ANDREW D. FOSTER
Brown University
MARK R. ROSENZWEIG
Yale University

Does Economic Growth Reduce Fertility? Rural India 1971–99

Introduction

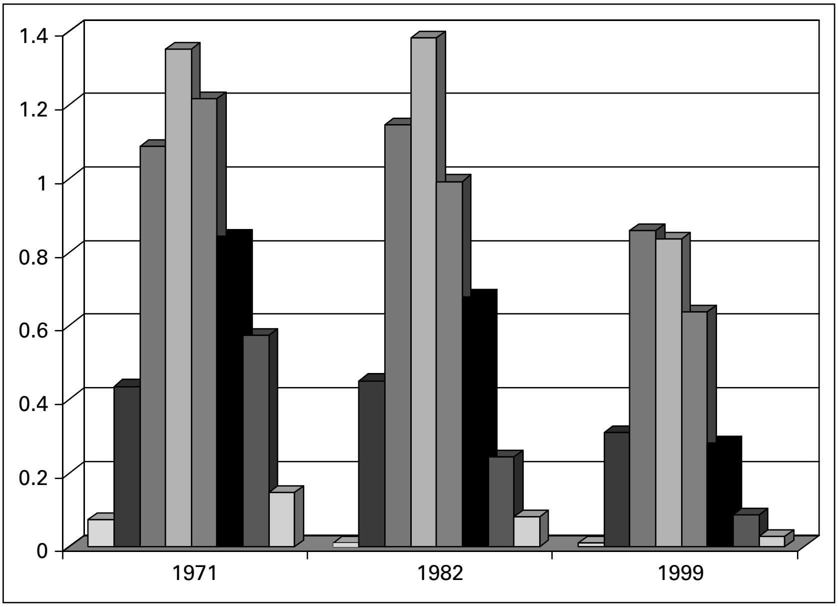
Reducing fertility is often seen as an important, if not necessary, means to achieve sustainable economic development. And, many countries have adopted policies ranging from subsidization of fertility control to restrictions on the size of families with the aim of reducing pressures on the environment and augmenting economic growth. Among policy advocates for direct measures that reduce fertility there is also skepticism that economic growth will lead to fertility reductions without at least major increases in the education of women. That there should be controversy about whether economic growth per se plays a major role in driving declines in human fertility seems at first look to be quite surprising. From a cross-sectional perspective richer, more developed economies tend to have lower fertility rates than do poorer less developed ones. Over time many formerly poor countries have begun to develop and this process of development has typically been accompanied by sustained fertility declines. There are, of course, important anomalies such as China, with its one-child policy, and countries such as Cuba, Costa Rica, and Sri Lanka with traditionally high levels of education, health and correspondingly low levels of fertility. There is also evidence that the timing of a first sustained decline in fertility is not well-connected with a particular level or threshold of economic development. These patterns have lead to a general impression that fertility decline is best understood either as a fairly mechanical response to falling mortality and/or as a transition in cultural perspective, with relatively little role given to changes in basic economic incentives.

Nonetheless, there is significant literature testing specific economic mechanisms thought to link economic growth and fertility decline and, on the whole, these results are supportive. In particular, there is evidence that fertility levels are negatively affected by the opportunity cost of time faced by women and that exogenously imposed increases in the number of children tend to result in reductions in average levels of child schooling (if not the schooling of every child in the household). This result, in combination with the finding that economic growth importantly raises both the returns to and levels of schooling (Foster and Rosenzweig 1996), is consistent with the proposition that economic growth lowers fertility through a quantity-quality tradeoff. Rosenzweig and Zhang (2006) also used twinning to show that the reductions in fertility due to the one-child policy in China increased human capital investments in children. Rosenzweig and Zhang review major studies using twins as a source of identification for examining fertility effects on child quality. They conclude that the results from all of these studies are consistent with the proposition that exogenous decreases in fertility decrease average quality. It seems what is missing is a data set of sufficient time frame and scope to go beyond testing the basic mechanisms. To assess the importance of these economic mechanisms it is necessary to obtain robust estimates of the magnitudes of the respective effects in a particular population and then trace out the implications of aggregate changes in economic conditions for the aggregate changes in fertility in the population.

This pair of requirements puts significant demands upon data. Estimation of the magnitudes of the value-of-time and quality-quantity effects requires data with substantial, plausibly exogenous, variation in economic conditions across time and space in the context of a reasonably unified policy environment (thus ruling out, for all intents and purposes, cross-country data). There must also be a setting in which there is substantial aggregate level change in fertility that is to be explained.

Rural India over the last three decades can in principle provide the appropriate setting for carrying out such an analysis. Figure 1 provides an illustration of fertility rates by year based on the NCAER ARIS-REDS panel survey of rural households covering the period 1971–99 that will be discussed in some detail below. As the figure shows, and consistent with other sources of data, while there was relatively limited change in rural age-specific fertility between 1971 and 1982, there was a pronounced decline across all age groups in the 1982–99 period. As will be documented below, over this interval there were both significant spatial variation in changes in economic conditions including substantial increases in the productivity of agriculture and agricultural wages and increases at a more modest pace in access to schools and health and family planning services. As previous research has shown, the variation in economic conditions was

FIGURE 1. Period 5-year Rural Fertility Rate, 1971–99, by Maternal Age and Year



driven by important differences in the suitability of land and climatic conditions to the adoption of first and subsequent generation green-revolution crops (Foster and Rosenzweig 1996). Moreover, given historically limited migration across villages as well as differences in state policies that have affected the growth of the non-farm sector there is also substantial village-level variation in rates of return and changes in rates of return to schooling (Foster and Rosenzweig 2005).

Recent assessments of fertility change in India have largely been consistent with the non-economic literature on fertility change in developing countries in that they suggest that fertility decline has and is likely to continue to proceed through a process of cultural diffusion facilitated in part through increased access to media and family planning services. Dyson (2002, p. 7) in an analysis of overall and regional trends reports "In my view the ongoing state-level fertility declines will continue during the medium term future largely independently of trends in conventional socio-economic variables like per capita incomes and urbanization. In other words, to a considerable extent these TFR declines now have a 'life of their own'." Bhat (2002 p. 378) notes the prominence given to maternal education as a source of fertility decline in India and argues, in contrast, "that fertility is declining in India primarily because of its decline among illiterate women, and they are doing so because of the diffusion of a *new reproductive idea* of having only a few children but investing more on their future." (Italics added). Brookins and Brookins (2002) indicate that "economic factors" explain 70 percent of the state level variation in fertility but female autonomy measures (considered separately) explain 84 percent of the state-level variation.

However, the economic factors that are used in the empirical analyses examining fertility change in India are simply broad measures of economic circumstance such as urbanization or income, which are poorly related to the particular economic mechanisms that are highlighted in economic models of fertility decline. Moreover, most analysis is cross-sectional which, given India's tremendous cultural heterogeneity, is a poor basis for inference about changes in fertility. Guilmoto and Rajan (2001, p. 713) note the spatial correlation in fertility decline and argue that "preoccupation with the effect on fertility of factors that are poorly correlated with spatial location, such as family planning campaigns or structural transformations of the economy, may have concealed the progression of fertility change through diffusion processes at the micro-level".

In this paper, we use a newly available panel data set that constitutes a representative sample of rural India over the period 1971–99. We first develop a simple dynamic model of fertility choice that incorporates the possibility of cost-of-time effects, a quantity-quality tradeoff, and increased access to health and family planning services. This model is used to structure the empirical analysis of fertility decision-making. A key feature of the empirical analysis is that it controls for household level fixed effects by linking households from different rounds of the survey. Without control for cultural and preference differences across Indian states and families that are absorbed in the family fixed effect we obtain results similar to those obtained by others from cross-sectional analyses—in particular, the importance of maternal literacy and the relative insignificance of costs of time or technical change. However, the results eliminating the family fixed effect provide strong support for the importance of increases in the value of time of women and of technical change-induced investments in child schooling that accompany economic growth in accounting for fertility decline, with little role for parental schooling. In particular, we find that aggregate wage changes, dominated by increases in the value of female wages, explain 15 percent of the decline in fertility over the 1982–99 period. In combination, changes in agricultural productivity and agricultural wage rates explain fully 61 percent of the decline. Health centers are found to have had a significant effect on fertility but the aggregate increases in the diffusion of health centers in villages only explains 3.4 percent of the fall. In summary, our results suggest that the process of economic growth has had a major impact on fertility in India over the last two decades and that, given sustained economic growth that continues to raise wages and increase returns to human capital, the fall in fertility in India will persist in the foreseeable future. A demographic revolution now appears to have at least in part resulted from, rather than just accompanied, the green revolution.

I. Theoretical Framework

Fertility reflects the outcome of a dynamic process in which parents make current fertility decisions based on their expectations of the returns to investments in children in the future, given their current resource constraints. To characterize the potential mechanisms by which economic change may influence fertility in the context of a changing economy, we use a simple dynamic economic model. The model incorporates two important features highlighted in economic analyses of fertility: the value-of time effects for parents and children and the trade-off between the number of children and human capital investment. We use the model to focus in particular on how changes in wage rates, by gender and age, and agricultural technical progress affect fertility and human capital investment.

