Asymmetric Fertility Elasticities*

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Abstract

Many governments around the world struggle with below-replacement fertility rates. Using historical data, we document that fertility is more responsive to anti-fertility policies than to pro-fertility ones. While canonical models with smooth Marshallian demand have difficulty explaining this phenomenon, we show that the asymmetry is consistent with a theory of fertility choice under reference-dependent preferences. In a dynamic economy where the reference point is endogenously formed, the theory offers a "slippery slope" perspective: fertility rates could fall even when the underlying economic fundamentals remain unchanged. Complementary to existing studies, our framework provides a new angle to interpret the recent global fertility decline. It also 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, reference dependence, precautionary motive

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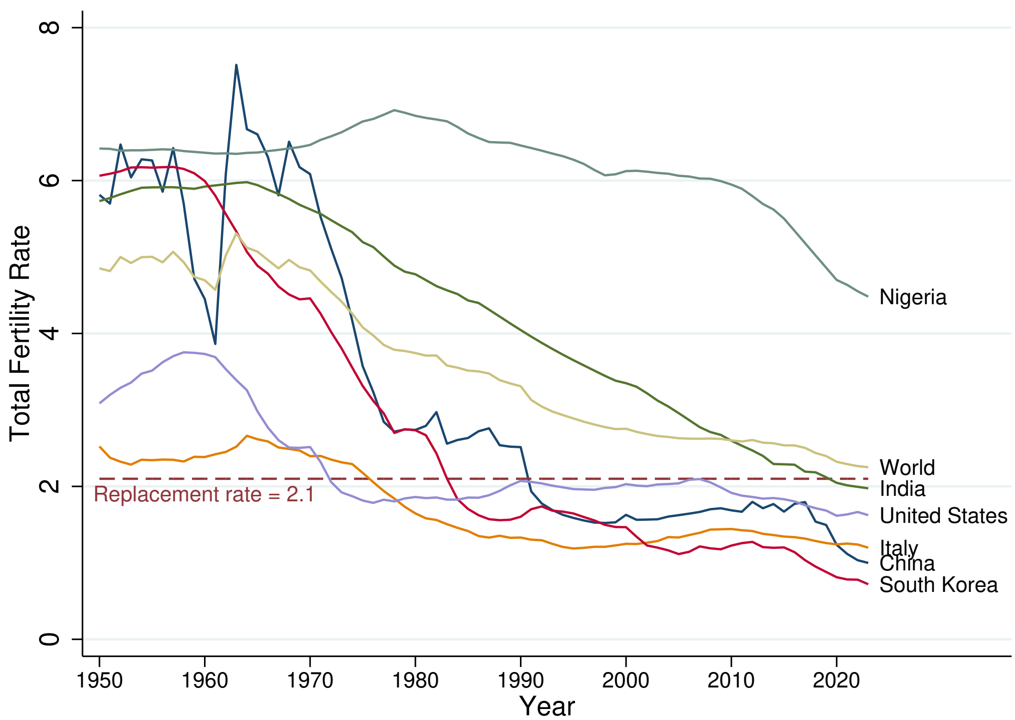
1. Introduction

Many governments around the world struggle with below-replacement fertility rates. Recent attempts to increase births have yielded disappointing results (Sobotka et al. 2019, Gauthier and Gietel-Basten 2024). The sustained below-replacement fertility rates (see Figure 1) indicate that the once-discounted "empty planet" future now seems altogether a plausible outcome (Bricker and Ibbitson 2019), threatening pension sustainability (Bongaarts 2004), economic dynamism (Hopenhayn et al. 2022), and economic growth (Jones 2022) in major civilizations.

Figure 1: Total Fertility Rate Across Countries



Notes: This figure plots the time series of fertility in several economies using data from the United Nations Population Division.

The failures of pro-fertility policies stand in sharp contrast with the perceived success that anti-fertility campaigns have achieved since the "population bomb" narrative (Ehrlich 1968) gained popularity and resulted in a continuing global wave of policy interventions.[1] Past studies

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

have shown that the anti-fertility policies played a key role in accounting for the rapid fertility decline in the past half century (Zhang 2017, De Silva and Tenreyro 2017).

Recently, many governments, including some that have employed anti-fertility policies in the past (e.g., China, Singapore, Thailand, etc), are adopting pro-fertility measures to counter below-replacement fertility rates, but with limited success (Gauthier and Gietel-Basten 2024). In retrospect, anti-fertility policies might have, ironically, 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 any systematic evidence in the data showing that fertility responds more to anti-fertility policies than to pro-fertility ones? If so, is this phenomenon–we call it asymmetric fertility elasticities–consistent with existing theories? If standard models cannot generate this asymmetry, what kind of model can? Lastly, what are the implications of asymmetric fertility elasticities for economists, demographers, and policymakers? We address these questions comprehensively in several steps.

First, we document that fertility rates respond more to anti-fertility policies than to pro-fertility ones in a range of data sources and empirical strategies. In particular, we estimate fertility responses to policy regimes using (1) panel regression on aggregate-level observations from the United Nations and (2) cohort exposure design on individual-level observations across countries from the World Value Survey (WVS). In both cases, we examine whether pro- and anti-fertility policies have effects of different sizes. 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 meta-analysis. In all specifications, we find that the coefficients of the anti-fertility policies are much larger than those of the pro-fertility policies. We also show that these findings are robust to alternative specifications and sample selection.

Second, we present a theory of fertility choice that nests standard models but allows for the possibility of asymmetric fertility elasticities. Such extension is needed because canonical models uniformly predict a smooth aggregate Marshallian demand for fertility. This prediction is inconsistent with the motivating facts we document and two other important empirical findings in the literature: (1) asymmetric (short-run) fertility responses to income shocks by Chatterjee and Vogl (2018), and (2) asymmetric fertility responses to policy implementation and reversal by González and Trommlerová (2023).

We develop a model of fertility choice with reference dependence over living standards that displays loss aversion. That is, an individual's disutility from not reaching her reference point is greater than the utility from an equivalent gain. The reason that reference dependence generates asymmetric fertility elasticities is simple: children offer utility to their parents, but they limit the amount of resources allocated to other goods, such as leisure, flexibility, or career outcome, that parents anchor on. For instance, The Wall Street Journal reports that in New Orleans, 42-year-old Beth Davis epitomizes some millennials' new views on childbearing: "I wouldn't mess up the dynamic in my life right now for anything, especially someone that is 100% dependent on me."[2] Hence, reference dependence generates a kink in the marginal benefit of consumption around the reference point in the model. As a result, symmetric shifts in the marginal cost of consumption, due to variations in the shadow price of children or income levels, have distinct effects depending on the direction of the shift – this explains the asymmetric fertility responses we find in the data.

The model with reference dependence is consistent with other long-standing patterns of fertility. For instance, we show that the model can be flexibly extended to include other choice margins such as labor supply and child quality-quantity trade-off. Hence, the model can accommodate cross-sectional fertility profiles and the long-run decline in fertility due to rising education premiums. Furthermore, because fertility is a normal good, the model is also consistent with the historical rise in fertility as countries initially escaped from the Malthusian trap with subsistence consumption (Vogl 2016).

Third, we embed the static model into a dynamic economy where the reference point follows an adaptive updating process (Thakral and Tô 2021) with random shocks. This assumption captures the "relative status" idea in the Easterlin hypothesis (Easterlin 1968) where material aspirations are endogenously determined by experiences rooted in family background.[3]

We prove that with reference dependence, the fertility rate could fall even without changes

[2] See https://www.wsj.com/lifestyle/relationships/americans-babies-childless-birthrate-daf438f9

[3] Because the economy is populated by representative agents, we can also entertain the idea that aspirations originate from social outcomes (Genicot and Ray 2017).

in the underlying economic fundamentals, what we call a "slippery slope" perspective.[4] While the economy receives symmetric shocks, the responses in fertility and consumption are asymmetric due to loss aversion. The accumulation of such asymmetric responses results in a downward trajectory of fertility. This perspective is distinct from traditional theories, where variations in fertility necessarily reflect changes in factors such as the return to education, the opportunity cost of children, etc. Therefore, besides matching asymmetric fertility responses to policy by design, the proposed fertility theory provides a unique explanation to the puzzle of falling U.S. birth rates since the Great Recession documented by Kearney et al. (2022). It also provides a new angle to interpret the global fertility decline in the past few decades, even in economies with little economic growth (Delventhal et al. 2021) or economies that have been the exemplars of family-friendly policies (e.g., Nordic countries).

Then, we study the policy implications of asymmetric fertility elasticities. To crystallize the role of reference dependence, 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 starting from different initial fertility levels.

This analysis offers several main policy insights. First, anti-fertility campaigns tend to overshoot because reference dependence exerts downward pressure on fertility, and hence fertility tends to slide down on its own even without policy interventions. Second, if the government aims to maintain a certain fertility level that is higher than the laissez-faire outcome, the amount of pro-fertility interventions needs to increase in time. Third, unless the social discount factor is zero, initiating the economy from the replacement rate–previously thought to be the cost-minimizing level by most policymakers (Striessnig and Lutz 2013)–is never cost-minimizing. In other words, governments have precautionary motives to set a higher fertility target than the replacement rate. Lastly, the cost-minimizing initial fertility depends on several 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 should not follow the traditional rule of thumb of "getting it close to the replacement rate" but requires a case-by-case analysis.

[4] Nevertheless, we provide an above-zero lower bound of expected fertility rate as $t \to \infty$.

Lastly, we carefully discuss other approaches to reconciling the asymmetry with existing models, including propagation channels, technological asymmetries, and binding credit constraints. While it is difficult to rule out these explanations completely, we show that (1) none of the alternatives can fit all empirical facts simultaneously, and (2) the main policy implications remain robust.

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. Therefore, while there is a sense among practitioners that raising fertility seems to be more difficult and hence the empirical findings might not come as a total surprise, we contribute to the literature by being the first to systematically document the asymmetric effectiveness using policy regimes and funding data.

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), Galor and Weil (2000), and Chatterjee and Vogl (2018) on the economic determinants of fertility, Doepke (2005) on the role of child mortality, Albanesi and Olivetti (2016) on the role of maternal morbidity, Hazan and Berdugo (2002) and Doepke and Zilibotti (2005) on the impacts of child labor, Greenwood et al. (2005a) on the household appliance revolution, Myrskylä et al. (2009) and Feyrer et al. (2008) on the "J-curve" hypothesis, Spolaore and Wacziarg (2022) on the spread of modernity, and Bricker and Ibbitson (2019) on the empty planet prediction. We make a theoretical contribution to the literature with a new perspective: with endogenous reference point of lifestyle, fertility rate faces sustained downward pressure even without any changes in the underlying economic or societal fundamentals. This prediction helps to resolve the "puzzle of falling U.S. birth rates since the Great Recession" (Kearney et al. 2022). Compared with traditional theories, the "slippery slope" perspective also generates a novel 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. 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 three important ways. First, we document and explain asymmetric fertility elasticities – a channel fundamentally different from the self-perpetuating channels they propose because the latter works equally well in either direction, whether it is to increase or decrease fertility. Second, we find that asymmetric fertility elasticities exist for countries with either high or low fertility rates in the split sample analyses. Third, 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, such as 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.[5] There are few studies combining these two literature.

Two notable exceptions have considered reference-dependent preferences 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. (2024) 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. In these models, reference dependence generates changes in the level of fertility, but not kinks in the aggregate Marshallian fertility demand. This paper differs by focusing on loss aversion, a special case of

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

reference dependence, and how it leads to asymmetric fertility elasticities.

The rest of the paper is organized as follows. In Section 2, we present the main empirical results. We then develop the theoretical framework and the "slippery slope" perspective in Section 3. We further discuss the policy implications of this new theory in Section 4. Section 5 discusses alternative explanations to the empirical observations. Section 6 concludes.

2. Motivating Facts

This section documents several facts that motivate our model and analysis. In particular, we establish asymmetric fertility responses to pro- versus anti-fertility policies using several data sources and econometric specifications.

2.1 Changing Landscape of Fertility Policies

We collect the main variable of interest, policy regimes 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 regimes on the prevailing fertility level, categorized into "lower", "raise", "maintain", and "no intervention." The United Nations assigned the entry values 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 regime around the world in 1986, eighteen years after the publication of The Population Bomb (Ehrlich 1968). As can be seen, a number of populous developing countries have already taken a policy regime aimed at lowering fertility levels, most notably China and India. Only several countries had adopted the pro-fertility regimes (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 regime 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 and improving women's rights. Most countries in Europe and many in Asia, on the other hand, have adopted the policy regime "raise" to address the issue of below-replacement fertility.

Figure 4 plots the histogram of policy regimes by the contemporaneous fertility level in the data. Naturally, "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 regimes 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 regime in 1976.[6] An immediate message this figure delivers is that while countries with initial anti-fertility policy regimes seem to be achieving their stated goals quite well, fertility levels in countries with the initial policy regime "raise" are still falling.

2.2 Asymmetries in Aggregate Fertility Responses

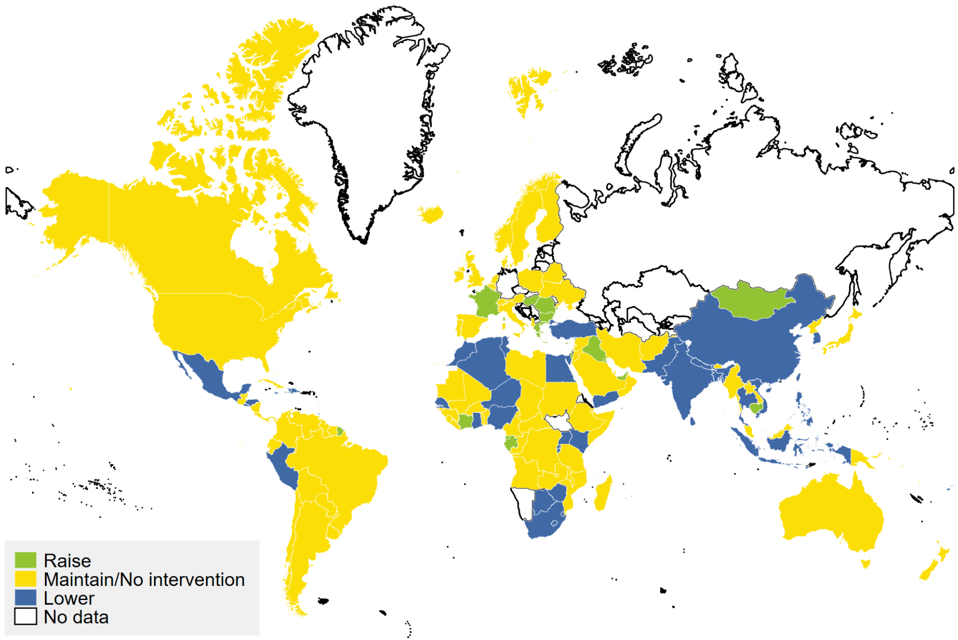
In Table 1, we formalize the intuition presented in Figure 5 by applying a simple two-way fixed effect model to examine the asymmetric response of TFR to fertility policies at the country level. In column (1), we regress the percentage change of TFR on the indicators of policy regimes in the previous year. We find that while a one-year exposure to the anti-fertility policy regime is associated with a 1.18% reduction in TFR, the association with the pro-fertility policy regime is much smaller and not statistically significant.

Considering that it may take several years for fertility policies and the associated fertility responses to come into effect, we adopt an alternative strategy in column (3), where the independent variable is the fraction of years with anti-fertility or pro-fertility policies in the past five years. The result is consistent with that in column (1).

In columns (2) and (4), we control for a rich set of variables that may influence fertility, including both the absolute level and growth rate of real GDP per capita, urbanization rate, infant mortality rate, female labor force participation, and years of schooling for women. The coefficients on both "lower fertility" and "raise fertility" become smaller after controlling for

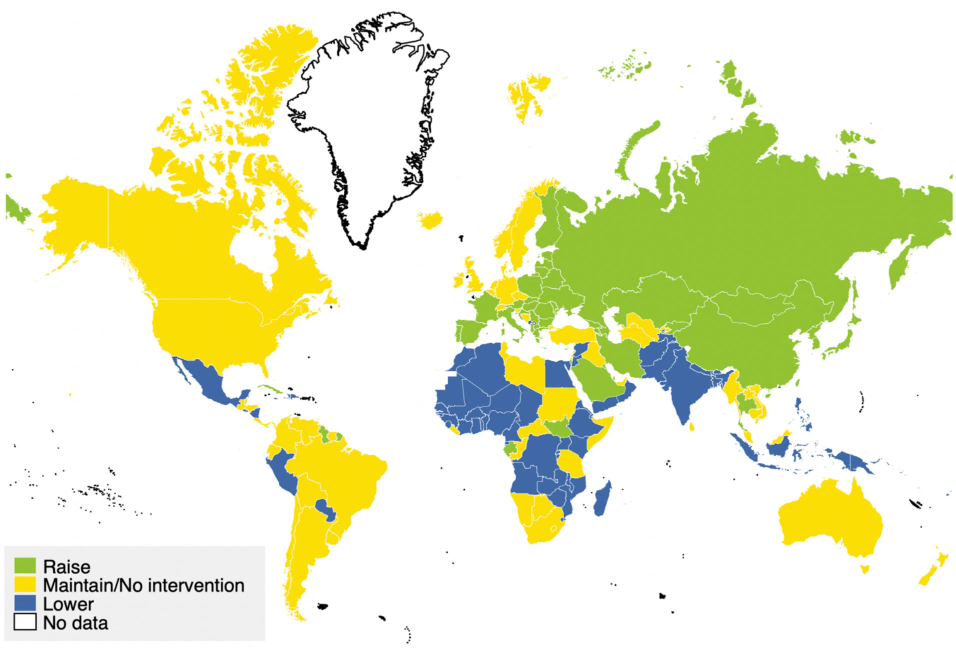
[6] This figure is also shown in De Silva and Tenreyro (2017).

