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HUMAN CAPITAL, PRODUCTIVITY, AND LABOR ALLOCATION IN RURAL PAKISTAN

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ABSTRACT

This paper investigates whether human capital affects the productivity and labor allocation of rural households in four districts of Pakistan. The investigation shows that households with better-educated males earn higher off-farm income and divert labor resources away from farm activities toward nonfarm work. Education has no significant effect on productivity in crop and livestock production. The effect of human capital on household incomes is partly realized through the reallocation of labor from low-productivity activities to nonfarm work. Female education and nutrition do not affect productivity and labor allocation in any systematic fashion, a finding that is consistent with the marginal role women play in market-oriented activities in Pakistan. As a by-product, our estimation approach also tests the existence of perfect labor and factor markets; the hypothesis that such markets exist is strongly rejected.

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1. INTRODUCTION

The role of human capital in the development process has attracted a lot of attention since the seminal contributions of Schultz (1961), Becker (1964), and Welch (1970). Recently, growth theorists such as Romer (1986, 1990), Lucas (1988, 1993), Stokey (1988, 1991), and others (for example, Azariadis and Drazen 1990; Ciccone 1994) have shown that the accumulation of human capital can sustain long-term growth. These theories have received support from the empirical work of economic historians such as Fogel (1990) and from macroeconomic regression analysis emphasizing the positive role of education on growth (for example, Mankiw, Romer, and Weil 1992; Barro and Sala-i-Martin 1992, 1995). Microeconomic evidence on this issue is both abundant and varied (see Jamison and Lau 1982 and Psacharopoulos 1984 and 1985 for surveys). Although there is little doubt that better-educated workers earn higher wages in the modern sector, whether education raises farm productivity remains a contentious issue. A widely-cited survey by Lockheed, Jamison, and Lau (1980) summarizes 39 equations from 18 different studies in 13 countries, concluding that education has a positive effect on farm productivity. Phillips (1987) argues that these results vary substantially by geographic region. Studies from Asia support the positive and significant relationship between education and farm efficiency, but the evidence from Latin America and Africa is mixed.

The purpose of this paper is to revisit this issue, using a panel survey of rural households from Pakistan.

This paper's contribution to the literature arises from its joint treatment of two issues that have usually been treated separately: the relationship between human capital and productivity, and the choice of farm and off-farm work. While a number of studies, for example, Jamison and Lau (1982) and the sources cited therein, examine the effects of human capital on agricultural output, they do not consider the allocation of labor between farm and off-farm activities. Unlike the works of Huffman (1980), Huffman and Lange (1989), and Kimhi (1996a, 1996b), the former strand of the literature seldom considers the endogeneity of labor inputs. Following Newman and Gertler (1994), Jolliffe (1996), and Yang (1997), this paper considers not only how human capital raises productivity, but also how households with different human capital endowments allocate labor to different activities.[1] If returns to education are highest in a particular activity, better educated households should reallocate their manpower to that activity, thereby providing evidence about the effect of education on output. This paper also moves beyond studies that focus either on crop production (for example, Jamison and Lau 1982 and the studies reviewed therein) or wages (for example, Alderman et al. 1996b; Haddad and Bouis 1991; Sahn and

[1]Newman and Gertler (1994) estimate a structural model of wages, marginal returns to farmwork, and marginal rates of substitution for different demographic groups within the household, taking into account the jointness of production and consumption among rural landholding households in Peru. Jolliffe (1996) estimates the returns to education in farm and off-farm work, and finds that they are much higher in the latter, thus affecting the allocation of labor in Ghanaian farm households. Yang (1997) considers the possibility that better-educated household members move into off-farm activities in China, and finds that schooling does not contribute to physical efficiency in farming but raises off-farm wages. The best educated person in the household, however, may make farm management decisions while participating in off-farm work.

Alderman 1988) and examines all the market-oriented activities of the household. This enables us to decompose the effect of human capital on total household income into a labor reallocation effect and activity-specific productivity effects. Our analysis also encompasses several complementary measures of human capital, enabling us to better disentangle the effects of education from other dimensions of human capital such as nutrition and innate ability.[2] Finally, our study contains several methodological innovations that ensure that the results are robust and as free as possible from endogeneity and omitted-variable bias.

The paper is organized as follows. We begin in Section 2 by introducing the conceptual framework underlying our work and discussing various econometric issues. The data are presented in Section 3. Regression results are examined in Sections 4 for income and 5 for labor. We find that households with better-educated males earn higher off-farm income and divert labor resources away from farm activities toward nonfarm work. Education has no significant effect on productivity in crop and livestock production. The effect of human capital on household incomes is partly realized through the reallocation of labor from low- to high-productivity activities, that is, nonfarm work. Female education and nutrition do not affect productivity and labor allocation in any systematic fashion. This is in line with the marginal role women play in market-oriented

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[2]The inclusion of several dimensions of human capital is a growing trend in the literature. For example, Haddad and Bouis (1991), Thomas and Strauss (1997), and Foster and Rosenzweig (1994) include individual-level calorie intake, height, and body mass index (BMI), in addition to education, in their studies of wage determinants in the rural Philippines and urban Brazil. Alderman et al. (1996a) examine the effects of cognitive skills, BMI, and height, in addition to experience and education, in their work on men's wage labor in rural Pakistan.

activities in Pakistan. As a by-product, our estimation approach also tests the existence of perfect labor and factor markets. The hypothesis that these markets exist is strongly rejected. Finally, we find evidence of fixed costs in undertaking income-generating activities. Conclusions are presented in Section 6.

2. CONCEPTUAL FRAMEWORK

We begin by presenting a simple conceptual framework for evaluating the effect of human capital on productivity and labor allocation. Consider rural households that derive their livelihood from several competing income-generating activities, indexed by *a*. A production function, g_a, is associated with each of these activities:

$$Y_a = g_a(L_a, X_a, T_a, Z), \qquad \textbf{(1)}$$

where Y_a denotes income, L_a denotes labor, X_a is a vector of variable inputs, and T_a stands for tools, equipment, and other semi-fixed factors. Z is a vector of human capital characteristics of the household. Human capital may affect Y_a in a variety of ways: better nutrition increases physical strength and raises labor efficiency; better education improves management and thus raises technological and allocative efficiency; leadership improves labor supervision skills. To the extent that human capital raises productivity, we expect a significant positive relationship between Y_a and Z. This possibility can be investigated by examining whether Z raises output Y_a, after controlling for inputs and semi-fixed factors. Human capital may raise the productivity of different inputs differently: the ability to better supervise workers and reduce shirking should raise the effectiveness of labor, not add to capital or land. The same can be said about nutrition. In contrast, better management skills could raise the productivity of all inputs and factors of production. To test whether human capital is not Hicks-neutral, one can verify whether Z raises the effectiveness of L_a and T_a differently in the production of Y_a.

It is also possible that human capital increases allocative efficiency without affecting technological efficiency—that is, that better-educated or smarter individuals choose more profitable levels of inputs. In this case, Z should affect net income but not necessarily gross revenue. Similarly, better-managed households may be better at taking advantage of economies of scope between activities. In this case, Z might affect the total net income of the household without necessarily affecting the productivity of individual activities. Analysis along these lines has been conducted by other researchers with varying degrees of sophistication (for example, Jamison and Lau 1982 and the studies cited therein); details are not presented here.

The productivity effects of human capital can also be investigated by observing how it affects household labor and input decisions. Let household choices be represented as an optimization problem whereby available manpower, $\overline{F}$, is allocated between leisure and production to maximize joint utility[3]:

[3] A collective model of the households does not seem required here given the extremely limited involvement of women in market-oriented activities in rural Pakistan (for example, Alderman and Chishti 1991; Brown and Haddad 1995; Sathar and Desai 1996).

$$\underset{L_a, F_a, X_a}{Max} \; U(S + \sum_a [Y_a - p\ X_a - w(L_a - F_a)],\ \overline{F} - \sum_a F_a)\ , \tag{2}$$

subject to production functions (see equation [1]) and to nonnegativity constraints,

$$L_a - F_a \geq 0 \text{ and } F_a \geq 0 \quad \text{for } all\ a\ . \tag{3}$$

U(.) is the household's utility function defined over income and leisure. *S* stands for unearned income, *p* for the price of inputs, *w* for the market wage rate, and F_a is manpower allocated to activity *a*. If markets for labor, inputs, and output are perfect, production decisions can be separated from preferences (for example, Singh, Squire, and Strauss 1986). Profit maximization then dictates that the return to variable inputs be equated with their price:

$$\frac{\partial Y_a}{\partial X_a} = p\ , \tag{4}$$

$$\frac{\partial Y_a}{\partial L_a} = w\ . \tag{5}$$

Solving the above system of equations yields labor- and input-use equations

$$L_a^D = h_a(w,\ p,\ T_a,\ Z)$$

and

$$X_a^D = f_a(w,\ p,\ T_a,\ Z)\,,$$

where the superscript D indicates demand (for labor and inputs, respectively), $h_a(\ )$ is the labor-use equation, and $f_a(\ )$ is the input-use equation. The effect of Z on labor and inputs can be studied by totally differentiating equations (4) and (5) to yield

$$\frac{dL}{dZ} = \frac{Y_{LZ}\ Y_{XX} - Y_{LX}\ Y_{XZ}}{Y_{LX}^2 - Y_{LL}\ Y_{XX}}\,, \qquad \textbf{(6)}$$

where we have dropped the a subscript to improve readability. Y_{LX} denotes the partial derivative of Y with respect to L and X, and so on for other terms. A similar expression can be derived for dX/dZ. Marginal returns to individual inputs are, as usual, assumed to be decreasing, that is, Y_{LL} and Y_{XX} are negative. The denominator of equation (6) is the second order condition, which must be negative at an interior optimum. Equation (6) thus shows that, if Y_{LZ}, Y_{XZ}, and Y_{LX} are all nonnegative, labor use must go up with Z. In other words, if human capital raises the marginal productivity of either labor or variable inputs or both, then it should also raise labor use, provided variable inputs increase marginal returns to labor. The same holds for variable inputs X. We have no a priori reason to suspect that variable inputs reduce marginal returns to labor in the farm and nonfarm activities of rural Pakistani households. Consequently, we expect labor and variable input use to go up if human capital raises their productivity.

The situation is somewhat different if labor markets are imperfect. In this case, de Janvry, Fafchamps, and Sadoulet (1991) have shown that household choices can be represented as a system of labor demand and supply with endogenous shadow cost of labor w^*. The factors that influence w^* can be identified by noting that utility maximization yields a household labor supply of the form

$$\sum_a F_a = F(w^*, S + w^* \bar{F} + \sum_a \Pi^a(w^*, T_a)), \tag{7}$$

where Π^a (.) is the profit function associated with activity a. If leisure is a normal good, the derivative of F(.) with respect to w^* is positive and with respect to income is negative. With these assumptions, factors that raise income also raise the shadow cost of labor w^*. To see why, equation (7) is totally differentiated with respect to w^* and, say, unearned income, S, while keeping total labor use, $\sum_a F_a$, constant. We get

$$\frac{d\,w^*}{d\,S} = -\frac{F_Y}{F_w}, \tag{8}$$

which is positive if the partial derivative of family labor supply with respect to income and wage, F_Y and F_w, are negative and positive, respectively. Other factors that reduce family labor supply exert a similar upward pressure on the shadow wage, w^*. The allocation of family labor to activity a thus depends, through w^*, on household manpower, $\bar{F}$, unearned income, S, and productive assets in other activities, T_a (see Evenson 1978; de Janvry, Fafchamps, and Sadoulet 1991). Labor and input use equations,

$$L_a^D = h_a(w^*, p, T_a, Z)$$

and

$$X_a^D = f_a(w^*, p, T_a, Z),$$

can be estimated indirectly by replacing w^* with a function of the household's manpower stock, $\overline{F}$, unearned income, S, and all its productive assets.

Comparing the models with and without perfect markets yields a number of testable predictions.[4] First, if markets are perfect and $w^* = w$, labor and input in activity *a* should depend only on wages, prices, and semi-fixed factors in that activity, not on unearned income and household characteristics such as household size and composition. Only if economies of scope are present should labor and input use in one activity be influenced by fixed factors in other activities. These ideas are at the basis of tests of perfect markets and allocative efficiency conducted by Benjamin (1992) and Udry (1996). Second, if markets are perfect, productive assets, T_a, should only have an income effect on household labor supply through their effect on profits, $\Pi_a(w, T_a)$. Hence the sign of T_a and nonearned income in the labor supply equation should be the same. In contrast, if markets

[4]Although we focus here on imperfections in the labor market, it is well known that efficient allocation of productive resources—and hence separability between production decisions and consumption preferences—only requires that N–1 markets be perfect, where N is the number of productive factors. For instance, if crops are produced with labor, land, and fertilizer, allocative efficiency can result even if a labor market is missing—provided the land and fertilizer markets are perfect; see, for instance, Udry (1996) and Gavian and Fafchamps (1996). In rural Pakistan, land transactions are even less frequent than labor transactions, so that it is natural to think of land as a semi-fixed factor and to focus the discussion on labor markets.

are imperfect, T_a could raise labor supply through its positive effect on returns to family labor, w^*. If this effect is strong enough, T_a may raise labor supply even when nonearned income, S, lowers it. Finally, if markets are perfect and economies of scope are absent, factors that raise returns to labor in one activity should have no effect on labor use in another activity. In contrast, if markets are imperfect, higher returns to labor in one activity raise w^*, thereby leading to a reduction of labor in other activities. If, for instance, schooling increases returns to labor in off-farm but not farmwork, this should reduce labor use in farmwork only if markets are imperfect.

In case we find evidence of market imperfections, it would be interesting to uncover the source of the imperfection. Our data on rural Pakistan indicate that most surveyed households are self-sufficient in labor and supply very little agricultural labor to the market. This situation is not unusual in poor developing countries (for example, Cleave 1974; Fafchamps 1993). One possible explanation suggested in the theoretical literature is the need to supervise hired workers (for example, Eswaran and Kotwal 1986; Dutta, Ray, and Sengupta 1989; Feder 1985; Frisvold 1994). This idea can be formalized by postulating that the effectiveness of labor depends on the share of total labor supplied by the household itself, that is, by letting

$$L_a^* = L_a \left(\frac{F_a}{L_a} \right)^{\gamma_a}, \qquad \textbf{(9)}$$

where L_a^* denotes effective labor, L_a is total labor in man-days, and F_a is household labor devoted to activity a. The parameter γ_a measures the importance of supervision: if $\gamma_a = 0$, hired labor is as effective as household labor; if $\gamma_a > 0$, household labor is more effective than hired labor, suggesting that labor supervision is problematic for hired-in workers. Whether issues of labor supervision are the reason behind market imperfections can thus be investigated by adding an F_a / L_a term to the production function equation and testing whether its coefficient is positive and significant.

3. CHARACTERISTICS OF SURVEYED HOUSEHOLDS

The data on which our analysis is based come from 12 rounds of a household survey conducted by the International Food Policy Research Institute (IFPRI) in four districts of Pakistan between July 1986 and September 1989 (see Nag-Chowdhury 1991 for details). A panel of almost 1,000 randomly selected households in 44 randomly selected villages were interviewed at 3- to 4-month intervals on a variety of issues ranging from incomes, agricultural activities, and labor choices to anthropometrics, education, land, and livestock (see Adams and He 1995; Alderman and Garcia 1993). Responses to these questions were combined by us to generate a consistent data set containing annual information about household composition, income, assets, inherited land, human capital, and labor. All asset variables refer to the beginning of the year.