The appendix contains the elements of the model. We assume a couple maximizes expected discounted utility, which is defined over consumption, the eventual stock of children, and the children's levels of human capital. A key element of the model is that the returns to human capital investments in children are higher the higher the level of expected agricultural technology. This reflects the complementarity of schooling and technological change, as in models of Nelson and Phelps 1966 and as found for India by Foster and Rosenzweig, 1995.

In the model, human capital for a child is produced using the time of the child (for example, studying, attending school) and the time of other children (reflecting the possible caretaker role of other children), the time of the mother and father, and purchased inputs to human capital per child. The efficiency by which human capital is produced may be affected by the parent's own human capital, as in Behrman et al. (1999). Household income derives from farm production on household land (if owned) using the labor of the children, mother and father plus earnings from off-farm work.

The time of children is allocated between on-farm activities, the labor market, and schooling. Mothers and fathers allocate their time between on-farm activities, the labor market, and human capital production of their children. Households can save to acquire productive assets, but cannot borrow. A key feature of the budget constraint is that the cost of increasing the number of children is higher the higher amount of human capital invested in them. Similarly, augmenting the average human capital of children is more expensive the larger the number of children. Thus, the budget constraint incorporates the basic quantity-quality trade-off. Households are assumed to choose at each age whether to have a child, consumption, savings, human capital investments, and labor allocations to maximize their expected utility given their constraints. Childbearing is chosen first and then, upon the realization of gender for that group of children, decisions are made about human capital investments. The decision rules for fertility and the average human capital of the children at each point in time are, respectively:

$$(1) \qquad n_{ijt} = n(x, A_{ijt}, N_{ijt}, h_{ij}^{m}, h_{ij}^{p}, w_{ijt}^{b}, w_{ijt}^{g}, w_{ijt}^{m}, w_{ijt}^{f}, \varphi_{ijt}, p_t^e, \nu_{ijt}).$$

$$(2) \qquad h_{ijt}^{\nu} = \theta_{ijt}^{b} h_{ijt}^{b} + \theta_{ijt}^{g} h_{ijt}^{g} = h(x, \theta_{ijt}^{b}, A_{ijt}, N_{ijt}, h_{ij}^{m}, h_{ij}^{p}, w_{ijt}^{b}, w_{ijt}^{g}, w_{ijt}^{m}, w_{ijt}^{f}, \varphi_{ijt}, p_t^e, \nu_{ijt}).$$

where n_{ijt} denotes childbearing by a couple at time t in household i and area j, x denotes the age of the woman, A_{ijt} is the assets held by the household, $N_{ijt-1} = \sum_{s=t-x+\alpha}^{t-1} n_{ijt}$ is the stock of children born to that woman previous to time t, h_{ij}^{k} for $k \in m,p,b,g,v$ denotes human capital of the mother, father, boy children, girl children, and the children on average, respectively, w_{ijt}^{k} for $k \in m,p,b,g$ is the wage for the mother, father, boys, and girls, respectively, φ_{jt} is the level of technology, p_t^e denotes the price of goods used to produce human capital, ν_{ijt} reflects time-specific unobservables such as household tastes, and θ_{ijt}^{k} for $k \in b,g$ denotes the fraction of children that are boys and girls, respectively.

The model yields a number of implications for how changes in the value of time of the parents and the children affect both fertility and investments in human capital. In particular, the model shows that wage effects will differ by both gender and age. For example, as shown in the appendix, a rise in the female wage will raise the cost of children and thus tend to lower fertility but an increase in the male adult wage may raise fertility. This is because of the assumption that mothers and possibly older sisters participate in the production of child human capital to a greater extent than do older boys or fathers.

In a low-income country context it has been recognized that the contribution of children to household earnings creates an incentive for larger families. What is less recognized, at least in economic analyses, is that the roles of girls and boys in the household, like that of mothers and fathers, may also differ and thus the value-of-time effects of children on fertility may also differ by gender. In particular, a rise in the boy wage will tend to lower the net marginal cost of boy children. However, a rise in the girl wage will tend to raise the cost of boys to the extent that girls contribute to the human capital of their brothers. There are symmetric effects for the wage rate of girls. However, if boys play little role as child care-givers, it is possible for the effects of boy and girl wages on fertility to be of opposite signs, with the boy wage having a positive effect (net costs of having children lower) and the girl-wage a negative effect (costs of caring for children higher), echoing the opposite parental wage effects.

Finally, it should be noted that the results for child wages depend on the presumption of an active labor market for children. Not surprisingly, there is some evidence for imperfections in child labor markets in rural India (Foster and Rosenzweig 2004). If the on-farm marginal product of boy labor exceeds the local boy child wage for large landowners, for example, then increases in the boy-wage will of course not affect the cost of childbearing. However, in that case an increase in landholdings for these households will increase the value of children's contribution to income and thus increase the opportunity cost of schooling and lower the net cost of adding a child. Thus, size of landholdings and fertility may be positively related and landholdings and schooling of children negatively related even though households with greater landholdings are wealthier.

The effects of changes in agricultural technology on fertility in the model are more complex. An increase in future technology will both raise the return to human capital investments, given childbearing, and raise the return to childbearing given human capital. However, because a rise in the human capital of children raises the cost of childbearing and vice-versa, the net effect on fertility and human capital investment is ambiguous. Nonetheless, previous work (Foster and Rosenzweig 1995) has shown that the Green Revolution in India did indeed raise the returns to and investment in schooling. Whether this results in a reduction or increase in fertility depends on a number of factors, not least of which is the extent to which households can effectively borrow against the future earnings of their children through reductions in assets. See Narisamhan et al. (1997) for an assessment of these two sources. Thus while the model suggests that a finding of a positive effect of agricultural technology improvements on fertility is possible, the finding that technological advances both reduce fertility and increase human capital investment would be evidence supportive of the importance of the quality-quantity trade-off as a source of fertility decline.

II. Data

a. Construction of Fertility and Child Schooling Variables

The main objective of our empirical analysis is to estimate equations (1) and (2) in order to assess the role of economic theory in explaining variation in fertility across households as well as the contribution of economic change to aggregate fertility decline in rural areas. Such an analysis, particularly given the presence of persistent household and village level unobserved heterogeneity, puts substantial demands on the data in terms of both geographical and temporal coverage and in terms of the broad spectrum of variables that are required. Traditional data sources at multiple points in time that have been used to study Indian fertility inclusive of the SRS and the NFHS are not up to the task for three reasons.[1] First, as these samples are constructed independently in each round it is not possible to link households or even villages across time and thus to control for unmeasured spatial and household variation in preferences, culture, and agro-climatic conditions. Second, the scope of economic variables collected is limited; for example there is no information on the wages of individuals in the household. Thus a key economic hypothesis concerning whether changes in the value of time associated with economic development affect fertility decisions cannot be addressed. Third, there is little information on institutions and market prices at the village level. While it is possible to examine changes over time in both economic conditions and fertility at the level of the district or state using a combination of census and other data sources, such analysis masks considerable intra-district variation in the price-signals facing individual households that are likely to impact their childbearing and other decisions.

We use data from a comprehensive village and household panel survey that provides information at three points in time on the demography, economic characteristics and village environment of rural Indian households residing in 240 villages over the period 1971–1999. The data are from a continuing survey of rural households residing in approximately 250 villages

1. See Narisamhan et al. (1997) for an assessment of these two sources.

located in the 17 major states of India that began in 1968 and has been carried out by the National Council of Applied Economic Research (NCAER). The first round of the survey for which there is complete village and household information, in 1971 [the Additional Rural Income Survey (ARIS)], includes 4,527 households in 259 villages and is meant to be representative of the entire rural population of India residing in the 17 major states. In the 1982 round (Rural Economic Development Survey (REDS)), 250 of the original 259 villages were revisited (the state of Assam was excluded) and 4,979 households surveyed, approximately two-thirds of which were the same households as in the 1971 round. In the 1999 round (REDS 1999), all of the 1971 villages were surveyed, but excluding the 8 sample villages in Jammu and Kashmir. In this survey round, all of the surviving households in the 1982 survey were surveyed again, including in this round all split-off households residing in the same villages, plus a small random sample of new households. Because of household division and the new sample design incorporating all village-resident male 1982 surveyed household members, the number of households in the 1999 round increased to 7,474.[2] The data in both 1982 and 1999 provide information on fertility, child schooling, household member characteristics, agricultural yields by seed type and crop, wages and prices at the village level, and landholdings by irrigation status.

Variables characterizing fertility and child investments are taken from information provided by all married women aged 15–59 residing in the surveyed households in each of the survey rounds. Measures of cumulative childbearing as well as the number of births in the last 5 years were constructed from the full birth histories provided by each married woman. After excluding households from non-panel states and removing cases in which data were incomplete, a working sample was constructed with 5,405 married women in 1971, 5,503 married women in 1982, and 10,019 married women in 1999.

