Technology, Social Norms, and Fertility Choices*

Helu Jiang † Yuanxin Li ‡ Nikita Sangwan § Sounak Thakur ¶

June 15, 2026

Abstract

We study how technological progress interacts with social norms to exacerbate pre-existing gender gaps. Our context is India, where the adoption of new agricultural technology (between the late-1960s and 1980s) dramatically increased crop yields and farm profits. Indian society is patrilocal, with adult sons co-residing with elderly parents and adult daughters marrying out. Increased profits raise sons' ability to support parents in old age, effectively increasing the relative returns to having a son. We empirically document that the new technology reduced fertility and increased the demand for sons. To better understand mechanisms, we formulate a model of sequential fertility choice with patrilocality. The calibrated model accounts for about 11% of the increase in the male-bias in the sex ratio and 80% of the fertility decline in India between the 1960s and 1990s. Counterfactual experiments indicate that early transfers conditional upon having 3 or 4 daughters are the most cost-effective instrument for reducing the male-bias in the sex ratio under the Green Revolution — pointing to the salience of economic motives in fertility decisions under the new technological regime.

JEL classification: J13, J16, J24, O13, O33

Keywords: Green Revolution, fertility, sex ratio, social norm, Indian economy.

---

[*] We gratefully acknowledge helpful comments from Christopher B. Barrett, Prashant Bharadwaj, Monishankar Bishnu, James Fenske, Maitreesh Ghatak, Chetan Ghate, Digvijay Singh Negi, Bharat Ramaswami, Yongkun Yin, and seminar and conference participants at the Indian Institute of Technology, Jodhpur, Institute of Economic Growth, Delhi and the 17th Annual Conference on Economic Growth and Development, Indian Statistical Institute, Delhi. All remaining errors are our own. The usual disclaimers apply. Jiang acknowledges financial support from the National Natural Science Foundation of China (72403154).

[†] Shanghai University of Finance and Economics. Email: jianghelu@sufe.edu.cn.

[‡] Shanghai University of Finance and Economics. Email: 2021210209@live.sufe.edu.cn.

[§] Queen's University Belfast, UK. Email: n.sangwan@qub.ac.uk.

[¶] Indian Institute of Technology, Kanpur. Email: sounakt@iitk.ac.in.

1 Introduction

Technological progress fosters economic growth by enhancing factor productivity (Solow, 1956; Romer, 1990). However, the distribution of the gains from technological progress could be gendered, depending on how technological change affects gender-specific comparative advantages, opportunity cost of time, or earnings (Rotella, 1981; Goldin, 2006; Qian, 2008; Greenwood *et al.*, 2005; Ngai & Petrongolo, 2017). A recent strand of literature further documents that, like technological progress, social norms can affect labor productivity by influencing investments in human capital (Ashraf *et al.*, 2020; Jayachandran & Pande, 2017). Relatively less is known about the interactions between social norms and technological change. For instance, can social norms generate gender-differentiated responses to technological change, even when the underlying technological change leaves gender-specific comparative advantage unaltered?

In this paper, we study how deeply entrenched social norms interacted with the introduction of new agricultural technology to alter the population sex ratio in India. India experienced a rapid demographic transition between the early-1970s and 2000s, but with a striking peculiarity: the decline in total fertility was accompanied by a spectacular increase in the male bias in the population sex ratio) (Figure 1), leading Amartya Sen to famously coin the term "missing women" (Sen, 1992). Contemporaneously, India adopted new agricultural technology. Popularly known as the "Green Revolution", — which led to dramatic improvements in the productivity of staple crops between the late 1960s and 1980s (Munshi, 2004; Evenson & Gollin, 2003). Indian society is patrilocal: adult sons co-reside with elderly parents and provide old-age support, while adult daughters marry out of the natal family (Jayachandran, 2015). By custom, adult sons are expected to care for parents in their old age, while adult daughters are not expected to make monetary contributions to the natal family.[1] When the Green Revolution increased labor productivity, patrilocality implied that sons' capacity to support elderly parents improved, while daughters' economic value to their natal family remained unchanged. The introduction of the Green Revolution thus increased the relative return to having a son, even though the underlying technology left gender-specific comparative advantages in production unaltered.)

The Green Revolution technology relied heavily on the use of high-yielding variety (HYV

---

[1] This sentiment resonates in an Indian proverb that states: "Raising a daughter is like watering your neighbors' garden." ((Jayachandran, 2015), pg. 75).

hereafter) seeds (mostly wheat and rice) developed under the aegis of International Agricultural Research Centers (IARCs) in Mexico and Philippines (Evenson & Gollin, 2003). The improved varieties of wheat were very successful under Indian agro-climatic conditions. Relative to traditional varieties, HYV wheat varieties yielded more than double the output per hectare, and were rapidly adopted in northern and northwestern India between 1966-1975 (Foster & Rosenzweig, 1996). The adoption of HYV seeds in rice cultivation was slower, and led to more modest improvements in yield (Dasgupta, 1977; Munshi, 2004). In general, HYV seeds produced high yields only when the inputs were combined optimally in appropriate proportions. (Foster & Rosenzweig, 1996) document that only educated farmers were able to realize the higher yields from the new technology. This appears to have induced a demand for "high-quality" children. The adoption of the new agricultural technology correlates with an increase in the demand for schooling and a reduction in the rate of infant mortality (Foster & Rosenzweig, 1996; Bharadwaj *et al.*, 2020).

We begin by empirically investigating the association between adoption of Green Revolution and fertility choices. We use mother-level information on retrospective birth histories, which we merge with information on the adoption of the agricultural technology at the district-year level. A mother's exposure to Green Revolution is defined as the fraction of cultivable land under HYV seeds in the district in the year she first gave birth. Following (Bharadwaj *et al.*, 2020), we exploit within-district variation in mothers' exposure to the new agricultural technology to identify our coefficients of interest. Our models control for interactions between state and year fixed effects, which allow each state to trend differently over time in a flexible manner. We find that complete adoption of Green Revolution is associated with the birth of 0.42 fewer children and an increase in the proportion of boys by 0.08. In terms of magnitude, these coefficients are sizable. The reduction in total fertility and the increase in the proportion of sons amount to about 7% and 16% of the mean, respectively.

To better understand the mechanisms through which the new agricultural technology could affect fertility and sex-composition choices, we formulate a dynamic model of sequential fertility. The model extends the Barro-Becker framework and incorporates institutional features of the Indian context, including patrilocal marriage and dowry payments for daughters. The model captures three channels through which the Green Revolution may affect fertility choices in the Indian setting. First, higher returns to education make the quantity-quality tradeoff more salient. Second, patrilocality increases the economic returns to sons relative to daughters, especially when the skill premium rises. Third, higher agricultural productivity and wages affect household fertility through income and opportunity-cost channels.

We calibrate the model to match pre-Green Revolution fertility, sex ratios, and the completed fertility distribution, and then simulate the introduction of the new technology. The quantitative exercise shows that the Green Revolution can account for a large share of the decline in fertility and the compression of the family-size distribution. In particular, the model explains 79.9% of the observed fertility decline, and 91.5% of the decline in the variance of children. The model also explains 86.2% of the increase in son-biased fertility-stopping behavior, even though this moment is not directly targeted in the calibration. However, the model explains only 10.8% of the observed decline in the pooled child sex ratio. This contrast is an important finding: the calibrated wage and skill-premium shocks can reproduce much of the fertility response to the Green Revolution, but they do not fully account for the deterioration in the child sex ratio.

To unpack the mechanisms, we perform counterfactual simulations that yield two key insights. First, social norms matter for the level of fertility and the level of the sex ratio. Allowing daughters to transfer resources to their natal parents improves the sex ratio and raises fertility, while removing dowry weakens son-biased stopping. These exercises show that patrilocality and dowry shape the demographic response to technological change, although neither counterfactual fully eliminates the Green Revolution-induced decline in the sex ratio in the current calibration. Second, financial transfers targeted toward daughters can improve the sex ratio by increasing the economic value of daughters. The policy simulations suggest that conditional transfers with intermediate daughter thresholds are more effective than very low or very high thresholds, and that early transfers tend to be more cost-effective than pensions because they arrive earlier in the life cycle and are discounted less heavily by forward-looking parents. These findings underscore that economic considerations, especially old-age support in a patrilocal setting, are central to parental fertility choices, and that policies enhancing the economic value of daughters can partially counteract the gendered consequences of technological progress.

This paper is related and contributes to several strands in the literature. First, the distributional consequences of economic growth has been a classic question in economics. Economists have long recognized that the distribution of gains from technological progress depends on how new technologies influence comparative advantages of different groups, and that the change in comparative advantage often varies by gender (Kramer & McMillan, 2006; Jensen, 2012; Barnwal *et al.*, 2017; D'Agostino, 2017; Bharadwaj *et al.*, 2020; Gehrke & Kubitza, 2021; Gollin *et al.*, 2021; Moorthy, 2022; Afridi *et al.*, 2023). For instance, skill-biased technological progress in the United States increased female labor force participation while reducing employment prospects for low-skilled men (Goldin, 2006; Acemoglu & Autor, 2011). A more recent literature highlights that the effects of social norms on human capital investments could be gendered, thus plausibly affecting gender-gaps in productivity in the long-run (Giuliano, 2020). However, the interaction between social norms and technology remains understudied. We address this gap by showing that a gender-neutral technological change produces gendered demographic outcomes when it operates in a patrilocal society — the key channel being sons' increased capacity to provide old-age support, which is independent of any change in gender-specific labor productivities.

Second, an extensive literature has studied the effects of the adoption of the new agricultural technology (also known as Green Revolution). Past research focuses on both direct outcomes like farm profits, productivity, wages and environmental factors like water quality (Foster & Rosenzweig, 1995, 1996; Gollin *et al.*, 2021; D'Agostino, 2017), and on more indirect outcomes such as the "quality" of children as proxied by indicators of health and education (Foster & Rosenzweig, 1996; Brainerd & Menon, 2014; von der Goltz *et al.*, 2020; Bharadwaj *et al.*, 2020). We add to this literature by documenting that the Green Revolution also altered the gender composition of births: fertility declined while the male bias in the sex ratio increased. This is consistent with the existing literature, which documents a negative relationship between total fertility and parental demand for daughters (Jayachandran, 2017; Anukriti, 2018). Our quantitative model sheds light on the mechanisms that give rise to the negative relationship in a context where dowries exist in a patrilocal setting.

Third, son-preferring behaviors have been documented in the context of Asian countries like India, China and Korea (Das Gupta & Shuzhuo, 1999; Clark, 2000; Rose, 1999; Jayachandran & Kuziemko, 2011; Bharadwaj & Lakdawala, 2013). A rich literature, mostly in the Indian context, has studied the motivations behind son-preferring behaviors (Dyson & Moore, 1983; Das Gupta *et al.*, 2003; Arnold *et al.*, 1998; Harris, 1993; Bhalotra *et al.*, 2020b). The current study contributes to the literature by quantifying the effect of social norms such as dowries and patrilocal co-residence on son-preferring behaviors. As our decomposition exercises show, both dowries and patrilocality play a significant role in motivating son-preferring behaviors. In fact, in our counterfactual simulations, removal of either dowry or patrilocality leads to sex ratios close to the model's genderneutral benchmark of 1000.

Our study finds that economic considerations (induced by norms such as dowry and patrilocality) are significant motivators of son-preferring behaviors. These findings are relevant from a policy perspective for the following reason: Economic considerations are more amenable to change via policy interventions as compared to religious beliefs — another major motivator of son-preferring behaviors. Recent research, both empirical and theoretical, suggest that altered economic considerations, like an exogenous change in dowries, affects son-preferring behaviors in India (Alfano, 2017; Bhalotra *et al.*, 2020a). Similarly, evidence from China suggests that the introduction of formal pension schemes reduces the male-bias in the population sex ratio (Ebenstein & Leung, 2010). Yin (2022) calibrates a model of fertility choice in the Indian setting, and shows that the (simulated) introduction of a pension scheme reduces the male bias in population sex ratio. While formal pensions covering a substantial segment of the population do not exist in India as yet, some Indian states, like Haryana, have experimented with cash transfers conditional on fertility outcomes. As Anukriti (2018) finds, and our model qualitatively replicates, Haryana's conditional transfers program has been somewhat counterproductive — it reduced fertility but increased the male bias in population sex ratio. Our paper studies the implications of alternative conditional transfer schemes on the population sex ratio. Our counterfactual simulations indicate that relatively large transfers conditional upon having a certain number of daughters would be effective in reducing the demand for sons.[2]

Third, son-preferring behaviors have been documented in the context of Asian countries like India, China and Korea (Das Gupta & Shuzhuo, 1999; Clark, 2000; Rose, 1999; Jayachandran & Kuziemko, 2011; Bharadwaj & Lakdawala, 2013). A rich literature, mostly in the Indian context, has studied the motivations behind son-preferring behaviors (Dyson & Moore, 1983; Das Gupta *et al.*, 2003; Arnold *et al.*, 1998; Harris, 1993; Bhalotra *et al.*, 2020b). We contribute by quantifying the role of specific social norms. As our decomposition exercises show, removal of either dowry or patrilocality leads to sex ratios close to the model's gender-neutral benchmark of 1000. From a policy perspective, these findings are significant because economic motivations for son preference are more amenable to intervention than religious or cultural beliefs. Evidence from China (Ebenstein & Le-

---

[2] Our model is calibrated to match fertility patterns in 1961. Therefore, our quantitative results would apply to that time period.

ung, 2010) and calibrated models for India (Yin, 2022) suggest that formal pensions can reduce male bias, but existing conditional transfer programs have had mixed results — Anukriti (2018) finds that Haryana's Devi Rupak program reduced fertility but increased male bias, a pattern our model qualitatively replicates. Our counterfactual simulations indicate that early transfers conditional on having at least 4 or 5 daughters would be the most cost-effective alternative.[3]

The remainder of this paper proceeds as follows: Section 2 discusses the background of the new agricultural technology and social norms in India. Section 3 describes the data source and presents empirical results. Section 4 describes the model in detail. Section 5 presents quantitative results based on calibration of the model. Section 6 presents the results of counterfactual experiments we conduct using the calibrated model. Section 7 concludes.

2 Background

2.1 Green Revolution

Green Revolution refers to an agricultural project that aimed at increasing food production by using plant genetics (High-Yielding Varieties seeds), modern irrigation system, and chemical fertilizers and pesticides. This program began in Mexico and then extended to many developing countries in Asia, Latin America, and Africa.

The government of India launched the Green Revolution in the year 1965, originally in the states of Punjab, Haryana, and western Uttar Pradesh (UP) (refer figure 2). The introduction of a high-yielding variety of seeds of wheat was considered as major milestones in the movement. Green Revolution in India lasted till 1978, which helped turn the country from a food-deficient economy to one of the leading agricultural nations in the world. Such dramatic improvement in agricultural productivity in the Indian economy allows us to use the Green Revolution as an exercise to investigate the gendered consequences of technological change.

---

[3] Our model is calibrated to match fertility patterns in 1961. Therefore, our quantitative results apply to that time period.

2.2 Social norms in India

This paper examines the impact of the introduction of Green Revolution technologies on gender bias in population through the lens of the economic consequences of three specific social norms. In particular, we solely focus on the patrilocality of marriage and the institution of dowry, and thus the implied son preference in the Indian economy.

Patrilocality refers to a pattern of marriage in which women move to their husband's house and co-reside with their husbands' families after marriage. In a patrilocal society, usually daughters provide care for their in-laws after leaving the home following marriage while sons provide care for their elderly parents.

Dowry refers to the financial liability of the bride's family to the groom's family, including various forms of properties such as cash, capital, and durable goods. Though several Indian laws have been enacted to prohibit and punish the payment of dowry, for example, the Dowry Prohibition Act 1961, dowry is still considered as a prevalent practice.

We are not making the statement that these are the only two forms of cultural norms that may lead to son-preference. There are research investigating the role of different cultural factors in understanding how son-preference is formed, for example, Trivers & Willard (1973) suggests that natural selection favor parents who are able to adjust the sex ratio of offspring; Das Gupta *et al.* (2003) argue that cultural factors, such as kinship systems and the role of ancestor worship, play an important role in son-preference; Pande & Astone (2007) find that among social factors, caste and religion are associated with son-preference. However, these are beyond the scope of this research.

3 Data and Empirical Estimation

We empirically investigate the reduced form impacts of exposure to the Green Revolution on the fertility choices of households. We describe our data sources, empirical strategy and results in detail below.

3.1 Data

We use mother-level retrospective birth history data from the first round of India's National Family Health Survey (NFHS-I), conducted in 1992-93. The survey covers women aged 15-49; we restrict the sample to women aged 40-49 for whom we are likely to observe complete fertility histories.

We combine these data with district-level information on the adoption of Green Revolution (GR) technology. A mother's exposure to GR is defined as the share of cultivable land under High Yielding Variety (HYV) seeds in her district in the year preceding the birth of her first child.[4] This definition captures local labour market conditions at the time the couple made their first fertility decision. As a robustness check, we also assign exposure based on HYV adoption in the year of the mother's marriage.

To measure GR adoption, we use the VDSA Meso dataset compiled by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), which records annual district-level area under cultivation and area planted with HYV seeds for six major crops.[5] We restrict our measure to wheat and rice, the two crops at the heart of India's Green Revolution. Figure 3 plots the five-year moving average of HYV adoption between 1966 and 1990, showing that the technology diffused gradually: the area under HYV seeds rose from under 20% to roughly 60% over this period.

Table 1 reports summary statistics. Our sample comprises 7,093 women, of whom 68% are in rural areas. Panel A describes our three fertility outcomes: total children ever born, the proportion of boys among all births, and an indicator for stopping childbearing after a boy. The average mother in our sample gave birth to slightly more than four children; 53% of births were male, consistent with India's documented male-biased sex ratio at birth; and 57% of mothers stopped childbearing after their last-born child was a boy. Rural fertility is significantly higher than urban fertility ($p<0.01$). Panel B describes maternal characteristics: average education is under three years, average age is 43, a large majority are Hindu, and 19% belong to a Scheduled Caste or Scheduled Tribe. Panel C summarises district-level GR exposure. The average district-year crops 26% of cultivated area under HYV seeds, but adoption is highly dispersed: the 25th and 75th percentiles of the distribution are 1% and 43%, respectively.

---

[4] Districts split from their parent districts after 1966 have been mapped back to their original boundaries. The few cases where a district was carved out from multiple parent districts are dropped; these account for less than 2.5% of observations.

[5] For details see `http://vdsa.icrisat.ac.in/`.

3.2 Empirical Strategy and Results

We estimate the impact of the Green Revolution, as measured by the adoption of HYV seeds, on fertility decisions. Our outcomes of interest include the total number of children, proportion of boys and the probability of stopping at a boy. We estimate the following specification:

$$y_{isdt} = \alpha_0 + \alpha_1 GR_{dt} + D_d + D_t + D_{st} + \gamma X_{idt} + \epsilon_{idt} \tag{1}$$

where y_{isdt} represents the outcome for mother i in state s in district d who first gave birth in year t. D_d and D_t represent vectors of district and year fixed effects, respectively. D_{st} represents a vector of state-by-year fixed effects. X_{idt} represents a vector of observed maternal characteristics such as their age, religion, caste, years of education, square of years of education assets.[6] Standard errors are clustered at the district-year level.

The new agricultural technology originated abroad, making its arrival plausibly unanticipated by Indian households. The ease of adoption further depended on geographic factors such as aquifer depth, which are beyond household control. Nevertheless, one may be concerned that adoption timing correlates with pre-existing fertility trends — for instance, if districts with faster economic growth were both early adopters and already further along the demographic transition.[7] Our identification strategy addresses this in three ways. District fixed effects absorb all time-invariant district characteristics and ensure identification comes from within-district variation in GR adoption over time. Year fixed effects account for economy-wide fertility trends unrelated to GR. State-by-year fixed effects allow each state's fertility to follow its own flexible time trend. Together, these controls ensure that α_1 is identified from within-district variation in GR adoption, net of flexible state-level trends.

