Asymmetric Fertility Elasticities*

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Abstract

Over the last five decades, a remarkable reversal has taken place where many countries around the world shifted their policy stances from suppressing to maintaining or promoting childbirth. Exploiting rich data from the historical episode, this paper documents that the effectiveness of pro-fertility policies has been significantly smaller than the anti-fertility ones – a new fact that is inconsistent with standard models with smooth fertility demand. We then develop a dynamic model where the government minimizes discounted policy expenditures and costs associated with fertility levels that are either too high or too low. We show that asymmetric fertility elasticities lead to two novel policy implications: First, the cost-minimizing fertility level is higher than the long-run target; Second, fertility levels possess intrinsic positional values that should be taken into account in policy evaluations. Lastly, we propose a new theory of fertility choice featuring loss aversion to provide a microfoundation of asymmetric elasticities.

JEL classification: J11, J13, J18

Keywords: fertility elasticity, positional value, loss aversion

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1. Introduction

Governments struggling with low fertility rates feel powerless and puzzled. Recent attempts to promote childbirth have yielded disappointing results and failed to put a halt to the global fertility collapse (Sobotka et al. 2019). Coupled with prevailing fertility rates that are far below the replacement level, this trend spells disaster for major civilizations in the name of a foreseeable "empty planet" (Bricker and Ibbitson 2019).

These facts sharply contrast with the level of success that fertility-reduction policies have achieved in the late twentieth century. These policies largely followed after the "population bomb" narrative (Ehrlich 1978)–a reincarnation of the Malthusian idea that growing population inevitably leads to catastrophes–gained global attention and sometimes resulted in draconian policy measures. Anti-fertility policies played an instrumental role in accounting for the rapid fertility decline during this era, especially among countries at early stages of economic development (De Silva and Tenreyro 2017). In retrospect, the success of anti-fertility policies might have instilled in policymakers the belief that policies designed to increase fertility would be equally effective.

In light of the drastic differences between the failures of pro-fertility policies and the success of anti-fertility policies, this paper asks the following research questions: Is it more difficult for the government to raise fertility than to reduce it? If so, what could be the reason behind and what are the implications for policymakers? We answer these questions using empirical, theoretical, and quantitative methods.

First, we evaluate the effectiveness of pro- and anti-fertility policies using data from the United Nations Population Division, the World Value Survey (WVS), and several other sources. We establish a new empirical fact that anti-fertility policy stances have much larger impacts on fertility compared with pro-fertility ones. This finding holds both in the short run and in the long run, regardless of whether country-level or individual-level data are used. To get a better sense of the intensity of these policies, we also estimate the elasticity of the total fertility rate (TFR) with respect to anti-fertility policies funding and compare our results with the meta-analysis by Stone (2020) on pro-fertility policies. The results show that the asymmetry holds when we use an elasticity measure to evaluate policy effectiveness. Overall, we find asymmetric fertility elasticity to be an extremely robust empirical regularity that holds across a battery of alternative specifications.

Second, we embed asymmetric fertility elasticities into a dynamic quantitative model where the government minimizes discounted policy expenditures and costs associated with fertility levels that are either too high or too low. We propose a new concept called the positional value of fertility which summarizes the (expected) net present value of future costs associated with any fertility level taking future optimizing behaviors into account.

In the baseline calibration, we show that asymmetric fertility elasticity implies that a cost-minimizing government should try to aim at a fertility rate that is above the long-run target, whether it is the replacement level or not. This insight yields two novel policy implications. For countries seeking to reduce fertility, the pace of fertility reduction should be slower than the scenario where such asymmetry is not present. On the other hand, for countries targeting increased fertility, the positional value of fertility level should be an important part to be incorporated into the cost-benefit analysis.

Lastly, we develop a new theory of fertility choice with loss aversion that provides a micro-foundation for asymmetric fertility elasticities. The idea is simple: due to the trade-off between fertility and non-fertility spending, which we will simply call consumption, households with loss aversion over current living standards are more reluctant to increase fertility than to reduce it upon symmetric changes in the shadow price of children. We provide an illustrative example to show how the mechanism works under a simple form of loss aversion. We also discuss why we think loss aversion is the most natural explanation for asymmetric elasticities.

Related Literature

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, 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 by showing that due to loss aversion over living standards, symmetric shocks to the shadow price of children generate downward pressure on fertility levels. In other words, we propose a new perspective where the fertility level evolves along a "slippery slope."

The most relevant paper in this literature is Lutz et al. (2006). They argue that due to demographic, sociological, and economic mechanisms, fertility reductions are self-perpetuating.[1] Moreover, 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 phenomenon that their framework misses because their propagation mechanism applies equally well in either direction. Second, 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 quantitative aspect. We first show that ignoring asymmetric policy responses will lead to overestimates of the efficacy of pro-fertility policies ex ante. With this consideration in mind, we then show that when pursuing an optimal policy in our framework, governments should account for the value of forming a positional value of fertility level when they evaluate pro-fertility policies.

This paper also 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.

Lastly, this paper connects the literature on fertility to behavioral economics. 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.[2] On the other hand, systematic behavioral patterns, in particular

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

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

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), and portfolio choice (Berkelaar et al. 2004). This paper is the first to incorporate loss aversion into a model of fertility choice.[3] Besides allowing our model to explain the asymmetry observed in the empirical analysis, we show that loss aversion also leads to intriguing policy implications in a dynamic stochastic environment.

The rest of the paper is organized as follows. In Section 2, we present several data facts and our main empirical result. We embed asymmetric fertility elasticities into a dynamic model and draw policy implications in Section 3. In Section 4, we build a theory of fertility demand under loss aversion to rationalize the empirical results. Section 5 concludes.

2. Data Facts and Empirical Results

In this section, we present several data facts and our main empirical results.

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 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

ture.

[3] There are two notable exceptions that consider reference-dependent preferences in the context of fertility choice. 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 suffer disutility if their children's human capital is below the population average. Neither paper considers loss aversion in consumption.

2001, the database has been updated biennially.

Figure 1 plots the fertility policy stance around the world in 1986, eighteen years after the publication of The Population Bomb. 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, mostly for cultural, ideological, or religious reasons.

The policy landscape looked drastically different in 2013. As shown in Figure 2, the anti-fertility policy stance had become much more prevalent in Africa, partly reflecting efforts by governments and international organizations who view family planning as a pathway to economic development. Most countries in Europe, on the other hand, have adopted the policy stance "raise" to address the issue of below-replacement fertility. There are also several countries, such as China and Turkey, that change from "lower" to "maintain" or "no intervention."

Figure 3 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 4 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 anti-fertility policy stances seem to be achieving their stated goals, fertility levels in countries with the policy stance "raise" are still falling. In the following section, we evaluate the relationship between these policy stances are subsequent fertility changes more systematically using panel data methods.

2.2 Evidence from Policy Stances

In this section, we use both country- and individual-level data to present evidence suggesting that the effectiveness of pro-fertility policies is smaller than anti-fertility ones.