The basic characteristics of the surveyed households are presented in Table 1. The median household size is eight people, half of whom are adults. Sources of income are

Table 1 Sample summary statistics

Household composition	Number of observations	Sample mean	Median	Standard deviation
Total household size	2,509	8.7	8	4.3
Adult males (20-65)	2,509	2.0	2	1.2
Adult females (20-65)	2,509	1.8	1	1.1
Young (6-20)	2,509	3.1	3	2.3
Children (0-5)	2,509	1.6	1	1.6
Old (>65)	2,509	0.3	0	0.6
Income (in 1986 rupees)				
Total income[a]	2,202	29,457	20,584	34,635
Net crop income	2,202	7,355	2,138	21,420
Net livestock income	2,202	4,566	3,643	6,176
Wages from agricultural work	2,202	287	0	1,210
Nonfarm earned income	2,202	8,823	6,036	10,067
Rental income	2,202	3,876	0	14,879
Remittances and transfers[b]	2,202	4,573	0	17,427
Assets				
Total land owned (acres)[c]	2,526	8.4	2.0	18.4
Irrigated land owned (acres)	2,526	3.8	0.0	9.7
Rainfed land owned (acres)	2,526	2.9	0.0	10.2
Total land owned by father (acres)	2,299	11.7	0.5	29.8
Inherited land (acres)	2,299	5.1	0.0	15.5
Value of farm tools and equipment (rupees)	2,374	9,054	1,011	27,359
Number of cattle	2,526	2.0	1	2.7
Number of buffaloes	2,526	1.8	0	2.6
Number of bullocks	2,526	0.3	0	0.8
Number of donkeys	2,526	0.2	0	0.7
Number of sheep and goats	2,526	2.9	2	4.9
Labor (days)				
Kharif family labor	2,526	70	27	106
Rabi family labor	2,526	46	20	68
Kharif hired labor	2,526	7	0	38
Rabi hired labor	2,526	7	0	26
Herding labor	2,526	135	36	250
Agricultural wage labor	2,526	0	0	7
Nonfarm labor	2,526	214	141	265

[a] Water tax is deducted from total income.

[b] Ninety-six percent of received transfers are remittances.

[c] Difference between total land and irrigated and rainfed land is noncultivable land—mostly pastures.

quite varied. Crops account for about one-fourth of average income; livestock accounts for another 15 percent. Nonfarm earned income—a mix of wages and self-employment income from crafts, trade, and services—represents 30 percent of average income; rental income and remittances amount to another 30 percent. Agricultural wage income is negligible among sample households. As already noted by Alderman and Garcia (1993) and by Adams and He (1995), livestock and nonfarm income are more equally distributed than crop income, rental income, or remittances. On average, households own eight acres of land, half of which is either canal- or well-irrigated. The median is much smaller, however, indicating that land is unequally distributed. The data also show large differences among households in inherited land and in the amount of land owned by the father of the household head. These two variables, in addition to the education of the father and mother of the household head, are used throughout as instruments for family background. Households spend roughly as much time herding as they do in crop production. Hired labor—mostly male—accounts, on average, for as little as 2.6 percent and 8.5 percent of total labor devoted to cultivation in the kharif and rabi seasons, respectively. Ninety-one percent of kharif farmers and 89 percent of rabi farmers do not use any hired labor. The use of outside help is somewhat higher at harvesttime: it accounts for 21.5 percent and 23.6 percent of total labor for kharif and rabi, respectively. Surveyed households do not report employing any wage worker for either herding or nonfarm activities. Although surveyed households use some hired labor for crop production, they spend very little time hiring themselves out as laborers. The sample may thus underrepresent farm laborers who are the poorest segments of rural society.[5] Wage work in nonfarm activities is common, though. Male members of the household do 84 percent of the crop work, 99 percent of herding, and 95 percent of nonfarm work. This is largely a consequence of purdah,[6] a system of secluding women, restricting them from moving into public places and enforcing high standards of female modesty upon them. This system limits women's mobility outside the home and restricts their participation in market work.[7] Women work mostly in or around the home.

Human capital variables are presented in Table 2. They include experience proxied by age and age squared; education measured in years of schooling; innate ability measured by Raven's test scores; childhood nutrition measured by height; and current nutritional status measured by the body mass index (BMI).[8] As a measure of experience, we use age and age squared rather than years of post-schooling wage work because, unlike in Alderman et al. (1996b), rates of school attendance are extremely low among older adult males and among adult females. Age and age squared are also more

[5]Panel surveys have a tendency to underrepresent wage laborers who are typically more mobile than farming households and have a higher probability of dropping out of subsequent survey rounds. The resulting attrition bias is not explicitly addressed in this paper due to the absence of suitable instruments, but it should be kept in mind when interpreting the results.

[6]See Ibraz 1993 and Jefferey 1979. Although purdah is now seen by many Pakistanis as a religious obligation prescribed by Islam, it was practiced by Muslims and Hindus alike before the partition of India. In his study of Punjab in the 1920s, for instance, Darling (1925) notes that Hindu Rajputs were the most dedicated to the practice, "a status symbol for which they pay dearly [in terms of wasted manpower and reduced profits]."

[7]Because of purdah, respondents are likely to have underreported female participation in market-oriented work.

[8]See Strauss and Thomas (1995) for a comprehensive review of attempts to account for various dimensions of human capital in measuring labor markets, health, and nutrition outcomes.

Table 2 Human capital summary statistics

	Number of observations	Sample mean	Median	Standard deviation
Husband and wife				
Age of head	2,436	48.2	47.0	13.7
Years of education of head	2,436	2.8	0.0	4.1
Raven's test of head	1,951	19.3	19.0	6.7
BMI of head	1,950	20.4	20.0	3.1
Height of head	2,395	167.3	168.0	6.5
Average days ill of head	2,441	15.0	1.0	33.3
Age of wife[a]	2,242	41.5	40.0	12.1
Years of education of wife[a]	2,242	0.3	0.0	1.5
Raven's test of wife[a]	1,884	14.5	14.0	5.1
BMI of wife[a]	1,876	21.2	20.5	4.0
Height of wife[a]	2,014	152.4	152.0	6.5
Average days ill of wife	2,253	6.2	0.0	15.1
Household averages				
Average age of adult males	2,497	38.0	37.0	8.6
Average years of education of adult males	2,497	3.7	2.5	3.9
Average Raven's test of adult males	2,075	20.1	19.5	6.2
Average BMI of adult males	1,987	20.4	20.0	2.9
Average height of adult males	2,426	167.4	167.5	6.1
Average days ill of adult males	2,457	11.1	1.0	27.3
Average age of adult females	2,493	37.1	36.0	8.2
Average years of education of adult females	2,493	0.6	0.0	1.6
Average Raven's test of adult females	2,165	14.7	14.0	4.9
Average BMI of adult females	2,198	21.0	20.7	3.5
Average height of adult females	2,322	152.4	152.0	6.2
Average days ill of adult females	2,394	5.8	0.0	13.7

[a] In polygamous households, average over all wives.

appropriate to capture life-cycle effects. Years of schooling is a measure of formal investment in human capital. Raven's (1956) Colored Progressive Matrices Test recognizes changes in patterns across a series of four pictures. It was initially developed to measure abstract thinking ability among illiterate children and has been widely used as a proxy for intelligence among illiterate adults in developing countries (for example, Knight and Sabot 1990). While abstract thinking ability, or ability to learn, is different from formal instruction, it can be affected by schooling. Since parents may choose to educate only those children with academic potential, years of schooling is likely to be correlated with innate ability. Raven's test scores thus reflect both innate ability and schooling. The explanatory power of Raven's test, conditional on years of schooling, is its ability to measure innate ability.[9]

Height and BMI proxy health and nutrition aspects of human capital. The BMI is defined as weight (in kilograms) divided by height (in meters) squared, a commonly used measure of fitness and nutritional status. Combined with other simple anthropometric measurements such as height, it has been shown to be a good predictor of muscular mass and physical strength among populations of developing countries (for example, Conlisk et al. 1992). Height, when evaluated for adults, captures the cumulative effects of childhood and adolescent nutrition as well as genetic endowments. Unlike BMI, it is not subject to short-term fluctuations. In this paper, we use only adult height to minimize endogeneity,

[9]Years of schooling also influences achievement as measured in test scores, for example, Glewwe and Jacoby (1994). The impact of test scores on rural labor market outcomes in Pakistan has been investigated by Alderman et al. (1996b). We do not use the math and reading scores because of the much lower number of valid observations.

that is, the possibility that taller parents may have taller offspring. We also investigate the possible endogeneity of current BMI by using lagged BMI in the sensitivity analysis.[10] Two separate sets of human capital variables are constructed for each household. In the first set, individual characteristics are averaged by gender over all household members 20 years and older, irrespective of their relationship to the head of household. The second set contains only information about the head of household and his wife.[11] The reason for constructing this second set is twofold. First, using average human capital of adult males and females may mask variations within these categories. Indeed, the head of the household and his wife are likely to have more decisionmaking power than other household members. Second, household averages may be subject to endogeneity bias: the prosperity and genes of the parents may be reflected in their offspring, thereby opening the door to a reverse causation between productivity and household-based human capital averages. Although less vulnerable to such problems, human capital of the husband and wife are only partial measures and therefore subject to measurement error. Moreover, if marriage-market selection exists, characteristics of husbands and wives are likely to be correlated (for example, Foster 1995). Since neither measure is perfect, our analysis is

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[10]We also experiment with self-reported days of illness as a measure of health status. While it is true that illness episodes may affect both the amount and efficiency of labor supplied, self-reported illness has been argued to be contaminated by self-reporting biases, with higher-income or more-educated individuals more likely to report being ill (for example, Sindelar and Thomas 1993). Illness episodes may also be correlated with factors that affect individuals' long-term productivity; a large literature on illness shows that the probability of illness is higher among less wealthy and less educated families (for example, Akin, Guilkey, and Popkin 1992). For these reasons, we treat the available information on sick days with caution. Labor allocation regress-ions with illness days are available at the following website: http://www-leland.stanford.edu/~fafchamp.

[11]In case of polygamous households, we take the average over all wives. The number of female-headed households in the sample is less than 1 percent.

conducted using both and we regard results about human capital as robust when they are present in both formulations. Following Jolliffe (1997) and Yang (1997), an alternative measure, the schooling of the most educated male or female in the household, is also used in the sensitivity analysis.

The two sets of variables are summarized in Table 2. The average head has spent 2.8 years in school; the median is zero. Female members of the household have a much lower level of education than males. Forty percent of males have no education versus 86 percent for females. Women also show a significantly lower score on Raven's test of progressive matrices, a test that supposedly measures innate ability irrespective of literacy level. This may be attributed to socially acquired attitudes by which women "try less hard" to perform than men, compounded by less familiarity with formal tests due to their lack of schooling (for example, Alderman et al. 1996a). The correlation coefficient between years of schooling and Raven's test score is fairly low, however: .43 for men, .28 for women. The sample population is short and, with average BMIs as low as 20.4 for males and 21 for females, only marginally well fed. Although women are less educated than men and rank lower in Raven's tests, they have a higher BMI. The t-test statistic for equality of means between male and female BMI's is highly significant (6.99 with 1,776 degrees of freedom for male and female averages; 6.81 with 1,441 degrees of freedom for head and wife). This is a common result due to the fact that women are shorter and have more body fat as a proportion of body weight (for example, Gibson 1990); it does not indicate that women in the sample are better-fed than men. The nutritional status of males and females within the same household appear unrelated: the coefficient of correlation between average male and female BMIs is .17. Women report less days lost to sickness, but we suspect that this may be due to self-reporting bias: women spend most of their time within the home where being sick is less disruptive and less noticeable. In contrast, men do all the work outside the home where their ability to work would suffer from reduced mobility and where sickness is harder to accommodate within one's routine.

4. TESTING THE PRODUCTIVITY OF HUMAN CAPITAL

We now test whether human capital raises productivity in any of the four activities in which the surveyed farmers are involved: kharif and rabi crop production; livestock raising; and nonfarm work. We proceed in two steps. In this section, we estimate production functions for the four activities and examine whether human capital has a significant effect on productivity. In the next section, we turn to labor allocation and estimate labor demand and supply equations.

CROP INCOME

Our choice of a suitable function form for the production functions is guided by two considerations: adequacy and parsimony. Consider crop production first. Since our main concern is to estimate the effect of human capital on productivity, we focus on a simple Cobb-Douglas formulation with three essential inputs: land, labor, and farm tools. No crop output can be obtained when any of these inputs is absent.[12] In contrast to land, tools, and labor, inputs such as fertilizer, draft power, or pesticides are not essential since some output can be obtained without them. Nonessential inputs can be thought of as raising the effectiveness of essential inputs. For instance, expenditures on fertilizer and other chemical inputs, X_a, are likely to raise the productivity of land. To the extent that certain characteristics of land are in fixed supply and cannot be substituted for by chemical inputs, X_a is expected to raise the productivity of land in a decreasing fashion. A simple parameterization that captures these ideas assumes that the contribution of land to total output can be represented as $A_a\ (1 + X_a)^{\delta_a}$. If $\delta_a = 0$, X_a does not add to land productivity; and if $\delta_a > 0$, land measured in efficiency units rises with X_a. Similar reasoning can be followed for human capital variables Z and other nonessential inputs.

Aggregation of different qualities of inputs must also be dealt with adequately. Crops can be produced on rainfed or irrigated land. Although land itself is essential for crop production, neither rainfed nor irrigated land are individually essential. Yet the productivity of land is likely to vary across land types. We decompose land into rainfed and irrigated and we define land in rainfed-equivalent units as $A_a^R + (1 + \beta_a)\ A_a^I$, where A_a^R and A_a^I denote rainfed- and irrigation-cultivated acreage, respectively. β_a expresses the efficiency of irrigated land relative to rainfed land: if $\beta_a > 0$, A_a^I is more productive than A_a^R; if $0 > \beta_a > -1$, A_a^I is less productive than A_a^R; if $\beta_a < -1$, A_a^I is

[12]Observations for which crop income is reported, but not labor or cultivated acreage, are treated as cases with missing labor or land information; they are excluded from the regression analysis. Observations with no recorded crop output are also omitted from the regressions: we suspect that many of them are for pasture and fodder crops harvested by the animals themselves, and should thus be regarded as observations with unrecorded output.

counterproductive, that is, it subtracts from output. Estimation is greatly simplified by noting that for any number x close to 0, $1 + x$ is nearly equal to e^x. Effective land can thus be written approximately as $A_a \; e^{\beta_a A_a^I / A_a}$. A similar approach can be used for other aggregation problems among highly substitutable inputs.

After adding the labor supervision term, the crop production function becomes

$$Y_a = \alpha_a \, L_a^{\alpha_{aL}} \left(\frac{F_a}{L_a} \right)^{\gamma_a \, \alpha_{aL}} A_a^{\alpha_{aA}} \; e^{\alpha_{aA} \, \beta_a \, A_a^I / A_a} \; T^{\alpha_{aT}} \; (1 + X_a)^{\alpha_{aX}} \; (1 + B)^{\alpha_{aB}} \; e^{\lambda_a \, Z} , \tag{10}$$

where Y_a is the total value of crop output, A_a is planted acreage, B is the number of bullocks owned, and Greek letters stand for parameters to be estimated. Given that Y_a cannot be negative and follows an approximatively log-normal distribution, it is natural to postulate multiplicative disturbances. Equation (10) is estimated by ordinary least squares after taking logs of both sides.

There are 12 human capital variables used in the estimation, 6 for males and 6 for females. As discussed in Section 3, they are age and age squared, years of schooling, Raven's test score, height, and BMI.[13] To control for possible omitted variable bias in the human capital variables, we add four variables that control for family background. They are the land owned by the household head's father; the land inherited by the household; the education of the head's father; and the education of the head's mother. Including these variables should reduce fears that observed correlation between human capital and

[13]Sickness days are not included because much of their effect is already captured by the labor variable.

productivity in fact captures the effect of family background. For instance, individuals whose fathers farmed or who inherited more land probably received more exposure to farming (for example, Rosenzweig and Wolpin 1985). These individuals may enjoy higher farm productivity thanks to returns to specific experience. Similarly, if children from landed households are better-fed and educated than those from landless families, and family background is not controlled for, human capital variables may capture the effect of exposure to farming, but not that of human capital itself. Returns to education might also be overestimated if analysis excludes parents' education.