Information is also provided in the survey on the activities of children. In particular, the school attendance of children are available from the individual roster files in 1982 and 1999. However, in the 1971 data this individual-level information on children is not available (it was lost after coding), although there is aggregate information at the household level on the fraction of children 5–14 currently in school. Consequently we constructed

2. Because of the custom of patrilocal exogamy, women leave the village when married. Thus the panel households in 1999 are defined in terms of male members related to the 1982 household head and who resided with him in 1982.

this household-level school attendance variable for all three survey years. In order to account for possible differences across households in the age-composition of children in this relatively wide age range (which may itself reflect fertility), the child attendance variable was normalized for each household using an age-standardized schedule based on the 1971 survey. In particular, the household 1971 fractions of children aged 5–14 in school were regressed on the fraction of children in each single-year of age in the household. The resulting 10 coefficients were then used to impute for each household predicted school attendance for children in the age group 5–14 given the actual age composition of the children in that age range from the household roster. In each year, the fraction of kids in school in each household was then adjusted by taking the actual fraction of children attending school and dividing by the predicted fraction given the household's age distribution of children.

Figure 2 depicts the average number of births in the five years prior to each survey date and the normalized current school attendance rates for children 5–14 for the three survey dates. Similar to the age-specific fertility rates in figure 1, the aggregate 5-year current fertility variable indicates that fertility started to decline only in the 1982–1999 interval, from about .8 births on average to .4 births. Over the same interval child school attendance rose at an accelerated pace, being 33 percent higher in 1982 than in 1971 and over 2.6 times higher in 1999.

b. Construction of Economic Variables

The data sets enable the measurement of three key economic variables spanning the 28-year period—agricultural productivity growth; wage change, by gender and age; and wealth change. To characterize the growth in agricultural productivity, we constructed from the village-level information on prices, seed types and yields an index of high-yielding variety (HYV) seed yields for each village for each of the three survey years using a Laspeyres-weighted index for four HYV crops—corn, rice, sorghum and wheat—of output per acre on irrigated lands. By using HYV yields on irrigated land we obtain a measure of the "best" or maximal yields that villagers could obtain using the new seeds. Figure 3 displays the substantial rise in HYV productivity over the 1971–1999 period, but as can be seen, agricultural productivity growth per-year is evidently slower in the 17-year period, 1982–1999 compared with the 11-year 1971–1982 period.

Because the yield measure inevitably reflects potential productivity with error, inclusive of measurement error, and the influence of weather outcomes, we estimated a predicted HYV yield equation, using as determinants

FIGURE 2. Fertility and School Enrollment Rates, by Year: 1971–99

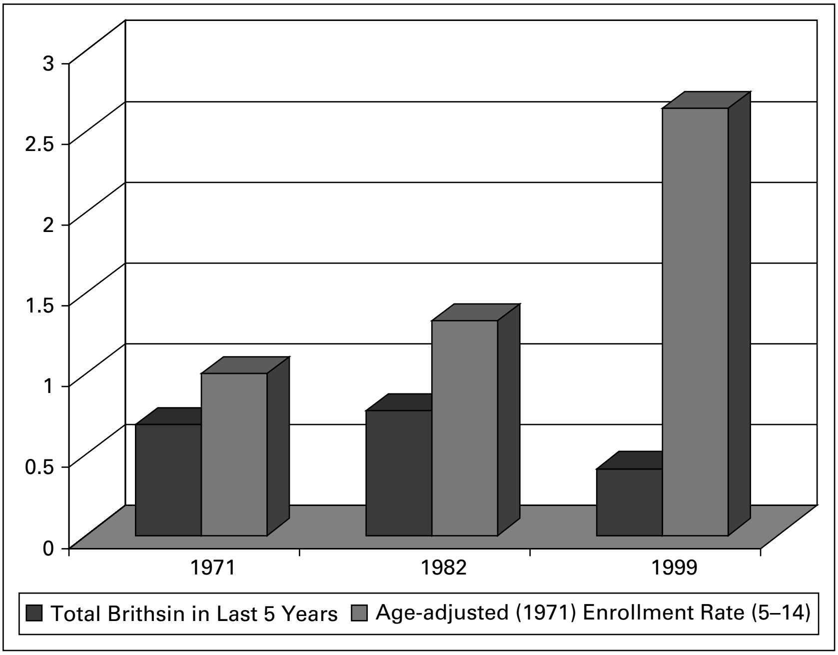
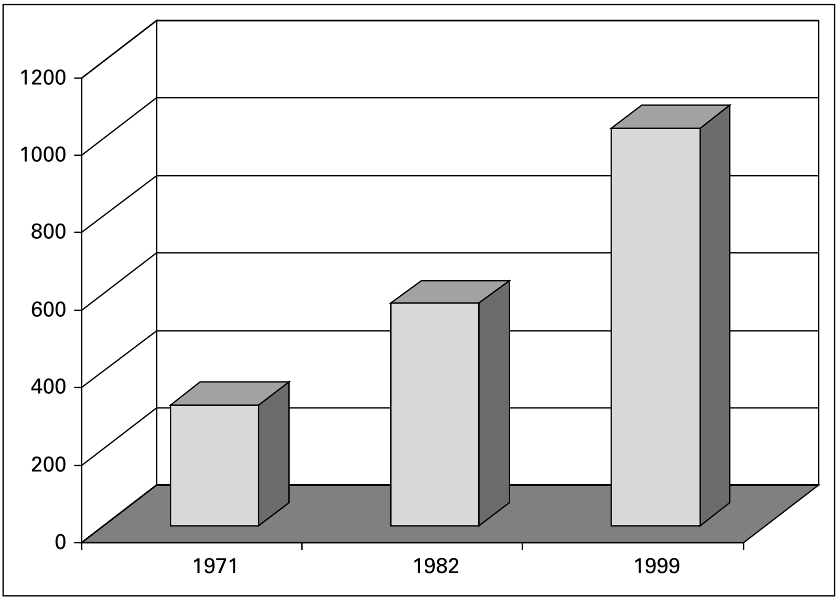


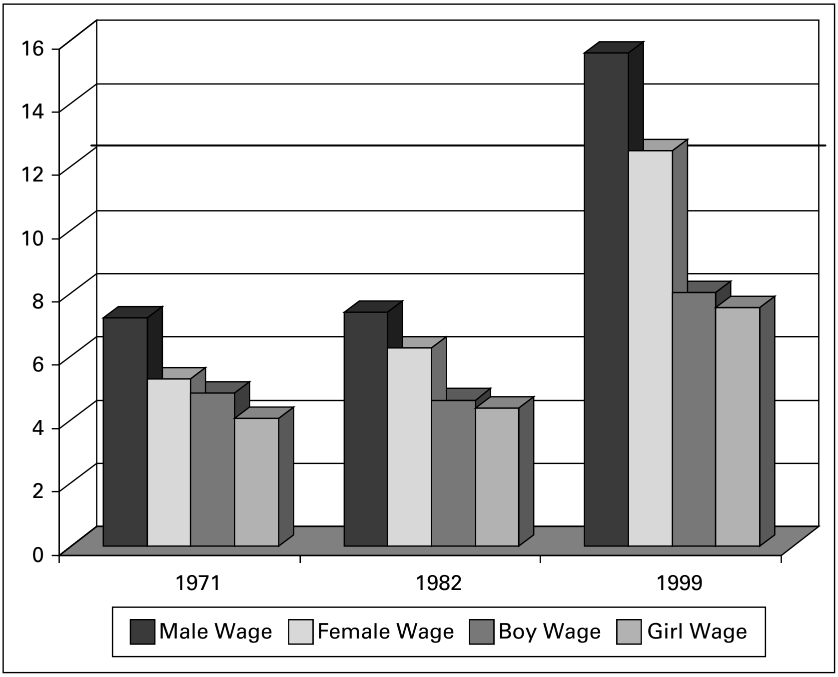
FIGURE 3. Average Maximum HYV Yield Index (Laspeyres-weighted HYV Crops), by Year: 1971–99



the types of crops grown in the village in the initial, pre-green revolution period (using the 1968 data). In particular, we regressed the log of the maximum yield in the village in the survey year on the pre-green revolution proportion of acreage devoted to rice or to wheat in that village, allowing the effects on yields to vary by survey year. We also included whether or not the village was in an Intensive Agricultural Development Program (IADP) district, again with the effects allowed to differ by year. Table A in appendix 2 reports the random-effects estimates. The three pre-green revolution variables combined with the period dummies account for over 38 percent of the variation across villages and time. The coefficient estimates indicate that initially wheat growing villages had significantly higher HYV yields compared with rice-growing and all other villages, but this initial advantage eroded almost completely by 1999. These estimates are in accord with scientific developments, which yielded benefits late for rice relative to wheat productivity. Similarly, the significant initial advantage of the IADP areas eroded substantially over time, reflecting both the spatial spread of advances in crop technology and the termination of the program in the late 1970's.

