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ADAPTING HOUSEHOLD BEHAVIOR TO AGRICULTURAL TECHNOLOGY IN WEST BENGAL, INDIA: WAGE LABOR, FERTILITY AND CHILD SCHOOLING DETERMINANTS

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ABSTRACT

Despite substantial research on the determinants and impacts of the green revolution, little attention has been given to how this new agricultural technology is related to the allocation of resources among persons and activities *within* households. This problem has been addressed here with data from farm-households in the State of West Bengal, India, using a framework where adoption of new technology, participation of men and women in the hired agricultural labor force, fertility and child schooling are jointly determined. Results show that the new technology has changed time allocation patterns of men and women promoting higher fertility and population growth. Some of the income gains of the new technology are being invested in larger families rather than increased schooling of children. Greater education and increased wages of women are likely to contribute to their higher labor force participation, reduction in fertility and increase in the schooling of the next generation of children.

KEYWORDS: Agricultural technology, agricultural wage labor, fertility, child schooling.

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I. Introduction

The emergence of the High Yielding Varieties (HYV) as alternatives to Traditional Varieties (TV) of wheat, rice and several other crops has been a major event in many developing countries during the last two decades. The output, income, and employment augmenting effects of this modern technology have been documented in many regions of the world (Ruttan, 1977). The existing studies have focussed on aggregate economic indicators at national, regional or sectoral levels. Analyses of technological change and *household* well-being are now needed to explore the implications of this process for intra-household allocation of the resources among persons and activities. The critical household activity is labor force participation -- in the market, on own enterprise, or in home-production -- by male, female and child members of the household. These activities change as household demand for children changes and parents become able and willing to invest more in the health, nutrition, schooling and training of their children and thereby improve their productivity (quality). Analysis of these interrelated household decisions help clarify efficient policies for rural development, and trace through the repercussions of these policies for the society.

II. Background and Objective

Although much has been written on the green revolution technology in India at the national level and for some regions, few studies have dealt with the eastern region of the country. The question assumes special significance for the eastern Indian states because of several factors. First, this region produces about three-fourths of the country's output of rice, the major food crop, but the yield per acre is less than in other regions. The new technology in rice came to this region at a later date and its adoption has varied widely within the states. The Gangetic delta region has favorable levels of rainfall, soil moisture, and fertility. It has been suggested that the unrealized potential for growth in yields is high here (Mukhopadhyay, 1982, 1990b; Widawsky and O'Toole, 1990). The region is also noted for its high population density, small farm size, and high incidence of rural poverty. Understanding how technological change is interrelated to economic and demographic factors at the household level in eastern India should help improve agricultural and rural development policies.

My objective here is to analyze rural households within a framework where adoption of a new technology, labor force participation, fertility and child education are endogenously determined subject to physical, economic, demographic and policy constraints. The model of the farm-household assumes that utility is maximized subject to income and time constraints. The household coordinates production, consumption, health, nutrition and issues relating to fertility, child education and gender differences (Rosenzweig and Evenson, 1977; Singh, Squire and Strauss, 1986; Schultz, 1990; Pitt, Rosenzweig and Hassan, 1990; Rosenzweig, 1991). The paper deals with this problem for land cultivating or landed households in West Bengal and concentrates on their off-farm work as hired agricultural labor. Information is not available on other labor activities or types of households. In Section III the hypotheses and basic model are presented. Section IV discusses the data, variables and estimation. Section V presents the results, and Section VI states the conclusion.

III. Hypothesis and Model

A distinctive feature of a farm-household (household engaged in farming on own and/or leased-in land) is that it may employ part or all of its family labor while a landless household cannot do so. It can only hire out its labor to work in the market. Also, on the consumption side, farm households may use part or all of their food output for their own consumption. The behavioral responses of household members to changes in technology, prices, wages and profit vary according to the nature of the household and its resource endowments. Technological change in agriculture implies switching over to new seed and other inputs. Such changes involve several simultaneous adjustments within households. The HYV technology is often associated with greater use of family and hired labor.[1] However, the different farming tasks are often sex-specific, and the new technology thereby affects male and female labor differently. It has been observed, for instance, that the use of weedicides displaces labor for weeding, a task predominantly done by women. Similar effects are documented for the introduction of machines (Boserup, 1984; Ghosh and Mukhopadhyay, 1984, 1988). However, the new technology increases cropping intensity, which in turn helps increase the total demand for

[1]Based upon the experience in South-east Asia, it has been argued that the Green Revolution technology had two phases of its effect on labor use. In the first phase labor use increased while in the second phase it decreased (Jayasuriya and Shand, 1986). Even if this argument holds in South Asia, eastern India would still be in the first phase now.

both male and female labor in agriculture (Mukhopadhyay, 1990a). The aggregate effects of change in technology would, therefore, depend upon the relative magnitudes of these negative and positive effects.

Adoption of HYV technology and adjustment in labor use may then be expected to affect the household's pattern of consumption including the demand for number and quality of children. If children are assumed to be normal good, the effects of income should be to increase demand for them. The net effect of changes in relative prices would depend upon how male and female wages influence fertility and their movement due to technical change. The increased value of male time is expected to have a reinforcing positive income effect on fertility, and increased value of women's time is expected to have an offsetting negative effect on the demand for children (Schultz, 1981). If the latter is not strong enough to balance the positive income effect, household demand for children would rise with technical change. Investment in human capital of children, nutrition, health and patterns of consumption may also change.