3.2.1 Fertility Outcomes

Table 2 reports the effects of adopting Green Revolution technology on fertility choices in the rural regions. The specifications increase in strictness across columns: Column (1) includes mother-level controls, Column (2) adds district-fixed effects, Column (3) incorporates year-fixed effects, Column (4) (our preferred specification) introduces state-specific

---

[6] Asset Index is the Principal Components Analysis (PCA) of the ownership of the following assets—sewing machine, clock/watch, sofa set, fan, radio/transistor, refrigerator, television, vcr/cvp, bicycle, motorcycle/scooter, car, tractor, thrasher, bullock cart and water pump.

[7] Purchasing fertilisers required upfront cash, linking adoption to access to credit and local economic conditions.

annual trends, and Column (5) applies the strictest specification with district-specific annual trends. We focus on rural areas because the Green Revolution operated through agricultural labour markets, which have limited reach in urban India; consistent with this, rates of rural-to-urban migration remain low and the rural-urban wage gap remains high (Munshi & Rosenzweig, 2016). Results for urban areas are reported in Appendix Table A.1 and show no significant effects across any outcome.

In Panel A of Table 2, we report the effect of exposure to the Green Revolution on the *Total children* (the count of children ever born to a mother). Panel B reports the *Proportion of boys* born of the total children and Panel C reports the *Stopping at a boy* (the likelihood of not bearing any more children conditional on the last born child being a boy).

Panel A shows a significant reduction in total fertility in regions exposed to Green Revolution. Estimates from our preferred specification (Column (4)) suggest that moving from a district with no adoption of HYV (High-Yield Variety) seeds to a district with 100% adoption is associated with a 0.4 unit ($p < 0.05$) decrease in the total number of children born per woman. This decline corresponds to approximately a 7% decline relative to the mean among women in districts with no GR exposure.

Interestingly, this reduction in fertility is accompanied by a notable shift in the gender composition of births, as shown in Panel B. We find an 8 percentage point ($p < 0.05$) increase in the proportion of boys born to mothers in regions with full adoption of HYV seeds. This change represents a 16% increase relative to the rural mean. This pattern suggests a possible increase in son preference or differential stopping behavior, where families with access to improved agricultural technologies may choose to stop having children earlier if a son is born. We indeed find evidence in support of this stopping behavior in Panel C. In rural areas, exposure to the Green Revolution was associated with a 12 percentage point increase in the probability of stopping at a boy. In terms of magnitude, it corresponds to about a 20% increase in the probability of stopping at a boy relative to the rural average.

We conducted a similar analysis for urban regions in India and found no significant changes in any of the fertility outcomes (see Appendix Table A.1). This finding underscores the critical role of Green Revolution technology in shaping the rural economy while highlighting its limited penetration and impact in urban areas.

Our main results are robust to alternative clustering of standard errors. When we cluster at the district level rather than the district-year level, the estimates in our preferred specification remain significant across all three outcomes, allaying concerns that our results are driven by within-district serial correlation in adoption (refer to Appendix Table A.2).

We also examine sensitivity to the definition of GR exposure. Our main specification assigns exposure based on HYV adoption in the year *preceding* the birth of the first child. Tables A.3 and A.4 report results under two alternative definitions: HYV adoption in the year of the mother's marriage, and HYV adoption in the birth year of the first child, respectively. The pattern of results is broadly consistent with our main findings. Under the marriage-year definition (Table A.3), the reduction in total fertility loses significance once district and year fixed effects are included, but the stopping-at-a-boy result remains significant across Columns (3)-(5), with a magnitude comparable to our baseline. Under the birth-year definition (Table A.4), the total fertility result is no longer significant in our preferred specification, while the proportion of boys remains significant. Notably, the stopping-at-a-boy result is insignificant under this definition, which is expected: assigning exposure based on the birth year of the *first* child conflates the timing of GR adoption with the timing of fertility itself, introducing a mechanical relationship that contaminates the stopping-behaviour estimates. Taken together, the robustness checks confirm that the core finding - GR adoption reduced fertility and strengthened son-biased stopping behaviour - is not an artefact of our particular exposure definition, and that our preferred lag-one specification best captures the labour market conditions faced by households at the time of their first fertility decision.

3.2.2 Parity analysis

We further investigate son preference by examining how the birth of a girl child at each parity is influenced by exposure to the Green Revolution (GR). Table A.5 presents the results of this analysis. Panel A reports the likelihood of a girl child being born at each parity, while Panel B provides estimates conditional on the last child being a boy. All columns follow the same specification as our preferred baseline model.

Across all parities, we observe negative coefficients, suggesting a reduced likelihood of a girl being born in regions exposed to the GR. This reduction is statistically significant for Parity 2 ($p < 0.1$) and Parity 5 ($p < 0.05$). When we condition the analysis on the last child being a boy, the coefficients become larger in magnitude, indicating a further decrease in the likelihood of a girl being born. Significant reductions are observed at Parity 2 ($p < 0.1$), Parity 3 ($p < 0.01$), and Parity 5 ($p < 0.05$). These findings suggest that the GR may have reinforced son preference, particularly in later parities and among families who had already given birth to a boy.

In summary, our findings highlight how improvements in agricultural productivity influence family size decisions and reinforce son preference, potentially through economic or cultural mechanisms. Building on this, we next examine whether the cultural practice of dowry responds to the Green Revolution.

3.2.3 Dowry Payments

Table A.6 examines the relationship between dowry payments and the Green Revolution. We use the ARIS-REDS (1999) data to estimate the dowry payments using the self-reported data on dowries paid for daughters and sisters. We use real dowry payments by discounting the effect of inflation using the CPI-AL inflation deflator. We have logarithmically transformed the dowry payments and to account for zero dowry payments, the dowry amounts were log-transformed by adding a small value of one rupee. All specifications include controls for household characteristics (such as caste category), district-fixed effects, marriage year fixed effects, and state-specific annual trends. As expected, we find higher dowry payments among landowners and Hindu households. Additionally, the results align with the theory of assortative matching, as higher levels of education for both the bride and groom are associated with increased dowry payments. However, across all specifications, the Green Revolution does not appear to have a significant impact on dowry payments. This null result is consistent with dowry rates being determined primarily by local marriage market customs rather than by contemporaneous changes in agricultural productivity, and motivates our modeling choice to treat the dowry schedule as exogenously fixed.

The reduced-form evidence establishes three important facts: Green Revolution adoption reduced total fertility, raised the proportion of boys born, and strengthened son-biased stopping behaviour while leaving dowry payments unchanged. These patterns are consistent with a world in which technological change raised the economic returns to sons relative to daughters, through labour market wages and patrilocal old-age support, without dismantling the marriage market institution of dowry itself. However, reduced-form estimates alone cannot tell us how much of the fertility and sex-ratio response is driven by the wage channel versus the old-age support channel, nor can they speak to what policies might reverse the male bias. To answer these questions, we develop a dynamic model of sequential fertility choice that incorporates the two defining institutional features of the Indian context (patrilocality and dowry) and use it to decompose the mechanisms and evaluate counterfactual policy interventions.

4 Model

We extend the standard Barro–Becker framework to construct a life-cycle model that features sequential birth decisions to quantitatively study how Green Revolution could have interacted with social norms. Our model of the household is unitary, and each household comprises a married couple in a heterosexual union. The sequential fertility decision setup that we use enables us not only to study the quantity-quality trade-off but also the change in gender composition in response to technological change — an outcome that is the key interest of this paper. The introduction of Green Revolution technologies is modeled as an increase in the overall wage rate and skill premium. This is empirically supported by Foster & Rosenzweig (1996).

4.1 The Stages of Life

Time is modeled as discrete. Each household, which consists of a married couple, is endowed with one unit of time.[8] It is assumed that each couple is randomly endowed with some assets. They begin with no children. In each period, the couple observes values of the state variables, which include the amount of assets (a_t), the number of children (n_t), and the number of sons ($n_{m,t}$). The couple goes through several stages of life. These are: the fertile stage", education-of-children stage", the dowry stage", the pre-retirement stage" and the "retirement stage". The choices and states relevant to the couple's problem depend on the stage of life they are in. In what follows, we describe the stages in the life of a married couple in greater detail.

1. Fertile stage: $t_0 \leq t \leq t_F$ In the first fertile period, the couple does not make a fertility decision. Instead, nature moves and one child is born with certainty, male with probability one-half and female with probability one-half.[9] Instead, the couple has to make

---

[8] We abstract from modeling home production due to the lack of detailed household-level time-use data in 1960s. A possible modeling approach is to assume task specialization by gender, with men participating in the labor market while women engage in home production, based on the fact documented in Hirway & Jose (2011) that a man spends much more time on market work and much less time on housework than a woman in India. This delivers similar results.

[9] The assumption that gender of the first child is random is consistent with fertility patterns in India (Bhalotra & Cochrane, 2010; Rosenblum, 2013; Alfano, 2017; Milazzo, 2018; Anukriti *et al.*, 2022).

consumption and savings decisions. From the second fertile period, the couple has to make a fertility choice in addition to its consumption and savings choices. The couple can make one of the following three fertility choices: natural”, contracept” or sex select”. If it chooses natural, a child will be born for sure at the end of the period. It will be male with half probability and female with half probability. If the couple chooses to contracept, no child will be born at the end of the period. If the couple chooses to sex select”, a male child is born at the end of the period with probability one-half, and no child is born with probability one-half. Thus, sex selection in the model should be interpreted as attempted male selection, or selective continuation of male pregnancies, rather than a technology that guarantees a male birth with certainty.

The state variables at the beginning of period t include the assets (a_t), the total number of children (n_t), and the total number of male children ($n_{m,t}$). Let $\mathbb{1}n,t,\mathbb{1}c,t,\mathbb{1}s,t$ denote alternative fertility choices (natural, contracept and select, respectively), and Vt^{i_t} is deterministic household utility associated with each alternative choice before the sex-selection utility cost is subtracted. Following Yin (2022), households differ in both the level of parental altruism and the utility cost of using sex selection. Specifically, the altruism parameter κ is drawn from a log-normal distribution, $\log(\kappa) \sim N(\mu_\kappa, \sigma_\kappa)$, and the utility cost of sex selection ξ is also drawn from a log-normal distribution, $\log(\xi) \sim N(\mu_\xi, \sigma_\xi)$. These household-specific types are realized before fertility decisions are made and remain fixed over the life cycle. In the computation, we also allow for idiosyncratic Gumbel choice shocks with scale parameter σ. The deterministic value of the sex-selection alternative is therefore $V_t^{\mathbb{1}s,t} - \xi$, while the deterministic values of natural birth and contraception are $V_t^{\mathbb{1}n,t}$ and $V_t^{\mathbb{1}_{c,t}}$, respectively.

A time cost of childrearing will be incurred when an additional child is born, denoted by τ. The ideal specification would charge τ per child per period throughout every period that a child resides in the household — both during the fertile stage and during the education stage. However, implementing this in the fertile stage raises a significant computational challenge: the rearing cost of children born in earlier fertile periods would need to be tracked period by period. Instead, we assume that the total childrearing cost that covers the t_F-period fertility stage will be incurred immediately at child’s birth in fertile stage. While in the later education stage, total children size is fixed and known, so τ will be charged per child per period.[10] Formally, the household’s decision problem at

---

[10] Another interpretation of this childrearing cost is the monetary cost of raising a child that is not related to education, for example, purchasing food and clothes, providing accommodations, and etc.

time t in the fertile phase may be written as follows: Let $\mathcal{I} = \mathbb{1} * n,t, \mathbb{1} * c,t, \mathbb{1} * s,t$ denote the set of fertility choices, corresponding to natural birth, contraception, and sex selection, respectively. The household's problem in the fertile stage is:

Let $i_t \in N,C,S$ denote the household's fertility choice in period t, where N denotes natural birth, C denotes contraception, and S denotes sex selection. The household's decision problem in the fertile stage is: Let $i_t \in N,C,S$ denote the household's fertility choice in period t, where N denotes natural birth, C denotes contraception, and S denotes sex selection. The household's decision problem in the fertile stage is: Let $i_t \in N,C,S$ denote the household's fertility choice in period t, where N denotes natural birth, C denotes contraception, and S denotes sex selection. The household's decision problem in the fertile stage is:

$$U_t(n_t, n_{m,t}, a_t) = \max_{i_t \in \{N,C,S\}} \widetilde{V}_t^{i_t}. \tag{2}$$

The choice-specific value is:

$$\widetilde{V}_t^{i_t} = \begin{cases} V_t^N, & \text{if } i_t = N, \\ V_t^C, & \text{if } i_t = C, \\ V_t^S - \xi, & \text{if } i_t = S. \end{cases} \tag{3}$$

For each alternative i_t, the deterministic value $V_t^{i_t}$ is given by:

$$V_t^{i_t} = \max_{C_t, a_{t+1}} \left\{ u_t + \beta \mathbb{E} \left[U_{t+1} \left(n_{t+1}, n_{m,t+1}, a_{t+1} \right) \right] \right\}. \tag{4}$$

The budget constraint is:

$$C_t + a_{t+1} = (1 + r_t) a_t + W_m \left[1 - \tau t_F \mathbb{E}_{i_t}(B_t) \right], \qquad C_t > 0, \quad a_{t+1} \geq 0. \tag{5}$$

The expected birth under each fertility choice is:

$$\mathbb{E}_{i_t}(B_t) = \begin{cases} 1, & \text{if } i_t = N \text{ (natural)}, \\ 0, & \text{if } i_t = C \text{ (contraception)}, \\ 0.5, & \text{if } i_t = S \text{ (sex selection)}. \end{cases} \tag{6}$$

The evolution of states depends on the fertility choice in the following way:

1. If $i_t = N$ (Natural):

$$n_{t+1} = n_t + 1, \qquad n_{m,t+1} = \begin{cases} n_{m,t} + 1, & \text{w.p. } 0.5, \\ n_{m,t}, & \text{w.p. } 0.5. \end{cases}$$

2. If $i_t = C$ (Contracept):

$$n_{t+1} = n_t, \qquad n_{m,t+1} = n_{m,t}.$$

3. If $i_t = S$ (Select):

$$(n_{t+1}, n_{m,t+1}) = \begin{cases} (n_t + 1, n_{m,t} + 1), & \text{w.p. } 0.5, \\ (n_t, n_{m,t}), & \text{w.p. } 0.5. \end{cases}$$

The instantaneous utility function u_t is given by:

$$u_t = u(C_t, n_{m,t}, n_{f,t}) = \log(C_t) + \kappa \left(n_{m,t}^{1-\varepsilon} \bar{I}_m + n_{f,t}^{1-\varepsilon} \bar{I}_f \right). \tag{7}$$

Here, C_t denotes the consumption good. Throughout the life cycle the household faces:

$$C_t > 0, \qquad a_{t+1} \geq \underline{a}, \tag{8}$$

where $\underline{a} \geq 0$ is a borrowing limit. In the baseline calibration we set $\underline{a} = 0$ (no borrowing), so all asset positions are non-negative. This rules out financing large families or dowry payments through debt. $\bar{I}m$ and $\bar{I}f$ denote innate parental love for sons and daughters, respectively. The parameter κ governs the degree of parental altruism, determining the relative weight parents place on utility from children versus own consumption. This is analogous to the altruism parameter in Yin (2022), who employs a similar specification in a model of fertility choice calibrated to the Indian context. $\varepsilon \in (0, 1)$ is a curvature parameter that captures diminishing marginal utility from additional children of the same sex, and we set it to be 0.5.[11] Once the fertile periods end, parents cannot have any more children. They must now make schooling choices for their children as described below.

Notice that the budget constraint is written in a way that saving decision is made before the realization of the stochastic birth outcome. To be more specific, the couple commits to a level of next-period assets based on expected income, and the asset carried into period $t + 1$ is the same regardless of whether a birth actually occurs under sex selection. The uncertainty about birth outcomes is absorbed entirely into the continuation value $\mathbb{E}[U_{t+1}(\cdot)]$,

---

[11] We adopt the convention $0^{1-\varepsilon} \equiv 0$, so that child utility is zero whenever no child of a given sex has been born.

where n_{t+1} and $n_{m,t+1}$ take different values with probability one-half each, but a_{t+1} is the same across both branches. This is a standard timing assumption in discrete-time fertility models: couples choose savings before observing the period's birth outcome, so asset accumulation is deterministic conditional on the fertility choice, while the sex and number of children evolve stochastically.

2. Education stage: $t_F < t \leq t_E$ Having observed the number and sex composition of their children and their accumulated assets, parents make binary schooling decisions for son(s) and daughter(s) ($\mathbb{1}_e^m$ and $\mathbb{1}_e^f$, respectively). We assume symmetric education decisions. In particular, we assume that schooling choices are uniform for all males (females). Schooling is costly. Thus, in addition to the childrearing cost τ, parents must incur a schooling cost of r_c for each child. With these notations, the couple's problem in the education period may be written as under:

$$\begin{aligned} U_t(n_{t_F}, n_{m,t_F}, a_t) = & \max_{C_t, a_{t+1}, \mathbb{1}_e^m, \mathbb{1}_e^f} \quad u_t + \beta U_{t+1}(n_{t_F}, n_{m,t_F}, a_{t+1}, \mathbb{1}_e^m, \mathbb{1}_e^f) \\ & s.t. \quad c_t + a_{t+1} + r_c(n_{m,t_F} \cdot \mathbb{1}_e^m + n_{f,t_F} \cdot \mathbb{1}_e^f) \\ & \qquad = (1 + r_t)a_t + W_{m,t}[1 - \tau(n_{m,t_F} + n_{f,t_F})] \end{aligned} \tag{9}$$

The education choices made by parents in every education period and accumulated schooling affect children's human capital in the end:

$$h_c^g = \sum_{j=t_F+1}^{t_E} \mathbf{1}_{e,j}^g, \quad g \in \{m, f\}. \tag{10}$$

It is important to note that sons' education entitles parents to a higher future consumption stream while there are no such benefits that correspond to educating daughters.[12] As mentioned above, schooling choice is binary, and may be thought of as a choice between imparting primary schooling or no schooling at all. It should be noted that only by providing schooling in each period of education stage can a child ultimately obtain the skill-premium.

3. Dowry stage: $t_E < t \leq t_C$ At this stage of life, the couple observes the value of all state variables which now includes the schooling choices for sons made in the last period. Now

---

[12] $\mathbb{1}_e^f$ is defined for formal symmetry but has no effect on the parents' budget through a future transfer channel in the baseline model. In the calibration, the optimal $\mathbb{1}_e^f = 0$, and the variable drops out of quantitative results. However, this modeling choice is deliberately relaxed in the social-norm counterfactual, where we allow married daughters to remit a fraction γ_f of their wage to their natal parents, and educating a daughter may become optimal.

the couple must marry off all its daughters by paying dowries. For any given number of daughters, dowry payment is a fixed fraction of father's wage. We denote this fraction as $D_f(n_f)$. The adult sons start working in this period, earning wages that potentially depend on their own level of human capital, and give a fixed fraction γ to their parents.

$$\begin{aligned} U_t(n_{t_F}, n_{m,t_F}, a_t, h_c^m) &= \max_{C_t, a_{t+1}} \quad u_t + \beta U_{t+1}(n_{t_F}, n_{m,t_F}, a_{t+1}) \\ s.t. \quad c_t + a_{t+1} &= (1 - D_f(n_f))W_{m,t} + (1 + r_t)a_t \\ &\qquad + n_{m,t_F}\gamma W_{mt}(1 + \theta h_c^m) \end{aligned} \tag{11}$$

Here, θ captures the skill-premium available to educated workers.

4. Pre-retirement stage: $t_C < t \leq t_R$ Households now still work full-time, and receive transfers from their sons.

$$\begin{aligned} U_t(n_{t_F}, n_{m,t_F}, a_t, h_c^m) &= \max_{C_t, a_{t+1}} \quad u_t + \beta U_{t+1}(n_{t_F}, n_{m,t_F}, a_{t+1}) \\ s.t. \quad c_t + a_{t+1} &= (1 + r_t)a_t + W_{m,t} + n_{m,t_F}\gamma W_{mt}(1 + \theta h_c^m) \end{aligned} \tag{12}$$

5. Retirement stage: $t_R < t \leq T_D$ This is the terminal period in the life of a couple. The elderly couple is now retired, and totally dependent on their own assets and transfers made by sons for sustenance.

$$\begin{aligned} U_t(n_{t_F}, n_{m,t_F}, a_t, h_c^m) &= \max_{C_t, a_{t+1}} u(C_t) + \beta U_{t+1}(n_{t_F}, n_{m,t_F}, a_{t+1}, h_c^m) \\ \text{s.t.} \quad C_t + a_{t+1} &= (1 + r) a_t + n_{m,t_F}\gamma W_{mt}(1 + \theta h_c^m), \quad a_{t+1} \geq 0 \end{aligned} \tag{13}$$

At the end of the terminal period, the couple leaves the world without leaving any bequest.

