Technological Changes, Social Norms and Fertility Choices *

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Abstract

This paper examines the issue of "missing women" in the context of a developing country, India, with a highly skewed and worsening sex ratio. In particular, we quantify the impact of a dramatic improvement in agricultural technology (also known as the Green Revolution) interacted with social norms (i.e., patrilocality and son preference), on fertility rates and sex ratio. Using National Family Health Survey data, empirical estimates reveal that increasing HYV adoption from the 25th to the 75th percentile of the distribution reduces fertility rates by 3.6%, increases the proportion of boys by 6.6%, and reinforces the stopping behavior by 8.6% in rural areas. To shed light on the mechanisms through which technological change can affect fertility behavior, we construct a life-cycle model with an endogenous sequential birth decision, where patrilocality interacts with technological change to increase the returns to having a son relative to having a daughter. Decomposition exercises confirm our empirical findings that gender-neutral technological changes can accentuate the extant gender biases. Our results also point to the importance of a well-established social security system in combating the gender imbalance, especially in developing countries with deeply embedded social norms.

JEL classification: J13, J16, O13, O33

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

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1 Introduction

Unlike Western populations that have a nearly balanced sex ratio, the sex ratio in the Indian population is skewed in favor of males. This male bias in population numbers has increased over time. For instance, between 1961 and 1991 the number of males per thousand females in the Indian population increased from 1063 to 1079. This jump in sex ratio appears to be driven by rural India where the sex ratio increased from 1038 to 1066 males per 1000 females. This is in stark contrast with urban areas that experienced a consistent fall over this period. In this paper, we investigate if the introduction of new agricultural technology, also known as the Green Revolution, beginning in the late 1960s, can account for a part of this change in sex ratio.

The empirical motivation for this research derives from two crucial patterns that we document in the data. First, the sex ratio was more skewed in favor of males in Green Revolution areas than in non-Green Revolution areas. Second, the sex-ratio differential between green and non-green revolution areas widened over time, especially after the introduction of ultrasound technology that facilitated sex-selective abortion.

The green revolution technology dramatically increased crop yields, most notably in the case of wheat —the staple food grain for a large section of the Indian population. The new agricultural technology could affect the sex ratio by skewing parents' fertility preferences in favor of boys through the following channels: First, the increased income brought by the rise in the overall labor productivity increases the fertility rates while the higher opportunity cost of parental time reduces it. The net change in fertility depends on which of these effects dominate. Its consequent effect on the sex ratio will depend on the existing son preference. Second, the new technology was such that it increased the skill premium, implying a higher return from having an educated male child. Third, on account of the patrilocality of Indian marriages, and associated strict social norms preventing married women from working on their parents' farms, the increase in agricultural productivity was effectively an increase in the returns to having a son relative to having a daughter. A son became more productive after the green revolution than he was before, while a daughter remained as unproductive after the green revolution as she was before.

We substantiate these conjectures using mother-level detailed fertility data from the second round of Demographic and Health Surveys (DHS) for India (1992-93). Accounting for endogenous adoption of the technology, our empirical estimates show a fall in the fer-

tility rate. This highlights that the substitution effect of the green revolution technology outweighed the income effect. On expected lines, the increased returns to a boy child strengthen the son-preference as the proportion of boys shoots up and stopping behavior is reinforced.
To quantify the effect of these mechanisms described above on fertility choices, we propose to formulate a life-cycle model that features endogenous sequential fertility decisions. In our framework, parents maximize their lifetime utility by choosing the total number of children and their sex composition. The model also factors in the patrilocality of Indian marriage — an important institutional pecularity in the context under study. Thus, while making fertility choices, parents are assumed to be mindful of the fact that a son would work on the family farm and support them in their old age. By contrast, a daughter would have to be married off at an expense, and she would not work on the family farm after marriage.

We first intend to use our model to quantitatively discipline the contributions of the four channels mentioned above in making the sex ratio more male-biased, i.e., income effect, quantity-quality trade-off, patrilocality of marriage, and son preference. Then we intend to perform a series of counterfactual exercises to evaluate the possibility of policies to reverse the gender imbalance. We expect to see the critical role of a better designed social security system, i.e., a well functioning pension system, in combating the gender bias, especially in developing countries where social norms are rooted.