The Model[2]

Consider a farm-household producing and consuming one composite staple commodity Q. The household's technology adoption probability function (V) is given by

$$V_i = V(Z_{1i}, Z_{2i}, Z_{1i}Z_{2i}),\ i = 1, ..., n \text{ households;} \tag{1}$$

where Z_{1i} are regional variables describing the location-specific stock of available technology, climate and soils that combine to determine the expected returns; Z_{2i} are household endowments and characteristics; $Z_{1i}Z_{2i}$ are potential interactions between community and household endowments.

The production of Q is given by the function

$$Q_i = Q(L_i, K_i, V_jL_i, V_jK_i, V_j),\ j = 1, 2, ..., R \text{ regions,} \tag{2}$$

where L, K are labor and non-labor inputs, V_j is the relevant technology in region j, and V_jL_i, V_jK_i are potential interaction variables affecting production.

The farm-household has a total time constraint:

$$T_{i,m} = t_{i,m,O} + t_{i,m,H} + t_{i,m,N} + t_{i,m,S} + t_{i,m,\ell} \tag{3a}$$

$$T_{i,f} = t_{i,f,O} + t_{i,f,H} + t_{i,f,N} + t_{i,f,S} + t_{i,f,\ell} \tag{3b}$$

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[2]The model relies on Becker and Lewis, 1974; DeTray, 1974; Schultz, 1981; and Singh, Squire and Strauss, 1986.

where T stands for total time available for male ('m') and female ('f') members of the household; t's refer to allocation of time into five categories; 'O' represents labor on own farm, 'H' is work off own farm, 'N' is number of children, 'S' is quality of children (Schooling, health, etc.); and 'ℓ' is leisure.

With no savings or intertemporal allocations to complicate lifetime choices, the farm-household's market income constraint is:

$$PX_i = PQ_i - [w_m(L_{i,m} - t_{i,m,O}) + w_f(L_{i,f} - t_{i,f,O})] + [w_m t_{i,m,H} + w_f t_{i,f,H}] \tag{4}$$

where X is the household's consumption of Q the produced commodity; P is the single price of the commodity, L is the own farm input of hired and family labor by sex, w_m, w_f stand for wage rates for male and female labor, respectively.

Substituting the production function (2) and time constraints (3a) and (3b) into the market income constraint (4), we have one single constraint for the farm-household:

$$\begin{aligned} & PX_i + [w_m(t_{i,m,N} + t_{i,m,S} + t_{i,m,\ell}) + w_f(t_{i,f,N} + t_{i,f,S} + t_{i,f,\ell}) \\ &= [PQ_i - (w_m L_{i,m} + w_f L_{i,f})] + w_m T_{i,m} + w_f T_{i,f} \\ &= \Pi + w_m T_{i,m} + w_f T_{i,f} = I_i^* \end{aligned} \tag{5}$$

where Π is profit and I^* full income consistent with profit maximizing output of the household.

The household is assumed to maximize a twice differentiable single utility function

$$U_i = U(X, t_{m,\ell}, t_{f,\ell}, N, S) \tag{6}$$

subject to constraint (5).

Constrained maximization of utility would yield demand functions for the household's choice variables in terms of prices, wages and income. The reduced form functions for adoption, labor force participation patterns, fertility and child quality depend upon profitability, physical-infrastructure and factors affecting the value of time (e.g., technology, market determined wages, demographic variables, etc.). The new technology has certain attributes that affect men and women differently. This is expected to have differential effects upon labor force participation by men and women. Within the household, differences in human and non-human resource endowments interact with market and community factors to determine desired fertility and investment in the quality of children.

IV. Data and Empirical Specification

The study is based on data from a stratified random survey of households conducted as part of the 'Differential Impact Study of Technological Change in Rice Cultivation in West Bengal' sponsored by the Rockefeller Foundation and conducted at the Indian Statistical Institute, Calcutta. The area of study covered 60 villages in 12 blocks of 6 districts in the state (see Appendix A and B) including 1930 households and 11,575 persons. This paper deals with farm-households only, and explores the determinants of their technology adoption, labor supply as agricultural wage labor, fertility and child schooling. Variables have been constructed at three levels: (i) individual persons, (ii) households, and (iii) communities. Definitions and sample statistics of variables are reported in Table 1. Methods of construction of village level technology variables and sample selection corrected wage rates for men and women are given below.

Ratios of Yields and Yield Variances

Two community variables have been constructed to represent exogenous technology characteristics. First, ratios of rice yield per acre for HYV to TV have been estimated for each village on the basis of mean yields averaged over preceding seven years and reported from each village.[3] This yield-ratio is assumed to be a lagged exogenous variable that represents profitability of the HYV to TV technology (see Griliches, 1957). The yields are given in Appendix C. Second, in order to construct a measure of risk, village-level ratios of variances of HYV to TV yields were estimated from farm data. Yield was regressed on farm-household endowments and regional dummies. Results show that regional agro-climatic characteristics, land size and land quality are strong determinants of yield variation (Appendix D).

Regional Dummies

The sample districts, blocks and villages have been identified by (i) agro-climatic and soil characteristics (e.g. annual rainfall, soil moisture and land level), and (ii) physical and social-economic infrastructure (e.g. public irrigation in village, electrification, presence of schools, health centers, markets). Based on these characteristics each district, block and village has been classified as either favorable (F) or unfavorable (UF) for agricultural development. The 60 villages were then grouped into 8 (2 × 2 × 2) regional clusters representing production environment in the state. Dummy variables have been used for these regions in the yield functions (see Appendix B for list of sample districts, blocks and villages and their classification).

[3]This estimate is discussed and used in a study using village data (Mukhopadhyay, 1990).

Participation and Wage Functions

Participation in agricultural wage employment as shown in our sample, is 32 percent for adult men and only 4 percent for adult women (Appendix E).[4] The rate is highest in age group 25-49 for both men and women. Participation by schooling shows that for both men and women the bulk of agricultural wage labor is supplied by persons with no schooling. At the primary education level, male participation is the lowest and female participation is virtually nil. However, participation increases at the secondary education level, especially for women.

