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Missing Women, the Marriage Market and Economic Growth

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“Ladki ko padhaane ke baad bhi woh apne ghar chali jaati hai. Padhaane se koi faida naheen”
(There is no point teaching a girl; she marries and goes away)¹

One increasingly documented feature of many low-income countries is the disparity in household resource allocations between boys and girls (e.g., Strauss and Thomas, 1998) and men and women (e.g., Udry, 1996). Perhaps the most salient manifestation of these gender differentials, as emphasized by Sen (1990, 1992), is the difference in sex-specific survival rates, particularly in South Asian countries, as reflected, for example, in ratios of the number of males to the number of females that are significantly higher than those observed in most developed countries. The consensus is that the tens of millions of “missing women” in these societies reflect gender disparities in human capital investments, which make girls and women relatively more vulnerable to sickness and disease that are more prevalent in low-income environments.

Much of the literature concerned with differential survival rates has focused on factors affecting the economic value to the household of women relative to men. These include the differential male intensity of agricultural technology (Boserup, 1970; Bardhan, 1974, 1988; Jacoby, 1995), opportunities for women to earn (Bardhan, 1977; Rosenzweig and Schultz, 1985), and patriarchal kinship systems (Dyson and Moore, 1993). All of these factors, however, appear to be slow-moving, endemic features of the societies in which the female “deficit” is observed and suggest that income change would be ineffective at least in any reasonable time period in altering the skewness of male-female survival differentials. For example, one important institutional feature of rural India identified as a root cause of gender differentials in human capital investments there is the practice of patrilocal exogamy, whereby sons remain with the origin or “parental” household and contribute to income while daughters migrate from their household’s village to move into, upon marriage, their husband’s parental household.² Investments in sons are seen as paying off for the parents, while

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¹Quote from one of 1,221 Indian parents interviewed in a survey covering school facilities in 188 villages in four Indian states for the Public Report on Basic Education (India Today, 1998).

²This institutional arrangement is widespread in India and cuts across northern and southern cultures. The Poverty, Gender Inequality and Reproductive Choice (PGIRC) survey, recently analyzed by Rao et al. (1998), of 1891 marriages in two Indian states in 1994 indicates that in the northern state over 93% of brides left the village while almost 84% left the village in the southern state.
those in daughters, who leave, do not. Increases in productivity in that context would appear to even worsen the relative returns to parents from investments in daughters and sons. Indeed, Drèze and Sen (1998) conclude in their comprehensive book on Indian development that there is little evidence that income has a significant relationship to gender differentials and that therefore “It is important to aim at more radical and rapid social change based on public action” (p. 178).

There is reason to be skeptical about the existing empirical evidence on the determinants of sex-specific survival, particularly as it relates to either whether differential survival rates respond to economic incentives or the efficacy of growth-promoting polices that do not also effect fundamental social change. For example, many empirical studies have exploited the spatial variation in sex-ratios within India to assess the fundamental causes of differential survival rates. A common finding of the cross-sectional studies based on Indian state and district data is that where women work more, sex ratios are more favorable to women (Bardhan, 1976; Rosenzweig and Schultz; Kishor, 1993; Murthi et al., 1995)). However, as Sen (1990) has pointed out, the joint association between female labor force participation and sex differentials in survival may be due to a third, unmeasured cultural factor, so that the interpretation of this association is unclear. Moreover, the common inference from these findings that mother’s earnings measure the returns to the investments in their daughters neglects the fact that the daughters when adults do not reside in the same village as the mothers. Marital migration is sufficiently important to show up even at the district level of aggregation. The 1981 Indian Census indicates that on average 17% of women over age 15 resided outside of the district in which they were born, with that proportion as high as 24% in Punjab state.

Drèze and Sen base their specific conclusion about the ineffectiveness of income growth on the finding in Murthi et al (1995) that across Indian districts in 1981 poverty and the female survival disadvantage were negatively related, although this seems to be inconsistent with the finding in Rose (forthcoming) that female survival is enhanced when there are favorable weather shocks.\(^3\) The relationship between income and survival

\(^3\)Sen and Drèze also find that upwardly-mobile lower castes were no less biased with respect to male/female survival chances.
rates, however, whatever its sign or magnitude, may have little relevance for assessing the consequences of growth. Economic growth is not just an exogenous rise in income, but usually results from a change in productivity that can significantly alter the returns to investments in human capital. Income effects can be small, but growth-induced changes in returns to investments can have large effects. The Indian “green revolution”, for example, substantially increased the productivity of agricultural production in many areas of India and raised the returns to schooling for men and women, particularly in those areas where the new crop varieties were most productive (Foster and Rosenzweig, 1996; Behrman et al., forthcoming).

In this paper we use panel data from India during the period of the initial years of the India green revolution to re-assess (i) whether gender differences in survival rates reflect gender differentials in the value of human capital and (ii) to what extent policies promoting economic growth can affect the female survival deficit in the absence of fundamental changes in cultural practices that differentiate the roles of men and women. In particular, we adopt a general equilibrium framework in which, consistent with patrilocal exogamy, sons contribute to parental household incomes and daughters do not, and therefore local productivity increases favor boys. We show that in this context advances in agricultural productivity can improve the survival chances of girls as long as there is a marriage market and the returns to the human capital of women are enhanced even if income effects on relative survival rates or preferences are insignificant. Moreover, we also demonstrate that it is not possible to identify empirically in the context of India how growth affects gender bias in household human capital investments or survival without taking into account the marriage market because of the marital migration of daughters. We find empirically, exploiting this feature of Indian social relations by constructing spatial marriage markets, that (i) the relative survival rates of boys and girls respond in opposite directions to changing local and regional returns to human capital associated with economic growth, (ii) if economic growth propelled by agricultural technical change had been distributed uniformly across India on average girl survival would have increased relative to that of boys, and (iii) changes in women’s participation in earnings activities had little to do with changing gender differentials in survival.

India is a particularly useful context for studying the relationship between economic growth and
gender bias in survival rates because of the large variation in both sex-specific survival rates and the productivity-enhancing effects of the green revolution across regions of India. Figure 1 displays the ratios of male to female children aged 0-4 in rural areas across 15 major Indian states from the 1971 Indian Census ranked from the highest to the lowest sex ratio. There are five Indian states where the sex ratio exceeds that in most Western industrialized societies, at 1.04. For example, the ratios in Punjab and Haryana are over four percentage points higher than the industrialized-country baseline. If the latter is close to the biological norm, then given that the number of male children aged 0-4 in Punjab and Haryana in 1971 was 1,405,133, the number of missing girls less than age five in those two states is over 56,000. This implies a mortality rate for girls that is over twice that of boys.

There are also apparently states with a “deficit” of males. This feature of the Indian Census data has not been much discussed; however, the state-specific sex ratios do appear to reliably reflect the spatial variation in prevailing attitudes towards sons and daughters. Data from national surveys of 4,118 and 4650 rural households in 1971 and 1982, respectively, described below, elicited from married women their “ideal” numbers of male and female children. Figure 1 provides the average differences in the ideal number of boys and girls as reported by the respondent women in the 1971 survey for the fifteen states alongside the Census child sex-ratios for that year. The figure suggests that, with the exception of the state of Kerala, most Indian women preferred boys, even in the “male deficit” states. However, there is also wide interstate variation in the gender preferences that corresponds to that for the sex ratios. For example, in Punjab and Haryana, the states with the highest female deficits for the age groups 0-4, women on average prefer to have families in which the number of boys exceeds the number of girls by one, while in Madhya Pradesh, a male deficit state, the preferred number of boys exceeds that for girls by only .35. The overall correlation between the gender differential in family size and the male/female sex-ratio is .64.

The two successive surveys also suggest that, contrary to the cross-sectional findings, gender preferences are not invariant to change, and may have been affected by economic growth. Figure 2 plots the

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4The same patterns of male and female deficits are observed in the censuses of 1951, 61 and 81.
increase in a Laspeyres-weighted index of crop productivity over the period 1971 through 1982 across the same Indian states as in Figure 1, ranked by the magnitude of the productivity increase, along with the change in the state-specific average preferences for excess male children across the two surveys. As can be seen, there are considerable differences across states in the extent to which, due mainly to the introduction of new high-yielding seed varieties in the late 1960's, agricultural productivity was augmented. For example, among the states with the highest productivity increase (Karnataka, Punjab and Gujurat) crop productivity rose by over 150%, while in the three lowest productivity change states (Madhya Pradesh, Kerala and Bihar) productivity rose by only 11% in the 11-year period. Most interestingly, the change in boy bias over the same time period is negatively correlated with the productivity increase (r=-.52) - in all three of highest growth states, for example, the “preferred” girl deficit fell (by a third of a child on average), while the deficit actually increased in the three lowest growth states.