2 Data and Empirical Estimation

2.1 Data

In this study, we combine data on fertility choices with district-level data on the green revolution. We use the second round of Demographic and Health Surveys (DHS) for India conducted in 1992-93. This data captures detailed reproductive histories of women in the age group of 15 to 49. Since we are interested in examining the fertility choices, we restrict the analysis to women aged 40-49 as this cohort of women would have completed their reproductive cycle. The sample of mothers surveyed is 8,060.[1] We examine the effect of the green revolution on overall fertility choices and by region, rural and urban separately, as we expect the rural regions to experience a greater impact from agricultural technological changes. We match the fertility history of a mother to her exposure to GR.

[1]We have excluded women with no children and those married more than once. These constitute less than 3% of the sample.

For this, each mother is assigned the exposure value of the district in which she lives in the year preceding the birth of her first child. As we take a lag of one year, our main sample becomes 7,093 mothers (88% of the original sample). The choice of the previous year is pertinent as it captures the contemporaneous market conditions at the time of the fertility decisions. As a robustness check, we will also carry out this exercise by matching it with the year of marriage.[2]

We construct our variable of interest, exposure to the green revolution (GR), using district-level Meso data collected as part of Village Dynamics Studies in South Asia (VDSA) from 1966 to 2011. It captures annual district-level data on the total area under cultivation and the area planted with High Yielding Variety (HYV) seeds of six major crops—rice, wheat, maize, sorghum, finger millet, and pearl millet. Our measure of exposure to GR is defined as the proportion of the area under HYV of rice and wheat. We focus only on rice and wheat as the green revolution in India was characterized by the rapid adoption of HYV of these two crops. Figure 2.1 plots a five-year moving average of the adoption of HYV between 1966-1990. It shows a clear upward trend in the proportion of area cultivated under the modern varieties of rice and wheat seeds.