Daily wage rate functions have been estimated for men and women separately, correcting for the selective sample of wage earners. The probit sample selection equation for wage employment status has been estimated as a reduced form specification. It includes individual level variables to represent demographic and human capital characteristics, e.g., age, age-squared, and education; household level variables, e.g., land, land quality, irrigation, and assets that represent household endowments affecting wage labor participation. In West Bengal, muslim women are "proscribed" from working in field as farm labor and so religion (muslim or not) is included. Village level ratios of yield and yield variance of HYV to TV rice are also included to examine the effects of technology characteristics upon wage labor status. The semi-logarithmic wage equations include the same variables as the wage labor status equation minus religion, land quality, and irrigation. These identifying variables are assumed to raise the shadow value of a person's time in non-market, self-employment, or non-farm activities and thus reduce the probability that the person will participate as wage labor in agriculture. The wage functions (Table 2) suggest that education reduces participation in hired agricultural labor force, but increases wages for both men and women workers. The mean educational level of women agricultural wage earners (1.52 years) is lower than that of men (3.95 years). The private rate of return to schooling, represented by the proportionate wage gain associated with a year of schooling, is 3.5 percent for women as against 1.6 percent for men. Land size, land quality and assets reduce wage labor participation of men and women as expected. Muslim religion, and technology variables also reduce female

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[4]Participation in agricultural wage labor market is only a part of the total labor supply of farm-household. Analysis of the allocation of labor to self-employment, non-farm employment and unpaid family employment is outside the scope of this paper because relevant data are not available. (For discussion on the extent of alternative types of work of rural households and their differences between men and women, see Boserup, 1990; Dixon, 1982; Ghosh, 1990; and Pradhan and Bennett, 1981.)

TABLE 1

Variable Definitions and Sample Statistics

Variable Definition	Mean (SD)	Variable Definition	Mean (SD)
IA. <u>Individual Endogenous Variables</u>:		IB. <u>Individual Exogenous Variables</u>:	
1. Average agricultural wage (ℓn) for hired male labor (Rupees per day)	2.78 (0.44)	5. Age of Adult Men (age 15–65)	35.1 (15.3)
2. Average agricultural wage (ℓn) for hired female wage (Rupees per day) (ℓn) for hired female	2.65 (0.50)	6. Age of Adult Women (age 15–65)	35.4 (15.4)
3. Proportion of men working as agricultural wage labor	.452 (.50)	7. Years of education: Adult Male	5.24 (4.20)
4. Proportion of women working as agricultural wage labor	.060 (.23)	8. Years of education: Male Wage Earners	3.95 (4.08)
		9. Years education: Adult Women	2.75 (3.66)
		10. Years of education: Female Wage Earners	1.46 (2.50)
IIA. <u>Household Endogenous Variables</u>:		IIB. <u>Household Exogenous Variables</u>:	
11. Proposition of Rice area under high yielding variety	.334 (.39)	17. Average years of schooling for Adult Men (age 15–65)	4.82 (3.79)
12. Number of days worked on agriculture as wage labor per (age 15–65) during preceding year	127. (66.35)	18. Average years of schooling for adult woman (age 15–65)	2.54 (3.00)
13. Number of days worked on agriculture as wage labor per agriculture as wage labor per during preceding year	8.86 (31.92)	19. Cultivable land owned by household (acre)	1.72 (1.83)
14. Number of children age 0-9 per woman age 15-49 in household	1.59 (1.39)	20. Proportion of land suitable for high yielding variety rice cultivation	.328 (.33)
15. Years of Schooling per Child Age 7–14 relative to village average: Boys	.854 (.77)	21. Proportion of land irrigated	.600 (.41)
16. Years of schooling per child age 7–14 relative to village average: Girls	.848 (.83)	22. Value of assets per household (in 1000 Rupees)	29.5 (55.16)

TABLE 1, continued

Variable Definition	Mean (SD)	Variable Definition	Mean (SD)
		III. Community Exogenous Variables:	
		23. Ratio of yield per acre of high yielding to traditional variety rice: estimated at village level	1.63 (.20)
		24. Ratio of variance of yield per acre of high yielding to traditional variety rice: estimated at village level	1.06 (.36)
		25. Proportion of muslims in sample households	.18 (.38)
		26. Regional Dummy Variables	
		Region 1	.158 (.37)
		Region 2	.104 (.30)
		Region 3	.077 (.27)
		Region 4	.150 (.36)
		Region 5	.146 (.35)
		Region 6	.091 (.28)
		Region 7	.109 (.31)
		Region 8	.163 (.37)

Name	Sample Size Number
Districts	6
Administrative Blocks	12
Village	60
Households	1930
Population: Men	6053
Population: Women	5522