Figure 2: Fertility Policy regime in 1986



Source: United Nations Population Division

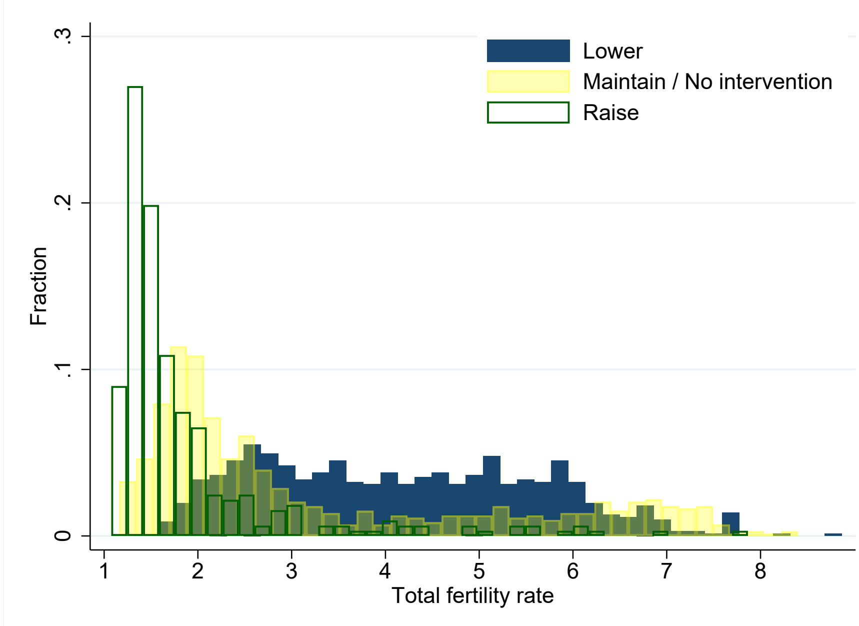
Figure 3: Fertility Policy regime in 2021



Source: United Nations Population Division

Notes: These figures plot the fertility policy regime across countries in 1986 and 2021 using data from the United Nations Population Division.

Figure 4: Policy regime 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.

these variables, but the asymmetry result persists. In addition, the asymmetry is unchanged when we use country population as weights in the regressions or restrict the sample to only countries which have experience both anti- and pro-fertility policies.[7]

To compare the coefficients more systematically, we compute the 95% confidence interval of their ratios using bootstrap methods. In most specifications, the interval does not include -1, rejecting symmetric effects. Figure 6 plots the joint confidence region of coefficients, and the result reinforces our conclusion about fertility policy's asymmetric effect.

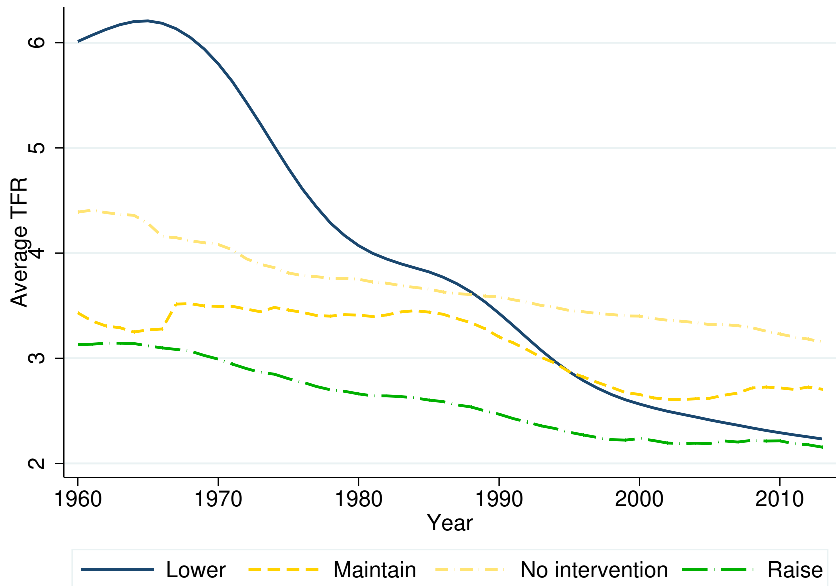
2.3 Asymmetries in Individual Fertility Responses

Besides aggregate-level responses, we also use a cohort exposure design to gauge the responses to pro- or anti-fertility policies at the individual level.

We match the country-level policy regimes to individual-level data from the World Value Survey (WVS), a large-scale repeated cross-sectional social survey that was conducted in seven

[7] These results are available upon request.

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 regime in 1976.

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. Like education, fertility decisions are mainly affected by the policy environment during individuals' childbearing time window. Therefore, we construct a policy exposure index using 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

Table 1: Population Policy and TFR

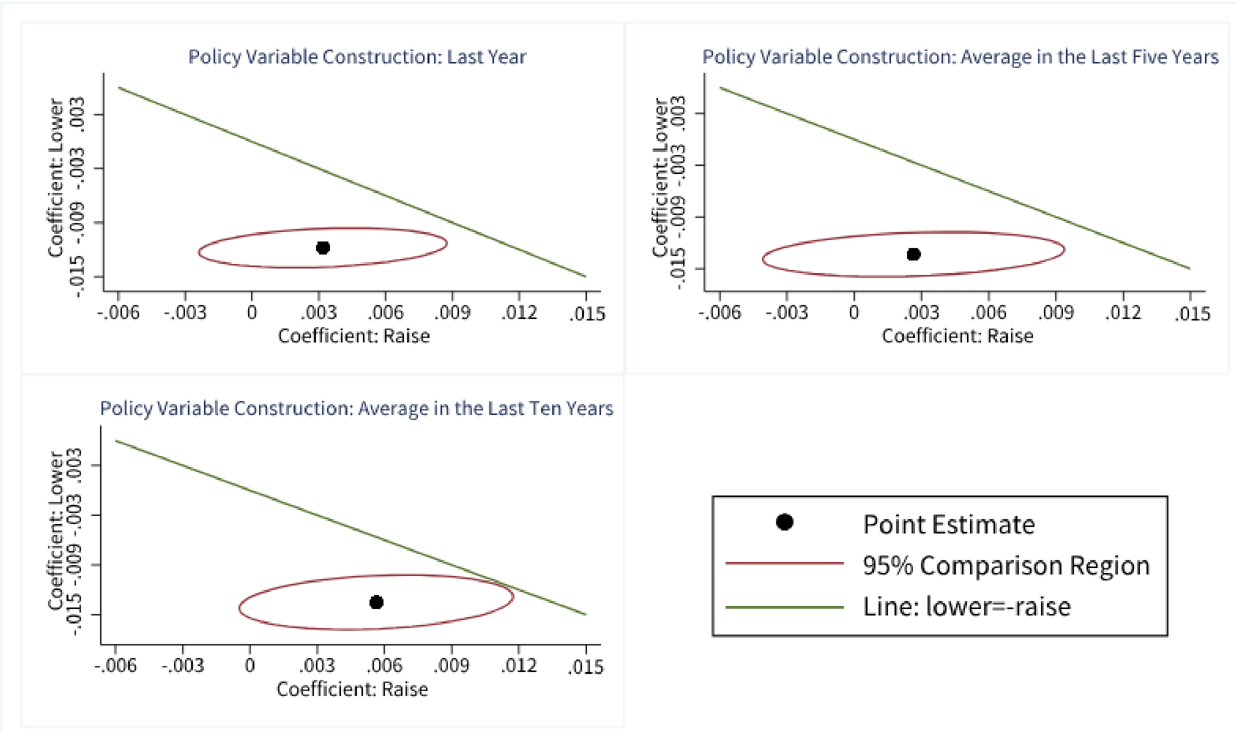
Dependent Variable	ΔTotal Fertility Rate/Lagged Fertility Rate			
Construction of Policy Variables	Last Year		Average in the Last Five Years	
	(1)	(2)	(3)	(4)
Lower fertility	-0.0118***	-0.0055***	-0.0133***	-0.0062***
	(0.0013)	(0.0016)	(0.0015)	(0.0021)
Raise fertility	0.0032	0.0006	0.0027	-0.0005
	(0.0034)	(0.0030)	(0.0041)	(0.0036)
	95% Confidence Intervals of Coefficients' Ratios			
Raise / Lower	[-0.849, 0.308]	[-1.198, 0.984]	[-0.812, 0.414]	[-1.059, 1.207]
Raise / Lower (Bootstrap)	[-0.865, 0.324]	[-0.988, 0.396]	[-0.834, 0.436]	[-1.042, 0.487]
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes
Observations	10301	7373	9545	6821
R^2	0.132	0.170	0.129	0.171

[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 regime 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. Columns (1) and (3) only 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 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.

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 2.1 by constructing indicators of different fertility policies and calculating each individual's

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) 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.

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:

$$\begin{aligned} \text{Child}_{icbt} = \alpha + \beta_1 \text{Policy\_Lower}_{icb} + & \beta_2 \text{Policy\_Raise}_{icb} \\ & + \eta \text{Age}_i \times \text{Gender}_i + \gamma_{ct} + \delta_b + \epsilon \end{aligned} \tag{1}$$

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.[8] $\text{Policy\_Lower}_{icb}$ and $\text{Policy\_Raise}_{icb}$ are the policy exposure variables defined in the last paragraph. $\text{Age}_i \times \text{Gender}_i$ 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 for these variables.

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

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

Table 2: Population Policy and the Number of Children

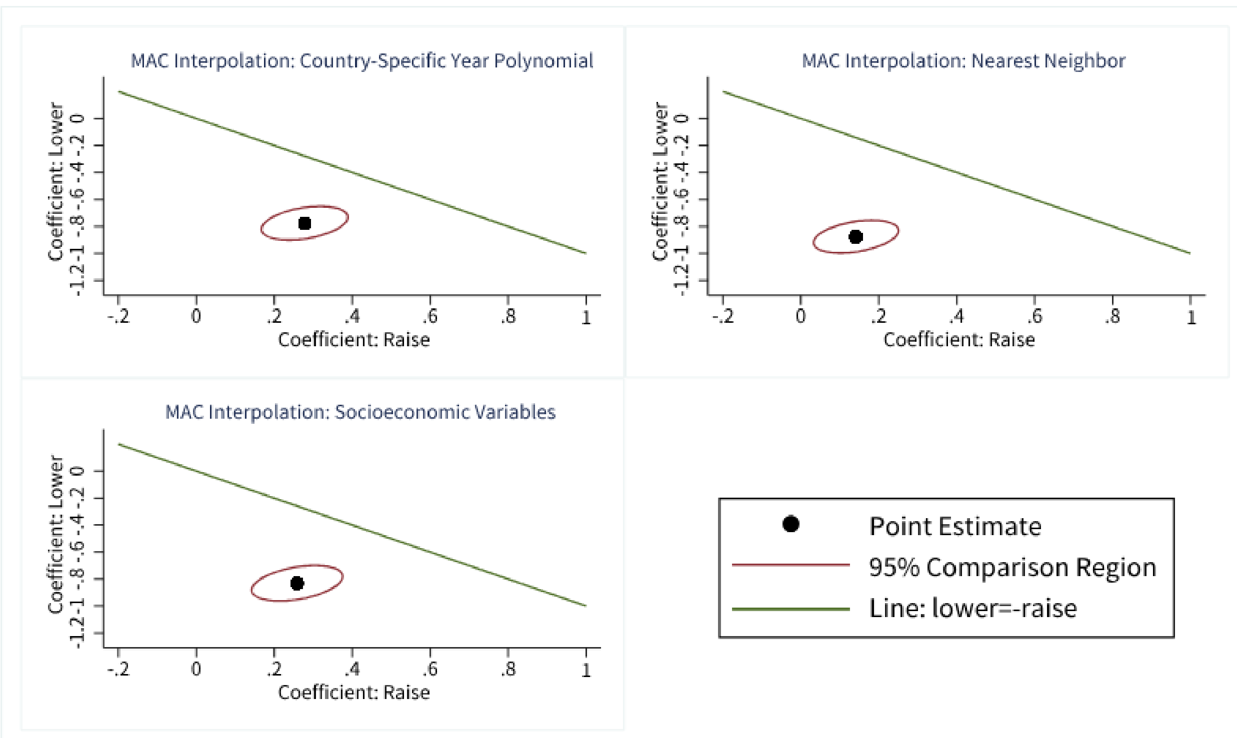
Dependent Variable	Number of Children								
Interpolation of MAC	Country-Specific Year Polynomial			Nearest Neighbor			Socioeconomic Variables		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Target: Lower fertility	-0.776***	-0.762***	-0.624***	-0.875***	-0.844***	-0.655***	-0.831***	-0.821***	-0.631***
	(0.076)	(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.

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. Similar to Figure 6, figure 7 plots the joint confidence region of coefficients reported in Table 2, and the result is consistent with our conclusion about fertility policy's asymmetric effect.

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 2. 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.

In Section B.5, we decompose the effect of fertility policies and show that it is mainly driven by effect on the intensive margin, i.e., changes in higher-order births. Therefore, the asymmetry does not seem to be driven by the effects on childlessness. In Section B.7, we also examine the heterogeneous effects of fertility policies across different income and education groups. The results reveal that the asymmetry in fertility policy effects becomes more pronounced as income or education level rises. The second finding, as will be discussed in more detail in Section 5, helps us rule out some alternative explanations such as binding liquidity constraints.

2.4 Asymmetries using Policy Funding Data

While Sections 2.2 and 2.3 show that the anti-fertility policy regime has significantly larger effects on fertility than the pro-fertility policy regime, 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 regimes. 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. We conduct the analysis at the country level.[9]

We first estimate the elasticity of anti-fertility policies. The empirical strategy we adopt is similar to the two-way fixed effect specification of Table 1 in Section 2.1. The only difference is that the dependent variable is now constructed using the ratio of anti-fertility policy expenditures to GDP.[10] The result is presented in Table A25. In brief, the result of the two-way fixed effect specification indicates that TFR will decrease by 6.4% when the funding-GDP ratio increases by 0.1%.

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-

[9] In Section C.2, we also compare the elasticity of pro-fertility policies with the elasticity of anti-fertility policies estimated at the individual level. At the individual level, the degree of asymmetry is even larger.

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

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." 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 A25 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 A25 to ensure comparability. Section C.3 provides a detailed description of the conversion method.

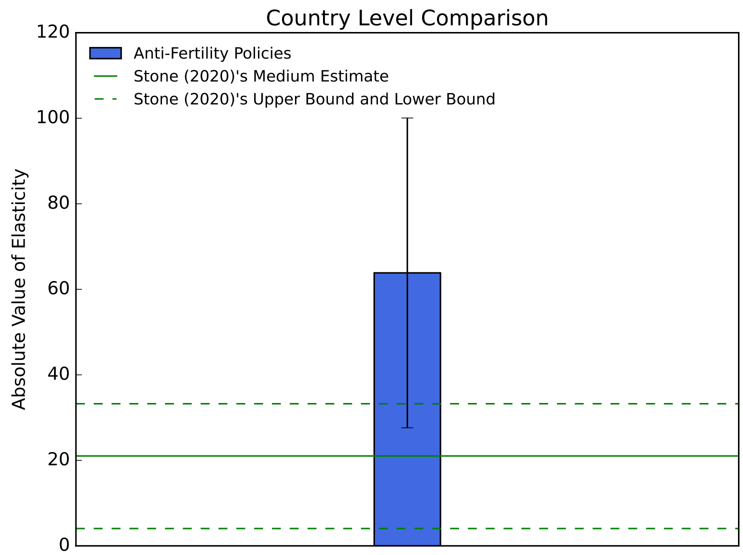
We present the comparison between anti-fertility policies and pro-fertility policies in Figure 8. The blue bar displays the estimated elasticities for anti-fertility policies in Table A25, with the error bar representing the 95% confidence interval. The solid line is the average of converted "medium" 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 8.[11] 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 2.3 using policy regimes.