In section 1 we set out the general equilibrium model incorporating patrilocal exogamy. In section 2 we describe the data and in section 3 discuss the construction of spatial marriage markets and provide tests of their scope based on an analysis of the determinants of the literacy of new brides. Section 4 contains the estimates of the determinants of both sex-differences in survival rates and maternal preferences for the sex composition of their families and section 5 provides further tests of marriage market effects of economic growth by examining growth effects on female labor force participation. The results are summarized in section 6.

1. The Model

To clarify the role of economic growth propelled by technical change in altering gender-specific human capital investments within the context of the “traditional” rural setting of India and to identify growth effects, we construct a simple general equilibrium model incorporating two major organizational features of Indian agriculture - the gender-based division of labor and patrilocal exogamy. Households produce an agricultural product utilizing the human capital of the male head, his sons and, depending on the local “culture”, his wife; import the human capital of the wife; produce the human capital of girls and boys utilizing
the human capital of the wife, and export the human capital of girls for marriage. In the model, married women, and their human capital, are thus productive even if they do not directly contribute to agricultural production because they contribute to the production of the human capital of male and female children. However, we assume that women have no decision-making power and daughters, unlike sons, do not contribute directly to (origin) family income or human capital.\(^5\) Returns to investments in daughters must accrue through the regional marriage market.

In particular, we consider a two-stage model in which an adult male in village \(i\) seeks to maximize his utility, given by

\[
(1) \quad u(c_i, h_s, h_d),
\]

which has as arguments household consumption \(c\) and the human capital of his sons \(h_s\) and his daughters \(h_d\) given a budget constraint. We assume that human capital for both sexes is a normal good and that boys’ and girls’ human capital are substitutes. In stage one, the household head selects the human capital of his spouse \(h_{wi}\), paying a cost of \(p_{hw}\) and receiving a culturally-determined dowry payment \(D\), while in stage two he invests in his children’s human capital, undertakes agricultural production and marries his daughter to another household receiving the market-determined “bride” price of \(p_h\) per unit of human capital and paying out the dowry cost \(D\).\(^6\) We assume that the human-capital production function for children of sex \(k\) depends on the wife’s human capital \(h_{wi}\) and human capital goods \(x_{ki}\) purchased in the market

\[
(2) \quad h^p(h_{wi}, x_{ki}),
\]

with wife’s human capital and the child \(x\)-good complements. Agricultural income \(\pi()\), which accrues in stage two, is determined by household assets \(A_i\); by the human capital of the husband \(h_{hi}\), his son \(h_{si}\), and his wife \(h_{wi}\).

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\(^5\)We make these assumptions in order to show that it is not necessary to change fundamentally women’s role in decision-making for economic growth to benefit women. Behrman et al. provide evidence that women played almost no role in agricultural decision-making, and this was unaffected by agricultural technical change.

\(^6\)The price per unit of human capital of brides is thus a component of the full dowry. The model can also accommodate a fixed bride price. The critical assumption is that the marriage market rewards the human capital of women by either decreasing the dowry paid to grooms or increasing the bride price for brides with higher levels of human capital.
and by the local technology indexed by a scalar $\theta$. We assume that the technology augments the productivity of all inputs used in agricultural production. Thus, the two-stage budget constraint is

$$c_i = \pi(\theta_i A_i, h_{wi}, h_{di}, \kappa_i h_{wi}) + p_i(h_{di} - h_{wi}) - p_s(x_{si} + x_{di})$$

where $\kappa_i (0 \leq \kappa_i \leq 1)$ is a culturally-determined scalar indicating the extent to which the wife engages in agricultural production in the local area, $p_s$ is the price of $x_s$, and $p_i(h_{di} - h_{wi})$ is the net income received in the marriage market given $h_{wi}$ and $h_{di}$ and the market-determined price $p_h$, with discounting ignored for notational simplicity.

The marginal rate of substitution, derived from the model, between the human capital of boys and girls is given by

$$mrs_{h_s h_d} = \left( \frac{\partial h_s / \partial x_s}{\partial h_d / \partial x_d} \right) \left( \frac{p_x - (\partial \pi / \partial h_s)(\partial h_d / \partial x_d)}{p_x - p_h} \right).$$

Expression (4) indicates that the relative net costs of boys’ and girls’ human capital investments depend on the locally-determined contribution of the boys’ human capital to the household’s agricultural profits and the market-determined price of female human capital. If there were no market price for the latter, then it is clear that, even with sex-neutral preferences, investments in girls would be locally more costly than that in boys. If there is a market, however, then it is not clear from (4) which gender is more costly to parents or how changes in farm technology alter the differential returns to gender-specific investments, because (imported) adult girls produce locally-productive boys and may also farm.

a. Partial Equilibrium Demand and Supply of Male and Female Human Capital.

The model permits the derivation of both the partial equilibrium (or $p_h$-conditional) demand for and supply of sex-specific human capital and the derivation of the equilibrium price $p_h$ of the traded good, female human capital, and thus an assessment of how changes in local and market-area technology affect investments in boys and girls. In the first stage of the model, in which the demand for imported female human capital is determined, the first-order condition for the human capital of the wife is

$$\frac{\partial \pi}{\partial h_s} + \frac{dh_s}{dh_w} + p_h \frac{dh_d}{dh_w} + \frac{\partial \pi}{\partial h_w} = p_h,$$

which indicates that the marginal cost of a unit of the wife’s human capital purchased in the marriage market.
In particular, $d h / d h \omega d p (\theta, \kappa, A, h, p, p_x)$. The model delivers the result that where women participate to a greater extent in earnings activities there is greater demand for importing female human capital, as long as sons’ and mother’s human capital are not strong substitutes in agricultural production (because female human capital contributes to the production of sons’ human capital).\textsuperscript{7} However, whether a local increase in farm productivity increases the demand for imported female human capital, given its market price, does not depend on whether or not women participate in farming. The effect of variation in the local farm technology, derived from (6), is given by

$$\frac{d h_w}{d \theta} = -\frac{\partial^2 \pi}{\partial \theta \partial(\kappa h_w)} \kappa + \frac{\partial^2 \pi}{\partial \theta \partial h_s} dh_s^w \frac{d h_w^c}{d p_{hw}} - \frac{\partial^2 \pi}{\partial \theta \partial h_s} \frac{d h_w^P}{d p_{hw}} + \frac{\partial \pi}{\partial \theta} \frac{d h_w}{d \pi},$$

where $c$ denotes a compensated effect, $dh_w/d\pi$ is the income effect and $p_{hw}$ is the wife-specific price of human capital. Expression (7) indicates that an increase in agricultural technology will raise the demand for adult female human capital for three reasons: it increases the productivity of women in agriculture, if women participate ($\kappa > 0$), it raises the productivity of adult sons and thus the returns from producing sons with female human capital, and it increases income. Thus even if women do not participate in agricultural production ($\kappa = 0$) and even if income effects are insignificant, increases in agricultural productivity lead to an increase in the local demand for female human capital that is derived from their complementary role in producing sons, sons who will be more productive as a result of the local technology change.

The local increase in productivity does not favor investments in girls, however, conditional on the

\textsuperscript{7}In particular,

$$\frac{d h_w}{d \kappa} = -\frac{\partial \pi}{\partial(\kappa h_w)} (\eta + 1) + \frac{\partial^2 \pi}{\partial(\kappa h_w) \partial h_s} \frac{dh_s^w}{d p_{hw}} dh_w^c + \frac{\partial^2 \pi}{\partial(\kappa h_w) \partial h_s} \frac{dh_w^P}{d p_{hw}} + \frac{\partial \pi}{\partial(\kappa h_w)} \frac{dh_w}{d \pi},$$

where $\eta = \frac{\partial \log(\partial \pi/\partial(\kappa h_w))}{\partial \log(\kappa h_w)}$ and $c$ denotes a compensated price effect.
market price of female human capital \( p_h \), as girls do not participate in the local economy. Solving the model conditional on the wife’s human capital \( h_{wi} \) and the market price of female human capital yields the set of partial equilibrium child human capital “supply” equations of the form:

\[
(8) \quad h_{S_i}^s = h_{S_i}^s(\theta_i, A_i, h_{hi}, h_{wi}, p_h)
\]

The effect of local technical change \( \theta_i \), given the mother’s human capital and the human-capital price, on the differential supply of gender-specific human capital is

\[
(9) \quad \frac{d h_{S_i}^s}{d \theta_i} = \frac{d h_{Sc}^c}{d \theta_i} \left[ \frac{\partial h_S^s}{\partial \xi_s} \frac{\partial \pi}{\partial \theta_i} \right] + \frac{\partial \pi}{d \pi} \left[ \frac{d h_{S_i}^s}{\partial \theta_i} - \frac{d h_{d_i}^d}{d \pi} \right]
\]

from which it can be seen that as long as boy and girl human capital are substitutes and income effects do not strongly favor girls, such locally-experienced technology change favors boys.