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

Figure 1: Fertility Policy Stance in 1986

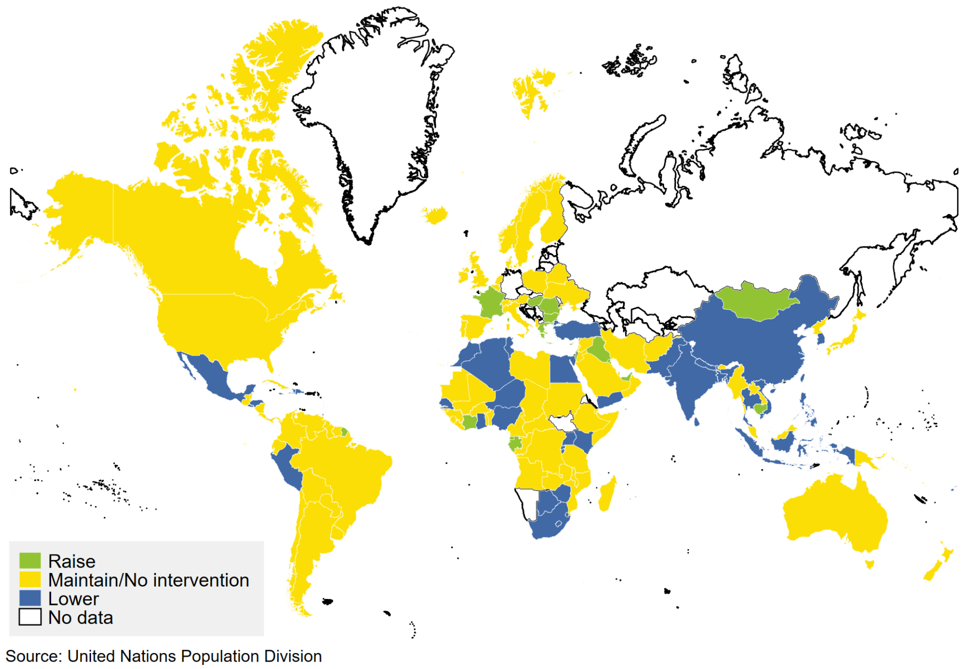


Figure 2: Fertility Policy Stance in 2013

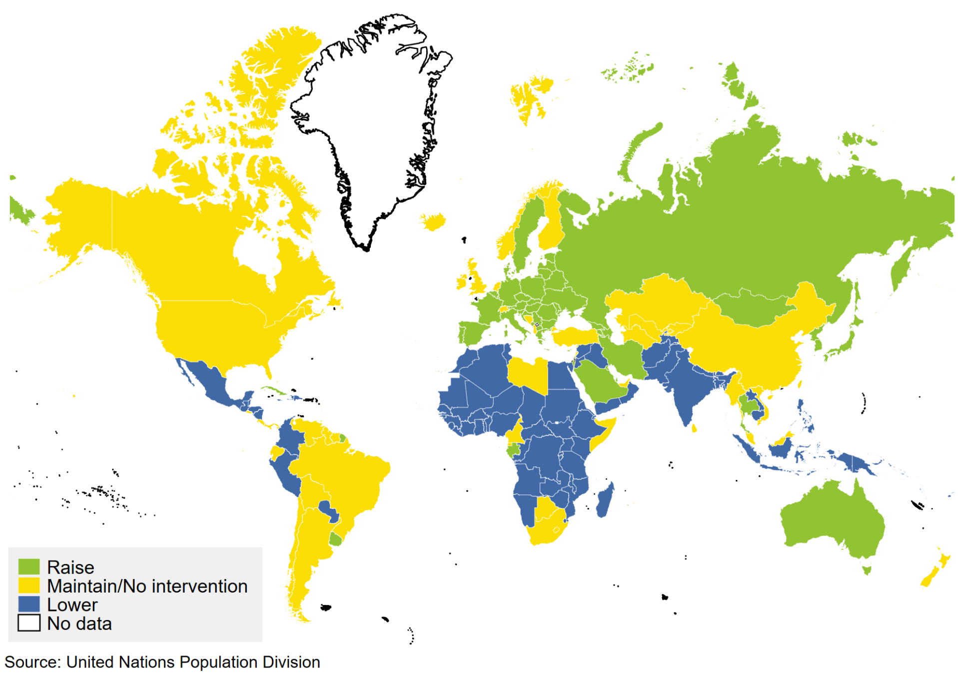
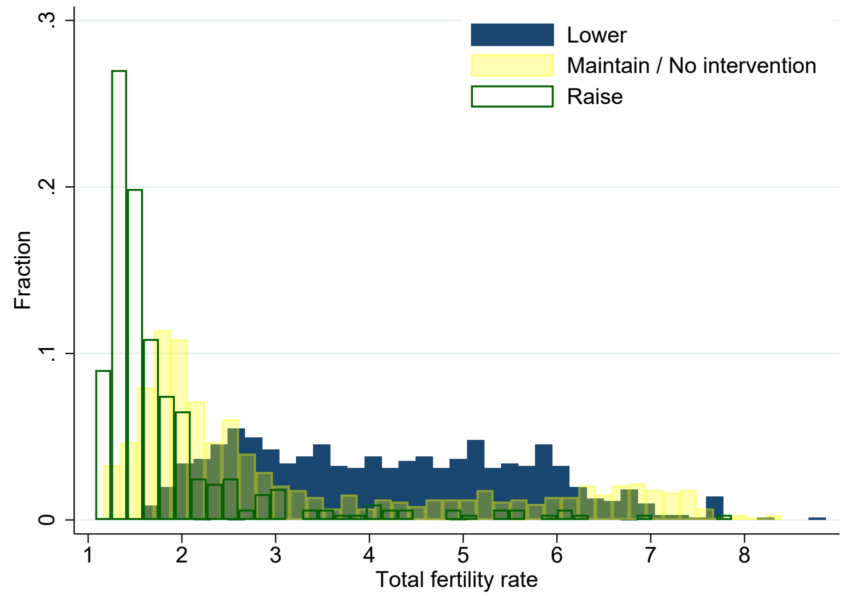


Figure 3: Fertility policies



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

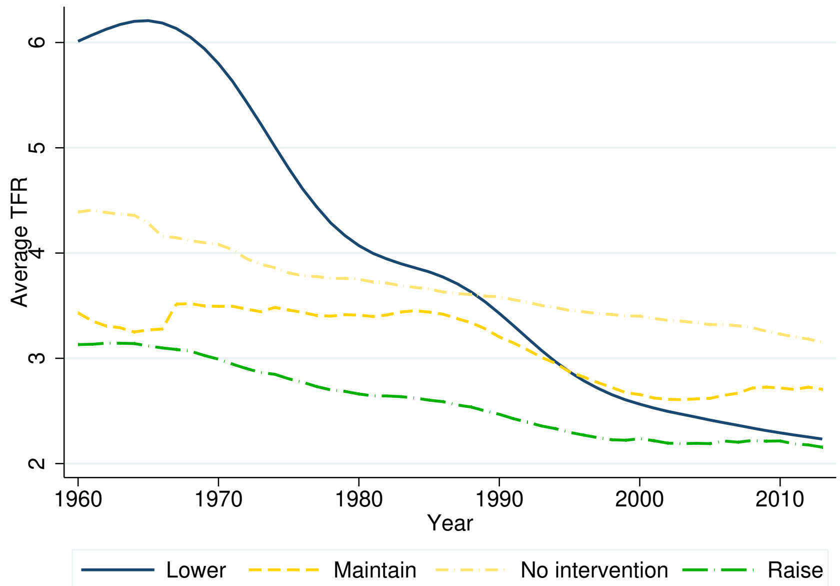
2.2.1 Analyses Using Country-Level Data

In this section, we 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 participation, and urbanization data 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, credibly 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.