2.5 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

[11] 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 8: Comparison Between Anti-Fertility Policies and Pro-Fertility Policies



Source: Estimated elasticity of anti-fertility policies is from regression result in Table A25; estimated elasticity of pro-fertility policies is calculated as discussed in Section 2.4, 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.

likely to adopt such policies. We provide evidence that our conclusion is robust to selection into treatment in Section B.8. Second, countries' choice of fertility policy is not exogenous, but rather affected by TFR itself. This introduces the problem of reverse causality, which we address with lagged fertility controls in Section B.9. In Sections B.4 and B.6, we also show that our findings on the cumulative effects of fertility policies and estimates of anti-fertility elasticities are consistent with other studies that use structural or quasi-experimental methods. Third, we show our conclusion is robust to employing alternative methods in the construction of dependent variables in Section B.10. Last, Section B.11 shows that the results in the cohort exposure design are robust to potential effects coming from exposures to fertility policies in early ages before the childbirth window.

2.6 Summary

To sum up, the empirical part of this paper establishes two facts.

Fact 1: Aggregate-level fertility is more responsive to anti-fertility policy regimes and expenditures than to pro-fertility ones.

Fact 2: Individual-level fertility is more responsive to anti-fertility policy regimes during the fertile window. The asymmetry is stronger for individuals with higher income or education.

These facts complement three other important empirical findings in the literature.

Fact 3: Chatterjee and Vogl (2018) find that fertility falls sharply in deep recessions but does not rise in rapid expansions, i.e., asymmetric short-run responses to income shocks.

Fact 4: González and Trommlerová (2023) find that when a pro-fertility policy in Spain was reversed, fertility fell below the original level, i.e., asymmetric responses to policy implementation and reversal.

One might wonder whether the findings in González and Trommlerová (2023) hold in a broader sample of country and time. In Sections B.1 and B.2, we extend their results using aggregate-level data and find empirical support. In Section B.3, we use a case study in Australia to further establish that individuals' (stated) utility levels also respond asymmetrically to policy implementation and reversal, i.e., a decrease in fertility subsidy has a larger impact on reported happiness than an equal-sized increase in fertility subsidy.

Fact 5: Kearney et al. (2022) document a puzzling fertility decline in the U.S. after the Great Recession but are unable to identify changes in economic, policy, or social factors that can account for the decline.

Taken together, these facts, especially 1 to 4, present a challenge to standard fertility models which are typically set up as a utility maximization problem:

$$\max_{c,n,\ldots} \quad U(c,n,\ldots), \quad \text{subject to} \quad c+\chi\cdot n+\ldots = I.$$

Because the objective function $U(\cdot)$ is smooth and the problem is concave, the model results in a smooth Marshallian demand curve $n(\chi, I, \ldots)$ in the aggregate economy where optimal fertility is a function of the cost of children χ, income I, 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 (Sommer 2016), (2) warm glow or altruistic preferences (Barro and Becker 1989), (3) representative or heterogeneous agents (Vogl 2016, Daruich and Kozlowski 2020), (4) continuous or discrete fertility choices (Baudin et al. 2015, Cordoba et al. 2016),[12] and (5) with or without the quantity-quality trade-off (De La Croix and Doepke 2003).

The smooth Marshallian demand $n(\chi, I, \ldots)$, however, cannot generate the asymmetric fertility elasticities because it implies that the elasticity of fertility to the cost of children or income does not depend on the direction that the cost changes. On the contrary, the data implies that the fertility responses to a rising χ (falling I) are much larger than the responses to a falling χ (rising I).

The upshot here is that there are two possible paths forward to interpret asymmetric fertility elasticities within the realm of economic models. First, one could argue that the mapping between policy expenditures and changes in χ depends on policy direction, i.e., technological asymmetry. Second, one could argue that there needs to be a kink in the Marshallian demand for fertility. In the next two sections, we follow the second path to propose a new theory that generates kinks in the fertility demand. We discuss its micro-foundations, policy implications, and the additional facts that this theory uniquely generates. Then, we carefully discuss other possibilities, including technological asymmetry, in Section 5.

3. The Model

This section presents a model of fertility choice under reference-dependent preference that nests the traditional models. We also develop the "slippery slope" perspective, discuss its properties, and calibrate 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 that there is a level of reference consumption (r) below which the household suffers from extra disutility, i.e., loss aversion.[13] The model is in-

[12] The aggregate Marshallian demand of fertility is still smooth once fertility choices at the household level, discrete or continuous, are integrated over the distribution of state space.

[13] 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.

tentionally designed to be simple to highlight the role played by reference dependence alone. As discussed in Section 3.4, the model can be enriched by including other choices such as leisure or child quality and the key results remain unchanged.

The maximization problem of the household is

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

subject to budget constraint

$$c+\chi\cdot n=I \tag{3}$$

where parameter χ is the cost of fertility in consumption units. The total amount of resources is given by I.

For variable $x\in\{c,n\}$, we assume that the utility function $u(\cdot)$ follows

$$u(x)=\frac{x^{1-\gamma}-1}{1-\gamma} \qquad \gamma>1 \tag{4}$$

where parameter γ governs the elasticity of substitution between consumption and fertility. The condition $\gamma>1$ guarantees that changes in χ affect the marginal cost of consumption c.

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

$$G(y)=\begin{cases} y & y\geq 0 \\ y-\alpha y^2 & y<0 \end{cases} \tag{5}$$

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

$$\max_{c,n} \quad u(c)+\frac{\beta}{2}u(n) \qquad \text{subject to} \quad c+\chi\cdot n=I. \tag{6}$$

In that case, the degree of loss aversion we calibrate in Section 3.5 reflects the degree of *differential loss aversion* between c and n.

Instead of the piecewise-linear loss aversion function

$$G(y) = \begin{cases} y & y \geq 0 \\ \alpha y & y < 0 \end{cases} \qquad \alpha \geq 1 \tag{7}$$

commonly used in the literature, we adopt the functional form in Equation (5) because it generates a continuous $G'(y)$ at $y = 0$. This allows us to (1) characterize optimal decisions using first-order conditions and (2) 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 (5) and (7) 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

$$r = c \tag{8}$$

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

3.2 Asymmetric Elasticities

In this section, we state and prove three 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,

$$\left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{+,\alpha>0} < \left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{-,\alpha>0} < 0 \tag{9}$$

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.

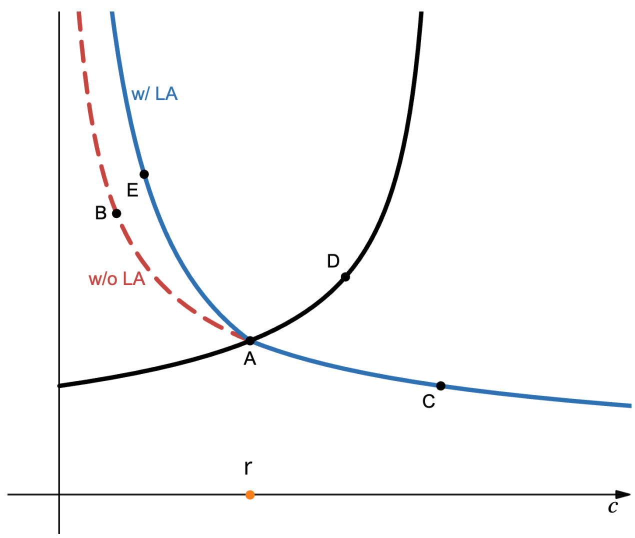
After substituting $n = \frac{1}{\chi} \cdot (I - c)$ into the objective function, the first-order condition on c is

$$u'(c) \cdot \big(1 + G'(u(c) - u(r)\big) = \frac{\beta}{\chi} \cdot u'\left(\frac{I - c}{\chi}\right) \tag{10}$$

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 9, 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 where the marginal benefit and marginal cost of c intersect. The fact that the level of consumption at point A coincides with the reference level r reflects the consistency condition.

Figure 9: Marginal benefit and cost of consumption

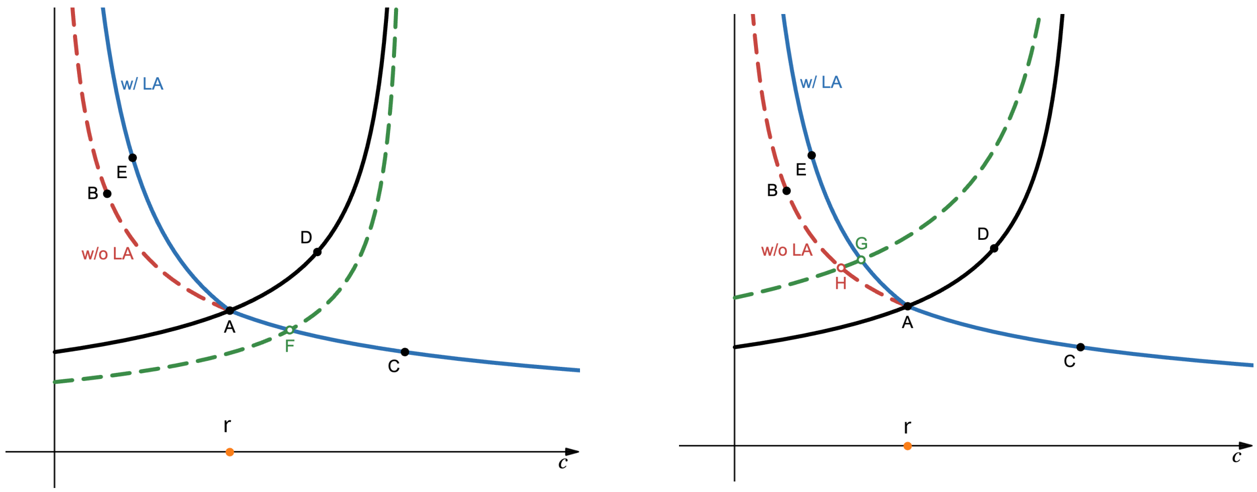


Notes: This figure plots the marginal benefit and cost of consumption. The abbreviation "LA" stands for "loss aversion."

Figure 10a 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 10b plots the comparative static when χ rises. In this case, the curve AD shifts up. Because the marginal utility of consumption is higher under loss aversion

Figure 10: Comparative statics with respect to child cost χ



(a) Child cost falls

(b) Child cost rises

Notes: These figures plot the comparative statics with respect to perturbations in child cost χ. The abbreviation "LA" stands for "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 (6) 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 10a and 10b, we have the following relationship that proves Proposition 1.

$$\left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{+,\alpha>0} \overset{\text{Figure 10b}}{<} \left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{+,\alpha=0} \overset{\text{smooth } \tilde{n}^*(\chi)}{=} \left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{-,\alpha=0} \overset{\text{Figure 10a}}{=} \left.\frac{\partial \log n^*}{\partial \log \chi}\right|_{-,\alpha>0} < 0 \quad (11)$$

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,

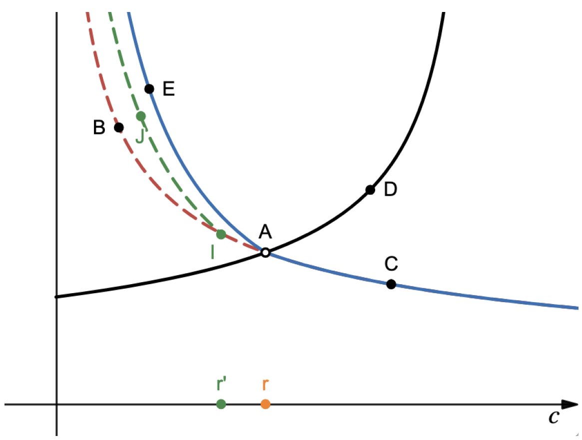
$$\left.\frac{\partial \log n^*}{\partial \log r}\right|_{+,\alpha>0} < \left.\frac{\partial \log n^*}{\partial \log r}\right|_{-,\alpha>0} = 0 \quad (12)$$

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

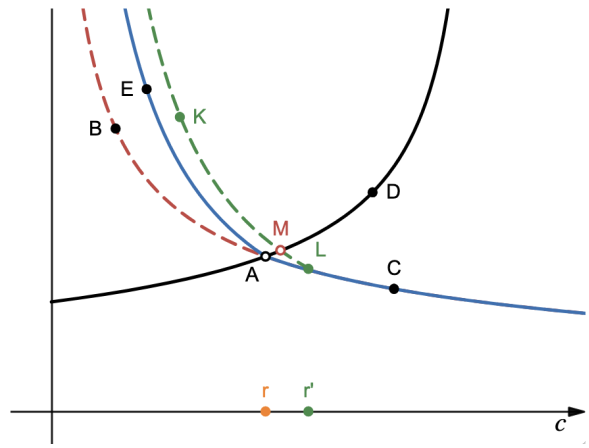
Proof: Likewise, we present a graphical proof of Proposition 2.

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 11: Comparative statics with respect to reference level r



(a) Reference falls



(b) Reference rises

Notes: These figures plot the comparative statics with respect to perturbations in the reference level r. The abbreviation "LA" stands for "loss aversion."

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 11a and 11b, we have the following relationship that proves Proposition 2.

$$\left.\frac{\partial \log n^*}{\partial \log r}\right|_{+,\alpha>0} \overset{\text{Figure 11b}}{<} \left.\frac{\partial \log n^*}{\partial \log r}\right|_{+,\alpha=0} \overset{r \text{ is irrelevant}}{=} \left.\frac{\partial \log n^*}{\partial \log r}\right|_{-,\alpha=0} \overset{\text{Figure 11a}}{=} \left.\frac{\partial \log n^*}{\partial \log r}\right|_{-,\alpha>0} = 0 \quad (13)$$

Proposition 3: When $\alpha > 0$, the optimal fertility response to a decrease in I is larger than the optimal response to an increase in I in the economy. Namely,

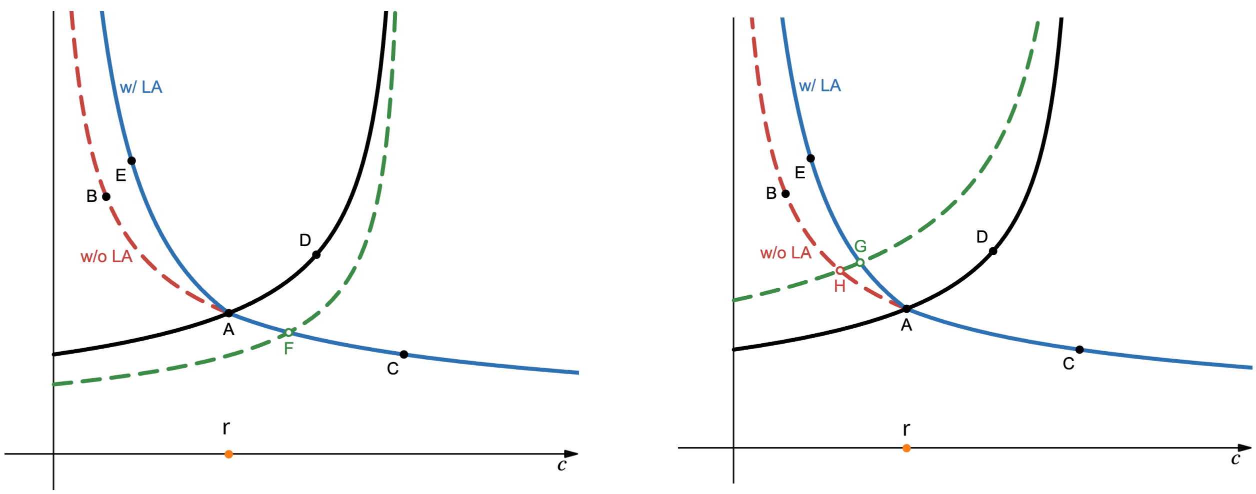
$$\left.\frac{\partial \log n^*}{\partial \log I}\right|_{-,\alpha>0} < \left.\frac{\partial \log n^*}{\partial \log I}\right|_{-,\alpha>0} < 0 \tag{14}$$

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

Proof: Likewise, we present a graphical proof of Proposition 3.

Figure 12a plots the comparative static when I rises. 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.

Figure 12: Comparative statics with respect to income I



(a) Income rises

(b) Income falls

Notes: These figures plot the comparative statics with respect to perturbations in income I. The abbreviation "LA" stands for "loss aversion."

On the other hand, Figure 12b plots the comparative static when I falls. In this case, the 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.