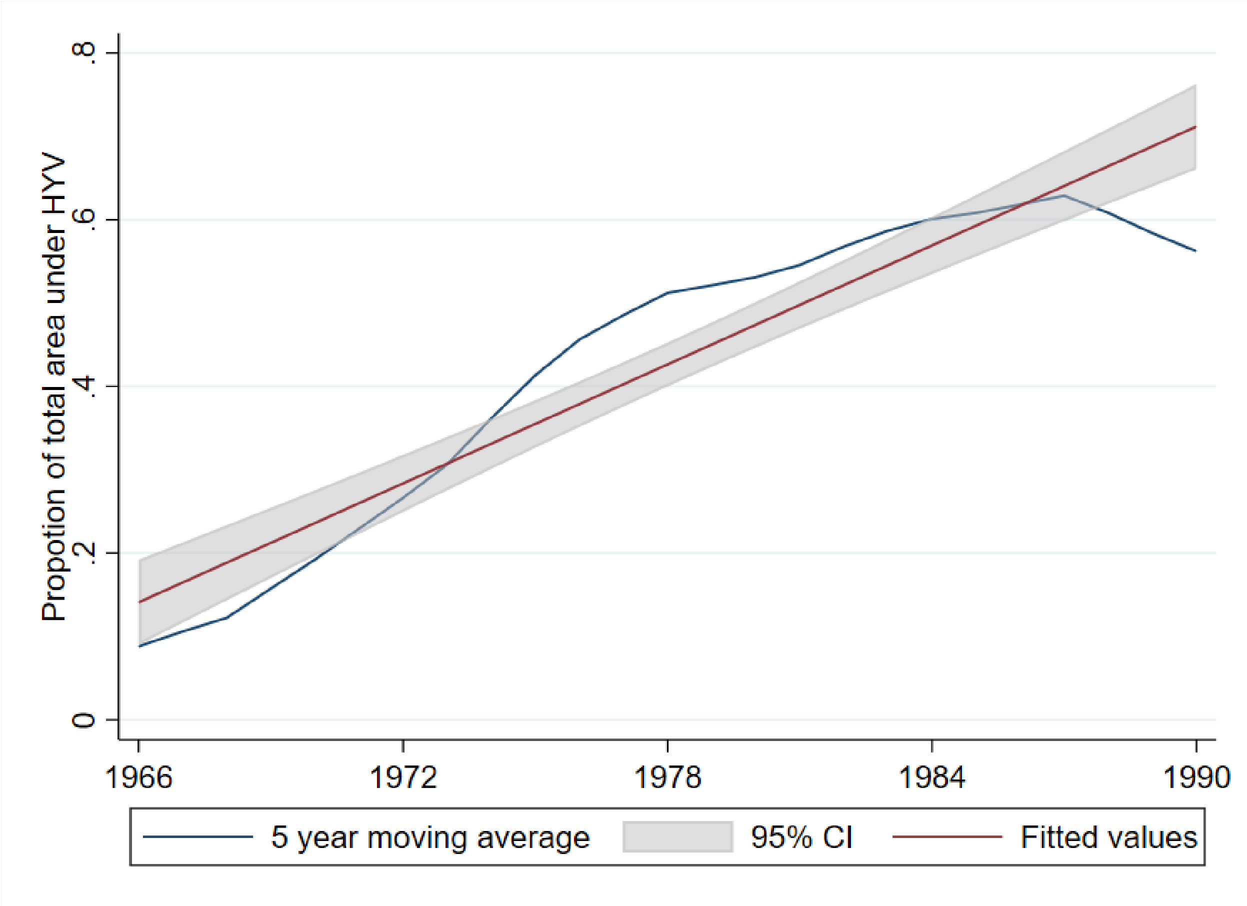
Table 2.1 lists the summary statistics for the matched sample. Panel A, lists the fertility choices made by mothers in our sample. The average number of live births per mother is slightly above 4. Of these, more than half (53%) are boys which aligns with the well-documented son-preference in India. More than half the mothers in our sample are from rural areas and are characterized by a higher fertility rate of 4.80 compared to 4.02 in urban areas and a more skewed sex ratio. We also find evidence in support of the stopping behavior wherein 56% of the mothers in our sample did not conceive any further if the last child born was a boy. And this is similar across the rural and urban regions. Panel C lists our variable of interest, i.e., the exposure to GR. A district in a year on average crops 26% of its cultivates area under HYV seeds.

2.2 Empirical Strategy

We estimate the impact of the green revolution, induced by the adoption of HYV, on the fertility decisions made by a cohort of women that was exposed to this technological

[2]The districts that were split from their parent post-1966 have been mapped back to original names. A few cases where a district was carved out from multiple parent districts are dropped from the analysis. These constitute less than 2.5% of the observations

Figure 2.1: Five year moving average of proportion of cultivated area under the HYV seeds



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

Table 2.1: 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	0.30	25^{th} percentile of the distribution of GR
GR (75^{th} percentile)	2097	0.43	0.30	75^{th} percentile of the distribution of GR

Source: NFHS II (1992-93) and VDSA (1966-1990).

change. These fertility choices relate to the number of children, son preference, and the sex composition of the children born. We estimate the following specification:

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

where y_{idt} represents the fertility choices of mother i in district d in year t. Characteristics of mothers—their age, square of age, religion, caste, years of education, square of years of education and asset index are included in X_{idt}.[3] We account for district-level heterogeneity (D_d) and control for year fixed effects (D_t) to absorb unobserved district and yearly variations in fertility choices. State-specific annual fixed effects (D_{dt}) allay any concerns of changes in state policies confounding our results. Standard errors are clustered at the district-year level.

We are identifying on the within-district variation in the adoption of HYV for a cohort of women that have completed their fertility cycle. The adoption of HYV might have been endogenous, depending on the irrigation facilities available to people and the soil suitability for cultivating rice and wheat. But, we do not expect this endogeneity in a cohort of women making fertility decisions at a common point of time within the same district. We also check the robustness of our results to clustering the standard errors at the district level. Our results remain unchanged.

