and Ross et al. (1993). Using this data, we estimate the elasticity of fertility with respect to the anti-fertility policy funding-GDP ratio. On the other hand, for pro-fertility policies, we rely on the meta-analysis conducted by Stone (2020) which summarizes a large number of recent studies on pro-fertility policies, including expenditures per child and the corresponding fertility responses. Similar to Section 2.2, we conduct the analysis both at the aggregate and the individual levels.

We first estimate the elasticity of anti-fertility policies. The empirical specifications we adopt are similar to specification (1) in Section 2.2.1 and specification (3) in Section 2.2.3. The only difference is that the dependent variable is now constructed using the ratio of anti-fertility policy expenditures to GDP.[7] The results are presented in Table 5. In column (1) of Table 5, we estimate the elasticity of anti-Fertility policies at the country level, and the result indicates that TFR will decrease by 6.4% when the funding-GDP ratio increases by 0.1%. In column (2), the analysis at the individual level shows that exposure to an anti-fertility policy that costs 0.1% percent of GDP during the childbearing window will reduce an individual's children number by 0.86.

For the elasticity of pro-fertility policies, we build on the meta-analysis by Stone (2020) to obtain an elasticity estimate for pro-fertility policies. In particular, Stone (2020) conducted a meta-analysis of academic studies on the effect of pro-fertility policies since 2000. Most of these studies focus on pro-fertility policies within a single country, and a few of them are cross-country research on a small sub-group of countries. In the analysis, 36 out of 53 studies contain

[7] Because both policy expenditures and nominal GDP are in contemporaneous prices, adjusting for inflation does not affect our result.

Table 5: Elasticity Estimation for Anti-Fertility Policy

Dependent Variable	ΔTotal Fertility Rate/ Lagged Total Fertility Rate	Number of Children
Setting	Country Level	Individual Level
	(1)	(2)
Anti-fertility policy funding-GDP Ratio	-63.84***	-864.160**
	(21.62)	(422.292)
Country Fixed Effect	Yes	No
Year Fixed Effect	Yes	No
Age-Gender Fixed Effect	No	Yes
Country-Survey Year Fixed Effect	No	Yes
Birth Year Fixed Effect	No	Yes
Observations	2546	92215
R^2	0.193	0.279

[1] Source: Anti-fertility policy Funding is from Nortman (1982), Nortman and Hofstatter (1978) and Ross et al. (1993); TFR is collected from the World Bank's World Development Indicators; information on the number of children, age, gender are collected from the World Value Survey. For country-level missing values, we conduct nearest neighbor interpolation.

[2] Note: The table presents the elasticity estimation of anti-fertility policies. Column (1) reports the result of regression of the change rate of TFR on anti-fertility policy funding-GDP ratio in the last five years at the country level. Column (1) controls two-way fixed effects. The standard error in column (1) is clustered at the country level. Column (2) reports the result of the regression of the number of children on the anti-fertility policy funding-GDP ratio during the treatment time window at the individual level. The interpolation method of MAC is the nearest neighbor method in column (2). Column (2) controls age-gender fixed effects, birth year fixed effect, and country-survey year fixed effect. The standard error in column (2) is clustered at the cohort level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

clear information about the policy period, expenditures per child, and fertility responses. Because each study may contain different specifications and empirical design, Stone (2020) provides bounds for fertility responses categorized into "low", "medium", and "high." Since some papers estimate the effects of multiple pro-fertility policies at the same time, we end up with 47 elasticity estimates.

The elasticity estimates in Stone (2020), however, are not immediately comparable to the anti-fertility estimates in Table 5 because Stone (2020) presented the results in terms of the percentage fertility change in response to an additional dollar given to each childbirth. Therefore, we use information on crude birth rates and age structure to convert the elasticity in Stone (2020) and Table 5 to ensure comparability. For country-level comparison, we convert Stone

(2020)'s meta-analysis result to a one unit increase in per child policy funding-household income's effect on the change rate of TFR; For individual-level comparison, we convert Stone (2020)'s meta-analysis result and the coefficient in column (2) of Table 5 to a one unit increase in per child policy funding-household income ratio's effect on the birth rate. Section C provides a detailed description on the conversion method.

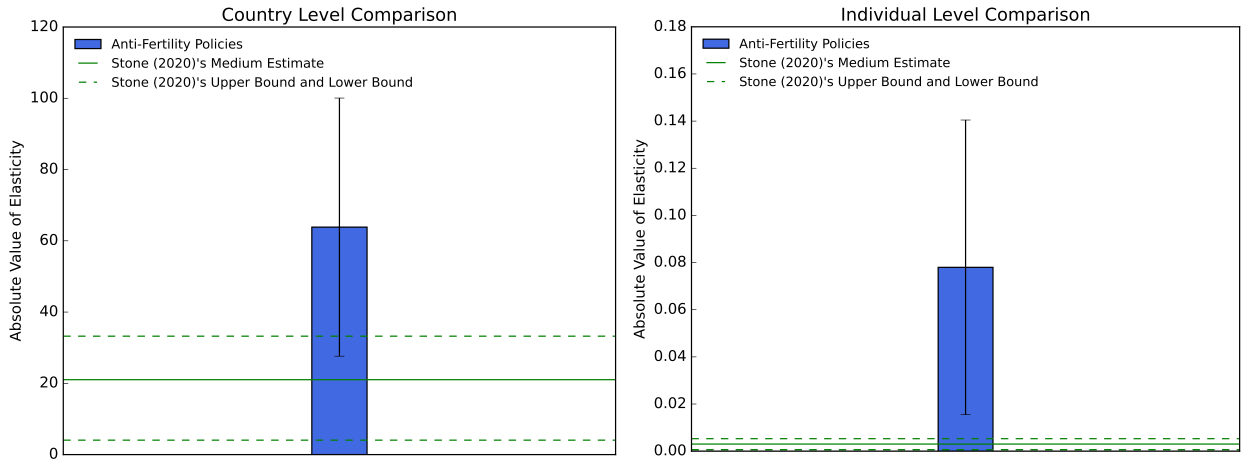
We present the comparison between anti-fertility policies and pro-fertility policies in Figure 9. The blue bars display the estimated elasticities for anti-fertility policies in Table 5, with the error bars representing the 95% confidence interval. The solid line is the average of converted "medium" estimated elasticity of pro-fertility policies from Stone (2020). Stone (2020) also summarized that the elasticity of pro-fertility policies generally falls between 0.5% and 4.1% in the meta-analysis, we thus convert and visualize these two bounds using dashed lines in Figure 9.[8] The comparison shows that anti-fertility policies' elasticity is considerably higher, even when we compare it with the upper bound of pro-fertility policies' estimated elasticity. The magnitude of asymmetry using policy expenditures at the country level is similar to the asymmetry effect we found in Section 2.2 using policy stances. At the individual level, the degree of asymmetry is even larger.

2.4 Robustness

We briefly flag several threats to our empirical findings and how we deal with each of them. The details of each check are presented in the Appendix. First, the asymmetry we observe may be driven by selection into treatment. That is, countries sensitive to anti-fertility policies are more likely to adopt such policies. We provide evidence that our conclusion is robust to selection into treatment in Section B.1. Second, countries' choice of fertility policy is not exogenous, but rather affected by TFR itself. This introduces the problem of reverse causality, which we deal with in Section B.2. Lastly, we show our conclusion is robust to employing alternative methods in the construction of dependent variables in Section B.3.

[8]It is unclear which studies Stone (2020) used to arrive at this range. We thus use the minimum birth rates that correspond to the studies included in Stone (2020) analysis to convert these two bounds. This method overestimates the elasticity of pro-fertility policies.

Figure 9: Comparison Between Anti-Fertility Policies and Pro-Fertility Policies



Source: Estimated elasticity of anti-fertility policies is from regression result in Table 5; estimated elasticity of pro-fertility policies is calculated as discussed in Section 2.3, and the data source are Stone (2020) and the Demographic indicators provided by the Population Division of Department of Economic and Social Affairs, United Nations.

2.5 Challenge to Existing Theories

The empirical facts presented above challenge existing models of fertility choice.

Briefly speaking, standard fertility models are set up as a utility maximization problem:

$$\max_{c,n,\ldots} \quad U(c,n,\ldots)$$

subject to budget constraint

$$c+\chi\cdot n+\ldots=I.$$

Because the objective function $U(\cdot)$ is smooth and the problem is concave, the model results in a smooth Marshallian demand curve $n(\chi,\ldots)$ in the aggregate economy where optimal fertility is a function of the cost of children χ and other prices in the economy.

The smoothness result holds uniformly in this class of models even when the setup is enriched in many different directions, such as considering (1) static or dynamic environments, (2) warm glow or altruistic preferences, (3) representative or heterogeneous agents, (4) continuous or discrete fertility choices, and (5) with or without the quantity-quality trade-off.

The smooth Marshallina demand $n(\chi,\ldots)$, however, is unable to generate the asymmetric fertility elasticities that we have documented in this paper because it implies that the elasticity of fertility to the cost of children does not depend on the direction that the cost changes. On the contrary, the data implies that the fertility responses to a rising χ are much larger than the responses to a falling χ.

2.6 Alternative Explanations

We flag two potential alternatives to reconcile the asymmetry with existing frameworks. First, as argued by Lutz et al. (2006), fertility decline could trigger various propagation mechanisms such as peer pressure, technological adoption, and so on. These propagation mechanisms, however, also work when fertility changes in the other direction. Therefore, for this explanation to generate asymmetric fertility elasticities, the underlying propagation mechanism needs to be inherently asymmetric and it begs the question.