Similarly, but perhaps more surprisingly given the focus in the literature on the relationship between the mothers’ rate of participation and differential investments in boys and girls, because girls do not participate in the household’s production sector, the extent to which their mothers participate does not lead to increases in investments in girls. In particular,

\[
(10) \quad \frac{d h_{i}^s}{d \xi_i} - \frac{d h_{d_i}^d}{d \xi_i} = \frac{\partial h^p}{\partial (\xi h)} \frac{\partial h^s}{\partial \xi_s} \left[ \frac{d h_{d_i}^d}{d \pi} - \frac{d h_{d_i}^d}{d \pi} \right] + \frac{\partial \pi}{d \pi} \left[ \frac{d h_{i}^s}{\partial \xi_i} - \frac{d h_{d_i}^d}{d \pi} \right]
\]

Expression (10) indicates that if the mother’s human capital and that of her sons are (plausibly) complements in agricultural production, where married women participate more heavily in the farming sector, investments in girls will actually be lower relative to boys, for given marriage-market returns.

Thus, in this model changes in the local role of women as earners, either via changes in culture (supply) or through changes in technology that make women more productive as workers (demand), do not lead to increased relative investments in girls unless there are also changes in the market price of female human capital \( p_h \). The observed positive cross-sectional relationships between sex-ratios in labor force participation and in child survival thus must reflect the joint operation of unmeasured cultural factors on gender preference, bargaining power influences or non-local factors that affect \( p_h \).\(^8\) Increases in the marriage-
market price of female human capital $p_h$, however, will lead to relatively more investments in girls:

$\frac{dh_s}{dp_h} - \frac{dh_d}{dp_h} = \left( \frac{dh_s^{Sc}}{dp_{xd}} - \frac{dh_d^{Sc}}{dp_{xd}} \right) \frac{\partial h_d}{\partial x_d} + (h_d - h_w) \left[ \frac{dh_s}{d\pi} - \frac{dh_d}{d\pi} \right],$

unless there are strong offsetting differential income effects.

b. General Equilibrium

To the extent that technical change and cultural factors associated with women’s role in earnings activities are spatially correlated, local changes in technology and women’s labor force participation rates will not be independent of the human capital price, if there is a market for female human capital. To understand how technological change and cultural factors affect differential boy-girl human capital investments thus requires attention to the equilibrium marriage market and to how changes in technology or changes in the culture of women’s work affect the equilibrium price of female human capital. If the price $p_h$ equilibrates the demand for wife’s human capital, then

$\sum_{i \in I_1} h_w^D(\theta, A, h_h, p_h, p_x) = \sum_{i \in I_2} h_d^S(\theta, A, h_h, h_w, p_h, p_x)$

where $I_1$ denotes the set of households at a given point of time in stage 1 (acquiring a spouse) and $I_2$ denotes the set of households in stage 2 (producing and receiving a return on child human capital). Solving implicitly gives expressions for the equilibrium price

$\frac{dh_s}{dp_h} - \frac{dh_d}{dp_h} = -\left( \frac{dh_s^{Sc}}{dp_{xd}} - \frac{dh_d^{Sc}}{dp_{xd}} \right) \frac{\partial h_d}{\partial x_d} + \frac{\partial \pi}{\partial h_w} \left[ \frac{dh_s}{d\pi} - \frac{dh_d}{d\pi} \right],$

from which it can be seen that as long as the sons’ and the head’s human capital are complements in production, more schooled heads will be associated with more schooled sons. The effect of variation in the wife’s human capital on the sex differential is more complicated, reflecting the roles of her human capital in both household and farm production:

$\frac{dh_s}{dh_w} = -\frac{\partial^2 \pi}{\partial x_h \partial h_s} + p_{xs} \frac{\partial^2 h_s^p}{\partial h_w \partial x_d} \frac{\partial h_c}{\partial p_{xs}}$

Two sufficient conditions to obtain the result that more educated mothers are associated with greater investments in the human capital of daughters in environments in which girls are provided less resources on average than are boys are that mother’s and sons’ human capital are substitutes in production and that there is complementarity between the mother’s human capital and human capital inputs $x$. In that case, given diminishing returns, the marginal productivity of girl-specific inputs will be higher than that for boys among more educated mothers.
(13) \[ p_h = p_h(\theta, k, A, h_k, h_w, p_x), \]
where the bold figures denote the vector of the corresponding variables within all of the localities in the relevant marriage market.

Substitution of (13) into (8) yields an expression for the local supply of daughters’ and sons’ human capital

(14) \[ h_{si}^S = h_{ki}^S(\theta, k, A, h_k, h_w, p_x, \theta, k, A, I, h_k, h_w, p_x) \]
in terms of (local) household characteristics as well as the vectors of household characteristics in the marriage market. Similarly, substitution of (13) into (6) yields an expression for the demand for the human capital of newly married wives

(15) \[ h_{wi}^D = h_{wi}^D(\theta, k, A, h_k, h_w, p_x, \theta, k, A, h_k, h_w, p_x) \]

Equations (14) and (15) distinguish between local and marriage-market effects. This distinction is important not only because it captures a realistic feature of marriage patterns in rural India. Absent such a distinction, it would not be possible to identify whether and how households respond to changing returns to human capital investments associated with technical change or to interpret locale-specific relationships between women’s labor-force participation rates and sex-differentials in child survival in the absence of observations on \( p_h \). To see this, note that the effect of a change in technology in one of the localities \( j \) in the marriage market in which household \( i \) belongs on the equilibrium female human capital price, obtained by differentiating (13) with respect to technical change in \( j \), is a function of the partial equilibrium demand and supply relationships derived from the model

(16) \[ \frac{dp_h}{d\theta_j} = \frac{\sum_{i \in I_1} dh_{si}^S/d\theta_j - dh_{wi}^D/d\theta_j}{\sum_{i \in I_1} dh_{wi}^D/dp_h - \sum_{i \in I_2} dh_{si}^S/dp_h}, \]

where \( I_1 \) (\( I_2 \)) denotes the set of stage one (two) households in sub-region \( j \). As long as there are diminishing returns to the mother’s human capital in producing daughters’ human capital and mother’s and sons’ human capital are not strongly complementary so that \( dh_{wi}^D/dp_h < 0 \), an increase in productivity anywhere in the
marriage market raises the equilibrium price of female human capital $p_h$. Thus, technical change occurring outside of locale $i$, given local technical change $\theta_i$, in contrast to the effect of a change in technology within $i$ but nowhere else, favors the female children in $i$:

$$\left(17\right) \quad \frac{dh_s^{S^*}}{d\theta_j} - \frac{dh_d^{S^*}}{d\theta_j} = \left[\frac{dh_s^S}{dp_h} - \frac{dh_d^S}{dp_h}\right] \frac{dp_h}{d\theta_j} < 0.$$  

Similarly, technical change occurring outside of $i$ but elsewhere in the marriage market to which $i$ belongs, given $\theta_i$, decreases the demand for wives’ human capital in $i$:

$$\left(18\right) \quad \frac{\partial h_w^*}{\partial \theta_j} = \frac{\partial h_w}{\partial p_h} \frac{\partial p_h}{\partial \theta_j} < 0$$

which is opposite in sign from the effect of local technical change on the demand for female human capital.

In the absence of measures of the changes in technology in the marriage market or of the market price of female human capital, however, the total effect of a change in technology within $i$ on the sex differential in children’s human capital is indeterminate:

$$\left(19\right) \quad \frac{dh_s^{S^{**}}}{d\theta_i} - \frac{dh_d^{S^{**}}}{d\theta_i} = \frac{dh_s^S}{d\theta_i} - \frac{dh_d^S}{d\theta_i} + \left[\frac{dh_s^S}{dp_h} - \frac{dh_d^S}{dp_h}\right] \sum_j \frac{dp_h}{d\theta_j} \frac{d\theta_i}{d\theta_i}$$

The sign and magnitude of (19) depends on the strength and sign of the relationship between the local change in technology and that occurring in all of the marriage-market localities - the spatial autocorrelation of technological change. Indeed, because of the opposing local and market demand and supply effects, it would not be possible to determine the effect of technical change on relative human capital investments if there were no intervillage exchange of daughters, as in that case $\theta_i$ and $\theta_j$ would coincide. Thus the fact that, due to exogamy, the returns to investments in boys are local and the returns to investments in girls are regional aids in the identification of the effects of incentives associated with economic growth on sex-differentiated human capital investments.