TABLE 2

Sample Selection Corrected Wage Function for Men and Women Age 15-65

	Men		Women	
Dependent Variable Estimation Method	Agricultural Wage Labor Status ML Probit	Log of Daily Wage Rate Heckman	Agricultural Wage Labor Status ML Probit	Log of Daily Wage Rate Heckman
Explanatory Variables:				
Age in Years	.0833 (10.19)	.044 (6.83)	.0582 (3.12)	.0309 (1.67)
Age^2	-.00113 (11.43)	-.000523 (6.15)	-.000957 (3.84)	-.000465 (1.81)
Years of Schooling	-.064 (11.05)	.0161 (3.39)	-.0570 (4.50)	.0352 (3.21)
Religion Dummy (Muslim = 1)	.118 (1.96)	—	-.694 (4.94)	—
Land in Acres	-.00138 (12.06)	-.000209 (1.70)	-.000876 (2.99)	.000582 (2.01)
Land Quality	-.014 (.20)	—	-.495 (4.51)	—
Irrigation	.292 (5.16)	—	.526 (.95)	—
Asset in Rupees ($\times 10^{-3}$)	-.00133 (3.08)	—	-.0011 (.95)	—
Village Level Yield Ratio	.0866 (.79)	.0731 (1.45)	-1.18 (6.35)	.111 (.66)
Village Level Yield Variance Ratio	-.155 (2.48)	.0302 (1.02)	-.269 (2.37)	-.0573 (.52)
Intercept	-.713 (2.89)	1.486 (8.82)	-.218 (.50)	3.81 (10.07)
Wage-earner Status (λ)		.458 (4.61)		-.566 (4.75)
Loglikelihood	-2088.0		-598.81	
χ^2 (d.f.)	855.53		239.75	
R^2		.192		.167
Dependent Variable Mean	.45	2.78	.06	2.65
Sample Size	3654	1651	3166	190

in hired agricultural labor. (More about these effects in Section V).[5] I have used Heckman's (Heckman, 1979) two-stage sample selection correction using the inverse of Mill's ratio (λ) from the wage status probit as an independent variable and have consistently corrected the standard errors of the second stage estimates for the fact that λ is a predicted variable. The coefficients for lambda are significant for both men and women but their signs are opposite, suggesting that low wage male workers are likely to work in wage employment while high wage female workers are more likely to work in agricultural wage labor. Wage rates estimated by these equations have been used in the reduced form equations for households. Reduced form equations have been estimated for: (i) Technology adoption probability function; (ii) supply function of adult male labor for agriculture wage employment; (iii) supply function of adult female labor for agricultural wage employment; (iv) number of children; (v) schooling of male children; and (vi) schooling of female children.

V. Results of the Estimates of Reduced Form Equations

Ordinary Least Squares and Tobit estimates of the reduced form equations are presented in Tables 3-5. Discussion is based mainly upon the Tobit estimates because of the censored nature of dependent variables that might cause OLS estimates to be biased (Maddala, 1988).

Technology Adoption

A farmer's decision to adopt the new agricultural technology (HYV) depends upon discounted returns per unit cost and the added risk or uncertainty that HYVs may entail compared to TVs. Expected returns are determined by the farm-household's endowments and community factors. Estimates of the technology adoption probability function show (Table 3) that quality of land owned and availability of irrigation encourage adoption. Village level profitability of the new relative to traditional technology also has positive effects on adoption. However, the size of land owned and the value of assets of the household are not important. This is consistent with the idea that the green revolution technology is scale neutral.[6] Levels of schooling also appear not significant. Formal education might facilitate and motivate change, but it is farmers'

[5]I tried an alternative specification of education by using primary (up to 3 years) and higher levels of schooling. Interactions between levels of education and village level technology variables were also included. Results showed that the total returns to education were virtually nil until 3 years of schooling. This may imply that dropping out of school in three years would not add as much to farm skill as one would gain by working in the field.

[6]Rosenzweig, 1991, however, found positive land and wealth effects for an all-India (except Orissa and West Bengal) study based upon district level data.

TABLE 3

Adoption of High Yielding Variety Technology in Rice Cultivation in Rural West Bengal 1990[a]

Estimation Method Explanatory Variables:	OLS (1)	ML Tobit (2)
Market wages in log of Rupees per day in agriculture:		
Men[b]	-.0889 (1.33)	-.177 (1.68)
Women[b]	.104 (1.77)	.143 (2.00)
Average years of schooling per adult in household:		
Men	-.0035 (1.00)	-.00102 (.20)
Women	-.00084 (.24)	-.00103 (.19)
Land owned in acres by household ($\times 10^{-3}$)	-.0895 (1.47)	-.0952 (1.02)
Proportion of land suitable for high yielding variety rice	.268 (11.14)	.431 (10.99)
Proportion of cultivable land irrigated	.477 (24.81)	.756 (23.12)
Value of total assets of households in Rupees ($\times 10^{-3}$)	.00209 (1.25)	.00378 (1.49)
Ratio of yield per acre of high yielding to traditional variety of rice[c]	.117 (2.85)	.157 (2.33)
Ratio of variances of yield per acre of high yielding to traditional variety rice[d]	.0124 (.55)	.0184 (.517)
Intercept	-.263 (1.03)	-.632 (1.56)
R^2	.354	
F(df)	87.5 (10,1595)	
Log Likelihood		-1034.4
Dependent Variable Mean Dependent Variable (Standard Deviation)	.334 (.389)	
Number of Observations	1606	

[a]Absolute values of *t*-ratios and asymptotic *t*-ratios are reported for OLS and Tobit estimates respectively beneath coefficients in parentheses.

[b]Daily wage rates (ℓn) imputed from sample selection corrected wage equations reported in Table 2.

[c]Estimated from village level yields of high yielding and traditional variety yields reported in Appendix C.

[d]Estimated from variances of yield equations reported in Appendix D.

knowledge of local conditions, on-the-job experience, and availability of extension services that is more relevant to their decision to adopt. It has been argued that the new technology has higher yield variability (Sen, 1971; Mehra, 1981) which might act as risk to deter adoption. Recently, Rosenzweig (1991) found a small effect of risk related to weather deterring adoption in semi-arid central India. Evidence also exists that the HYVs are not more risk prone than the TVs (Mukhopadhyay, 1976; Hazell, 1980). Most of the earlier studies are based on aggregate data, whereas the present study uses farm data to estimate ratios of variances in yield for new relative to traditional technology. The observed variance in the new technology is higher than that in traditional technology only by a small margin; the mean value of this ratio is 1.07 and standard deviation is 0.36. With given land quality, assured irrigation and expected higher profit, additional risk in yields does not affect farmers' decision to adopt. Farmers appear to be influenced by considerations of cost minimization. The new technology uses a higher proportion of male to female labor (Mukhopadhyay, 1985, 1988). An increase in wages of men would increase cost and decrease the proportion of land under the high yielding variety. Conversely, an increase in women's wage would decrease area under traditional varieties and encourage adoption of the new technology.