The second alternative explanation points to the asymmetry in the toolbox of fertility policies available to the government. Maybe when the government wants to reduce fertility, it has access to a set of more effective tools, but when it wants to raise fertility, the set of tools becomes much less cost-effective. Therefore, the mapping between policy funding and the actual change in the shadow price of children that households face would depend on the policy direction.

We argue that there are two limitations to this "technological irreversibility" argument. First, the fertility policy toolbox available to the government is indeed diverse but technologically reversible. We categorize fertility policies into four categories, and for each of them, there have been historical examples of the policy being pursued in either direction:

1. Propaganda. During the one-child policy era in China, propaganda trying to persuade people to reduce fertility was widespread such as "It's better to make a family disappear than to make a second new birth appear" (Wang 2018). On the other hand, in recent pro-fertility campaigns in many developed economies, there has also been propaganda to encourage people to have more children, such as "Have one for mum, one for dad, and one for the country" in Australia or "Do it for Denmark."

2. Family policies. Again, during the one-child policy era in China, parents needed to pay

fines if their fertility exceeded the government-set quota. On the other hand, financial incentives such as the Child Tax Credit or baby bonuses have been adopted in a number of countries to encourage births.

3. Access to family planning technologies. Providing families with better access to contraceptive technologies has been one of the key policy instruments used in the global family planning movement. On the other hand, Decree 770 in Romania was a notorious example where the government restricted access to family planning technologies with the goal of raising fertility.

4. Reproductive coercion. During the anti-fertility movements in countries such as Bangladesh and China, there were examples of forced sterilization or abortion. On the other hand, during the Decree 770 episode in Romania, the government set a monthly birth quota for factory workers (Hord et al. 1991).

The key observation here is that while these four categories of policies have different levels of cost-effectiveness and repugnancy, each of them is *technologically feasible* in either direction. If governments systematically rely on certain policy categories depending on the policy direction, one needs to provide additional theories to provide a rationale for this choice.

The second limitation of the technological irreversibility explanation is fertility rate's asymmetric fertility responses to the *same policy*'s implementation and reversion within several years, as we have documented in Section 2.2.2. Such asymmetry in fertility rates' responses to policy implementation and reversion cannot be explained by technological irreversibility. The model we present in Section 3 rationalizes these findings.

3. The Model

This section presents a model of fertility choice under loss aversion and the proof that the model generates asymmetric fertility elasticities. We also develop the "slippery slope" perspective and discuss its properties after calibrating the model to match the data.

3.1 Setup

We consider the simplest problem of fertility choice where a representative household trades off fertility (n) versus consumption (c). In line with the behavioral economics literature, most notably Kahneman et al. (1991), we assume a level of reference consumption (r) below which the household suffers from extra disutility.[9]

The maximization problem of the household is

$$\max_{c,n} \quad \frac{1}{2}[u(c)+\beta u(n)] + \frac{1}{2}[G(u(c)-u(r))+u(r)] \tag{4}$$

subject to budget constraint

$$c + \chi \cdot n = 1 \tag{5}$$

where parameter χ is the cost of fertility in consumption units. The total amount of resources is normalized to one.

For any variable x, we assume that the utility function $u(\cdot)$ follows

$$u(x) = \frac{x^{1-\gamma}-1}{1-\gamma} \qquad \gamma > 1 \tag{6}$$

where parameter γ governs the elasticity of substitution between consumption and fertility. The sufficient condition $\gamma > 1$ guarantees that χ affects the optimal level of consumption c.

For any variable y, we assume that the loss aversion function $G(\cdot)$ follows

$$G(y) = \begin{cases} y & y \geq 0 \\ y - \alpha y^2 & y < 0 \end{cases} \tag{7}$$

where parameter $\alpha \geq 0$ governs the degree of loss aversion. If $\alpha = 0$, then $G(y) = y$ and the

[9] As pointed out by Kőszegi and Rabin (2006), Crawford and Meng (2011), and Thakral and Tô (2021), one could consider reference dependence over other aspects of the utility function – the number of children n in our model. In that case, the degree of loss aversion we calibrate in Section 3.5 reflects the degree of *relative loss aversion* between c and n.

household problem is simply

$$\max_{c,n} \; u(c) + \frac{\beta}{2} u(n) \qquad \text{subject to} \quad c + \chi \cdot n = 1. \tag{8}$$

which results in symmetric elasticities when we perturb the value of χ.

Instead of the piecewise-linear loss aversion function

$$G(y) = \begin{cases} y & y \geq 0 \\ \alpha y & y < 0 \end{cases} \qquad \alpha \geq 1 \tag{9}$$

commonly used in the literature, we adopt the functional form in Equation (7) because it generates a continuous $G'(y)$ at $y = 0$. This allows us to avoid inaction regions where an incremental change in χ leaves optimal c and n unchanged. As long as the change in χ is large enough, both functional forms in (7) and (9) generate asymmetric elasticities.

To close the model, we specify how the reference level of consumption is formed (Kőszegi and Rabin 2006). Given that this is a static model with representative households, we impose a natural consistency condition

$$r = c \tag{10}$$

so that the reference level coincides with the optimal consumption chosen by the household.

3.2 Asymmetric Elasticities

In this section, we state and prove two propositions on asymmetric fertility elasticities.

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 in the economy. Namely,

$$\left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{+,\alpha>0} < \left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{-,\alpha>0} < 0 \tag{11}$$

where n^* is the optimal fertility that solves the household maximization problem.

Proof: Because the assumption on $G(\cdot)$ generates continuous first-order conditions, we provide a graphical proof of Proposition 1.

After substituting $n = \frac{1}{\chi} \cdot (1-c)$ into the objective function, the first-order condition on c is

$$u'(c) \cdot \left(1 + G'(u(c) - u(r)\right) = \frac{\beta}{\chi} \cdot u'\left(\frac{1-c}{\chi}\right) \tag{12}$$

where the left-hand-side is the marginal benefit of consumption and the right-hand-side is the marginal cost of consumption. When $\alpha > 0$, the marginal benefit of consumption is continuous but has a kink around $c = r$.

In Figure 10, curve AD plots the marginal cost of consumption; curve BAC plots the marginal benefit of consumption when $\alpha = 0$, i.e., no loss aversion; and curve EAC plots the marginal benefit of consumption under loss aversion. When $c < r$, the household has a higher marginal benefit of consumption under loss aversion. Point A in the figure represents the optimal choice of c. The fact that the level of consumption at point A coincides with the reference level r reflects the consistency condition.

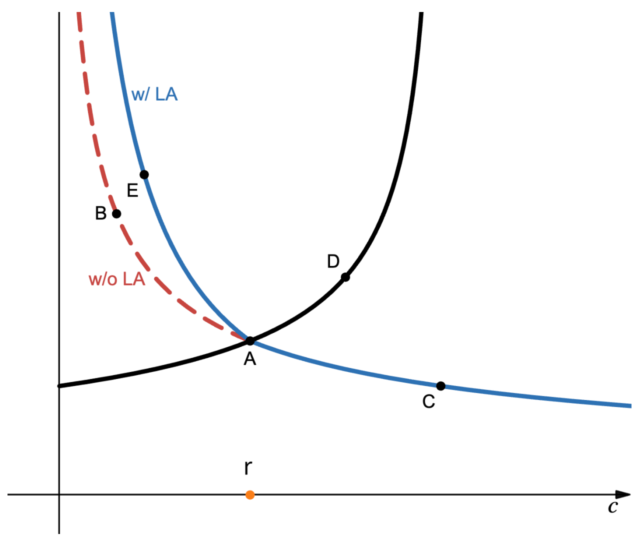


Figure 10: Marginal benefit and cost of consumption

Figure 11 plots the comparative static when χ falls. Because $\gamma > 1$, the marginal cost of consumption is an increasing function of χ. Hence, a falling χ shifts the curve AD downward. Point F characterizes the optimal level of consumption holding r unchanged. The response of consumption, and hence fertility due to the budget constraint, is identical with and without loss aversion.

On the other hand, Figure 12 plots the comparative static when χ rises. In this case, the

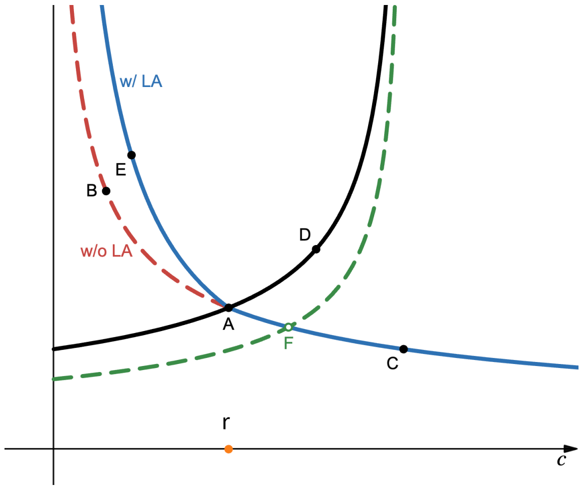


Figure 11: Child cost falls

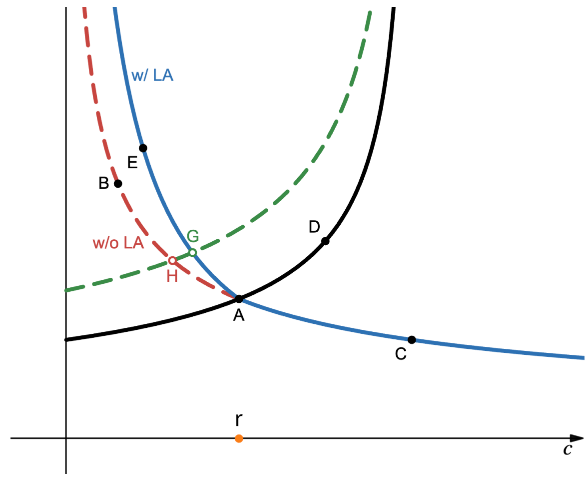


Figure 12: Child cost rises

curve AD shifts up. Because the marginal utility of consumption is higher under loss aversion when $c < r$, optimal consumption falls less when $\alpha > 0$. As a result, the adjustment in n is necessarily larger with loss aversion because the budget constraint still needs to hold.