2. Data

The model suggests that to identify whether and how economic growth affects economic incentives to

$$\frac{dh_w}{dp_h} = (1 - \frac{\partial h_w^p}{\partial h_w}) \frac{dh_w^c}{dp_h} - \frac{\partial h_w^p}{\partial x_d} \frac{dh_w^c}{dp_h} + (h_d - h_w) \frac{dh_w}{d\pi}$$
invest in the human capital of boys and girls in the Indian context requires time-series data that enables the construction of both local and regional (marriage-market) variables. We use data from two national probability surveys of rural Indian households carried out in 1970-71, the National Council of Applied Economic Research (NCAER) Additional Rural Investment Survey (ARIS), and 1981-82, the NCAER Rural Economic Development Survey (REDS). Both surveys were of approximately 4500 households. The first was administered to households in 259 villages in 16 Indian states. The second survey was administered in the same villages, except for villages in the state of Assam. Each survey elicited information on the demography of the households, inclusive of a complete birth and death history for children; the family size and sex preferences of mothers; the socioeconomic characteristics of all household members; aspects of production costs and returns, and village infrastructure.

The existence of comparable household surveys at two points in time separated by 11 years enables the construction of a panel data set at the lowest administrative level, the village, for 245 villages that can be used to assess the effects of the changing local and marriage market economic circumstances on household allocations and preferences. There are three other key features of the data: First, the initial survey took place in the initial years of the Indian green revolution, when rates of agricultural productivity growth began to increase substantially in many areas of India. Second, two-thirds of the households surveyed in 1981-82 were the same as those in 1970-71. This household panel was used by Behrman et al. based on methodology developed in Foster and Rosenzweig to estimate rates of technical change for each of the villages between the two survey dates. Third, because the names of the villages are provided in the data along with their district and state affiliations and because of the spatially clustered sample design, it is possible to identify and construct variables characterizing regional marriage markets that, as the model suggests, may be critical determinants of sex differentials in human capital investments in the context of patrilocal exogamy and that are not based on arbitrary administrative boundaries.¹⁰

¹⁰Another advantage of the data set over those constructed from district aggregates is that we can match the characteristics of children to their parents and, in general, respondents to their behavior. The matching of parents to children cannot be performed with aggregate census data.
We use the measures of the village-specific rates of technical change over the period 1971-82 and the survey data aggregated at the village and marriage-market levels to form panel data sets to estimate the determinants of changes in sex-differences in mortality, differences in the preferred number of boys and girls, the demand for literate wives, and rates of agricultural labor-force participation by married women. We constructed village-level rates of mortality by sex at the two survey dates from the individual retrospective fertility/mortality histories for all children born no more than five years preceding each survey, to minimize recall error, by summing, using the appropriate survey-specific sampling weights, all the deaths and births in each of the five-year periods for each village. We then obtained for each village/year the mean schooling (literate or not, completed primary schooling or not) levels and mean wealth of the parents of those children born in the intervals that were used to construct the aggregate mortality rates. We also constructed for each village/year the mean number of boys and girls that were reported as an “ideal” family by the married female respondents in the two surveys.

To carry out the analysis of the demand for schooled women in the marriage market a second village-level panel was constructed from the two household surveys containing information on the proportion of women who had married into the villages in the five year interval preceding each survey and who were literate, the proportion of their new husbands who had completed primary schooling and the mean wealth of the husbands’ families. Finally, to examine the determinants of changes in female labor force participation, we constructed village-level aggregate variables for all married women aged 25 through 59 measuring the proportion who participated in agricultural activities, who were literate and who had husbands who had completed primary schooling along with their average family wealth.

Table 1 provides the means and standard deviations for the constructed village-level variables for the 1970-71 round and the mean change for each variable over the 1971-82 period. As can be seen, as observed for the Census-based sex-ratio data, the average death rate differential between boys and girls born in the period 1966-71 favored boys, and this differential worsened somewhat over the period 1971-82. Both the mortality differential favoring boys and its change over time are consistent with the level of and change in the
sex preferences expressed by the surveyed mothers - on average mothers preferred to have a completed family size with slightly more than one half more boys than girls in 1970-71, and this differential also increased slightly, to .7, by 1982. In the same period when the desired and actual deficit of girls did not fall, however, on average participation rates by married women in agricultural activities rose dramatically, from 17% to 55% and the literacy rates of the mothers of the children more than tripled, suggesting that increases in the “economic returns” from women’s work and the increased literacy of mothers did not give rise to lessened favoritism towards males. And, in the same time period, output per acre rose by 24%. As we will see, however, these aggregate statistics mask important relationships between economic growth, and indirectly, female labor-force participation, and differential survival by sex.

3. The Marriage Market

A central implication of the model, given the presence of patrilocal exogamy and geographically determined marriage-markets, is that the relative return to sons and daughters should be differentially affected by local (i.e., village) and regional (i.e., marriage-market specific) technical change, with local technical change increasing the relative return to sons and regional technical change increasing the relative return to daughters. Identification of economic growth effects on sex bias in human capital investments in the Indian context thus requires distinguishing between local and marriage market influences. To construct the marriage-market aggregates for our data, we geo-coded all of the survey villages by latitude and longitude based on the village names, their district-state affiliations, and detailed district-level maps. A critical empirical issue, however, is the geographic span of the marriage market. Although the data sets we use do not provide information on the geographic origins of the married women in the sample, information from the PGIRCS household survey carried out in the northern state of Uttar Pradesh and the southern state of Karnataka in 1994 (Rao et al.) indicated that in both states at least 90% of the imported brides had come from villages within 67 kilometers of the sample villages. Based on this information pertaining to marriage migration and the

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11 11 villages could not be located on maps. These are dropped from the sample of villages. Estimates excluding the marriage-market variables obtained using all of the villages and obtained using only geo-coded villages were not qualitatively or statistically different.
geo-codes in our data set, we therefore encircled each of the 234 surveyed villages that we could locate using a radius of 67 kilometers to form a set of village groups that would share the same geographic marriage market. We then constructed aggregates of the technical change variable and the relevant variables characterizing the parents of the newly married and of young children from those households residing in the sampled villages within each of the radius-based marriage markets for the two survey years.

Given the evidently limited breadth of the marriage market relative to the vast size of India, without spatially-clustered sampling it would be almost impossible to obtain reasonably reliable estimates of marriage market aggregates. Due to the cluster design of the survey, however, the average number of sample villages within each 67-kilometer marriage “market” is 3.79, corresponding to an average of over 50 households per marriage-market. Correlations between the village variables and the radial-based marriage-market aggregates are high, as expected given the scope of the markets, but are not perfect - for example, the correlation between the village and regional female agricultural participation rate is .67 and that for crop productivity growth is .49. Figure 3 displays the location of the sample villages, Indian district boundaries and, to scale, the 67km-radius marriage market boundary. As can be seen, using radial distance rather than administrative boundaries yields a significantly different set of marriage markets for each village. Two or more districts are represented in almost 30% of the marriage markets defined by radial distance, and in over 30% of the districts there were at least two distinct distance-based marriage markets.

In order to further assess whether our spatial constructs plausibly correspond to marriage markets and to compare them with district-based measures, we estimate a linear approximation to equation (13) determining the equilibrium human capital of brides and test the predictions of the model with respect to the effects of local and marriage-market specific technical change using both our 67 kilometer-based marriage-market variables and district-level aggregates. The model suggests that, given the short-run fixed supply of educated brides, if high rates of technical change in the village increase the demand for more schooled brides, then for given technical change in the village, higher rates of technical change in the relevant marriage market will result in an equilibrium in which less educated brides are imported in the village.
The equation we estimate is

\[
\begin{align*}
h_{\text{wit}} &= \theta_{\text{it}} A_{\text{it}}^2 + 3 h_{\text{hit}} + 4 p_{\text{xit}} + 5 \kappa_{\text{i}} + 6 \tilde{\theta}_{\text{it}} + 7 \tilde{A}_{\text{it}} + 8 \tilde{h}_{\text{hit}} + 9 \tilde{h}_{\text{wit}} + 10 \tilde{p}_{\text{xit}} + 11 \tilde{\kappa}_{\text{i}} + 12 \tilde{\theta}_{\text{wit}} + w_{\text{wit}}
\end{align*}
\]

where the subscript \(t\) denotes time; the bars above variables denote that they are marriage-market aggregates, so that \(\tilde{A}_{\text{it}}\) measures the average asset holdings of stage-one households in villages constituting the marriage-market for village \(i\) and so forth; unobserved culturally-determined aspects of the return to female on-farm employment \((\kappa_{\text{i}})\) are assumed to be time invariant; \(w_{\text{wit}}\) denotes an i.i.d. mean-zero taste shock, and \(\tilde{\theta}_{\text{wit}}\) is the marriage-market average of these shocks.