Estimation results for kharif crop output and rabi crop output are reported in Table 3. We also estimate a combined (annual) crop output regression to investigate the possibility that human capital increases a household's ability to allocate resources among seasons without raising productivity within each season separately. Results are presented in the last four columns. Two sets of regressions are run in each case, one using the average human capital of the household, the other using only the human capital of the head and his wife. The latter set offers a less complete representation of the human capital of the household, but it is not subject to the omitted variable bias that arises if better able or better educated couples have both higher incomes and better-fed, better-educated children. Effects that are fixed for each village are included in all regressions

Table 3 Crop production function estimation

	Kharif output				Rabi output				Total crop output			
	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t
Factors of production												
Cultivated acreage	0.323	**4.712**	0.390	**5.660**	0.402	**6.545**	0.342	**5.083**	0.419	**4.014**	0.454	**4.584**
Share of irrigated acreage	0.478	**1.853**	0.344	1.063	–0.125	–0.570	0.095	0.439	0.104	0.289	0.435	1.496
Value of farm tools	0.116	**3.387**	0.123	**3.048**	0.038	1.384	0.071	**2.025**	–0.013	–0.280	0.154	**2.723**
Number of bullocks	0.397	**3.561**	0.444	**3.483**	0.211	**2.680**	0.208	**2.255**	0.371	**3.072**	0.367	**2.842**
Cultivation labor	0.190	**3.623**	0.159	**2.937**	–0.049	–1.265	–0.076	–1.673	0.155	**2.282**	0.094	1.181
Share of family labor	0.099	0.445	0.263	1.276	0.104	0.535	0.062	0.216	0.311	0.991	0.064	0.260
Input expenditures (log+1)	0.209	**4.080**	0.172	**3.072**	0.221	**3.715**	0.255	**3.642**	0.621	**6.106**	0.210	**4.099**
Human capital	*Average human capital of household*		*Human capital of husband and wife*		*Average human capital of household*		*Human capital of husband and wife*		*Average human capital of household*		*Human capital of husband and wife*	
Males												
Age	–0.015	–0.388	0.017	0.522	0.015	0.590	0.011	0.497	–0.041	–0.963	–0.042	–1.217
Age squared	0.000	0.219	–0.000	–0.558	–0.000	–0.703	–0.000	–0.575	0.001	1.149	0.000	1.375
Years of education	0.011	0.630	0.021	1.261	–0.022	**1.930**	–0.022	**1.799**	0.037	**1.771**	0.011	0.532
Raven's test score	0.011	1.358	0.006	0.708	–0.003	–0.473	0.000	0.033	–0.007	–0.701	–0.006	–0.645
Height	0.017	**2.105**	0.010	1.106	0.006	0.979	–0.002	–0.348	0.008	0.790	0.001	0.128
BMI	0.016	1.046	0.028	**1.691**	0.022	**1.978**	0.015	1.114	–0.017	–0.801	–0.023	–1.005
Females												
Age	0.033	0.878	–0.031	–0.883	–0.008	–0.301	0.007	0.211	–0.009	–0.242	0.022	0.615
Age squared	–0.000	–0.927	0.000	0.984	0.000	0.263	–0.000	–0.517	–0.000	–0.127	–0.000	–0.805
Years of education	0.050	1.360	0.070	**1.984**	–0.034	–1.181	–0.017	–0.410	–0.082	–1.564	0.040	0.937
Raven's test score	–0.012	–1.288	–0.011	–1.147	0.003	0.402	–0.017	**1.855**	–0.006	–0.486	–0.009	–0.720
Height	0.003	0.341	0.016	1.769	0.004	0.716	0.003	0.551	–0.005	–0.440	–0.002	–0.182
BMI	–0.003	–0.256	–0.001	–0.056	–0.000	–0.020	0.011	1.227	–0.017	–0.826	–0.018	–1.086
Family background												
Land owned by father (log+1)	–0.056	–1.364	–0.139	**2.613**	0.031	0.798	–0.034	–0.666	–0.072	–1.028	–0.128	–1.390
Inherited acres (log+1)	0.020	0.344	0.133	**1.915**	0.028	0.660	0.077	1.311	0.140	1.579	0.241	**2.073**
Father's schooling	0.006	0.131	–0.010	–0.199	0.067	**1.847**	0.075	**1.809**	–0.045	–0.620	0.091	1.230
Mother's schooling	–0.274	–1.162	–0.345	–1.330	0.062	0.411	–0.002	–0.008	0.008	0.019	–0.801	–1.380
Shifters												
Dummy for 1986	–0.434	**3.078**	–0.431	**2.702**	–0.276	**3.185**	–0.331	**3.235**	–0.756	**4.623**	–0.512	**2.946**
Dummy for 1987	–0.247	**1.892**	–0.296	**1.862**	–0.476	**5.697**	–0.536	**5.554**	–1.078	**5.916**	–0.607	**3.311**
Intercept	0.459	0.185	0.375	0.152	4.536	**3.100**	5.535	**3.571**	4.088	1.481	7.298	**2.760**
Number of observations	677		546		752		601		1,013		733	
Number of households	404		332		413		343		480		375	
R-squared	0.7231		0.7325		0.5919		0.5757		0.5226		0.4941	

Notes: Dependent variable is the log of the deflated value of crop output. Estimator is ordinary least squares with village fixed effects. Zero land and zero labor observations have been eliminated. Robust standard errors with household clusters are reported. All values are in 1986 rupees; (log+1) means that the regressor is computed as Log(x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

to control for soil, weather, and market conditions. To minimize the bias naturally resulting from correlation between harvesting labor and yield—a good harvest requires more labor to gather crops in the field—harvesting labor is excluded from the labor variable. Labor thus includes only the reported labor for land preparation, irrigation, and cultivation. Robust standard errors with household clustering are reported to correct for the possible correlation between error terms within each household.

Results indicate that cultivated acreage, farm tools, bullocks, cultivation labor, and expenditures on variable inputs are good predictors of output. Estimates of the supervision parameter γ_a are positive but not significant in any of the regressions, suggesting that, if supervision costs are present, they are not large. This result contrasts with the findings reported by Frisvold (1994) that show supervised labor in rural India to be significantly less productive than family labor. Year and village dummies are significant, confirming that crop production varies systematically across time and space—hardly a surprising result. Human capital variables are, in general, nonsignificant. Households with taller adult males appear to achieve higher output in the kharif season; higher BMI of adult males is associated with higher output in kharif and rabi. These effects, however, do not carry over to total crop output. Age and Raven's test scores are nonsignificant in all regressions, suggesting that experience and innate ability are not important determinants of crop output in the survey areas once we control for schooling. Better-educated males obtain a lower crop output in the rabi season, but the effect of schooling on total crop output is positive and marginally significant. The effect vanishes, however, if only the education of the head of household is considered. These results suggest that schooling has an effect on crop output by causing household members to neglect the drier rabi season, and not by raising productivity per se. Family background variables are in general nonsignificant. Land owned by the head's father has a negative effect on crop productivity, but this effect is significant only for one of the kharif regressions. Father's schooling is positively associated with rabi output, but only when the head's own schooling is negatively significant. Taken together, our results coincide with evidence indicating that returns to schooling are low in Third World agriculture (for example, Rosenzweig 1980; Jolliffe 1996), but contrast with conclusions reached by Jamison and Lau (1982).

Because of the controversial nature of our findings regarding human capital, we conduct an extensive sensitivity analysis. First, we examine whether households with more human capital respond more efficiently to market signals even though they may produce the same output. To do so, we replace total crop revenues as the dependent variable with crop income net of variable costs. Imputed labor costs are not included because more than 90 percent of (nonharvest) crop labor is provided by the household. Since net crop income can be negative, the assumption of multiplicative errors in equation (10) is replaced with additive errors and equation (10) is estimated via nonlinear least squares. Results (in Appendix Table 9) generally confirm previous results: factors of production have the expected sign and are highly significant, but schooling has no effect on net crop incomes. High BMI among adult males has a highly significant positive effect on net crop income.

Second, we investigate whether the nonsignificant effect of schooling is due to the fact that the management gains from schooling are a household public good: as long as a single member of the household is educated, he or she can help the others make better production decisions (for example, Jolliffe 1997). To test this hypothesis, we replace average schooling with the maximum education level attained by an adult male or female member of the household. Results (Appendix Table 10) do not change: schooling either has a negative (rabi) or nonsignificant (kharif, combined) effect on output.

Third, we reestimate crop output regressions with household random effects to control for the possibility that household-specific disturbances correlated with human capital blur the effect of human capital on output. Results are qualitatively unaffected (Appendix Table 11). We repeat the exercise with household fixed effects; in this case, none of the human capital variables are significant (Appendix Table 12).[14] Fourth, we reestimate equation (10) with instrumental variables, using the determinants of household labor supply (see Section 5) as instruments. These determinants include family composition, owned land, livestock assets, and nonearned income. The resulting production function estimates (Appendix Table 13) tend to be smaller and less significant for all factors of production, suggesting that our instruments, although highly significant,

[14]When household fixed effects are included, village fixed effects and household-level time-invariant variables such as family background are dropped. Variations in average human capital from year to year reflects variations in household composition more than anything else.

are not sufficiently precise. Human capital variables are, in general, nonsignificant, except for height of adult males for kharif.

Fifth, we investigate whether the reported effect of BMI on crop output may be due to endogeneity bias—better harvest means more food available and hence better nutrition, rather than the reverse causation of better nutrition leading to more work effort in crop production. To reduce the potential bias, we reestimate the crop production function with lagged BMI, which implies losing one third of the observations. Results (Appendix Table 14) show no significant relationship between lagged adult BMI and crop output. This suggests that endogeneity bias may be responsible for the spurious correlation between BMI and crop output reported in Table 3. Schooling is negatively significant for rabi, nonsignificant otherwise. Sixth, we investigate whether human capital is nonneutral in the sense that it raises the effectiveness of certain inputs more than others. To do so, we reestimate equation (10) with interaction terms between essential inputs and key human capital variables. Results (Appendix Table 15) do not invalidate previous results. In the rabi season, male schooling is shown to raise the efficiency of land but to decrease total productivity even more, so that the total effect is negative, as in Table 3. Annual crop output is not affected by male schooling.

Finally, it is possible that our estimates of the productivity of human capital are biased because certain individual traits that correlate positively with output are correlated negatively with education or nutrition. To understand why, suppose, for instance, that individuals who derive most of their income from nonfarm activities neglect farming in ways that are hard to measure, for example, by planting or irrigating late, supervising labor less effectively, and in general applying less care to their fields. If better educated males are more involved in nonfarm activities, an omitted variable bias may arise that tends to depress the estimated effect of schooling on crop productivity. To correct this bias, we use the labor allocation regressions to identify the omitted variable and control for its effect on productivity. The idea behind the correction mechanism is that households who neglect farming because they are heavily involved in livestock or nonfarm activities have large positive residuals in the labor allocation regressions (see Section 5). These residuals can be included in equation (10) to identify the effect of unobserved productivity in nonfarm and livestock activities on crop output, after correction for the fact that labor is a censored variable. The approach is similar in spirit to the use of the inverse Mills ratio to control for self-selection bias (for example, Heckman 1976; Maddala 1983), except that the selection equation is a tobit, not a probit. This parallels work by Pitt, Rosenzweig, and Hassan (1990), who use residuals from a health production function in their analysis of intrahousehold food distribution, and Behrman, Birdsall, and Deolalikar (1995) in their analysis of marriage market outcomes in India.

Formally, let y_i and ϵ_i denote the *i*th observation of the dependent variable and the *i*th residual in any of the income equations, respectively. Similarly, let z_i and u_i denote the dependent variable and the residuals in the tobit labor choice equation, respectively. The regressors in the y_i and z_i are denoted x_i and w_i, respectively. The residuals are assumed to be normally distributed. Their standard deviations are written σ_ϵ and σ_u, respectively; ρ is the correlation coefficient between the two. In case $z_i > 0$, we have

$$\begin{aligned} E[y_i \mid x_i, u_i] &= \beta' x_i + E[\epsilon_i \mid u_i] \\ &= \beta' x_i + \rho \frac{\sigma_\epsilon}{\sigma_u} u_i . \end{aligned} \tag{11}$$

In case $z_i = 0$, we get

$$\begin{aligned} E[y_i \mid x_i, u_i] &= \beta' x_i + E[\epsilon_i \mid u_i \leq -\alpha' w_i] \\ &= \beta' x_i + \int_{-\infty}^{-\alpha' w} \epsilon_i \, f(\epsilon_i \mid u_i) \, d\epsilon_i , \end{aligned} \tag{12}$$

which, by application of Theorem 20.4 in Greene (1997, 975), is equivalent to

$$\beta' x_i - \rho \sigma_\epsilon \frac{\phi(\frac{\alpha' w_i}{\sigma_u})}{1 - \Phi(\frac{\alpha' w_i}{\sigma_u})} , \tag{13}$$

where ϕ(.) and Φ(.) denote the probability function and cumulative distribution function of a standard normal variable. All production and income regressions are reestimated with selection/effort correction terms constructed by replacing u_i, σ_u, ϕ(.), and Φ(.) in equations (12) and (13) by their predicted values from tobit labor choice regressions.[15]

[15]As indicated in the next section, the complete tobit results can be found at the following website: http://www-leland.stanford.edu/~fafchamp.

Two selection/effort correction terms are constructed, one for livestock and one for nonfarm labor.

Results (Appendix Table 16) are virtually identical to those reported in Table 3, except that schooling is no longer significant in the total crop output regression. Other human capital results are essentially unchanged. As anticipated, nonfarm residuals are negative in all regression, suggesting that households who invest more labor in nonfarm work than predicted by the labor choice regression spend less "quality time" in their fields. The effect is significant only in one of the kharif regressions, however.

LIVESTOCK, NONFARM, AND TOTAL INCOME

We now turn to the household's noncrop activities. A production function is estimated for livestock. Essential inputs into livestock production are livestock itself and labor. Different categories of livestock are aggregated using the same approximation used for crop land, that is, the contribution of livestock to output is decomposed into a size effect—the number of animals—and a herd composition effect, $e^{\sum_i \beta_i N_i/N}$, where N_i is the number of animals in category i, N is total livestock, and β_i is a parameter to be estimated. Land is treated as a nonessential input since households can purchase fodder from the market. Land is, however, expected to raise the productivity of livestock thanks to better and cheaper access to crop residues and fodder (see Fafchamps and Kurosaki 1997 for evidence). The livestock production function boils down to

$$Y_b = \alpha_b \, L_b^{\alpha_{bL}} \, B^{\alpha_{bB}} \, e^{\sum_i \beta_i N_i/N} \, (1 + A_o)^{\alpha_{bA}} \, e^{\alpha_{bI} A_o^I/A_o} \, e^{\lambda_b Z} + \epsilon \,, \qquad \textbf{(14)}$$

where A_o and A_o^I denote total and irrigated owned land, respectively. The labor supervision term is ignored since all herding is performed by household members. Livestock income Y_b is net of production costs and capital losses. Some 21 percent of livestock income observations are negative as a result of animal losses due to theft or disease. Postulating multiplicative errors is thus inappropriate. Instead, we postulate additive disturbances ϵ and estimate equation (14) via nonlinear least squares. Households with no livestock are excluded from the regression. The same 12 categories of human capital variables are used as in the crop regressions.

Background variables are included to minimize omitted variable bias. An equivalent production function is estimated for nonfarm production. To approximate nonfarm capital, we use data on trading inventories. The estimated equation is thus

$$Y_n = \alpha_n \, L_n^{\alpha_{nL}} \, K^{\alpha_{nK}} \, e^{\lambda_n Z} + \epsilon \,, \qquad \textbf{(15)}$$

where K denotes nonfarm inventories.[16] Nonfarm income Y_n is net of production costs. To control for the possibility that returns to human capital may differ in farm and nonfarm

[16]In an attempt to construct a more comprehensive measure of nonfarm capital, we also compute an alternative measure of nonfarm capital as the sum of inventories plus the value of durables such as vehicles, refrigerators, and sewing machines, which are known to serve as the basis for numerous nonfarm businesses in rural Pakistan. Because household durables are also consumption goods, however, this measure is subject to the risk of spurious correlation with income. Results using this alternative measure of nonfarm capital must thus be interpreted with extreme caution.

labor, the negligible amounts of off-farm agricultural wages and labor recorded in the data are excluded from Y_n and L_n. Since 22 percent of nonfarm income observations are null or negative, we again postulate additive errors ϵ and estimate equation (15) using nonlinear least squares.

We also estimate a total net income regression of a form similar to the forms of equations (14) and (15). It includes all semi-fixed assets such as owned land, farm tools, livestock, and nonfarm capital. Total labor is included as well as the share of labor devoted to crops and livestock. Since total income can be negative, equation (15) is estimated with nonlinear least squares. Year and village fixed effects are included.