[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.

Figure 4: 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.

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. We are also working on using synthetic control methods to estimate policy impacts. Lastly, we believe that it is important to document and discuss this salient pattern in the data, especially when the policy implication concerns the future of humanity.

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 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, and (4) 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. Second, if fertility policies take the form of improved access to contraceptive technologies or propaganda instead of direct economic incentives, their effect may be 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 baseline 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 if we consider the fact 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.

2.2.2 Analyses Using Individual-Level Data

Section 2.2.1 provides evidence of the short-run asymmetric effect 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

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***	-0.0071***	-0.0129***	-0.0076***	-0.0102***	-0.0042*
	(0.0013)	(0.0055)	(0.0015)	(0.0016)	(0.0020)	(0.0022)
Raise fertility	0.0013	0.0016	0.0034	0.0013	0.0023	0.0002
	(0.0034)	(0.0030)	(0.0039)	(0.0034)	(0.0040)	(0.0039)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes	No	Yes
Observations	10726	9146	10726	9146	9937	8462
R^2	0.133	0.174	0.133	0.173	0.123	0.170

[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 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 ten years is used as the dependent 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, and female labor participation rate. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

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 difference-in-difference method. Chen et al. (2020) studies 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 assumptions regarding 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 series of socioeconomic variables. Subsequently, we assume that each individual's treatment window is an 11-year period centered on the MAC of their living country at the age of 18. 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.

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

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

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:

$$
\begin{aligned}
\text{Child}_{icbt} = \alpha + \beta_1 \text{Policy\_Lower}_{icbt} + & \beta_2 \text{Policy\_Raise}_{icbt} \\
& + \eta \text{Age}_i \times \text{Gender}_i + \gamma_{ct} + \delta_b + \epsilon
\end{aligned} \tag{2}
$$

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 children number.[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 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 these variables.

Table 2 presents the empirical results using individual-level data. Columns (1), (4), and (7) contain the results from estimating the specification (2) 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 quite 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

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

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.

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 the total fertility rate (TFR) 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. The comparison shows similar asymmetric effects of anti- versus pro-fertility policies.

2.3.1 Effectiveness of Anti-Fertility Policies

For anti-fertility policy, we adopt a strategy similar to specification (1) in Section 2.2.1. 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 3. We find that as the funding-GDP ratio of anti-fertility policies increases by 0.1 percentage point, the TFR decreases by 6%-8% decrease in the following year, a quite significant change.[8]

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

[8] The estimates are similar to the ones obtained by De Silva and Tenreyro (2017) where they use percentage changes in funding-GDP ratio as the explanatory variable and do not control for the levels of GDP per capita, urbanization rate, infant mortality rate, and female labor force participation rate.

Table 2: 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***	-0.844***	-0.655***	-0.875***	-0.831***	-0.821***	-0.631***
	(0.220)	(0.210)	(0.185)	(0.201)	(0.188)	(0.208)	(0.243)	(0.232)	(0.215)
Target: Raise fertility	0.278	0.304*	0.131	0.168	-0.007	0.141	0.259	0.262	0.046
	(0.181)	(0.162)	(0.186)	(0.167)	(0.185)	(0.189)	(0.221)	(0.191)	(0.202)
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Income Level-Age-Gender FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Education Level-Age-Gender FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Macroeconomic Controls	No	No	Yes	No	No	Yes	No	No	Yes
Observations	205324	183738	163768	231257	205288	182719	210785	186911	170841
R^2	0.281	0.294	0.301	0.285	0.297	0.303	0.279	0.295	0.298

[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; columns (2), (5), and (8) control for income group×age group×gender fixed effect and education group×age group×gender fixed effect; column (3), (6), and (9) control for the average real GDP per capita and its grow rate during individuals' assumed treatment time window. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Table 3: Elasticity Estimation for Anti-Fertility Policy

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	-60.72***	-79.71***
	(22.65)	(25.29)
Country Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Control Variables	No	Yes
Observations	2754	2648
R^2	0.220	0.278

[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 regressions of the change rate of TFR on the average anti-fertility policy funding-GDP ratio in the last five years. 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, and female labor participation rate. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

2.3.2 Effectiveness 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 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." Because some papers estimate the effects of multiple pro-fertility policies at the same time, we end up 47 elasticity estimates.

The elasticity estimates in Stone (2020), however, are not directly comparable to the ones on anti-fertility policies in Section 2.3.1 where we estimate the (log) fertility changes in response to a 1 percentage point increase of policy funding to GDP. Stone (2020), on the other hand, 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 GDP to convert the elasticity in Stone (2020) to ensure comparability.

2.3.3 Comparison of Elasticities

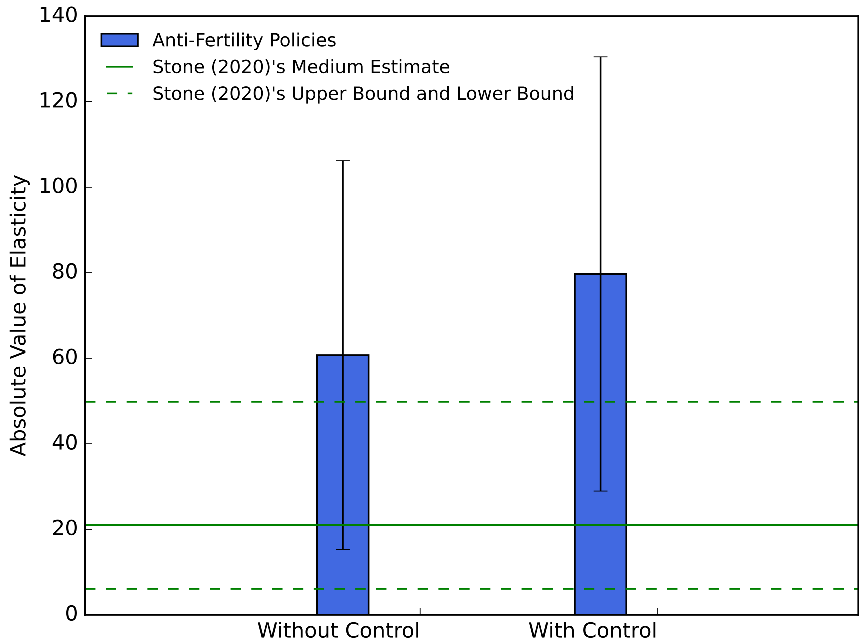
We present the comparison between anti-fertility policies and pro-fertility policies in Figure 5. The blue bars display the estimated elasticities for anti-fertility policies in Table 3, with the error bars representing the 95% confidence interval. The solid line is the average of converted "medium" 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 5.[9] 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. Interestingly, the magnitude of asymmetry using policy expenditures is quite similar to the asymmetry effect we found in Section 2.2 using policy stances.

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. Third, we control country-specific linear trends to ease the concern of omitted variable bias in Section B.3. Lastly, we show our conclusion is robust to employing alternative methods in the construction of dependent variables in Section B.4.