Because, as discussed in footnote 3, maternal human capital affects investments in children who then remain on the farm (sons) or who are exported to other households in the marriage market (daughters), OLS estimation of (20) given the unobservability of the cultural variables \(\kappa_{\text{i}}, \kappa_{\text{y}}\) will in general yield biased estimates of the coefficients. This problem may be addressed in part by estimating (2) in cross-time differences:

\[
\begin{align*}
h_{\text{wit}} &= \theta_{\text{it}} A_{\text{it}}^2 + 3 h_{\text{hit}} + 4 p_{\text{xit}} + 5 \kappa_{\text{i}} + 6 \tilde{\theta}_{\text{it}} + 7 \tilde{A}_{\text{it}} + 8 \tilde{h}_{\text{hit}} + 9 \tilde{h}_{\text{wit}} + 10 \tilde{p}_{\text{xit}} + 11 \tilde{\kappa}_{\text{i}} + 12 \tilde{\theta}_{\text{wit}} + w_{\text{wit}}
\end{align*}
\]

in which fixed cultural unobservables are swept out. There is still a problem, however, because an exogenous (say, taste-driven) shock to the demand for wives’ human capital in period \(t\) will, given the model, result in, among other things a higher level of husband’s human capital (because period \(t+1\) husbands are the sons of the period \(t\) wives), thus inducing a correlation between the differenced regressors in (21) and the differenced residual. To eliminate this correlation, we employ instrumental variables, using the initial values of the variables in (21), which will be uncorrelated with the differenced residuals given the assumption of i.i.d. taste shocks, as instruments.

The model also suggests, however, that the residuals, containing aggregated taste shocks, will be spatially correlated within marriage markets. Moreover, to the extent that marriage markets overlap, there may be correlations across marriage markets. We divided the 234 geo-coded sample villages into 84 clusters in such a way that any two villages not in the same cluster are separated by more than 67 kilometers. Given the spatial clustering of villages and the resulting non-overlapping marriage market structure, standard errors are
The overall precision of the estimates is reduced by the fact that the number of villages importing new brides in the five-year interval preceding both surveys is only 169.

The first column of Table 2 reports the fixed-effects, instrumental-variables (FE-IV) estimates of the determinants of the proportion of new brides - women married in the five years preceding the survey - who are literate as a function of own village and marriage-market variables, where the marriage market is assumed to be the district in which the village is situated. The marriage market variables include, in addition to the aggregate technical change variable, the proportion of marrying men in the market who have completed primary school, and who thus are competitors with the schooled men in the village, and the schooling and average wealth of the parents of the brides in the marriage market, which presumably determine in part the supply of schooled brides to the market. The first-column estimates indicate that, given marriage-market conditions outside the village, higher rates of technical change in the village are associated with a higher demand for literate wives, but, as the model suggests, if the village is situated in a marriage market (district, in this case) that also has a high rate of technical change, less-schooled brides are able to be attracted to the village. These results together thus suggest that technical change increases the demand, via the marriage market, for women with higher levels of human capital. However, the marriage-market variables are only marginally significant, and the marriage-market groom’s schooling coefficient, although statistically insignificant, is the wrong sign.

In the second column of Table 2, the estimates obtained using the radial-distance-based marriage market variables instead of the district-based measures are reported. The marriage-market variable coefficients are now estimated with more precision, and the marriage-market groom’s schooling coefficient is now the theoretically-correct sign. These results, based on plausible spatial market structures rather than somewhat arbitrary administrative constructs, are thus more strongly consistent with the hypothesis that competition in the marriage market affects the human capital of the brides imported in any village, with technical change

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12The overall precision of the estimates is reduced by the fact that the number of villages importing new brides in the five-year interval preceding both surveys is only 169.
clearly increasing the demand for higher levels of human capital among young women in the marriage market.

To further assess whether the 67-kilometer radial boundary is appropriate, as suggested by the PGIRCS, we add to the second-column specification technical change variables aggregated using radii of 314 kilometers and 1000 kilometers, respectively. The estimates for this expanded specification are reported in the third column of Table 2. As can be seen, neither of the technical change coefficients for the distances beyond 67 kilometers are statistically significant (they are also not jointly significant), and their inclusion does not alter significantly any of the other coefficients relative to their magnitudes in the specification in which these variables are excluded. We conclude therefore that the groupings of villages into clusters based on the 67-kilometer radius criterion provides a reasonable approximation to the relevant set of marriage-markets for the survey data.

4. Determinants of Sex Bias

We employ a similar estimation procedure to estimate growth effects on sex biases in human capital investment using the marriage-market aggregates. The major difference in specification is that, as discussed above, we now condition on maternal literacy. As for the wives demand equation, differencing the linear approximation to the human capital supply for children of sex $k$, given by (8), across time periods removes fixed cultural attributes:

$$h_{kit} = \theta^1_k t + 2k \ A_{kit} + 3k \ h_{hit} + 4k \ p_{xit} + 6k \ \tilde{\theta}^7_k + 7k \ \tilde{A}_{it}$$

$$+ 8k \ h_{hit}^\prime + 9k \ \tilde{h}_{wit}^\prime + 10k \ \tilde{p}_{xit}^\prime + 11k \ \tilde{h}_{wit}^\prime + \ k_{it}$$

where $h_{kit}$ is measured both (inversely) by the death rate of children of sex $k$ in the five-year period preceding $t$ and by the preferred number of children of sex $k$ reported by mothers. The variables with bars are the relevant period-one marriage market variables in time-period $t$ that forecast the demand for and supply of female human capital in the second period, including the average wealth and schooling attainments of the parents of children born in the past five years in the regional marriage market.

We also difference the human capital equation across children of opposite sex in order to obtain the effects of technical change and other variables on differences in human-capital investment by sex, in conformity to the theoretical expression (17):
The post-birth fertility interval may also affect mortality, and this may be influenced by the gender of the child born.

\[ D_h_{kit} = D_{1k} \theta_{it} + D_{2k} A_{it} + D_{3k} h_{hat} + D_{4k} p_{xt} + D_{6k} \theta_t + D_{7k} \tilde{A}_{it} + D_{8k} \tilde{h}_{kit} + D_{9k} \tilde{h}_{wit} + D_{10k} \tilde{p}_{xit} + D_{11k} \tilde{h}_{wii} + D_{kit} \tilde{A}_{kit} \]

where \( D_{1k} = 1s - 1d \) and so forth and \( D_h_{kit} \) is the over-time change in the mortality sex differential and the preferred difference in numbers of boys and girls. Note that by differencing mortality and preferred children by sex we also remove to a first-order the effects of changes in unmeasured factors that influence total family size and thus, indirectly, the overall level of mortality. In particular, because parents cannot determine \textit{ex ante} the sex of a particular child, variables such as contraceptive availability, fecundity, or tastes for children that influence mortality by affecting the timing of a particular birth and which are both unmeasured and may vary over time should, to first order, have the same impact on the probability of death regardless of the sex of the child. Differencing by sex removes the confounding effects of these fertility-related factors.\(^{13}\)

As for the marriage equation, period-t shocks to human capital supply will in general be correlated with the right-hand-side time-differenced human capital measures and other time-differenced state variables and initial period state variables can serve as instruments for the over-time differenced variables. However, wives’ human capital in period t is not a legitimate instrument for differenced wives’ human capital because the shocks to maternal human capital demand at the level of the village (\( \tilde{w}_{it} \)) and marriage market (\( \tilde{w}_{it} \)) and those from child human capital supply (\( D_{kit} \) and \( iD_{kit} \), respectively) will be correlated. For example, early period shocks that affect human capital investment in female children will be manifested in the change in the stocks of capital of young mothers in the marriage markets over the 11-year interval of the data. In this case, the values of \( \theta \) in the village and the regional marriage market at the time when the mothers in periods t and t+1 were married are legitimate instruments because, as is evident in equation (15), the demand for wives’ human capital at a particular point in time is affected by the local and regional rates of technological progress at that time. Lagged technology shocks in the village and in the marriage markets thus affect the human capital of mothers but do not have a direct effect on current human capital investments given the current values of \( \theta \) and \( \theta \) bar. As in Behrman et al., we thus divided up the years in which the women married into three intervals

\(^{13}\)The post-birth fertility interval may also affect mortality, and this may be influenced by the gender of the child born.
- pre-1971, when technical change is assumed to be minimal, 1971-76 and 1977-81 - and created dummy
variables for each interval. These dummy variables interacted with the 1971-82 technical change variable were
then utilized as instruments for change in wives’ human capital between 1971 and 1982.