Estimation results for livestock, nonfarm, and total income are summarized in Table 4. Village fixed effects are included in the regression but omitted from the table. Factors of production are in general significant and have the right sign in all regressions, except for trading inventories (a proxy for nonfarm capital), which has a negative and significant sign in the total income regression. Many share parameters are significant as well, suggesting the presence of heterogeneity among inputs. Bullocks are significantly more productive than cattle; sheep and goats, less productive. Year and village dummies often are significant, again emphasizing the existence of systematic income differences across space and time.

Regarding human capital, the strongest result concerns the effect of male education on nonfarm and total income: it is positive in all four regressions and highly significant in three. One additional year of education is associated with an increase of 2.8 to 4.6

Table 4 Livestock, nonfarm, and total income regressions

	Livestock net income								Nonfarm net earned income			
	Total earned income											
	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t
Factors of production												
Total labor	0.026	**2.363**	0.044	**3.492**	0.590	**22.225**	0.609	**18.902**	0.101	**2.965**	0.202	**6.098**
Share of crop labor									–0.098	–0.877	–0.321	**3.600**
Share of livestock labor									–0.050	–0.541	–0.876	**8.535**
Number of livestock	0.903	**16.645**	0.841	**13.203**					0.344	**7.109**	0.200	**4.857**
Share of bullocks	0.806	**5.782**	0.768	**4.797**					–0.316	–1.105	0.557	**2.592**
Share of buffaloes	–0.061	–0.190	0.312	0.999					–0.534	**5.237**	0.298	**3.326**
Share of donkeys	–0.516	–1.255	–1.133	**2.214**					0.263	0.796	–0.531	–1.671
Share of sheep and goats	–0.417	**2.808**	–0.513	**3.030**					–0.876	**6.815**	–0.216	**2.012**
Total land[a]	–0.174	**4.827**	–0.092	**2.220**					0.182	**5.312**	0.038	1.085
Share of irrigated land[a]	0.106	1.124	–0.195	–1.824					–0.164	–1.766	0.188	**2.274**
Value of farm tools									0.093	**5.610**	0.080	**5.586**
Trading inventories					0.011	**3.020**	0.001	0.119	–0.033	**4.428**	0.011	1.649
Human capital												
Adult males												
Age	–0.031	–1.510	0.047	1.972	–0.002	–0.175	–0.032	**2.156**	0.021	0.976	–0.018	–1.112
Age squared	0.000	1.706	–0.000	**2.165**	–0.000	–0.393	0.000	1.951	–0.001	–1.948	0.000	1.093
Years of education	0.009	0.896	0.018	1.632	0.028	**4.442**	0.046	**7.381**	0.089	**10.116**	0.004	0.563
Raven's test score	–0.008	–1.566	–0.012	**2.216**	0.006	1.665	0.002	0.547	0.009	1.860	0.009	**2.282**
Height	0.022	**4.039**	0.018	**3.436**	–0.005	–1.700	–0.005	–1.409	0.025	**4.941**	–0.001	–0.321
BMI	0.045	**4.298**	0.025	**2.309**	0.005	0.913	–0.007	–1.218	0.034	**3.292**	0.012	1.705
Adult females												
Age	–0.009	–0.456	0.028	1.273	–0.026	**2.107**	–0.013	–0.888	–0.033	–1.523	–0.004	–0.222
Age squared	0.000	0.416	–0.000	–0.777	0.000	1.561	0.000	1.783	0.000	0.837	0.000	0.858
Years of education	–0.077	**2.495**	0.001	0.028	–0.016	–1.442	–0.008	–0.488	–0.006	–0.382	0.036	**2.321**
Raven's test score	–0.000	–0.058	0.007	1.026	0.002	0.644	–0.002	–0.408	0.044	**6.833**	0.007	1.326
Height	0.019	**3.433**	0.009	1.550	–0.001	–0.259	–0.003	–0.970	–0.042	**8.617**	–0.003	–0.670
BMI	0.016	1.990	0.008	1.141	0.018	**3.994**	0.007	1.704	0.061	**8.827**	0.003	0.487
Family background												
Father's holding (log+1)	–0.005	**2.186**	–0.002	–0.724	0.000	0.477	–0.004	**3.090**	–0.001	–0.803	0.002	1.444
Inherited land (log+1)	0.004	1.158	0.003	1.024	0.002	1.618	0.006	**2.984**	0.002	0.902	0.003	1.454
Father's education	–0.110	**3.467**	–0.161	**3.956**	–0.013	–0.739	–0.002	–0.096	–0.045	**2.038**	0.108	**4.680**
Mother's education	1.266	**9.043**	0.910	**5.540**	0.195	**3.506**	0.110	1.554	0.185	1.805	–0.204	–1.647
Shifters												
Dummy for 1986	–0.021	–0.268	–0.029	–0.328	0.111	**2.896**	0.114	**2.557**	–0.424	**6.356**	–0.067	–1.059
Dummy for 1987	0.172	**2.212**	0.176	**2.061**	0.096	**2.514**	0.133	**2.986**	–0.344	**5.540**	0.064	1.106
Intercept	0.000	0.705	0.000	0.729	0.862	1.198	2.557	1.185	1.403	0.742	2.191	0.922
Number of observations	1,303		1,016		1,451		1,143		1,392		1,095	
R-squared	0.396		0.419		0.638		0.653		0.685		0.539	

Notes: Estimator is nonlinear least squares. Village fixed effects included but not shown. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

[a] In the livestock regression, land is cultivated acreage; in the total earned income equation, land is owned acreage.

percent in nonfarm earned income. An additional year of schooling is also estimated to raise total income by 8.9 percent, if average human capital is used as a regressor, but by 0.4 percent if only the education of the head of household is used. Female education is significant and positive in the total income regressions, which show it increasing total income by 3.6 percent. But female education is not significant or negative in other regressions, suggesting that the coefficient estimate may be subject to omitted variable bias. Male and female height and BMI are significant and positive in several of the regressions, suggesting that better-fed households achieve higher incomes. To summarize, production regressions indicate that male education has a strong positive effect on nonfarm and total income, but no or little effect on crop output. Better-fed households in general achieve higher incomes, but the effect is not present in all regressions, and may reflect endogeneity of BMI. Experience, innate ability, and female education do not appear to have any robust effect on incomes.

5. HUMAN CAPITAL AND LABOR USE

We now examine how human capital affects labor used in four activities: kharif and rabi crop production, herding, and nonfarm work. We also examine total family labor supply. The labor and input use equations,

$$L_a^D = h_a(w^*, p, T_a, Z)$$

and

$$X_a^D = f_a(w^*, p, T_a, Z),$$

discussed in Section 2, form the basis of our estimation strategy. Since the shadow cost of labor w^* is not observable, we include factors that influence total labor supply when markets are imperfect, namely household size and composition, nonearned income, family background, and productive assets in other activities.[17] For kharif and rabi, the dependent variable L_a is the sum of family and hired labor. In the case of herding and off-farm work, it consists exclusively of family labor since the hiring of labor by the household was not observed in these activities. Around 37 percent of kharif and rabi labor observations are zeroes; the corresponding percentages for herding and off-farm work are 45 percent and 38 percent, respectively. The dependent variable is thus a censored variable. Latent labor use L_a^* is assumed to follow:

$$1 + L_a^* = \theta_a \bar{F}^{\theta_{am}} e^{\sum_m \beta_{am} \bar{F}_m/\bar{F}} O^{\theta_{aB}} e^{\theta_{ao} O^I/O} T^{\theta_{aT}} K^{\theta_{aK}} B^{\theta_{aB}} e^{\sum_c \theta_{ac} B_c/B} S^{\theta_{aS}} e^{\sum_u \theta_{au} S_u/S} e^{\theta_{aZ} Z} e^{\epsilon} \qquad \textbf{(16)}$$

for $a = \{k, r, h, n\}$, with actual labor $L_a^* = L_a$ if $L_a > 0$. A similar equation is assumed to represent latent labor supply, $F^* \equiv \sum_a F_a$. The θ's are parameters to be estimated and the disturbance term ϵ is assumed to be normally distributed. Variable $\bar{F}_a$ stands for the

[17] Jacoby (1993) uses a different approach and derives shadow wages from marginal products estimated from a farm production function.

number of household members in different age/sex categories and $\bar{F} \equiv \sum_m \bar{F}_m$.[18] As with other share variables, the parameters of each of the age/sex categories indicate the efficiency of that category relative to the excluded category, adult males. O is total owned land; O_I is owned irrigated land; T is farm tools; B_c is the total number of livestock in category c and $B \equiv \sum_c B_c$; S_u stands for the three categories of unearned income: remittances, rental income, and pensions, with $S \equiv \sum_u S_u$; and unearned income is expected to have a negative effect on labor supply.[19] Z, as before, denotes a vector of human capital variables and family background variables. We focus our discussion on specifications without reported illness days, given the caveats regarding self-reported illness. Year and village fixed effects are included to control for location and year-specific changes in climatic and market environments.

We first estimated equation (16) for each labor use category and for total labor in log form using the tobit model. We also estimated equation (16) with the human capital of husband and wife instead of the family average.[20] However, the appropriateness of a tobit model for analyzing labor allocation decisions is conditional on the assumption that the variables affecting the decision to participate in an activity also affect the number of hours worked, conditional on participation. To see why, let us rewrite equation (16) more compactly as

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[18]The categories are adult males and adult females aged 20 to 65; children aged 0-5; youth aged 6-19; and the elderly 66 and above.

[19]Shares variables are set to zero whenever their denominator is zero.

[20]These tobit results can be found in Appendix Tables 17 and 18.

$$l_i^* = \beta' x_i + \sigma_\epsilon \epsilon_i ,$$

where l_i^* is the log of $L_i^* + 1$ for household i, ϵi is a standard normal variable, and β and x_i are vectors of parameters and explanatory variables, respectively. In tobit estimation, the dependent variable l_i is assumed to depend on the value of the underlying latent variable according to the following rule: if l_i^* is greater than zero, we observe $l_i = l_i^*$; otherwise, $l_i = 0$. As Cragg (1971) and Lin and Schmidt (1984) point out, it is nevertheless possible that the decision to work may be determined differently from days worked conditional on participation, so that

$$\begin{aligned} Prob[l_i^* > 0] &= \Phi(\lambda' x_i), \quad z_i = 1 \ if \ l_i^* > 0 , \\ Prob[l_i^* \leq 0] &= 1 - \Phi(\lambda' x_i), \quad z_i = 0 \ if \ l_i^* \leq 0 , \end{aligned} \qquad \textbf{(17)}$$

while

$$E[l_i \mid z_i = 1] = \beta' x_i + \sigma_\epsilon \epsilon_i .$$

The tobit model is a special case of the above where $\lambda = \beta/\sigma_\epsilon$. A likelihood ratio test of the restriction implicit in the tobit model was proposed by Greene (1997, 970). It involves subtracting the sum of the log-likelihoods of the probit and truncated regressions from the tobit log-likelihood. Using this approach, we test in each labor use regression, equation (17), the null hypothesis that $\lambda = \beta/\sigma$. Except for total labor, likelihood ratio test results are all above 1,000, well above the χ^2 critical values with 35 degrees of freedom that are 49.52 and 56.53 at the 5 percent and 1 percent level of significance, respectively. The simple tobit model is thus inappropriate except for total labor. The decision to participate in a particular activity appears different from the decision of how much labor to allocate to that activity, given participation. These results are consistent with threshold effects created by fixed costs: if households must incur certain costs up front before initiating a particular income generating activity, the decision to undertake that activity will differ from that of how much labor to allocate to it conditional on having undertaken it.

We therefore estimate the labor use equation separately from the decision to undertake a particular activity. We apply the two-step Heckman estimator used for selection models (see Maddala 1983; Greene 1997 for details).[21] Year and village fixed effects are included but not shown. Family background variables—father's landholdings, inherited land, and father's and mother's education—are used as identifying restrictions. They are preferable to unearned income since rents, pensions, and remittances may be influenced by past labor supply or asset accumulation decisions. Given that virtually all households have some kind of market-oriented activity, the selection issue does not arise in the case of total family labor. Estimates are reported in Table 5 for crop labor and in Table 6 for herding, nonfarm, and total labor. Similar results are obtained for the human capital of husband and wife but are not reported for the sake of brevity. σ stands for the estimated standard deviation of the residuals in the labor equation; ρ is the estimated correlation coefficient between the residuals in the selection and labor equations.

[21]We experienced difficulties estimating the corresponding maximum likelihood estimator due to the presence of a large number of village fixed effects.

For crop labor (Table 5), household size is not a significant determinant of whether the household farms in either season, but it has a paramount influence on the amount of labor allocated to crop production, hence providing additional evidence against the existence of perfect labor markets. If factor markets were complete, production decisions should be separable from household characteristics affecting total labor supply (for example, Benjamin 1992). Household demographic composition is also significant in all of the regressions; estimated coefficients show that persons in all age/sex categories, conditional on participation, supply less labor than adult males. This result is in full agreement with the dominant role that adult males play in all market-oriented activities (see Section 3). Elderly households are less likely to farm, a reminder that crop work is strenuous and taxing. In contrast, ownership of bullocks affects the decision to farm, but not labor use. This again is consistent with imperfect factor markets. Indeed, one would expect households who do not own their own draft animals to be reluctant to engage in crop production if rental markets for draft animals are imperfect and unreliable (for example, Rosenzweig and Wolpin 1993). Ownership of bullocks thus appears a sunk cost required for successful farming. Education of adult males has a negative effect on the decision to farm during the drier rabi season, and an additional negative effect on labor use in both seasons; these results indicate that better educated males opt out of farming.

Turning to herding and nonfarm work (Table 6), we see that larger households spend more time in herding and nonfarm activities and are more likely to engage in

Table 5 Estimation of crop labor use with selection correction

	Kharif labor				Rabi labor			
	Selection		Days worked		Selection		Days worked	
	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z
Household composition								
Household size (log)	0.242	1.414	0.484	**5.058**	0.030	0.178	0.424	**4.828**
Adult females (share)	–1.227	–1.558	–0.482	–1.087	–0.948	–1.195	–0.874	**2.128**
Children (share)	–1.106	**1.897**	–0.825	**2.515**	–0.484	–0.836	–1.172	**3.908**
Young (share)	–1.050	**1.947**	–0.566	**1.961**	–0.336	–0.625	–0.535	**2.011**
Old(share)	–3.269	**3.292**	–1.238	**2.354**	–1.981	**2.033**	–2.124	–4.396
Human capital								
Adult males								
Age	–0.065	–1.514	–0.006	–0.241	–0.053	–1.241	–0.032	–1.452
Age squared	0.001	1.294	0.000	0.187	0.001	1.204	0.000	1.400
Years of education	–0.021	–1.060	–0.023	**2.252**	–0.034	**1.765**	–0.021	**2.276**
Raven's test score	–0.003	–0.286	0.003	0.642	0.003	0.308	–0.005	–0.948
Height	0.006	0.680	–0.003	–0.519	0.018	**1.950**	0.010	**2.128**
BMI	0.007	0.390	–0.015	–1.364	–0.000	–0.008	0.001	0.126
Adult females								
Age	0.058	1.333	–0.015	–0.603	0.022	0.513	–0.025	–1.129
Age squared	–0.001	–1.451	0.000	0.693	–0.000	–0.790	0.000	1.112
Years of education	–0.061	**1.689**	–0.047	**2.098**	–0.088	**2.417**	–0.010	–0.469
Raven's test score	0.037	**2.835**	–0.005	–0.725	0.027	**2.088**	–0.007	–1.163
Height	–0.000	–0.015	–0.001	–0.123	–0.002	–0.248	0.001	0.160
BMI	0.004	0.258	0.001	0.111	0.020	1.246	–0.014	**1.698**
Factors and inputs								
Total owned land (log+1)	0.346	**4.167**	0.010	0.294	0.249	**3.042**	0.077	**2.512**
Share of irrigated land	0.182	0.973	0.149	1.517	0.354	**1.883**	0.005	0.057
Value of farm tools (log+1)	0.124	**3.638**	0.087	**3.701**	0.168	**5.008**	0.049	**2.284**
Number of livestock (log+1)	0.572	**6.952**	0.345	**6.856**	0.596	**7.194**	0.340	**7.531**
Share of buffaloes	0.136	0.734	–0.238	**2.088**	–0.051	–0.282	–0.038	–0.354
Share of bullocks	2.297	**3.288**	0.060	0.211	1.075	**1.783**	0.183	0.699
Share of donkeys	–0.960	**1.788**	0.012	0.028	–0.069	–0.139	–0.397	–1.169
Share of sheep and goats	–0.575	**3.108**	–0.612	**4.910**	–0.568	**3.107**	–0.221	**1.933**
Nonfarm capital	–0.028	**1.776**	0.001	0.126	–0.043	**2.868**	0.015	1.536
Family background								
Father's holding (log+1)	0.180	**2.383**			0.141	**1.917**		
Inherited land (log+1)	–0.129	–1.362			–0.040	–0.422		
Father's education	–0.098	**1.730**			–0.080	–1.396		
Mother's education	–0.131	–0.648			0.001	0.004		
Nonearned income								
Total unearned (log+1)	–0.064	**3.973**	–0.029	**3.319**	–0.033	**2.053**	–0.006	–0.797
Share of rental income	–0.737	**4.366**	–0.077	–0.788	–0.845	**5.034**	–0.218	**2.467**
Share of pension income	0.605	**1.928**	0.040	0.211	0.029	0.094	0.087	0.496
Shifters								
Dummy for 1986	0.334	**2.444**	0.436	**5.232**	0.106	0.772	0.021	0.282
Dummy for 1987	–0.540	**4.113**	–0.870	**10.455**	–0.343	**2.587**	–0.061	–0.822
Intercept	–1.014	–0.424	3.987	**2.851**	–2.724	–1.116	3.072	**2.393**
Selection terms								
Tan(Rho * Pi/2)	0.347	**3.369**			–0.095	**.**		
Log(Sigma)	–0.169	**6.205**			–0.240	**10.412**		
Rho	0.333				–0.095			
Sigma	0.845				0.787			
Number of observations	1,385				1,385			
Log-likelihood	–1711.6				–1652.1			