Wage data by gender and age (adult/child) at the village level were computed somewhat differently from each of the three survey rounds. For 1982 and 1999, wages by crop (and by task in 1999) were collected at the village level. Crop-area (crop and task) weighted average wages by age and gender were then constructed for these two years. In 1971, earnings by sector and time worked were reported on an individual basis. These individual reported wage data were averaged for the different demographic groups and then aggregated at the village level. Figure 4 provides the computed real, village-level agricultural wages for adult males and females and boys and girls (ages 5-14) in 1982 rupees at the three survey dates. As can be seen, wages for all four groups rose significantly in the 28-year period between 1971 and 1999, but in the 1982–99 period adult wages rose at a faster pace than did child wages compared with the 1971–82 period. In 1971, for example, the adult female wage is less than 10 percent higher than the male child wage. By 1982 the adult female wage was 35 percent higher, while by 1999 the adult female wage is 56 percent higher than the child male wage. To the extent that the parental value of time, particularly that of women, is an important cost of child-rearing while child earnings are an important return to having children this growth in the adult/child wage gap could be an important factor in explaining the fall in fertility in the latter period. The adult male wage rose at a faster pace than the adult female wage between 1982 and 1999 compared to the earlier period as well, but to the extent that fathers

FIGURE 4. Real (1982 Rupees) Agricultural Wages of Adult Males and Females and Boys and Girls, by Year: 1971–99



spend less time than mothers in child care this change is less relevant to fertility change than the adult/child wage gap change.

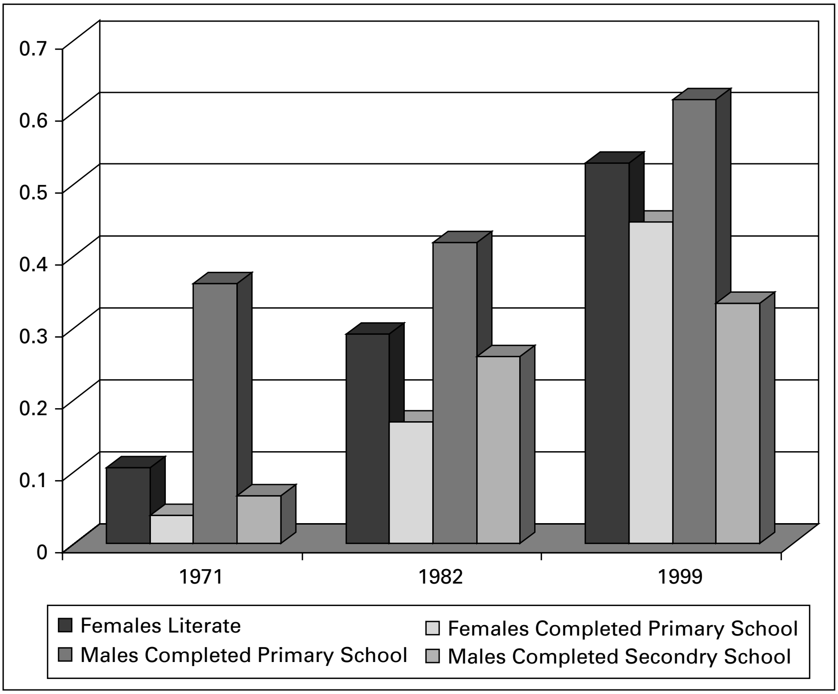
The main component of wealth in rural India, which is well-measured compared to other components, is land wealth. We constructed the total value of landholdings, in 1982 rupees, for each household in each of the three survey rounds. Average household land wealth also rose substantially between 1971 and 1999—from an average value of 21,000 rupees in 1971 to 33,000 rupees in 1982 and to 95,000 rupees in 1999. Increases in the value of land make it easier to raise large families and to increase human capital investment at the intensive margin. However, increases in land productivity via irrigation, a major component of the land value increase, also raises the return to child labor if child labor markets are imperfect and thus also increases the opportunity cost of child schooling.

c. Additional Variables

Many studies find that parental schooling and literacy, particularly that of mothers, is an important determinant of fertility and child schooling.

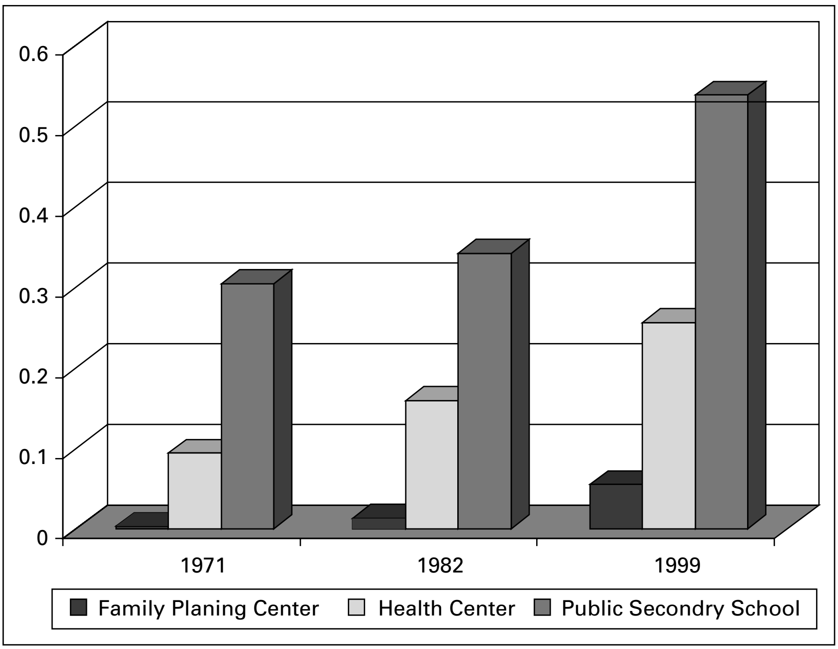
From the roster data in all three surveys we constructed variables indicating whether each mother was literate and/or completed primary school and for each father whether he had completed primary or secondary school. In figure 5 it can be seen that average schooling levels increased for mothers and fathers. In particular, the literacy of married women aged 15-59 rose from under 10 percent in 1971 to over 50 percent in 1999. Moreover, not only did primary schooling rise for mothers between 1971 and 1999, it rose relative to their husbands—in 1971, husbands were nine times more likely than wives to have completed primary school; in 1999, the fraction of wives with primary schooling was only 28 percent lower than that of husbands. The closing of the gender gap in parental schooling appears to have occurred in both the 1971–82 and 1982–99 periods.

FIGURE 5. Parental Schooling, by Gender, Level and Year: 1971–99



The provision of health, family planning and school services also increased between 1971 and 1999. All three survey rounds provided information on the presence of health centers and family planning facilities in the village at the time of the survey. The 1999 REDS also provided information on schools by whether they were public or private and by level, including information on when the schools were established. From this establishment information we were able to construct a time-series of village secondary schools for each sampled village that could be matched to the survey dates. Figure 6 shows the growth in the fraction of villages with each of these facilities. As can be seen, although there is some growth in the coverage of family planning facilities over the period there are very few villages (5 percent) with such facilities even by 1999; it is thus unlikely that formal family planning facilities played a major role in the observed fertility decline, even if such facilities were effective in reducing the cost of fertility control. On the other hand, the proportion of villages with a health center grew from 9 percent in 1971 to over 26 percent in 1999. Health facilities could contribute to fertility decline by lowering infant mortality and by raising the returns to schooling to that extent that healthier children are better students. The presence of secondary schools in villages also rose substantially, from 30 percent coverage in 1971 to 54 percent village coverage in 1999. However, as noted, lowering the cost of schooling by increasing school proximity does not necessarily induce lower fertility, as it in part makes children cheaper.

FIGURE 6. Proportion of Households in a Village with Family Planning and Health Facilities and Secondary Schools, by Year: 1971–99



d. Linking Households

The panel component of the data allows the linkage of not only villages but also individual households across time, to the extent that they were sampled, as noted above. This permits one to control for unobservables that are persistent over time within families that might otherwise lead to a correlation between outcome variables like fertility, parental attributes such as education, and measures of household wealth. In this case we connect families at the "dynasty" level. A dynasty consists of the original sampled household based on the year it was surveyed (1971 for most households but also 1982 and 1999 for the new households introduced in each round to assure representativeness) plus all sampled sub-households that split from these original households. Preferences of families within dynasties are likely to be similar and to have a large persistent component that is ignored in prior work on fertility in India. The data do not allow the linking of individuals across time. However, there would seem to be limited benefit from linking women across such extended gaps in the survey rounds for the purpose of removing individual effects, given that fertility mostly occurs for women at young ages.

III. Estimates

a. Fertility

We estimate a linearized version of the fertility decision rule (1) of the model, in which the number of children born in the five years prior to the survey for each married woman in each household is the dependent variable and the right-hand-side determinants include the mother's age and it's square; the number of her previous children born; variables indicating whether the mother is literate or completed primary school; variables indicating whether the husband completed primary or secondary schooling; the log wage rates of men, women, boys and girls; the log of the agricultural productivity measure; the log value of household landholdings; and variables representing whether or not the village has a health center, family planning facility or school. The number of observations from the three survey rounds is 18,896, including 6,650 dynasties.

Three estimation procedures are used: The first is OLS, which exploits both the cross-sectional and over-time variation in the variables over the households, villages and states. The second set of estimates controls for state fixed-effects, and thus controls for variation across states in time-persistent preferences, traditions and agroclimatic conditions. The third incorporates a dynasty fixed effect, and thus additionally controls for persistent variations across families in preferences for schooling and family size. Identification of parameters from the estimates including a dynasty fixed effect thus comes from variation across women within families (dynasties) and over time within families (dynasties). Elimination of the influence of the dynasty fixed-effect does not eliminate all sources of bias. We discuss some of these as we examine the point estimates. For all estimation procedures coefficient standard errors are corrected for clustering at the state-year level.