Table 3 presents the estimates of the determinants of the difference (boys minus girls) in the sex-
specific mortality of children born in the last five years prior to the survey date. We first report in column one
OLS estimates based only on the 1971 cross-section and that excludes the marriage-market variables. The
specification thus ignore both the existence of unmeasured, area-specific cultural factors and exogamy, as im
many of the studies of Indian sex-specific survival rates. These results indicate a weak effect of maternal
literacy on differential mortality, with a doubling of maternal literacy resulting in a marginally significant .01
increase in the morality differential, presumably through a relative decline in female mortality. The second
column presents results based on the preferred FE-IV procedure but again ignoring the effects of marriage-
market characteristics. While these estimates yield a statistically significant effect of maternal literacy on
differential mortality, there appears to be little evidence of an effect of technical change on mortality
differentials, and thus no evidence that mortality differentials by sex respond to economic growth.

If, however, as predicted by the model, local and regional-specific technical change have opposite
effects on sex differences in mortality and if, as seems plausible, technical change is spatially autocorrelated,
then one might expect based on (19) that estimates that do not control for technical change in the relevant
marriage market would bias towards zero the estimates of technical change effects at the local level. This is
confirmed by the results in column 3. With technical change for both the village and the marriage-market
included in the specification, consistent both with exogamy and with the responsiveness of human capital
investments to investment returns, the estimate of the effect of local technical change on the mortality
differential is negative and statistically significant and the estimate of the effect of technical change occurring
in the marriage market on the local differential is positive and statistically significant. In particular, the
estimates indicate that a 10 percent increase in local technical change, at the mean, results in a 2.6 point drop
in male relative to female child mortality, while a 10 percent increase in technical change in the marriage
market results in a 2.6 point relative decrease in female male mortality.

The estimated effects of marriage-market specific technical change might be biased, given the model, if marriage-market conditions other than technical change are correlated with technical change and influence differential mortality. Indeed, when these characteristics are also included (column 4), the effect of technical change in the marriage market is larger and more significant, with a 10 percent increase resulting in a 3.4 point relative decrease in female mortality.

Several other aspects of the preferred specification (column 4) are also of note. As might be expected given that other villagers in the marriage market are, in effect, competitors in the supply of human capital, the effects of the other included variables on mortality differentials at the local and regional level, are of opposite signs, although in several cases the estimates are not significantly different from zero. Thus, for example, while a doubling of local female literacy results in a 3 point increase in the relative mortality of boys (thus increasing the relative supply of girls), a doubling of female literacy in the region as a whole results in a 10 point decrease in the relative mortality of boys, although the latter effect is not precisely measured. Finally, consistent with the cross-sectional evidence from the literature (e.g., Drèze and Sen) there appear to be no effects of wealth or health centers on differential mortality. The reduction in the mortality disparity between boys and girls associated with technical change thus appears to be due mainly to the change in the returns to human capital investments. The lack of importance of income effects evidently provides a misleading picture of how income growth fueled by technical change affects gender differences in human capital investments.

An alternative explanation for the estimates in Table 3 is that rather than capturing differential incentives for sex-specific investments they merely reflect the demand for overall health care and changes in the level of health care which might, given different prevailing rates of mortality by sex, differentially affect survival of male and female children. Table 4 presents the same specifications replacing the mortality differential by the reported family-size preferences by sex as measures of the sex-specific returns to human capital investment. These results generally mirror those arising from the mortality data, consistent with the hypothesis that the mortality differences at least in part reflect sex preferences and not only biological
influences. The correspondence is particularly close for the variables of greatest interest, those relating to technical change and wealth.\textsuperscript{14} In particular, without controls for marriage-market specific technical change there is an insignificant effect of village-level technical change on sex-specific preferences. Again, however, when both local and regional technical change are included (column 3) they are both significant, and opposite in sign from the corresponding coefficients in Table 3, while the coefficients associated with the wealth variables are not statistically significant. In the preferred specification which includes marriage-market aggregates of all the included village-level right-hand side variables, the estimates indicate that a 10 percent increase in village technical change results in a .097 increase in the preferred “deficit” of girls, while a 10 percent increase in marriage-market specific change results in a .342 decrease in the deficit. These estimates imply, given the 1970-71 average degree of son preference reported in Table 1 (.531), that a uniform 10 percent increase in technical change would have resulted, \textit{ceteris paribus}, in a 46 percent reduction in the degree of son-preference. Economic growth evidently can reduce the number of missing women, even in the absence of changes in cultural institutions and even when household gender preferences are insensitive to income variation.

5. Specification Test: Local Technical Change and Maternal Employment

Because the conclusion that excess female mortality is responsive to the relative returns to female and male human capital rests importantly on the findings that village and marriage-market specific technical change have opposite effects on sex differentials in mortality, on preferences, and on the demand for wives’ human capital it is important to consider whether this pattern of results might be attributable to specification error. As an additional empirical test of whether the aggregated regional variable effects plausibly represent marriage-market influences and to assess the role, if any, of changes in maternal earnings contributions in

\textsuperscript{14}One interesting difference between the results for gender differentials in mortality and maternal gender preferences is that maternal literacy has a statistically significant effect on the former but not on the latter. These findings may suggest that maternal schooling has an effect on the efficiency of resource allocations that affect survival rather than on maternal gender preference. For example, consistent with the expression in footnote 8, increases in the productivity of investment resources can have a greater impact on girls if average resource allocations to girls are lower.
Suppose that \( h_{wi} = \theta_i^* + e_i, \ \theta_i = \theta_i^* + u_i, \ Var(u_i) = Cov(u_i, u_j) = A, \) and \( Cov(\theta_i^*, \theta_j^*) = B, \) and that there are a large number of villages in each marriage market. Then a regression on \( h_{wi} \) and \( \theta_i \) yields local and regional coefficients with opposite signs: \( \bar{h}_{wi} = \theta_i^* - A/(A + B)\bar{\theta}_i. \)

The most plausible alternative explanation for the finding that both local and regional measures of technical change affect local human capital investments is that only true technical change experienced by the village matters for investments in the village but the technical change index is measured with error. This simple measurement-error model, however, cannot reproduce the observed pattern of technical-change effects unless (true) technical change exhibits negative spatial autocorrelation, which seems implausible. With true positive spatial autocorrelation, measurement error would bias the local technical change toward zero and the regional technical change measure away from zero in the opposite direction so that both coefficients would be of the same sign. In order for the technical change coefficients to exhibit opposite signs the measurement error component must itself be spatially autocorrelated and that autocorrelation must be stronger than that for the true component.\(^{15}\) Spatial autocorrelation in measurement errors might emerge, for example, given that a profit function was used to obtain the technical change estimates if there is an unobserved price that is spatially autocorrelated and influences agricultural profitability.

We address this potential concern empirically by examining the effects of local and regional technical change on the employment of married women in agriculture which, given the relative absence of labor migration, should not be affected by regional technical change. If the same pattern of opposite signs on local and regional technical change is not found for this variable then the possibility that measurement error

\(^{15}\)Suppose that \( h_{wi} = \theta_i^* + e_i, \ \theta_i = \theta_i^* + u_i, \ Var(u_i) = Cov(u_i, u_j) = A, \) and \( Cov(\theta_i^*, \theta_j^*) = B, \) and that there are a large number of village in each marriage market. Then a regression on \( h_{wi} \) and \( \theta_i \) yields local and regional coefficients with opposite signs: \( h_{wi} = \theta_i^* - A/(A + B)\bar{\theta}_i. \)
underlies the other results can be ruled out.\footnote{Although we do not explicitly model women’s time allocation in this paper, the specification of the profit function, $\pi(\theta,A,t,h_{hi},h_{si},h_{wi})$, may be thought of as the result, in part, of choices about how women’s time is allocated between agriculture and some other (local) activity with a fixed return given their level of human capital. Under these conditions, given the assumed separability of women’s time allocation from other decisions, agricultural participation should depend on local technical change, assets, husband’s and sons’ human capital, but not on regional technical change. It may also be established in this context that sufficient conditions for high human capital women to be more productive in high-technical change areas at least in part due to their higher productivity in these areas.}

We employ the same specification and estimation procedure to estimate the determinants of maternal agricultural employment that we used to estimate the determinants of the sex differentials in mortality and maternal preferences, except that we add weather variables that might influence the short-term demand for labor. The survey data provide at the village level information on whether or not the village had experienced in each of the survey years weather conditions that adversely affected crops, and we include this variable along with its aggregate marriage market counterpart in the specification.