Thus, combining the cases in Figures 12a and 12b, we have the following relationship that proves Proposition 1.

$$\left.\frac{\partial \log n^*}{\partial \log I}\right|_{-,\alpha>0} \overset{\text{Figure 12b}}{<} \left.\frac{\partial \log n^*}{\partial \log I}\right|_{-,\alpha=0} \overset{\text{smooth } \tilde{n}^*(I)}{=} \left.\frac{\partial \log n^*}{\partial \log I}\right|_{+,\alpha=0} \overset{\text{Figure 12a}}{=} \left.\frac{\partial \log n^*}{\partial \log I}\right|_{+,\alpha>0} < 0 \quad (15)$$

Proposition 3 explains the non-linear fertility responses to short-run income shocks documented by Chatterjee and Vogl (2018). In particular, they show that conceptions fall sharply in deep recessions but do not rise in rapid expansions. Through the lens of our model, when the reference level r is fixed in the short run, households choose to lower fertility to avoid a sharp reduction in consumption during a recession; but when income rises, fertility only rises modestly because consumption is also increasing.

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:

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

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 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 or the socially determined aspirations in Genicot and Ray

(2017). 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. 2005b), changing infant mortality (Doepke 2005), varying returns to human capital investments (Becker et al. 1990), etc.

Theorem: The *"slippery slope" perspective* predicts that starting from any consistent reference level $r_0 = c_0$, 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 first inspect the evolution of expected fertility $\mathbb{E}(n_t)$ in the extreme case where $\phi = 1$ and leave the proof of the case $\phi \in [0,1)$ to the Appendix.

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. 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 immediate with $r_t = c_{t-1} + \epsilon_t$. Then we are back to the case analyzed in Figures 11a and 11b. 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. Because $\mathbb{E}_{t-1}(r_t) = c_{t-1}$, the expected path of reference level will drift up following the process of consumption.

For the case where $\phi \in (0,1)$, we present a proof of the "slippery slope" in Appendix D where we map the updating process (16) into continuous time,

$$dr_t = (1-\phi)\cdot(c(r_t)-r_t)dt + \sigma dB_t \tag{17}$$

where B_t is a standard Brownian motion.

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

3.4 Implications on Leisure or Child Quality?

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 and/or the child quantity-quality trade-off.[14]

Regarding leisure, 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:

$$\max_{e,l,n} \quad \frac{1}{2}[u(c)+\beta u(n)] + \frac{1}{2}[G(u(c)-u(r))+u(r)] \tag{18}$$

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

$$c = f(e,l) \tag{19}$$

The budget constraint is

$$e = w\cdot(1-l-\chi\cdot n) \tag{20}$$

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,

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

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 property is that even in a richer 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.

The same argument applies to the case of the child quantity-quality trade-off once we regard variable c as a composite good of expenditures on own consumption and children's quality.

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 or some specific historical 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 $\{\alpha,\beta,I,\chi,\gamma,\phi,\sigma\}$. First, we normalize $I=1$ and 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 gauge 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.

3.6 Results

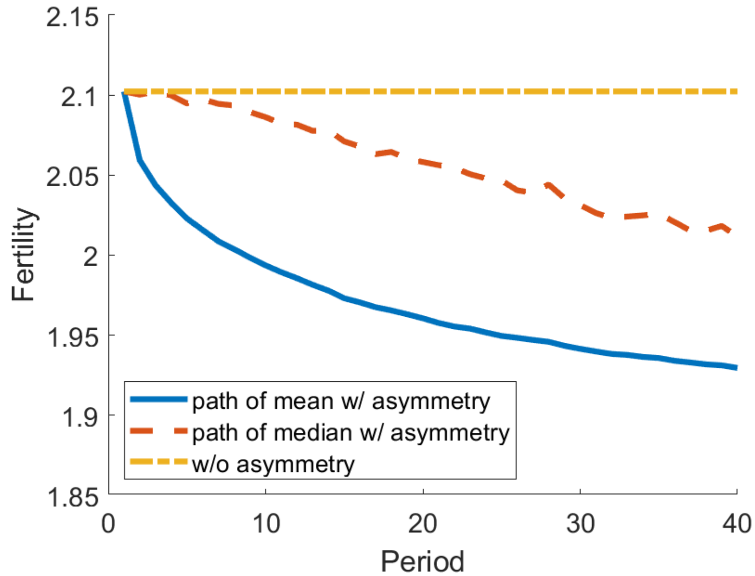
After calibrating the model, we simulate $N = 1000$ paths for $T = 40$ periods. Every path starts with $n_0 = 2.1$ and $r_0 = c_0 = 1 - \chi \cdot n_0$, i.e., a reference level consistent with the prevailing consumption decision.

Figure 13 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 falls in n_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 14. 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 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 (Caucutt et al. (2002)), maternal morbidity (Albanesi and Olivetti 2016), or returns to education (Becker

Figure 13: The "Slippery Slope"



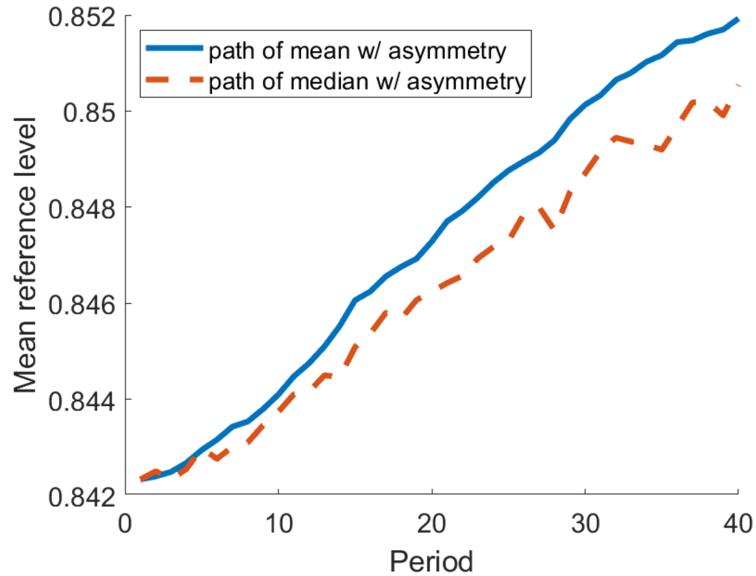
Notes: This figure plots the simulated path of average and median fertility with and without asymmetric fertility elasticities.

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 changing aspirations or priorities across cohorts.

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 changes in economic fundamentals cannot explain the unexpected drop in fertility in the United States after the Great Recession. Instead, they argue that changing priorities may be the main driver in the background. The model complements their view with three additional insights. First, fertility declines without changing economic fundamentals could actually be quite common.[15] In fact, as the persistence of social norm ϕ falls in the model, such drops in fertility may even occur half of the time along the "slippery slope" due to shocks to the reference level. Second, current declines in fertility may have historical roots. For example, if the parents of the current young generation did very well in

[15] For example, Spolaore and Wacziarg (2022) document that the spread of French social norms shaped the fertility decline in Europe from 1830 to 1970. Kearney and Levine (2015) establish media influence on teenage childbearing around 2010 in the United States.

Figure 14: The Time Path of Reference Consumption Level



Notes: This figure plots the simulated path of average and median reference level with asymmetric fertility elasticities.

the past, then the young generation will have a higher reference level, which may result in lower fertility if these high expectations are not met. Third, the model implies that if the government wants to maintain a certain level of fertility, it needs 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

$$\mathscr{S}(n_t|\overline{n}) = \lambda \cdot (\log(n_t) - \log(\overline{n}))^2 \tag{21}$$

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

$$\min_{n_0} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \rho^t \mathscr{S}(n_t|\overline{n}) \tag{22}$$

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 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 households' optimization problems because these policies come in various forms in real life. Even within narrowly defined policy categories such as baby bonuses, policies can be delivered in different ways that would have distinct 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, Conde-Ruiz et al. 2010). While a full-fledged Ramsey problem would certainly be interesting, we leave it for future research.

Lastly, we simplify the problem by assuming that the government can only make one decision – permanently changing the cost of children with full commitment. This assumption lets us abstract away from frequent policy reversals and credibility issues. Given that population and fertility goals are one of the policy decisions with the longest planning horizon, 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.

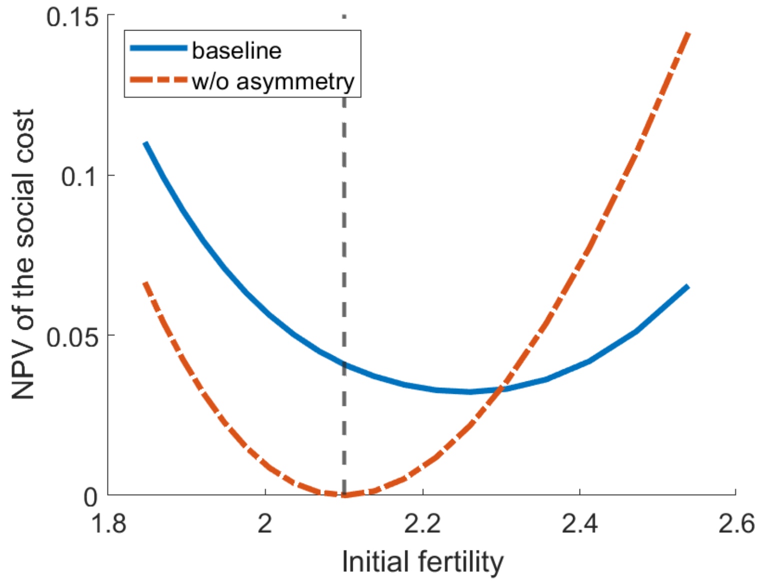
Implication 1: Unless the discount factor is zero, choosing the replacement rate as the initial level of fertility is never cost-minimizing.

Figure 15 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 16 and 17 explain why $n^* = 2.25$ leads to a lower cost. Figure 16 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.[16]

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

Figure 15: Initial Fertility and Expected NPV of Social Costs



Notes: This figure plots the expected NPV of social costs across different levels of initial fertility level n_0 with or without asymmetric fertility elasticities.

Figure 17 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 $n_0 = \overline{n}$. 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: if the government aims to maintain a certain level of fertility that is higher than the laissez-faire outcome, the amount of pro-fertility interventions needed increases in time.

Because fertility falls on its own in expectation, if the government wants to maintain n_0, it is insufficient to make a permanent reduction in χ at $t = 0$. As a result, if the government is allowed to change χ every period through family policies, the amount of support will be an increasing function of time.

Implication 3: The cost-minimizing initial fertility level depends on the degree of asymmetry, the reference updating process, and the social discount factor. Therefore, the optimization problem of a cost-minimizing government is more intricate than the traditional approach of "getting it closer to the replacement rate."

Figure 16: Path of Expected Fertility

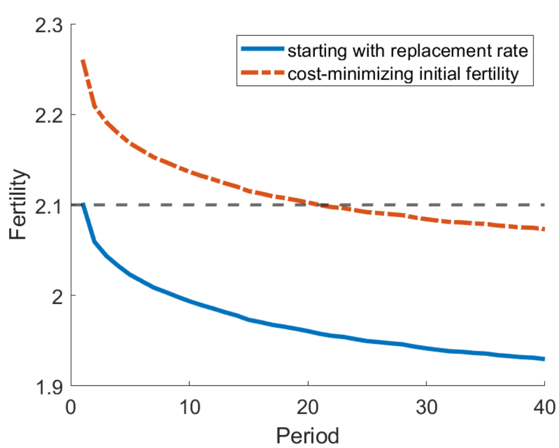
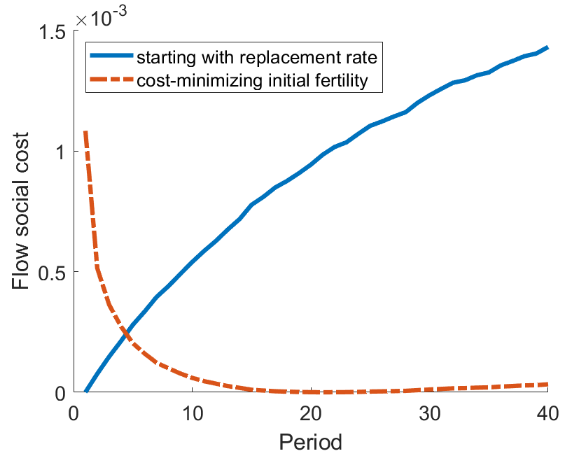


Figure 17: Path of Expected Social Costs



Notes: These figures plot the expected path of fertility and flow social costs with different initial fertility level n_0.

5. Alternative Explanations

We flag several potential alternatives to reconcile the asymmetry with existing frameworks and discuss which results are robust to these alternative explanations.

5.1 Propagation Channels

As argued by Lutz et al. (2006), fertility decline could trigger various propagation mechanisms such as peer pressure, technological adoption, and so on. For example, Rossi and Xiao (2024) present empirical evidence of social spillovers in the context of the one-child policy in China.

The presence of propagation channels, however, does not necessarily generate asymmetries because they could also work when fertility increases. That is, propagation channels make fertility elasticities larger but not asymmetric. Therefore, for this explanation to work, the proposed propagation mechanism needs to be inherently asymmetric and it begs the question.

5.2 Liquidity Constraints

One explanation points to (potentially) binding liquidity constraints. For example, Chatterjee and Vogl (2018) argues that the presence of liquidity constraints raises marginally utility more during recessions, leading to stronger fertility responses.

To some extent, reference dependence and binding constraints capture the same idea as loss aversion: the marginal utility of consumption becomes extra higher when income or consumption falls below a certain threshold. Theoretically, the model based on reference dependence with adaptive updating could be more appealing because it provides an explicit micro-foundation of where such thresholds originate and how they evolve in response to past economic conditions.

Empirically, there is little doubt that liquidity constraints matter for fertility decisions, such as the fertility timing and the quantity-quality trade-off. But when it comes to explaining the asymmetries, there are three challenges to the "liquidity constraints" view. First, many anti-fertility policies that raise the shadow price of children do not make the liquidity constraint tighter. For instance, when the government provides more access to family planning or implements anti-fertility propaganda, households' financial constraints are unlikely to be directly affected. Second, the "liquidity constraints" explanation cannot explain the policy implementation and reversal findings by González and Trommlerová (2023) where the government provides financial incentives to have children. Lastly, our results in Section B.7 indicate that the asymmetry is more salient for individuals with higher education or income – who should be further away from the liquidity constraints.

5.3 Technological Asymmetries

Another alternative explanation points to the asymmetry in the toolbox of fertility policies available to the government. What if 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? In other words, the mapping between policy expenditure and the actual change in the shadow price of children that households face would depend on the policy direction.

We argue that there are three limitations to this "technological asymmetry" view. First, fertility responds asymmetrically to the *same policy*'s implementation and reversion, as documented by González and Trommlerová (2023) and our results in Section B.1. Furthermore, our results from the Australian case study in B.3 indicate that reported happiness also responds asymmetrically to changes in the amount of baby bonus of the *same size*. Technological asymmetries cannot account for these results.

Second, as documented by Chatterjee and Vogl (2018), fertility rates are more responsive to recessions than to expansions. Technological asymmetries in policy instruments are also silent in explaining this fact.

Lastly, we argue that the fertility policy toolbox available to the government is diverse but *technologically reversible*. We categorize fertility policies into four groups. For each group, 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 rewards such as the Child Tax Credit or baby bonuses have been adopted in many countries to encourage births. Likewise, financial punishment was also used to raise fertility in the past. For instance, a 6% income tax was levied on men from the age of 25 to 50, and married women from 20 to 45 years of age in the Soviet Union and some other communist countries.

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 to raise 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). There have also been many "soft" forms of reproductive coercion through social norms such as gender norms and early marriage.

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 justify this choice.

For example, one potential explanation is loss aversion to reproductive liberty or human rights. As living standards rise with fertility rates falling, individuals living in those countries can no longer tolerate violations of their reproductive freedom by policymakers. Hence, governments resort to benign but less cost-effective measures such as financial incentives. Our model in Section 3 is consistent with this explanation.

5.4 Summary

To summarize, Table 3 provides an overview of the potential explanations, how well they match the empirical facts, and which implications hold under each explanation. While it is difficult to completely rule out the alternative explanations, we argue that reference dependence provides a simple and intuitive avenue to fit all empirical facts jointly.

6. 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 fact that challenges canonical fertility theories. To explain this fact, we propose a new model of fertility choice under loss aversion to living standards. Besides matching asymmetric elasticities to policies by design, the model also explains three other empirical regularities that appear to be puzzling at first sight. First, it generates asymmetric responses to

Table 3: Comparison with Alternative Explanations

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

Notes: This table summarizes whether each of the alternative explanations could account for the empirical facts and lead to the corresponding policy implications.

income shocks as documented by Chatterjee and Vogl (2018). Second, it generates asymmetric responses to policy implementation and reversal as documented by González and Trommlerová (2023). Lastly, the model's "slippery slope" perspective resolves the puzzling decline in fertility without detectable changes in the underlying economic fundamentals as documented by Kearney et al. (2022).