4.1.1 Green Revolution in the Model

We assume that the married couple in the problem attained adulthood in the pre-Green Revolution era. We assume that this cohort is homogeneous in their education levels. Once married, the couple may find itself in either a non-Green Revolution world or a Green Revolution world. The Green Revolution world differs from the non-Green Revolution world in two ways: First, in the Green Revolution world $W_{m,t}$ is higher than in the non-Green Revolution world. Second, there are positive returns to children's education in the Green Revolution world, whereas there are no returns to educating children in the non-Green Revolution world. Therefore, $\theta > 0$ in the Green Revolution world, but

$\theta = 0$ in the non-Green Revolution world. We solve and simulate our model under each of the two scenarios (i.e., the non-Green Revolution scenario and the Green Revolution scenario). The non-Green Revolution scenario serves as our benchmark, which we use for calibration.

4.1.2 Time in the Model and Model Solution

There are 8 fertile periods, 1 education period, and 1 dowry period in the model. After that, agents enter the post-dowry stage, which consists of 4 pre-retirement periods and 1 retirement period. In the quantitative analysis, the life-cycle problem is solved by backward induction over the fertile, education, and dowry stages. For computational convenience, the pre-retirement and retirement stages are solved jointly after the dowry-stage saving decision using the optimal consumption path implied by log utility. One period in the model can be interpreted as a coarse life-cycle period rather than a fixed calendar year. The model admits no analytical solution in the fertility and education stages and is solved numerically by backward induction. The high computational complexity of the state space is managed by discretising the asset grid.

5 Quantitative Analysis

The model admits no analytical solution. We solve the model numerically for any given set of parameter values by backward induction. We first calibrate the model economy to the pre-Green Revolution era where agents are homogeneous in their human capital. Then, we simulate the introduction of Green Revolution, modeled as a general increase in labor productivity, which translates into an increase in the wage rate, and a corresponding increase in the skill premium applicable to educated children.

5.1 Calibration

There are several parameters in the benchmark model. We first utilize the data and the existing research to externally calibrate a subset of parameters. The remaining parameters are internally calibrated using the method of simulated moments. In the current quantitative exercise, the internally calibrated parameters are the innate parental love for daughters $\overline{I}_f$, the mean and dispersion of the altruism parameter κ, the median and dispersion of the utility cost of sex selection ξ, the scale parameter of the idiosyncratic choice shock, and the childrearing time cost τ.

5.1.1 Externally-calibrated Parameters.

In the benchmark model where agents are homogeneous in their human capital, we normalize W_m to be 1. The initial assets vary among households and follows a Pareto distribution with the shape parameter as 1.35 and scale parameter as 0.52. The shape parameter is estimated by matching the degree of inequality in assets in Sarma & Jayakumar (2017), in which they have provided the percentage share of assets held by asset deciles. The scale parameter is estimated using the average annual ratio of income to assets, which is about 0.25 reported in Narain & Veld (2008), then the implied average period's (equivalent to two years in real life) ratio of income to assets in our model is about 0.5. Since we normalize the wage to be 1, the average value of assets should be about 2 under the Pareto distribution.[13]

We fix the annual interest rate $R = 1 + r = 1.02$ and assume a discount factor β equal to 0.98, which implies a discount rate slightly lower than the interest rate as in Attanasio & Marcos (2008). In the model, we use the corresponding two-year values, setting the gross interest rate to 1.0404 and the discount factor to 0.9604. The child-utility curvature parameter ϵ is taken from Doepke (2004), which is set to be 0.5.

The fraction of a son's income remitted to parents is $\gamma = 0.058$, proxied by the share of household consumption expenditure accruing to members aged ≥ 65 in the NSS 61st round.[14] The cost of schooling is set as 3% of household income per child per year.[15] Since the education stage in the current model is compressed into one period, the schooling cost parameter used in the quantitative model is adjusted accordingly. The childrearing time cost τ is not fixed externally in the current calibration. Instead, it is internally estimated together with the preference and sex-selection-cost parameters, because τ strongly affects both fertility and the upper tail of the family-size distribution.

As for the dowry rate $D_f(n_f)$, we use the ARIS-REDS (1999) data to estimate the average proportion of annual household income given as dowry to daughters. We estimate this

---

[13] Figures C.1 in Appendix C displays the distribution histogram of initial assets.

[14] As we do not have individual-specific consumption data, we assume that all members of the household share the household consumption expenditure (recall based on the last 30 days) equally. Therefore, using the 61st round of the National Sample Survey (NSS) data conducted in 2004-05, we proxy the share accruing to the elderly members (age$\geq$ 65) of the household as the share of the elderly members in the household size. For pan-India, it is 0.057, while for the rural areas it is 0.059.

[15] Based on Tilak (2002), who uses NCAER HDI Survey (1994) data covering over 33,000 rural households across 16 major Indian states, the average household expenditure on elementary education amounts to approximately 2.93% of annual household income in rural India.

separately by the number of daughters.[16] This fixed dowry schedule is disciplined by the empirical dowry null result in Section 3.2.3. Table 3 summarizes all the parameters to be externally calibrated.

5.1.2 Internally-calibrated Parameters.

We are left with 7 parameters to be calibrated internally from the model. These are $\overline{I}_f$ (parents' innate love for daughters), μ_κ and σ_κ (the mean and dispersion of the parental altruism distribution), $\overline{\xi}$ and σ_ξ (the median and dispersion of the utility cost of sex selection), σ (the scale of the idiosyncratic choice shock), and τ (the childrearing time cost). The parameter κ governs the degree of parental altruism, determining the relative weight parents place on utility from children versus own consumption. Following Yin (2022), we allow this parameter to vary across households and assume that it is drawn from a lognormal distribution:

$$\log(\kappa) \sim N(\mu_\kappa, \sigma_\kappa^2).$$

This heterogeneity helps the model generate dispersion in fertility outcomes beyond that induced by the initial asset distribution. The utility cost of sex selection is also allowed to vary across households. Following Yin (2022), we interpret this cost as capturing the psychological cost of sex-selective abortion, concerns about side effects, and other household-specific barriers to using sex-selection technology. We assume that

$$\log(\xi) \sim N(\log \overline{\xi}, \sigma_\xi^2),$$

where $\overline{\xi}$ is the median utility cost of sex selection. In the household's fertility problem, this cost is subtracted from the value of choosing sex selection. The parameter σ governs the scale of idiosyncratic Gumbel choice shocks in the fertility decision. Finally, τ is internally calibrated because the childrearing cost strongly affects both the level of fertility and the upper tail of the family-size distribution.

We use the method of simulated moments (SMM) to estimate these parameters. Formally, let $\boldsymbol{\phi}$ denote the vector of unknown parameters to be estimated:

$$\boldsymbol{\phi} = \left(\overline{I}_f, \mu_\kappa, \sigma_\kappa, \overline{\xi}, \sigma, \tau, \sigma_\xi\right).$$

---

[16] According to ARIS-REDS (1999) data, the mean dowries as a proportion of annual household earnings by number of daughters of the respondent are as follows: for one daughter, the dowry rate is 0.58; 0.59 for two daughters; 0.51 for three daughters; 0.53 for four daughters; 0.35 for five daughters; and 0.40 for six daughters. Since one period in our model corresponds to a longer period than one calendar year, we scale these values before substituting them into the model.

The SMM criterion function may be written as:

$$J_N(\boldsymbol{\phi}) = g(\boldsymbol{\phi})' W g(\boldsymbol{\phi}). \tag{14}$$

Note that $J_N(\boldsymbol{\phi})$ is a quadratic form in $\boldsymbol{\phi}$ that is always non-negative. The vector $g(\boldsymbol{\phi})$ denotes the scaled difference between simulated and empirical moments, and W is set equal to the identity matrix after scaling the moments.

Specifically, we target seven moments for the non-Green Revolution group: total fertility, the pooled child sex ratio, the shares of households with 2, 4, 5, and at least 7 children, and the variance of the number of children. The moment vector is:

$$g(\boldsymbol{\phi}) = \begin{pmatrix} \left(\mathrm{TFR}_{\mathrm{sim}}(\boldsymbol{\phi}) - \mathrm{TFR}_{\mathrm{data}}\right)/s_1 \\ \left(\mathrm{SR}_{\mathrm{sim}}(\boldsymbol{\phi}) - \mathrm{SR}_{\mathrm{data}}\right)/s_2 \\ \left(P_{\mathrm{sim}}(n=2;\boldsymbol{\phi}) - P_{\mathrm{data}}(n=2)\right)/s_3 \\ \left(P_{\mathrm{sim}}(n=4;\boldsymbol{\phi}) - P_{\mathrm{data}}(n=4)\right)/s_4 \\ \left(P_{\mathrm{sim}}(n=5;\boldsymbol{\phi}) - P_{\mathrm{data}}(n=5)\right)/s_5 \\ \left(P_{\mathrm{sim}}(n\geq 7;\boldsymbol{\phi}) - P_{\mathrm{data}}(n\geq 7)\right)/s_6 \\ \left(\mathrm{Var}_{\mathrm{sim}}(n;\boldsymbol{\phi}) - \mathrm{Var}_{\mathrm{data}}(n)\right)/s_7 \end{pmatrix}. \tag{15}$$

The scaling vector $(s_1, \ldots, s_7)$ normalizes moments that are measured in different units, so that the fertility rate, sex ratio, probability moments, and variance can enter the criterion function jointly. The SMM estimator is defined as the value of $\boldsymbol{\phi}$ that minimizes the criterion function:

$$\widehat{\boldsymbol{\phi}}^{\mathrm{SMM}} = \underset{\boldsymbol{\phi}}{\operatorname{argmin}}\, J_N(\boldsymbol{\phi}). \tag{16}$$

Table 4 summarizes the internally calibrated parameters and the targeted moments. The estimated value of $\bar{I}_f$ is 3.50, while parental love for sons is normalized to $\bar{I}_m = 1$. This value should not be interpreted literally as parents having three and a half times stronger affection for daughters than for sons. Instead, $\bar{I}_f$ captures the residual value of daughters needed to rationalize the observed fertility and sex-composition moments after accounting for economic forces that favor sons, including old-age transfers from sons and dowry payments for daughters. In this sense, a relatively high value of $\bar{I}_f$ is also consistent with parents valuing a mixed sex composition of children (Jayachandran, 2017).

The estimated median of the parental altruism parameter is $\exp(\mu_\kappa) = 0.02931$, while the dispersion parameter is $\sigma_\kappa = 1.372$. The low median implies that, for most households, own consumption remains an important component of household welfare relative to child utility. At the same time, the large dispersion generates substantial heterogeneity in the desire for children. The model includes both households with weak child preferences and households with very strong child preferences. This heterogeneity is important for matching the upper tail of the fertility distribution.

The estimated median utility cost of sex selection is $\bar{\xi} = 0.648$, with dispersion $\sigma_{\xi} = 0.254$. This means that sex selection is costly for all households, but the cost differs across households. Some households face relatively low utility costs and are therefore more likely to use sex selection, while others face higher costs and rely more on natural fertility or contraception. This helps the model jointly discipline the pooled sex ratio and the fertility distribution.

The estimated Gumbel shock scale is $\sigma = 0.226$. This parameter smooths fertility choices across households and states, preventing the model from generating excessively sharp deterministic decision rules. The estimate is large enough to generate variation in choices near indifference points, but not so large that fertility behavior becomes mostly random. Finally, the estimated childrearing time cost is $\tau = 0.0458$. This number should be interpreted in light of the current timing assumption: in the fertile stage, the model charges the expected cost τt_F at the time of birth. Since $t_F = 8$, a natural birth implies a fertile-stage time cost of approximately $8 \times 0.046 = 0.366$ of male wage income. Thus, the estimated τ is economically meaningful even though its per-period value appears modest.

Panel B shows that the model matches the main targeted moments well. The model closely matches the fertility rate, the pooled child sex ratio, and the variance of children. The model also captures the family-size distribution reasonably well, although it slightly overpredicts the share of two-child, four-child, and seven-or-more-child households and slightly underpredicts the share of five-child households. Overall, the targeted moments indicate that the estimated model can jointly reproduce the average level of fertility, the gender composition of children, and the dispersion of completed fertility in the non-Green Revolution group.

5.1.3 Model Fit and External Validity

Table 4 shows that presents the calibration results and model fit, the benchmark model closely replicates the fertility rate and the sex ratio before Green Revolution.[17] We show

---

[17] Fertility rate is constructed from the NFHS-I data using the sample of women aged 40-49 in the NGR districts of rural India. The sex ratio is constructed from the 1960 Census of India.

how the total distance and each moment change with respect to the corresponding parameter's value in Appendix, and we further perform robustness check by verifying the values of some key parameters. Specifically, we use dowry rate $D_f(n_f)$ that outliers have been dropped, and the results are similar to those in the benchmark. Detailed results can be found in Table C.1.

5.2 Green Revolution

To model the Green Revolution, we allow for a 43% increase in the general wage rate and a 46% rise in the skill premium.[18] Table 6 compares the model-predicted Green Revolution outcomes with the corresponding moments in the data.[19] The model predicts that the total fertility rate falls from 4.783 to 4.592, compared with a decline from 4.780 to 4.541 in the top-coded data. Thus, the model accounts for 79.9% of the observed fertility decline. The model also captures the compression of the family-size distribution: it explains 71.7% of the decline in the share of households with at least seven children and 91.5% of the decline in the variance of children.

The model performs less well for the pooled child sex ratio. In the data, the sex ratio falls from 959.92 to 938.85 girls per 1,000 boys, indicating a substantial deterioration in the gender balance of children. In the model, the sex ratio falls only from 959.99 to 957.70. Therefore, the model explains 10.8% of the observed decline in the sex ratio. This contrast is an important quantitative finding: the calibrated Green Revolution shock, operating through higher wages and a higher return to education, can account for a large share of the decline in fertility and the compression of the family-size distribution, but it does not by itself generate the full deterioration in the sex ratio observed in the data.

Table 5 reports the stopping-at-boy moment, which is not targeted in the estimation. The model underpredicts the level of stopping at boys in both the non-Green Revolution and Green Revolution economies. However, it captures the change in this moment well. The model-predicted stopping-at-boy share rises from 0.509 to 0.533, compared with an increase from 0.560 to 0.590 in the data. This implies that the model accounts for 86.2% of

---

[18] Foster & Rosenzweig (1996) report the change in the skill premium and Chavan & Bedamatta (2006) document the change in the wage rate.

[19] Because the model has eight fertile periods, completed fertility in the data is top-coded at eight children when constructing the moments used in the quantitative analysis. Specifically, households with more than eight children are assigned eight children. This makes the empirical fertility distribution comparable to the model, in which completed fertility cannot exceed eight children. The same top-coding rule is applied to both the non-Green Revolution and Green Revolution groups.

the observed increase in son-biased stopping behavior.

Overall, the simulated Green Revolution reproduces several qualitative patterns documented in the reduced-form analysis: fertility falls, the upper tail of the fertility distribution shrinks, the variance of children declines, and son-biased stopping increases. The main limitation is that the model generates only a small decline in the pooled child sex ratio. The magnitudes should be interpreted as aggregate pre/post changes rather than as direct analogues of the full-adoption coefficients in Section 3.2.1. More specifically, the reduced-form estimates establish that within-district variation in HYV exposure predicts fertility choices, while the quantitative exercise asks how much of the aggregate shift from the pre-Green Revolution to post-Green Revolution environment can be generated by the calibrated wage and skill-premium changes.

6 Counterfactual Experiments

In this section, we first decompose the impact of Green Revolution into the wage effect and the skill premium effect, and then we unpack social norms by disentangling the effects of patrilocality and the institution of dowry. Finally, we conduct a set of counterfactual policy experiments.

6.1 Decomposition Exercise

We first decompose the impact of Green Revolution into two channels: the wage effect and the skill premium effect. In particular, we shut down the increase in the skill premium and the increase in the wage respectively, to disentangle the effects from each channel. We expect to see that gender-neutral technological changes can affect fertility and gender composition through the pre-existing institutions of patrilocality and dowry.

Table 7 presents the results. Under the full Green Revolution scenario, the model predicts that fertility falls by 4.28%, the pooled child sex ratio falls by 0.41%, the variance of children falls by 9.91%, and the share of households stopping at boys rises by 4.74%. The increase in the skill premium is the larger channel for the sex-ratio decline, accounting for 54.2% of the benchmark decline, while the wage increase accounts for 36.2%. The remaining 9.6% reflects the interaction between the wage increase and the skill-premium increase.

The two channels operate differently. The wage channel mainly reduces fertility: when only male wages increase, the fertility rate falls by 2.47%, compared with a 1.04% decline under the skill-premium-only counterfactual. This is consistent with the idea that higher wages raise the opportunity cost of childrearing. By contrast, the skill-premium channel is more important for son-biased stopping and for the compression of the fertility distribution. When only the skill premium increases, the stopping-at-boy moment rises by 3.92%, and the variance of children falls by 11.21%. The average schooling of sons also rises sharply under the skill-premium-only counterfactual, while it is unchanged under the wage-only counterfactual.

The decomposition therefore suggests that the Green Revolution affects fertility mainly through the wage channel, while the skill-premium channel is more important for education investment, fertility dispersion, and son-biased stopping. The effect on the pooled child sex ratio is present but quantitatively modest in the current calibration.

6.2 Social Norm Exercise

In the Indian context, patrilocality and dowry are two social norms that previous literature has cited as motivations for son-preferring fertility behaviors (Jayachandran, 2015; Alfano, 2017; Bhalotra *et al.*, 2020a). Next, we examine the relative importance of each of these two social norms by performing counterfactual experiments. In the first exercise, we keep dowries but allow daughters to work on the labor market after marriage and make transfers to their retired parents. In the second exercise, we eliminate dowry payments while maintaining the assumption that married daughters do not earn income in the baseline. In the third exercise, we combine the two changes by allowing daughters' transfers and eliminating dowry payments at the same time.

Table 8 presents the results. The counterfactuals show that changing gendered institutions affects not only the sex ratio but also fertility. Allowing daughters to transfer resources to their natal parents raises the NGR sex ratio from 959.98 to 969.12 girls per 1,000 boys, indicating that patrilocality is an important source of son preference in the baseline. However, this counterfactual also increases fertility substantially: the NGR fertility rate rises from 4.78 to 5.25. This occurs because daughters become more valuable to parents, which raises the value of children and weakens the incentive to stop fertility early.

Removing dowry has a smaller effect on the level of the sex ratio in the current calibration. The NGR sex ratio rises only slightly, from 959.98 to 960.54, while the NGR fertility rate increases from 4.78 to 4.87. This suggests that, under the current estimated parameters, dowry payments affect fertility and stopping behavior more than they affect the pooled child sex ratio. In particular, removing dowry lowers the NGR stopping-at-boy moment from 0.5090 to 0.4826, consistent with the idea that dowry increases the relative cost of daughters and strengthens son-biased stopping.

When both daughters' transfers and dowry removal are introduced, the NGR sex ratio rises to 969.12 and fertility rises to 5.27. The combined counterfactual therefore improves the sex ratio relative to the benchmark, but it also raises fertility. Moreover, none of the social-norm counterfactuals eliminates the Green Revolution-induced decline in the sex ratio. The sex ratio still falls under each counterfactual, although the magnitude remains modest. These results suggest that gendered economic institutions affect the level of fertility and the level of the sex ratio, while the Green Revolution shock continues to generate changes through wage and skill-premium channels.

Overall, the social-norm exercises highlight an important trade-off. Policies or institutional changes that increase the economic value of daughters can improve the sex ratio, but they may also increase fertility by raising the overall value of children. Conversely, removing dowry weakens son-biased stopping and modestly increases fertility, but it does not by itself generate a large improvement in the pooled sex ratio in the current calibration.