The first column of table 1 reports the OLS estimates. These appear to replicate the findings of recent cross-sectional studies—the "economic variables" wages, HYV yield rates and wealth are all statistically insignificant—but maternal literacy, the presence of health centers and urbanization are each statistically significant and negatively related to fertility. Inclusion of a state fixed effect, in column two, however, suggests that these results are spurious, reflecting substantial differences across Indian states in unobservables such as preferences for female schooling and agro-climatic conditions affecting yields that affect fertility decisions and that are also correlated with the fertility determinants. In this specification, the log female wage rate is statistically and negatively related to fertility as is log HYV yield, whose coefficient is almost double in absolute value its OLS counterpart. Moreover, the female literacy coefficient is almost halved and is no longer statistically significant.

The statistically-preferred (Hausman-Wu tests) estimates that control for persistent differences across dynasties conform even more closely to the economic model implications. The results indicate that increases in female wage rates lower fertility while increases in the wage rates of boys, which offsets their costs, increase fertility. The point estimates suggest that a doubling of female wage rates (mother's value of time), approximately the magnitude of the change between 1982 and 1999, would decrease the five-year birth rate, ceteris paribus, by about 10 percent, given the 1982 birth-rate levels. A similar increase in the wage rates of boys (value of children) would increase birth rates by about 7 percent.[3] Interestingly, increases in girls' wage rates also lower fertility, which suggest, as noted, that girls assist

3. The number of children born could directly affect adult and child wages—a positive shock to fertility might lower the labor force participation rate of women, thus raising the female adult wage. If these direct within-village supply-demand effects are strong, then the negative female wage effect is positively biased (too small in absolute value). Similarly, an exogenous increase in the number of children would lower the wage child wage. Again, the estimated positive male child wage may be too small in absolute value

TABLE 1. Determinants of the Number of Live Births in Last 5 Years to Married Women Aged 15–59, by Estimation Procedure

Variable/estimation procedure	*OLS*	*Fixed-effects state*	*Fixed-effects dynasty*
Log maximum HYV yield in village	–0.063	–0.116	–0.185
	(0.0685)	(0.0724)	(0.0766)
Log male wage	–0.0647	0.0681	–0.039
	(0.0662)	(0.0576)	(0.0471)
Log female wage	0.0185	–0.078	–0.0711
	(0.0479)	(0.0382)	(0.0363)
Log male child wage	0.0187	0.0109	0.0484
	(0.0210)	(0.0243)	(0.0256)
Log female child wage	0.00637	–0.022	–0.0458
	(0.0221)	(0.0171)	(0.0241)
Log value of landholdings	–0.00166	–0.00324	0.0029
	(0.0019)	(0.0018)	(0.0024)
Mother literate	–0.0578	–0.0301	–0.0236
	(0.0246)	(0.0257)	(0.0299)
Mother completed primary school	–0.00612	–0.00497	0.0271
	(0.0261)	(0.0256)	(0.0301)
Father completed primary school	–0.00315	–0.00868	0.00866
	(0.0206)	(0.0215)	(0.0229)
Father completed secondary school	–0.00271	–0.00344	0.0105
	(0.0175)	(0.0167)	(0.0205)
Health center in village	–0.0324	–0.0413	–0.127
	(0.0180)	(0.0164)	(0.0435)
Family planning center in village	0.0251	0.0183	0.0923
	(0.0313)	(0.0224)	(0.0784)
Secondary school in village	0.0328	–0.116	0.0271
	(0.0168)	(0.0275)	(0.0164)
Proportion district urban	–0.189	–0.152	–1.21
	(0.0983)	(0.0895)	(0.6080)
Year = 1982	0.192	0.169	0.147
	(0.0790)	(0.0633)	(0.0635)
Year = 1999	0.16	0.0946	0.0273
	(0.1220)	(0.1170)	(0.1070)
Number of mother-years	18896	18896	18896

Source: Authors' calculations.

All specifications also include children ever born as of 5 years ago, mother's current age and mother's age squared. All estimated standard errors corrected for clustering by state and year.

All estimated standard errors corrected for clustering by state and year.

in child-rearing. Increases in HYV yields also reduce fertility, consistent with the hypothesis that technical change raises the return to schooling and thus reduces numbers of children to augment schooling investment in children. The point estimate suggests that a doubling of yields, for given wealth and schooling and wage rates, would lower fertility rates by 24 percent.

None of the dynasty fixed-effects coefficients for the parental schooling variables are statistically significant—the impressive rise in female literacy in rural areas depicted in figure 5 thus does not seem to be a significant factor in determining the fertility decline once family, village, and state-level heterogeneity is taken into account. However, the presence of a health center does appear to be associated with reductions in fertility—the point estimate in column three suggests that women in a village with a health center have a birth rate that is 17 percent lower than those women residing in identical conditions in a village without a health center. Note, however, that the point estimate for the health center yielded by the dynasty-fixed effects procedure is less than half in absolute value of that obtained using OLS. The presence of a village family planning clinic, however, does not appear to be important and this result is robust to estimation procedure. This result may be due to the relatively small presence of these clinics in rural India, as seen in figure 6, or the relative availability of family planning information and devices from other sources.

b. School Attendance

Table 2 reports, for the three estimation procedures, the estimates of the determinants of the age-adjusted school attendance rates of children aged 5–14. The specification is the same as that for fertility, corresponding to (2), except that we have added the proportion of boys in the age range to assess if there is discrimination by the gender of children. Because, as noted, the schooling measure is aggregated at the household rather than at the mother or child-level and not all households have children in the relevant age range, the number of observations for this analysis is about half of that for the fertility analysis, 9,158.

The quantity-quality dimension of the economic model of fertility suggests that the coefficients for the variables determining family size and child schooling should be of opposite sign. The principal economic determinants of fertility in table 1, column three, are the HYV yield and the female wage, both of which were negatively associated with fertility. In the third column of table 2, which reports the statistically-preferred within-dynasty estimates, the coefficients on these variables are indeed positive, although the coefficient on the log female wage is only marginally statistically significant with a one-tail test. The point estimate for the log HYV yield variable suggests that a doubling of HYV yields would increase children's school attendance by 50 percent, using again the 1982 mean. Doubling the female wage would also increase attendance, by 8 percent. Neither the

TABLE 2. Determinants of Age-Adjusted School Attendance Rates of Children Aged 5–14, by Estimation Procedure

Variable/estimation procedure	*OLS*	*Fixed-effects state*	*Fixed-effects dynasty*
Log maximum HYV yield in village	0.131	0.469	0.681
	(0.1620)	(0.1440)	(0.1970)
Log male wage	0.388	–0.0501	–0.0282
	(0.1650)	(0.1410)	(0.1490)
Log female wage	–0.0659	0.196	0.111
	(0.1460)	(0.1210)	(0.0863)
Log male child wage	0.0625	0.0835	0.0504
	(0.1090)	(0.0838)	(0.0724)
Log female child wage	–0.0659	0.196	–0.0509
	(0.1470)	(0.1210)	(0.0700)
Log value of landholdings	0.00536	0.00823	0.00601
	(0.0040)	(0.0035)	(0.0055)
Mother literate	0.555	0.413	0.302
	(0.0348)	(0.0485)	(0.0536)
Mother completed primary school	–0.035	–0.0672	–0.0779
	(0.0527)	(0.0392)	(0.0511)
Father completed primary school	0.304	0.33	0.166
	(0.0471)	(0.0454)	(0.0348)
Father completed secondary school	0.0935	0.0153	0.023
	(0.0630)	(0.0528)	(0.0576)
Proportion of children boys	0.217	0.24	0.269
	(0.0499)	(0.0506)	(0.0457)
Health center in village	0.147	0.114	–0.0567
	(0.0416)	(0.0431)	(0.0874)
Family planning center in village	–0.00273	0.0145	–0.0629
	(0.0923)	(0.0971)	(0.1680)
Secondary school in village	–0.00273	–0.00568	0.00642
	(0.0977)	(0.0432)	(0.0777)
Proportion district urban	0.838	0.647	–2.21
	(0.2550)	(0.2600)	(1.1400)
Year = 1982	0.11	–0.227	–0.278
	(0.1430)	(0.1350)	(0.1520)
Year = 1971	0.397	–0.0119	0.14
	(0.2500)	(0.2220)	(0.2670)
Number of household-years	9158	9158	9158

Source: Authors' calculations.

All specifications also include children ever born, mother's current age and mother's age squared.

All estimated standard errors corrected for clustering by state and year.

male nor female child wage is the theoretically appropriate sign, although neither is estimated with any precision.

Maternal literacy, negatively associated with fertility, also is positively associated with schooling, although in this case the coefficient is statistically significant. Whether the father has a primary school education also is positively associated with child schooling. The point estimates indicate that attendance rates of children with literate mothers are 23 percent higher compared with children of illiterate mothers; attendance rates are 13 percent higher if the father completed primary school. As for the fertility estimates, however, the magnitudes of the within-dynasty point estimates are less than half the OLS estimates. It is still possible that individual households *within* dynasties differ in preferences for schooling, in which case the estimated schooling associations may still be picking up variation in tastes for schooling. Note that variations in wages and HYV yields, aggregated at the village level are orthogonal to differences in unobserved, within-dynasty household-specific preferences.