Lastly, the framework offers two lessons to policymakers. First, governments concerned with population externalities have a precautionary motive to set a higher fertility target than previously thought. Second, the amount of pro-fertility expenditures may need to increase in time to sustain a certain level of fertility that is higher than the laissez-faire outcome.

As many economists and policymakers have already 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 and opens new doors for future studies.

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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	4.1236	2.0330	0.8270	8.8730	10544
Change Rate of TFR	-0.0129	0.0271	-0.2613	0.9263	10302
Policy Variables					
Fertility Policy: Lower	0.3031				11839
Fertility Policy: Raise	0.1346				11839
Fertility Policy: Lower (Average In the Last Five Years)	0.3067	0.4534	0.0000	1.0000	10588
Fertility Policy: Raise (Average In the Last Five Years)	0.1315	0.3302	0.0000	1.0000	10588
Anti-fertility policy funding -GDP Ratio	6.93×10^{-6}	2.79×10^{-5}	9.11×10^{-9}	0.0012	2808
Anti-fertility policy funding -GDP Ratio (Average In the Last Five Years)	6.94×10^{-6}	1.84×10^{-5}	1.38×10^{-8}	0.0003	2548
Control Variables					
Real GDP Per Capita	11228.14	20251.41	115.4357	145221.2	10638
Change Rate of Real GDP Per Capita	0.0192	0.0732	-0.6500	1.8245	10368
Urbanization Rate	49.7498	25.83	2.0770	100.0000	11701
Change Rate of Urbanization Rate	0.0128	0.0300	-0.8621	0.8000	11701
Infant Mortality Rate (Per 1000 Births)	57.4807	48.5621	1.6000	276.9000	10675
Change Rate of Infant Mortality Rate	-0.0326	0.0382	-0.5000	0.4167	10567
Female labor Participation Rate	49.3026	17.9328	8.5000	90.8000	10243
Change Rate of Female labor Participation Rate	0.0060	0.0446	-0.6897	0.9600	10015

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

Table A2: (continued)

	Mean	SD	Min	Max	Obs
Fertility Policy: Raise (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
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	

B. Additional Empirical Results

B.1 Asymmetries in Policy Implementation and Reversals

González and Trommlerová (2023) study the implementation and reversal of a generous baby bonus in Spain. They find that while introducing the baby bonus raises fertility by 3%, reversing it reduces fertility by 6%.

Motivated by their results, we investigate whether the asymmetric effects between policy implementation and reversal can be found in our dataset. We employ the following empirical specification:

$$\Delta \text{TFR}_{it}/\text{TFR}_{it-1} = \alpha + \sum_{P_1}\sum_{P_2} \beta_{P_1,P_2} \mathbb{1}(\text{Policy}_{it} = P_1) \times \mathbb{1}(\text{Policy}_{i,t-1} = P_2) + \sigma_i + \eta_t + \epsilon \tag{23}$$
$$P_1, P_2 \in \{R, L, S\}$$

In Equation (23), 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 regime.[17] The results are presented in Table A3, where $\beta_{N,N}$ serves as the baseline for comparison.

Echoing the findings in Section 2.2, we find that switching from "no intervention / maintain" to "lower" has a larger and more significant impact on TFR than switching from "no intervention / maintain" to "raise." Furthermore, we also find that switching from pro- to anti-fertility regimes has larger effects than switching from anti- to pro-fertility regimes, even though the difference is not statistically significant due to limited numbers of countries with such switches.

Consistent with the results in González and Trommlerová (2023) on the implementation and reversal of the Spanish baby bonus, the estimates in Table A3 indicate that if a country first switches from "no intervention / maintain" to "raise,", and then switches from "raise" back to "lower", the fertility responses in the second phase is more than twice as large as that in the first phase – quantitatively very close to what González and Trommlerová (2023) find.

[17] In Section B.2, 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 A3.

Table A3: Asymmetric Response of Policy Implementation and Reversion

This Period \ Last Period	No Intervention/ Maintain	Lower	Raise
No Intervention/ Maintain		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)

B.2 Asymmetries in Policy Implementation and Reversals: An Alternative Strategy

One potential concern is that our observations in Table A3 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 regime into the same policy period. Then we check the current policy's effect on TFR, conditional on the previous policy period's policy regime, instead of conditional on last year's policy regime. Figure A1 provides an example of González and Trommlerová (2023)'s period division method. The empirical result of this alternative strategy is presented in Table A4. The conclusion is similar to those in Table A3.

Figure A1: An Example for Time Period Division

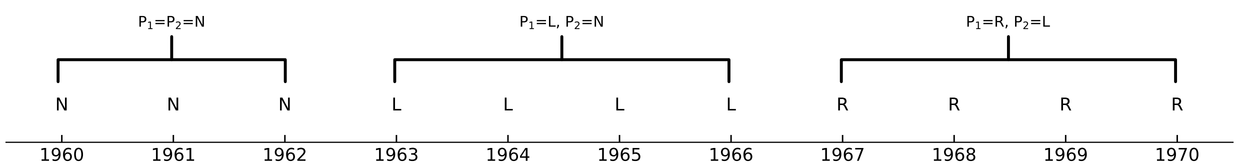


Table A4: Asymmetric Response of Policy Implementation and Reversal

	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)

B.3 Asymmetries in Policy Effect on Utility

An important implication of the our fertility choice model is that fertility policies have asymmetric effects on utility. In particular, an unexpected increase in the cost of raising children has a larger impact on utility than an unexpected decrease in that cost. In this section, we test this hypothesis by evaluating the effects of two unexpected changes in Australia's baby bonus policy on the reported happiness of the affected individuals. On May 11, 2004, the Australian government announced that all babies born after July 1, 2004, would be eligible for a $3000 baby bonus, compared to $842 for babies born before July 1. This increase in the baby bonus in 2004 had a statistically significant but not substantial positive effect on the birth rate (Drago et al. 2011). Interestingly, similar to the Spanish child allowances studied by González and Trommlerová (2023), in October 2012, it was announced that the baby bonus for second and subsequent children born after July 1, 2013, would decrease from $5000 to $3000.

We identify the effects of the two unexpected policy changes on parents' utility using the HILDA (Household, Income and Labour Dynamics) Survey from Australia, a household-based panel study conducted annually since 2001. Although HILDA does not record the exact birth dates of family members, it provides information on their ages as of June 30 each year. This allows us to determine whether a baby was born before or after the two baby bonus reforms. We first adopt a cross-sectional empirical strategy that compares the reported happiness of the parents whose children were born just before and just after July 1:

$$\text{happiness}_i = \alpha + \beta \mathit{Treatment}_i + \gamma \text{control}_i + \epsilon \tag{24}$$

Where i represents an individual who had at least one birth in the previous year in the 2004/2013 wave of the HILDA survey. happiness_i denotes the degree of happiness of individual i, ranging from the lowest level, 0, to the highest level, 5.[18] Treatment_i is an indicator of being affected by the baby bonus reforms. For the 2004 baby bonus increase, Treatment_i equals 1 if the individual's last birth was after July 1, 2004, and 0 otherwise; for the 2013 baby bonus cut, Treatment_i equals 1 if the individual had at least two children and the last birth was after July 1, 2013, and 0 otherwise. control_i includes family size fixed effects, children number fixed effects, age fixed effects, logarithm of total family income, and the interaction between state fixed effects and socioeconomic status decile fixed effects. For the 2013 baby bonus cut, an indicator of whether the last birth was after July 1, 2013, is also included. All control variables are interacted with gender fixed effect. Under the assumption that having the last birth after July 1 in the corresponding year is randomly assigned among sampled individuals, the coefficient β identifies the causal effect of the baby bonus reforms on affected parents' utility. We argue this assumption holds for two reasons: first, since most individuals in HILDA are interviewed only a few months after July 1, the baby bonus reforms' effect on their fertility decisions should not have been realized by the interview time; second, as discussed by Gans and Leigh (2009), parents' ability of controlling the exact birth time of an existing fetus is highly limited.[19]

We present the estimation results of the 2004 baby bonus increase's effect on affected parents' utility in Table A5. The coefficient in column 1 of Table A5 identifies the baby bonus increase's effect on affected parents' happiness, which is not statistically different from 0. In columns 2 and 3 of Table A5, we estimate Equation (24) using HILDA samples from wave 2003 and wave 2002 as a placebo test, and the coefficients are also not significant.

In Table A6, we present the 2013 baby bonus cut's effect on affected parents' utility. The coefficient in column 1 of Table A6 identifies the baby bonus cut's effect on affected parents' happiness, which is negatively significant and approximately 15 times larger than the coefficient in column 1 of Table A5. Given that the size of the 2004 baby bonus increase and the 2013 baby bonus decrease are both around \$2000, the empirical result supports the hypothesis that a policy raising the cost of having children generates a larger impact on utility than a policy

[18] This variable is obtained from HILDA question SCQ-A9h, "Mental Health: Been a Happy Person"

[19] According to Gans and Leigh (2009), fewer than 0.5% of annual births shifted in response to the policy, indicating that it was difficult for parents to manipulate the timing of births to qualify for the additional baby bonus.

Table A5: The 2004 Baby Bonus Increase's Effect on Happiness

Dependent Variable	Happiness (1-10)		
Model	Ordered Probit		
Sample Year	2004	2003	2002
	(1)	(2)	(3)
I(last_birth$_i$ > July 1)	0.037	0.273	0.223
	(0.240)	(0.265)	(0.210)
Control Variables	Yes	Yes	Yes
Observations	423	422	422
R^2	0.389	0.323	0.304

[1] Source: Dataverse (2024).
[2] Note: The table reports the result of evaluating the 2004 baby bonus increase's effect on affected parents' happiness. The sample in column (1) includes individuals who had at least one birth in the previous year in the 2004 wave of the HILDA survey; the sample in column (2) includes individuals who had at least one birth in the previous year in the 2003 wave of the HILDA survey; the sample in column (3) includes individuals who had at least one birth in the previous year in the 2002 wave of the HILDA survey. The independent variable is an indicator of having last birth after July 1 in the corresponding sample year. Control variables include family size fixed effects, children number fixed effects, age fixed effects, logarithm of total family income, and the interaction between state fixed effects and socioeconomic status decile fixed effects. All control variables are interacted with gender fixed effect. Heteroskedasticity robust standard errors are used. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

lowering the cost of having children. In columns 2-5 of Table A6, we conduct placebo tests by estimating Equation (24) with: (1) a placebo policy year of 2012 or 2011; (2) a placebo policy change decreasing the baby bonus for the third or the fourth child. None of the coefficients in columns 2-5 differ significantly from 0.

Lastly, we also provide empirical evidence on fertility policy's asymmetric effect on utility adopting the following panel regression model:

$$\text{happiness}_{it} = \alpha + \beta \text{treatment}_{it} + \gamma \text{control}_{it} + \rho_i + \tau_t + \epsilon \tag{25}$$

Where i represents an individual in the HILDA survey, and (t) represents the year. Similar to Equation (24), happiness$_{it}$ is the degree of happiness, and (controlit) is the interaction between a set of control variables and gender fixed effect. ρ_i and τ_t are individual fixed effect and year fixed effect, respectively. Treatment$_i$ is an indicator of being affected by the baby bonus reforms. For the 2004 baby bonus increase, Treatment$_i$ equals 1 if $t = 2004$ and the individual's

Table A6: The 2013 Baby Bonus Cut's Effect on Happiness

Dependent Variable	Happiness (0-5)				
Model	Ordered Probit				
Sample Year	2013			2012	2011
	(1)	(2)	(3)	(4)	(5)
I(last_birth$_i$ > July 1) × I(Children_number$_i$ > 1)	-0.569**			0.029	-0.207
	(0.279)			(0.272)	(0.424)
I(last_birth$_i$ > July 1) × I(Children_number$_i$ > 2)		-0.372			
		(0.305)			
I(last_birth$_i$ > July 1) × I(Children_number$_i$ > 3)			-0.785		
			(0.536)		
Control Variables	Yes	Yes	Yes	Yes	Yes
Observations	656	656	656	681	469
R^2	0.192	0.190	0.190	0.189	0.303

[1] Source: Dataverse (2024).
[2] Note: The table reports the result of evaluating the 2013 baby bonus cut's effect on affected parents' happiness. The sample in columns (1)-(3) includes individuals who had at least one birth in the previous year in the 2013 wave of the HILDA survey; the sample in column (4) includes individuals who had at least one birth in the previous year in the 2012 wave of the HILDA survey; the sample in column (5) includes individuals who had at least one birth in the previous year in the 2011 wave of the HILDA survey. The independent variable in columns (1), (4) and (5) is the interaction between an indicator of having last birth after July 1 in the corresponding sample year and an indicator of having at least two children; the independent variable in column (2) is the interaction between an indicator of having last birth after July 1, 2013 and an indicator of having at least three children; the independent variable in column (2) is the interaction between an indicator of having last birth after July 1, 2013 and an indicator of having at least four children. Control variables include family size fixed effects, children number fixed effects, age fixed effects, logarithm of total family income, an indicator of having last birth after July 1 in the corresponding sample year, and the interaction between state fixed effects and socioeconomic status decile fixed effects. All control variables are interacted with gender fixed effect. Heteroskedasticity robust standard errors are used. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

last birth was after July 1, 2004, at the survey time point of year t, and 0 otherwise. For the 2013 baby bonus cut, Treatment_i equals 1 if $t = 2013$, the individual had at least two children, and the last birth was after July 1, 2013, at the survey time point of year t, and 0 otherwise. The empirical results are presented in Table A7. The coefficient in column 1 identifies the 2013 baby bonus cut's effect, and the coefficient in column 2 identifies the 2004 baby bonus increase's effect. The coefficient in column 1 is significantly negative, while the coefficient in column 2 is not significant and much smaller than the coefficient in column 1. In summary, the empirical results presented in Table A7 are consistent with the conclusions we derived from Table A5 and Table A6.

B.4 Decomposition of Fertility Changes

In this section, we calculate fertility policies' cumulative effect on TFR basing our empirical result in Section 2.3. For each country, we calculate the cumulative effects on TFR using the following formula:

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

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

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 A8 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 number is comparable with existing studies' conclusion, which find that anti-fertility policies can explain 6%-7% of the fertility decline in 1964-1993's Colombia (Miller, 2010), 4%-20% in 1989-1996's Iran (Salehi-Isfahani et al., 2010), 63% in all developing countries during 1960-1985 (Bongaarts et al., 1990). 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.

Table A7: Asymmetries in policy effect on utility: panel regression result

Dependent Variable	Happiness (0-5)	
Sample Year	2010-2013	2001-2008
	(1)	(2)
$\text{I}(\text{last\_birth}_{it} > \text{July 1}) \times \text{I}(\text{Children\_number}_{it} > 1) \times \text{I}(t = 2013)$	-0.177*	
	(0.102)	
$\text{I}(\text{last\_birth}_{i} > \text{July 1}) \times \text{I}(t = 2004)$		0.047
		(0.046)
Individual FE	Yes	Yes
Year FE	Yes	Yes
Control Variables	Yes	Yes
Observations	52382	83923
R^2	0.677	0.554

[1] Source: Dataverse (2024).
[2] Note: The table reports the result of evaluating the 2013 baby bonus cut and the 2004 baby bonus increase's effect on affected parents' happiness. The sample in column (1) includes all individuals appear in HILDA waves 2010-2013; the sample in column (2) includes all individuals appear in HILDA waves 2001-2008. The independent variable in column (1) is the interaction among an indicator of having last birth after July 1 in the corresponding sample year, an indicator of year 2013, and an indicator of having at least two children, and the pairwise interactions between the three indicators are included as control; the independent variable in column (2) is the interaction among an indicator of having last birth after July 1 in the corresponding sample year and an indicator of year 2004. Control variables include family size fixed effects, children number fixed effects, age fixed effects, logarithm of total family income, an indicator of having last birth after July 1, and the interaction between state fixed effects and socioeconomic status decile fixed effects. All control variables are interacted with gender fixed effect. Individual fixed effects and year fixed effects are also controlled. Heteroskedasticity robust standard errors are used. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Table A8: 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.

In Figure A2, we present the estimated cumulative anti-fertility 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 China, and De Silva and Tenreyro (2017) for a wider set of countries).

B.5 Decomposition of Policy Effect

In this section, we decompose the effect of fertility policy on the number of children. Table A9 employs an empirical specification similar to Equation (1) to distinguish the fertility policy's impact into extensive-margin and intensive-margin effects. Columns (1) and (2) of Table A9 replicate the results from Table 2, estimating the total effect of fertility policies using the OLS and PPML models, respectively. Columns (3) and (4) of Table A9 estimate the intensive-margin effect of fertility policies by restricting the sample to individuals with at least one child. Columns (5) and (6) of Table A9 estimate the extensive-margin effect by using an indicator for having a child as the dependent variable. The findings suggest that both anti-fertility and pro-fertility policies predominantly influence the intensive margin.