[9] 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 5: Comparison Between Anti-Fertility Policies and Pro-Fertility Policies



Source: Estimated elasticity of anti-fertility policies is from regression result in Table 3; estimated elasticity of pro-fertility policies is calculated as discussed in 2.3.2, 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.

3. A Dynamic Model of Fertility Policies

In this section, we remain agnostic about the particular micro-foundation of asymmetric fertility elasticities but study the policy implications of such asymmetry in a dynamic model of fertility policies. In the model, the government minimizes discounted policy expenditures and costs associated with fertility levels that are either too high or too low.

The goal of the model is twofold. First, it points out an important theoretical point that with asymmetric fertility elasticities, fertility level possesses positional value in a dynamic stochastic environment. Second, in the baseline calibration, we show that such positional values are potentially large and should be taken into account in policy evaluations.

The organization of this section is as follows. We first present the model setup in Section 3.1. Section 3.2 discusses the modeling assumptions. Then, we present the calibration in Section 3.3 and the main quantitative results in Section 3.4.

3.1 Model Setup

At time t, the government's state variable is the reference level of fertility n_t^r which is the level of fertility that would prevail if the government does not intervene.[10] It solves the following optimization problem:

$$\mathscr{W}(n_t^r) = \max_{n_t} \; - \underbrace{\mathscr{P}(n_t, n_t^r)}_{\text{policy expenditure}} - \underbrace{\mathscr{S}(n_t, \overline{n})}_{\text{social cost}} + \beta \cdot \mathbb{E}_\epsilon \mathscr{W}(n_{t+1}^r) \tag{3}$$

where the total policy expenditure of changing fertility from the reference level n_t^r is

$$\mathscr{P}(n_t, n_t^r) = \begin{cases} \pi^+ \cdot \left(\log(n_t) - \log(n_t^r)\right) & \text{if } \; n_t \geq n_t^r \\ \pi^- \cdot \left(\log(n_t^r) - \log(n_t)\right) & \text{if } \; n_t < n_t^r \end{cases} \tag{4}$$

Parameters $\pi^+ > \pi^- > 0$ capture the asymmetric fertility elasticity we established in the empirical findings. The fact that $\pi^+ > \pi^-$ can be micro-founded using the loss aversion model presented in the next section, but we want to emphasize here that the dynamic implications of asymmetric fertility elasticities do not hinge on the particular micro-foundation.

Motivated by the approach proposed by Thakral and Tô (2021), we model an adaptive reference updating process subject to idiosyncratic shocks

$$\log(n_{t+1}^r) = \phi \cdot \log(n_t) + (1-\phi) \cdot \log(n_t^r) + \epsilon \tag{5}$$

The parameter $\phi \in [0,1]$ governs how fast the reference is being updated over time. When $\phi = 1$, the updating is immediate, so the policy expenditure only needs to be paid once to move the reference fertility level in the future. When $\phi = 0$, however, the updating is absent, so the policy expenditure needs to be paid in every period for a given choice of n_t that is different from n_t^r. We assume that ϵ is randomly drawn from a normal distribution $\epsilon \sim \mathscr{N}(0, \sigma_\epsilon^2)$.

The social cost of fertility deviations from $\overline{n}$ is given by a convex function

$$\mathscr{S}(n_t, \overline{n}) = \lambda \cdot (\log(n_t) - \log(\overline{n}))^2 \tag{6}$$

[10]Due to the budget constraint, the optimization problem can be equivalently stated if the state variable is the reference living standard c_t^r.

To focus on the impacts of asymmetric fertility elasticity itself, we assume that the social cost is symmetric around some fertility level $\overline{n}$, whether it is the replacement level or not.

We define $\mathscr{W}(n_t^r)$ as the *positional value* of the (reference) fertility level. It encapsulates the net present value of the cost-minimizing policy expenditures and social costs of fertility.

3.2 Discussions

There are several points worth noting here.

First, we assume away household utility in the optimization problem because fertility policies may take many forms besides changing the shadow price of children. For example, policies could even change people's preferences through propaganda. This additional layer makes it difficult to evaluate household welfare without specifying the policy instrument being used. In a world with heterogeneity and production, such policies could also change welfare through redistribution and reallocation channels. Moreover, welfare evaluation in the presence of endogenous fertility is an extremely complicated issue (e.g., see Golosov et al. 2007). Therefore, we focus on a simple cost-minimization problem in this paper.

Second, we study a stationary problem to crystallize how asymmetric fertility elasticities result in positional values of fertility level. In the context of the demographic transition from high to low fertility rates, it is interesting to study how the optimal path of fertility policies differs with and without the presence of asymmetric fertility elasticities. We leave this for future research.

Lastly, we would like to emphasize that this is not a model that is built to predict how the governments actually make pro- or anti-fertility policies in real life. The government, first of all, might not even notice the existence of asymmetric fertility elasticities. Moreover, fertility policies have always been controversial, sensitive, and highly affected by culture, religion, and ideology, as they distort one of the most important choices in people's lives. The calculations involved in policy-making go far beyond the simple cost-benefit analysis presented in this section.

3.3 Calibration

First, we calibrate policy expenditures π^+ and π^- from the empirical results presented in Figure 5. In particular, Figure 5 indicates that a 0.1% increase in funding to GDP ratio, if interpreted causally, raises fertility by 2% or reduces it by 7% on average across specifications. Therefore, we set $\pi^+ = 0.05$ and $\pi^- = 0.014$.

Second, we calibrate an annual model and choose $\beta = 0.96$ to reflect a 4% social discount rate. This number lies in between the 6% proposed by Nordhaus (2007) and the 1.5% proposed by Stern (2008).

Third, we choose $\overline{n}$ and λ to parameterize the social cost function. Setting $\overline{n} = 2.1$, i.e., at the replacement level of fertility, seems to be a natural choice because it is "widely considered among policymakers and the public as the desirable level of long-term fertility" (Striessnig and Lutz 2013). The choice of λ, on the other hand, is much more contentious because there is little empirical consensus on how large the social cost of above- or below-replacement fertility level is. Empirical estimates on the potential environmental damage, pension burden, and ideas creation vary widely. Therefore, we experiment with different scenarios of λ, ranging from low-cost scenario $\lambda = 0.02$, medium-cost scenario $\lambda = 0.2$, to high-cost scenario $\lambda = 2$. To give a better sense of these numbers, the total fertility rate (TFR) in the United States in 2022 is 1.64 children per woman which is 18% below the replacement level. Under these three scenarios, the annualized social cost of this below-replacement fertility level is 0.065%, 0.65%, and 6.5% of GDP respectively.