Elimination of the influence of cross-village time-persistent heterogeneity also appears to reduce and eliminate the estimated positive association between the presence of health centers and school attendance. We also cannot find any association for any estimation procedure between the presence of schools and school attendance, although it is notable that the OLS and within-state estimates are not even the correct sign. It is not unlikely that the village distribution of government schools over time increasingly reached villages with lower preferences for schooling, biasing downward even the within-village (and-dynasty) estimates of the school proximity effect.

IV. Explaining Fertility Change

Are the fertility estimates in table 1 informative about the aggregate fall in rural fertility observed between 1982 and 1999? In particular, how much can the changes in wage rates and in agricultural productivity between 1982 and 1999 account for the 46 percent decline in period fertility in that time span? To quantify the contribution of economic change to fertility decline, we use the actual changes in the economic variables, depicted in figures 3 through 6 and the table 1 coefficients. For a variable to have played an important role in explaining the change in fertility, the estimated effect of the variable on fertility must be non-trivial and the change in the variable over the time span must also be substantial. An example is the urbanization variable. Although this variable has a statistically significant effect on fertility, over the 1982–99 period in our data there was almost no average change in the percent of urban districts.

The estimated contributions of the health centers and female literacy to fertility decline illustrate the two conditions that are required for a variable to have played an important role in fertility change. The coefficient on the presence of a health center in the village in table 1 is statistically significant, and health center presence evidently reduces fertility non-trivially, by 17 percent, perhaps due to the contribution of health centers to lowering infant and child mortality. However, as indicated in figure 6, coverage of health centers increased by less than 10 percentage points over the period. The growth in health center coverage in rural Indian villages, given its estimated effect, therefore can only account for 3.4 percent (.0965*(–.127)/.358) of the fertility decline.[4]

In contrast, female literacy increased by 81 percent (figure 5) between 1982 and 1999. However, we could find no evidence that changes in female literacy affect fertility. Thus, despite the rise in female literacy, female literacy appears to have played no role in the fertility decline over the period, while despite the evident strong effect of health centers on fertility, the limited spread of health centers meant that the role of health centers in inducing fertility decline too was only marginal.[5]

In contrast to the change in health center coverage, the rise in adult wages from 1982 to 1999 was substantial, and was greater than that for child wages (figure 4). And in contrast to the estimated effects of female literacy, wage rate effects on fertility are evidently strong. Based on the set of four wage coefficient estimates in table1 and the changes in the complete set of wages, we calculate that the rise in agricultural wage rates accounts for 23 percent of the rural fertility decline between 1982 and 1999 (15 percent of the decline is explained by the doubling of the female wage alone). The 79 percent increase in HYV yields accounts for another 36 percent of the decline in the birth rate, net of the wage rate effects. Note that real agricultural wage rates did not increase significantly in the 1971–82 period, when fertility did not fall. The rise in HYV yields, however, should also have led to a fertility decrease in that period.

We can also disaggregate the total contribution of the post-1982 change in agricultural productivity to the post-1982 fertility decline into that part due to induced wage change and that part due to direct effects, such as the greater

4. Over the period 1971–99, the proportion children dying by the age of 5 fell from .0562 to 6.0229. Thus at most (assuming a one-to-one replacement rate) the decline in infant and child mortality could contribute to fertility decline is a reduction of fertility of 3.4 percent (www.indiastat.com/india/ShowData.asp?secid=90643&ptid=17796&level=4 [November 2006]).

5. Another example is the urbanization variable. Although this variable has a statistically significant effect on fertility, over the 1982–99 period in our data, there was almost no average change in the percent of urban districts.

incentives to increase investments in child schooling seen in table 2. To do this we need to estimate the effects of variation in HYV yields on wages. Table 3 reports within-village estimates of the effects of the predicted log HYV yield on the log of each of the four wage rates using data from all three surveys covering the period 1971–99. Also included in the specifications are the log of the village population, whether there is a public secondary school in the village, the proportion of the district that is urban and year dummy variables. The estimates indicate that for all but girls, increases in HYV yields pushed up wages significantly—the point estimates suggest that the 79 percent increase in HYV yields between 1982 and 1999 increased real male wages by 23 percent, real female wages by 19 percent and the real wages of boys by 24 percent in that period. The total effect of agricultural technical change on the fertility decline is the effect on fertility due to the increase in wages (3.2 percent) induced by technical change plus the direct effect, net of wages, from table 1 (36 percent). Thus, the increase in HYV yields over the 1982–99 period accounts for 39.2 percent of the fall in rural fertility, of which 92 percent is the direct effect net of wages.

TABLE 3. FE-Village Estimates, 1971–99: Determinants of Log Agricultural Wages for Men Women, Boys and Girls

Variable/Group	*Men*	*Women*	*Boys*	*Girls*
Log maximum HYV yield in village	0.332	0.276	0.347	0.0229
	(0.0814)	(0.0969)	(0.1500)	(0.1730)
Log population in village	−0.0169	−0.00884	−0.0107	−0.00606
	(0.0047)	(0.0055)	(0.0077)	(0.0089)
Public secondary school in village	0.0187	0.0209	0.0404	0.105
	(0.0311)	(0.0371)	(0.0539)	(0.0625)
Proportion district urban	0.269	−0.0652	−2.57	−1.46
	(2.1800)	(2.6000)	(3.5300)	(4.1400)
Year = 1982	−0.577	−0.569	−0.391	−0.546
	(0.0619)	(0.0737)	(0.1160)	(0.1290)
Year = 1971	−0.342	−0.496	0.17	−0.557
	(0.1170)	(3.5600)	(0.2180)	(0.2510)
N	717	717	668	682

Source: Authors' calculations.
Estimated coefficient standard errors in parentheses.

The importance of the rise in wage rates in accounting for rural fertility decline, particularly the wages of women, presupposes that women participate in the rural labor market. The survey data for 1982 and 1999 provide detailed information on the daily time allocation of women for typical days in three agricultural seasons. These data permit estimates of both labor force participation and time worked. We define a woman as being in the labor force if she works as either an agricultural worker, wage worker, salary worker or is self-employed (non-farm) for at least one hour during a typical day.[6] Based on this definition, over 79 percent of women aged 25-49 were in the labor force in 1982 and over 74 percent in 1999. Among these women in the labor force, the average number of hours in the day spent in these activities was close to six.

If part of the story of fertility decline is the increased return to women's allocation of time to employment, then we ought to observe that increases in agricultural productivity, which pushed up wages, also induced increased female work time. To assess this, we estimated reduced-form regressions, again using the within-dynasty estimator, of the determinants of both fertility and female labor supply for mothers aged 25-49. By reduced-form we mean that we excluded from the specifications the variables that could have endogenously been affected by changes in labor supply, such as wage rates, land values and parental schooling. The reduced-form, FE-dynasty estimates for fertility and labor supply (log of hours worked per day average over the three seasons) are reported in table 4. As can be seen, increases in agricultural productivity did indeed induce a shift in female time from rearing children to working in the labor market. Although over the period 1982 through 1999 female market work time declined, where agricultural productivity growth was higher, fertility was significantly reduced, consistent with the estimates in tables 1 and 3, and female labor market time was significantly increased.

V. Conclusion

The results in this paper provide clear evidence of the importance of changes in the implicit cost or shadow price of children and women as sources of fertility change during the process of economic growth. This basic insight was provided by Gary Becker to help understand how it could be that a process that fundamentally and broadly expanded a household's choice set could result, without invoking a need for overall changes in preferences, in a reduction in the number of children per household. But these results should not be understood to imply that a relationship between fertility change

6. Following conventional practice, we excluded from the definition of labor force activity such household production activities as grain grinding and pounding, collecting fuel, making dung cakes, and fetching water.

TABLE 4. FE-Dynasty Estimates: Reduced-Form Determinants of Fertility (1971–99) and Maternal Labor Supply (1982–99)

Variable	*Live births in last 5 years*	*Log hours worked per day*
Log maximum HYV yield in village	−0.0708	0.441
	(0.0343)	(0.1410)
Health center in village	−0.0997	−0.00671
	(0.0404)	(0.0224)
Family planning center in village	0.0997	0.0963
	(0.0530)	(0.0377)
Secondary school in village	0.0406	−0.0299
	(0.0215)	(0.0232)
Proportion district urban	−1.09	−0.263
	(0.4630)	(0.3000)
Year = 1999	−0.245	−0.37
	(0.0412)	(0.1050)
Mother's age	−0.133	0.0195
	(0.0082)	(0.0058)
Mother's age squared	0.00111	−0.000178
	(0.0001)	(0.0001)
Number of mother-years	16261	10631

Source: Authors' calculations.
All estimated standard errors corrected for clustering by state and year.

and economic growth occurs without structural change. Economic growth generally is not just an expansion in income but arises through changes in the nature of production and thus in the organization of economic units including the household. Thus economic growth may largely affect fertility through the nature of economic incentives available to the household, with household preferences and decision-making being reasonably fixed.