When $\alpha = 0$, the household maximization problem reduces to the one in Equation (8) which generates a smooth Marshallian demand $\tilde{n}^*(\chi)$. Therefore, the fertility elasticity is the same in whichever direction we perturb χ. Therefore, if we combine the cases in Figures 11 and 12, we have the following relationship that proves Proposition 1.

$$\left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{+,\alpha>0} \overset{\text{Figure 12}}{<} \left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{+,\alpha=0} \overset{\text{smooth } \tilde{n}^*(\chi)}{=} \left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{-,\alpha=0} \overset{\text{Figure 11}}{=} \left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{-,\alpha>0} < 0 \tag{13}$$

In the next proposition, we show that fertility response is also asymmetric when the household faces perturbations of the reference level r in different directions.

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 in the economy. Namely,

$$\left.\frac{\partial \log n^*}{\partial \log r}\right|_{+,\alpha>0} < \left.\frac{\partial \log n^*}{\partial \log r}\right|_{-,\alpha>0} = 0 \tag{14}$$

where n^* is the optimal fertility that solves the household maximization problem.

Proof: Likewise, we present a graphical proof of Proposition 2.

When reference level r falls, the marginal benefit of consumption shifts to curve JIC. The optimal consumption c stays at point A with or without loss aversion. Therefore, optimal fertility n is unaffected by the fall in r.

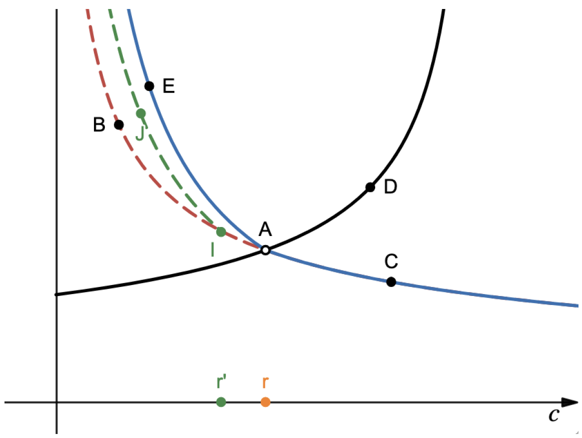


Figure 13: Reference falls

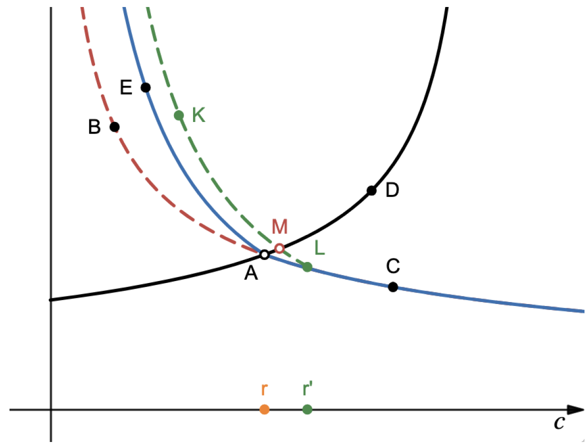


Figure 14: Reference rises

On the other hand, when r rises, the marginal benefit of consumption shifts to curve KLC. Therefore, while the optimal consumption stays at point A when $\alpha = 0$, it rises to M when $\alpha > 0$. As a result, fertility falls to balance the budget constraint when there is loss aversion.

Combining the two cases in Figures 13 and 14, we have the following relationship that proves Proposition 2.

$$\left.\frac{\partial \log n^*}{\partial \log r}\right|_{+,\alpha>0} \overset{\text{Figure 14}}{<} \left.\frac{\partial \log n^*}{\partial \log r}\right|_{+,\alpha=0} \overset{r \text{ is irrelevant}}{=} \left.\frac{\partial \log n^*}{\partial \log r}\right|_{-,\alpha=0} \overset{\text{Figure 13}}{=} \left.\frac{\partial \log n^*}{\partial \log r}\right|_{-,\alpha>0} = 0 \qquad (15)$$

3.3 The "Slippery Slope" Perspective

After establishing the asymmetry in a static environment, we study the dynamic implications of this phenomenon and present the definition of the "slippery slope" perspective.

In period t, the cohort of fertile households takes reference consumption r_t in the economy as given and makes the optimal fertility choice that maximizes their static utility. The decision problem is identical to the one presented in the previous section. Their optimizing behavior generates $c_t(r_t)$ and $n_t(r_t)$ which are functions of the reference r_t.

Motivated by Thakral and Tô (2021), we assume that the reference consumption r_t follows an adaptive reference updating process

$$r_t = \phi \cdot r_{t-1} + (1-\phi) \cdot c_{t-1} + \epsilon_t \qquad \epsilon_t \sim \mathcal{N}(0, \sigma^2) \tag{16}$$

where ϵ_t is realized in period t before the household makes fertility decision. Parameter ϕ governs the persistence of past reference r_t. Different from the setting in Thakral and Tô (2021) with deterministic updating, we assume that there exists a random component ϵ_t that captures changing aspirations or priorities across cohorts. Importantly, the distribution of ϵ_t is symmetric around zero, so we are not building in any trends in r_t by assumption.

There are two points worth noting here. First, Equation (16) captures one of the core intuitions in the Easterlin hypothesis. Easterlin (1968) conjectures that an individual's fertility depends on the "relative status" of her income compared with the living standard she experienced when she grew up. She will have more children if the "relative status" is high due to the income effect. Relative to Easterlin (1968), our setup incorporates (1) the persistence of past reference r_t, (2) random component ϵ_t, and most importantly (3) loss aversion around the relative status.

Second, while we focus on shocks to the reference level r_t and provide intuitions by invoking results from Proposition 2, the results will be qualitatively the same if we additionally consider idiosyncratic shocks to the cost of children χ and invoke results from Proposition 1. In real life, shocks to the cost of children could originate from innovations in household appliances (Greenwood et al. 2005), changing infant mortality (Doepke 2005), varying returns to human capital investments (Becker et al. 1990), etc.

Definition: The *"slippery slope" perspective* predicts that starting from any reference level r_0, the expected fertility $\mathbb{E}(n_t)$ declines with time while the expected consumption $\mathbb{E}(c_t)$ and reference level $\mathbb{E}(r_t)$ rises with time.

Proof: We focus on the evolution of expected fertility $\mathbb{E}(n_t)$ in two polar cases where $\phi = 1$ and $\phi = 0$, leaving the intermediate cases to numerical simulations below.

When $\phi = 1$, Equation (16) indicates that the reference level r_t follows a random walk and is unaffected by past household decisions c_{t-1}. Therefore, there are no expected drifts in reference level, consumption, and fertility, i.e.,

$$\mathbb{E}(r_t) = r_0 \qquad \mathbb{E}(n_t) = n_0 \qquad \mathbb{E}(c_t) = c_0 \qquad \forall t$$

When $\phi = 0$, Equation (16) indicates that the updating is perfect with $r_t = c_{t-1} + \epsilon_t$. Then we are back to the case analyzed in Figures 13 and 14. In half of the times, $\epsilon_t \leq 0$ and hence $c_t = c_{t-1}$. In the other half of the times, $\epsilon_t > 0$ and hence $c_t > c_{t-1}$. In other words, consumption either stays unchanged or goes up with probability one-half, which is equivalent to saying that fertility n_t either stays unchanged or goes down with probability one-half.

The value of ϕ in the data is likely somewhere between 0 and 1. Therefore, we conduct a numerical simulation of the "slippery slope" after calibrating the parameters in the model.

3.4 Implications on Leisure?

Before presenting the calibration and the numerical results, we would like to highlight the dynamic implications of the "slippery slope" on other decisions that individuals make in real life, such as labor supply versus leisure.[10]

The key observation here is that the "slippery slope" perspective *does not* necessarily imply declining leisure over time, which would run against existing evidence (Bick et al. (2018)), as long as leisure is considered as part of the living standard.

In particular, we can enrich the model with the labor-leisure decision where households solve:

$$\max_{e,l,n} \quad \frac{1}{2}[u(c) + \beta u(n)] + \frac{1}{2}[G(u(c) - u(r)) + u(r)] \tag{17}$$

The living standard c is a composite function of expenditures e and leisure l:

$$c = f(e, l) \tag{18}$$

The budget constraint is

$$e = w \cdot (1 - l - \chi \cdot n) \tag{19}$$

[10]We thank Chad Jones for this insightful comment.

where w is the productivity and $\chi \cdot n$ is the time cost of children. The loss aversion $G(\cdot)$ over living standard c is the same as before.

The household maximization problem can be solved via two-stage budgeting: first, we find the optimal combination of expenditure e and leisure l to achieve any living standard c; then, we find the optimal living standard c^* by equating its marginal benefits with marginal costs. As a result, the labor-leisure decision does not interact with the fertility choice once the living standard c is controlled for.

The key implication of this separation is that in a dynamic environment, the predictions on the expected fertility $\mathbb{E}(n_t)$, the expected consumption $\mathbb{E}(c_t)$, and the reference level $\mathbb{E}(r_t)$ remain essentially the same as the "slippery slope" perspective. On the other hand, whether leisure time rises or falls with the rising living standard (or productivity w) depends entirely on the composite function $f(e,l)$. For example, one can generate declining hours over time by using the class of utility functions proposed by Boppart and Krusell (2020) where income effects dominate substitution effects.