6.3 Policy Evaluation

The social-norm counterfactuals above show that the male bias generated by the Green Revolution operates through economic channels rather than through innate preferences. This has a direct policy implication: if son preference is economically motivated, it may be amenable to economic remedies. We therefore ask whether appropriately designed financial transfer programmes can reduce the demand for sons by raising the expected economic value of daughters to their natal parents. We consider two instruments — a pension scheme and early transfers — each of which may be unconditional or conditioned on having a minimum number of daughters.

6.3.1 Policy 1: Pension System

In a patrilocal society, elderly parents co-reside with adult sons. Thus, transfers from co-residing adult sons serve as an informal social security. This "pension" motive might give rise to various son-preferring behaviors, including a male-biased sex ratio. We conduct a set of counterfactual exercises where we introduce a formal social security system into the model, and simulate its impact on sex ratios. Thus, we obtain a schedule of pension schemes with varying degrees of generosity and corresponding sex ratios that they entail. This schedule presents the policymaker with a menu of choices of the generosity of the pension system and the sex ratio that she may choose from.

In our setup, pensions are defined as receipts by the elderly couple at the "pre-retirement" stage and "retirement" stage of life. Pensions may be unconditional or conditional upon having a certain number of daughters. We allow the generosity of pensions to vary, with the standard pension being denoted as 1. This means that a total of one period's unskilled wage (in the relevant regime, i.e. Green or non-Green Revolution) is paid as pension over the 5 periods of the pre-retirement and the retirement periods of life.

In the Green Revolution regime, we find that the sex ratio responds to variations in the generosity of pensions, shown by Figure 4. Conditioning pensions on having a certain number of daughters leads to larger improvements in the sex ratio, provided that the conditionality is not too stringent. For instance, conditioning payment of pensions on having 4 or 5 daughters is more effective than unconditional pensions or conditioning on having other numbers of daughters. The rationale is as follows. Since Indian parents prefer to have a mix of sons and daughters, conditioning pensions on having fewer than 4 daughters does not provide sufficient incentive for households to significantly alter their fertility behaviors, as parents were having at least two daughters even in the absence of pensions. On the other hand, conditioning on 6 daughters is less effective because such families are relatively rare, limiting the proportion of families that would be influenced. To sum up, conditioning on 4 or 5 daughters produces the optimal effect, balancing the tradeoff between the strength of the incentive to change fertility choices and the share of households affected.[20]

6.3.2 Policy 2: Early Transfers

The second instrument we consider is early transfers, paid during the education stage rather than in retirement. The key difference from the pension policy is not merely timing, but the mechanism through which the policy operates. Since fertility decisions are

---

[20] We have also examined the impact of this policy on the fertility rate. Detailed results in Appendix C Figure C.14 show that the conditional payment of pensions on having 3 or 4 daughters has a positive impact on increasing the fertility rate.

made in the fertile stage — before any transfer isreceived — neither pensions nor early transfers directly affect choices at the moment they are paid out. Both policies work entirely through anticipation: forward-looking parents factor the expected present value of future transfers into their fertility and sex-composition decisions at the fertile stage. Early transfers are more powerful than pensions for a straightforward discounting reason: a transfer paid in the education period is discounted by $\beta^{t_E - t}$ from fertile period t, whereas a pension paid in retirement is discounted by $\beta^{t_R - t}$, with $t_E < t_R$. Because early transfers arrive sooner, they are less heavily discounted and therefore receive greater weight in parents' expected utility at the time fertility choices are made. Conditional on the same fiscal outlay, early transfers thus generate stronger incentives to alter fertility behaviour than pension-style transfers.

Figure 5 illustrates how the sex ratio responds to the generosity of early transfers in the Green Revolution regime. Conditioning payment on having at least 4 or 5 daughters is the most effective when generosity is below 0.6, for the same reason as in the pension case: conditioning on fewer daughters provides insufficient incentive to alter behaviour (since most families already have two or three daughters), while conditioning on six is too stringent to affect many households. As generosity increases beyond 0.6, conditioning on 0, 1, 2, or 3 daughters also performs well, because the larger transfer amount is sufficient to induce behavioural change even at lower daughter thresholds.[21]

6.3.3 Total Budget

Further, we compare which policy is more cost-effective, i.e., which achieves a greater improvement in the sex ratio at a smaller cost. We perform the following cost-benefit analysis. Given that pensions conditioned on having 4 or 5 daughters and early transfers conditioned on having 0, 1, 2, 3, 4 or 5 daughters deliver the best outcomes, we compare these cases for the two forms of policies.

Figure 6 shows the effects of different policies on the sex ratio under a given total budget in the post-Green Revolution regime. Several findings emerge. First, among all instruments considered, early transfers conditioned on having at least 4 or 5 daughters are the most cost-effective: they achieve sex ratios close to the model's gender-neutral benchmark of 1,000 at relatively modest budget levels. The mechanism is anticipation: because these transfers are paid during the education stage, they are discounted less heavily by

---

[21] Figure C.15 in Appendix C shows that conditioning on 3 or 4 daughters has a positive impact on the fertility rate, a co-benefit absent from more stringent conditionality thresholds.

forward-looking parents when evaluating fertility choices in the fertile stage, and therefore generate stronger behavioral responses per dollar spent than pension-style transfers, which are deferred to retirement. This result reinforces the model's central mechanism — parents respond strongly to the expected economic value of daughters relative to sons, and instruments that raise that value earlier in the life cycle are disproportionately effective. Second, pensions conditioned on at least 4 or 5 daughters also perform well, but require a larger total budget to achieve comparable improvements in the sex ratio. The gap in cost-effectiveness between early transfers and pensions is entirely attributable to discounting: the same nominal transfer buys less behavioural change when it arrives later. Overall, early transfers conditioned on having at least 4 or 5 daughters emerge as the preferred policy instrument for reducing male bias in the sex ratio under the Green Revolution regime, combining strong effectiveness with lower fiscal cost.[22]

7 Conclusion

We study how the introduction of new agricultural technology interacts with existing social norms to alter fertility and the sex composition of children. Our context is India, which adopted new agricultural technology, popularly known as the Green Revolution, between the late 1960s and 1980s, leading to a dramatic increase in the yield of staple crops such as wheat and rice. Indian society is patrilocal: adult daughters marry out of the household, while adult sons are more likely to co-reside with parents and provide support in old age. When the Green Revolution increased agricultural incomes and raised the returns to education, it effectively increased sons' capacity to support parents, while daughters — who marry out of the natal family — did not generate comparable economic returns. We empirically document a robust association between the adoption of Green Revolution technology and an increase in the demand for sons. To better understand the mechanisms, we formulate a quantitative model of sequential fertility choice featuring patrilocal marriage and dowry. We calibrate the model to match pre-Green Revolution fertility, sex ratios, and the completed fertility distribution, and simulate the introduction of the new technology. The model accounts for 79.9% of the observed fertility decline and 91.5% of the decline in the variance of children, but only 10.8% of the observed decline in the pooled child sex ratio. At the same time, the model explains 86.2% of the rise in son-biased fertility-stopping behavior. We use the model to conduct counterfactual exercises

---

[22] Counterfactual policy experiments for the pre-Green Revolution benchmark can be found in Appendix C Figure C.7 and C.10. We also present the total budget costs under different levels of generosity of the two policies in Appendix C Figure C.3, C.8, C.5, and C.11, as well as the sex ratio given the total budget costs in Appendix C Figures C.4, C.9, C.6, and C.12.

and evaluate whether financial transfer programs can reduce parental demand for sons. The simulations suggest that transfers targeted toward daughters can improve the sex ratio, especially when eligibility is based on intermediate daughter thresholds, and that early transfers are more cost-effective than pensions because they arrive earlier in the life cycle. Our findings point to the salience of economic considerations — particularly old-age support in a patrilocal setting — as a key factor shaping parental fertility choices, and suggest that policies enhancing the economic value of daughters to parents can partially mitigate the gendered effects of technological progress.

References

Acemoglu, Daron, & Autor, David. 2011. Skills, tasks and technologies: Implications for employment and earnings. *Pages 1043–1171 of: Handbook of Labor Economics*, vol. 4. Elsevier.

Afridi, Farzana, Bishnu, Monisankar, & Mahajan, Kanika. 2023. Gender and mechanization: Evidence from Indian agriculture. *American Journal of Agricultural Economics*, **105**(1), 52–75.

Alfano, Marco. 2017. Daughters, dowries, deliveries: The effect of marital payments on fertility choices in India. *Journal of Development Economics*, **125**, 89–104.

Anukriti, S. 2018. Financial incentives and the fertility-sex ratio trade-off. *American Economic Journal: Applied Economics*, **10**(2), 27–57.

Anukriti, Sharma, Bhalotra, Sonia, & Tam, Eddy HF. 2022. On the quantity and quality of girls: Fertility, parental investments and mortality. *The Economic Journal*, **132**(641), 1–36.

Arnold, Fred, Choe, Minja Kim, & Roy, Tarun K. 1998. Son preference, the family-building process and child mortality in India. *Population studies*, **52**(3), 301–315.

Ashraf, Nava, Bau, Natalie, Nunn, Nathan, & Voena, Alessandra. 2020. Bride price and female education. *Journal of Political Economy*, **128**(2), 591–641.

Attanasio, Low, & Marcos. 2008. Explaining Changes in Female Labor Supply in a Life-Cycle Model. *American Economic Review*, **98**(4), 1517—1552.

Barnwal, Prabhat, Dar, Aaditya, von der Goltz, Jan, Fishman, Ram, McCord, Gordon C, & Mueller, Nathan. 2017. Modern Crop Variety Diffusion and Infant Mortality in the Developing World, 1961-2000.

Bhalotra, Sonia, & Cochrane, Tom. 2010. Where have all the young girls gone? On the rising trend in sex selection in India. *University of Bristol Working Paper*.

Bhalotra, Sonia, Chakravarty, Abhishek, & Gulesci, Selim. 2020a. The price of gold: Dowry and death in India. *Journal of Development Economics*, **143**, 102413.

Bhalotra, Sonia, Brulé, Rachel, & Roy, Sanchari. 2020b. Women's inheritance rights reform and the preference for sons in India. *Journal of Development Economics*, **146**, 102275.

Bharadwaj, Prashant, & Lakdawala, Leah K. 2013. Discrimination begins in the womb: Evidence of sex-selective prenatal investments. *Journal of Human Resources*, **48**(1), 71–113.

Bharadwaj, Prashant, Fenske, James, Kala, Namrata, & Mirza, Rinchan Ali. 2020. The Green revolution and infant mortality in India. *Journal of Health Economics*, 102–314.

Brainerd, Elizabeth, & Menon, Nidhiya. 2014. Seasonal effects of water quality: The hidden costs of the Green Revolution to infant and child health in India. *Journal of Development Economics*, **107**, 49–64.

Chavan, & Bedamatta. 2006. Trends in Agricultural Wages in India 1964-65 to 1999-2000. *Economic and Political Weekly*, **41**(38), 4041–4051.

Clark, Shelley. 2000. Son preference and sex composition of children: Evidence from India. *Demography*, **37**(1), 95–108.

D'Agostino, Anthony. 2017. Technical change and gender wage inequality: long-run effects of India's green revolution. *Available at SSRN 3400889*.

Das Gupta, Monica, & Shuzhuo, Li. 1999. Gender bias in China, South Korea and India 1920–1990: Effects of war, famine and fertility decline. *Development and Change*, **30**(3), 619–652.

Das Gupta, Monica, Zhenghua, Jiang, Bohua, Li, Zhenming, Xie, Chung, Woojin, & Hwa-Ok, Bae. 2003. Why is son preference so persistent in East and South Asia? A cross-country study of China, India and the Republic of Korea. *The Journal of Development Studies*, **40**(2), 153–187.

Dasgupta, Biplab. 1977. India's green revolution. *Economic and Political Weekly*, 241–260.

Doepke, Matthias. 2004. Accounting for fertility decline during the transition to growth. *Journal of Economic growth*, **9**(3), 347–383.

Dyson, Tim, & Moore, Mick. 1983. On kinship structure, female autonomy, and demographic behavior in India. *Population and Development review*, 35–60.

Ebenstein, Avraham, & Leung, Steven. 2010. Son preference and access to social insurance: evidence from China's rural pension program. *Population and Development Review*, **36**(1), 47–70.

Evenson, Robert E, & Gollin, Douglas. 2003. Assessing the impact of the Green Revolution, 1960 to 2000. *Science*, **300**(5620), 758–762.

Foster, Andrew D, & Rosenzweig, Mark R. 1995. Learning by doing and learning from others: Human capital and technical change in agriculture. *Journal of Political Economy*, **103**(6), 1176–1209.

Foster, Andrew D, & Rosenzweig, Mark R. 1996. Technical change and human-capital returns and investments: evidence from the green revolution. *The American Economic Review*, 931–953.

Gehrke, Esther, & Kubitza, Christoph. 2021. Agricultural Productivity and Fertility Rates: Evidence from the Oil Palm Boom in Indonesia. *Journal of Human Resources*, 0520–10905R1.

Giuliano. 2020. Gender and culture. *Oxford Review Of Economic Policy*, **36**, 944–961.

Goldin, Claudia. 2006. The quiet revolution that transformed women's employment, education, and family. *American Economic Association: Papers and Proceedings*, May, pg. 1–21.

Gollin, Douglas, Hansen, Casper Worm, & Wingender, Asger Mose. 2021. Two blades of grass: The impact of the green revolution. *Journal of Political Economy*, **129**(8), 2344–2384.

Greenwood, Jeremy, Seshadri, Ananth, & Yorukoglu, Mehmet. 2005. Engines of liberation. *The Review of Economic Studies*, **72**(1), 109–133.

Harris, Marvin. 1993. The evolution of human gender hierarchies: A trial formulation. *Sex and gender hierarchies*, **57**, 79.

Hirway, Indira, & Jose, Sunny. 2011. Understanding women's work using time-use statistics: The case of India. *Feminist Economics*, **17**(4), 67–92.

Jayachandran, Seema. 2015. The roots of gender inequality in developing countries. *Annual Review of Economics*, **7**(1), 63–88.

Jayachandran, Seema. 2017. Fertility decline and missing women. *American Economic Journal: Applied Economics*, **9**(1), 118–139.

Jayachandran, Seema, & Kuziemko, Ilyana. 2011. Why do mothers breastfeed girls less than boys? Evidence and implications for child health in India. *The Quarterly Journal of Economics*, **126**(3), 1485–1538.

Jayachandran, Seema, & Pande, Rohini. 2017. Why are Indian children so short? The role of birth order and son preference. *American Economic Review*, **107**(9), 2600–2629.

Jensen, Robert. 2012. Do labor market opportunities affect young women's work and family decisions? Experimental evidence from India. *The Quarterly Journal of Economics*, **127**(2), 753–792.

Kramer, KarenL, & McMillan, GarnettP. 2006. The effect of labor-saving technology on longitudinal fertility changes. *Current Anthropology*, **47**(1), 165–172.

Milazzo, Annamaria. 2018. Why are adult women missing? Son preference and maternal survival in India. *Journal of Development Economics*, **134**, 467–484.

Moorthy, Vivek S. 2022. Agricultural Technological Change, Female Earnings, and Fertility: Evidence from Brazil. *The Economic Journal*.

Munshi, Kaivan. 2004. Social learning in a heterogeneous population: technology diffusion in the Indian Green Revolution. *Journal of development Economics*, **73**(1), 185–213.

Munshi, Kaivan, & Rosenzweig, Mark. 2016. Networks and misallocation: Insurance, migration, and the rural-urban wage gap. *American Economic Review*, **106**(01), 46–98.

Narain, Gupta, & Veld. 2008. Poverty and resource dependence in rural India. *Ecological Economics*, **66**(1), 161–176.

Ngai, L Rachel, & Petrongolo, Barbara. 2017. Gender gaps and the rise of the service economy. *American Economic Journal: Macroeconomics*, **9**(4), 1–44.

Pande, Rohini P, & Astone, Nan Marie. 2007. Explaining son preference in rural India: the independent role of structural versus individual factors. *Population Research and Policy Review*, **26**, 1–29.

Qian, Nancy. 2008. Missing women and the price of tea in China: The effect of sex-specific earnings on sex imbalance. *The Quarterly Journal of Economics*, **123**(3), 1251–1285.

Retherford, Robert D., & Mishra, Vinod K. 2001. *An evaluation of recent estimates of fertility trends in India*. National Family Health Survey Subject Reports 19. International Institute for Population Sciences and East-West Center, Mumbai, India and Honolulu, Hawaii.

Romer, Paul M. 1990. Endogenous technological change. *Journal of Political Economy*, **98**(5, Part 2), S71–S102.

Rose, Elaina. 1999. Consumption smoothing and excess female mortality in rural India. *Review of Economics and statistics*, **81**(1), 41–49.

Rosenblum, Daniel. 2013. The effect of fertility decisions on excess female mortality in India. *Journal of Population Economics*, **26**(1), 147–180.

Rotella, Elyce J. 1981. The transformation of the American office: changes in employment and technology. *The Journal of Economic History*, **41**(1), 51–57.

Sarma, Saha, & Jayakumar. 2017. Asset Inequality in India. *Social Scientist*, **45**(3/4), 53–67.

Sen, Amartya. 1992. Missing women. *BMJ: British Medical Journal*, **304**(6827), 587.

Solow, Robert M. 1956. A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, **70**(1), 65–94.

Tilak, Jandhyala BG. 2002. Elasticity of household expenditure on education in rural India. *South Asia Economic Journal*, **3**(2), 217–226.

Trivers, Robert L, & Willard, Dan E. 1973. Natural selection of parental ability to vary the sex ratio of offspring. *Science*, **179**(4068), 90–92.

von der Goltz, Jan, Dar, Aaditya, Fishman, Ram, Mueller, Nathaniel D., Barnwal, Prabhat, & McCord, Gordon C. 2020. Health Impacts of the Green Revolution: Evidence from 600,000 births across the Developing World. *Journal of Health Economics*, **74**, 102373.

Yin, Yongkun. 2022. Missing Women: A Quantitative Analysis. *Unpublished manuscript*.

Table 1: Summary Statistics

Variable	N	Mean	S.D.	Definition
Panel A: Dependent variables				
Overall				
Total children	7093	4.55	2.17	Total children ever born
Proportion of Boys	7093	0.53	0.26	Proportion of boys born
Stopping at Boy	7093	0.57	0.50	Indicator for last born child being a boy
Rural				
Total children	4830	4.80	2.21	Total children ever born
Proportion of Boys	4830	0.54	0.26	Proportion of boys born
Stopping at Boy	4830	0.57	0.50	Indicator for last born child being a boy
Urban				
Total children	2263	4.02	2.00	Total children ever born
Proportion of Boys	2263	0.52	0.28	Proportion of boys born
Stopping at Boy	2263	0.57	0.50	Indicator for last born child being a boy
Panel B: Mother's Characteristics				
Education	7093	2.78	4.32	Mother's years of education
Age	7093	42.66	2.41	Mother's age (in years)
Hindu	7093	0.81	0.39	=1 if household head is hindu, 0 otherwise
SC-ST	7093	0.19	0.39	=1 if household head belong to socially disadvantaged SC-ST category, 0 otherwise
Asset Index	7093	-0.04	0.90	PCA of assets owned
Panel C: Exposure to GR (district-year level)				
GR	2097	0.26	0.30	Acreage under HYV
GR (25^{th} percentile)	2097	0.01	-	25^{th} percentile of the distribution of GR
GR (75^{th} percentile)	2097	0.43	-	75^{th} percentile of the distribution of GR

Source: NFHS I (1992-93) and VDSA (1966-1990).
Note: This table shows the summary statistics.