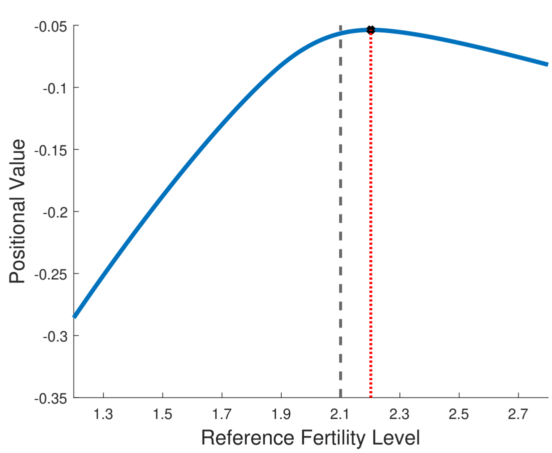
Lastly, we need to calibrate parameters ϕ and σ_ϵ in the reference updating process. Unfortunately, there is little empirical evidence on the value of ϕ in the context of fertility choice. In the baseline case, we set $\phi = 0.13$ so that the expected half-life of the original reference level n_t^r is five years. There is also little empirical guidance on σ_ϵ so we experiment with different values. In particular, we try $\sigma_\epsilon = 0.01$ and $\sigma_\epsilon = 0.05$ and $\sigma_\epsilon = 0.1$ so that a one-standard-deviation shock to the reference point have 1%, 5%, or 10% effects.

3.4 Quantitative Results

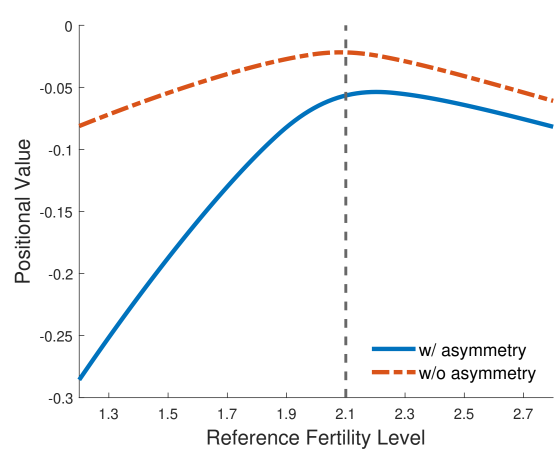
Figure 6a shows that the positional value in the baseline case with medium social cost $\lambda = 0.2$ and medium reference level shock $\sigma_\epsilon = 0.05$. There are three immediate interesting observations. First, positional value $\mathscr{W}(\cdot)$ is hump-shaped, reflecting that deviations of reference fertility level n_t^r from $\overline{n} = 2.1$ are not desirable. Second, even though the static social cost is zero when $n_t^r = 2.1$, the positional value $\mathscr{W}(2.1)$ is less than zero. This is due to the existence of shocks to the reference level which will change people's fertility decisions in later periods, resulting in social costs and policy expenditures in the future. Third, the positional value $\mathscr{W}(\cdot)$ is optimized at $n^* \approx 2.2$ that is bigger than the replacement level $\overline{n} = 2.1$. This is due to the asymmetric fertility elasticities.

To see the last point more clearly, Figure 6b plots the positional value with and without asymmetric fertility elasticities, or in this model, asymmetric costs of changing fertility. To plot the $\mathscr{W}(\cdot)$ without asymmetric costs, we set π^+ to take the same value as π^-. There are two important observations. First, the fact that n^* is bigger than the replacement rate is entirely due to the presence of asymmetric fertility elasticities. Second, for countries with low fertility rates, the same amount of fertility increase generates a much larger rise in the positional value when $\pi^+ > \pi^-$.

(a) Positional Value in the Baseline Case

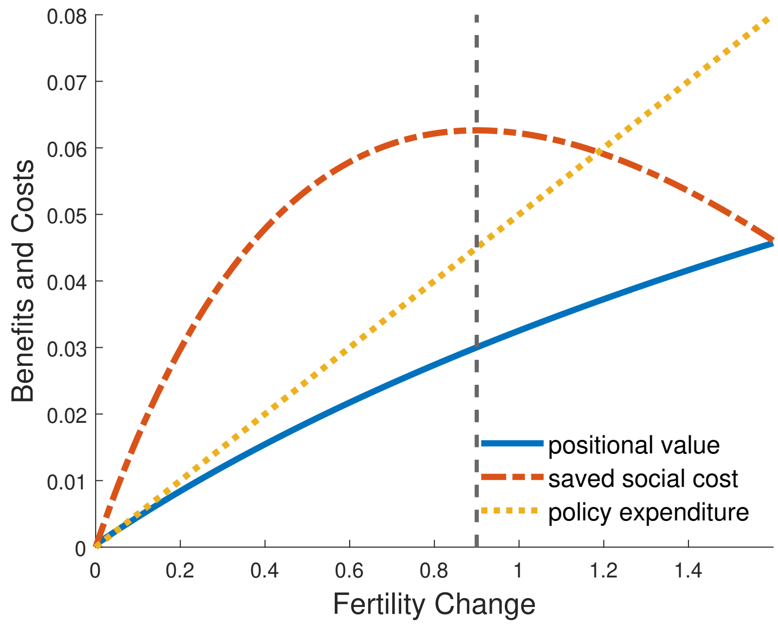


(b) The Role of Asymmetric Fertility Elasticities



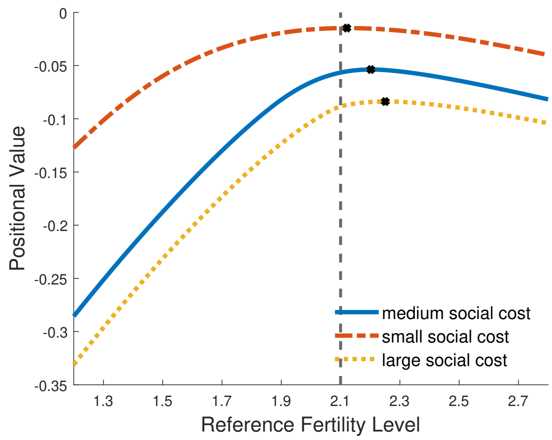
To show the quantitative relevance of positional values, Figure 7 plots the benefits and costs of pro-fertility policies starting with a baseline economy with $n_t^r = 1.2$. The horizontal axis plots the one-period increase in fertility $n_t - n_t^r$ under different pro-fertility policy scenarios. The vertical axis plots the costs and benefits associated with these policies. The direct policy expenditure is given by $\pi^+ \cdot (n_t - 1.2)$. The saved social cost refers to the one-period difference between $\mathscr{S}(n_t, \overline{n})$ and $\mathscr{S}(1.2, \overline{n})$. The change in positional value is given by $\beta \mathbb{E}_\epsilon \mathscr{W}(\tilde{n}_{t+1}^r) - \beta \mathbb{E}_\epsilon \mathscr{W}(\hat{n}_{t+1}^r)$ where $\tilde{n}_{t+1}^r$ is next period's reference level under different policy choices n_t while $\hat{n}_{t+1}^r$ is next period's reference level without the pro-fertility policy in place. As can be seen, the positional value is sizable, accounting for a quarter to one-half of the total benefits.

Figure 7: Benefits and Costs of Pro-Fertility Policies

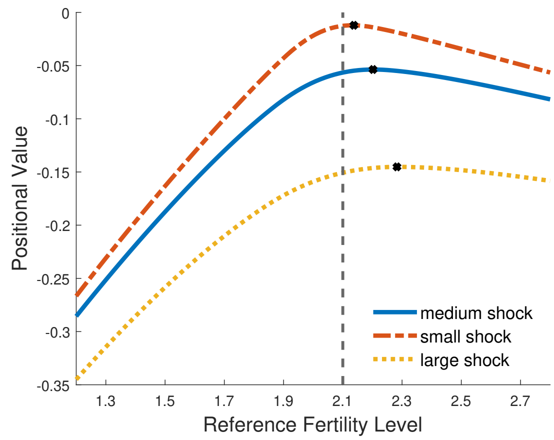


Lastly, to show the role of other parameters, Figure 8a, 8b, and 8c plot the positional values $\mathscr{W}(\cdot)$ under different choices of λ, σ_ϵ, and ϕ respectively. As can be seen, the reference fertility level that maximizes the positional value n^* rises with the social cost of fertility λ and the scale of shocks to the reference level σ_ϵ. Moreover, $\mathscr{W}(\cdot)$ is much steeper at values below $\overline{n}$ when the reference updating is slow.