2.3 Empirical Results

Table 2.2 reports the adoption of the green revolution technology on fertility choices. Column (1) reports the effect on the total number of children born. Column (2) lists the proportion of boys born and Column (3) reports the likelihood of not bearing any children conditional on the last born child being a boy. Panel A reports the overall findings while Panel B and C report the results for the rural and urban samples, respectively. The effects of the green revolution are expected to be more pronounced in rural areas.

In Column (1) of Panel A, we find a contraction in the total fertility by 0.32 from exposure to the green revolution. A unit increase in the exposure to GR reduces the number of children born to a mother by 7%. This translates into a 3% fall in total live births as we move

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

Table 2.2: Effect of Green Revolution on Fertility choices

	Total children (1)	Proportion of Boys (2)	Stopping at a boy (3)
		Panel A: Overall	
Exposure to GR	-0.322**	0.0646**	0.0369
	(0.151)	(0.0273)	(0.0489)
Observations	7,089	7,089	7,089
R-squared	0.333	0.048	0.050
Mean (y)	4.64	0.53	0.57
		Panel B: Rural	
Exposure to GR	-0.417**	0.0844**	0.116*
	(0.197)	(0.0350)	(0.0631)
Observations	4,818	4,818	4,818
R-squared	0.318	0.061	0.061
Mean (y)	4.89	0.54	0.57
		Panel C: Urban	
Exposure to GR	0.0617	0.0688	-0.0732
	(0.244)	(0.0465)	(0.0894)
Observations	2,252	2,252	2,252
R-squared	0.422	0.106	0.116
Mean (y)	4.1	0.53	0.57
Difference (Rural-Urban)	-0.4787	0.0156	0.1892
Mother characteristics	✓	✓	✓
District F.E.	✓	✓	✓
Year F.E.	✓	✓	✓
State $\times Year F.E.$	✓	✓	✓

Source: NFHS II (1992-93) and VDSA (1966-1990)
Note: Panel A reports the overall estimates which are further bifurcated by region - Rural (Panel B) and Urban (Panel C). '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. The last column 'Difference' reports the difference in the outcome variable between the rural and urban regions. Mother characteristics include age fixed effects, religion fixed effects, caste fixed effects, years of education and asset index. Mean (y) refers to the mean of the dependent variable. Standard errors clustered at district-year level reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

from the 25^{th} to the 75^{th} percentile of exposure to GR.[4] This drop in fertility is driven by the rural areas that experience a fall of 9% (Column (1), Panel B) with a null effect in the urban regions (Column (1), Panel C).

Interestingly, the fall in the number of children is accompanied by an increase in the proportion of boys born (Column (2), Panel A). We find a rise of 0.06 percentage points (or 12%) in boy's proportion. Once again, it is the rural regions that observed this effect while the effect in urban regions remains insignificant. A movement from the 25^{th} to the 75^{th} percentile of exposure in rural areas increases the proportion of boys being born by 6.56%. Although the effect is significant and more pronounced in rural regions, we do not find it to be significantly different from urban areas.

Finally, the results in Column (3) show that there is no significant effect on the overall likelihood of stopping at a boy child. But Panel B of Column (3), shows a significant effect in the rural regions. An increase in exposure from the 25^{th} percentile to the 75^{th} percentile of the distribution leads to 8.55% more mothers stopping at a boy child. In contrast to rural areas and on expected lines, we find no significant effect for urban areas.

In summary, adoption of the green revolution reduces total fertility and is associated with increased son-preference in rural areas as observed in the increase in the proportions of sons and the stopping behavior. The null effect in urban areas also serves as a placebo check and indicates that we are correctly capturing the effect of the green revolution. Although the effect is significant and more pronounced in rural regions, the total children ($p < 0.15$) and stopping behavior ($p < 0.10$) are weakly different and the proportion of boys are not different from urban areas.