Column one of Table 5 reports the FE-IV estimates of the determinants of the female agricultural participation rate excluding the regional aggregate variables. The estimates indicate that in villages with higher rates of agricultural technical change, rates of participation in agricultural activities by married women rose significantly. Although the female literacy coefficient is negative, the fact that it is not significantly different from zero provides support for the notion that high human capital women are more valued in high-technical change areas at least in part due to their higher productivity in these areas.\footnote{Behrman et al. find substantial evidence that the higher demand for female human capital can be explained largely with reference to the value of maternal human capital in the production of child schooling. They also find little evidence that female human capital affects HYV adoption and profitability, suggesting that any returns do not operate through more effective management of new technologies. Apparently, to the extent that high technical change increases the demand for women’s human capital it does so only by expanding the market for unskilled agricultural labor.}

The point estimate of the village-level technical change effect, which indicates that a 10\% increase in crop productivity is associated with a 37\% increase in women’s participation (at the 1970-71 mean) is, moreover, robust to the inclusion of the marriage-market aggregates (column two), which are jointly
statistically insignificant - neither technical change outside the village nor contemporaneous weather conditions there have any effect on female agricultural employment within the village, as expected. These results thus suggest that the regional effects observed for the sex-differentiated child investments are the result of marriage market influences. Moreover, the finding that married women increased their participation in agricultural activities in high-growth villages, coupled with the estimates in Tables 3 and 4 that, for given rates of technical change in the external marriage market, increased rates of technical change in the village favored investments in boys, indicates that this increase in boy bias occurred despite the increased participation in earnings activities by mothers. This suggests that growth effects on sex biases in human capital investments at the local level dominated any influences of the increase in the earnings contributions of mothers.18

6. Conclusion

While there is general agreement that sex differences in child survival in South Asia are related to the perceived economic value of girl and of boy children, there is little consensus about the underlying sources of variation in these values as well as the potential for economic and policy change that might reduce excess female mortality. The results of this paper address two significant aspects of this debate: whether household gender bias and the relative survival rates of boys and girls are responsive to economic returns and the extent to which sex differentials in mortality can be influenced by income growth without radical alteration of social institutions.

Because most of the literature on sex differentials in mortality in India has made use of cross-sectional data, it has tended to emphasize the importance of relatively unchanging and perhaps unchangeable attributes of different regions of India. Regardless of whether the characteristics of interest are modes of agricultural production (Bardhan, 1974) or cultural mores such as those arising from kin intermarriage (Dyson and Moore) this perspective, combined with weak cross-sectional relationships between income and sex-specific survival

18We do not attempt to estimate the direct effect of maternal participation in earnings activities on the sex bias variables because we do not have a plausible instrument. Local shocks to productivity, for example, affect both the maternal decision to work and the returns to investments in the children and technical change in the village affects both the returns to agricultural activities for women and also directly the returns to investments in boys.
rates, has led to policy prescriptions that are pessimistic about growth-promoting initiatives compared with effecting direct social change as the best means of reducing gender differentials in investments. Our results based on panel data covering the initial years of the Indian green revolution, which are consistent with the cross-sectional findings on the weakness of income effects, however, provide strong support for the proposition that increases in productivity arising from technical change without radical alterations in cultural institutions can significantly affect differentials in mortality through their effects on the returns to human capital investments.

In addition to providing support for the general hypothesis that sex-differentials in mortality are sensitive to returns to human capital, our results show the importance of accounting for institutional details in the analysis of sex differentials in mortality. Indeed, we used the attributes of one major cultural institution in India, exogamous marriage, within a general equilibrium framework, to aid in the identification of the effects of technical change on sex-specific household preferences and investments. Consistent with this, and interactions between agricultural technical change and human capital returns, we found evidence that high human capital women tend to be in demand within areas of high technical change and that relative preference for female children and the relative survival of female children increase when there is technical change in the marriage-market destination areas for girls. By contrast, local technical change tends to favor sons. Because in this context the local and regional technical change effects are offsetting and technical change is spatially autocorrelated, an analysis that did not distinguish between local and regional effects that arise from marriage-related migration might incorrectly conclude that mortality differentials are only weakly affected by changes in economic returns arising from economic change. Our findings suggest that, despite the offsetting effects of local and regional technical change, the latter are sufficiently strong so that on net more rapid economic growth, at least that propelled by agricultural technical change, favors girls. On the other hand, we found no evidence that increased maternal employment was related to the more favorable treatment of daughters, given marriage market returns.

The pattern of results relating technical change by region to sex preference, mortality differentials, and
the demand for wives’ human capital, also suggests that, at least at the margin, marriage markets operate sufficiently well to reward parents for investment in their daughters if there are returns to those investments in the economy. The migration of daughters from their parental homes is not the root cause of gender differences in parental investments as many have suggested. This result that may have additional implications for social policy. In the absence of such marriage-market rewards, attempts to redistribute resources such as with legislation requiring daughters to provide support for their parents as discussed, for example, in DasGupta (1987) may have the desired effect of reducing female mortality. On the other, hand, if marriage markets operate efficiently and price returns appropriately, intergenerational redistributive policies will have little effect on parental investments in girls. The evidence in this paper that parents’ decisions about the allocation of scarce resources toward their daughters are importantly responsive to economic conditions in the relevant marriage market support the latter view. Our results thus point to the potential effectiveness of changes in policy that augment economic growth and increase the overall economic value of women’s human capital in reducing the number of “missing” Indian women.
References


#98-06, Brown University, 1998.


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<tr>
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<td>Mean boy-girl difference in death rates, children ages 0-4</td>
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<td>-.0161</td>
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<td></td>
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<td>(.975)</td>
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<tr>
<td>Percent of women 15+ working on farm</td>
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<td>37.8</td>
</tr>
<tr>
<td></td>
<td>(23.1)</td>
<td>(37.2)</td>
</tr>
<tr>
<td>Percent of new brides in last five years literate</td>
<td>18.5</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>(31.1)</td>
<td>(41.7)</td>
</tr>
<tr>
<td>Percent of new grooms in last five years literate</td>
<td>62.4</td>
<td>1.79</td>
</tr>
<tr>
<td></td>
<td>(35.0)</td>
<td>(47.6)</td>
</tr>
<tr>
<td>Percent of new grooms in last five years completed primary school</td>
<td>21.2</td>
<td>28.5</td>
</tr>
<tr>
<td></td>
<td>(32.9)</td>
<td>(41.6)</td>
</tr>
<tr>
<td>Percent of mothers 15-50 literate</td>
<td>11.2</td>
<td>25.6</td>
</tr>
<tr>
<td></td>
<td>(18.3)</td>
<td>(34.5)</td>
</tr>
<tr>
<td>Percent of husbands of mothers completed primary school</td>
<td>23.4</td>
<td>25.9</td>
</tr>
<tr>
<td></td>
<td>(22.6)</td>
<td>(35.5)</td>
</tr>
<tr>
<td>Laspeyres-weighted HYV output per acre</td>
<td>2918.8</td>
<td>694.7</td>
</tr>
<tr>
<td></td>
<td>(954.8)</td>
<td>(966.9)</td>
</tr>
<tr>
<td>Percent of population with health center in village</td>
<td>16.7</td>
<td>7.93</td>
</tr>
</tbody>
</table>
Table 2
FE-IV Estimates: Determinants of the Proportion of New Brides Who Are Literate