Table 2: Effect of Green Revolution on Fertility Choices in Rural India

	(1)	(2)	(3)	(4)	(5)
	Panel A: Total children				
Exposure to GR	-2.091***	-2.381***	-0.331*	-0.417**	-0.436*
	(0.133)	(0.146)	(0.186)	(0.197)	(0.229)
Observations	4,830	4,820	4,818	4,818	4,818
Mean Y	5.729	5.729	5.729	5.729	5.729
	Panel B: Proportion of Boys				
Exposure to GR	0.014	0.006	0.049	0.084**	0.102***
	(0.018)	(0.024)	(0.030)	(0.035)	(0.039)
Observations	4,830	4,820	4,818	4,818	4,818
Mean Y	0.531	0.531	0.531	0.531	0.531
	Panel C: Stopping at a boy				
Exposure to GR	0.045	0.014	0.114**	0.116*	0.092
	(0.031)	(0.041)	(0.055)	(0.063)	(0.071)
Observations	4,830	4,820	4,818	4,818	4,818
Mean Y	0.575	0.575	0.575	0.575	0.575
Mother characteristics	✓	✓	✓	✓	✓
District F.E.		✓	✓	✓	✓
Year F.E.			✓	✓	✓
State $\times Year F.E.$				✓	✓
District $\times Year F.E.$					✓

Source: NFHS I (1992-93) and VDSA (1966-1990)
Note: Panel A reports the overall estimates of exposure to GR on total children, Panel B reports the proportion of boys and Panel C reports the stopping at a boy. 'Total children' is the number of live births a mother reported; 'Proportion of Boys' is the ratio of the number of boys born to the total children; 'Stopping at a boy' is the probability that the mother did not give birth to any child conditional on the last child being a boy. Exposure to GR is the share of area planted with HYV variety seeds of rice and wheat in the year preceding the birth of first child in the district where the mother resides. Mean Y reports the mean of the dependent variable in each panel in the districts with zero exposure to green revolution. Mother characteristics include age fixed effects, religion fixed effects, caste fixed effects, years of education and asset index. Standard errors clustered at district-year level reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 3: Externally-calibrated Parameters for the Benchmark Model

Parameter	Value	Description	Source
Production			
W_m	1	Unskilled male wage	Normalization
Preference			
β	0.961	Discount factor	Literature
R	1.040	Interest rate	Literature
ϵ	0.500	Fertility discount rate	Doepke (2004)
$\bar{I_m}$	1	Utility from sons	Normalization
Fertility			
γ	0.058	Fraction of son's income to parents	NSS 61st round
r_c	0.030	Resource cost for children's education	NCAER HDI (1994)
$D(n_f)$: Dowry as a fraction of resources by number of daughters			ARIS-REDS (1999)
n_f:			
1	0.290		
2	0.295		
3	0.255		
4	0.265		
5	0.175		
6	0.200		
7	0.220		
8	0.160		

Note: This table summarizes parameters externally calibrated.

Table 4: Internally-calibrated Parameters and Targeted Moments for the Benchmark Model

Panel A. Internally-calibrated parameters

Parameter	Value	Description
$\bar{I}_f$	3.500	Innate parental love for daughters
μ_κ	-3.530	Log-mean of parental altruism; median $\kappa = 0.02931$
σ_κ	1.372	Dispersion of parental altruism
$\bar{\xi}$	0.648	Median utility cost of sex selection
σ_ξ	0.254	Dispersion of sex-selection utility cost
σ	0.226	Scale of idiosyncratic Gumbel choice shocks
τ	0.046	Childrearing time cost

Panel B. Targeted moments: Non-Green Revolution group

Moment	$\text{Model}_{\text{NGR}}$	Data_{NGR}
Fertility Rate	4.783	4.780
Sex Ratio	959.985	959.920
$P(n = 2)$	0.101	0.092
$P(n = 4)$	0.189	0.176
$P(n = 5)$	0.148	0.162
$P(n \geq 7)$	0.258	0.233
Variance of Children	4.162	4.166

Notes: The pooled child sex ratio is measured as girls per 1,000 boys. The data moments are computed after top-coding completed fertility at eight children: households with more than eight children are assigned eight children, consistent with the maximum fertility allowed in the model.

Table 5: Non-targeted Stopping-at-Boy Moment in Model and Data

Non-targeted Moment	$\text{Model}_{\text{NGR}}$	Data_{NGR}	Model_{GR}	Data_{GR}
Stopping at Boys	0.509	0.560	0.533	0.590

Notes: The stopping-at-boy moment is reported but not targeted in the SMM estimation. It is defined as the share of households whose last observed birth is a boy. In the model, households whose last birth occurs in the final fertile period are excluded from this calculation to avoid right-censoring.

Table 6: Model-Predicted Moments and Data Under the Green Revolution

Moment	$\text{Model}_{\text{NGR}}$	Model_{GR}	Data_{NGR}	Data_{GR}	$\%\Delta_{\text{Model}}$	$\%\Delta_{\text{Data}}$	Explained
Fertility Rate	4.783	4.592	4.780	4.541	-4.0%	-5.0%	79.9%
Sex Ratio	959.985	957.704	959.920	938.850	-0.2%	-2.2%	10.8%
$P(n=2)$	0.101	0.106	0.092	0.111	$+4.7\%$	$+20.7\%$	22.7%
$P(n=4 \text{ or } 5)$	0.337	0.354	0.338	0.362	$+5.0\%$	$+7.1\%$	70.3%
$P(n \geq 7)$	0.258	0.214	0.233	0.178	-16.9%	-23.6%	71.7%
Stopping at Boys	0.509	0.533	0.560	0.590	$+4.6\%$	$+5.4\%$	86.2%
Variance of Children	4.162	3.731	4.166	3.695	-10.4%	-11.3%	91.5%

Notes: $\text{Model}_{\text{NGR}}$ and Data_{NGR} report the pre-Green Revolution levels in the model and in the data. Model_{GR} and Data_{GR} report the corresponding post-Green Revolution levels. $\%\Delta_{\text{Model}}$ is computed as $(\text{Model}_{\text{GR}} - \text{Model}_{\text{NGR}})/\text{Model}_{\text{NGR}}$. $\%\Delta_{\text{Data}}$ is computed analogously using the data. "Explained" is the ratio of the model-implied change to the observed change. A positive value means that the model predicts a change in the same direction as the data. The sex ratio is measured as girls per 1,000 boys. The stopping-at-boy moment is not targeted in the SMM estimation.

Table 7: Decomposition of the Green Revolution Effect

Variable	$\%\Delta_{\text{Total}}$	$\%\Delta_{W}$	$\%\Delta_{\text{SP}}$
Fertility Rate	-4.28%	-2.47%	-1.04%
Sex Ratio	-0.41%	-0.15%	-0.22%
Stopping at Boys	$+4.74\%$	$+1.14\%$	$+3.92\%$
Variance of Children	-9.91%	-0.22%	-11.21%
Sex Select	$+3.04\%$	-0.29%	$+3.49\%$
Natural Birth	-4.43%	-2.51%	-1.14%
Average Son Schooling	$+90.54\%$	$+0.00\%$	$+92.43\%$
Share of sex-ratio effect	100.0%	36.2%	54.2%

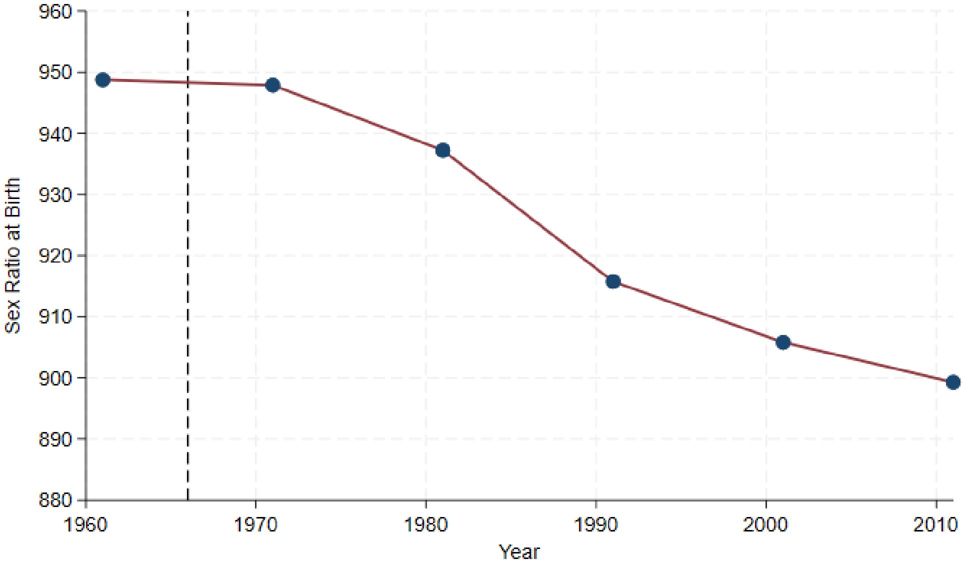
Notes: $\%\Delta_{\text{Total}}$ refers to the percentage change between the pre-Green Revolution benchmark and the full Green Revolution scenario, which incorporates both the wage increase and the skill-premium increase. $\%\Delta_{W}$ refers to the percentage change between the pre-Green Revolution benchmark and a counterfactual in which only the wage increases, holding the skill premium fixed at its pre-Green Revolution level. $\%\Delta_{\text{SP}}$ refers to the percentage change between the pre-Green Revolution benchmark and a counterfactual in which only the skill premium increases, holding the wage fixed at its pre-Green Revolution level. The last row reports the share of the benchmark sex-ratio effect accounted for by each channel. The two shares do not sum to 100% because the remaining 9.6% is an interaction effect.

Table 8: Social Norm Counterfactuals

Counterfactual	TFR_{NGR}	TFR_{GR}	%Δ TFR	SR_{NGR}	SR_{GR}	Δ SR	%Δ SR	Stop_{NGR}	Stop_{GR}
Benchmark	4.783	4.578	−4.28%	959.985	956.015	−3.97	−0.41%	0.509	0.533
Daughter transfers	5.247	4.880	−7.00%	969.119	964.658	−4.46	−0.46%	0.514	0.537
No dowry	4.870	4.614	−5.25%	960.536	957.611	−2.93	−0.30%	0.483	0.506
Daughter transfers + no dowry	5.273	4.876	−7.52%	969.122	964.958	−4.16	−0.43%	0.492	0.513

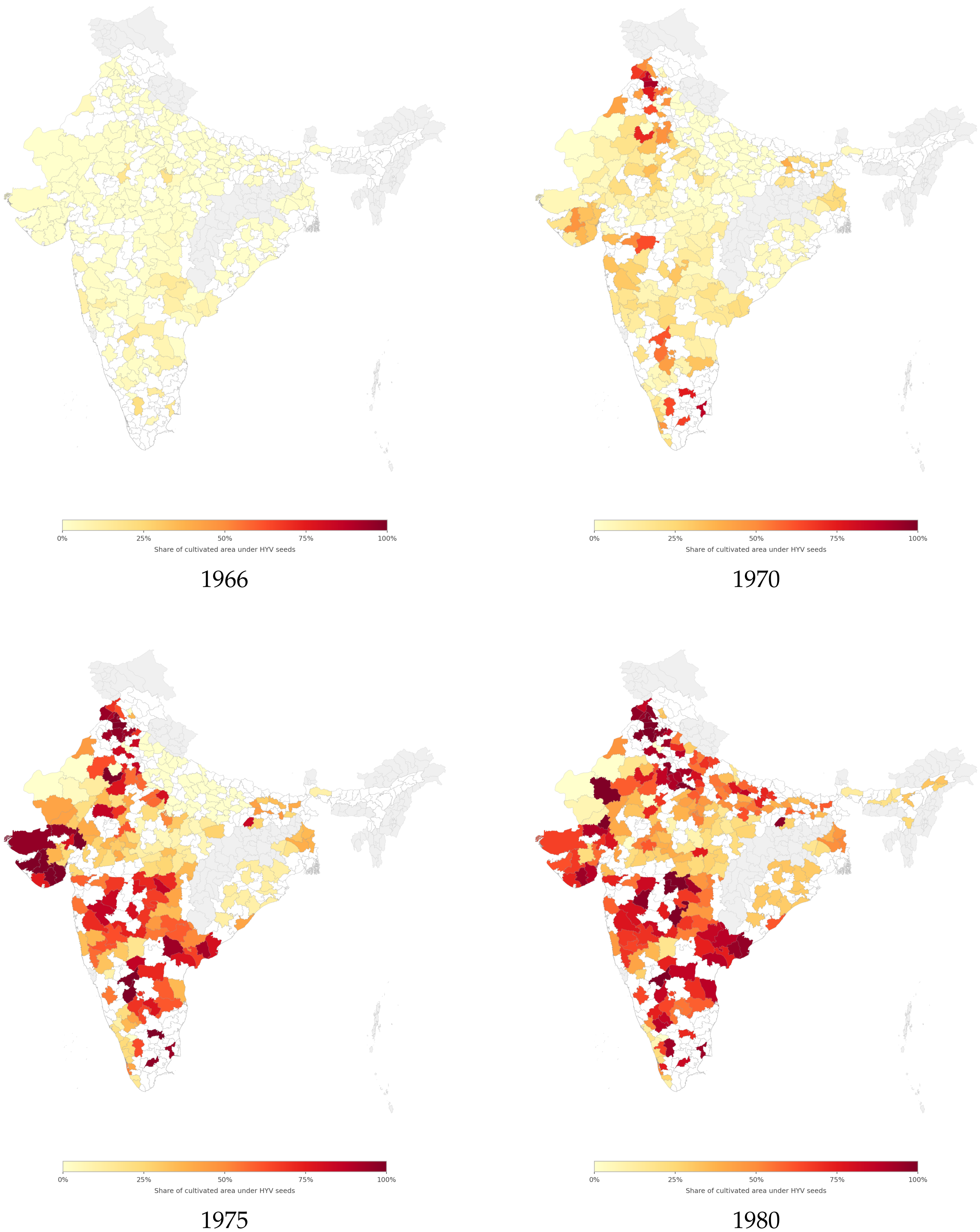
Notes: The benchmark corresponds to the baseline model with the original dowry schedule and no daughter transfers. "Daughter transfers" allows married daughters to earn income and remit a fraction $\gamma_f = 0.058$ to their natal parents, with female wages set to 52% of male wages. "No dowry" sets the dowry schedule to zero. Δ SR is computed as $\text{SR}_{\text{GR}} - \text{SR}_{\text{NGR}}$, measured in girls per 1,000 boys. %Δ TFR and %Δ SR are computed as the percentage change from NGR to GR within each counterfactual. The stopping-at-boy moment is reported but not targeted in the estimation.

Figure 1: Sex ratio at birth



Source: Census Data (1961-2011). Pew (ADD REF)
Note: This figure shows the sex ratio at birth is the number of girls born alive per 1000 boys born alive. The numbers for 1960-1990 are constructed using the 1961-1991 Census data on the sex ratio of births in the previous five years. For 2000 and 2010, we use the sex ratios of babies born in the previous year as per the Census 2001 and 2011, respectively.

Figure 2: District-level Adoption of Green Revolution Technology in India



1966

1970

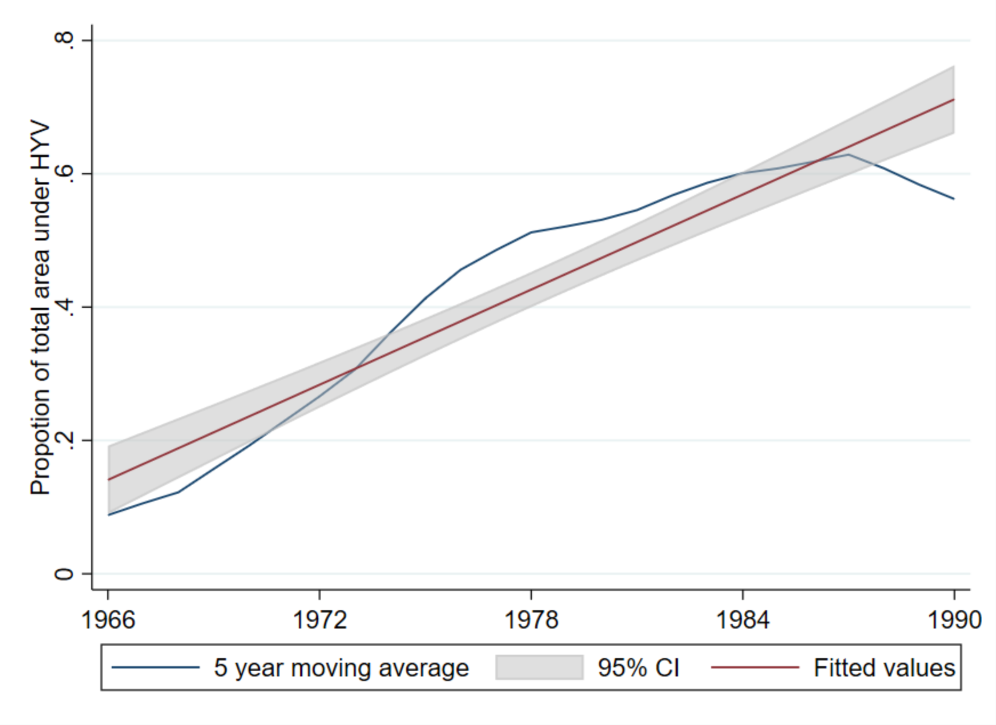
1975

1980

Source: VDSA Meso Data, ICRISAT (1966-1990).

Note: Each panel shows the share of cultivated area under High Yielding Variety (HYV) seeds of rice and wheat at the district level for the indicated year. Colour intensity ranges from light yellow (low adoption) to dark red (full adoption). White districts within sample states indicate missing data. Light grey districts lie outside the 16 states covered by the VDSA dataset.

Figure 3: Five year moving average of the proportion of area cultivated under the HYV seeds



Source: VDSA (1966-1990)
Note: This figure shows the average proportion of area cultivated under the HYV seeds. We divide the total area cultivated under rice and wheat by the area planted with HYV variety of seeds.