Labor Supply of Men and Women

Equations for participation by men and women in agricultural wage labor market are reported in Table 4. The own wage effects on labor supply of both men and women are positive and significant. Cross wage effects are negative, though not statistically significant. This pattern of own and cross wage effects suggests substitution in non-market time as has been found in several studies in India and elsewhere (Rosenzweig, 1984; Duraisamy, 1988; Schultz, 1990). According to my estimates, a one standard deviation increase in (ℓn) wage (.44) of a man would raise the number of days worked off-farm by 52 days per adult male in household, an increase of 41% from a sample mean of 127 days. For a woman with slightly higher standard deviation (.50) the increase would be 33 days, more than three times the sample mean of 9 days. The average level of education of adult men in the household has a negative effect upon both men's and women's supply of agricultural wage labor. Formal schooling encourages participation in managerial, supervisory and non-farm activities (Rosenzweig, 1984). This tendency may be responsible for the results obtained for male education. However, the level of education of women in the family does not show a significant effect upon their hired agricultural wage labor supply.

TABLE 4

Supply of Agricultural Wage Labor of Men and Women Age 15–65 in Rural West Bengal 1990[a]

Dependent Variable	Number of Days Worked in Agriculture per Adult Man		Number of Days Worked in Agriculture per Adult Woman	
Estimation Method Explanatory Variables:	OLS (1)	ML Tobit (2)	OLS (3)	ML Tobit (4)
Market wages in log of Rupees/Day in agriculture:				
Men[b]	8.098 (5.98)	8.47 (5.69)	-.817 (1.26)	-.388 (.08)
Women[b]	-1.200 (1.09)	-1.40 (1.20)	1.38 (2.73)	7.65 (1.82)
Average years of schooling per adult in household:				
Men	-.380 (5.71)	-.384 (5.30)	-.121 (3.77)	-.809 (3.25)
Women	.101 (1.40)	.098 (1.24)	-.032 (.92)	-.215 (.74)
Land owned in acres by household ($\times 10^{-3}$)	-.00153 (1.24)	-.00127 (.94)	-.00108 (1.83)	-.00974 (1.87)
Proportion of land suitable for high yielding variety rice	-1.64 (3.36)	-1.73 (3.24)	-1.20 (5.14)	-6.35 (3.71)
Proportion of cultivable land irrigated	1.37 (3.51)	1.90 (4.23)	.031 (.16)	2.80 (1.88)
Value of total assets of household ($\times 10^{-3}$)	-.00686 (2.01)	-.00853 (2.28)	-.00297 (1.83)	-.00482 (2.31)
Ratio of yield per acre of high yielding to traditional variety rice[c]	1.14 (1.34)	1.091 (1.19)	-2.85 (7.16)	-18.77 (6.10)
Ratio of variances of yield per acre of high yielding to traditional rice[d]	-.831 (1.81)	-.961 (1.91)	.153 (.70)	-1.94 (6.10)
Intercept	-5.97 (1.15)	-6.77 (1.18)	7.01 (2.82)	36.63 (1.90)
R^2	.079		.091	
χ^2 (d.f.)				
F (d.f.)	13.71 (10,1595)		15.99 (10,1595)	
Log Likelihood		-5079.0		-1036.0
Dependent Variable Mean (Dependent Variable Standard Deviation)	127.45 (66.34)		88.67 (31.92)	
Number of Observations	1606		1606	

[a]Absolute values of t-ratios and asymptotic t-ratios are reported for OLS and Tobit estimates respectively beneath coefficients in parentheses.

[b]Daily wage rates (ℓn) imputed from sample selection corrected wage equations reported in Table 2.

[c]Estimated from village level yields of high yielding and traditional variety yields reported in Appendix C.

[d]Estimated from variances of yield equations reported in Appendix D.

The size and quality of land, and total assets of households reduce hired agricultural labor supply of both men and women. This may be due to larger productivity and income leading to increased demand for leisure. The proportion of women's labor is reduced in the HYV technology as shown in the negative effect of the ratio of HYV to TV yields at the village level. Irrigation increases off-farm labor supply of men and women. This suggests that in order to supplement cash incomes farmers often rent out irrigation pumps as well as other implements and bullocks along with the labor to operate them. Farmers also minimize risks of income loss through allocation of labor between on-farm and off-farm activities consistent with their physical and human capital endowments.[7] Such adjustments in allocation of labor of men and women among on-farm, off-farm and non-farm activities are observed in other Asian countries undergoing technical change in agriculture (see Castillo *et al.*, 1986 and other articles in Shand, 1986).

Fertility and Schooling of Children

The bearing and rearing of children uses more of women's time than men's. If the value of women's time is their earnings potential, and it increases relative to men's, the perceived costs of having children rise and fertility is likely to decrease. Earnings potential is measured commonly by market wage opportunities. Self-employment and unpaid family work are also related to earnings potential through the opportunity cost of wages foregone, assuming the same type of labor for these different activities. Thus increases in market wages of women compared to those of men should be associated with lower fertility. Higher parental education, earnings, and non-earned family resources are expected to affect positively investment in child quality.