Notes: Estimator is two-step Heckman procedure. Village fixed effects included but not shown. Human capital variables are household averages. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

Table 6 Estimation of livestock and nonfarm labor use with selection correction

	Herding labor				Nonfarm labor				Total labor	
	Selection		Days worked		Selection		Days worked		Days worked	
	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z
Household composition										
Household size (log)	–0.011	–0.085	0.360	**3.146**	0.798	**5.829**	0.522	**6.356**	0.835	**9.323**
Adult females (share)	–1.520	**2.407**	–1.889	**3.240**	–0.425	–0.680	–1.368	**3.535**	–1.441	**3.447**
Children (share)	–1.285	**2.734**	–1.490	**3.162**	–1.040	**2.215**	–1.348	**4.764**	–1.746	**5.651**
Young (share)	–0.457	–1.071	–1.039	**3.035**	–0.951	**2.284**	–0.882	**3.403**	–1.088	**3.930**
Old(share)	–1.746	**2.261**	–1.808	**2.711**	–1.355	**1.796**	–1.074	**2.247**	–2.168	**4.316**
Human capital										
Adult males										
Age	–0.022	–0.630	–0.022	–0.791	–0.021	–0.625	–0.021	–1.020	–0.024	–1.076
Age squared	0.000	0.844	0.000	0.832	0.000	0.378	0.000	1.111	0.000	1.145
Years of education	–0.033	**2.071**	0.000	0.007	0.029	**1.958**	0.006	0.669	0.009	0.860
Raven's test score	–0.005	–0.677	–0.009	–1.371	0.008	0.985	–0.011	**2.162**	–0.001	–0.268
Height	0.013	**1.717**	0.002	0.260	0.007	0.916	0.008	**1.690**	0.012	**2.409**
BMI	0.003	0.186	–0.010	–0.799	0.043	**2.746**	0.010	1.065	0.010	0.963
Adult females										
Age	–0.002	–0.055	–0.016	–0.598	–0.063	**1.874**	–0.002	–0.086	–0.027	–1.206
Age squared	–0.000	–0.236	0.000	0.389	0.001	**1.881**	0.000	0.258	0.000	1.042
Years of education	–0.006	–0.189	–0.013	–0.517	–0.068	**2.156**	0.029	**1.658**	–0.072	**3.425**
Raven's test score	–0.007	–0.726	0.005	0.643	0.001	0.147	–0.011	**1.823**	–0.004	–0.633
Height	–0.002	–0.297	0.007	1.068	–0.003	–0.425	–0.001	–0.183	–0.002	–0.363
BMI	–0.014	–1.136	0.005	0.443	–0.001	–0.083	–0.020	**2.650**	–0.013	–1.622
Factors and inputs										
Total owned land (log+1)	0.089	1.460	–0.046	–1.160	–0.070	–1.236	0.073	**2.576**	0.016	0.391
Share of irrigated land	–0.053	–0.362	0.192	**1.713**	0.033	0.237	–0.400	**4.689**	–0.074	–0.784
Value of farm tools (log+1)	–0.035	–1.267	–0.017	–0.663	–0.064	**2.178**	0.000	0.024	0.009	0.486
Number of livestock (log+1)	0.495	**7.359**	0.396	**3.588**	–0.413	**6.033**	–0.094	**2.324**	0.165	**3.730**
Share of buffaloes	0.386	**2.514**	–0.106	–0.678	–0.096	–0.625	–0.058	–0.617	0.033	0.324
Share of bullocks	0.527	1.308	0.947	**2.549**	–0.063	–0.154	0.048	0.188	0.120	0.422
Share of donkeys	0.400	0.848	0.215	0.564	0.509	1.131	0.095	0.339	0.215	0.681
Share of sheep and goats	–0.162	–1.037	–0.363	**2.637**	0.613	**3.665**	0.128	1.373	–0.056	–0.534
Nonfarm capital	–0.025	**1.827**	–0.004	–0.335	0.028	**1.932**	0.036	**4.655**	0.022	**2.445**
Family background										
Father's holding (log+1)	0.009	0.158			–0.046	–0.969			0.004	0.117
Inherited land (log+1)	–0.024	–0.339			–0.069	–1.235			–0.045	–1.044
Father's education	–0.097	**1.929**			0.085	**1.940**			–0.039	–1.244
Mother's education	–0.097	–0.418			0.105	0.505			0.364	**2.718**
Nonearned income										
Total unearned (log+1)	–0.000	–0.030	–0.031	**3.243**	–0.044	**3.589**	–0.024	**3.216**	–0.046	**5.646**
Share of rental income	0.103	0.765	0.179	**1.705**	0.207	1.552	0.148	**1.792**	0.001	0.010
Share of pension income	–0.214	–0.796	0.417	**1.901**	0.237	0.830	0.107	0.713	0.156	0.885
Shifters										
Dummy for 1986	0.681	**5.825**	–0.857	**6.105**	0.136	1.194	0.056	0.811	0.153	**2.013**
Dummy for 1987	0.412	**3.791**	–0.933	**8.374**	0.174	1.558	0.227	**3.434**	–0.152	**2.069**
Intercept	0.177	0.089	5.404	**3.267**	0.427	0.213	5.637	**4.594**	4.713	**3.569**
Selection terms										
Tan(Rho * Pi/2)	0.031	0.066			–1.040	.				
Log(Sigma)	–0.190	**6.876**			–0.291	**13.616**				
Rho	0.031				–0.778					
Sigma	0.827				0.748				0.936	
Number of observations	1385				1385				1385	
Log-likelihood	–1662.3				–1744.4				0.112[a]	

Notes: Except for total labor, estimator is two-step Heckman procedure. Tobit is used for total labor. Village fixed effects included but not shown. Human capital variables are household averages. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

[a] Pseudo R-square.

nonfarm work. This latter result is in line with income diversification strategies for risk smoothing: as the household adds members, it diversifies its income base (for example, Binswanger and McIntire 1987; Bromley and Chavas 1989). There is also evidence that herding competes with crop work for household manpower. Unearned income has a negative coefficient on the probability of undertaking kharif and rabi labor, and decreases the number of days in herding and nonfarm work. These results indicate that leisure (and, possibly, unobserved home services) is a normal good. In contrast, factors of production have a positive effect on labor supply[22]: households with more land and livestock work less off the farm. This constitutes further evidence that factor markets are incomplete.

Males with a higher BMI are also more likely to work in the nonfarm sector, although higher BMI does not affect days worked. However, the selection of nonfarm work by higher BMI males may reflect lower energy intensity in that activity than in farmwork (Higgins and Alderman 1997). Taller males are more likely to herd, and are more likely to work in the nonfarm sector. Both results are consistent with the higher productivity achieved by better-fed males in nonfarm work and by taller men in herding (see Section 4). Together, these results indicate that nutrition has an effect on

[22]Strictly speaking, Tables 5 and 6 estimate labor demand regressions. Since there is no hired labor in herding and nonfarm work, however, labor demand and supply are identical. There is a small difference between family labor and total labor use in crop activities due to hired labor, but hired laborers account for such a small proportion of total cultivation labor that the results obtained using family labor supply instead of total labor use are virtually identical to those in Table 5.

productivity and that rural households adjust their labor allocation accordingly.[23] It is remarkable that returns to nutrition, like those on education, are highest in nonfarm activities; households with better educated males are less likely to herd, but are more likely to work in nonfarm activities.

Unlike the robust results regarding the human capital of adult males, those concerning females are quite sensitive to model specification. Given the very little amounts of recorded labor provided to crops, herding, or nonfarm work by female members of the household, we interpret the lack of robustness as indicative of omitted variable bias and discount the results accordingly. Better-educated females are less likely to work in the farm and nonfarm sectors, although, conditional on participation, better educated females provide more time in nonfarm work. The number of females participating in nonfarm work, however, is very low. Better-fed women also work less during the rabi season, and work less in the nonfarm sector. Given the marginal role that women play in market work (for example, Brown and Haddad 1995; Alderman and Chishti 1991; and Section 3), female human capital variables probably capture wealth effects in a country where social prestige is attached to observing female seclusion or purdah (for example, Jefferey 1979; Darling 1925). Wealthy families are more likely to marry better-educated women, feed them better, and expect them to work less because

[23]This result is to be compared with that of Foster and Rosenzweig (1993) who find a positive and significant effect of calorie consumption on piece-rate harvest wages. In a later paper, Foster and Rosenzweig (1996) examine worker selection of piece-rate and time-wage contracts and find that more productive workers are likely to select piece-rate contracts.

these families can afford to lose an additional wage earner. Another possibility is that wealthier households educate their daughters better.

All in all, higher education of adult males is associated with less herding and farmwork in both kharif and rabi seasons, but more nonfarm labor. This effect is fairly strong: one additional year of schooling leads to 3.3 percent, 3.4 percent, and 2.4 percent less work in kharif, rabi, and herding, respectively, and to 2.0 percent more labor off the farm.[24] There is, therefore, agreement between the labor allocation and the productivity regressions discussed in Section 4: better-educated males are more productive in nonfarm work; they respond to this by reallocating their time away from less productive to more productive activities. The net effect of this reallocation on total family labor is nonsignificant.

Further evidence that better-educated households opt out of farming can be found by observing how cultivated acreage and expenditures on variable inputs vary across households. Tobit regression results are presented in Table 7. They confirm that better-schooled households put significantly less emphasis on farming. Long-term nutrition as measured by height is positively associated with crop production: taller individuals put

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[24]These numbers are computed using the fact that $E[L] = E[L|L > 0]\ Prob[L > 0]$ and, thus, that

$$\frac{\partial\ E[L]}{\partial\ X} = \frac{\partial\ E[L|L>0]}{\partial\ X}\ Prob[L>0] + E[L|L>0]\ \frac{\partial\ Prob[L>0]}{\partial\ X}.$$

$\partial\ E[L|L > 0]/\partial\ X$ is computed from estimated coefficients using $E[L|L > 0]\ \ \partial\ E[log(L)|L > 0]/\partial\ X$.

Table 7 Tobit regression on crop expenditures and cultivated acreage

	Expenditures on variable inputs				Cultivated acreage			
	Kharif season		Rabi season		Kharif season		Rabi season	
	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z
Household composition								
Household size (log)	–0.012	–0.047	0.299	0.941	0.142	1.585	0.172	**2.044**
Adult females (share)	–1.687	–1.386	–2.828	**1.899**	–0.631	–1.531	–0.334	–0.853
Children (share)	–1.121	–1.245	–1.563	–1.422	–0.638	**2.108**	–0.518	**1.807**
Young (share)	–1.221	–1.515	–1.873	**1.906**	–0.665	**2.479**	–0.230	–0.910
Old(share)	–3.292	**2.224**	–3.968	**2.197**	–0.086	–0.180	–0.100	–0.220
Human capital								
Adult males								
Age	–0.026	–0.393	0.078	0.963	–0.029	–1.326	–0.026	–1.232
Age squared	0.000	0.183	–0.001	–0.937	0.000	1.415	0.000	1.352
Years of education	–0.041	–1.358	–0.084	**2.301**	–0.019	**1.873**	–0.034	**3.628**
Raven's test score	0.001	0.072	0.004	0.203	0.002	0.406	0.003	0.684
Height	0.024	**1.688**	0.056	**3.208**	0.011	**2.220**	0.017	**3.685**
BMI	0.029	0.964	0.011	0.293	–0.002	–0.200	0.008	0.830
Adult females								
Age	0.054	0.807	0.023	0.282	0.003	0.124	–0.016	–0.751
Age squared	–0.001	–0.935	–0.000	–0.460	–0.000	–0.235	0.000	0.579
Years of education	–0.048	–0.768	–0.031	–0.406	–0.021	–0.930	–0.017	–0.810
Raven's test score	0.081	**4.229**	0.047	**1.991**	0.001	0.143	–0.003	–0.534
Height	–0.000	–0.006	0.002	0.095	–0.001	–0.142	0.001	0.247
BMI	0.045	**1.848**	0.006	0.202	0.000	0.010	0.010	1.246
Factors and inputs								
Total owned land (log+1)	0.319	**2.735**	0.471	**3.308**	0.182	**4.804**	0.148	**4.175**
Share of irrigated land	1.031	**3.769**	1.442	**4.336**	–0.334	**3.635**	–0.259	**2.967**
Value of farm tools (log+1)	0.544	**9.373**	0.684	**9.630**	0.110	**4.822**	0.116	**5.424**
Number of livestock (log+1)	1.369	**10.526**	1.379	**8.703**	0.242	**5.163**	0.233	**5.361**
Share of buffaloes	0.498	**1.660**	0.428	1.166	–0.204	**1.960**	–0.141	–1.414
Share of bullocks	2.298	**2.862**	1.158	1.182	–0.458	**1.841**	0.002	0.010
Share of donkeys	–1.112	–1.161	–0.003	–0.002	–0.468	–0.963	0.000	0.001
Share of sheep and goats	–1.388	**4.317**	–1.016	**2.605**	–0.428	**3.554**	–0.304	**2.761**
Nonfarm capital	0.008	0.224	0.045	1.049	–0.028	**2.246**	–0.004	–0.326
Share of shop inventory	–2.097	**4.984**	–2.346	**4.561**	0.137	0.832	0.010	0.063
Family background								
Father's holding (log+1)	0.301	**2.882**	0.314	**2.471**	0.015	0.458	0.009	0.293
Inherited land (log+1)	0.117	0.922	0.023	0.149	0.027	0.700	0.041	1.094
Father's education	–0.124	–1.332	–0.078	–0.683	–0.054	**1.705**	–0.027	–0.863
Mother's education	0.811	**2.095**	0.572	1.205	–0.076	–0.512	0.164	1.128
Nonearned income								
Total unearned (log+1)	–0.059	**2.502**	–0.052	**1.800**	–0.006	–0.714	–0.009	–1.240
Share of rental income	–0.950	**3.598**	–1.565	**4.852**	–0.001	–0.016	–0.196	**2.296**
Share of pension income	0.119	0.229	–0.881	–1.395	–0.346	**1.922**	–0.155	–0.920
Shifters								
Dummy for 1986	–0.452	**2.026**	–0.297	–1.097	0.003	0.042	–0.116	–1.599
Dummy for 1987	–0.307	–1.432	–0.823	**3.147**	0.109	1.426	–0.019	–0.274
Intercept	–8.065	**2.085**	–14.652	**3.105**	–1.068	–0.826	–3.069	**2.503**
Selection-term	2.578		3.120		0.700		0.694	
Number of observations	1338		1338		895		983	
Censored	322		369		102		109	
Noncensored	1016		969		793		874	
Pseudo R-square	0.1791		0.1387		0.2473		0.2289	

Notes: Village fixed-effects included but not shown. Household average human capital used. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

systematically more emphasis on crops. This result is not surprising given that working in the fields is a strenuous activity for which returns to physical strength are high. Other results of interest indicate that livestock ownership has a strong significant effect on the use of variable inputs and on cultivated acreage, thereby suggesting that economies of scope between livestock and crops exist in rural Pakistan. Households with higher nonearned (but nonrental) income spend less on variable inputs. This suggests that credit constraints are not a serious obstacle to expenditures on variable inputs. Indeed, if most households faced a binding liquidity constraint, households that received extra cash through remittances and other nonearned income would spend more on variable inputs than households that did not. Households fortunate enough to have an external source of income tend to deemphasize crop production.