3.5 Calibration

We conduct a relatively simple calibration of the parameters in the model. We want to emphasize that the goal of the calibration is not to match a particular economy in some specific episodes. While it is for sure interesting and valuable to do so for tailored policy analysis, the primary goal of this section is to give some reasonable values to these parameters and see how the model behaves.

In total, we need to assign value to $\{\alpha, \beta, \chi, \gamma, \phi, \sigma\}$. First, we set the cost of children $\chi = 0.075$ following the past literature such as Greenwood and Seshadri (2002). Then, we calibrate $\beta = 34$ so that in the static equilibrium where the consistency condition $r = c$ holds, the fertility level rests at the replacement rate $n = 2.1$.

Second, because parameter γ governs the elasticity of substitution between consumption and fertility, We target it to match the cost-effectiveness of pro-fertility policies found in the literature (see Stone (2020)). In particular, I target an elasticity of 0.3 where a 1 percent fall in the price of children raises the fertility rate by 0.3%. This gives $\gamma = 5.9$.

The value of α is calibrated to match the degree of asymmetry, i.e., the ratio of elasticities when we perturb χ in different directions, estimated in the empirical section. After targeting $\left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{+,\alpha>0} \Big/ \left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{-,\alpha>0} = 3$, the calibrated value of α is 98.

Lastly, there is little empirical guidance for us to set the values for ϕ and σ. Therefore, we pick $\phi = 0.95$ and $\sigma = 0.01$ exogenously given that we are calibrating the model at the annual frequency. The qualitative predictions of the model are unaffected by these choices as long as ϕ is between 0 and 1.

3.6 Quantitative Results

After calibrating the model, we simulate $N = 1000$ paths for $T = 40$ periods. Every path starts with $n_0 = 2.1$ and $r_0 = c_0 = 1 - \chi \cdot n_0$, i.e., a reference level consistent with the prevailing consumption decision.

Figure 15 plots the mean and the median of fertility across paths over time. As can be seen, when there is no loss aversion ($\alpha = 0$), the household's decision problem is identical in each period and hence $n_t = 2.1$ for all t. When there is loss aversion ($\alpha > 0$), however, average fertility is declining over time, as predicted by the "slippery slope" perspective. Moreover, the fact that the median is higher than the mean points to a skewed distribution of fertility evolution driven by large positive shocks ϵ_t. Lastly, while expected fertility is a declining function of time, it will not go all the way down to zero. We can provide a lower bound to $\lim_{T\to\infty} \mathbb{E}(n_T)$ by simply plugging $r = 1$ into the household decision problem. This is because the expected reference level is bounded above by the amount of total resources.

The flip side of the falling fertility is a rising reference level $\mathbb{E}(r_t)$ presented in Figure 16. Over time, households have higher expectations of their living standard on average. Because the shock ϵ_t is symmetric around zero, this trend in reference is entirely driven by the loss aversion in preferences. In other words, consider two households starting with identical r_{t-1} and c_{t-1} in Equation (16), but one has $\epsilon_t = \Delta$ and the other one has $\epsilon_t = -\Delta$ where Δ is a small positive number. Due to loss aversion, the optimal responses of these two households are not equal in magnitude – the one receiving a positive shock will raise her consumption relatively more.

The "slippery slope" perspective is very different from traditional views of fertility evolution because where fertility trends are mostly, if not all, driven by the evolution of economic fundamentals such as resource scarcity (Malthus 1872, Vogl 2016), opportunity costs of children

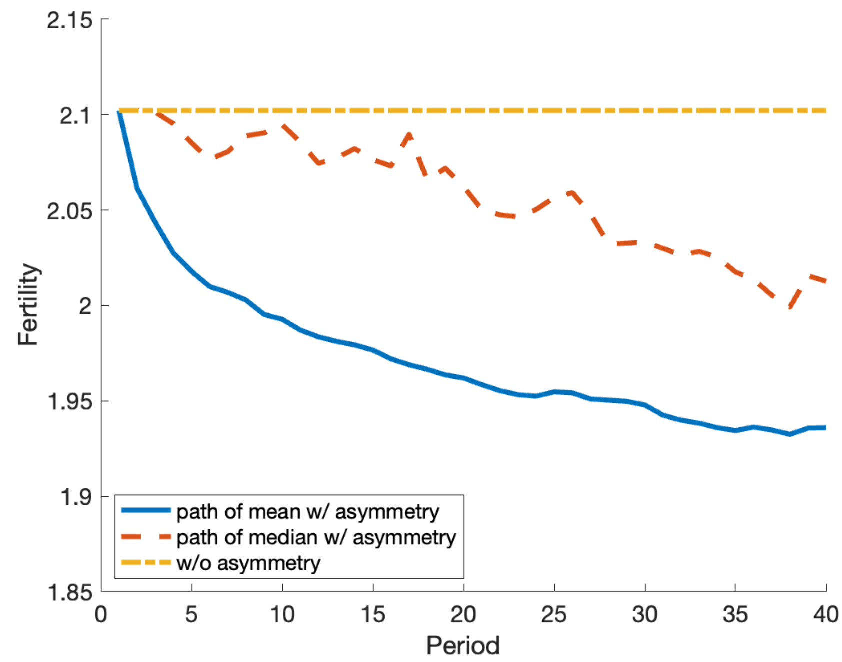


Figure 15: The "Slippery Slope"

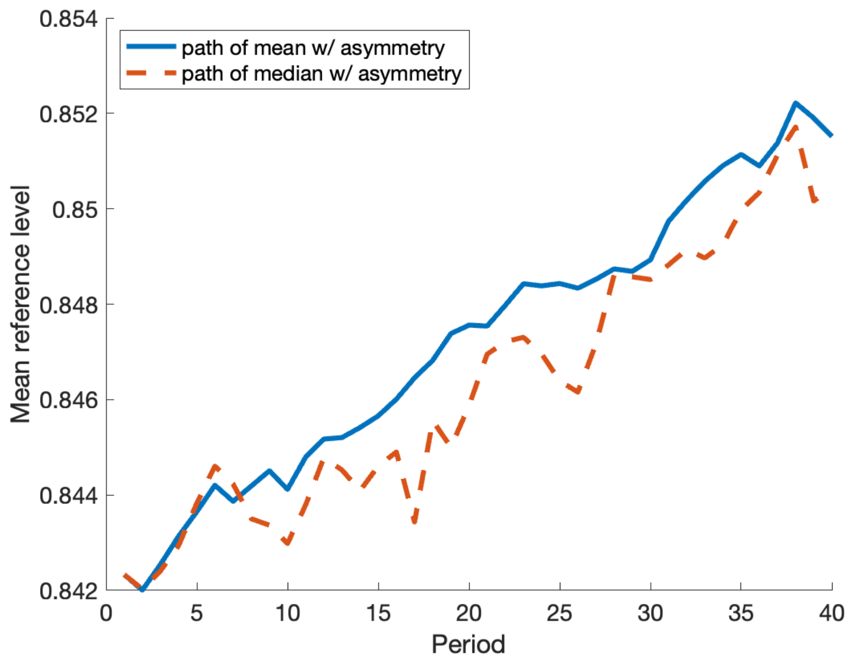


Figure 16: The Time Path of Reference Consumption Level

(Caucutt et al. (2002)), maternal morbidity (Albanesi and Olivetti 2016), or returns to education (Becker et al. 1990, Galor and Weil 2000). The model presented here, however, provides an intriguing exception. Along the "slippery slope," the fertility trend is driven by symmetric shocks to the reference consumption which can be interpreted as aspirations or priorities.

The framework in this paper provides theoretical support to the conclusion in Kearney et al. (2022). In their paper, Kearney et al. (2022) shows that the unexpected drop in fertility in the United States after the Great Recession cannot be explained by changes in economic fundamentals. Instead, they argue that changing priorities may be the main driver in the background. The model complements their view with two additional predictions. First, the observed drop in fertility in the last decade may not be a special episode in history. As the persistence of social norm ϕ falls, such drops in fertility may even occur half of the time along the "slippery slope." Second, if the government wants to maintain a certain level of fertility, it may need to pour more and more resources into family policies over time.

4. Policy Implications

In this section, we further develop the policy implications of the "slippery slope" perspective.

4.1 Setup

To better structure the analysis, we consider the following scenario: At $t = 0$, the government is allowed to make a permanent change to the cost of children χ and start off the economy from an equilibrium where the consistency condition holds. In each period, the government faces social costs $\mathscr{S}(n_t|\overline{n})$ that takes the form

$$\mathscr{S}(n_t|\overline{n}) = \lambda \cdot (\log(n_t) - \log(\overline{n}))^2 \tag{20}$$

where $\overline{n}$ is some predetermined level of fertility and parameter λ governs the scale of the social cost. The government's problem is to choose the level of initial fertility to minimize the net present value of the social cost subject to the fact that fertility evolves along the "slippery slope" presented in the previous section. In other words, the government solves

$$\max_{n_0} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \rho^t \mathscr{S}(n_t|\overline{n}) \tag{21}$$

where ρ is the social discount factor. The values of n_t are optimizing decisions by each generation of households subject to the stochastic evolution of the reference consumption level.

4.2 Discussions

There are three points worth noting here. First, the social cost $\mathscr{S}(\cdot)$ is a parsimonious way to capture the well-established externalities of childbearing decisions, such as environmental considerations (Bohn and Stuart 2015) and parents' lack of property rights on their children's output (Schoonbroodt and Tertilt 2014). The important assumption here is that the social cost is symmetric around some level $\overline{n}$. Therefore, if the solution to the government problem is different from $\overline{n}$, it is not caused by in-built asymmetries in the social cost function.