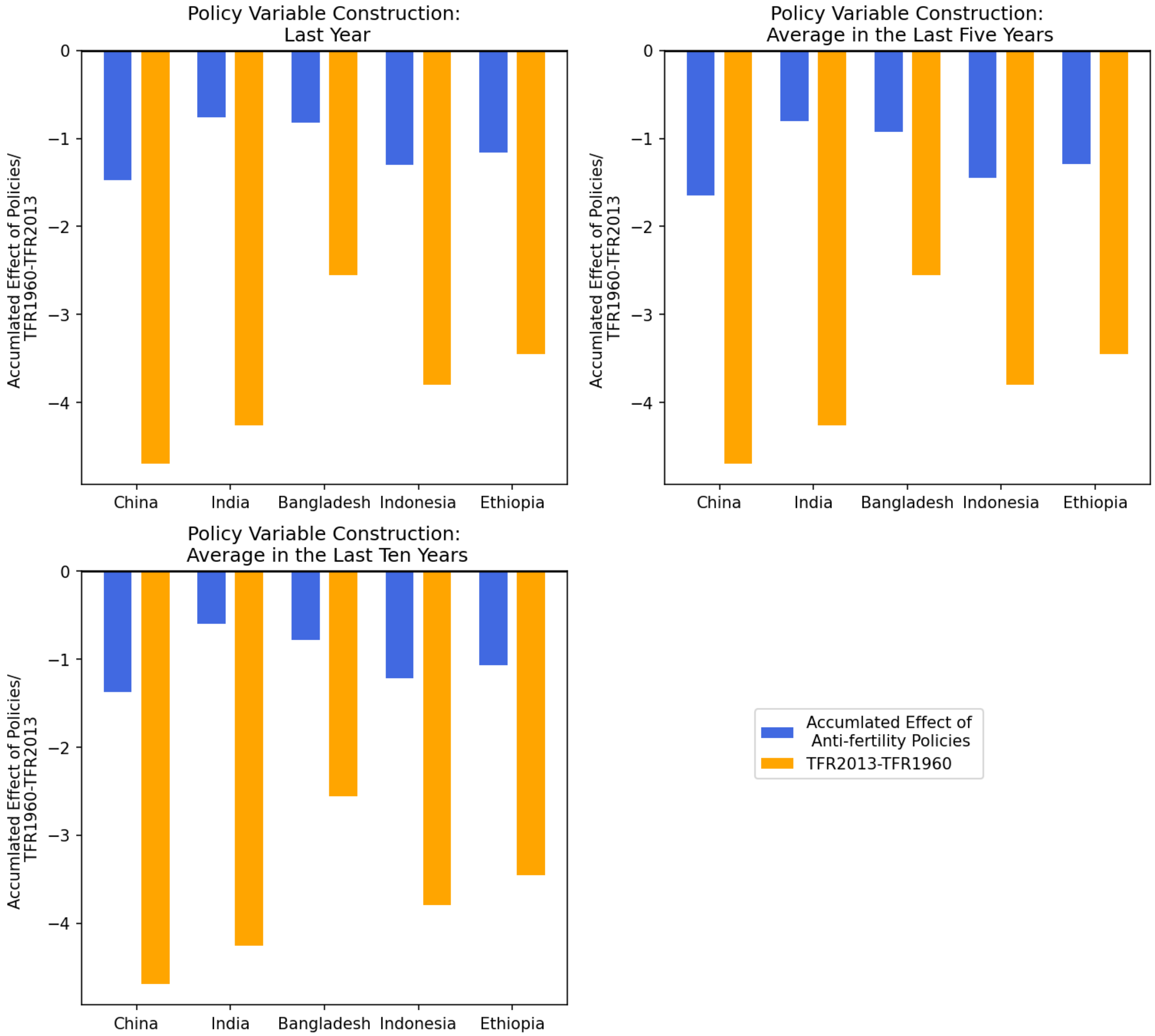
Building on the results from Table A9, we calculate the size of the intensive-margin effect and compare it with the total effect in Table A10. The first column of Table A10 presents the total

Table A9: Decomposition of Fertility Policy's Effect on Children Number

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

[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; country level control variables are collected from the World Bank World Development Indicators. For missing values in country level control variables, we conduct nearest neighbor interpolation.
[2] Note: The table reports the result of decomposing fertility policy's effect on children number into extensive margin effect and intensive margin effect. Columns (1) and (2) estimate fertility policy's total effect on children number using OLS model and PPML model, respectively; column (3) and column (4) estimate fertility policy's intensive margin effect by replicating column (1) and (2)'s specification on individuals with at least one child; column (5) and (6) estimate fertility policy's extensive margin effect by using OLS model and probit model to identify exposure to fertility policy's effect on individual's probability of having at least one child. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

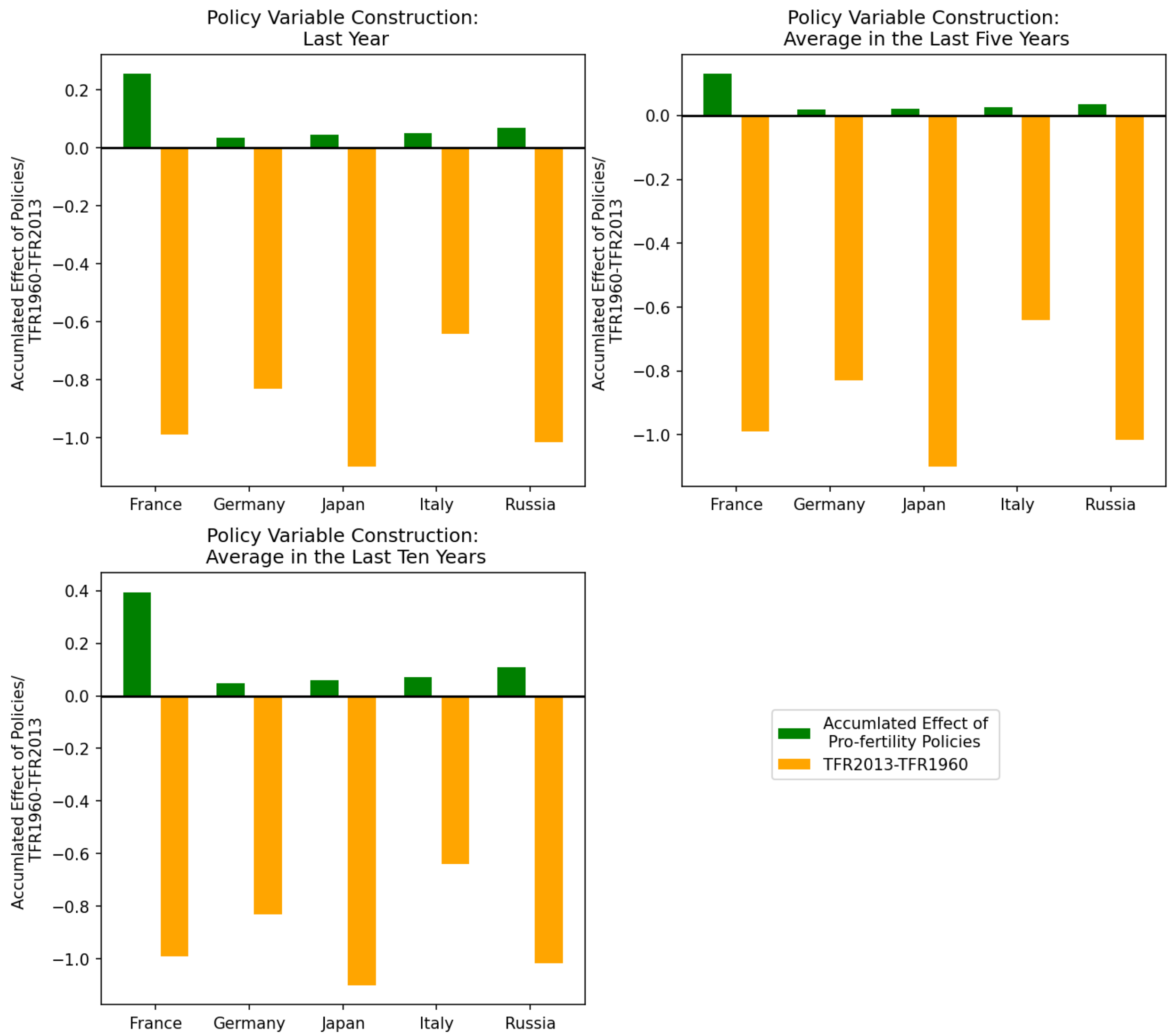
Figure A2: Anti-Fertility Policies' Cumulative Effect on TFR (for Several Important Countries)



Notes: This figure plots anti-fertility policies' cumulative effect on TFR between 1960 and 2013 for several important countries, computed from coefficients in column (2), (4) of Table 1.

effect of fertility policies, as estimated in the first two columns of Table A9. The second column of Table A9 calculates the intensive-margin effect by multiplying the coefficients in columns (3) and (4) of Table A9 with the fraction of individuals having at least one child in our dataset. The results demonstrate that the effect of fertility policies is largely concentrated on the intensive

Figure A3: Pro-Fertility Policies' Cumulative Effect on TFR (for Several Important Countries)



Notes: This figure plots pro-fertility policies' cumulative effect on TFR between 1960 and 2013 for several important countries, computed from coefficients in column (2), (4) of Table 1.

margin.[20]

Lastly, we estimate the effects of fertility policies conditional on the number of children, as presented in Table A11. The results indicate that the impact of anti-fertility policies is less pronounced for individuals with a stronger preference for children. Furthermore, the asymmetry

[20]Due to the differences in empirical settings, the estimated intensive-margin effect slightly exceeds the total effect in some cases.

Table A10: Caculation of Intensive Margin Effect

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

in the effects of fertility policies remains robust to restricting sample based on the number of children.

B.6 Comparison with Existing Studies on the Effect of Anti-fertility Policies

In this section, we compare our estimation of anti-fertility policies' effectiveness with that of 14 existing studies. For each study, we standardize their results to reflect the percentage of births averted by the policy[21]. After that, we compute the percentage of births that could be averted by anti-fertility policies implemented in the same country during the corresponding time period basing on the coefficients we estimate in Section 2.3. Finally, we contrast the magnitude of the estimated effects of anti-fertility policies from our analysis with those reported in the existing studies in Table A13.

We categorize existing studies based on their regions of focus and visualize the comparative results in Figures A4 and A5. To facilitate comparison, we plot the ratio of the estimated policy effect from our analysis to that from the existing studies. Both our country-level and individual-level analyses produce estimated policy effects that align closely with the conclusions of existing studies.

[21] An exception is the study by Li and Zhang 2007, whose results can't be converted to the percentage of births averted, but are directly comparable with our country-level specification.

Table A11: Fertility Policies' Effect Conditional on Children Number

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

[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; country level control variables are collected from the World Bank World Development Indicators. For missing values in country level control variables, we conduct nearest neighbor interpolation.
[2] Note: The table reports the result of fertility policy's effect conditional on children number. The empirical specification adopted is the same with column (5) in Table 2, while the sample used is restricted according to individual's children number. Standard errors are clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Table A13: Comparison with Existing Studies on the Effect of Anti-fertility Policies

Study	Region	Period	Effect Type	Estimated Effect	Our Estimation (Country Level)	Our Estimation (Individual Level)
Qiang et al., 2020	China	1971-2016	% of Births Averted	15.3-22.8	11.7-25.4	26.5-37.2
Huang et al., 2021	China	1979-2005	% of Births Averted	12	7.3-16.6	30.4-42.2
Li and Zhang, 2007	China	1983-1998	Annually Decline of Fertility	6.7-8.3	0.5-1.3	can't evaluate
Babiarz et al., 2018	China	1970-1988	% of Births Averted	20.5	5.3-12.3	18.3-25.7
Ngo, 2020	Vietnam	1988-2009	% of Births Averted	7.4	6.1-14	25-35.1
Chen, 1991	China	1987	Decrease of Children Number Per Women	0.36	can't evaluate	0.624-0.875
Cleland et al., 1994	Bangladesh	1975-1977	% of Births Averted	6	1.6-3.9	2.8-3.9
Phillips et al., 1988	Bangladesh	1978-1984	% of Births Averted	25	2.2-5.2	7.1-10
Bongaarts et al., 1990	Developing Countries	1960-1985	% of Births Averted	31	13.4-29.4	11.6-16.2
Bongaarts, 2020	sub-Saharan Africa	1989-2019	% of Births Averted	13.2	8.3-18.7	9.9-13.9
Bailey, 2012	US	1964-1973	% of Births Averted	19-30	3-7	25-35.1
Miller, 2010	Colombia	1965-1993	% of Births Averted	5	7.8-17.7	14.5-20.4
Joshi and Schultz, 2007	Bangladesh	1977-1982	% of Births Averted	15	3.3-7.7	5.3-7.5
Salehi-Isfahani et al., 2010	Iran	1989-1996	% of Births Averted	6.1-6.4	2.4-5.8	11.3-15.9

[1] Source: Studies included for comparison are listed in the first column. Estimated effects of anti-fertility policies in the last two columns are calculated based on coefficients in Table 1 and Table 2. TFR from the Penn World Table 10.0 (Barro and Lee, 2013) is also used in the calculation of estimated policy effect.
[2] Note: This table presents the comparison between the estimated effect of anti-fertility policies' basing on empirical result in Table 1 and Table 2 and that from existing studies.

B.7 Heterogeneity Analysis

In this section, we present the empirical results on the heterogeneous effects of fertility policies across different income and education groups. Tables A14 and A15 display the result of regressing children number on the interaction terms between the fertility policy variables and indicators for income groups (ranging from the lowest income level, 1, to the highest income level, 10) and education level groups (low, medium, and high). The results show that the effect of anti-fertility policies intensifies as income and education levels increase, while the effect of pro-fertility policies diminishes with higher income and education levels. To summarize, the asymmetric fertility elasticities becomes more salient as income and education level rises.

Table A14: Heterogeneity by Income

Dependent Variable	Number of Children		
Interpolation of MAC	Country-Specific Year Polynomial	Nearest Neighbor	Socioeconomic Variables
	(1)	(2)	(3)
Lower fertility#Income	-0.153***	-0.166***	-0.166***
	(0.0233)	(0.0269)	(0.0274)
Lower fertility	-0.0563	-0.0880	-0.0425
	(0.258)	(0.258)	(0.302)
Raise fertility#Income	-0.0842**	-0.0877**	-0.0891**
	(0.0353)	(0.0360)	(0.0375)
Raise fertility	0.706***	0.610**	0.734**
	(0.249)	(0.250)	(0.285)
Baseline Controls	Yes	Yes	Yes
Income Level-Age-Gender FE	No	No	No
Education Level-Age-Gender FE	No	No	No
Macroeconomic Controls	No	No	No
Observations	192565	214856	195463
R^2	0.278	0.282	0.276

Table A15: Heterogeneity by Education

Dependent Variable	Number of Children		
Interpolation of MAC	Country-Specific Year Polynomial	Nearest Neighbor	Socioeconomic Variables
	(1)	(2)	(3)
Lower fertility#Low Edu	-0.184	0.131	0.184
	(0.258)	(0.255)	(0.286)
Lower fertility#Middle Edu	-1.061***	-1.168***	-1.101***
	(0.245)	(0.234)	(0.264)
Lower fertility#High Edu	-2.097***	-2.260***	-2.226***
	(0.267)	(0.267)	(0.284)
Raise fertility#Low Edu	1.106***	0.830***	0.931***
	(0.235)	(0.270)	(0.297)
Raise fertility#Middle Edu	0.519***	0.298	0.427*
	(0.174)	(0.198)	(0.231)
Raise fertility#High Edu	-0.0692	-0.177	-0.0728
	(0.201)	(0.204)	(0.237)
Baseline Controls	Yes	Yes	Yes
Income Level-Age-Gender FE	No	No	No
Education Level-Age-Gender FE	No	No	No
Macroeconomic Controls	No	No	No
Observations	195136	219708	200325
R^2	0.287	0.292	0.290