Figure 4: Sex Ratio vs. Pension Generosity for Different Condition Values: Green Revolution

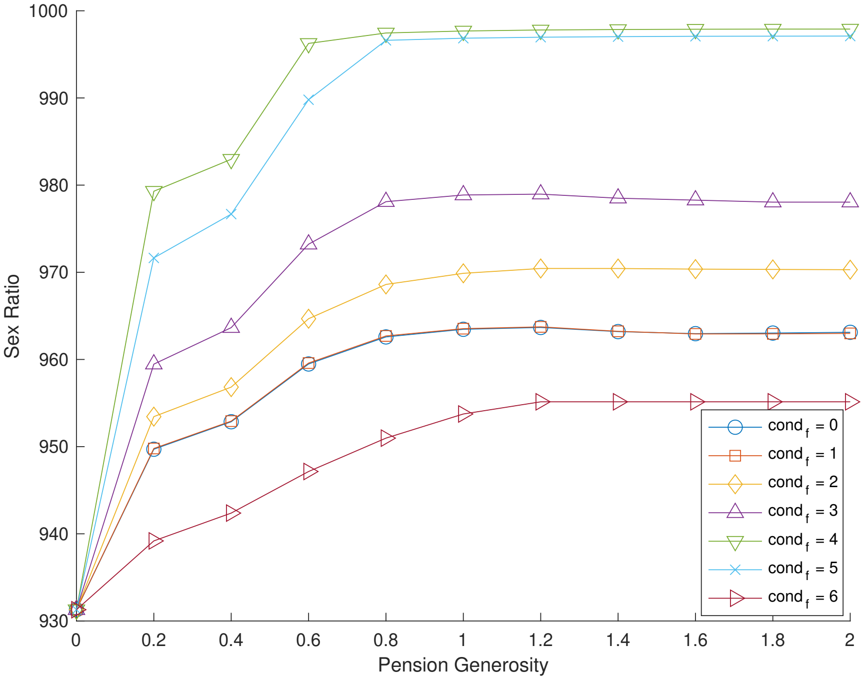


Figure 5: Sex Ratio vs. Early Transfer Generosity for Different Condition Values: Green Revolution

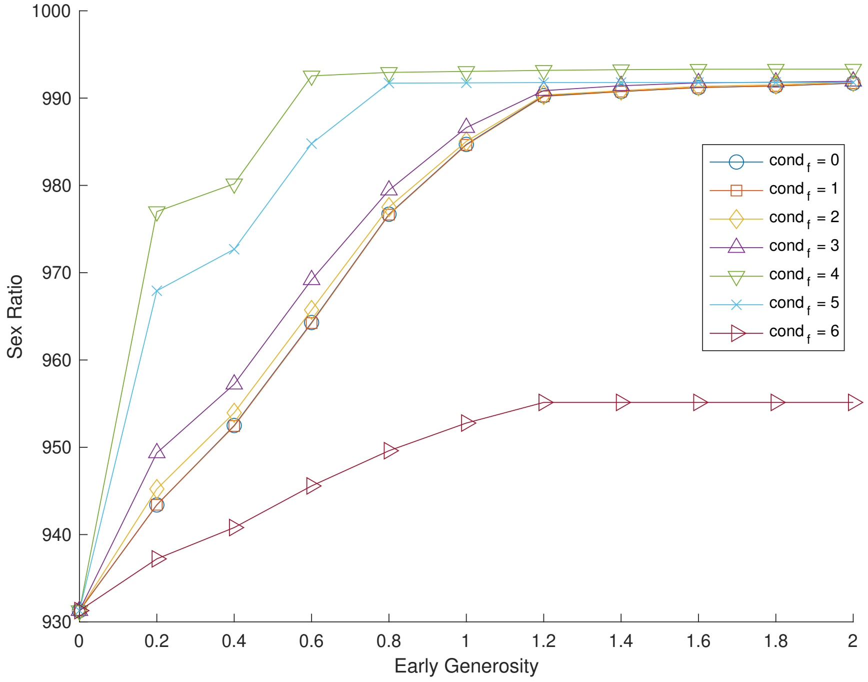
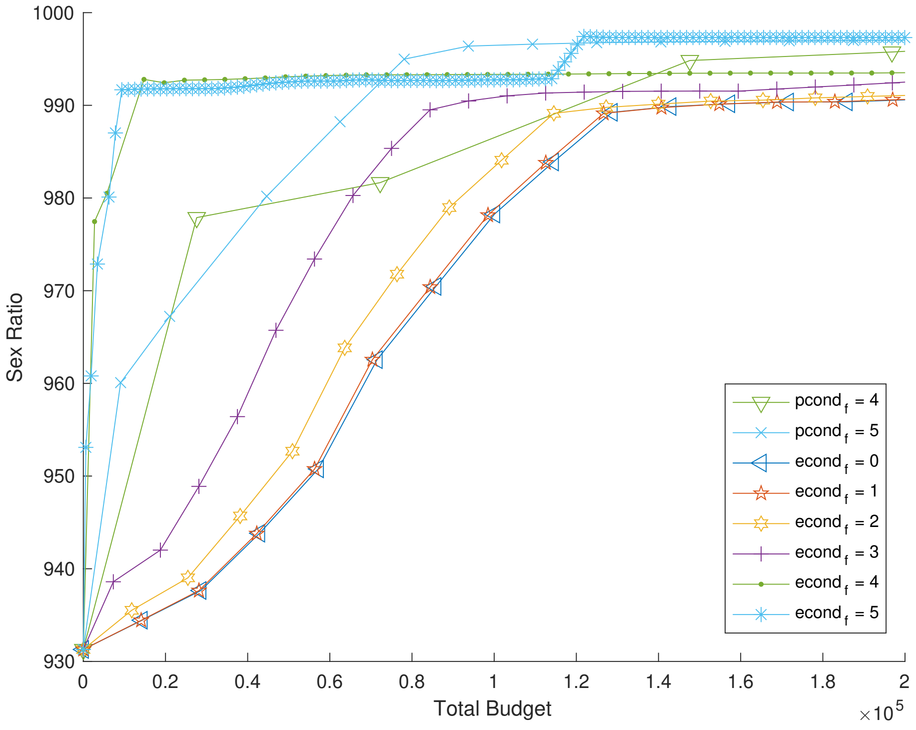


Figure 6: Sex Ratio vs. Total Budget for Pensions and Early Transfers: Green Revolution



Appendix

A Additional Tables and Figures

Table A.1: Effect of Green Revolution on Fertility Choices in Urban India

	(1)	(2)	(3)	(4)	(5)
	Panel A: Total Children				
Exposure to GR	-1.136***	-1.931***	0.142	0.0617	-0.05
	-0.126	-0.169	-0.221	-0.244	-0.279
Observations	2,263	2,254	2,252	2,252	2,252
R-squared	0.238	0.374	0.418	0.422	0.471
	Panel B: Proportion of Boys				
Exposure to GR	0.0383*	0.0296	0.0321	0.0688	0.0708
	(0.0217)	(0.0307)	(0.0434)	(0.0465)	(0.0542)
Observations	2,263	2,254	2,252	2,252	2,252
R-squared	0.005	0.081	0.095	0.106	0.182
	Panel C: Stopping at A Boy				
Exposure to GR	0.0260	-0.0160	-0.0182	-0.0732	-0.0610
	(0.0379)	(0.0512)	(0.0807)	(0.0894)	(0.111)
Observations	2,263	2,254	2,252	2,252	2,252
R-squared	0.008	0.099	0.106	0.116	0.187
Mother characteristics	✓	✓	✓	✓	✓
District F.E.		✓	✓	✓	✓
Year F.E.			✓	✓	✓
State $\times Year F.E.$				✓	✓
District $\times Year F.E.$					✓

Source: NFHS I (1992-93) and VDSA (1966-1990)
Note: Panel A reports the overall estimates of exposure to GR on total children, Panel B reports the proportion of boys and Panel C reports the stopping at a boy. 'Total children' is the number of live births a mother reported; 'Proportion of Boys' is the ratio of the number of boys born to the total children; 'Stopping at a boy' is the probability that the mother did not give birth to any child conditional on the last child being a boy. Exposure to GR is the share of area planted with HYV variety seeds of rice and wheat in the year preceding the birth of first child in the district where the mother resides. Mother characteristics include age fixed effects, religion fixed effects, caste fixed effects, years of education and asset index. Standard errors clustered at district-year level reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A.2: Robustness Checks: District clustered standard errors

	(1)	(2)	(3)	(4)	(5)
	Panel A: Total children				
Exposure to GR	-2.091***	-2.381***	-0.331*	-0.417**	-0.436*
	(0.187)	(0.166)	(0.196)	(0.207)	(0.254)
Observations	4,830	4,820	4,818	4,818	4,818
Mean Y	5.729	5.729	5.729	5.729	5.729
	Panel B: Proportion of Boys				
Exposure to GR	0.014	0.006	0.049	0.084**	0.102***
	(0.018)	(0.025)	(0.034)	(0.037)	(0.042)
Observations	4,830	4,820	4,818	4,818	4,818
Mean Y	0.531	0.531	0.531	0.531	0.531
	Panel C: Stopping at a boy				
Exposure to GR	0.045	0.014	0.114**	0.116*	0.092
	(0.029)	(0.039)	(0.057)	(0.066)	(0.077)
Observations	4,830	4,820	4,818	4,818	4,818
Mean Y	0.575	0.575	0.575	0.575	0.575
Mother characteristics	✓	✓	✓	✓	✓
District F.E.		✓	✓	✓	✓
Year F.E.			✓	✓	✓
State $\times Year F.E.$				✓	✓
District $\times Year F.E.$					✓

Source: NFHS I (1992-93) and VDSA (1966-1990)
Note: Panel A reports the overall estimates of exposure to GR on total children, Panel B reports the proportion of boys and Panel C reports the stopping at a boy. 'Total children' is the number of live births a mother reported; 'Proportion of Boys' is the ratio of the number of boys born to the total children; 'Stopping at a boy' is the probability that the mother did not give birth to any child conditional on the last child being a boy. Exposure to GR is the share of area planted with HYV variety seeds of rice and wheat in the year preceding the birth of first child in the district where the mother resides. Mean Y reports the mean of the dependent variable in each panel in the districts with zero exposure to green revolution. Mother characteristics include age fixed effects, religion fixed effects, caste fixed effects, years of education and asset index. Standard errors clustered at district level reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A.3: Effect of Green Revolution on Fertility Choices in Rural India (Robustness check using marriage year)

	(1)	(2)	(3)	(4)	(5)
	Panel A: Total children				
Exposure to GR	-1.305***	-1.051***	0.339	0.407	0.510*
	(0.182)	(0.230)	(0.238)	(0.258)	(0.286)
Observations	2,229	2,210	2,208	2,208	2,208
Mean	5.175	5.175	5.175	5.175	5.175
	Panel B: Proportion of Boys				
Exposure to GR	0.004	-0.010	0.020	0.031	0.027
	(0.028)	(0.038)	(0.041)	(0.045)	(0.050)
Observations	2,229	2,210	2,208	2,208	2,208
Mean	0.526	0.526	0.526	0.526	0.526
	Panel C: Stopping at a boy				
Exposure to GR	0.082*	0.077	0.139**	0.146**	0.157*
	(0.047)	(0.064)	(0.069)	(0.074)	(0.082)
Observations	2,229	2,210	2,208	2,208	2,208
Mean	0.560	0.560	0.560	0.560	0.560
Mother characteristics	✓	✓	✓	✓	✓
District F.E.		✓	✓	✓	✓
Year F.E.			✓	✓	✓
State $\times Year F.E.$				✓	✓
District $\times Year F.E.$					✓

Source: NFHS I (1992-93) and VDSA (1966-1990)
Note: Panel A reports the overall estimates of exposure to GR on total children, Panel B reports the proportion of boys and Panel C reports the stopping at a boy. 'Total children' is the number of live births a mother reported; 'Proportion of Boys' is the ratio of the number of boys born to the total children; 'Stopping at a boy' is the probability that the mother did not give birth to any child conditional on the last child being a boy. Exposure to GR is the share of area planted with HYV variety seeds of rice and wheat in the year of marriage of the mother in the district where the mother resides. Mean Y reports the mean of the dependent variable in each panel in the districts with zero exposure to green revolution. Mother characteristics include age fixed effects, religion fixed effects, caste fixed effects, years of education and asset index. Standard errors clustered at district-year level reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A.4: Effect of Green Revolution on Fertility Choices in Rural India (Robustness check using birth year)

	(1)	(2)	(3)	(4)	(5)
	Panel A: Total children				
Exposure to GR	-1.972***	-2.261***	-0.209	-0.264	-0.219
	(0.121)	(0.137)	(0.172)	(0.194)	(0.220)
Observations	5,520	5,513	5,511	5,511	5,511
Mean	5.855	5.855	5.855	5.855	5.855
	Panel B: Proportion of Boys				
Exposure to GR	0.014	0.000	0.036	0.059*	0.090***
	(0.016)	(0.021)	(0.027)	(0.032)	(0.035)
Observations	5,520	5,513	5,511	5,511	5,511
Mean	0.53	0.53	0.53	0.53	0.53
	Panel C: Stopping at a boy				
Exposure to GR	0.027	-0.045	-0.013	-0.007	-0.005
	(0.028)	(0.039)	(0.053)	(0.060)	(0.061)
Observations	5,520	5,513	5,511	5,511	5,511
Mean	0.569	0.569	0.569	0.569	0.569
Mother characteristics	✓	✓	✓	✓	✓
District F.E.		✓	✓	✓	✓
Year F.E.			✓	✓	✓
State $\times YearF.E.$				✓	✓
District $\times YearF.E.$					✓

Source: NFHS I (1992-93) and VDSA (1966-1990)
Note: Panel A reports the overall estimates of exposure to GR on total children, Panel B reports the proportion of boys and Panel C reports the stopping at a boy. 'Total children' is the number of live births a mother reported; 'Proportion of Boys' is the ratio of the number of boys born to the total children; 'Stopping at a boy' is the probability that the mother did not give birth to any child conditional on the last child being a boy. Exposure to GR is the share of area planted with HYV variety seeds of rice and wheat in the year of the birth of the first child in the district where the mother resides. Mean Y reports the mean of the dependent variable in each panel in the districts with zero exposure to the green revolution. Mother characteristics include age fixed effects, religion fixed effects, caste fixed effects, years of education and asset index. Standard errors clustered at district-year level reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A.5: Impact of Exposure to Green Revolution on Fertility by Parity in Rural Regions

VARIABLES	Parity 2 (1)	Parity 3 (2)	Parity 4 (3)	Parity 5 (4)	Parity 6 (5)
Panel A: Birth of a Girl Child					
Exposure to GR	-0.104*	-0.0907	-0.000472	-0.160**	-0.0130
	(0.0629)	(0.0627)	(0.0696)	(0.0764)	(0.0981)
Observations	4,818	4,583	4,102	3,342	2,450
R-squared	0.061	0.073	0.081	0.094	0.110
Mean (y)	0.46	0.43	0.4	0.36	0.33
Panel B: Birth of A Girl Child Conditional on Last Child Born Being A Boy					
Exposure to GR	-0.127*	-0.197***	-0.0570	-0.256**	-0.117
	(0.0750)	(0.0757)	(0.0840)	(0.102)	(0.133)
Observations	3,573	3,340	2,960	2,340	1,652
R-squared	0.077	0.094	0.098	0.128	0.157
Mean (y)	0.61	0.59	0.55	0.52	0.48
Mother characteristics	✓	✓	✓	✓	✓
District FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
State $\times Year F.E.$	✓	✓	✓	✓	✓

Source: NFHS I (1992-93) and VDSA (1966-1990)
Note: Panel A reports the likelihood of a girl child being born at each parity level, while Panel B presents the likelihood conditional on the last child being a boy. All specifications include controls for household characteristics, district fixed effects, marriage year fixed effects, and state-specific annual trends, consistent with the preferred baseline model. Standard errors clustered at the district-year level are reported in parenthesis $(***p < 0.01, **p < 0.05, *p < 0.1)$.

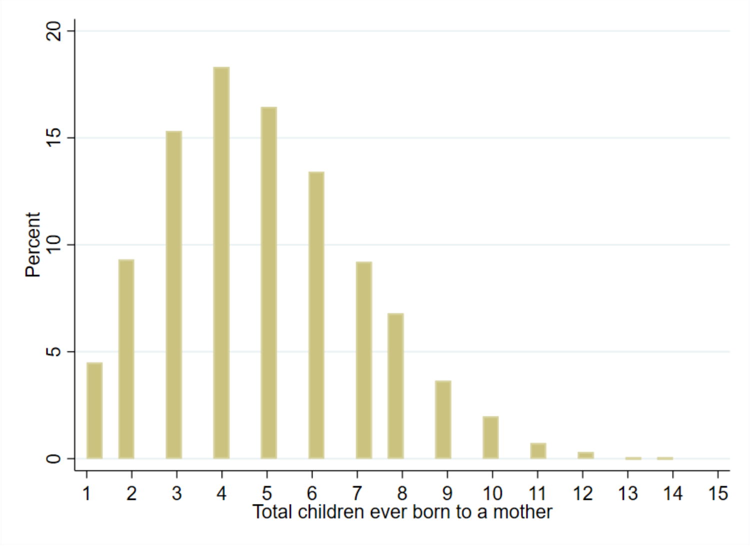
Table A.6: Effect of Green Revolution on Dowry payments

	(1)	(2)	(3)	(4)
GR	-0.150	-0.151	-0.148	-0.147
	(0.100)	(0.0981)	(0.0974)	(0.0974)
Years of schooling		0.120***	0.0727***	0.0727***
		(0.00622)	(0.00780)	(0.00780)
Years of schooling of spouse			0.0601***	0.0601***
			(0.00682)	(0.00682)
Year of birth				0.00324
				(0.00641)
Hindu	0.530***	0.430***	0.397***	0.398***
	(0.106)	(0.105)	(0.104)	(0.104)
Land owners	0.448***	0.340***	0.314***	0.315***
	(0.0679)	(0.0689)	(0.0701)	(0.0702)
Observations	14,082	14,082	14,082	14,082
R-squared	0.308	0.331	0.339	0.339
Household controls	✓	✓	✓	✓
District F.E.	✓	✓	✓	✓
Marriage Year F.E.	✓	✓	✓	✓
State $\times Year F.E.$	✓	✓	✓	✓

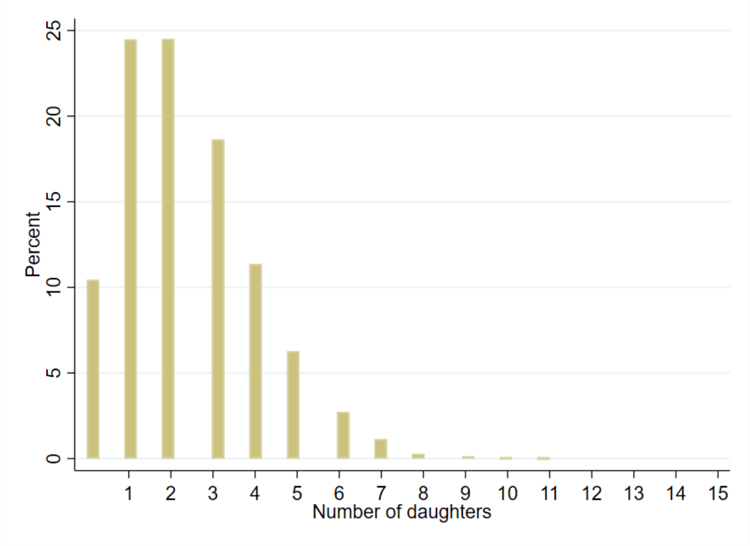
Source: REDS and VDSA (1966-1990)
Note: The dependent variable is the log transformation of the real dowry payments. A small value of one rupee was added to the real dowry payments to deal with zero values in the log-transformation and the real dowries were calculated by deflating the reported dowry payments. Exposure to GR is the share of area planted with HYV variety seeds of rice and wheat in the year of marriage. Household characteristics include religion, caste, and land ownership. Standard errors clustered at district-year level reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Figure A.1: Distribution of Total Birth and Number of Daughters Ever Born to A Mother

(a) Total Birth



(b) Daughters



B Parameters Construction

To calibrate the model parameters, we draw on multiple nationally representative datasets for India. *Fertility rates* are taken from NFHS-I data, restricting the sample to women aged 40–49 in the NGR districts of rural India. The *sex ratio* is set using the district-wise data on number of men and women from the NGR districts from the 1960 Census of India. The fraction of a son's income transferred to parents is set at 0.06, derived from the 61st round of the National Sample Survey (NSS). Specifically, this measure reflects the share of household consumption expenditure over the previous 30 days attributable to elderly members (age ≥ 65). The estimated share is 0.057 for India as a whole and 0.059 for rural areas; we use their weighted average. The resource cost of children's education is set at 0.03 per child, based on data from the NSSO 52nd Round (1995–96). According to this survey, the share of elementary education expenditure in total consumption expenditure is approximately 0.066 in rural India. Dividing by the average rural fertility rate of approximately 2.2 children enrolled in school at any given time yields a per-child education cost of about 0.03.[23]

The time cost of raising children is set at $\tau = 0.08$ per child, based on the 1998 Indian Time Use Survey. According to the survey, women in rural areas spent on average 17.28 hours per week on household activities related to children and 56.39 hours on market and non-market production. We compute the per-child time cost as the ratio of children-related hours to total working hours, divided by the rural fertility rate. Using the SRS estimate of the rural total fertility rate of approximately 3.8 for the late 1990s — which is higher than the NFHS-I estimate due to well-documented underreporting of births in the NFHS (Retherford & Mishra, 2001) — we obtain $\tau \approx 0.08$.[24] Dowry payments, expressed as a fraction of household resources by the number of daughters, are estimated from the 1999 ARIS–REDS survey as the proportion of annual household income given as dowry to a daughter. Table B.1 presents these numbers. Since one period in our model equals two years, we divide these estimates by 2 to obtain the per-period dowry rates used in the model (see Table 3).

---

[23] The denominator reflects the average number of children of school-going age per household, rather than the total fertility rate, as not all children are enrolled in school simultaneously.

[24] Retherford and Mishra (2001) demonstrate that NFHS birth history data substantially underestimate fertility due to displacement of births to earlier years, and that the true TFR for 1996–98 was likely between 3.39 and 3.55 for India as a whole. The corresponding rural TFR would be higher.