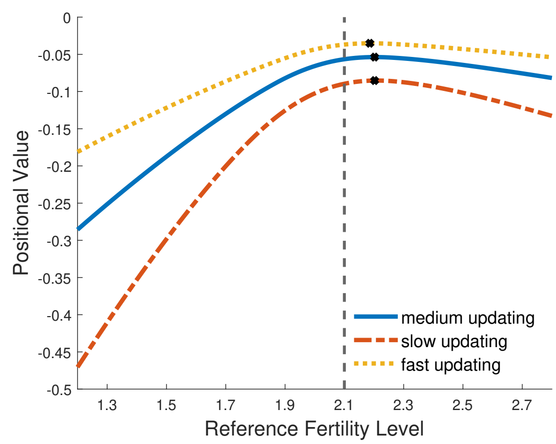
(a) The Role of Social Cost λ



(b) The Role of Reference Level Shocks σ_ϵ



(c) The Role of Reference Updating Speed ϕ



4. A Behavioral Theory of Fertility Choice

In this section, we show that a theory of fertility choice under loss aversion rationalizes the empirical findings of asymmetric fertility elasticities.

4.1 Why Loss Aversion?

Loss aversion is a natural candidate to generate asymmetric policy responses. It was discussed in Tversky and Kahneman (1991) that even in risk-free environments, loss aversion can imply that demand responds asymmetrically to price increases compared with price decreases. Since loss aversion focuses on differences in the magnitude of marginal gains compared with marginal losses, the narrative is a local story that can not be explained by diminishing marginal utility or convex preferences. In considering fertility, local effects on demand seem to be the plausible story, since most policies are small relative to household income.

Before introducing the model, we acknowledge that while we are proposing *one theory* that can explain the asymmetry, we do not want to claim, at the current stage, that this is *the theory* for this phenomenon. While we will argue that loss aversion is a natural and plausible story, we will also briefly discuss a couple of alternative alternatives, and why we find them less satisfactory at this stage.

An immediate alternative explanation is that governments may have different sets of policy instruments at their disposal when they try to reduce versus increase fertility. A closer examination suggests that this is not the case. Historically, governments tend to resort to propaganda, access to contraception or abortion, taxation, and reproductive coercion to discourage childbirth. The key insight here is that all these methods, even those primarily discussed in the context of reducing fertility, are *technologically feasible* when governments attempt to promote childbirth. For instance, propaganda of "hero mothers" was used in countries such as China, Russia, and Singapore; restrictions on contraception and abortion were adopted via Decree 770 in Romania in 1967; and tax instruments, either rewards or punishments, are widely adopted in most development economies; "soft" coercion through norms, social pressure, and legislation that are widespread around the world. It is also not unimaginable that one day, some countries that are desperately seeking to raise fertility will use "hard" reproductive coercion to achieve their goal, just like some countries that used coercive methods to reduce childbirth not so long ago.

At a deeper level, we conjecture that the smaller effectiveness of pro-fertility policy stances and expenditures are, to some extent, reflecting the governments' conscious choices among different policy instruments. In other words, there exist instruments that could be very effective in raising fertility, such as banning contraception, but such policies would be extremely unpopular among the constituents due to the loss aversion channel we propose below.

4.2 Model Setup

The problem we study is simple: individuals choose consumption c and fertility n, taking the reference level of consumption x and the relative price of raising children, χ, as given.

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

subject to budget constraint

$$c + \chi n = y$$

Following Kőszegi and Rabin (2006), we will refer to $U(c,n)$ as the consumption utility function, and $G(\cdot)$ as the gain-loss utility function. We assume $U(c,n) = u(c) + v(n)$ for strictly increasing and concave functions $u(c)$ and $v(n)$. In particular, we assume that

$$v(n) = \frac{n^{1-\gamma}-1}{1-\gamma} \qquad \gamma > 1$$

The condition that $\gamma > 1$ ensures that an increase in the cost of children χ raises the marginal cost of consumption to be defined below. This is equivalent to assuming that children and consumption are net complements in our additively separable specification when loss aversion is not present.[11]

Following Köbberling and Wakker (2005) and Santoro et al. (2014), we assume loss aversion in consumption of the following form:

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

This functional form is especially desirable for illustrative purposes because $G(\cdot)$ is everywhere differentiable, including at the reference level (corresponding to $y = 0$). This enables us to use the first-order condition to characterize optimal solutions.

[11] We show that the proof goes through as long as $\gamma \neq 1$ so that consumption is affected by the shadow price of children. Relative to fertility and consumption being substitutes, we think complementarity is a more natural assumption and it is also adopted by models with altruism such as Barro and Becker (1989).

The last ingredient of our model is a *consistency condition* that in equilibrium,

$$x = c. \tag{7}$$

In our static setting, we consider that agents first form decision rules depending on the reference state x. Consistency as a mode of determining x reflects that individual reference points are formed by observing their peers, and in an equilibrium where all agents are identical this reference point ends up being a common consumption level shared by all.

4.3 Optimal Fertility Choice Under Loss Aversion

We substitute the budget constraint into the objective function. Because the objective function is differentiable and globally concave, the first-order condition of consumption characterizes the optimum and is given by

$$\underbrace{(1-\alpha)u'(c) + \alpha u'(c) G'(u(c) - u(x))}_{\text{marginal benefit of consumption}} = \underbrace{\frac{1}{\chi} v'\left(\frac{y-c}{\chi}\right)}_{\text{marginal cost of consumption}} \tag{8}$$

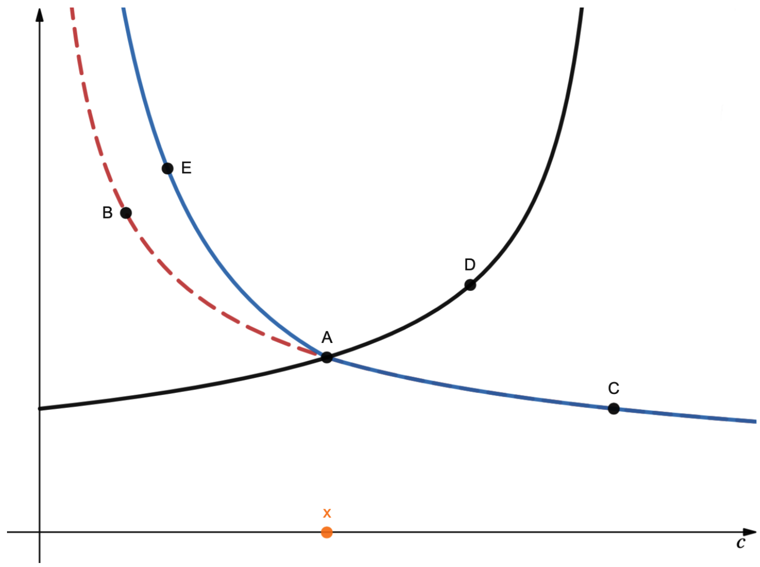
Figure 9 shows that once the consistency condition is imposed, point A characterizes the individual's optimal choice when there is loss aversion. Since the first-order derivative of the gain-loss utility functions is not differentiable at the reference point, there is a kink point in the marginal utility curve at point A. This asymmetry is due to loss aversion.