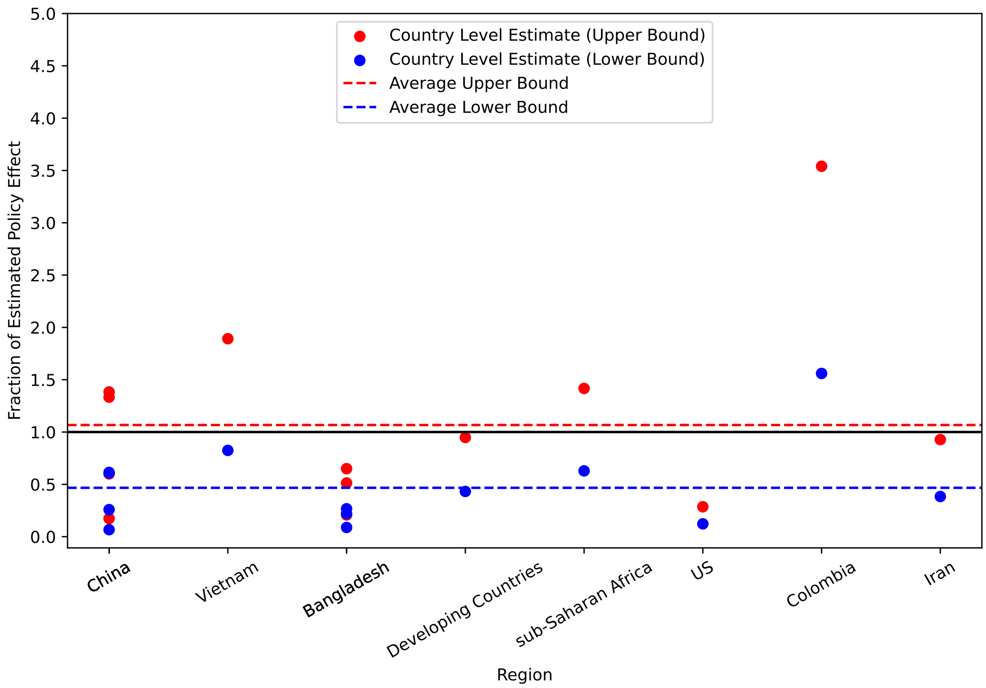


Figure A4: Comparison Between Existing Studies and Country Level Result

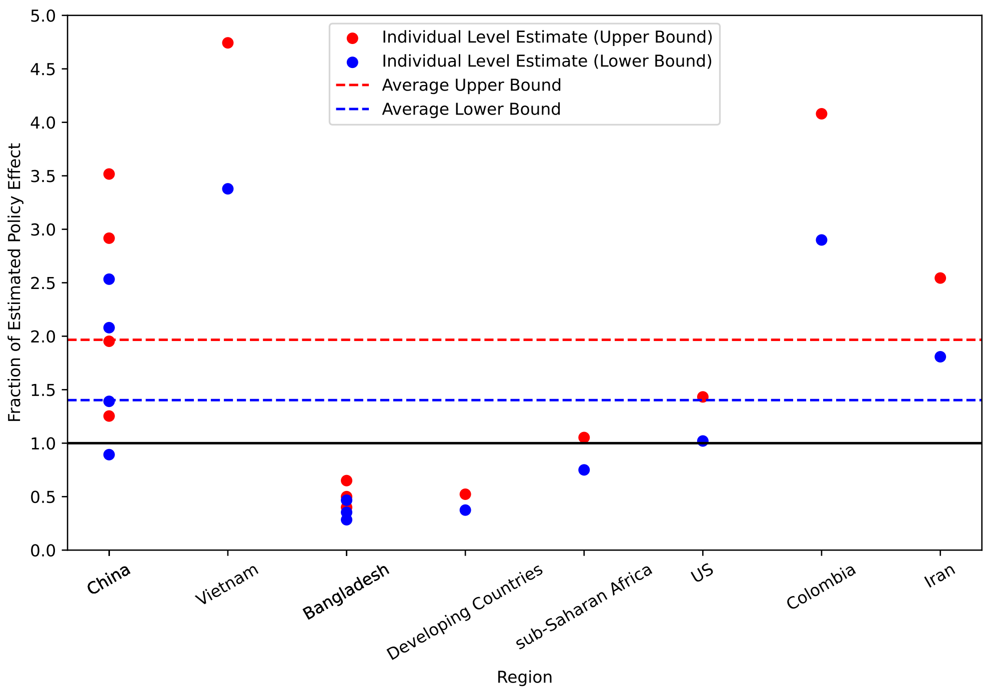


Figure A5: Comparison Between Existing Studies and Individual Level Result

B.8 Robustness: Selection Into Treatment

In this section, we provide evidence that our result is robust to selection into treatment. In Table A16, A17 and A18, 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 results for policy regimes are presented in Table A19 and Table A17, and the conclusion is consistent with our findings in Table 1 and Table 2. In Table A18, we also present the results for elasticity estimation. In Table A19, Table A20 and Table A21, we conduct analysis using subsamples divided according to TFR in 1960. To summarize, our conclusion is robust to selection into treatment.

Table A16: 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	-0.0052***	-0.0052***	-0.0054***	-0.0059***
	(0.0015)	(0.0017)	(0.0018)	(0.0022)
Raise fertility	0.0005	0.0011	0.0002	0.0002
	(0.0030)	(0.0030)	(0.0038)	(0.0036)
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	10301	7373	9545	6821
R^2	0.201	0.225	0.199	0.225

[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 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 dependent variable. Columns (1)-(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.

B.9 Robustness: Reverse Causality

We present robust results regarding reverse causality in this section. In Table A22 and A23, 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.10 Alternative Construction Methods of Independent Variables

In this section, we provide empirical results using several alternative construction methods of dependent variables. In Figure A6, 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 A8. In Figure A7, 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 A6: Population Policy and TFR Using Different Year Ranges

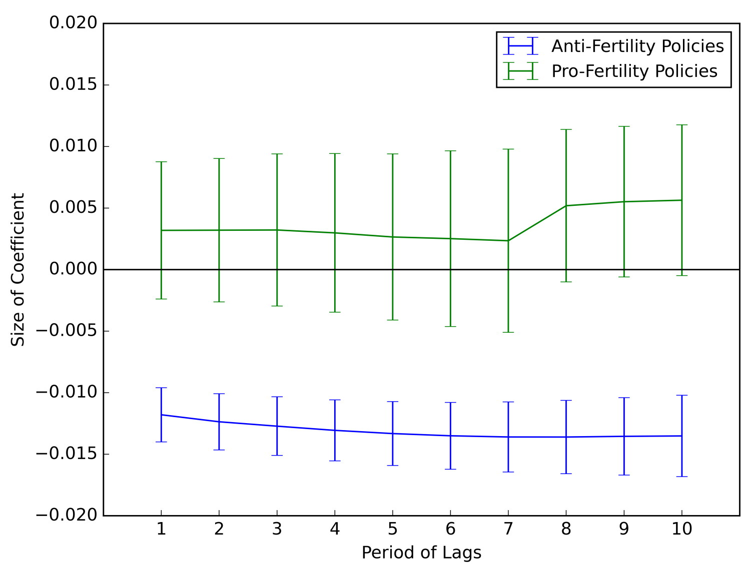


Table A17: Population Policy and the Number of Children: Selection Into Treatment

Dependent Variable	Number of Children					
Interpolation of MAC	Nearest Neighbor					
1960 Variables	TFR	GDP per capita	Urbanization Rate	IMR	Female Labor Participation Rate	Years of Education
	(1)	(2)	(3)	(4)	(5)	(6)
Target: Lower fertility	-0.314***	-0.737***	-0.625***	-0.509***	-0.872***	-0.574***
	(0.077)	(0.076)	(0.075)	(0.074)	(0.075)	(0.074)
Target: Raise fertility	-0.205***	0.201***	0.105	0.005	0.072	0.125*
	(0.068)	(0.064)	(0.065)	(0.065)	(0.067)	(0.065)
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes
Cohort FE*Variables in 1960	Yes	Yes	Yes	Yes	Yes	Yes
Observations	231257	231257	231257	231257	231257	231257
R^2	0.289	0.286	0.287	0.287	0.286	0.287

[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; country level control variables are collected from the World Bank World Development Indicators. For missing values in country level control variables, 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 nearest neighbour for each country. All columns control for age group×gender fixed effect, country×survey year fixed effect and birth year fixed effect – a set of baseline controls. Each column among (1) to (6) controls the interaction term between birth year fixed effect and one country level variables in 1960, including TFR, real GDP per capita, urbanization rate, infant mortality rate, female labor participation rate, and average years of education for women. Standard errors are clustered at the cohort level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Table A18: Elasticity Estimation for Anti-Fertility Policy: Selection Into Treatment

Dependent Variable	ΔTotal Fertility Rate/ Lagged Total Fertility Rate	Number of Children					
Setting	Country Level	Individual Level					
1960 Variables		TFR	GDP per capita	Urbanization Rate	IMR	Female Labor Participation Rate	Years of Education
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Anti-fertility policy funding-GDP Ratio	-63.84***	-864.160**	-854.5**	-575.4	-915.5**	-648.6	-754.0
	(21.62)	(422.3)	(423.3)	(407.7)	(414.1)	(410.7)	(416.2)
Country Fixed Effect	Yes	No	No	No	No	No	No
Year Fixed Effect	Yes	No	No	No	No	No	No
Year Fixed Effect × Control Variables and TFR in 1960	Yes	No	No	No	No	No	No
Age-Gender Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Country-Survey Year Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Cohort Fixed Effect × Variables in 1960	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2546	92215	92215	92215	92215	92215	92215
R^2	0.193	0.279	0.279	0.280	0.279	0.280	0.280

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 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 and the interaction term between year fixed effect and TFR, real GDP per capita, urbanization rate, infant mortality rate, and female labor participation rate in 1960. The standard error in column (1) is clustered at the country level. Columns (2)-(7) report 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 columns (2)-(7). Columns (2)-(7) control age-gender fixed effects, birth year fixed effect, and country-survey year fixed effect. Each column among (2) to (7) controls the interaction term between birth year fixed effect and one country level variables in 1960, including TFR, real GDP per capita, urbanization rate, infant mortality rate, female labor participation rate, and average years of education for women. The standard errors in columns (2)-(7) are clustered at the cohort level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Table A19: 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***	-0.0041***	-0.0085***	-0.0040*
	(0.0014)	(0.0015)	(0.0018)	(0.0020)
Raise fertility	0.0003	0.0001	-0.0005	0.0002
	(0.0058)	(0.0055)	(0.0058)	(0.0056)
Observations	5724	4027	5292	3723
R^2	0.335	0.385	0.311	0.363
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***	-0.0096*	-0.0157***	-0.0111
	(0.0028)	(0.0057)	(0.0027)	(0.0071)
Raise fertility	0.0017	0.0014	0.0012	0.0009
	(0.0038)	(0.0039)	(0.0051)	(0.0052)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Control Variables	No	Yes	No	Yes
Observations	4527	3346	4253	3098
R^2	0.125	0.146	0.127	0.155

[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 regime 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 A20: Population Policy and the Number of Children: Using Subsamples

Panel A: Subsample with High TFR in 1960			
Dependent Variable	Number of Children		
Interpolation of MAC	Nearest Neighbor		
	(1)	(2)	(3)
Target: Lower fertility	-0.358***	-0.397***	-0.516***
	(0.085)	(0.086)	(0.090)
Target: Raise fertility	-0.313**	-0.187	-0.072
	(0.156)	(0.158)	(0.155)
Observations	111144	104375	101083
R^2	0.249	0.274	0.275
Panel B: Subsample with Low TFR in 1960			
Dependent Variable	Number of Children		
Interpolation of MAC	Nearest Neighbor		
	(1)	(2)	(3)
Target: Lower fertility	-1.434***	-1.543***	-1.431***
	(0.151)	(0.151)	(0.149)
Target: Raise fertility	-0.119*	-0.091	-0.212***
	(0.071)	(0.072)	(0.077)
Baseline Controls	Yes	Yes	Yes
Income Level-Age-Gender FE	No	Yes	Yes
Education Level-Age-Gender FE	No	Yes	Yes
Macroeconomic Controls	No	No	Yes
Observations	120113	100913	81636
R^2	0.205	0.209	0.223

[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; country level control variables and TFR in 1960 are collected from the World Bank World Development Indicators. For missing values in country level control variables, we conduct nearest neighbor interpolation.

[2] Note: The table reports the result of subsample 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 nearest neighbour for each country. Panel A uses countries with TFR equal to or higher than the median in 1960 and panel B uses countries with TFR lower than the median in 1960. Columns (1) controls for age group×gender fixed effect, country×survey year fixed effect and birth year fixed effect – a set of baseline controls; columns (2) additionally controls for income group×age group×gender fixed effect and education group×age group×gender fixed effect; columns (3) additionallys 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.

Table A21: Elasticity Estimation for Anti-Fertility Policy: Using Subsamples

Panel A: Subsample with High TFR in 1960		
Dependent Variable	ΔTotal Fertility Rate/ Lagged Fertility Rate	Number of Children
Setting	Country Level	Individual Level
	(1)	(2)
Anti-fertility policy funding-GDP Ratio	11.6889	-1450.749**
	(278.7503)	(630.3075)
Observations	796	77721
R^2	0.613	0.262

Panel B: Subsample with Low TFR in 1960		
Dependent Variable	ΔTotal Fertility Rate/ Lagged Fertility Rate	Number of Children
Construction of Policy Variables	Country Level	Individual Level
	(1)	(2)
Anti-fertility policy funding-GDP Ratio	-76.8414***	432.4566
	(25.3146)	(573.1311)
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	2052	14494
R^2	0.158	0.279

[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) 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. Columns (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.

Table A22: 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***	-0.0048***	-0.0133***	-0.0053***
	(0.0015)	(0.0017)	(0.0016)	(0.0020)
Raise fertility	0.0032	0.0011	0.0033	0.0009
	(0.0037)	(0.0034)	(0.0043)	(0.0037)
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	9489	6809	9489	6809
R^2	0.132	0.182	0.133	0.182

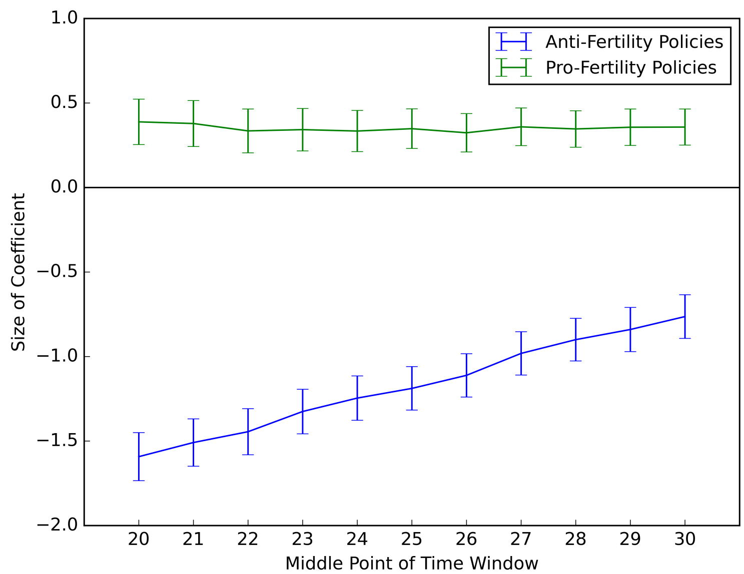
[1] Source: Policy variables are collected from the UN World Population Policies Database; TFR and control variables are collected from the World Bank's World Development Indicators. For missing values, we conduct nearest neighbor interpolation.
[2] Note: The table reports the result of regressions of 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 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. Columns (1), (3) control for country fixed effect, year fixed effect, and average TFR in the last five years; columns (2), (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 A23: 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)
Anti-fertility policy funding-GDP Ratio	-69.42***
	(24.09)
Country Fixed Effect	Yes
Year Fixed Effect	Yes
Average TFR in the Last Five Years	Yes
Observations	2542
R^2	0.208

[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) control for country fixed effect, year fixed effect, and average TFR in the last five years. Standard error is clustered at the country level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

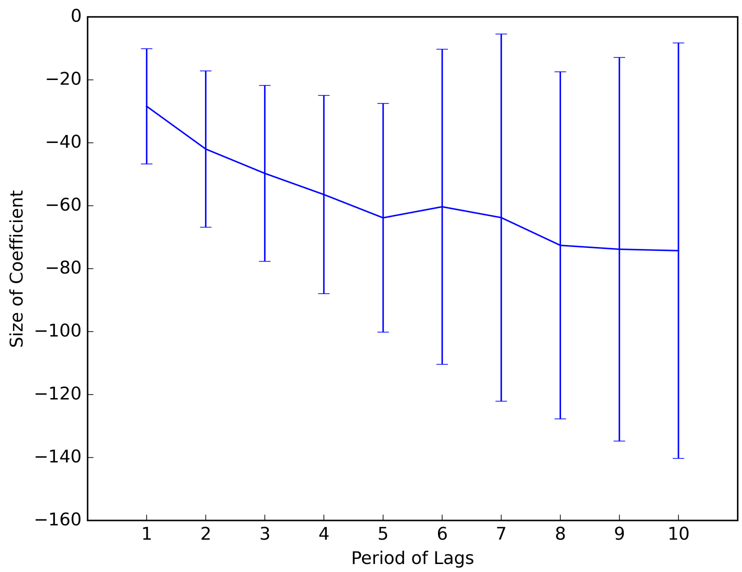
Figure A7: Population Policy and Children Number Using Different Time Windows



B.11 Effect of Early Year Policy Exposure

In this section, we examine the effect of early-year policy exposure on fertility decisions. The specification is similar to Equation (1), but it includes policy exposure during the ages of 0-6 and

Figure A8: Elasticity Estimation for Anti-Fertility Policy Using Different Year Ranges



7-12 as additional independent variables. The results are presented in Table A24. The impact of exposure to fertility policy during the ages of 7-12 on the number of children is significant but much weaker than exposure during MAC. This may indicate that fertility policy influences children's preferences through their early experiences. Additionally, exposure to anti-fertility policies has a larger effect on children number compared to pro-fertility policies, which is consistent with what we observe for policy exposure during MAC. Exposure to fertility policy during the ages of 0-6 doesn't have a significant impact on children number.