Second, we choose to set up a cost-minimization problem instead of a Ramsey problem where the government maximizes the discounted utility of the households for two main reasons. First, it is ex-ante unclear how fertility policies enter the households' decision problem because these policies come in so many forms in real life. Even within narrowly defined policy categories such as baby bonuses, such policies can be delivered in many different ways that would have drastically different implications on households' utility. Second, choosing the "right" social welfare function in the context of endogenous fertility is a well-known issue in the literature (e.g., see Golosov et al. 2007). While a full-fledged Ramsey problem would certainly be interesting, we leave that for future research.

Lastly, we simplify the problem by assuming that the government can only make one decision – permanently changing the cost of children. This assumption lets us abstract away from commitment problems and frequent policy reversals. Given that population and fertility goals are one of the policy decisions with the longest planning horizon and large switching costs, we think this assumption is not too far away from reality.

4.3 Results

We conduct a simple calibration of $\{\overline{n}, \rho, \lambda\}$ before presenting the results. Like the calibration in Section 3.5, the goal here is to choose some reasonable parameters and demonstrate the *qualitative* implications.

We set $\overline{n} = 2.1$, the replacement rate, as it is the level of fertility that maintains a constant population in the long run. It is also one of the most commonly stated policy goals (Striessnig and Lutz 2013). The parameter value of λ is set to be 0.2. To get a sense of what this value implies, the total fertility rate in the United States in 2022 is 1.64 children per woman. With $\lambda = 0.2$, this below-replacement fertility results in a social cost that is 0.64% of GDP. Lastly, we choose $\rho = 0.96$ as the social discount factor in the benchmark analysis.

Implication 1: Unless the discount factor is zero, choosing the replacement rate as the initial level of fertility is never cost-minimizing.

Figure 17 plots the relationship between initial fertility and the expected net present value of social costs. When there is no loss aversion ($\alpha = 0$), the cost-minimizing initial fertility is $n_0 = \overline{n} = 2.1$ – the replacement rate. If the government chooses the level of child costs such that $n_0 = 2.1$, it sets the economy on a path with $n_t = 2.1$ for all t which implies zero social costs in each period. When there is loss aversion ($\alpha > 0$), however, the cost-minimizing initial fertility n^* is *higher* than the replacement rate. In the baseline quantification, n^* is around 2.25 children per woman.

Figures 18 and 19 explain why $n^* = 2.25$ leads to a lower cost. Figure 18 indicates that if the government chooses $n_0 = \overline{n} = 2.1$, expected fertility quickly falls below $\overline{n}$ due to the slippery slope nature of $\mathbb{E}(n_t)$. On the other hand, if the economy starts at $n_0 = n^* = 2.25$, the trajectory $\mathbb{E}(n_t)$ *crosses* the replacement rate from above.[11]

Figure 19 translates these two trajectories of expected fertility into the units of social costs $\mathbb{E}\mathscr{S}(n_t|\overline{n})$. While the path with $n_0 = 2.1$ results in monotonically rising social costs, the path with $n^* = 2.25$ has a path of social cost that first decreases to zero and then increases.

Importantly, when the government evaluates a fertility path where $\mathbb{E}(n_t)$ crosses $\overline{n}$ from above, there is a novel inter-temporal trade-off of social costs. And as long as the social discount factor $\rho > 0$, we can always find some $n_0 > \overline{n}$ that strictly dominates the path with $n_0 = \overline{n}$.

[11]These two paths follow the same trajectory because we use the same seed for random shocks ϵ_t.

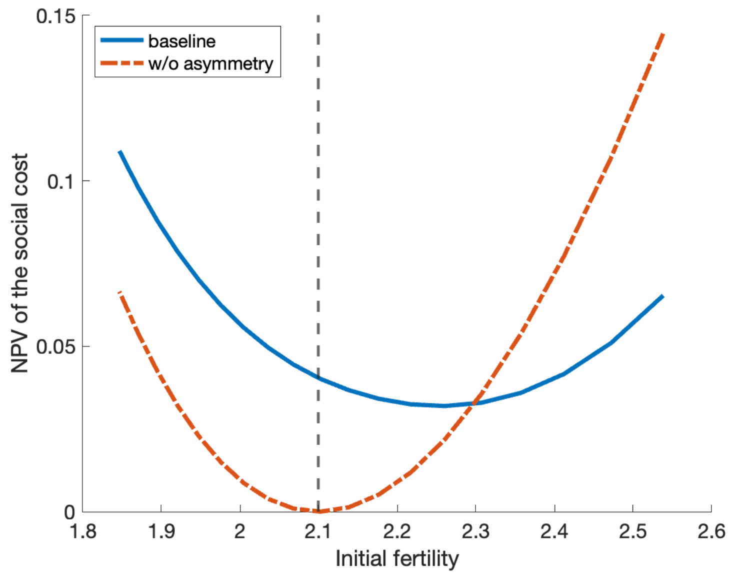


Figure 17: Initial Fertility and Expected NPV of Social Costs

In other words, under asymmetric fertility elasticities and the presence of shocks ϵ_t, the government has *precautionary motives* to set $n_0 > \overline{n}$ in anticipation of the likely event of future fertility decline.

Implication 2: The cost-minimizing initial fertility level depends on the degree of asymmetry, the reference updating process, and the social discount factor.

Lastly, Figure 19 also clarifies that the exact value of n_0 that minimizes the net present value of the social cost depends on several parameters. In particular, the slope of the fertility trajectory depends crucially on the degree of loss aversion α, the persistence of past reference ϕ, and the dispersion of shocks σ. On top of that, the calculations of the inter-temporal trade-off of social costs depend crucially on the social discount factor ρ.

5. Conclusion

A remarkable reversal has taken place in the past few decades as many countries shifted their policy priorities from suppressing to maintaining or promoting childbirth.

Exploiting rich data from this era, we document asymmetric responses to pro- versus anti-fertility policies – a novel fact that challenges existing fertility theories. To explain this fact,

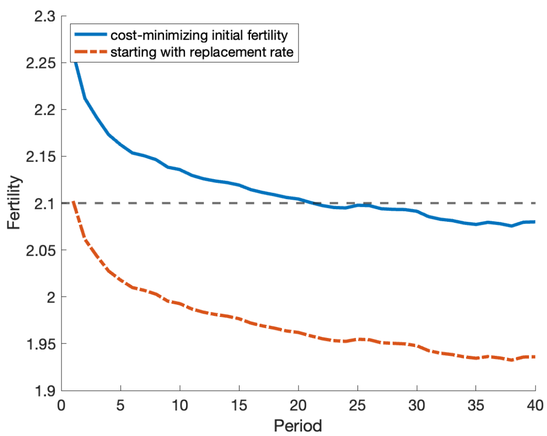


Figure 18: Path of Expected Fertility

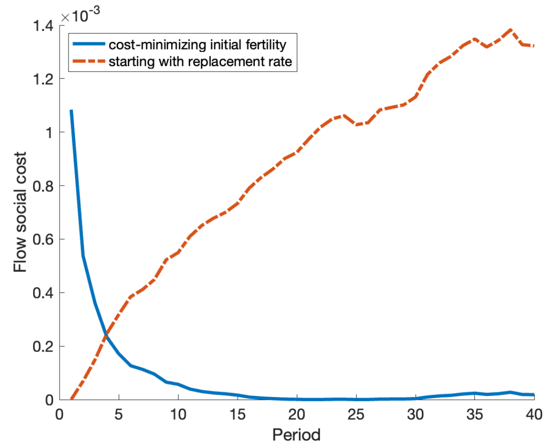


Figure 19: Path of Expected Social Costs

we propose a new model of fertility choice under loss aversion to living standards. The model naturally leads to a "slippery slope" perspective where fertility rates face sustained downward pressure even without any changes in the underlying economic fundamentals. This perspective suggests that governments concerned with population externalities have a precautionary motive to set a higher fertility target than previously thought.

As many economists and policymakers have pointed out, understanding the cause, the consequence, and the methods to address the below-replacement fertility rate is one of the most fundamental challenges for generations to come. We believe that this paper takes a valuable first step in this important research agenda. We look forward to more papers on this topic in the future.