Before we conclude, it is instructive to examine the influence that human capital has on income, as predicted by estimated model parameters. Human capital has two separate effects: a direct productivity effect $\frac{\partial Y_a}{\partial Z_h}$, which is the focus of much of the empirical literature on human capital (for example, Jamison and Lau 1982), and an indirect labor reallocation effect $\frac{\partial Y_a}{\partial L_a}\frac{\partial L_a}{\partial Z_h}$, which we have studied here (see also Jolliffe 1996). The combined contribution of human capital to total income is the sum of the two effects over all the activities undertaken by the household:

$$\frac{\partial Y}{\partial Z_h} = \sum_a \left[\frac{\partial Y_a}{\partial Z_h} + \frac{\partial Y_a}{\partial L_a}\frac{\partial L_a}{\partial Z_h}\right]. \qquad \textbf{(18)}$$

Table 8 uses equation (18) to construct estimates of the contribution to income of one additional year of schooling for all the adult males of the household. The labor reallocation effect is computed using the formula given in footnote (25). Results illustrate the paramount role played by labor reallocation: without it, one extra year of schooling for all adult males in the household raises annual income by 1.4 percent, an already remarkable figure.[25] Combined with a reallocation of labor away from low productivity farming to high productivity nonfarm work raises income by an additional 0.4 percent. In other words, one-fifth of the contribution of human capital to income happens through labor reallocation, a phenomenon that until now has received very little attention. In nonfarm income alone, the labor reallocation effect is stronger: one-third of the increase in nonfarm income due to better education results from households shifting labor resources away from farming. In contrast, the total labor supply effect is quite small: as shown in Table 8, increased labor supply in response to higher marginal return to labor thanks to schooling raises total income by only 0.1 percent, compared to a direct effect of 8.9 percent. Most of the labor allocation effect on income is thus due to a pure reallocation among competing activities, not to an increase in family labor supply.

[25]This figure rises to 1.7 percent if simple tobit estimates are used instead of Heckman two-step estimates.

Table 8 Predicted effect of male education on earned income

	Kharif	Rabi	Livestock	Off-farm	Total (1)	Total (2)
In percentages						
Productivity effect	1.1%	–2.2%	0.9%	2.8%	1.4%	
Share of labor in activity	19.0%	0.0%	2.6%	59.0%		
Labor use	–4.2%	–4.6%	–7.2%	7.6%		
Labor allocation effect	–0.8%	0.0%	–0.2%	4.5%	1.7%	
Combined production and labor allocation effect	0.3%	–2.2%	0.7%	7.3%	3.1%	8.9%
Share of labor in total income						10.1%
Labor supply						0.9%
Labor supply effect						0.1%
Total with labor supply effect						9.0%
In absolute terms						
Average net income	4,702	2,653	4,565	9,110	21,029	21,029
Productivity effect on income	52	–58	41	255	290	
Labor allocation effect on income	–38	0	–9	408	362	
Total production and labor allocation effect	14	–58	33	664	652	1,872
Labor supply effect						19
Total with labor supply effect						1,891

Notes: Total (1) is computed by aggregating over the four income sources listed in columns 1 to 4 and computing percentages from the 'absolute terms' part of the table. Total (2) is computed directly from the total income and family labor supply regressions. The two need not agree.

6. CONCLUSION

In this paper, we have examined how various facets of human capital affect the productivity of rural households in Pakistan. We showed that human capital can be analyzed not only through its direct effects on output and incomes, but also via its indirect effects on labor allocation. Results indicate that education raises off-farm productivity and induces rural Pakistani households to shift labor resources from farm to off-farm activities. This effect is strong, robust, and demonstrated via both the direct and indirect methods. One additional year of schooling for all adult males raises household incomes by 4.5 percent. One-fifth of this additional income is achieved by reallocating labor away from farming and toward nonfarm work. Because we have controlled for background characteristics and innate ability, we can reasonably conclude that it is the skills acquired in school that raise the productivity of adult males in rural nonfarm work, not their innate intelligence or the wealth of their parents, with which education is often correlated.

Although wife's education does have a positive and significant effect on total income, the effect of female human capital on productivity is not robust. The beneficial effect of education accrues mostly to males. Using market-oriented activities as sole criterion, female education seems to be a wasted investment in rural Pakistan.[26] This is

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[26]It can be argued, however, that there are social gains to female education (for example, Subbarao and Raney 1995) even in countries with low female labor-force participation. These gains occur through reductions in infant mortality and fertility associated with increases in female education. A recent study for Pakistan shows that these externalities can be considerable: an additional year of school for 1,000 women, at an estimated cost of US$30,000, would increase wages by 20 percent and prevent 60 child deaths, 500 births, and three maternal deaths (Summers 1992).

hardly surprising, given that schooling raises labor productivity in activities that are off-limits to women. Purdah thus appears as the major culprit for low returns to female education. These low returns, in turn, probably explain the extreme gender gap that has historically been found in Pakistani education (for example, World Bank 1996; Sawada 1997).[27] This suggests that removing barriers to women's participation in the labor force could enable women to reap returns to their human capital and encourage parents to invest more in girls' education, health, and nutrition.

Other dimensions of human capital such as better nutrition are important too. Height, a proxy for nutrition in childhood and adolescence, was shown to raise productivity and labor effort in livestock production. These effects are again confined to male adults; no systematic and robust relationship was uncovered between female nutrition and market-oriented activities in rural Pakistan.

Our analysis provides strong evidence against the perfect labor and factor market hypothesis. This stands in contrast to the work of Benjamin (1992) but agrees with other empirical work (for example, Gavian and Fafchamps 1996; Udry 1996). It is also in line with much of the development literature in which incomplete markets are regarded as part of the economic landscape in Third World rural communities (for example, de Janvry 1981; Feder 1985; Eswaran and Kotwal 1986; Bardhan 1984; Basu 1997).

One may be tempted to see in our results a microeconomic justification for the recent emphasis on human capital accumulation as an engine of growth (for example,

[27]Recent evidence nevertheless suggests that the gap has begun to close (World Bank 1996).

Romer 1986, 1990; Lucas 1988). Such interpretation is unwarranted. Our analysis is a partial equilibrium analysis that investigates how better nutrition and education raised household income and affected labor allocation in rural Pakistan. These results were obtained in the context of a rural labor market with a very low supply of educated people and a mediocre nutritional status in general. In such an environment it is not surprising that a few stronger and better skilled individuals prosper by providing a handful of goods and services that require literacy and strength. It would therefore be misleading to take our partial equilibrium numbers and infer from them that the return to schooling at the national level is as high as 9 percent. With these words of caution, it is nevertheless encouraging to find robust evidence that human capital helps households improve their livelihood.

APPENDIX

Table 9 Regression on total annual crop income net of variable input cost

	Coefficient	t	Coefficient	t
Factors and inputs				
Cultivated acreage	0.179	**4.832**	0.213	**4.851**
Cultivation labor	0.066	**2.461**	0.116	**3.628**
Value of farm tools	0.074	**3.920**	0.096	**3.865**
Number of bullocks	0.031	0.660	0.079	1.415
Input expenditures (log +1)	0.395	**10.860**	0.327	**6.211**
Share of family labor	–0.001	–0.010	–0.181	**2.015**
Share of irrigated land	1.257	**6.094**	0.710	**2.337**
Human capital				
Adult males				
Age	–0.016	–0.923	–0.048	**2.499**
Age squared	0.000	0.728	0.000	**2.655**
Years of education	–0.008	–1.033	0.006	0.603
Raven's test score	0.011	**3.103**	0.003	0.711
Height	0.003	0.774	–0.003	–0.706
BMI	0.037	**4.329**	0.039	**4.424**
Adult females				
Age	0.029	1.680	0.062	**2.921**
Age squared	–0.000	–1.239	–0.001	**3.013**
Years of education	0.047	**2.901**	0.069	**3.951**
Raven's test score	0.012	**2.111**	0.010	1.551
Height	0.002	0.495	0.008	1.848
BMI	–0.014	**2.048**	–0.017	**2.522**
Family background				
Father's holding (log +1)	–0.003	**2.230**	–0.004	**2.056**
Inherited land (log +1)	0.011	**5.316**	0.017	**5.942**
Father's education	0.012	0.544	0.010	0.347
Mother's education	–0.440	**3.061**	–0.671	**3.146**
Shifters				
Dummy for 1986	–0.413	**6.493**	–0.477	**6.125**
Dummy for 1987	–0.171	**3.404**	–0.250	**3.695**
Intercept	0.144	0.969	0.375	0.800
Number of observations	972		777	
R-squared	0.761		0.739	

Notes: Estimator is nonlinear least squares. Village fixed effects included but not shown. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observances; t and F statistics in bold are significant at the 10 percent level or better.

Table 10 Crop production function estimated with maximum education of adult males and females

	Kharif output		Rabi output		Total output	
	Coefficient	t	Coefficient	t	Coefficient	t
Factors of production						
Cultivated acreage	0.319	**4.702**	0.408	**6.655**	0.412	**3.956**
Share of irrigated acreage	0.468	1.808	–0.131	–0.597	0.117	0.325
Value of farm tools	0.113	**3.298**	0.038	1.377	–0.012	–0.258
Number of bullocks	0.387	**3.470**	0.221	**2.777**	0.370	**3.065**
Cultivation labor	0.187	**3.615**	–0.045	–1.149	0.153	**2.262**
Share of family labor	0.101	0.447	0.119	0.616	0.318	1.014
Input expenditures (log +1)	0.210	**4.078**	0.225	**3.819**	0.615	**6.002**
Human capital						
Adult males						
Age	–0.004	–0.119	0.003	0.100	–0.036	–0.820
Age squared	–0.000	–0.021	–0.000	–0.264	0.000	0.985
Maximum years of education	0.016	1.316	–0.021	**2.438**	0.013	0.859
Raven's test score	0.010	1.325	–0.004	–0.621	–0.003	–0.361
Height	0.017	**2.114**	0.006	0.975	0.010	0.916
BMI	0.017	1.085	0.022	1.979	–0.016	–0.731
Adult females						
Age	0.038	1.020	–0.008	–0.319	–0.014	–0.358
Age squared	–0.001	–1.066	0.000	0.289	0.000	0.031
Maximum years of education	0.030	1.256	–0.015	–1.024	–0.042	–1.376
Raven's test score	–0.012	–1.309	0.003	0.381	–0.007	–0.567
Height	0.003	0.287	0.005	0.758	–0.004	–0.353
BMI	–0.004	–0.296	–0.000	–0.011	–0.017	–0.842
Family background						
Father's holding (log +1)	–0.060	–1.469	0.028	0.751	–0.058	–0.818
Inherited land (log +1)	0.020	0.357	0.031	0.739	0.139	1.554
Father's education	–0.005	–0.112	0.071	1.950	–0.024	–0.317
Mother's education	–0.244	–1.119	0.017	0.124	–0.065	–0.159
Shifters						
Dummy for 1986	–0.428	**3.044**	–0.275	**3.147**	–0.754	**4.606**
Dummy for 1987	–0.240	–1.840	–0.474	**5.650**	–1.080	**5.933**
Intercept	0.262	0.107	4.786	**3.285**	3.777	1.376
Number of observations	677		752		1,013	
Number of households	404		413		480	
R-squared	0.7237		0.5925		0.5211	

Notes: Dependent variable is the log of the deflated value of crop output. Estimator is ordinary least squares with village-fixed effects. Zero land and zero labor observations have been eliminated. Robust standard errors with household clusters are reported. All other human capital variables refer to the household average. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

Table 11 Crop production function estimation, household random effects estimates

	Kharif output				Rabi output				Total output			
	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z
Factors of production												
Cultivated acreage	0.321	**5.383**	0.390	**5.946**	0.392	**7.366**	0.337	**5.509**	0.422	**5.161**	0.450	**5.331**
Share of irrigated acreage	0.380	1.563	0.324	1.141	–0.148	–0.725	0.079	0.342	0.161	0.449	0.485	1.274
Value of farm tools	0.119	**3.187**	0.124	**3.015**	0.048	1.528	0.083	**2.303**	–0.013	–0.262	0.169	**3.172**
Number of bullocks	0.377	**3.408**	0.436	**3.473**	0.201	**2.431**	0.194	1.989	0.367	**2.569**	0.353	**2.355**
Cultivation labor	0.183	**3.842**	0.158	**2.906**	–0.073	–1.891	–0.093	**2.055**	0.118	1.787	0.067	0.982
Share of family labor	0.099	0.318	0.260	0.777	0.088	0.540	0.049	0.270	0.376	1.159	0.082	0.272
Input expenditures (log +1)	0.197	**4.527**	0.168	**3.511**	0.193	**3.948**	0.236	**4.224**	0.644	**8.469**	0.207	**6.347**
Human capital	*Average human capital of household*		*Human capital of husband and wife*		*Average human capital of household*		*Human capital of husband and wife*		*Average human capital of household*		*Human capital of husband and wife*	
Adult males												
Age	–0.017	–0.502	0.016	0.481	0.017	0.606	0.010	0.375	–0.042	–0.903	–0.045	–1.097
Age squared	0.000	0.304	–0.000	–0.510	–0.000	–0.682	–0.000	–0.393	0.001	1.066	0.000	1.236
Years of education	0.012	0.690	0.020	1.212	–0.023	–1.708	–0.023	–1.685	0.036	1.585	0.011	0.503
Raven's test score	0.010	1.186	0.006	0.669	–0.003	–0.480	0.000	0.064	–0.008	–0.704	–0.007	–0.603
Height	0.018	**2.268**	0.010	1.272	0.007	1.131	–0.002	–0.261	0.009	0.790	0.002	0.238
BMI	0.018	1.033	0.028	1.648	0.027	1.913	0.015	1.072	–0.011	–0.460	–0.021	–0.959
Adult females												
Age	0.033	0.971	–0.031	–0.840	–0.010	–0.367	0.006	0.199	–0.002	–0.045	0.025	0.536
Age squared	–0.000	–1.083	0.000	0.955	0.000	0.343	–0.000	–0.547	–0.000	–0.281	–0.000	–0.697
Years of education	0.053	1.394	0.071	1.555	–0.029	–0.939	–0.017	–0.472	–0.080	–1.554	0.042	0.677
Raven's test score	–0.012	–1.149	–0.011	–0.998	0.004	0.472	–0.017	–1.803	–0.004	–0.294	–0.008	–0.569
Height	0.003	0.319	0.016	1.869	0.005	0.746	0.004	0.520	–0.004	–0.322	–0.002	–0.187
BMI	–0.004	–0.271	–0.001	–0.084	0.001	0.133	0.013	1.284	–0.016	–0.892	–0.017	–1.040
Family background												
Father's holding (log +1)	–0.057	–1.095	–0.140	**2.291**	0.028	0.646	–0.035	–0.696	–0.074	–0.995	–0.122	–1.512
Inherited land (log +1)	0.016	0.257	0.133	1.782	0.039	0.759	0.080	1.295	0.134	1.524	0.230	**2.308**
Father's education	0.002	0.047	–0.010	–0.189	0.064	1.425	0.076	1.623	–0.044	–0.602	0.089	1.168
Mother's education	–0.246	–1.059	–0.337	–1.313	0.045	0.207	–0.005	–0.019	0.055	0.173	–0.830	**2.154**
Shifters												
Dummy for 1986	–0.439	**3.633**	–0.435	**3.126**	–0.262	**3.081**	–0.331	**3.357**	–0.752	**5.055**	–0.541	**3.458**
Dummy for 1987	–0.241	–1.997	–0.291	**2.044**	–0.471	**5.792**	–0.536	**5.516**	–1.120	**7.547**	–0.622	**4.036**
Intercept	0.561	0.268	0.460	0.213	4.236	**2.501**	5.510	**3.117**	3.453	1.203	7.160	**2.549**
Number of observations	677		546		752		601		1013		733	
Number of households	404		332		413		343		480		375	
R-squared within	0.0902		0.1023		0.0690		0.0777		0.1423		0.0859	
R-squared between	0.7924		0.8156		0.6522		0.6584		0.6173		0.6217	
Overall R-squared	0.7227		0.7324		0.5905		0.5751		0.5219		0.4934	