In India, the Green Revolution, by changing the opportunities available to farming households, lead not just to an expansion in income but to changes in the labor market. There was a rise in the returns to skills, which lead to increased investment in schooling, a process that not only resulted in lower levels of fertility but likely changed the opportunities of children to pursue other opportunities outside of traditional agriculture. The Green Revolution, along with other economic changes that were likely in part responsive to the increased growth and occupational diversification made possible by the overall expansion in agricultural productivity, also expanded worker productivity and thus lead to an expansion in labor demand. The resulting rise in wages not only made child-rearing more expensive but shifted the nature of women's activities both within and outside the household. As a result patterns emerge that look much like a fundamental change in women's autonomy. However, the results in this paper suggest that fertility change can in large part be explained through a rise in the female wage, regardless of the source of this rise. Future work should examine this issue more directly.

Clearly the rapid economic growth enjoyed by India in the period since the 1999 survey used in this paper has continued to alter the nature of economic relations and thus will likely further impact the decisions that parents make regarding childbearing. Expansion in opportunities in urban and peri-urban areas that are both a direct consequence of growth in the tradeable service sector, and that arise indirectly through the general expansion in economic activity that is linked to this growth, will continue to alter the incentives faced by rural households. To the extent that these changes have and continue to increase both the returns to education and the economic activity of women outside the home, it is likely that the process of fertility decline will continue. These processes will also likely further link labor and other markets across villages and, in return, reduce the power of the empirical strategies adopted in this paper, that is the use of fundamental differences across villages in the nature of opportunities available to households to test basic hypotheses about the responsiveness of households to these opportunities. Thus our continued understanding of how fertility is changing in rural India and how these changes are, in turn, affecting economic well being is contingent not only on the continued collection of the kind of detailed wide-spectrum panel data that has been utilized in this paper, but in the development of new empirical and theoretical approaches as well.

Finally, our finding that economic models emphasizing the importance of changes in incentives can explain a substantial proportion of fertility change does not imply that policy interventions, such as those improving health, did not or cannot significantly affect fertility. The effects of national policy initiatives such as vaccination campaigns that vary little across space or time cannot be picked up using our methodologies. Moreover, we did find evidence that health centers were associated with fertility decline; however, over the period examined, there was little aggregate change in health center presence in the sample villages.

APPENDICES

Appendix 1

The expected utility for a couple *i* residing in area *j* and where the wife is age *x* at time *t* is

$$u_{ijxt} = E_t \sum_{s=t}^{t+\omega-x} \beta^{s-t} u(c_{ijs}, n_{ijs}, h_{ijs} N_{ijs-1}; \nu_{ijs})$$
(A1)
$$+ \sum_{s=t-x+\alpha}^{t+\omega-x} n_{ijs} (\theta^b_{ijs} r(\varphi_{ijt+\omega-x}, h^b_{ijs}) + \theta^g_{ijs} r(\varphi_{ijt+\omega-x}, h^g_{ijs}))$$

where α is the minimum and ω the maximum ages of childbearing, β is the discount factor, c_{ijs} denotes single period consumption, n_{ijt} denotes childbearing at time t, $N_{ijt-1} = \sum_{s=t-x+\alpha}^{t-1} n_{ijt}$ is the stock of children bornprevious to time t, ν_{ijt} denotes household tastes, $\theta^b_{ijt} + \theta^g_{ijt} = 1$ are the fraction of boys and girls respectivelyborn at time t, r() denotes the parental return to child human capital, whether through financial transfers or utility, $\varphi_{ijt-x+\omega}$ denotes technology faced by the children when the parents are old, and h^b_{ijt} and h^g_{ijt} are sex specific levels of human capital for these children. As constructed in (A1) the returns to humancapital investments in children are higher the higher the level of expected agricultural technology.

Human capital for a child of gender k

(A2) $$h^k_{ijt} = h^k(t^{bk}_{ijt}, t^{gk}_{ijt}, t^{mhk}_{ijt}, t^{phk}_{ijt}, e^k_{ijt}, h^m_{ij}, h^p_{ij})$$

is produced using the time of the child (e.g., studying, attending school) and the time of other children (reflecting the possible caretaker role of other children), the time of the mother (m) and father (p), purchased inputs to human capital per child, e^k_{ijt}, and parental human capital levels.

Household income derives from farm production on household land (if owned) using the labor of the children, mother and father plus earnings from off-farm work:

(A3) $$y_{ijt} = \varphi_{ijt} f(n_{ijt}\, \theta^b_{ijt}\, t^{bf}_{ijt} + t^{br}_{ijt}, n_{ijt}\, \theta^g_{ijt}\, t^{gf}_{ijt} + t^{gr}_{ijt}, t^{mf}_{ijt} + t^{mr}_{ijt}, t^{pf}_{ijt} + t^{pr}_{ijt}, A_{ijt}, h^m_{ij}, h^p_{ij})$$
$$+ w^b_{ijt} (n_{ijt}\, \theta^b_{ijt}\, t^{bo}_{ijt} - t^{br}_{ijt}) + w^g_{ijt} (n_{ijt}\, \theta^g_{ijt}\, t^{go}_{ijt} - t^{gr}_{ijt}) + w^{mo}_{ijt} (t^{mo}_{ijt} - t^{mr}_{ijt})$$
$$+ w^{po}_{ijt} (t^{po}_{ijt} - t^{pr}_{ijt}),$$

where φ_{ijt} denotes agricultural technology, A is the stock of productive assets, such as land, and thesuperscript br, gr, mr and pr time terms denote hired labor. The time of children is allocated between on-farm activities, the labor market, and schooling; e.g., for girls:

(A4) $$t_{ijt}^{gg} + t_{ijt}^{gb}\frac{\theta_b}{\theta_g} + t_{ijt}^{gf} + t_{ijt}^{go} = T^{1}$$

The time of mothers and fathers is allocated between on-farm activities, the labor market, and the human capital production of their children. The time constraint for mothers is thus

(A5) $$n_{ijt}\,\theta_{ijt}^{b}\,t_{ijt}^{mhb} + n_{ijt}\,\theta_{ijt}^{g}\,t_{ijt}^{mhg} + t_{ijt}^{mf} + t_{ijt}^{mo} = T$$

with a parallel constraint for fathers.

The budget constraint in each period is thus

(A6) $$c_{ijt} + p_t^e\, n_{ijt}\,(\theta_{ijt}^{b}\, e_{ijt}^{b} + \theta_{ijt}^{g}\, e_{ijt}^{g}) + s_{ijt} = y_{ijt},$$

where p_t^e denotes the cost of purchased goods that increase child human capital such as health services and s_{ijt} denotes net savings, with

(A7) $$A_{it} + s_{it} = A_{it+1}$$

reflecting the use of savings to acquire productive assets. We assume that local economic conditions follow a random walk so that the best predictors of current and future technologies and wages are current levels of those variables.

Households choose at each age x whether to have a child, consumption, savings, human capital investments, and labor allocations to maximize their expected utility (A1) given constraints (A2)–(A7). Childbearing is chosen first and then, upon the realization of gender for that group of children, decisions are made about human capital investments. Although closed-form explicit comparative statics for dynamic models of this sort are unavailable, basic insight into the underlying processes can be obtained by examining the implied shadow prices of children and human capital and to obtain value-of-time effects. In particular, consider the sex-specific per-child net cost function

(A8) $$p^{k*}\,(h^k, p_e, w^k, w^k, w^m, w^p),$$

1. Note that if each boy receives t units of human capital input from the girls, the girls must each contribute t θ^b/θ^g units.

and implied conditional time and good demand functions denoted by, for example,

(A9) $$t^{mkh*}\ (h^k, p_e, w^b, w^g, w^m, w^p)$$

which characterizes the minimum net cost in terms of expenditures on children net of child earnings to produce the specified levels of children and human capital in a given period.

The first-order conditions for fertility and human capital are

(A10) $$0 = \frac{\partial u}{\partial n_{ijt}} + \frac{\partial V}{\partial n_{ijt}} + \theta^b_{ijt} r^b(\varphi_{ijt+\omega-x}, h^b_{ijs}) + \theta^g_{ijt} r^g(\varphi_{ijt+\omega-x}, h^g_{ijs})$$
$$-\lambda(\theta^b_{ijt}\pi^b_{ijt} + \theta^b_{ijt}\pi^b_{ijt})$$

and

(A11) $$u_{ijxt} = \frac{\partial u}{\partial h_{ijt}} + n_{ijt}\left(\theta^b_{ijt}\frac{\partial r^b}{\partial h^b_{ijt}} + \theta^g_{ijt}\frac{\partial r^g}{\partial h^g_{ijt}}\right) - \lambda n_{ijt}\left(\theta^b_{ijt}\frac{\partial \pi^b}{\partial h^b_{ijt}} + \theta^g_{ijt}\frac{\partial \pi^g}{\partial h^g_{ijt}}\right),$$

respectively, where V denotes the maximized value of (A1) at time t + 1 and λ is the period t Lagrange multiplier on the budget constraint.