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Appendix

A. Summary Statistics

A.1 Summary Statistics of Aggregate Data

Table A1: Summary Statistics of Aggregate Data

	Mean	SD	Min	Max	Obs
Dependent Variables					
TFR	4.1109	2.0216	0.8270	8.8730	10976
Change Rate of TFR	-0.0130	0.0268	-0.2613	0.9263	10726
Policy Variables					
Fertility Policy: Lower	0.2622				14711
Fertility Policy: Raise	0.1161				14711
Fertility Policy: Lower					
(Average In the Last Five Years)	0.2619	0.4333	0.0000	1.0000	13427
Fertility Policy: Raise					
(Average In the Last Five Years)	0.1125	0.3096	0.0000	1.0000	13427
Anti-fertility policy funding					
-GDP Ratio	6.65×10^{-6}	2.68×10^{-5}	9.11×10^{-9}	0.0012	3068
Anti-fertility policy funding					
Anti-fertility policy funding					
(Average In the Last Five Years)	6.64×10^{-6}	1.76×10^{-5}	1.13×10^{-8}	0.0003	2808
Control Variables					
Anti-fertility policy funding					

Continued on next page

Table A1: Summary Statistics of Aggregate Data (Continued)

(In 2005 Dollars)	20165.58	35868.75	382812.7	147.9402	11618
Change Rate of					
Real GDP Per Capita	-0.0175	0.0745	-0.6642	1.7775	11328
Urbanization Rate	48.2997	25.2770	2.0770	100.0000	14578
Change Rate of					
Urbanization Rate	0.0132	0.0297	-0.8621	0.8000	14578
Infant Mortality Rate					
(Per 1000 Births)	61.2946	49.5256	1.6000	276.9000	13280
Change Rate of					
Infant Mortality Rate	-0.0322	0.0359	-0.5000	0.4167	13280
Female labor Participation Rate	49.01113	17.9245	8.5000	90.8000	11160
Change Rate of					
Female labor Participation Rate	0.0059	0.0440	-0.6897	0.9600	11160

A.2 Summary Statistics of Micro Data

Table A2: Summary Statistics of Micro Data

	Mean	SD	Min	Max	Obs
Dependent Variables					
Number of Children	1.7088	1.5752	0.0000	5.0000	450869
Policy Variables					
Fertility Policy: Lower					
(Time Window: 13-23)	0.0567	0.1097	0.0000	0.5714	332524
Fertility Policy: Raise					

Continued on next page

Table A2: Summary Statistics of Micro Data (Continued)

(Time Window: 13-23)	0.0161	0.0680	0.0000	0.5714	332524
Fertility Policy: Lower					
(Time Window: 15-25)	0.0558	0.1094	0.0000	0.5714	316757
Fertility Policy: Raise					
(Time Window: 15-25)	0.0168	0.0697	0.0000	0.5714	316757
Fertility Policy: Lower					
(Time Window: 20-30)	0.0542	0.1082	0.0000	0.5714	276009
Fertility Policy: Raise					
(Time Window: 20-30)	0.0187	0.0187	0.0000	0.5714	276009
Individual Control Variables					
Gender: Male	0.4804				445989
Gender: Female	0.5196				445989
Age	41.3552	16.2896	13.0000	103.0000	446066
Age: 15-24	0.1710				444812
Age: 25-34	0.2313				444812
Age: 35-44	0.2060				444812
Age: 45-54	0.1609				444812
Age: 55-64	0.1240				444812
Age: 65 and More Years	0.1068				444812
Education: Lower	0.2801		-		412614
Education: Middle	0.4316				412614
Education: Higher	0.2883				412614
Income: Lower Step	0.0936				411355

Continued on next page

Table A2: Summary Statistics of Micro Data (Continued)

Income: Second Step	0.1017				411355
Income: Third Step	0.1303				411355
Income: Fourth Step	0.1432				411355
Income: Fifth Step	0.1819				411355
Income: Sixth Step	0.1290				411355
Income: Seventh Step	0.1011				411355
Income: Eighth Step	0.0629				411355
Income: Ninth Step	0.0284				411355
Income: Tenth Step	0.0279				411355
Macro Control Variables					
Real GDP Per Capita					
(Time Window: 13-23)	8247.1410	10632.76	148.7257	61317.37	338619
Real GDP Per Capita Change Rate					
(Time Window: 13-23)	0.0542	0.0786	-0.4329	1.6001	334225
Real GDP Per Capita					
(Time Window: 15-25)	8510.9745	8510.97	148.7257	75601.22	341104
Real GDP Per Capita Change Rate					
(Time Window: 15-25)	0.0560	0.0803	-0.4329	1.6001	336982
Real GDP Per Capita					
(Time Window: 20-30)	9148.7555	9148.76	148.7257	81632.84	337379
Real GDP Per Capita Change Rate					
(Time Window: 20-30)	0.0583	0.0805	-0.4329	1.6001	333524

B. Additional Empirical Results

B.1 Robustness: Selection Into Treatment

In this section, we provide evidence that our result is robust to selection into treatment. In Table A3 and A4, we include the interaction term between year fixed effect and TFR, real GDP per capita, urbanization rate, infant mortality rate, female labor participation rate in 1960. The empirical result shows that the asymmetric effect of fertility policy exists even when we conditional on countries' initial economic and social situation in 1960. The result for policy stances is presented in Table A5, and the conclusion is consistent with our findings in Table 1. In Table A4, we present the results for elasticity estimation, which shows that anti-fertility policies may work better in countries starting with lower fertility rate. To summarize, our conclusion is robust to selection into treatment.

B.2 Robustness: Reverse Causality

We present robust results regarding reverse causality in this section. In Table A7 and A8, we control average TFR in the last five years to ease the concern of reverse causality. The empirical result is similar to that in our baseline setting, and the asymmetric effect of fertility policy remains.

B.3 Alternative Construction Methods of Independent Variables

In this section, we provide empirical results using several alternative construction methods of dependent variables. In Figure A1, we replicate the analysis in Table 1, while replacing the independent variable by policy exposure in the last N years, where we change vary N in the range $[1, 10]$. A similar method is applied to the elasticity estimation of anti-fertility policies in Figure A3. In Figure A2, we replicate the analysis in Table 3, while assuming that the middle point of all individuals' treatment time window is the same in the construction of policy exposure variables, regardless of their residential country and year of birth. We vary this middle point from 20 years old to 30 years old.

Table A3: Population Policy and TFR: Selection Into Treatment

Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate					
Construction of Policy Variables	Last Year		Average in the Last Five Years		Average in the Last Ten Years	
	(1)	(2)	(3)	(4)	(5)	(6)
Lower fertility	-0.0052***	-0.0052***	-0.0054***	-0.0059***	-0.0056***	-0.0057*
	(0.0015)	(0.0017)	(0.0018)	(0.0022)	(0.0024)	(0.0029)
Raise fertility	0.0005	0.0011	0.0002	0.0002	0.0028	0.0020
	(0.0030)	(0.0030)	(0.0038)	(0.0036)	(0.0035)	(0.0036)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect× Control Variables and TFR in 1960	Yes	Yes	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes	No	Yes
Observations	10301	7373	9545	6821	8595	6126
R^2	0.201	0.225	0.199	0.225	0.212	0.251

[1] Source: Policy variables are collected from the UN World Population Policies Database; TFR and control variables are collected from the World Bank's World Development Indicators. For missing values, we conduct nearest neighbor interpolation.
[2] Note: The table reports the result of regressions of the change rate of TFR on fertility policy variables. In columns (1) and (3), the indicator of fertility policies in the last year is used as the dependent variable; in columns (3) and (4), the fraction of years exposed to corresponding fertility policies in the last five years is used as the dependent variable. Columns (1) and (4) control for country fixed effects and the interaction between year fixed effect and TFR, real GDP per capita, urbanization rate, infant mortality rate, and female labor participation rate in 1960; columns (2) and (4) add control variables. Control variables include both the absolute level and growth rate of real GDP per capita, urbanization rate, infant mortality rate, female labor participation rate, and years of schooling for women. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Table A4: Elasticity Estimation for Anti-Fertility Policy: Selection Into Treatment

Dependent Variable	ΔTotal Fertility Rate/ Lagged Total Fertility Rate	
Construction of Policy Variables	Average in the Last Five Years	
	(1)	(2)
Anti-fertility policy funding-GDP Ratio	-75.22***	-72.89**
	(20.21)	(32.42)
Country Fixed Effect	Yes	Yes
Year Fixed Effect× Control Variables and TFR in 1960	Yes	Yes
Control Variables	No	Yes
Observations	2546	2203
R^2	0.441	0.428

Source: Anti-fertility policy funding is from Nortman (1982), Nortman and Hofstatter (1978) and Ross et al. (1993); TFR, GDP, and control variables are collected from World Bank's World Development Indicators. For missing values, we conduct nearest neighbor interpolation.
Note: The table reports the result of regressions of the change rate of the number of children on the average anti-fertility policy funding-GDP ratio in the last five years. Column (1) controls for country fixed effect and the interaction between year fixed effect and TFR, real GDP per capita, urbanization rate, infant mortality rate, and female labor participation rate in 1960; column (2) adds control variables. Control variables include both the absolute level and growth rate of real GDP per capita, urbanization rate, infant mortality rate, female labor participation rate, and years of schooling for women. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Table A5: Population Policy and TFR: Using Subsamples

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		Average in the Last Ten Years	
	(1)	(2)	(3)	(4)	(5)	(6)
Lower fertility	-0.0076***	-0.0041***	-0.0085***	-0.0040*	-0.0090***	-0.0031
	(0.0014)	(0.0015)	(0.0018)	(0.0020)	(0.0024)	(0.0028)
Raise fertility	0.0003	0.0001	-0.0005	0.0002	0.0000	0.0010
	(0.0058)	(0.0055)	(0.0058)	(0.0056)	(0.0056)	(0.0056)
Observations	5724	4027	5292	3723	4752	3343
R^2	0.335	0.385	0.311	0.363	0.299	0.349
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		Average in the Last Ten Years	
	(1)	(2)	(3)	(4)	(5)	(6)
Lower fertility	-0.0150***	-0.0096*	-0.0157***	-0.0111	-0.0144***	-0.0133*
	(0.0028)	(0.0057)	(0.0027)	(0.0071)	(0.0035)	(0.0056)
Raise fertility	0.0017	0.0014	0.0012	0.0009	0.0055	0.0050
	(0.0038)	(0.0039)	(0.0051)	(0.0052)	(0.0043)	(0.0048)
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	4527	3346	4253	3098	3843	2783
R^2	0.125	0.146	0.127	0.155	0.154	0.199