C. Comparison of Elasticities

C.1 Elasticity Estimation Result of Anti-fertility Policies

Table A25 presents the estimates of anti-fertility policy elasticities.

C.2 Elasticity Comparison at Individual Level

In this section, we compare the elasticity of pro-fertility policies with the elasticity of anti-fertility policies estimated at the individual level. Similar to the methodology we adopted in Sec-

Table A24: Population Policy and the Number of Children: Effect of Early Year Policy Exposure

Dependent Variable		Number of Children		
Interpolation of MAC		Country-Specific Year Polynomial	Nearest Neighbor	Socioeconomic Variables
Exposure Period		(1)	(2)	(3)
MAC	Target: Lower fertility	-0.585***	-0.573***	-0.526***
		(0.077)	(0.076)	(0.081)
	Target: Raise fertility	0.109	0.057	0.111
		(0.074)	(0.071)	(0.075)
7-12	Target: Lower fertility	-0.089***	-0.087***	-0.073**
		(0.030)	(0.031)	(0.032)
	Target: Raise fertility	0.031	0.012	0.014
		(0.037)	(0.035)	(0.038)
0-6	Target: Lower fertility	-0.030	-0.036	0.030
		(0.066)	(0.068)	(0.061)
	Target: Raise fertility	-0.032	-0.059	0.087
		(0.055)	(0.056)	(0.065)
Baseline Controls		Yes	Yes	Yes
Observations		106753	114883	105244
R^2		0.272	0.275	0.271

[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, 0-6 years old and 7-12 years old. The interpolation method of MAC is third order year polynomial for each country in columns (1), nearest neighbor method in columns (2), and regression on real GDP per capita, years of schooling, urbanization rate, and female labor participation rate in columns (3), respectively. Variables used to predict MAC in columns (3) are from World Bank World Development Indicators, and we conduct nearest neighbor interpolation for these variables before using them to predict MAC. Columns (1), (2), and (3) control for age group×gender fixed effect, country×survey year fixed effect and birth year fixed effect – a set of baseline controls. Standard errors are clustered at the cohort level. *, **, and *** indicate significance at 10, 5, and 1 percent levels, respectively.

Table A25: Elasticity Estimation for Anti-Fertility Policy

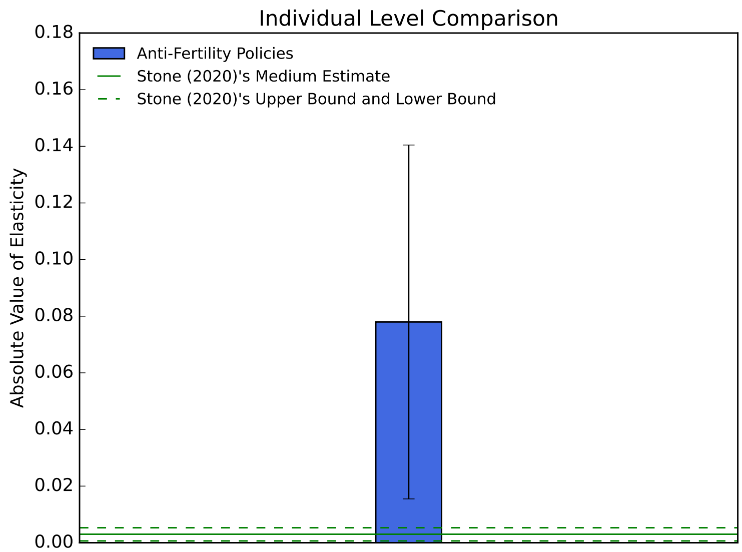
Dependent Variable	ΔTotal Fertility Rate/ Lagged Fertility Rate	Number of Children
Setting	Country Level	Individual Level
	(1)	(2)
Anti-fertility policy funding-GDP Ratio	-63.84***	-864.160**
	(21.62)	(422.292)
Country Fixed Effect	Yes	No
Year Fixed Effect	Yes	No
Age-Gender Fixed Effect	No	Yes
Country-Survey 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. Columns (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.

tion 2.4, we use an empirical specification analogous to the individual cohort-exposure specification (1) in Section 2.3 to estimate the elasticity of anti-fertility policies. The analysis at the individual level shows that exposure to an anti-fertility policy costing 0.1% of GDP during the childbearing window reduces the number of children an individual has by 0.86. For pro-fertility policies, we derive elasticities by converting the meta-analysis results from Stone (2020). In Figure A9, we compare anti-fertility policies and pro-fertility policies at the individual level. The conclusion is consistent with our findings in Section 2.4.

Figure A9: Comparison Between Anti-Fertility Policies and Pro-Fertility Policies: Individual Level



Source: Estimated elasticity of anti-fertility policies is from regression result in Table A25; estimated elasticity of pro-fertility policies is calculated as discussed in Section 2.4, 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.

C.3 Conversion of Elasticities

In this section, we briefly introduce how we make our estimation result in Section 2.4 comparable with Stone (2020)'s meta-analysis result.

C.3.1 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.3.2 Country Level

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

$$
\begin{aligned}
e_s/\text{birth\_rate} &= \frac{\Delta\text{birth\_rate}}{\Delta f_2 \times \text{birth\_rate}} \times \frac{1}{\text{birth\_rate}} &(26)\\
&= \frac{\Delta\text{birth\_rate}}{\text{birth\_rate}} \times \frac{1}{\Delta f_2 \times \text{birth\_rate}} &(27)\\
&= \frac{\Delta\text{TFR}}{\text{TFR}} \times \frac{1}{\Delta f_2 \times \text{birth\_rate}} &(28)\\
&= \frac{\Delta\text{TFR}}{\text{TFR}} \times \frac{1}{\Delta f_1} &(29)\\
&\equiv e_c &(30)
\end{aligned}
$$

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:

$$
\begin{aligned}
f_2 \times \text{birth\_rate} &= \frac{\text{per child benefit}}{\text{per household income}} \times \text{birth\_rate} && (31)\\
&= \frac{\text{per child benefit} \times \text{size of target group}}{\text{per household income}} \times \frac{\text{birth\_rate}}{\text{size of target group}} && (32)\\
&= \frac{\text{policy funding}}{\text{per household income}} \times \frac{1}{\text{population}} && (33)\\
&= \frac{\text{policy funding}}{\text{GDP per capita} \times \text{population}} && (34)\\
&= \frac{\text{policy funding}}{\text{GDP}} \equiv f_1 && (35)
\end{aligned}
$$

C.3.3 Individual Level

Our individual-level empirical specification estimates a 100% increase in the 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-the 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:

$$
\begin{aligned}
\frac{e_i \times 0.5 \times r}{\text{birth\_rate} \times 28} &= \frac{\Delta \text{N\_children\_per\_treated}}{\Delta f_1} \times \frac{1}{\text{birth\_rate}} \times \frac{0.5 \times r}{28} && (36)\\
&= \frac{\Delta \text{N\_children\_per\_treated}}{\Delta f_2} \times \frac{0.5 \times r}{28} && (37)\\
&= \frac{\Delta \text{N\_children\_per\_treated}}{\Delta f_2} \times \frac{0.5 \times \text{N\_treated\_individuals}}{\text{population}} \times \frac{1}{28} && (38)\\
&= \frac{\Delta \text{N\_children}}{\Delta f_2 \times \text{population}} \times \frac{1}{28} && (39)\\
&= \frac{\Delta \text{N\_children}}{45 - 18 + 1} \times \frac{1}{\Delta f_2 \times \text{population}} && (40)\\
&= \frac{\Delta \text{N\_children\_born\_per\_year}}{\text{population}} \times \frac{1}{\Delta f_2} \equiv e_b && (41)
\end{aligned}
$$

Where (12) follows from our discussion in Section C.3.2; (13) follows from the definition of r; (16) is by the following assumption:

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

D. Proofs

Proof of the 'slippery-slope' condtion: We will show that for the following process

$$dr_t = (1-\phi)(c(r_t) - r_t)dt + \sigma dB_t \tag{42}$$

there exists a unique invariant distribution, and under the invariant distribution, $\mathbb{E}(r_t - r^*) > 0$.

The existence and uniqueness of the invariant distribution follows immediately as $c(r)$ is a bounded, Lipschitz function. The invariant distribution admits an absolutely continuous density. Dropping the t-subscripts, the form of the density can be derived using the stationary Fokker-Planck equation for the density of r:

$$(1-\phi)(c(r) - r)p(r) = \frac{\sigma^2}{2}p'(r) \tag{43}$$

The solution to this equation is

$$p(r) = \lim_{\eta \to -\infty} \frac{\exp\left\{\frac{2}{\sigma^2}\int_\eta^r (1-\phi)(c(s)-s)ds\right\}}{\int_{-\infty}^{\infty} \exp\left\{\frac{2}{\sigma^2}\int_\eta^r (1-\phi)(c(s)-s)ds\right\}dr} \tag{44}$$

for any η. To simplify, first notice that we can choose $\eta < r^*$ without loss of generality. Then, for $r \leq r^*$, we have

$$\int_\eta^r (c(s) - s)ds = \int_\eta^r (r^* - s)ds \tag{45}$$

$$= -\frac{1}{2}(r-r^*)^2 + \frac{1}{2}(r^* - \eta)^2 \tag{46}$$

For $r > r^*$, we have, letting $c(r) = r^*$ for $r < r^*$ and $c(r) = c^*(r)$ for $r \geq r^*$,

$$\int_\eta^r (c(s) - s) ds = \int_\eta^r (c(s) - r^* + r^* - s) ds \tag{47}$$
$$= \int_\eta^r (r^* - s) ds + \int_{r^*}^r (c^*(s) - r^*) ds \tag{48}$$
$$= -\frac{1}{2}(r - r^*)^2 + \frac{1}{2}(r^* - \eta)^2 + \int_{r^*}^r (c^*(s) - r^*) ds \tag{49}$$
$$\tag{50}$$

Thus, we have

$$\exp\left\{\frac{2}{\sigma^2}\int_\eta^r (1-\phi)(c(s) - s) ds\right\} = \exp\left\{\frac{1-\phi}{\sigma^2}(r^* - \eta)^2\right\} \tag{51}$$
$$\cdot \exp\left\{-\frac{1-\phi}{\sigma^2}(r - r^*)^2\right\} \tag{52}$$
$$\cdot \exp\left\{\frac{2(1-\phi)}{\sigma^2}\mathbb{1}_{[r>r^*]}\left(\int_{r^*}^r (c^*(s) - r^*) ds\right)\right\} \tag{53}$$

This implies that the limit in terms of η will converge, so that we have

$$p(r) = \frac{\exp\left\{-\frac{1-\phi}{\sigma^2}(r - r^*)^2\right\}\exp\left\{\frac{2(1-\phi)}{\sigma^2}\mathbb{1}_{[r>r^*]}\left(\int_{r^*}^r (c^*(s) - r^*) ds\right)\right\}}{\int_{-\infty}^\infty \exp\left\{-\frac{1-\phi}{\sigma^2}(r - r^*)^2\right\}\exp\left\{\frac{2(1-\phi)}{\sigma^2}\mathbb{1}_{[r>r^*]}\left(\int_{r^*}^r (c^*(s) - r^*) ds\right)\right\} dr} \tag{54}$$

Then, $\mathbb{E}r > r^*$ if $\int (r - r^*) p(r) dr > 0$. To obtain the sign, we only need to consider the numerator, as the constant of integration does not determine the sign. Thus, we consider whether

$$\int_{-\infty}^\infty (r - r^*) \exp\left\{-\frac{1-\phi}{\sigma^2}(r - r^*)^2\right\}\exp\left\{\frac{2(1-\phi)}{\sigma^2}\mathbb{1}_{[r>r^*]}\left(\int_{r^*}^r (c^*(s) - r^*) ds\right)\right\} dr \tag{55}$$
$$= \int_{-\infty}^{r^*} (r - r^*) \exp\left\{-\frac{1-\phi}{\sigma^2}(r - r^*)^2\right\} dr \tag{56}$$
$$+ \int_{r^*}^\infty (r - r^*) \exp\left\{-\frac{1-\phi}{\sigma^2}(r - r^*)^2\right\}\exp\left\{\frac{2(1-\phi)}{\sigma^2}\left(\int_{r^*}^r (c^*(s) - r^*) ds\right)\right\} dr \tag{57}$$
$$= I_1 + I_2 \overset{?}{>} 0 \tag{58}$$

First, we consider the lower-part, I_1:

$$\int_{-\infty}^{r^*} (r - r^*) \exp\left\{-\frac{1-\phi}{\sigma^2}(r-r^*)^2\right\} dr = -\frac{\sigma^2}{2(1-\phi)} \tag{59}$$

For the upper part, we employ integration-by-parts:

$$u(r) = \exp\left\{\frac{2(1-\phi)}{\sigma^2}\left(\int_{r^*}^{r} (c^*(s) - r^*) ds\right)\right\} \tag{60}$$

$$u'(r) = \frac{2(1-\phi)}{\sigma^2}(c^*(r) - r^*) \exp\left\{\frac{2(1-\phi)}{\sigma^2}\left(\int_{r^*}^{r} (c^*(s) - r^*) ds\right)\right\} \tag{61}$$

$$v(r) = -\frac{\sigma^2}{2(1-\phi)} \exp\left\{-\frac{1-\phi}{\sigma^2}(r-r^*)^2\right\} \tag{62}$$

$$v'(r) = (r - r^*) \exp\left\{-\frac{1-\phi}{\sigma^2}(r-r^*)^2\right\} \tag{63}$$

$$\int_{r^*}^{\infty} (r - r^*) \exp\left\{-\frac{1-\phi}{\sigma^2}(r-r^*)^2\right\} \exp\left\{\frac{2(1-\phi)}{\sigma^2}\left(\int_{r^*}^{r} (c^*(s) - r^*) ds\right)\right\} dr \tag{64}$$

$$= -\frac{\sigma^2}{2(1-\phi)} \exp\left\{-\frac{1-\phi}{\sigma^2}(r-r^*)^2\right\} \exp\left\{\frac{2(1-\phi)}{\sigma^2}\left(\int_{r^*}^{r} (c^*(s) - r^*) ds\right)\right\}\Bigg|_{r=r^*}^{r\to\infty} \tag{65}$$

$$+ \int_{r^*}^{\infty} (c^*(r) - r^*) \exp\left\{-\frac{(1-\phi)}{\sigma^2}(r-r^*)^2\right\} \exp\left\{\frac{2(1-\phi)}{\sigma^2}\int_{r^*}^{r} (c^*(s) - r^*) ds\right\} dr \tag{66}$$

$$= \frac{\sigma^2}{2(1-\phi)} \tag{67}$$

$$+ \int_{r^*}^{\infty} (c^*(r) - r^*) \exp\left\{-\frac{(1-\phi)}{\sigma^2}(r-r^*)^2\right\} \exp\left\{\frac{2(1-\phi)}{\sigma^2}\int_{r^*}^{r} (c^*(s) - r^*) ds\right\} dr \tag{68}$$

where the limit as $r \to \infty$ is zero because $c^*(r)$ is bounded above by y, and a normal random variable has finite moment-generating function, i.e. $\mathbb{E}\, e^{t|Z|} < \infty$ when Z is normally distributed. Thus, we have that:

$$I_1 + I_2 = \int_{r^*}^{\infty} (c^*(r) - r^*) \exp\left\{-\frac{(1-\phi)}{\sigma^2}(r-r^*)^2\right\} \exp\left\{\frac{2(1-\phi)}{\sigma^2}\int_{r^*}^{r} (c^*(s) - r^*) ds\right\} dr \tag{69}$$

which is strictly positive unless $c^*(r) - r^* \leq 0$ for all $r > r^*$, and therefore $\mathbb{E}(r - r^*) \geq 0$.