Table 5 reports estimates of fertility, and schooling of boys and girls less than age 15. As expected, market wages of women have a negative effect upon fertility, while the effect of men's wages are positive, confirming that the value of women's time adds to the cost of children. Effects on fertility of education of both women and men are negative. The amount of land owned and the village level yield ratio signifying technological potential have positive effects upon fertility. This is perhaps due to the relatively lower use of women's labor in HYVs and their withdrawal into home production activities that do not conflict with child bearing. Other aggregate studies on district level data in India have found corroborating evidence (Vosti and Lipton, 1991).

The significant coefficients in the equations for child schooling show that schooling of boys is affected positively by the wages and education levels of both men and women. For girls, however, both wage effects

[7]These observations are of course tentative because I am considering here only one type of labor supply and the conclusions cannot be confirmed without evidence on the other types.

TABLE 5

Fertility and Schooling of Boys and Girls Age 0–14, in Rural West Bengal, 1990[a]

Dependent Variable	Number of Children Age 0–9 per Woman Age 15–49		Years of schooling per boy age 5–14 in household as proportion of Village Average		Years of schooling per girl age 5–14 in household as propor- of Village Average	
Estimation Method Explanatory Variables	OLS (1)	ML Tobit (2)	OLS (3)	ML Tobit (4)	OLS (5)	ML Tobit (6)
Market Wages in log of Rupees per day in agriculture:						
Men[b]	1.857 (6.70)	2.177 (6.74)	.225 (1.03)	.217 (.75)	−.337 (1.42)	−.680 (1.20)
Women[b]	−1.759 (8.15)	−2.156 (8.35)	.303 (1.71)	.453 (1.93)	−.124 (.63)	−.154 (.55)
Average years of schooling per adult in household:						
Men	−.0738 (5.41)	−.0861 (5.45)	.0408 (3.91)	.0535 (3.86)	.0692 (6.02)	.118 (7.03)
Women	.115 (.78)	.0242 (1.42)	.0182 (1.60)	.0247 (1.67)	.0332 (2.65)	.0394 (2.25)
Land owned in acres by household ($\times 10^{-3}$)	.819 (3.24)	1.117 (3.75)	.159 (.76)	.182 (.66)	.142 (.64)	.178 (.54)
Proportion of land suitable for high yielding variety rice	−.123 (1.23)	−.144 (1.25)	−.0034 (.04)	.0571 (.58)	.154 (1.88)	.241 (2.02)
Proportion of cultivable land irrigated	.0241 (.30)	.0135 (.15)	.0404 (.70)	.0630 (.78)	.124 (1.90)	.178 (1.89)
Value of total assets of household in Rupees ($\times 10^{-3}$)	.000226 (.03)	.000179 (.22)	.000505 (.07)	.00812 (.08)	.000910 (1.31)	.000944 (.95)
Ratio of yield per acre of high yielding to traditional variety rice[c]	1.096 (6.44)	1.313 (6.61)	−.0341 (.25)	−.0775 (.43)	.0615 (.42)	−.0174 (.08)
Ratio of variances of yield per acre of high yielding to traditional variety rice[d]	−.155 (1.65)	−.198 (1.82)	−.0619 (.86)	−.0348 (.37)	−.0785 (1.05)	−.0229 (.20)
Intercept	−.163 (.15)	−.407 (5.45)	−.793 (.45)	−1.41 (1.26)	1.53 (1.68)	2.09 (1.61)
R^2	.126		.105		.148	
χ^2 (d.f.)						
F (d.f.)	23.12 (10,1595)		10.52 (10.891)		14.69 (10.845)	
Log Likelihood		−1714.8		−1117.4		−1075.7
Dependent Variable Mean (Dependent Variable Standard Deviation)	1.598 (1.39)		.854 (.771)		.848 (.834)	
Number of Observations	1606		902		856	

[a]Absolute values of *t*-ratios and asymptotic *t*-ratios are reported for OLS and Tobit estimates respectively beneath coefficients in parentheses.

[b]Daily wage rates (ℓn) imputed from sample selection corrected wage equations reported in Table 2.

[c]Estimated from village level yields of high yielding and traditional variety yields reported in Appendix C.

[d]Estimated from variances of yield equations reported in Appendix D.

are negative (though not significant for women's wages). The education of both adult men and women in the household is positively and significantly associated with children going to school. For given levels of wages, parental education induces higher schooling of both boys and girls. With higher wages, both men and women would invest more in the schooling of boys and withdraw girls from schools perhaps to substitute for women in the household who have joined the wage labor force. With more education, however, both men and women increase the schooling of boys as well as girls.

VI. Conclusions

Substantial attention has been given in economic development literature to the effects of the green revolution upon agricultural production and income. However, little is known about its consequences on household behavior. This paper has used cross-section data from a survey of rural households in West Bengal, India, and examined the determinants of adoption of the HYV technology by farm-households, labor supply by male and female members of such households to agricultural labor market, fertility and child schooling.

The empirical findings suggest that the farmers' decision to adopt new technology depends mainly upon the quality of their land, access to irrigation and profitability. The wage rate of male labor is negatively related to the proportion of land under HYV, while the wage of female labor is positively related to HYV adoption. This is consistent with efforts to minimize labor costs because HYVs use a higher proportion of male-to-female labor than do TVs.

Both men and women respond positively to their own wage rates in working for the agricultural labor market. But education, land ownership and value of household assets tend to reduce wage labor participation in off farm work in agriculture. Extent of HYV technology in the village has a negative influence upon women's wage labor supply as expected.

Fertility, or the demand for children, is affected negatively by women's wage rate and positively by men's wage rate. Land ownership and technology have positive effects upon fertility. Education of both men and women have strong negative effects upon fertility. Education has also unequivocally positive effects upon the schooling of children, both boys and girls. The results also suggests a tendency for households to withdraw girls from schools probably to substitute for adult women in household production when the latter have better opportunities to work in the agricultural labor market.