[1] Source: Policy variables are collected from the UN World Population Policies Database; TFR and control variables are collected from the Penn World Table 10.0, Barro and Lee (2013), and the World Bank's World Development Indicators. For missing values, we conduct nearest neighbor interpolation.
[2] Note: The table reports the result of subsample regressions of the change rate of TFR on fertility policy variables. Panel A uses countries with TFR higher than the median in 1960 and panel B uses countries with TFR equal to or lower than the median in 1960. In columns (1) and (2), fertility policy stance in the last year is used as the dependent variable; in columns (3) and (4), the fraction of years exposed to corresponding fertility policies in the last five years is used as the dependent variable. Columns (1) and (3) control for two-way fixed effects; columns (2) and (4) add additional control variables. Control variables include both the absolute level and growth rate of real GDP per capita, urbanization rate, infant mortality rate, female labor participation rate, and years of schooling for women. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Table A6: Elasticity Estimation for Anti-Fertility Policy: Using Subsamples

Panel A: Subsample with High TFR in 1960		
Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate	
Construction of Policy Variables	Average in the Last Five Years	
	(1)	(2)
Anti-fertility policy funding-GDP Ratio	11.6889	-450.0354
	(278.7503)	(486.8131)
Observations	796	596
R^2	0.613	0.697
Panel B: Subsample with Low TFR in 1960		
Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate	
Construction of Policy Variables	Average in the Last Five Years	
	(1)	(2)
Anti-fertility policy funding-GDP Ratio	-76.8414***	-113.3831*
	(25.3146)	(63.6806)
Country Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Control Variables	No	Yes
Observations	2052	1864
R^2	0.158	0.202

[1] Source: Anti-fertility policy Funding is from Nortman (1982), Nortman and Hofstatter (1978) and Ross et al. (1993); TFR and control variables are collected from the Penn World Table 10.0, Barro and Lee (2013), and the World Bank's World Development Indicators. For missing values, we conduct nearest neighbor interpolation.

[2] Note: The table reports the result of subsample regressions of the change rate of TFR on the average anti-fertility policy funding-GDP ratio in the last five years. Panel A uses countries with TFR higher than the median in 1960 and panel B uses countries with TFR equal to or lower than the median in 1960. Column (1) controls for two-way fixed effects; Column (2) adds additional control variables. Control variables include both the absolute level and the growth rate of real GDP per capita, urbanization rate, infant mortality rate, female labor participation rate, and years of schooling for women. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Table A7: Population Policy and TFR: Control Average TFR in the Last Five Years

Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate					
Construction of Policy Variables	Last Year		Average in the Last Five Years		Average in the Last Ten Years	
	(1)	(2)	(3)	(4)	(5)	(6)
Lower fertility	-0.0121***	-0.0048***	-0.0133***	-0.0053***	-0.0140***	-0.0057**
	(0.0015)	(0.0017)	(0.0016)	(0.0020)	(0.0020)	(0.0026)
Raise fertility	0.0032	0.0011	0.0033	0.0009	0.0064	0.0033
	(0.0037)	(0.0034)	(0.0043)	(0.0037)	(0.0041)	(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
Average TFR in the Last Five Years	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9489	6809	9489	6809	8543	6118
R^2	0.132	0.182	0.133	0.182	0.159	0.221

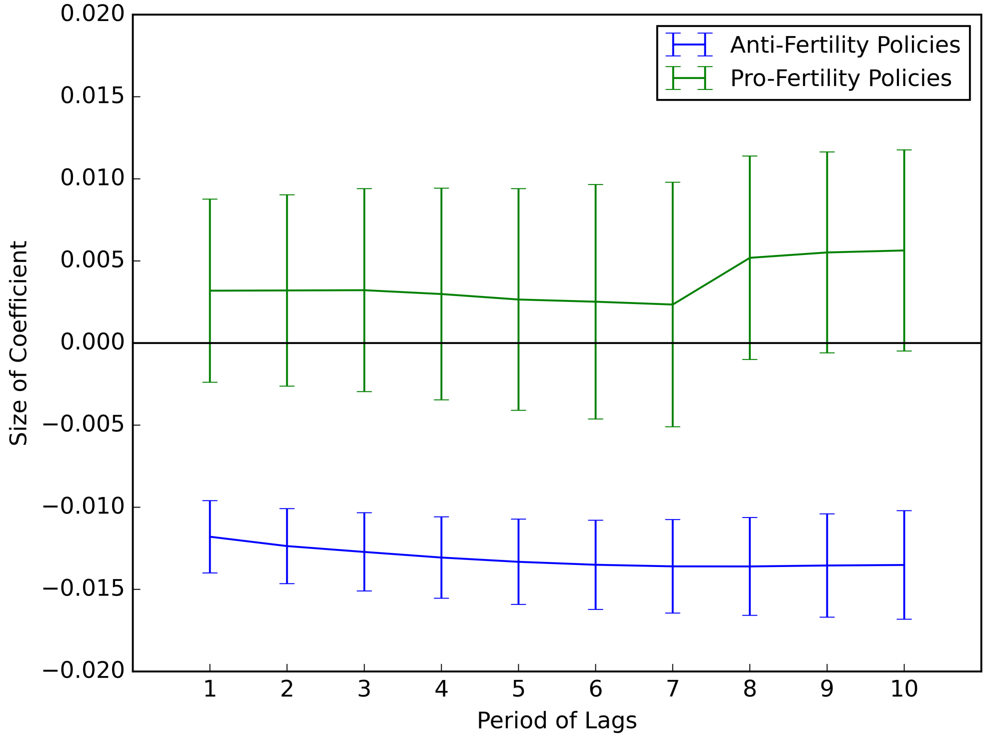
[1] Source: Policy variables are collected from the UN World Population Policies Database; TFR and control variables are collected from the World Bank's World Development Indicators. For missing values, we conduct nearest neighbor interpolation.
[2] Note: The table reports the result of regressions of the change rate of TFR on fertility policy variables. In columns (1) and (2), the indicator of fertility policies in the last year is used as the dependent variable; in columns (3) and (4), the fraction of years exposed to corresponding fertility policies in the last five years is used as the dependent variable; in columns (5) and (6), the fraction of years exposed to corresponding fertility policies in the last five years is used as the dependent variable. Columns (1), (3) and (5) control for country fixed effect, year fixed effect, and average TFR in the last five years; columns (2), (4) and (6) add control variables. Control variables include both the absolute level and growth rate of real GDP per capita, urbanization rate, infant mortality rate, and female labor participation rate. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Table A8: Elasticity Estimation for Anti-Fertility Policy: Control Average TFR in the Last Five Years

Dependent Variable	ΔTotal Fertility Rate/ Lagged Total Fertility Rate	
Construction of Policy Variables	Average in the Last Five Years	
	(1)	(2)
Anti-fertility policy funding-GDP Ratio	-69.42***	-72.33***
	(24.09)	(24.24)
Country Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Control Variables	No	Yes
Average TFR in the Last Five Years	Yes	Yes
Observations	2542	2199
R^2	0.208	0.277

[1] Source: Anti-fertility policy funding is from Nortman (1982), Nortman and Hofstatter (1978) and Ross et al. (1993); TFR, GDP, and control variables are collected from World Bank's World Development Indicators. For missing values, we conduct nearest neighbor interpolation.
[2] Note: The table reports the result of regressions of the change rate of TFR on the average anti-fertility policy funding-GDP ratio in the last five years. Columns (1) and (3) control for country fixed effect, year fixed effect, and average TFR in the last five years; column 2 adds control variables. Control variables include both the absolute level and growth rate of real GDP per capita, urbanization rate, infant mortality rate, and female labor participation rate. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Figure A1: Population Policy and TFR Using Different Year Ranges



B.4 Asymmetric Response of Policy Implementation and Reversion: An Alternative Strategy

One potential concern is that our observations in Table 2 may be the result of a lagged policy effect, e.g., it takes time for the reversion of anti-fertility policies to work fully. In that case, we may underestimate $\beta_{N,L}$, which could drive our empirical observation of $\beta_{L,N} > \beta_{N,L}$. To address this concern, we adopt an alternative strategy similar to that of González and Trommlerová (2023). We first group consecutive years with the same policy stance into the same policy period. Then we check the current policy's effect on TFR, conditional on the previous policy period's policy stance, instead of conditional on last year's policy stance. Figure A4 provides an example of González and Trommlerová (2023)'s period division method. The empirical result of this alternative strategy is presented in Table A9. The conclusion is similar to those in Table 2.

Figure A2: Population Policy and Children Number Using Different Time Windows

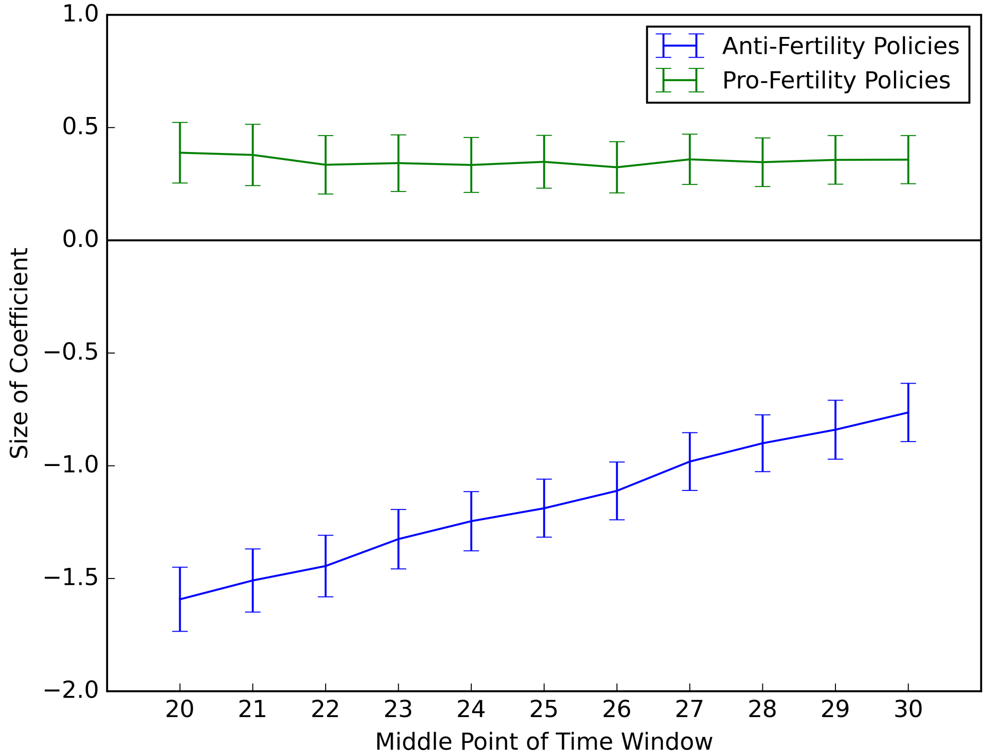


Table A9: Asymmetric Response of Policy Implementation and Reversion: Alternative Strategy