Table B.1: Dowry as a Fraction of Annual Household Income by Number of Daughters

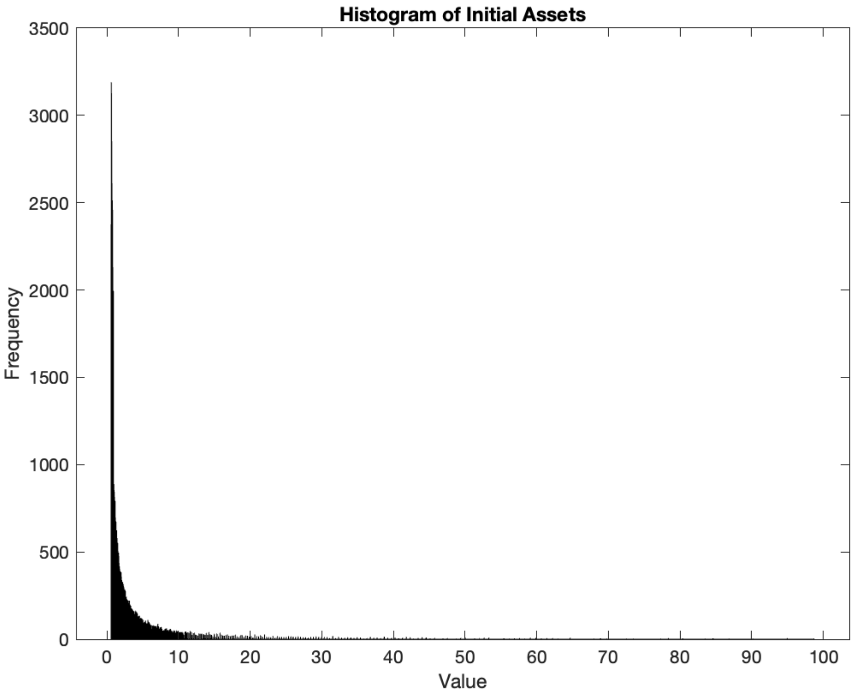
No. of Daughters	Mean	Std. Error	95% CI Lower	95% CI Upper
1	0.576	0.033	0.512	0.640
2	0.590	0.033	0.526	0.654
3	0.510	0.040	0.432	0.588
4	0.526	0.050	0.427	0.625
5	0.350	0.056	0.240	0.461
6	0.399	0.089	0.224	0.574

C Quantitative Analysis

C.1 Distribution of Initial Assets

Figure C.1 illustrates the initial asset distribution, which is calibrated based on real-world data and follows a Pareto distribution. This distribution reflects a socioeconomic structure where the majority of households hold a small amount of assets, with only a small fraction being affluent.

Figure C.1: Distribution of Initial Assets



Note: The X-axis represents the value of initial assets, while the Y-axis corresponds to the number of households, or alternatively, the frequency of occurrence.

C.2 Robustness Checks

Alternative Dowry Schedules. The new dowry schedule is estimated to be 0.295 given 1 girl, 0.310 given 2 girls, 0.275 given 3 girls, 0.295 given 4 girls, 0.230 given 5 girls and 0.200 given 6 girls. Table C.1 shows that when this new set of dowry data, the impact on the fitting results of the baseline model is not significant.

Table C.1: Robustness Check

Parameter	Description	Value	Fertility Rate	Sex Ratio	Stopping at Boys
$D_f(n_f)$	Dowry rate (by n_f)	0.295	4.761	959.536	0.509

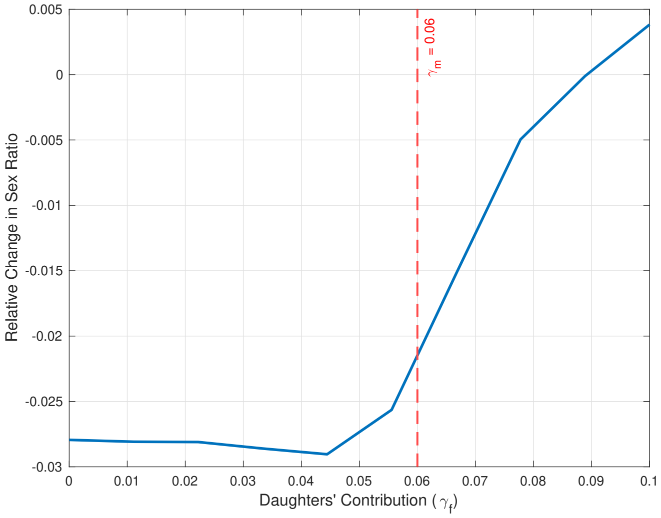
Social Norms Figure C.2 presents the results of varying γ_f (the fraction of daughters' income contributed to their parents) and the gender wage ratio. In panel (a), the gender wage ratio is held constant at 0.52 while the fraction of daughters' income contributed to parents is varied. In panel (b), the fraction of daughters' income contributed to parents is fixed at $\gamma_f = 0.06$, and the gender wage ratio w_f/w_m is varied.

The figures show that increasing daughters' economic contribution attenuates the male-biasing effect of the Green Revolution, but the effect is quantitatively modest in the current calibration. When daughters generate no economic returns for parents, the Green Revolution lowers the sex ratio by roughly 0.4%. As γ_f increases, the relative decline in the sex ratio first becomes slightly larger and then gradually weakens. Similarly, as the gender wage ratio w_f/w_m increases, the relative decline in the sex ratio becomes less negative, although the response flattens at higher values of the wage ratio.

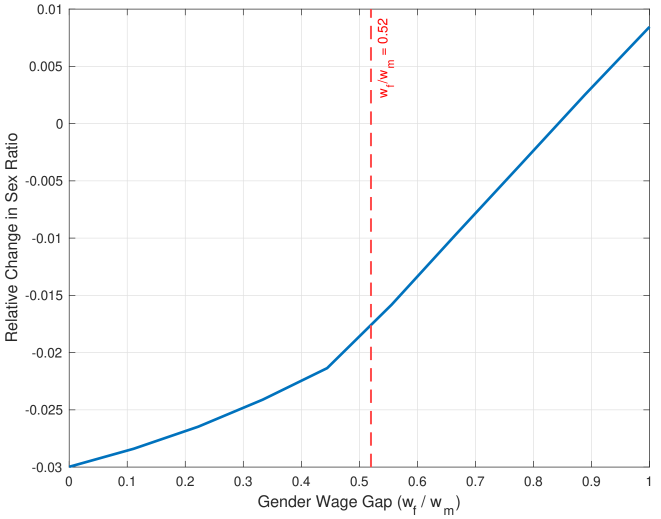
These results suggest that patrilocality remains an important mechanism, but increasing daughters' economic value alone does not eliminate the Green Revolution's male-biasing effect in the current calibration. Even when daughters' transfers rise or the gender wage gap narrows, the relative change in the sex ratio remains negative. Thus, policies that increase daughters' economic contribution to their natal parents can partially offset son preference, but they are not sufficient by themselves to fully undo the gendered effects of technological change.

Figure C.2: Sex Ratios vs. Daughters’ Contribution and Gender Wage Gap

(a) Daughters’ Contribution given Gender Wage Gap=0.52



(b) Gender Wage Gap given Daughters’ Contribution=0.06



Note: The Y-axis measures the relative change in the sex ratio between the Green Revolution and non-Green Revolution regimes, $(SR_{GR} - SR_{NGR})/SR_{NGR}$. Negative values indicate that the Green Revolution increases male bias. Panel (a) varies γ_f, the fraction of daughters’ income transferred to parents, from 0 to 0.1, with the gender wage ratio held constant at $w_f/w_m = 0.52$. Panel (b) varies the gender wage ratio w_f/w_m from 0 to 1, with γ_f held constant at 0.06. The dashed red line indicates the benchmark value of the corresponding parameter: $\gamma_f = 0.06$ in panel (a) and $w_f/w_m = 0.52$ in panel (b).

C.3 Policies for Sex Ratio under Post-Green Revolution

C.3.1 Pensions for Sex Ratio under Post-Green Revolution

In the subsequent analysis, we present the budgetary implications associated with varying levels of generosity in pension or early transfers schemes, as well as the corresponding effects on the sex ratio. It is observed that, given the same budget allocation, pension schemes are most effective in mitigating male bias when conditioned on households having 4 or 5 daughters. Similarly, early transfers schemes also demonstrate the highest efficacy under the same conditions, namely when households have 4 or 5 daughters.

Figure C.3: Total Pension vs. Pension Generosity for different conditions: Green Revolution

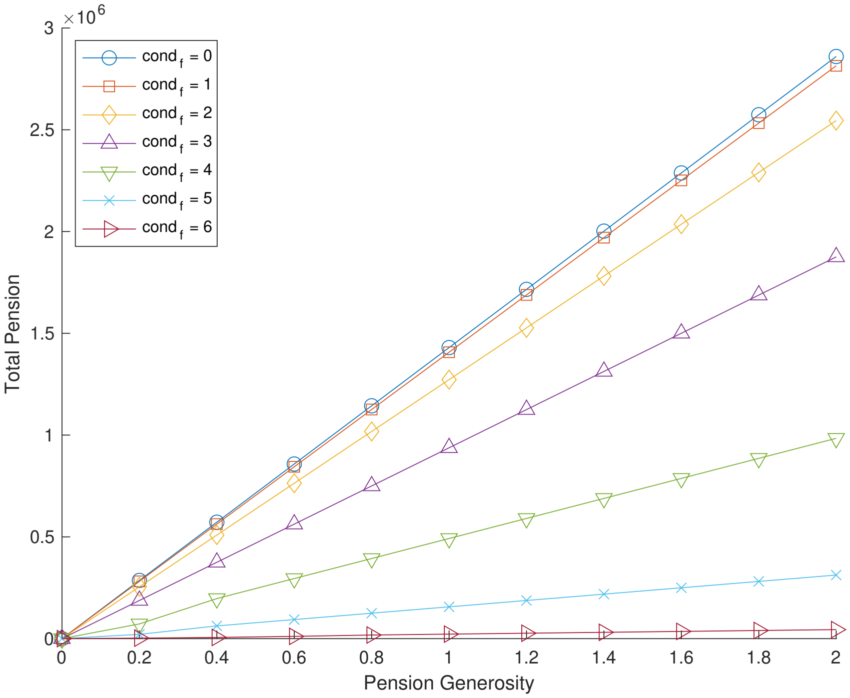


Figure C.4: Sex Ratio vs. Total Pension for different conditions: Green Revolution

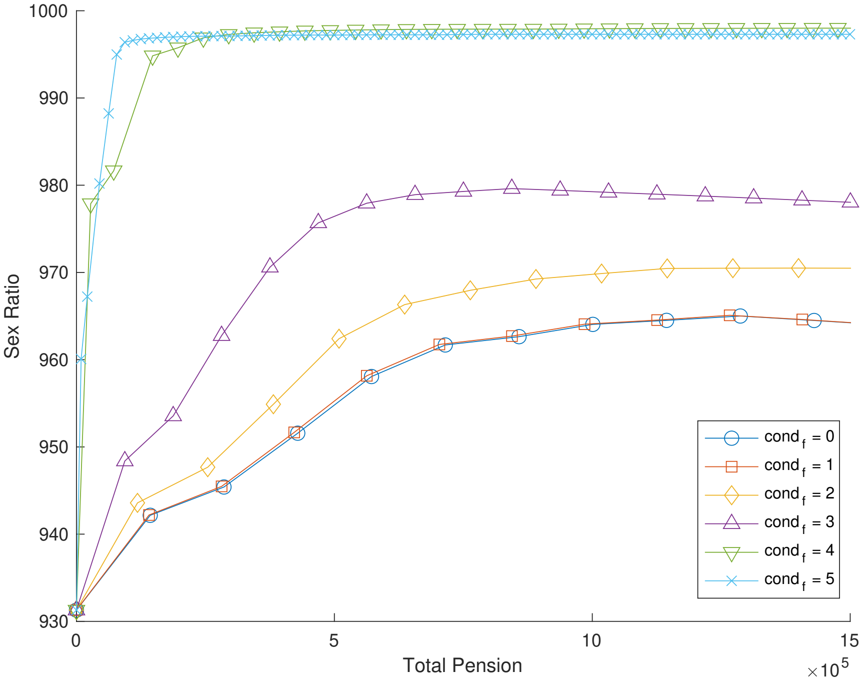
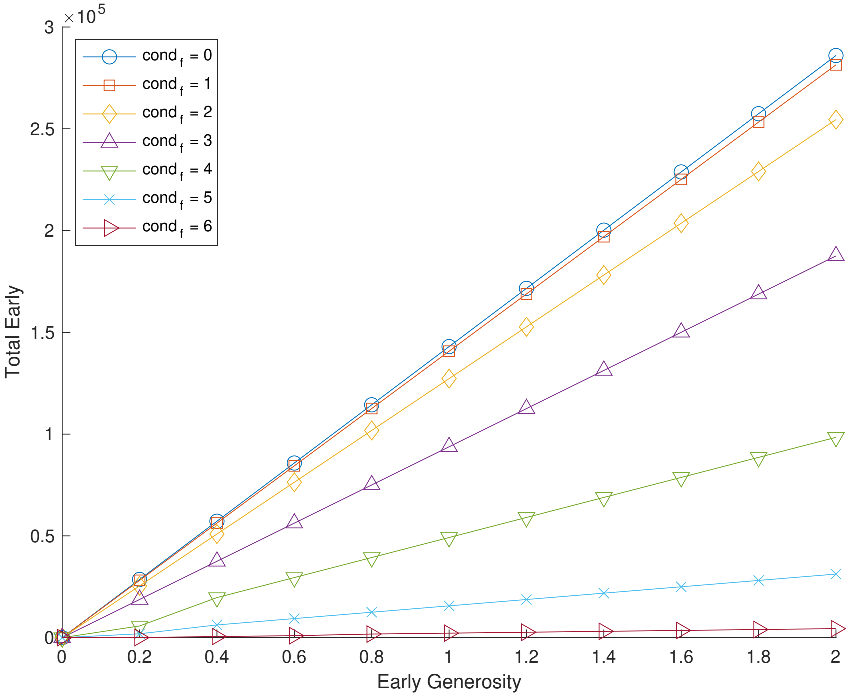
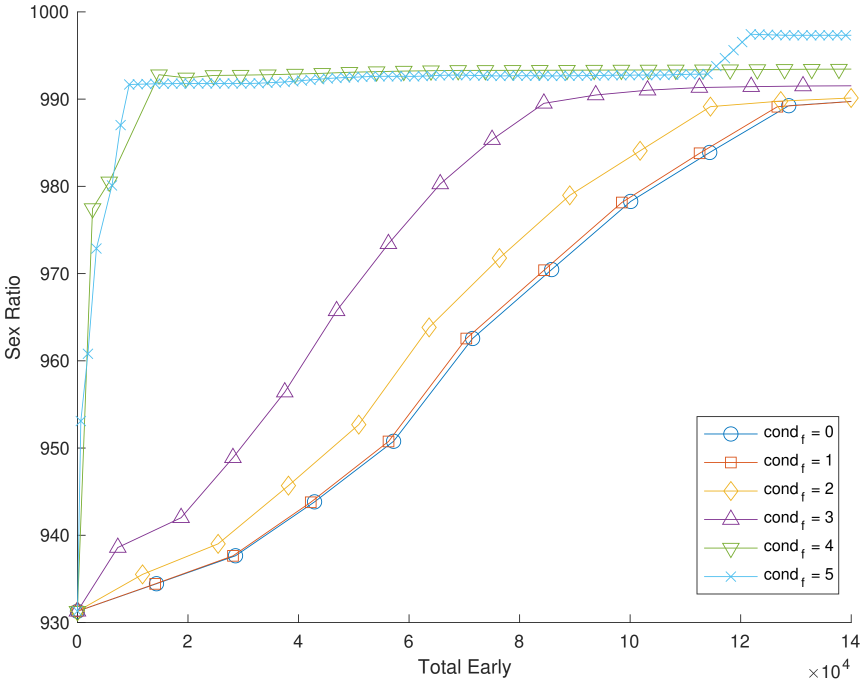


Figure C.5: Total Pension vs. Early Transfer Generosity for different conditions: Green Revolution



C.3.2 Early Transfers for Sex Ratio under Post-Green Revolution

Figure C.6: Sex Ratio vs. Total Early Transfer for different conditions: Green Revolution



C.4 Policies for Sex Ratio under Non Green Revolution

In the subsequent analysis, we examine the effects of pensions and early transfers under Non Green Revolution. Our findings reveal that, in the case of pension schemes, when the budget is sufficiently allocated, not only households with 4 or 5 daughters but also those under other conditions achieve improvements in outcomes. This suggests that adequate budgetary support can extend the effectiveness of pension policies beyond the previously identified optimal conditions under Non Green Revolution.

C.4.1 Pension under Non Green Revolution

Figure C.7: Sex Ratio vs. Pension Generosity for different conditions: Non Green Revolution

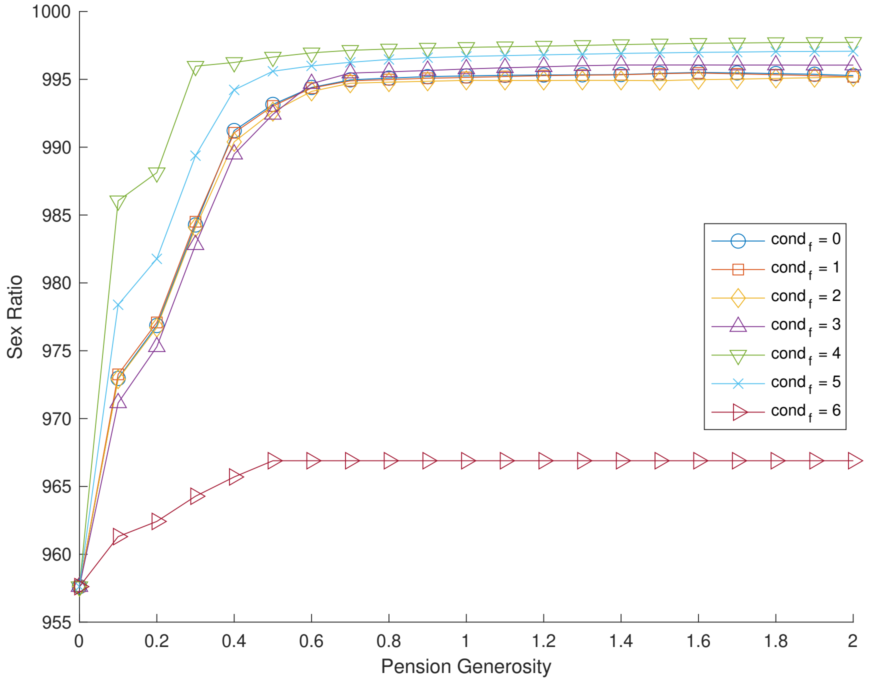


Figure C.8: Total Pension vs. Pension Generosity for differen conditions: Non Green Revolution

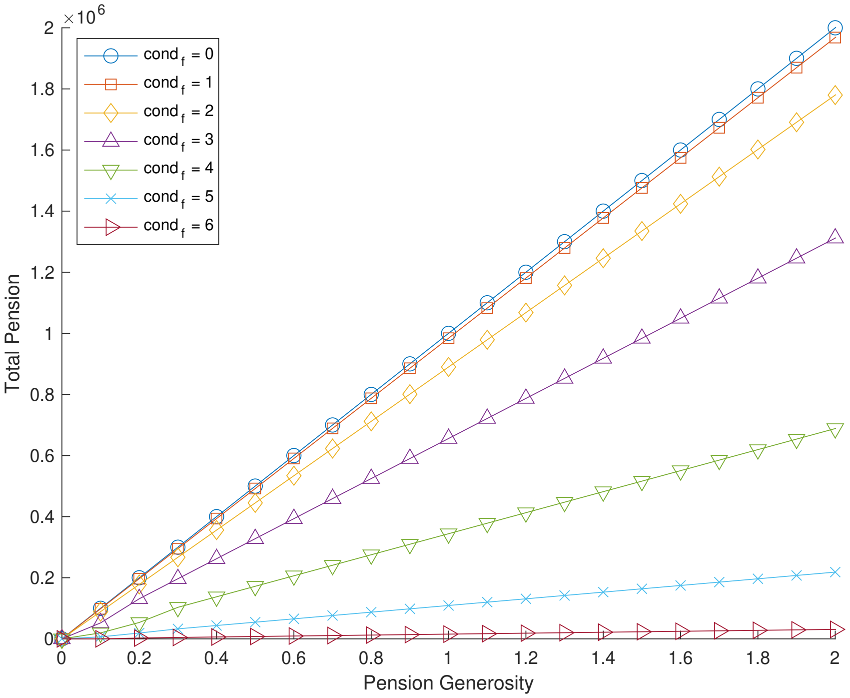
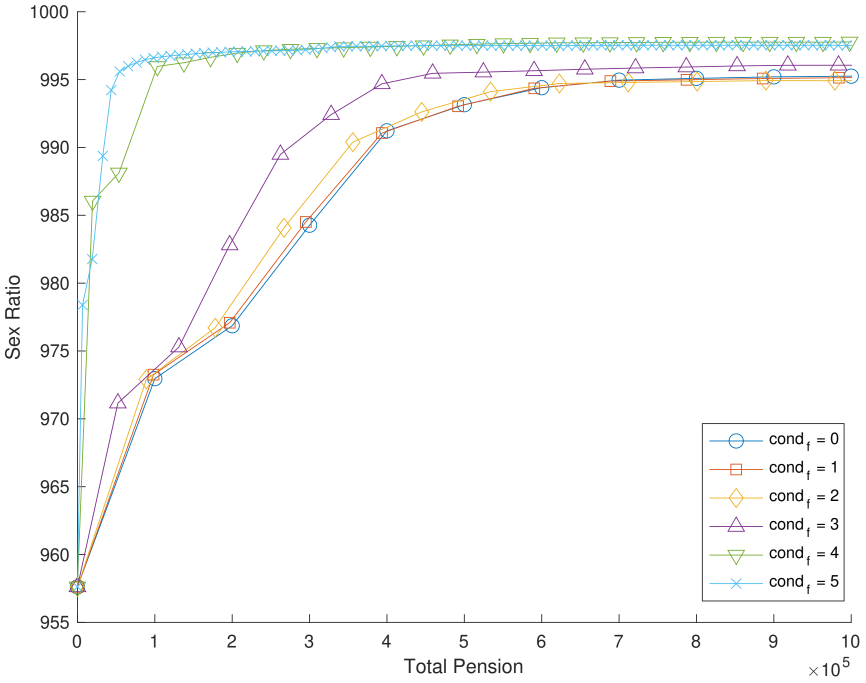