Notes: Dependent variable is the log of the deflated value of crop output. Zero land and zero labor observations have been eliminated. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

Table 12 Crop production function, household fixed-effects estimates

Total output	Kharif output		Rabi output			
	Coefficient	t	Coefficient	t	Coefficient	t
Factors of production						
Cultivated acreage	0.193	1.612	0.185	1.970	0.221	1.546
Share of irrigated acreage	–0.123	–0.337	–0.170	–0.489	0.671	1.160
Value of farm tools	–4.153	–1.081	–7.893	**2.978**	–14.560	**3.212**
Number of bullocks	0.220	1.477	–0.036	–0.343	0.152	0.811
Cultivation labor	0.124	1.789	–0.136	**2.751**	–0.048	–0.522
Share of family labor	0.332	0.769	0.109	0.532	0.679	1.572
Input expenditures (log +1)	0.147	1.954	0.004	0.059	0.682	**6.080**
Human capital						
Adult males						
Age	0.174	1.413	0.141	1.676	0.057	0.392
Age squared	–0.002	–1.482	–0.001	–1.316	–0.000	–0.065
Years of education	–0.065	–0.747	0.044	0.722	0.043	0.393
Raven's test score	0.108	1.525	–0.065	–1.377	–0.005	–0.051
Height	–0.094	–1.460	–0.001	–0.036	–0.019	–0.250
BMI	0.037	0.748	0.042	1.277	0.086	1.428
Adult females						
Age	0.061	0.574	0.016	0.219	0.120	0.913
Age squared	–0.001	–0.505	0.000	0.184	–0.001	–0.845
Years of education	0.033	0.223	0.099	1.026	0.025	0.122
Raven's test score	0.025	0.244	0.076	1.171	0.110	0.884
Height	0.020	0.286	–0.010	–0.199	–0.031	–0.342
BMI	–0.025	–0.801	–0.014	–0.636	–0.006	–0.150
Shifters						
Dummy for 1986	0.364	0.453	1.395	**2.587**	2.291	**2.463**
Dummy for 1987	0.233	0.489	0.581	1.730	0.546	0.926
Intercept	44.265	1.311	66.107	**2.928**	112.664	**2.898**
Number of observations	690		764		1,030	
Number of households	413		421		490	
R-square within	0.1345		0.1845		0.1813	
R-square between	0.0175		0.1564		0.0495	
Overall R-square	0.0213		0.1457		0.0402	

Notes: Dependent variable is the log of the deflated value of crop output. Zero land and zero labor observations have been eliminated. Human capital variables refer to the household average. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

Table 13 Crop production function, instrumental variables estimates

	Kharif output				Rabi output				Total output			
	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t
Factors of production												
Cultivated acreage	0.012	0.034	0.624	1.303	0.906	**2.237**	0.255	0.467	0.203	0.288	2.211	1.982
Share of irrigated acreage	–1.080	–0.769	–3.000	–1.710	–1.883	–1.316	–2.636	–1.225	0.405	0.155	6.423	1.031
Number of bullocks	0.349	**2.636**	0.325	1.610	0.018	0.108	0.199	0.984	0.397	**2.272**	–0.106	–0.298
Cultivation labor	0.303	1.243	0.290	0.925	0.168	0.861	–0.126	–0.500	0.059	0.187	–0.412	–0.661
Share of family labor	–0.847	–0.311	3.138	1.007	–1.289	–0.729	–0.094	–0.059	–0.958	–0.333	–1.526	–0.488
Input expenditures (log +1)	0.372	**2.348**	0.266	1.079	–0.297	–0.883	0.382	1.175	0.636	1.407	–0.021	–0.083
Value of farm tools	0.104	1.594	–0.006	–0.056	0.073	1.126	0.031	0.361	0.016	0.172	–0.044	–0.298
Human capital	*Average human capital of household*		*Human capital of husband and wife*		*Average human capital of household*		*Human capital of husband and wife*		*Average human capital of household*		*Human capital of husband and wife*	
Adult males												
Age	–0.023	–0.599	0.000	0.064	0.027	0.646	–0.000	–0.045	–0.054	–0.854	0.000	0.092
Age squared	0.000	0.503	0.066	1.469	–0.000	–0.648	–0.021	–0.719	0.001	0.987	0.048	0.880
Years of education	0.016	0.844	0.002	0.151	–0.017	–1.057	–0.012	–0.882	0.020	0.873	0.001	0.054
Raven's test score	0.008	0.835	0.003	0.247	–0.005	–0.658	0.006	0.500	–0.002	–0.140	–0.028	–1.151
Height	0.021	**2.074**	0.009	0.314	–0.003	–0.305	0.022	1.028	0.004	0.305	–0.024	–0.548
BMI	0.014	0.750	–0.023	–0.268	0.015	0.895	–0.065	–0.834	–0.031	–1.153	0.015	0.092
Adult females												
Age	0.026	0.636	0.000	0.303	–0.009	–0.270	0.000	0.417	–0.036	–0.865	–0.000	–0.007
Age squared	–0.000	–0.676	0.053	0.594	0.000	0.253	–0.073	–0.771	0.000	0.662	–0.234	–1.205
Years of education	0.044	1.052	–0.012	–0.712	–0.056	–1.379	–0.013	–0.839	–0.128	–1.784	0.005	0.196
Raven's test score	–0.011	–1.118	0.002	0.141	0.015	1.124	0.001	0.125	–0.006	–0.486	0.001	0.051
Height	–0.006	–0.522	0.005	0.205	0.004	0.482	0.028	1.249	–0.006	–0.530	–0.071	–1.281
BMI	–0.001	–0.070	0.022	0.215	–0.008	–0.413	0.055	0.640	–0.014	–0.521	0.031	0.195
Family background												
Father's holding (log +1)	–0.040	–0.783	–0.150	**2.042**	0.070	1.403	–0.003	–0.055	–0.005	–0.084	–0.051	–0.424
Inherited land (log +1)	0.031	0.379	0.145	1.246	–0.009	–0.151	0.043	0.569	0.051	0.538	0.002	0.010
Father's education	–0.011	–0.197	–0.016	–0.200	0.103	**2.328**	0.097	1.261	–0.022	–0.273	–0.009	–0.060
Mother's education	–0.391	–1.355	–0.545	–1.235	0.045	0.240	0.060	0.148	0.006	0.014	0.081	0.085
Shifters												
Dummy for 1986	–0.509	–1.885	–0.605	–1.644	–0.063	–0.292	–0.400	**2.297**	–0.657	**2.238**	–0.570	**2.034**
Dummy for 1987	–0.235	–1.252	–0.152	–0.422	–0.255	–1.278	–0.549	**3.370**	–1.119	**3.700**	–0.623	**2.318**
Intercept	1.783	0.628	7.016	1.659	10.034	**2.864**	7.118	1.429	5.894	1.188	10.138	0.873
Number of observations	655		505		729		557		981		686	
Number of households	392		311		404		323		468		355	
R-squared	0.6863		0.5776		0.3979		0.4515		0.5146	.		

Notes: Dependent variable is the log of the deflated value of crop output. Estimator is ordinary least squares with village fixed effects. Zero land and zero labor observations have been eliminated. Robust standard errors with household clusters are reported. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

Table 14 Crop production function with lagged BMI

	Kharif output				Rabi output				Total output			
	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t
Factors of production												
Cultivated acreage	0.213	**2.865**	0.254	**3.439**	0.394	**6.647**	0.383	**5.771**	0.592	**5.100**	0.560	**5.335**
Share of irrigated acreage	0.298	0.955	0.408	0.937	–0.254	–0.949	–0.208	–0.741	–0.182	–0.383	–0.525	–0.934
Value of farm tools	0.151	**3.481**	0.153	**2.967**	0.048	1.653	0.039	1.050	–0.015	–0.225	0.163	**2.508**
Number of bullocks	0.206	**2.081**	0.187	1.667	–0.092	–1.325	–0.097	–1.152	0.146	1.235	0.024	0.177
Cultivation labor	0.134	**2.257**	0.083	1.575	0.114	**2.440**	0.140	**2.594**	–0.025	–0.321	0.089	1.083
Share of family labor	0.059	0.409	0.021	0.126	0.137	1.273	0.253	1.978	0.080	0.189	–0.086	–0.538
Input expenditures (log +1)	0.327	**4.846**	0.304	**4.211**	0.132	**2.648**	0.172	**3.092**	0.672	**4.993**	0.165	**3.817**
Human capital	*Average human capital of household*		*Human capital of husband and wife*		*Average human capital of household*		*Human capital of husband and wife*		*Average human capital of household*		*Human capital of husband and wife*	
Adult males												
Age	–0.014	–0.381	–0.028	–0.963	0.025	0.955	–0.020	–0.647	0.003	0.066	–0.119	**3.353**
Age squared	0.000	0.065	0.000	0.558	–0.000	–1.177	0.000	0.562	–0.000	–0.109	0.001	**3.252**
Years of education	0.008	0.362	–0.011	–0.541	–0.027	**2.105**	–0.047	**3.070**	0.027	1.181	–0.004	–0.161
Raven's test score	0.017	**2.204**	0.019	**2.402**	–0.002	–0.262	0.001	0.126	0.008	0.771	0.016	1.683
Height	0.010	1.128	0.006	0.722	0.009	1.263	0.003	0.350	–0.017	–1.421	–0.026	**2.047**
BMI	–0.006	–0.267	–0.008	–0.383	0.015	1.039	0.012	0.803	–0.030	–1.148	–0.034	–1.262
Adult females												
Age	0.036	0.774	0.008	0.212	–0.021	–0.792	0.040	1.059	–0.012	–0.228	0.094	1.992
Age squared	–0.000	–0.586	0.000	0.237	0.000	1.028	–0.001	–1.294	0.000	0.237	–0.001	–1.930
Years of education	0.037	0.821	0.118	1.723	–0.045	–1.533	–0.002	–0.038	–0.150	–1.949	–0.039	–0.325
Raven's test score	–0.016	–1.691	–0.026	**2.288**	0.014	1.585	–0.003	–0.305	–0.020	–1.395	–0.008	–0.560
Height	–0.008	–0.890	0.004	0.467	–0.001	–0.153	–0.000	–0.050	–0.003	–0.314	–0.002	–0.154
BMI	0.017	1.193	0.011	0.733	0.002	0.160	–0.000	–0.041	–0.044	–1.774	–0.016	–0.758
Family background												
Father's holding (log +1)	–0.050	–0.948	–0.094	–1.461	0.107	**2.200**	0.054	0.910	–0.022	–0.215	0.022	0.234
Inherited land (log +1)	0.022	0.298	0.103	1.094	–0.076	–1.428	–0.047	–0.668	0.032	0.264	–0.011	–0.084
Father's education	–0.004	–0.068	0.035	0.618	0.071	1.580	0.126	**2.583**	0.005	0.063	0.107	1.486
Mother's education	–0.062	–0.288	–0.213	–0.696	0.292	**2.054**	0.123	0.658	–0.028	–0.043	–0.750	–0.888
Shifters												
Dummy for 1987	0.108	0.931	0.169	1.366	–0.407	**5.113**	–0.489	**5.328**	–0.702	**4.973**	–0.332	**2.370**
Intercept	2.356	0.896	2.342	0.986	4.797	**2.867**	5.772	**3.058**	8.708	**2.607**	12.935	**3.914**
Number of observances	530		431		555		443		771		566	
Number of households	382		316		367		299		450		356	
R-squared	0.6972		0.6932		0.6367		0.6196		0.5431		0.5081	

Notes: Dependent variable is the log of the deflated value of crop output. Estimator is ordinary least squares with village fixed effects. Zero land and zero labor observations have been eliminated. Robust standard errors with household clusters are reported. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

Table 15 Crop production function with human capital cross terms

	Kharif output				Rabi output				Total output			
	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t
Factors of production												
Cultivated acreage	–0.727	–0.693	–0.431	–0.427	–1.178	–1.319	–0.898	–0.927	–0.776	–0.440	–1.061	–0.558
Share of irrigated acreage	0.378	1.755	0.371	1.696	–0.002	–0.016	–0.039	–0.260	–0.083	–0.247	–0.109	–0.318
Value of farm tools	0.144	**5.004**	0.142	**4.911**	0.037	1.540	0.038	1.599	–0.029	–0.702	–0.029	–0.691
Number of bullocks	0.227	**2.685**	0.227	**2.662**	0.160	**2.622**	0.165	**2.703**	0.263	**2.553**	0.271	**2.601**
Cultivation labor	–0.037	–0.084	0.488	0.578	0.534	1.203	1.132	1.861	0.750	0.823	0.319	0.253
Share of family labor	–0.152	–0.713	–0.161	–0.752	–0.010	–0.104	0.016	0.166	0.219	0.659	0.234	0.697
Input expenditures (log +1)	0.249	**5.076**	0.248	**5.047**	0.185	**4.110**	0.180	**3.970**	0.671	**7.746**	0.668	**7.697**
Land interacted with												
Age	0.003	0.596	0.004	0.909	–0.002	–0.541	–0.002	–0.363	0.006	0.953	0.005	0.707
Years of education	0.003	0.241	0.003	0.279	0.014	1.617	0.023	**2.299**	0.021	1.393	0.024	1.448
Height	0.005	0.852	0.003	0.552	0.010	1.810	0.008	1.341	0.006	0.532	0.008	0.665
Labor interacted with												
Age	–0.004	**2.059**	–0.001	–0.267	0.001	0.467	0.001	0.317	–0.003	–1.090	–0.006	–1.339
Years of education	0.002	0.304	0.002	0.237	–0.011	**2.564**	0.001	0.113	–0.004	–0.525	0.003	0.238
Height	0.002	0.662	–0.002	–0.414	–0.003	–1.228	–0.007	–1.957	–0.003	–0.539	0.000	0.001
Human capital												
Age			–0.014	–1.136			–0.001	–0.093			0.013	0.565
Years of education			–0.003	–0.093			–0.055	**2.683**			–0.037	–0.616
Height			0.019	1.019			0.017	1.361			–0.017	–0.489
Family background												
Father's holding (log +1)	–0.063	–1.697	–0.060	–1.644	0.044	1.233	0.044	1.250	–0.074	–1.126	–0.079	–1.197
Inherited land (log +1)	0.032	0.637	0.031	0.621	0.001	0.034	0.006	0.155	0.076	0.962	0.084	1.056
Father's education	0.042	1.066	0.041	1.013	0.072	**2.384**	0.083	**2.649**	–0.051	–0.898	–0.047	–0.804
Mother's education	–0.144	–0.608	–0.137	–0.578	–0.013	–0.125	–0.016	–0.138	–0.275	–0.645	–0.250	–0.601
Shifters												
Dummy for 1986	–0.066	–0.763	–0.061	–0.697	–0.216	**3.094**	–0.217	**3.122**	–0.244	**2.040**	–0.239	–1.965
Dummy for 1987	0.044	0.527	0.055	0.638	–0.446	**6.765**	–0.447	**6.812**	–0.695	**5.837**	–0.706	**5.868**
Intercept	3.934	**7.971**	1.326	0.413	6.588	**20.084**	4.085	1.868	3.094	**3.993**	5.688	0.930
,												
Number of observations	1,019		1,019		1,046		1,046		1,448		1,448	
Number of households	486		486		486		486		555		555	
R-squared	0.6753		0.6761		0.5549		0.5578		0.5132		0.5140	

Notes: Dependent variable is the log of the deflated value of crop output. Estimator is ordinary least squares with village fixed effects. Zero land and zero labor observations have been eliminated. Robust standard errors with household clusters are reported. Human capital variables are averages over adult males. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

Table 16 Crop production function with residuals from labor allocation regressions