In sum, the new agricultural technology may have raised the income of farm-households, but its impacts upon the status of women is more ambiguous. The new technology has changed their time allocation pattern and thereby promoted higher fertility and population growth. If labor force participation in agricultural wage employment for women decreases relative to men and more of women's labor is allocated to the production of HYV crops on their own farms, women's status and control over economic resources may actually be diminished. The increase in fertility associated with many aspects of HYV's compared to TV's also suggests that some of the income gains achieved through the new agricultural techologies are being invested in larger families rather than increased schooling of children. Greater education of women and increased wages of women are more likely to be changes that will contribute to a reduction in fertility and an increase in the schooling of the next generation of children in east India.

Due to data limitations, the paper has been restricted to the study of farm-households and the participation of their members only in agricultural wage employment. The next step in analysis is to extend this study to landless and non-farm rural households, and collect information on their time allocated to self-employment, non-farm employment, and unpaid family work. A more comprehensive understanding of the relationships between change in agricultural technology and household behavior will be obtained when all major labor allocations are jointly studied for landless and landed rural households in India.

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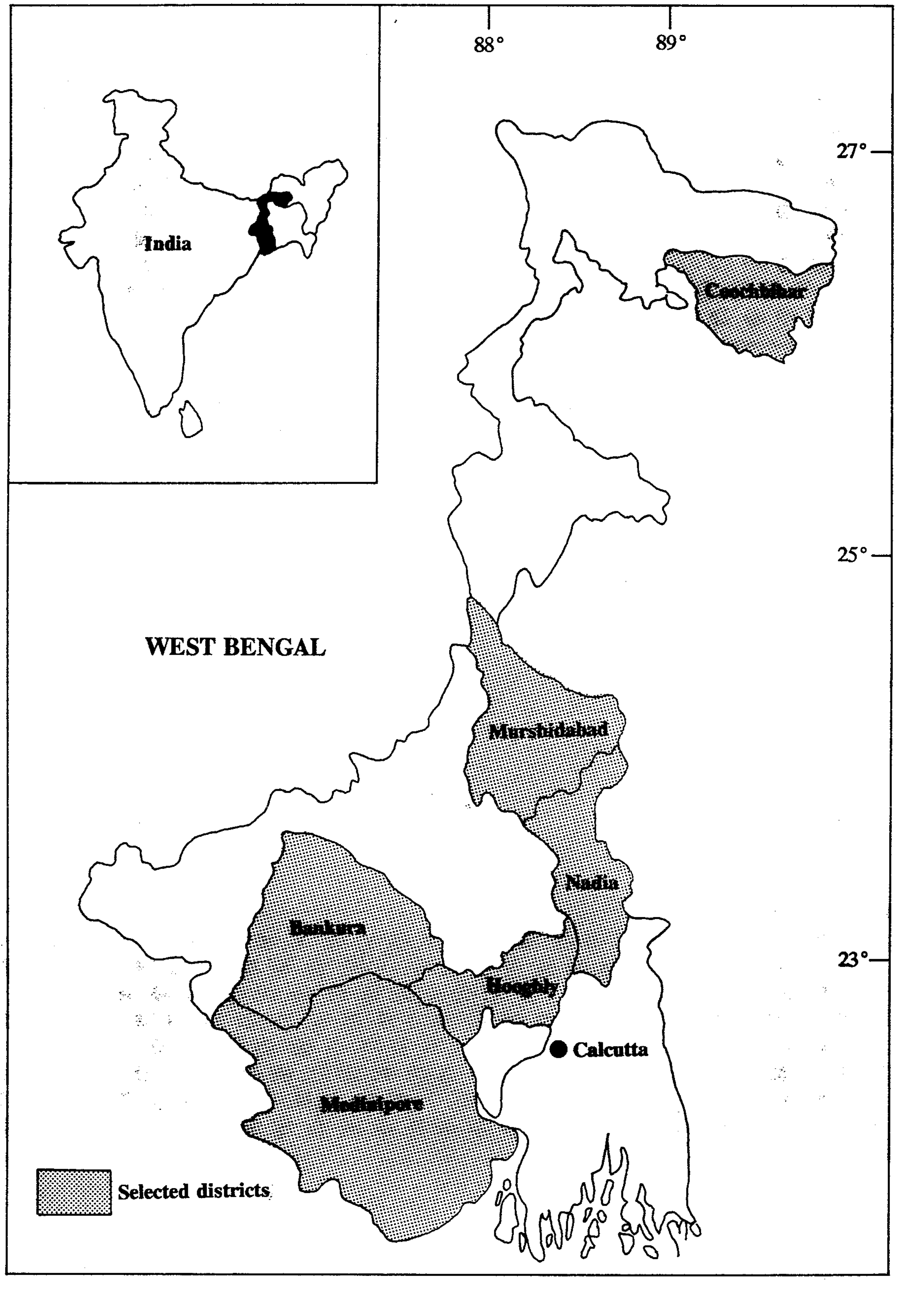
APPENDIX A