3 Model

In this section, we construct a life-cycle model that features sequential birth decisions to quantitatively study the impact of Green Revolution interacted with social norms on fertility decisions. The sequential fertility decision setup enables us not only to study the quantity-quality trade-off but also the gender composition, which is the key interest of this paper. The new agricultural technology brought by the Green Revolution affected families' fertility decisions by skewing parents' fertility preferences in favor of boys

[4] 25th percentile=0.01 and 75th percentile=0.43

through the following channels. First, positive income effect from the overall increase in labor productivity allow households to have more children. Second, the increase in opportunity cost of raising a kid substitutes parents away from the quantity to the quality. A change in the total number of children would already have embodied a change in the gender ratio, with the presence of son preference. Third but most importantly, on account of patrilocality of Indian marriages, the increase in agricultural productivity was effectively an increase in the returns to having a son relative to having a daughter — a son became more productive after green revolution than he was before, while a daughter remained as unproductive after green revolution as she was before.

3.1 Production

The production function of the final goods Y_t is Cobb-Douglas, taking two inputs, labor and land, denoted by N_t and L_t respectively.

$$Y_t = A_t N_t^{\rho} L_t^{1-\rho} \tag{2}$$

Both gender of individuals can work so that the total labor takes the CES composite of male and female labor, denoted by $N_{m,t}$ and $N_{f,t}$ respectively.

$$N_t = A_{Nt}[\psi_{m,t}^{\frac{1}{\rho_N}} N_{m,t}^{\frac{\rho_N - 1}{\rho_N}} + \psi_{f,t}^{\frac{1}{\rho_N}} N_{f,t}^{\frac{\rho_N - 1}{\rho_N}}]^{\frac{\rho_N}{\rho_N - 1}} \quad \text{where} \quad \psi_{m,t} + \psi_{f,t} = 1 \tag{3}$$

We normalize the price of the final good P_t to be 1, and use $P_{L,t}$ to denote the price of the land and $W_{m,t}$ and $W_{f,t}$ the wage rates. Assume there is a fixed maximum of land such that $L_t \leq \bar{L}$. ρ measures the elasticity of substitution between the labor and the land and ρ_N measures the elasticity of substitution between male and female labor.

3.2 Households

For the purpose of illustration, we ignore the subscript i for individuals. Agents are heterogeneous in their human capital h. Assume the model economy starts after agents get married at t_M, the fertility cycles ends at t_F, daughters leave the family at t_C, agents work until they retire at t_R, and they die in the last period t_D, i.e., $t_M \leq t_F \leq t_C \leq t_R \leq t_D$. Every agent is endowed with one unit of time in each period, and they decide on the time allocation problem between working, childrearing, and home production. Leisure is not considered in the model.

Fertility Decision. Agents make fertility decision sequentially. Depending on the existing number (n) and composition of children n_m, they decide whether to have another child or not. There are three types of fertility decisions. First, if the agents pay a fixed cost (ϕ_b), they can choose not to have an additional child. ϕ_b can be interpreted as any birth-control methods. Second, if the agents choose not to use birth controls, they can naturally have another child and the gender of the child is random with equal probabilities. We rule out the possibility of having twins to simplify the analysis. Third, if the agents choose not to use birth controls and pay another cost, denoted by ϕ_a, they can "control" the gender of child. ϕ_a can be interpreted as abortion technology. In this case, the probability of having a boy is q_m and the probability of having a girl is q_f where $q_m > \frac{1}{2}$ if the parent prefers a son or vice versa. To simplify the analysis, we assume households have perfect control over the gender of the additional child if they pay ϕ_a cost, and thus the probability of having a boy is assumed to be 1.

Childrearing Activities. Childrearing induces two types of costs, including resource cost and time cost. We use ϕ to denote the resource cost. In terms of the time cost, parents have to allocate e_m and e_f fraction of their time to educate their sons and daughters respectively. To simplify the algebra, we only consider the symmetric case in the sense that the time allocated to sons can differ from time allocated to daughters, but it is symmetric among sons or daughters. On top of the traditional childrearing costs, parents need to decide how to allocate a fraction of savings to their daughters as dowries when their daughters leave the family, denoted by d^f. If parents can provide a higher amount of dowries, their daughters will be more likely to marry a better husband and thus enjoy a higher utility. Parents are altruistic in the way that they care about their children. Parameters that capture taste towards sons and daughters are β_m and β_f.