<table>
<thead>
<tr>
<th>Variable</th>
<th>District is Marriage</th>
<th>Marriage Market Radius=67 Km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Market</td>
</tr>
<tr>
<td>Own Village</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion of grooms with primary</td>
<td>.264</td>
<td>.347</td>
</tr>
<tr>
<td>schooling</td>
<td>(1.73)^a</td>
<td>(1.91)^b</td>
</tr>
<tr>
<td>Mean wealth (x10^6)</td>
<td>2.57</td>
<td>.662</td>
</tr>
<tr>
<td></td>
<td>(0.89)</td>
<td>(0.44)</td>
</tr>
<tr>
<td>Technical change</td>
<td>.00104</td>
<td>.00159</td>
</tr>
<tr>
<td></td>
<td>(3.34)</td>
<td>(4.86)</td>
</tr>
<tr>
<td>External Marriage Market</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean technical change</td>
<td>-.000587</td>
<td>-.00126</td>
</tr>
<tr>
<td></td>
<td>(1.47)</td>
<td>(1.92)</td>
</tr>
<tr>
<td>Mean technical change &gt;67 Km, &lt;314 Km</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean technical change &gt;314 Km, &lt;1000 Km</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Proportion of grooms with primary</td>
<td>.100</td>
<td>-.305</td>
</tr>
<tr>
<td>schooling</td>
<td>(0.38)</td>
<td>(1.11)</td>
</tr>
<tr>
<td>Mean wealth</td>
<td>-.8.58</td>
<td>-.510</td>
</tr>
<tr>
<td></td>
<td>(1.21)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>Proportion of bride mothers literate</td>
<td>.374</td>
<td>.239</td>
</tr>
<tr>
<td></td>
<td>(1.45)</td>
<td>(1.16)</td>
</tr>
<tr>
<td>Proportion of bride fathers with</td>
<td>-.194</td>
<td>-.191</td>
</tr>
<tr>
<td>primary schooling</td>
<td>(1.17)</td>
<td>(1.37)</td>
</tr>
<tr>
<td>N</td>
<td>338</td>
<td>338</td>
</tr>
</tbody>
</table>
\(^a\)Absolute values of t-ratios in parentheses in column corrected for district-level common error. \(^b\)Absolute values of t-ratios in parentheses in column corrected for marriage-market common error.
Table 5  
FE-IV Estimates: Determinants of the Proportion of Married Women Participating in Agricultural Work

<table>
<thead>
<tr>
<th>Variable</th>
<th>Own Village</th>
<th>External Marriage Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical change</td>
<td>.000914 (2.06)</td>
<td>- -.000077 (0.10)</td>
</tr>
<tr>
<td>Proportion women literate</td>
<td>-.264 (1.03)</td>
<td>-.0580 (1.13)</td>
</tr>
<tr>
<td>Mean age of women</td>
<td>-.00600 (1.21)</td>
<td>-.118 (1.52)</td>
</tr>
<tr>
<td>Proportion husbands completed primary school</td>
<td>.329 (1.85)</td>
<td>.361 (1.97)</td>
</tr>
<tr>
<td>Mean wealth ($x10^{-6}$)</td>
<td>.155 (0.20)</td>
<td>1.05 (0.37)</td>
</tr>
<tr>
<td>Adverse weather in village</td>
<td>-.0580 (1.13)</td>
<td>-.118 (1.52)</td>
</tr>
</tbody>
</table>

N  440  440

*Absolute values of t-ratios in parentheses corrected for marriage-market common error.*
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical change - village</td>
<td>-</td>
<td>-.000143</td>
<td>-.000370</td>
<td>-.000376</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.10)</td>
<td>(2.11)</td>
<td>(2.72)</td>
</tr>
<tr>
<td>Mean technical change - marriage market</td>
<td>-</td>
<td>-</td>
<td>.000336</td>
<td>.000492</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1.79)</td>
<td>(2.80)</td>
</tr>
<tr>
<td>Proportion mothers literate - village</td>
<td>.0540</td>
<td>.177</td>
<td>.164</td>
<td>.164</td>
</tr>
<tr>
<td></td>
<td>(1.60)^a</td>
<td>(2.57)</td>
<td>(2.54)</td>
<td>(2.10)</td>
</tr>
<tr>
<td>Proportion mothers literate - marriage market</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-.558</td>
</tr>
<tr>
<td>Proportion of fathers who completed primary school - village</td>
<td>.0173</td>
<td>-.0823</td>
<td>-.0716</td>
<td>.0571</td>
</tr>
<tr>
<td></td>
<td>(0.56)</td>
<td>(1.46)</td>
<td>(1.43)</td>
<td>(0.91)</td>
</tr>
<tr>
<td>Proportion of fathers who completed primary school - marriage market</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-.295</td>
</tr>
<tr>
<td>Mean household wealth (x10^-6) - village</td>
<td>-.202</td>
<td>.0571</td>
<td>-.431</td>
<td>.356</td>
</tr>
<tr>
<td></td>
<td>(0.60)</td>
<td>(0.07)</td>
<td>(0.59)</td>
<td>(0.34)</td>
</tr>
<tr>
<td>Mean household wealth (x10^-6) - marriage market</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-.252</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.34)</td>
</tr>
<tr>
<td>Health center in village</td>
<td>-.00556</td>
<td>-.00434</td>
<td>-.0169</td>
<td>.0193</td>
</tr>
<tr>
<td></td>
<td>(0.25)</td>
<td>(0.18)</td>
<td>(0.77)</td>
<td>(0.56)</td>
</tr>
<tr>
<td>Proportion of population covered by health center in marriage market</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-.0413</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.56)</td>
</tr>
<tr>
<td>N</td>
<td>216</td>
<td>432</td>
<td>432</td>
<td>432</td>
</tr>
</tbody>
</table>

^a Absolute values of t-ratios in parentheses corrected for marriage-market common error.
Table 4

Determinants of the Difference in the Mother’s Preferred Number of Surviving Boys and Girls

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Cross-Section</td>
<td>1971-82</td>
<td>1971-82</td>
<td>82</td>
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<tr>
<td>Technical change - village</td>
<td>-</td>
<td>.00309</td>
<td>.00132</td>
<td>.00139</td>
</tr>
<tr>
<td></td>
<td>(0.57)</td>
<td>(2.68)</td>
<td>(3.20)</td>
<td></td>
</tr>
<tr>
<td>Mean technical change - marriage market</td>
<td>-</td>
<td>-</td>
<td>-.00149</td>
<td>-.00162</td>
</tr>
<tr>
<td></td>
<td>(2.04)</td>
<td>(1.96)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion mothers literate - village</td>
<td>-.710</td>
<td>-.330</td>
<td>-.278</td>
<td>.0833</td>
</tr>
<tr>
<td></td>
<td>(2.21)</td>
<td>(0.44)</td>
<td>(0.37)</td>
<td>(0.08)</td>
</tr>
<tr>
<td>Proportion mothers literate - marriage</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-.371</td>
</tr>
<tr>
<td>market</td>
<td>(0.34)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion of fathers who completed primary school - village</td>
<td>.497</td>
<td>.654</td>
<td>.609</td>
<td>.660</td>
</tr>
<tr>
<td></td>
<td>(1.78)</td>
<td>(1.34)</td>
<td>(1.25)</td>
<td>(1.28)</td>
</tr>
<tr>
<td>Proportion of fathers who completed primary school - marriage market</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.0146</td>
</tr>
<tr>
<td>Mean household wealth (x10^-6) - village</td>
<td>-1.92</td>
<td>-2.53</td>
<td>-.355</td>
<td>-5.68</td>
</tr>
<tr>
<td></td>
<td>(0.62)</td>
<td>(0.42)</td>
<td>(0.06)</td>
<td>(0.88)</td>
</tr>
<tr>
<td>Mean household wealth (x10^-6) - marriage market</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.651</td>
</tr>
<tr>
<td>Health center in village</td>
<td>-.306</td>
<td>.0321</td>
<td>.0873</td>
<td>-.455</td>
</tr>
<tr>
<td></td>
<td>(1.03)</td>
<td>(0.07)</td>
<td>(0.18)</td>
<td>(0.87)</td>
</tr>
<tr>
<td>Proportion of population covered by health center in marriage market</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.05</td>
</tr>
<tr>
<td>N</td>
<td>216</td>
<td>432</td>
<td>432</td>
<td>432</td>
</tr>
</tbody>
</table>

*Absolute values of t-ratios in parentheses corrected for marriage-market common error.
Figure 1. Actual (Census) Sex Ratio of Children 0-4 and Average Household Preferences for Boys Minus Girls (Survey) in 1971, Rural Areas by State
Figure 2. Proportionate Change in Crop Output per Acre and the Change in Preferred Boys Minus Girls Among Rural Households Across Indian States, 1971 - 1982
Figure 3: Location of ARIS/RDS Sample Villages with District Boundaries

67km-radius marriage market