4.4 Comparative Statics

When the cost of children χ falls, the marginal cost curve AD shifts downward. Figure 10a shows that the response in consumption c is the same with or without loss aversion – point F is the optimal response in both cases. Due to the budget constraint, the changes in n are the same as well.

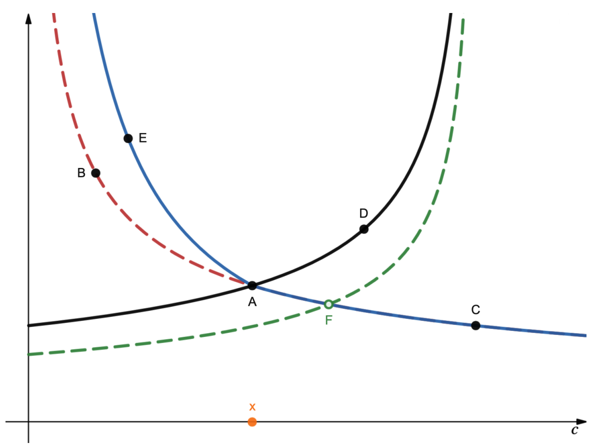
When the cost of children χ increases, the consumption responses are different. In Figure 10b, without loss aversion, point G is the optimal choice. With loss aversion, however, the individual's optimal consumption is H. Because the consumption response is smaller with loss

Figure 9: Optimal Fertility Choice

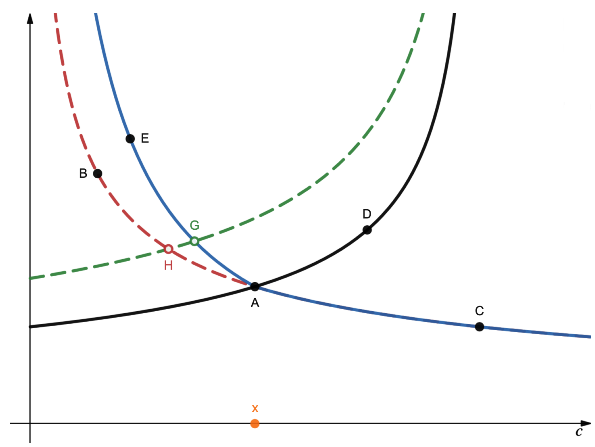


aversion, the fertility response needs to be larger with loss aversion to satisfy the budget constraint.

(a) Small Decrease in χ



(b) Small Increase in χ



Without loss aversion, the fertility response to changes in the cost of children is symmetric. Therefore, the responses must be asymmetric when there is loss aversion.

4.5 Interpretation of Loss Aversion

In this simple model, asymmetric fertility elasticity is generated by loss aversion over consumption. We want to emphasize that the same intuition can be applied to more general environments with additional household choices.

For example, in models with the quantity-quality trade-off (De La Croix and Doepke 2003, Kim et al. 2021), households may have loss aversion over child quality. Because higher fertility raises the shadow price of child quality, parents with such loss aversion will also be more reluctant to increase the number of children when the government offers pro-fertility incentives.

Likewise, in models with endogenous labor supply, individuals may have loss aversion over their career outcome or socioeconomic status. Because child-rearing reduces one's available time, workers with such loss aversion will also have asymmetric fertility responses.

5. Conclusion

In this paper, we study the divergence between the failures of pro-fertility policies and the success of anti-fertility policies using empirical, theoretical, and quantitative methods.

Empirically, we establish that anti-fertility policy stances have much larger impacts on fertility compared with pro-fertility ones using panel regression, cohort exposure design, and meta-studies.

To study the empirical importance of this observation, we embed asymmetric fertility elasticities into a dynamic quantitative model, calibrate it, and derive several policy implications. We show that reference dependence and asymmetric fertility elasticities imply that there exists a positional value of maintaining a steady-state fertility rate that is above the long-run target, whether it is the replacement level or not. For countries that seek to reduce fertility, the pace of fertility reduction should be slower than the scenario where such asymmetry is not present. For countries that strive to raise fertility, the positional value of fertility level is an important part to be incorporated into the cost-benefit analysis.

Lastly, we propose a micro-foundation of asymmetric fertility elasticities by developing a behavioral theory of fertility choice with loss aversion. The idea is simple: due to the trade-off between fertility and consumption, households with loss aversion over current living standards are more reluctant to increase fertility than to reduce it upon symmetric changes in the shadow price of children.

To conclude, while there are still many challenges in ascertaining the magnitude and mechanisms of asymmetric fertility elasticities in the data, we believe that this paper takes an important first step in documenting and explaining this phenomenon. We look forward to more research 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. In Table A5 and A6, we provide further evidence by running a subsample regression, in which countries are grouped according to their TFR in 1960. To summarize, our conclusion is robust to selection into treatment.

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	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0054***	-0.0054***	-0.0052***	-0.0052***
	(0.0014)	(0.0015)	(0.0017)	(0.0018)
Raise fertility	0.0001	0.0006	0.0001	0.0000
	(0.0032)	(0.0030)	(0.0036)	(0.0033)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect× Control Variables and TFR in 1960	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes
Observations	10726	9146	10726	9146
R^2	0.227	0.247	0.227	0.246

[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, 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 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	-76.44***	-85.56***
	(19.93)	(24.46)
Country Fixed Effect	Yes	Yes
Year Fixed Effect× Control Variables and TFR in 1960	Yes	Yes
Control Variables	No	Yes
Observations	2754	2648
R^2	0.439	0.447

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, 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 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	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0076***	-0.0056***	-0.0080***	-0.0057***
	(0.0014)	(0.0014)	(0.0018)	(0.0018)
Raise fertility	0.0003	0.0005	0.0009	0.0007
	(0.0034)	(0.0055)	(0.0062)	(0.0056)
Observations	5936	5247	5936	5247
R^2	0.339	0.390	0.337	0.388
Panel B: Subsample with Low TFR in 1960				
Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate			
Construction of Policy Variables	Last Year		Average in the Last Five Years	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0150**	-0.0117**	-0.0151***	-0.0117**
	(0.0028)	(0.0049)	(0.0023)	(0.0047)
Raise fertility	0.0016	0.0030	0.0024	0.0038
	(0.0038)	(0.0037)	(0.0044)	(0.0043)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes
Observations	4789	3899	4789	3899
R^2	0.128	0.147	0.128	0.147

[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, 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 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	31.1799	-70.2463
	(281.7425)	(305.4117)
Observations	960	960
R^2	0.570	0.601
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	-93.8484***	-109.3809***
	(27.0860)	(4.0160)
Country Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Control Variables	No	Yes
Observations	1789	1683
R^2	0.195	0.228

[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, and female labor participation rate. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

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.