Consumption and Saving. Households' consumption consists of two types of goods: consumption good C and home-produced good X. Home production takes time and human capital as the input.

$$X = A_X \cdot (sh)^{\rho_X} \tag{4}$$

where s represents the time spent in home production. We assume males, including both fathers and sons, always work in their farms, however females, including mothers and daughters, can either work or participate in home production. As discussed in the empirical section, child labor is not rare in the Indian context. Therefore we allow child labor in the model economy, however, children's productivity will be lower than that of adults, captured by the parameters τ_m, τ_f, and τ_h where $\tau_m \leq 1$ and $\tau_f + \tau_h \leq 1$.

Time Allocation. In the periods before retirement, everyday households decide how much time to allocate to working in the farm, childrearing activities, and home production, denoted by l, s, e^m and e^f respectively. After retirement, agents cannot work in the farm, they both contribute their unit of time to home production and agents live on support from sons.

Human Capital Accumulation. We assume adults' human capital cannot change, meaning there is no skill depreciation or on-the-job training. However, children's human capital, denoted by h^j depends on parents' human capital and the effort that parents invest. Here the parameter θ captures the importance of innate and acquired skills.

$$\Delta h^j = A_h(\frac{h_m + h_f}{2})^{1-\theta}(e^j + e_0)^{\theta} \quad j \in \{m, f\} \tag{5}$$

3.3 Household's Problem

Agent's utility consists of two parts: consumption $u(C_t, X_t)$ and children. Consumption includes the consumption of final goods and the consumption of home-production goods.

$$u(C_t, X_t) = C_t^{\sigma}(X_t - \bar{X}_t)^{1-\sigma}$$

Then we can write the period utility function into the following form:

$$\begin{aligned} u_t &= u(C_t, X_t, n_t, n_{m,t}) \\ &= u(C_t, X_t) + \beta_m n_{m,t}^{-\epsilon}(n_{m,t} I_{m,t}) + \beta_f n_{ft}^{-\epsilon}(n_{f,t} I_{f,t}) \end{aligned} \tag{6}$$

where

$$I_t^m = \begin{cases} \bar{I_m} & \text{if} \quad t < t_C \\ \bar{I_m} + I_m(W_{m,t}, h^m) & \text{if} \quad t \geq t_C \end{cases}$$

$$I_t^f = \begin{cases} \bar{I_f} & \text{if} \quad t < t_C \\ \bar{I_f} + I_f(\frac{D_f}{n_{f,t}}, h^f) & \text{if} \quad t \geq t_C \end{cases}$$

where $D_f = \sum_{t=t_0}^{t=t_C} d_t^f$. $\bar{I_m}$ and $\bar{I_f}$ captures the "pure love" from parents towards children. Assume $0 < \epsilon < 1$, so that more children bring higher utility to parents, but at a decreasing rate. Notice that $I_m(W_{m,t}, h^m)$ is an increasing function in $W_{m,t}$ and h^m since these two would determine sons' wage income. $I_f(D_f, h^f)$ increases in D_f and h^f since we assume higher dowries and better education would enable daughters to marry a better family and enjoy a better life.

4 Quantitative Analysis

We will calibrate the model economy to the pre Green Revolution era, introduce Green Revolution as a general increase in labor productivity (and thus an increase in the wage rate) together with a rise in the skill premium, and then perform a series of quantitative analysis.

Decomposition Exercise. We will first decompose the impact of Green Revolution on the sex ratio into four channels: income effect, quantity-quality tradeoff, social norm of patrilocality and son-preference. In particular, we intend to shut down the increase in the wage rate, shut down the increase in the skill premium, allow daughters to work and support their parents, and shut down heterogeneity in preference parameters towards sons and daughters respectively to disentangle the effects from each channel. We expect to see that gender-neutral technological changes can accentuate the extant gender biases, with the presence of patrilocality and son preference.

Policy Evaluation. In a patrilocal societies, elderly parents co-reside with adult sons. Thus, transfers from co-residing adult sons serves as social security in settings that lack formal pension systems. 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 effects 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.

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