Figure C.9: Sex Ratio vs. Total Pension for different conditions: Non Green Revolution



C.4.2 Early Transfers under Non Green Revolution

Figure C.10: Sex Ratio vs. Early Transfer Generosity for different conditions: Non Green Revolution

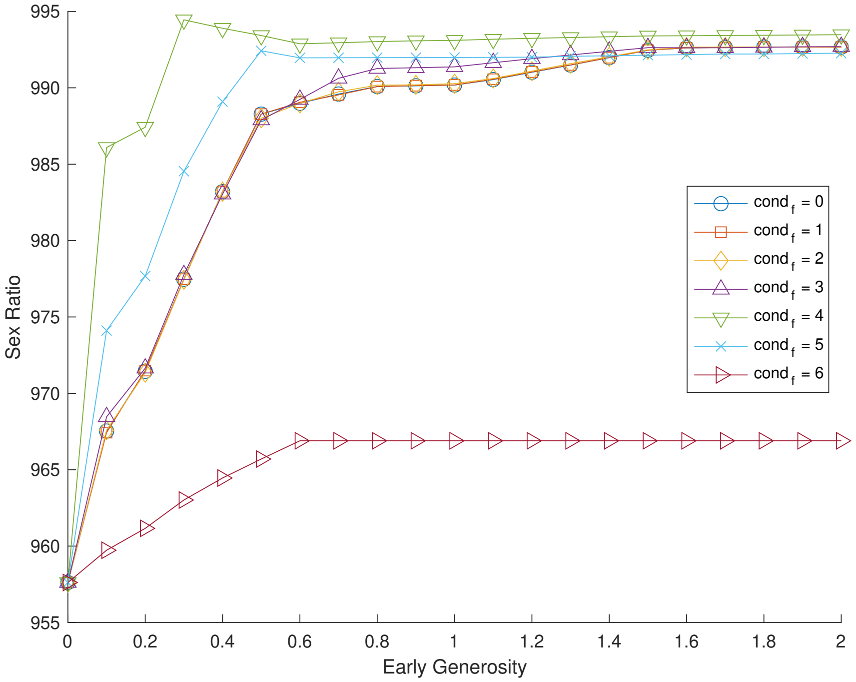


Figure C.11: Total Pension vs. Early Transfer Generosity for different conditions: Non Green Revolution

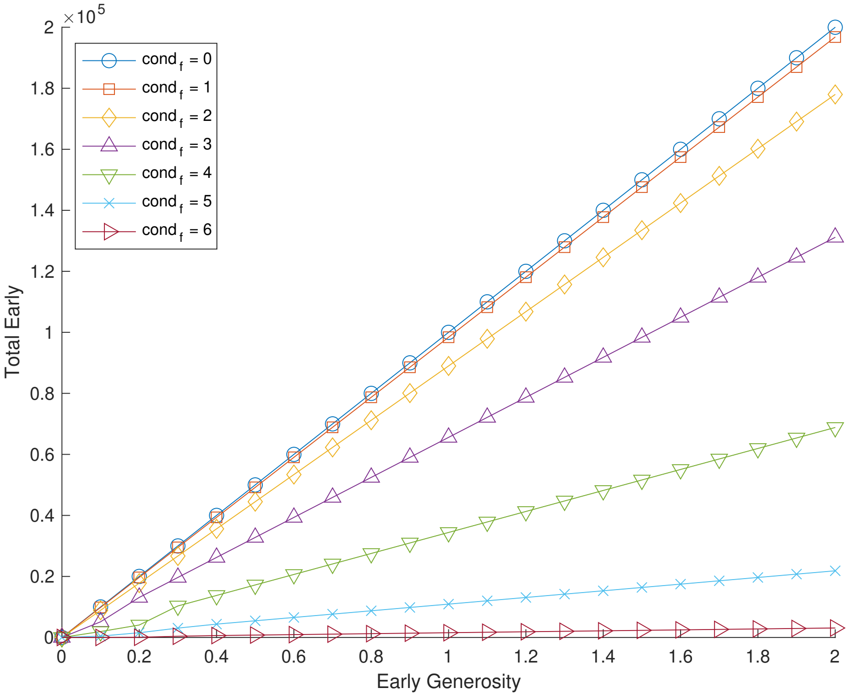
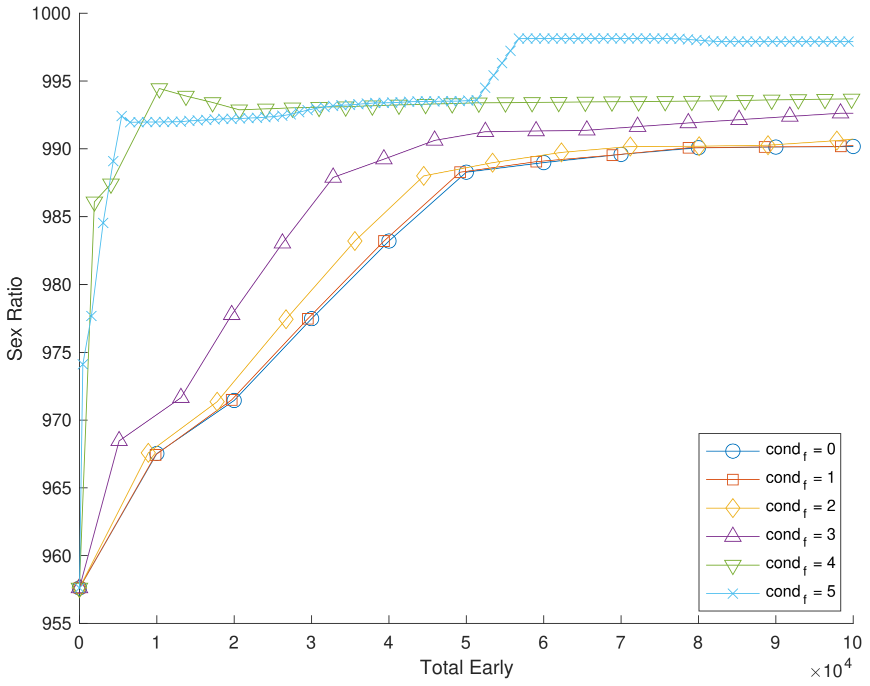


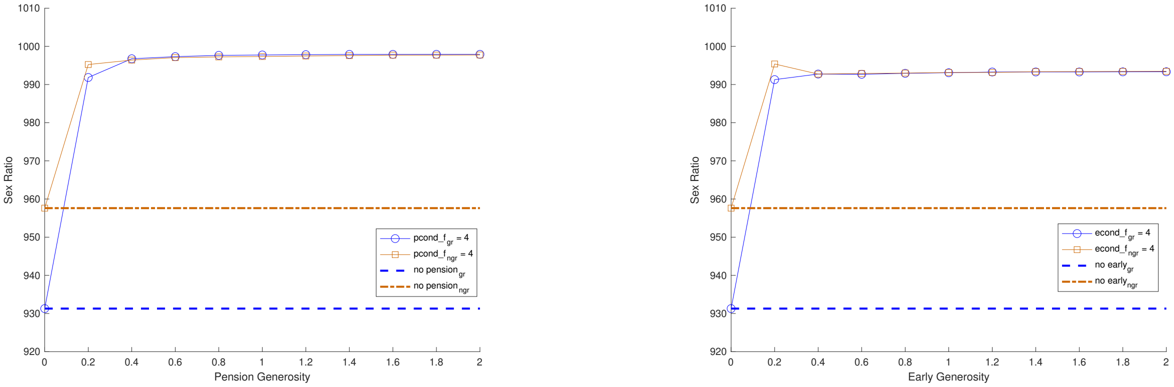
Figure C.12: Sex Ratio vs. Total Early Transfer for different conditions: Non Green Revolution



In the preceding analysis, we concluded that policies conditioned on households with 4 or 5 daughters yield the most favorable outcomes. Figure C.13 compares the effects of pension and early transfer policies — conditioned on 4 or 5 daughters — under both the non-Green Revolution and Green Revolution regimes. The dashed horizontal lines indicate the baseline sex ratios in the absence of any policy: approximately 957 under NGR and 931 under GR.

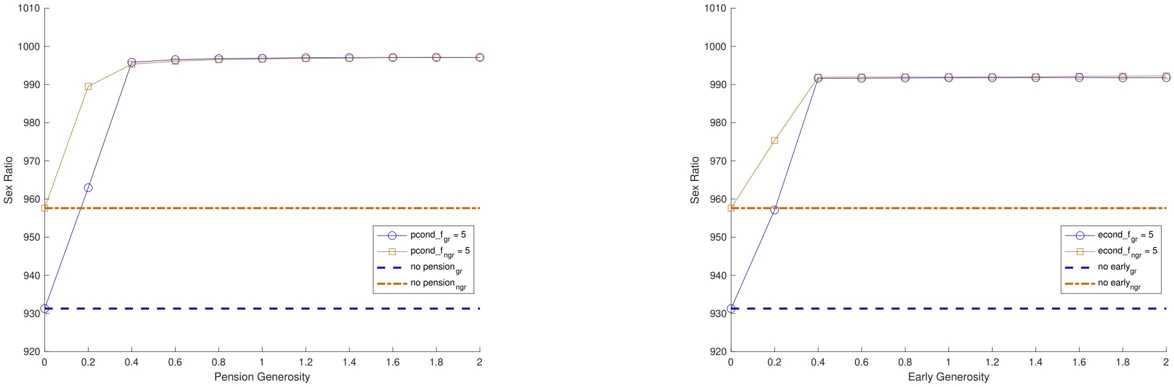
Two findings stand out. First, both pension and early transfer policies substantially improve the sex ratio under both technological regimes, raising it from the baseline to near the model's genderneutral benchmark of 1000 at moderate levels of generosity. This confirms that targeted conditional transfers are effective in addressing gender imbalances regardless of the underlying technological environment. Second, the policy effects are remarkably similar across the NGR and GR regimes — the sex ratio curves under the two regimes nearly coincide once transfers are introduced. This indicates that, although the Green Revolution significantly widens the male bias in the absence of policy intervention (the GR baseline is 26 points below the NGR baseline), conditional transfers of sufficient generosity can fully offset this additional male bias. In other words, the gendered consequences of technological change can be effectively neutralized through appropriately designed financial incentives that raise the economic value of daughters to parents.

Figure C.13: Sex Ratio vs. Pension Generosity and Early Transfers for Different Numbers of Daughters: Non Green Revolution and Green Revolution



(a) Sex Ratio vs. Pension Generosity (4 Daughters)

(b) Sex Ratio vs. Early Generosity (4 Daughters)



(c) Sex Ratio vs. Pension Generosity (5 Daughters)

(d) Sex Ratio vs. Early Generosity (5 Daughters)

C.5 Policies for Fertility Rate under Post-Green Revolution

We also examine the impact of the two transfer policies on the fertility rate under the Green Revolution regime. Figure C.14 presents the fertility rate under varying levels of pension generosity. The effects on fertility differ markedly across conditionality thresholds. Conditioning pensions on having 3 or 4 daughters leads to a substantial increase in the fertility rate, from the baseline of approximately 4.8 to over 5.2, as parents are incentivized to have more children in order to meet the daughter threshold and qualify for the transfer. Conditioning on 5 daughters also raises fertility, though more modestly. In contrast, unconditional pensions and pensions conditional on 0 or 1 daughter lead to a decline in fertility. This occurs because the additional income from pensions substitutes for the old-age support motive, reducing the need to have sons, and thereby lowering overall fertility. Pensions conditional on 6 daughters have virtually no effect, as very few families reach this threshold.

Figure C.15 presents the corresponding results for early transfers. In contrast to pensions, early transfers raise the fertility rate under nearly all conditionality thresholds. Conditioning on 4 daughters produces the largest increase in fertility (to approximately 5.5), followed closely by conditioning on 3 daughters. Unconditional transfers and transfers conditional on 0, 1, or 2 daughters also increase fertility substantially at higher levels of generosity. This difference between pension and early transfer effects on fertility is intuitive: early transfers are received during the education stage, when parents are still making active fertility decisions, and thus have a more direct pro-natalist effect. Pensions, by contrast, are received after the fertile period, and their income effect can reduce the demand for children when conditioned on low thresholds.

Combining these findings with the sex ratio results from Section 6, early transfers conditional on 4 or 5 daughters emerge as the most attractive policy option: they simultaneously improve the sex ratio toward the model's genderneutral benchmark of 1000 and increase the fertility rate. Pension policies conditional on 4 daughters also achieve both objectives, though at a higher fiscal cost.

Figure C.14: Fertility Rate vs. Total Pension for different conditions: Green Revolution

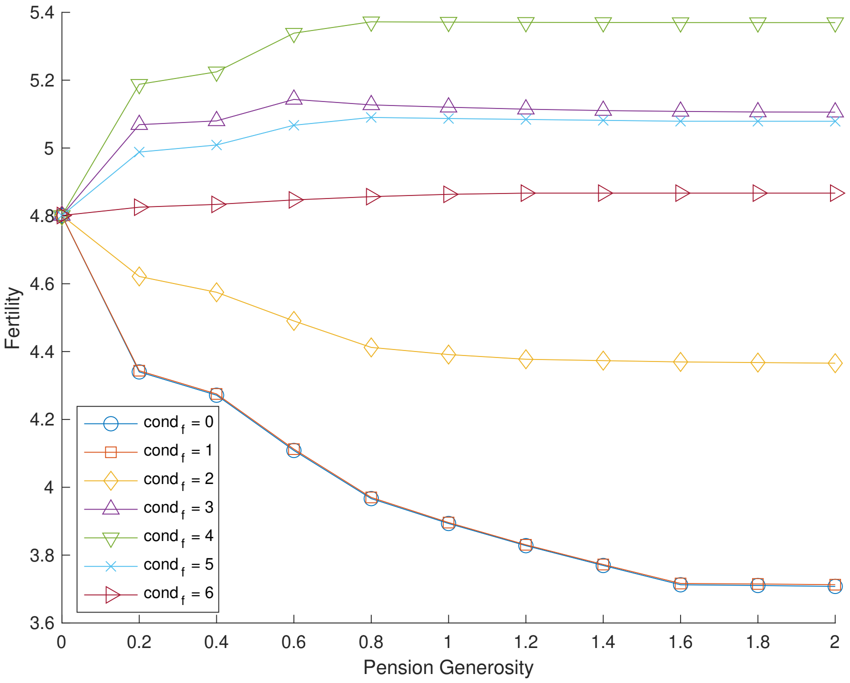


Figure C.15: Fertility Rate vs. Early Transfer Generosity for different conditions: Green Revolution

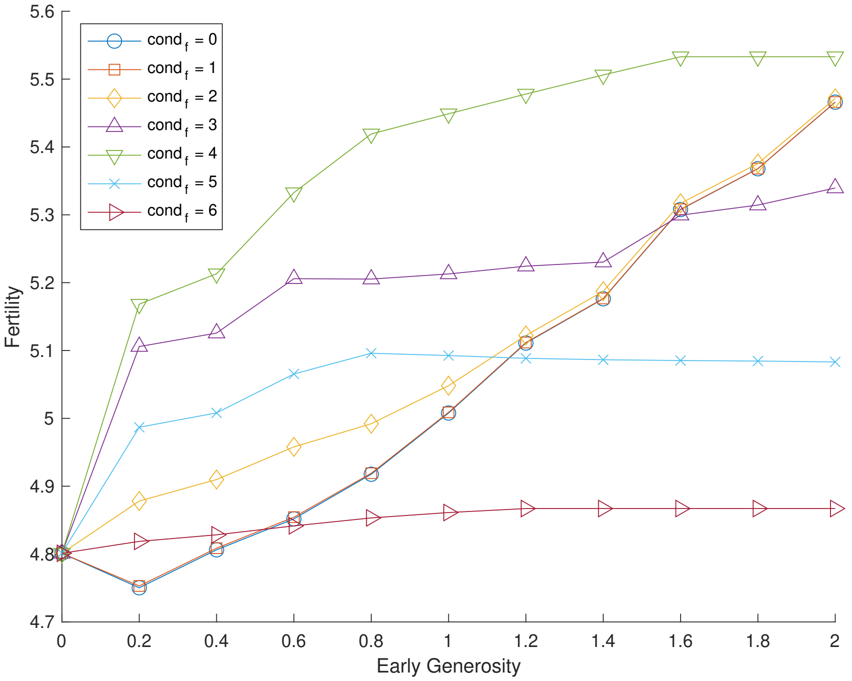


Figure C.16: Fertility Rate vs. Total Pension for different conditions: Non Green Revolution

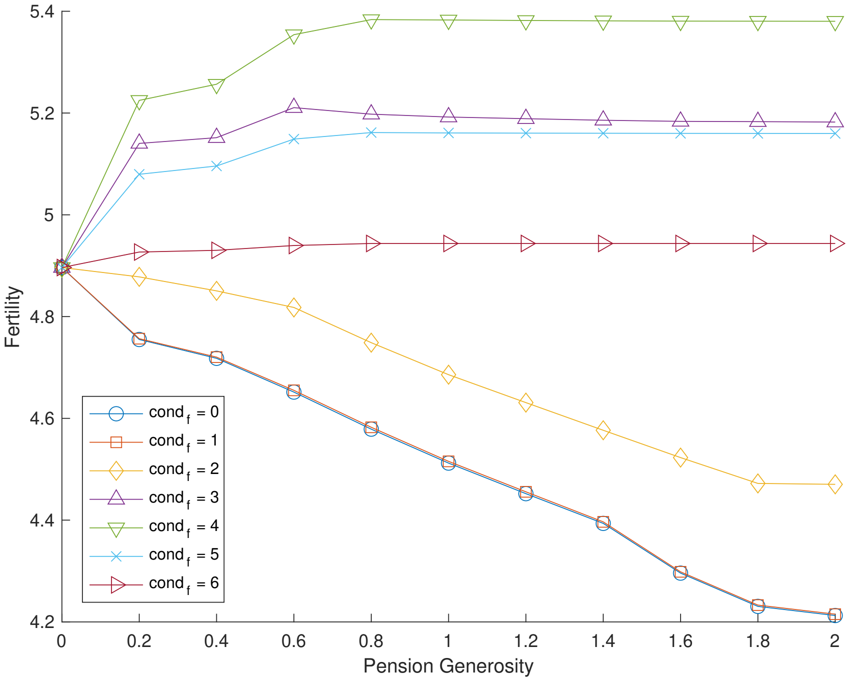


Figure C.17: Fertility Rate vs. Early Transfer Generosity for different conditions: Non Green Revolution