	No Intervention/ Maintain	Lower	Raise
No Intervention/ Maintain	NA	-0.0009	-0.0011
		(0.0037)	(0.0053)
Lower	-0.0137***	-0.0099**	-0.0158***
	(0.0018)	(0.0042)	(0.0042)
Raise	0.0025	0.0143**	0.0039
	(0.0039)	(0.0064)	(0.0054)

C. Comparison of Elasticity

In this section, we briefly introduce how we make our estimation result in Section 2.3 comparable with Stone (2020)'s meta analysis result.

Figure A3: Elasticity Estimation for Anti-Fertility Policy Using Different Year Ranges

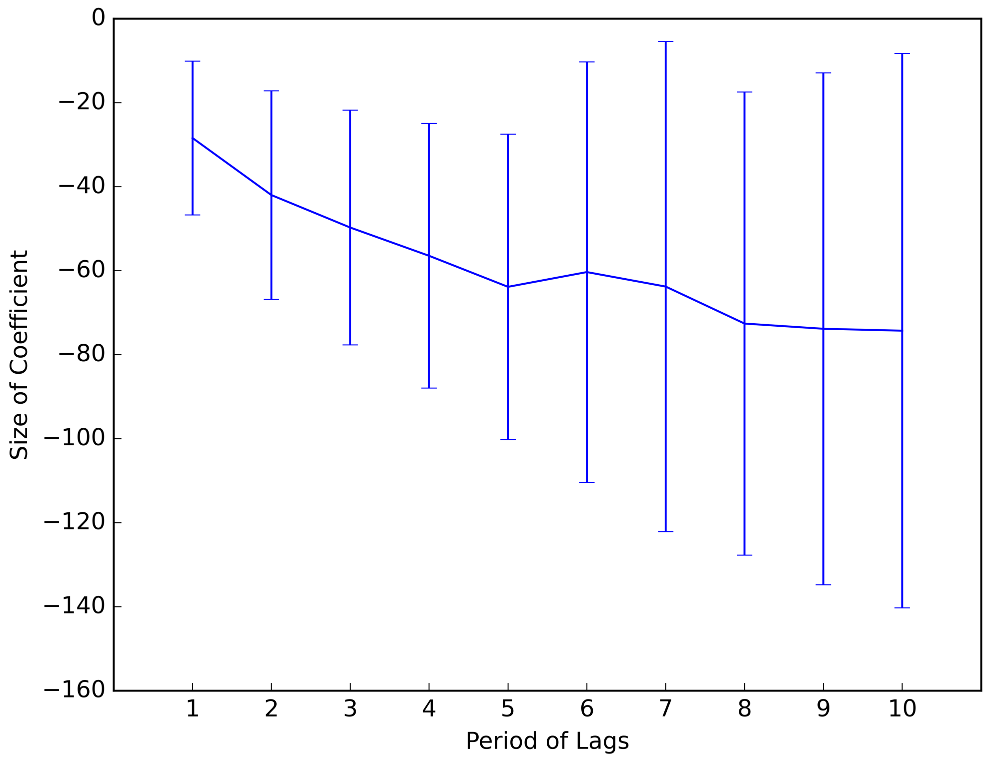
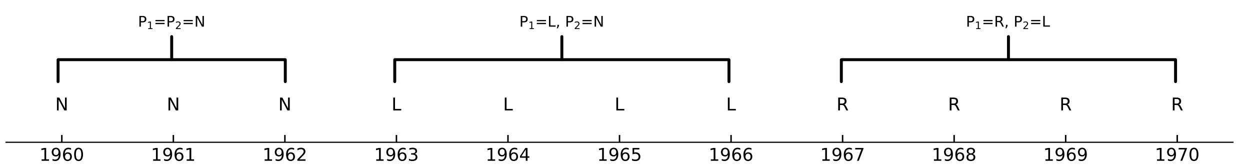


Figure A4: An Example for Time Period Division



C.1 Notation

e_s: a 100% increase in per child benefit-household income ratio's effect on birth rate change rate (summarized by Stone (2020))

e_c: a 100% increase in fertility policy funding-GDP ratio's effect on TFR change rate (estimated by our country level regression)

e_i: a 100% increase in fertility policy funding-GDP ratio's effect on children number (estimated by our individual level regression)

e_b: a 100% increase in fertility policy funding-GDP ratio's effect on birth rate

f_1: policy funding-GDP ratio

f_2: children benefit-household income ratio

r: the ratio of number of individuals aging within [MAC-5, MAC+5] to population size

C.2 Country Level

Our country-level empirical specification estimates **a 100% increase in anti-fertility policy funding-GDP ratio's effect on TFR change rate** (e_c). Stone (2020)'s meta-analysis result reflects **a 100% increase in children benefit-household income ratio's effect on birth rate change rate** (e_s). We adopt the following method to make Stone (2020)'s meta-analysis result comparable with our estimates:

$$
\begin{aligned}
e_s/\text{birth\_rate} &= \frac{\Delta\text{birth\_rate}}{\Delta f_2 \times \text{birth\_rate}} \times \frac{1}{\text{birth\_rate}} && (22)\\
&= \frac{\Delta\text{birth\_rate}}{\text{birth\_rate}} \times \frac{1}{\Delta f_2 \times \text{birth\_rate}} && (23)\\
&= \frac{\Delta\text{TFR}}{\text{TFR}} \times \frac{1}{\Delta f_2 \times \text{birth\_rate}} && (24)\\
&= \frac{\Delta\text{TFR}}{\text{TFR}} \times \frac{1}{\Delta f_1} && (25)\\
&\equiv e_c && (26)
\end{aligned}
$$

where (3) uses the fact that $\frac{\Delta\text{birth\_rate}}{\text{birth\_rate}} = \frac{\Delta\text{TFR}}{\text{TFR}}$; (4) uses the fact that $f_2 \times \text{birth\_rate} = f_1$, which in turn depends on the following assumption:

Assumption 1. *Household income can be approximated by GDP per capita.*

Assumption 2. *The size of the pro-fertility policy's target group can be approximated by the number of children born.*

Under Assumption 1 and Assumption 2, we'll have:

$$
\begin{aligned}
f_2 \times \text{birth\_rate} &= \frac{\text{per child benefit}}{\text{per household income}} \times \text{birth\_rate} && (27)\\
&= \frac{\text{per child benefit} \times \text{size of target group}}{\text{per household income}} \times \frac{\text{birth\_rate}}{\text{size of target group}} && (28)\\
&= \frac{\text{policy funding}}{\text{per household income}} \times \frac{1}{\text{population}} && (29)\\
&= \frac{\text{policy funding}}{\text{GDP per capita} \times \text{population}} && (30)\\
&= \frac{\text{policy funding}}{\text{GDP}} \equiv f_1 && (31)
\end{aligned}
$$

C.3 Individual Level

Our individual level empirical specification estimates **a 100% increase in anti-fertility policy funding-GDP ratio's effect on children number** (e_i). We convert both our result and Stone (2020)'s result to **a 100% increase in anti-fertility policy funding-GDP ratio's effect on birth rate** (e_b). For pro-fertility policies, it is straightforward to calculate $e_b = e_s \times \text{birth\_rate}$.

For anti-fertility policies, we take the following steps to convert e_i to e_b:

$$
\begin{aligned}
\frac{e_i \times 0.5 \times r}{\text{birth\_rate} \times 28} &= \frac{\Delta\text{N\_children\_per\_treated}}{\Delta f_1} \times \frac{1}{\text{birth\_rate}} \times \frac{0.5 \times r}{28} && (32)\\
&= \frac{\Delta\text{N\_children\_per\_treated}}{\Delta f_2} \times \frac{0.5 \times r}{28} && (33)\\
&= \frac{\Delta\text{N\_children\_per\_treated}}{\Delta f_2} \times \frac{0.5 \times \text{N\_treated\_individuals}}{\text{population}} \times \frac{1}{28} && (34)\\
&= \frac{\Delta\text{N\_children}}{\Delta f_2 \times \text{population}} \times \frac{1}{28} && (35)\\
&= \frac{\Delta\text{N\_children}}{45 - 18 + 1} \times \frac{1}{\Delta f_2 \times \text{population}} && (36)\\
&= \frac{\Delta\text{N\_children\_born\_per\_year}}{\text{population}} \times \frac{1}{\Delta f_2} \equiv e_b && (37)
\end{aligned}
$$

Where (12) follows from our discussion in Section C.2; (13) follows from the definition of r; (16) is by the following assumption:

Assumption 3. *All children are produced by individuals aged 18-45.*

Assumption 3 is necessary for us to convert **effect on children number** to **effect on birth rate**.