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	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0121***	-0.0065***	-0.0134***	-0.0070***
	(0.0014)	(0.0015)	(0.0016)	(0.0017)
Raise fertility	0.0031	0.0013	0.0033	0.0009
	(0.0037)	(0.0033)	(0.0043)	(0.0038)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes
Average TFR in the Last Five Years	Yes	Yes	Yes	Yes
Observations	9881	8446	9881	8446
R^2	0.134	0.182	0.133	0.182

[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. Columns (1) and (3) control for country fixed effect, year fixed effect, and average TFR in the last five years; 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, and female labor participation rate. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

B.3 Robustness: Control Country-Specific Linear Trend

In this section, we provide empirical results controlling country-specific linear trend, which are presented in Table A9 and Table A10. Including country-specific linear trends doesn't seem to affect our conclusion.

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***	-71.28***
	(24.09)	(18.38)
Country Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Control Variables	No	Yes
Average TFR in the Last Five Years	Yes	Yes
Observations	2754	2648
R^2	0.220	0.278

[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.

Table A9: Population Policy and TFR: Control Country-Specific Linear Trend

Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate			
Construction of Policy Variables	Last Year		Average in the Last Five Years	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0040**	-0.0050**	-0.0038	-0.0054**
	(0.0018)	(0.0019)	(0.0026)	(0.0026)
Raise fertility	-0.0006	-0.0001	-0.0004	0.0009
	(0.0039)	(0.0037)	(0.0047)	(0.0045)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Country-Specific Linear Trend	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes
Observations	10726	9146	10726	9146
R^2	0.204	0.220	0.203	0.220

[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. Columns (1) and (3) control for country fixed effect, year fixed effect, and country-specific linear trends; 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, 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 A10: Elasticity Estimation for Anti-Fertility Policy: Control Country-Specific Linear Trend

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	-84.25*	-82.24*
	(47.09)	(48.62)
Country Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Country-Specific Linear Trend	Yes	Yes
Control Variables	No	Yes
Observations	2754	2648
R^2	0.333	0.359

[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 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, year fixed effect, and country-specific linear trend; 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.

B.4 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 2, 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.

Figure A1: Population Policy and TFR Using Different Year Ranges

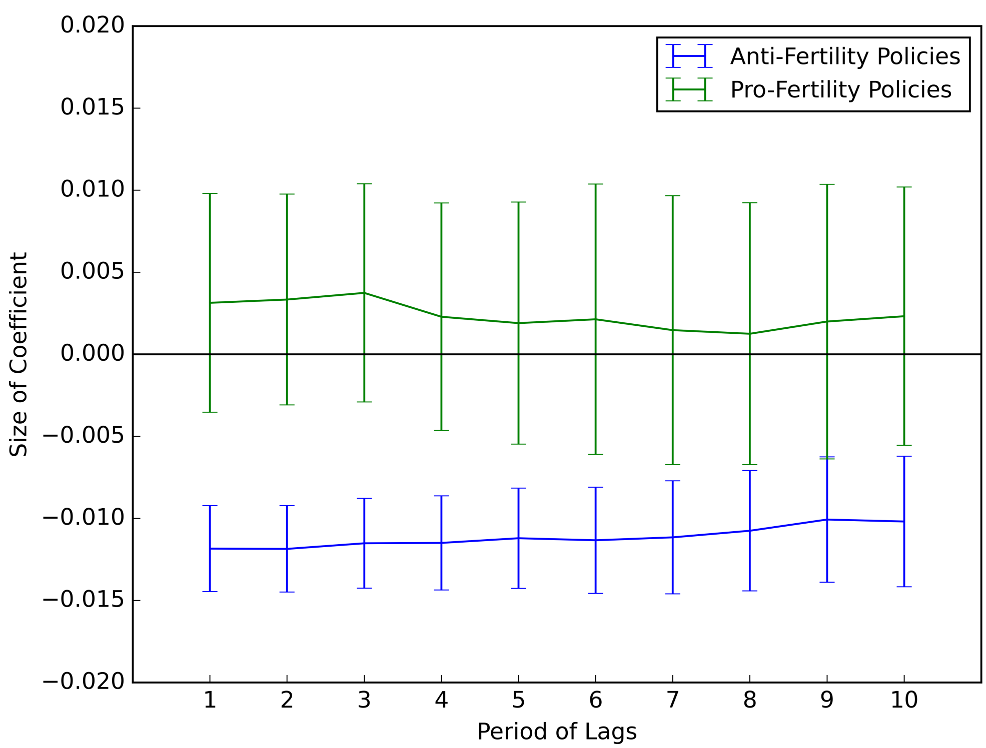

Figure A2: Population Policy and Children Number Using Different Time Windows

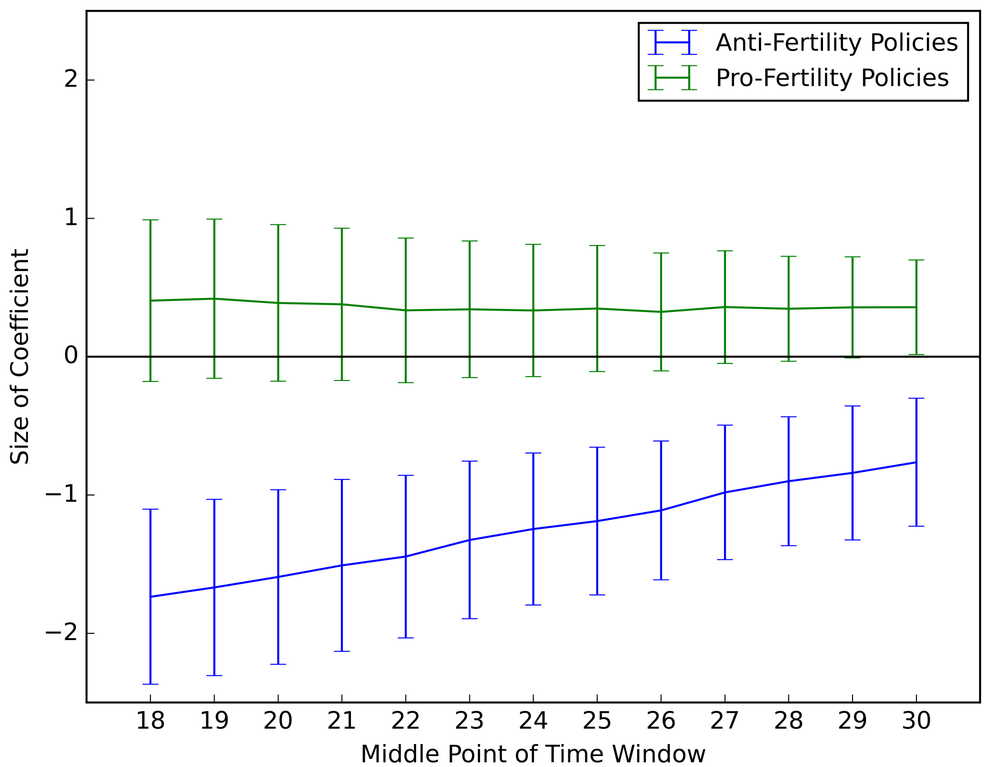

Figure A3: Elasticity Estimation for Anti-Fertility Policy Using Different Year Ranges