Differentiating the cost function (A8) with respect to the female wage w^f and using the envelope theorem yields the value-of-time effect on fertility for women

(A12) $$\frac{d\pi^{k*}}{dw^f} = t^{mkh}* > 0.$$

The effect of the boy wage on the shadow price of a male child is

(A13) $$\frac{d\pi^{b*}}{dw^b} = t^{bb*} - T < 0$$

and the effect of a change in the girl wage on the shadow price of boys is given by

(A14) $$\frac{d\pi^{b*}}{dw^g} = t^{bg}* < 0.$$

There are symmetric expressions for the shadow price of girls.

If the on-farm marginal product of boy labor exceeds the local boy child wage for large landowners, for example, then an increase in landholding for these households will have an analogous effect

(A15) $$\frac{d\pi^{b^*}}{dA} = (t^{bb} * - T) f_A / f_{t\ b} < 0.$$

where the subscripted-f terms denote the corresponding marginal products.

Appendix 2

TABLE A. Random-Effects Estimates: Determinants of Log Maximum HYV Yield Index, 1971–99

Variable	
Proportion village acreage planted in wheat in 1968* (Year = 1971)	1.48
	(0.302)
Wheat * (Year = 1982)	−0.875
	(0.383)
Wheat * (Year = 1999)	−1.22
	(0.390)
Proportion village acreage planted in rice in 1968* (Year = 1971)	0.318
	(0.160)
Rice * (Year = 1982)	−0.113
	(0.204)
Rice * (Year = 1999)	−0.194
	(0.202)
IADP * (Year = 1971)	0.285
	(0.123)
IADP * (Year = 1982)	−0.291
	(0.157)
IADP in 1971* (Year = 1999)	−0.344
	(0.158)
Year = 1971	5.05
	(0.084)
Year = 1982	0.903
	(0.106)
Year = 1999	1.67
	(0.106)
R2	0.382
Number of villages	240
Number of observations	702

Source: Authors' calculations.

Estimated coefficient standard errors in parentheses.

Comments and Discussion

Mihir Desai: As Lazear (2000) notes, establishing the role of economic incentives in dictating demographic change and family structure has been one of the great achievements of "economic imperialism." Yet various accounts of the rapid changes in Indian fertility in the final two decades of the twentieth century have given short shrift to the role of economic incentives. These accounts have found little evidence for the role of a crass economic calculus in family decision-making and, instead, have emphasized loftier ideals—the diffusion of ideas on the role of women, female literacy and the spread of knowledge through public health systems. In India, economic imperialism, perhaps unsurprisingly, seems to have met a reluctant audience. Foster and Rosenzweig enter this contested area with a desire to reconcile the dramatic recent Indian experience with the considerable extant evidence on the significance of economic incentives. If imperialists were given to doubt, Foster and Rosenzweig provide them much comfort with their efforts.

Foster and Rosenzweig contribute to this debate by utilizing a novel data source and by innovating on traditional Beckerian logic. Various NCAER surveys have been knitted together to allow for a panel data set that permits for the removal of dynasty fixed effects. The theoretical framework emphasizes traditional value-of-time and quantity-quality tradeoffs but Foster and Rosenzweig innovate by providing a role for girls in family care that parallels the role of mothers. This innovation leads to novel, if somewhat strained, empirical predictions on the effects of girl wages. The empirical framework is fairly straightforward with predicted signs on wage rates and agricultural productivity that reverse between the regressions that explain the number of children and educational attainment.

The OLS findings help explain why others have disputed the role of economic incentives while the dynasty fixed effects results reveal why the OLS results should not be trusted. Taken together, the results provide a stark victory for the imperialists: changes in agricultural productivity and wages accounted for eighty percent of the documented decline in the rural fertility rate. Public health facilities, while associated with a statistically significant effect, explain little of the decline given their wide presence at the beginning of the sample. Female literacy does not materialize as an important factor in changes in fertility rates. Dynasty fixed effects appear to have revived the imperial project in India.

This study provides a convincing refutation to the prevailing wisdom that economic growth has not driven the decline in rural fertility. While the general thrust of the results is very convincing, it is worth pausing to consider some qualifications. First, the dramatic changes to the OLS results when using state fixed effects and dynasty fixed effects raise questions on the appropriate fixed effects to employ. The use of year and dynasty fixed effects control for persistent unobservables that drive variation across families. As such, identification comes from comparing women within dynasties and women over time within families. Given that the windows between sample years are so long, dynasty fixed effects allow for comparisons between a mother with herself through time (which is presumably minimal), between daughters and mothers through time, and between daughters in a period. The final comparison would seem the most valuable and the use of dynasty/year effects would control for non-persistent unobservable variables as well. This is particularly important given that public health campaigns might have influenced those unobservables over the time period under analysis. More generally, the authors have used community fixed effects in other work and it would be nice to see how much power there is in controlling for communities rather than families. Finally, the centrality of the dynasty fixed effects to the results recommends greater discussion of what dynasties look like and how many women are in typical dynasties.

Second, the paper links the dramatic reduction in rural fertility to the dramatic increases in rural productivity from the Green Revolution. While this argument is generally convincing, it is worth dwelling on the fact that the rural fertility decline came well after the revolution in agricultural productivity (1982 to 1999 relative to 1971 to 1982, in the sample here). This fact would recommend estimating these equations by period rather than just allowing for period fixed effects. Moreover, the mapping of the coefficients to estimates of the contribution of agricultural productivity would more appropriately use period-specific coefficients given the asynchronous nature of the changes. Finally, the case for the role of agricultural productivity would be even more convincing if predicted wage changes based on a first-stage regression of wages on changes in productivity were employed rather than actual wages. It is entirely plausible that agricultural productivity changes have a lagged effect on family decision-making and these lags could usefully have been considered further in this analysis.

Finally, the authors begin their paper by contrasting the role of economic incentives with the view that a "new reproductive idea" has disseminated in rural India giving rise to changes in beliefs that have a "life of their own." This alternative hypothesis about the role of public health campaigns is not fully confronted in their analysis. While the number of health centers is controlled for, these centers are complemented with mass media campaigns, outreach campaigns, and changing technologies of reproductive health. Of course, the dynasty fixed effects allow for some comfort in this regard but there are alternative hypotheses. While migration is assumed to be minimal (and the authors cite evidence of minimal migration), it is conceivable that the effects of migration on wages are largest in areas close to urban areas and that these areas also feature access to mass media campaigns and the easiest access to changed reproductive health technologies. Such an alternative hypothesis would require something more than a dynasty fixed effect to force it to surrender. Subsequent efforts might usefully consider the "splitters" in families (considered in other work by the authors) to fully identify the relative effects of public health efforts and economic incentives in dictating reproductive and schooling decisions.

Until then, Foster and Rosenzweig have clearly demonstrated that economic incentives have mattered greatly for the decline in rural fertility in India. The relative importance of other factors, including public health campaigns and the dissemination of ideas, remains an open question. As Garrett (2007) has noted, a remarkable opportunity awaits as a flood of dollars dedicated to public health issues needs to be targeted effectively in the coming decades. Foster and Rosenzweig's effort should be required reading for decision-makers charged with disseminating those funds. Their efforts remind us that spending public health dollars, and measuring their impact, should be embedded in a deep understanding of how families respond to economic incentives.

Ajay Shah: There has been a considerable debate about the role of economic factors in shaping fertility. The paper has an exciting dataset where households are observed in 1971, 1982, and 1999. A fascinating feature of the results lies in the 'dynasty' fixed effects. The coefficient of log female wage and the coefficient of log max HYV yield in the village—both of which are unclear in a straight OLS—become negative and statistically significant once dynasty fixed effects are controlled for.

There are technical difficulties with the econometrics in that a fixed effects OLS model is used when faced with a problem that is clearly count data. It may, however, be possible to argue that under certain conditions this does not gravely affect the results.

While the coefficient of log female wage is of the correct sign and statistically significant, it still appears to be implausibly small. Broadly speaking, in most countries, the demographic transition takes place across two to three doublings of the female wage. In other words, we know that TFRs drop dramatically when wages rise by a factor of 4x to 8x. The reported coefficient in the paper appears to be associated with smaller effects. This may, of course, be because when female wages go up by 4 to 8 times, the values of many of the other explanatory variables also change considerably. However, it may suggest that there are complexities in the income–fertility relationship that are not being fully understood by the authors.

The importance of a primary health centre (PHC) in the village is a surprising result. Empirical evidence from the National Fertility and Health Survey (NFHS)—which is arguably the best quality household survey data in India—suggests that once standard explanatory variables are controlled for, the presence of a PHC does nothing for many health measures. In this context, the finding of the paper that PHCs matter for fertility is surprising. Similar concerns arise on the role of school access. One possibility could involve selectivity effects: the decision by a government to place a PHC or a school may itself respond to the kinds of variables that affect fertility. The PHC or school dummy may, then, be picking up the explanatory variables which shape the decision of the government, such as income, road access, etc.

In interpreting the results, it is interesting to think about potentially unmet interest for contraceptive technology. Could it be that the diffusion of knowledge about HYV is correlated with the diffusion of knowledge about contraceptive technology? If so, there may be a spurious correlation between the two.

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