	Kharif output				Rabi output				Total output			
	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t
Factors of production												
Cultivated acreage	0.367	**5.431**	0.454	**6.410**	0.382	**6.141**	0.312	**4.625**	0.448	**4.222**	0.471	**4.565**
Share of irrigated acreage	0.473	1.773	0.324	0.947	–0.112	–0.502	0.024	0.093	0.128	0.355	0.436	1.370
Value of farm tools	0.114	**3.231**	0.105	**2.512**	0.046	1.566	0.067	1.888	–0.020	–0.419	0.158	**2.589**
Number of bullocks	0.386	**3.466**	0.398	**3.058**	0.180	**2.201**	0.154	1.548	0.409	**3.314**	0.375	**2.708**
Cultivation labor	0.180	**3.435**	0.127	**2.363**	–0.036	–0.893	–0.057	–1.246	0.145	**2.172**	0.096	1.157
Share of family labor	0.159	0.788	0.184	1.025	0.118	0.624	0.325	1.396	0.363	1.177	0.155	0.591
Input expenditures (log +1)	0.193	**3.804**	0.144	**2.612**	0.221	**3.622**	0.276	**3.939**	0.615	**6.058**	0.210	**4.024**
Human capital	*Average human capital of household*		*Human capital of husband and wife*		*Average human capital of household*		*Human capital of husband and wife*		*Average human capital of household*		*Human capital of husband and wife*	
Adult males												
Age	–0.027	–0.763	–0.008	–0.267	0.010	0.394	0.002	0.079	–0.031	–0.773	–0.048	–1.203
Age squared	0.000	0.644	0.000	0.177	–0.000	–0.518	0.000	0.007	0.000	0.961	0.001	1.294
Years of education	0.006	0.369	0.020	1.175	–0.024	**2.020**	–0.024	–1.865	0.024	1.192	0.006	0.299
Raven's test score	0.013	1.621	0.002	0.301	–0.003	–0.544	–0.003	–0.458	0.000	0.023	–0.004	–0.413
Height	0.013	1.653	0.001	0.168	0.006	1.014	0.003	0.401	0.006	0.657	–0.003	–0.249
BMI	0.010	0.612	0.023	1.325	0.021	1.765	0.013	0.854	–0.020	–0.908	–0.030	–1.208
Adult females												
Age	0.017	0.484	–0.036	–0.963	–0.011	–0.435	–0.010	–0.276	–0.026	–0.735	0.023	0.572
Age squared	–0.000	–0.541	0.000	1.162	0.000	0.414	0.000	0.052	0.000	0.511	–0.000	–0.706
Years of education	0.049	1.370	0.064	1.708	–0.037	–1.247	–0.015	–0.354	–0.097	–1.843	0.047	1.117
Raven's test score	–0.012	–1.403	–0.014	–1.490	0.003	0.337	–0.014	–1.487	–0.003	–0.261	–0.007	–0.554
Height	0.003	0.340	0.009	1.081	0.006	0.967	0.003	0.534	–0.007	–0.601	–0.001	–0.136
BMI	–0.001	–0.059	0.006	0.418	0.004	0.383	0.021	**2.294**	–0.011	–0.519	–0.013	–0.681
Family background												
Father's holding (log +1)	–0.025	–0.615	–0.088	–1.808	0.033	0.818	–0.006	–0.120	–0.010	–0.183	–0.053	–0.785
Inherited land (log +1)	–0.006	–0.097	0.086	1.275	0.022	0.516	0.051	0.871	0.043	0.615	0.148	1.731
Father's education	0.016	0.313	0.013	0.252	0.069	1.768	0.083	1.783	–0.030	–0.414	0.114	1.417
Mother's education	–0.284	–1.235	–0.377	–1.492	0.053	0.327	–0.086	–0.372	–0.008	–0.019	–0.913	–1.592
Residuals												
Herding labor residuals	–0.048	–1.180	–0.098	**2.013**	0.031	0.861	0.052	1.123	0.104	1.935	0.073	1.214
Off–farm labor residuals	–0.029	–0.767	–0.081	–1.928	–0.016	–0.515	–0.030	–0.754	–0.067	–1.439	–0.034	–0.623
Shifters												
Dummy for 1986	–0.448	**3.186**	–0.427	**2.695**	–0.291	**3.241**	–0.370	**3.339**	–0.686	**4.142**	–0.491	**2.722**
Dummy for 1987	–0.261	–1.921	–0.286	–1.730	–0.472	**5.566**	–0.495	**5.074**	–1.075	**5.885**	–0.588	**3.115**
Intercept	1.874	0.889	3.997	**2.026**	4.273	**2.779**	5.007	**3.016**	4.578	1.620	7.895	**2.795**
Number of observations	655		505		729		557		981		686	
Number of households	392		311		404		323		468		355	
R-squared	0.7296		0.7493		0.5895		0.5795		0.5337		0.4954	

Notes: Dependent variable is the log of the deflated value of crop output. Estimator is ordinary least squares with village fixed effects. Zero land and zero labor observations have been eliminated. Robust standard errors with household clusters are reported. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

Table 17 Tobit regression of labor use: Household average human capital

	Kharif labor		Rabi labor		Herding		Nonfarm		Total labor	
	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z
Household composition										
Household size (log)	0.392	**2.392**	0.311	**1.995**	0.413	1.149	2.394	**7.598**	0.835	**9.323**
Adult females (share)	–1.620	**2.123**	–1.522	**2.079**	–5.262	**3.151**	–1.870	–1.273	–1.441	**3.447**
Children (share)	–1.569	**2.776**	–1.203	**2.231**	–4.883	**3.855**	–3.754	**3.456**	–1.746	**5.651**
Young (share)	–1.316	**2.616**	–0.848	**1.761**	–2.085	**1.892**	–2.964	**3.033**	–1.088	**3.930**
Old(share)	–3.372	**3.701**	–3.345	**3.834**	–5.676	**2.830**	–4.560	**2.549**	–2.168	**4.316**
Human capital										
Adult males										
Age	–0.044	–1.066	–0.060	–1.514	–0.043	–0.477	–0.077	–0.972	–0.024	–1.076
Age squared	0.000	0.951	0.001	1.578	0.001	0.692	0.001	0.736	0.000	1.145
Years of education	–0.042	**2.239**	–0.046	**2.590**	–0.072	**1.774**	0.076	**2.095**	0.009	0.860
Raven's test score	–0.001	–0.056	–0.001	–0.133	–0.012	–0.593	0.006	0.334	–0.001	–0.268
Height	0.006	0.654	0.023	**2.719**	0.035	**1.797**	0.022	1.251	0.012	**2.409**
BMI	–0.001	–0.058	0.005	0.267	–0.002	–0.038	0.101	**2.858**	0.010	0.963
Adult females										
Age	0.047	1.119	0.000	0.009	–0.029	–0.317	–0.147	**1.834**	–0.027	–1.206
Age squared	–0.001	–1.140	–0.000	–0.289	–0.000	–0.026	0.002	**1.869**	0.000	1.042
Years of education	–0.056	–1.426	–0.058	–1.539	–0.041	–0.482	–0.127	**1.728**	–0.072	**3.425**
Raven's test score	0.018	1.484	0.010	0.869	–0.017	–0.647	–0.010	–0.446	–0.004	–0.633
Height	0.002	0.179	–0.005	–0.509	0.007	0.335	–0.007	–0.383	–0.002	–0.363
BMI	0.012	0.815	0.004	0.297	–0.035	–1.046	–0.015	–0.506	–0.013	–1.622
Factors and inputs										
Total owned land (log+1)	0.207	**2.860**	0.159	**2.294**	0.174	1.081	–0.151	–1.078	0.016	0.391
Share of irrigated land	0.162	0.947	0.252	1.541	0.076	0.204	–0.267	–0.810	–0.074	–0.784
Value of farm tools (log+1)	0.208	**5.725**	0.213	**6.177**	–0.121	–1.565	–0.126	**1.901**	0.009	0.486
Number of livestock (log+1)	0.807	**9.895**	0.864	**11.080**	1.520	**8.406**	–1.064	**6.868**	0.165	**3.730**
Share of buffaloes	0.067	0.358	0.163	0.904	1.106	**2.664**	–0.380	–1.056	0.033	0.324
Share of bullocks	1.178	**2.336**	0.946	**1.951**	2.379	**2.102**	–0.435	–0.438	0.120	0.422
Share of donkeys	–0.937	–1.546	–0.264	–0.478	1.470	1.212	1.646	1.506	0.215	0.681
Share of sheep and goats	–0.856	**4.287**	–0.656	**3.467**	–0.579	–1.360	1.527	**4.180**	–0.056	–0.534
Nonfarm capital	–0.038	**2.266**	–0.039	**2.465**	–0.068	**1.932**	0.087	**2.829**	0.022	**2.445**
Family background										
Father's holding (log+1)	0.178	**2.766**	0.145	**2.345**	–0.006	–0.043	–0.043	–0.346	0.004	0.117
Inherited land (log+1)	–0.096	–1.242	0.007	0.101	–0.051	–0.297	–0.190	–1.249	–0.045	–1.044
Father's education	–0.118	**2.059**	–0.111	**2.031**	–0.300	**2.387**	0.144	1.315	–0.039	–1.244
Mother's education	0.198	0.795	0.161	0.674	0.118	0.209	0.231	0.498	0.364	**2.718**
Nonearned income										
Total unearned (log+1)	–0.054	**3.637**	–0.021	–1.488	–0.019	–0.585	–0.110	**3.850**	–0.046	**5.646**
Share of rental income	–0.705	**4.295**	–0.855	**5.446**	0.297	0.849	0.505	1.606	0.001	0.010
Share of pension income	0.441	1.373	0.093	0.302	–0.482	–0.687	0.726	1.199	0.156	0.885
Shifters										
Dummy for 1986	0.671	**4.803**	0.091	0.681	1.038	**3.455**	0.315	1.184	0.153	**2.013**
Dummy for 1987	–1.062	**7.751**	–0.314	**2.420**	0.542	**1.859**	0.627	**2.449**	–0.152	**2.069**
Intercept	–0.381	–0.158	–1.118	–0.485	–0.360	–0.069	2.776	0.596	4.713	**3.569**
Selection-term	1.625		1.568		3.381		3.145		0.936	
Number of observations	1,385		1,385		1,385		1,385		1,385	
Censored	353		323		601		430		19	
Noncensored	1,032		1,062		784		955		1,366	
Pseudo R-square	0.213		0.191		0.092		0.064		0.112	

Notes: Village fixed effects included but not shown. Kharif and rabi labor include hired labor. Total family labor = family labor in kharif and rabi cultivation, herding, and off–farm work. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

Table 18 Tobit regression of labor use: Husband and wife human capital

	Kharif labor		Rabi labor		Herding		Nonfarm		Total labor	
	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z
Household composition										
Household size (log)	0.509	**2.777**	0.628	**3.533**	0.654	1.594	3.142	**8.506**	1.124	**11.681**
Adult females (share)	–1.755	**2.119**	–1.815	**2.248**	–3.695	**2.045**	–2.783	–1.679	–2.110	**4.888**
Children (share)	–1.705	**2.851**	–1.702	**2.932**	–4.978	**3.705**	–6.093	**5.038**	–2.693	**8.575**
Young (share)	–1.238	**2.394**	–1.200	**2.386**	–2.093	–1.850	–4.615	**4.375**	–1.987	**7.289**
Old (share)	–2.798	**2.932**	–3.630	**3.907**	–3.900	–1.848	–7.957	**4.062**	–3.307	**–6.604**
Human capital										
Adult males										
Age	–0.028	–0.757	–0.004	–0.101	0.139	1.605	–0.116	–1.529	0.031	1.579
Age squared	0.000	0.460	–0.000	–0.198	–0.002	–1.946	0.001	1.519	–0.000	–1.886
Years of education	–0.025	–1.300	–0.024	–1.324	–0.102	**2.395**	0.086	**2.253**	0.008	0.812
Raven's test score	–0.007	–0.752	–0.017	–1.838	0.011	0.520	–0.030	–1.486	–0.009	–1.830
Height	0.005	0.556	0.028	**3.233**	0.021	1.067	0.028	1.586	0.013	**2.766**
BMI	–0.016	–0.840	–0.003	–0.173	0.025	0.603	0.118	**3.187**	0.025	**2.571**
Adult females										
Age	0.084	**2.043**	0.010	0.251	–0.035	–0.380	–0.110	–1.335	–0.005	–0.214
Age squared	–0.001	**2.034**	–0.000	–0.229	0.000	0.205	0.001	1.652	0.000	0.009
Years of education	–0.039	–0.800	–0.073	–1.525	–0.004	–0.035	0.128	1.370	0.021	0.844
Raven's test score	–0.001	–0.079	–0.002	–0.184	–0.041	–1.468	0.003	0.129	–0.008	–1.211
Height	–0.000	–0.019	–0.002	–0.260	0.011	0.499	0.009	0.451	0.010	1.962
BMI	0.028	1.995	0.015	1.116	–0.041	–1.339	–0.031	–1.143	–0.006	–0.900
Factors and inputs										
Total owned land (log+1)	0.205	**2.553**	0.178	**2.289**	0.278	1.534	–0.284	–1.737	–0.061	–1.437
Share of irrigated land	0.057	0.308	0.016	0.088	0.209	0.516	–0.288	–0.776	–0.077	–0.799
Value of farm tools (log+1)	0.187	**4.665**	0.179	**4.608**	–0.111	–1.272	–0.271	**3.518**	–0.026	–1.277
Number of livestock (log+1)	0.728	**8.120**	0.726	**8.345**	1.596	**7.870**	–1.090	**6.141**	0.147	**3.168**
Share of buffaloes	–0.071	–0.342	0.150	0.752	1.848	**3.981**	–0.683	–1.659	–0.079	–0.739
Share of bullocks	0.945	1.698	0.734	1.361	1.863	1.478	–0.961	–0.849	–0.080	–0.269
Share of donkeys	0.021	0.034	–0.243	–0.420	3.199	**2.566**	0.293	0.252	0.407	1.313
Share of sheep and goats	–0.771	**3.499**	–0.549	**2.574**	–0.298	–0.622	1.581	**3.736**	–0.017	–0.150
Nonfarm capital	–0.048	**2.564**	–0.060	**3.358**	–0.118	**2.969**	0.114	**3.200**	0.039	**4.106**
Family background										
Father's holding (log+1)	0.218	**2.862**	0.192	**2.609**	–0.091	–0.527	0.006	0.041	0.045	1.120
Inherited land (log+1)	–0.137	–1.474	–0.039	–0.426	–0.232	–1.097	0.015	0.077	0.000	0.002
Father's education	–0.064	–1.054	–0.068	–1.166	–0.300	**2.243**	–0.042	–0.348	–0.114	**3.657**
Mother's education	0.168	0.607	0.262	0.973	0.125	0.195	–0.827	–1.565	0.034	0.242
Nonearned income										
Total unearned (log+1)	–0.062	**3.705**	–0.027	–1.709	–0.046	–1.261	–0.094	**2.841**	–0.047	**5.398**
Share of rental income	–0.655	**3.597**	–0.856	**4.865**	0.262	0.674	0.541	1.499	0.044	0.471
Share of pension income	0.329	0.936	0.238	0.704	–0.420	–0.551	0.755	1.098	0.110	0.600
Shifters										
Dummy for 1986	0.788	**5.188**	0.169	1.148	0.604	1.846	0.267	0.890	0.182	**2.312**
Dummy for 1987	–1.037	**6.906**	–0.292	**2.028**	0.155	0.485	0.682	**2.343**	–0.101	–1.315
Intercept	–0.613	–0.248	–3.078	–1.286	–2.738	–0.501	2.190	0.445	1.872	1.463
Selection-term	1.564		1.521		3.239		3.110		0.849	
Number of observations	1,089		1,089		1,089		1,089		1,089	
Censored	256		239		473		345		12	
Noncensored	833		850		616		744		1,077	
Pseudo R-square	0.2132		0.1916		0.1101		0.0719		0.1457	

Notes: Village fixed effects included but not shown. Kharif and rabi labor include hired labor. Total family labor = family labor in kharif and rabi cultivation, herding, and off-farm work. All values are in 1986 rupees; (log +1) means that the regressor is computed as Log (x+1) to avoid losing zero observations; t and F statistics in bold are significant at the 10 percent level or better.

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