Map of Study Area



APPENDIX B

Sample Districts, Blocks and Villages Classified by Development Environment

District			Block			Village		
No.	Classification	Name	No.	Classification	Name	No.	Classification	Name
1	F	Nadia	1	F	Haringhata	1	F	Chanda
						2	F	Shimulpukuria
						3	F	Bhandarkona
						4	UF	Moraldanga
						5	UF	Sonakur
			2	UF	Santipur	6	F	Lalmath
						7	F	Krishipally
						8	UF	Kandokhola
						9	UF	Nobla
						10	UF	Barjiakur
2	F	Hooghly	3	F	Pandua	11	F	Panchghora
						12	F	Jamgram
						13	F	Ilchhoba
						14	UF	Rosna
						15	UF	Mohnod
			4	UF	Khanakul	16	F	Kohiba
						17	F	Kurkuri
						18	UF	Lalsar
						19	UF	Patul
						20	UF	Mahikul
3	F	Murshidabad	5	F	Beldanga	21	F	Ratanpur
						22	F	Pulinda
						23	F	Gopinathur
						24	UF	Benada
						25	UF	Dalna
			6	UF	Kandi	26	F	Ranagram
						27	F	Indrahata
						28	UF	Srikrishnapur
						29	UF	Bhabanandapur
						30	UF	Ranipur

APPENDIX B, continued

District			Block			Village		
No.	Classif-ication	Name	No.	Classif-ication	Name	No.	Classif-cation	Name
4	UF	Coochbihar	7	F	Tufanganj	31	F	Chilakhana
						32	F	Bhelakhoba
						33	F	Soladanga
						34	UF	N. Moradanga
						35	UF	Gobindapur
			8	UF	Coochbihar-1	36	F	Gosaiganj
						37	F	Patachora
						38	UF	Latlapur
						39	UF	Lonkabor
						40	UF	Panishala
5	UF	Bankura	9	F	Taldanga	41	F	Belsalya
						42	F	Radhamohanpur
						43	F	Barameshya
						44	UF	Chakshyampur
						45	UF	Brahmakanya
			10	UF	Chhatna	46	F	Gurputa
						47	F	Dalpur
						48	UF	Dhaban
						49	UF	Lonagarh
						50	UF	Jorhira
6	UF	Medinipur	11	F	Debra	51	F	Nachipur
						52	F	Dhamtal
						53	F	Bhagabanbasan
						54	UF	Rampurchak
						55	UF	Jalimpur
			12	UF	Nandigram	56	F	Rasikachak
						57	F	Srikrishnapur
						58	UF	Dibakarpur
						59	UF	Bamunara
						60	UF	Baroghuni

Note: 'F' and 'UF' stand for 'Favorable' and 'Unfavorable' respectively for agricultural development.

APPENDIX C

Average Village-level Rice Yields (Kilogram per Acre) for High Yielding and Traditional Varieties and Their Ratio for 60 Sample Villages

	Rice Yield (kg per acre)			Rice Yield (kg per acre)	
Serial No. of Village	HYV (1)	TV (2)	Serial No. of Village	HYV (1)	TV (2)
1	1507	1005	31	1397	807
2	1887	1043	32	1477	853
3	1689	1081	33	1142	1010
4	1725	978	34	1082	987
5	1833	1098	35	1486	1076
6	1669	1063	36	1395	829
7	1802	978	37	1457	815
8	1841	974	38	1488	795
9	1625	1006	39	1458	1014
10	1502	948	40	1444	1003
11	1500	880	41	1457	947
12	1729	1047	42	1489	973
13	1511	1027	43	1446	998
14	1821	1007	44	1095	979
15	1794	1086	45	1181	989
16	1775	1029	46	1361	793
17	1655	1014	47	1362	842
18	1732	955	48	1441	802
19	1665	2027	49	1463	729
20	1724	1097	50	1449	738
21	1633	1116	51	1482	905
22	1484	1052	52	1872	975
23	1551	1109	53	1576	1039
24	1344	845	54	1590	1012
25	1435	775	55	1616	1134
26	1508	787	56	1686	996
27	1354	837	57	1772	939
28	1159	1017	58	1777	921
29	1218	1012	59	1439	826
30	1422	839	60	1652	994

APPENDIX D

Functions for Rice Yield (Kilogram per acre) for High Yielding and Traditional Varieties

Explanatory Variables:	Dependent Variable: Rice Yield per Acre	
	High Yielding Variety	Traditional Variety
Land owned in acres	.237 (2.19)	−.010 (.10)
Proportion of land suitable for high yielding variety rice	23.41 (.59)	55.3 (2.28)
Proportion of land irrigated	184. (1.64)	71.3 (1.15)
Average years of schooling per adult male in household	7.93 (1.06)	9.29 (1.61)
Average years of schooling per adult female in household	.130 (.004)	14.1 (2.83)
Regional Dummies:		
Region 1 ($\times 10^3$)	.141 (10.98)	.851 (10.52)
Region 2 ($\times 10^3$)	.147 (11.01)	.775 (8.30)
Region 3 ($\times 10^3$)	.124 (8.67)	.681 (5.16)
Region 4 ($\times 10^3$)	.159 13.91	.815 (10.47)
Region 5 ($\times 10^3$)	.124 (11.32)	.866 (11.93)
Region 6 ($\times 10^3$)	.945 (6.27)	.878 (11.93)
Region 7 ($\times 10^3$)	.126 (11.61)	.647 (9.22)
Region 8 ($\times 10^3$)	.111 (9.53)	.668 (9.57)
R^2	0.82	0.65
Mean and Standard Deviation of Dependent Variable	1543.79 (758.91)	902.26 (664.48)
Number of observations	784	1153

Absolute *t*-values are given in parentheses beneath coefficients.

APPENDIX E

Participation in Agricultural Wage Labor by Age, Sex and Levels of Education
Farm-Households in Rural West Bengal, 1990
Wage labor in agriculture as percent of population*

Years of Schooling	Sex	Age						
		5-14	15-24	25-34	35-49	50-64	65+	Total
0	M	4	68	76	70	52	30	45
	F	1	13	13	11	5	2	8
1-3	M	—	59	56	57	42	20	19
	F	—	3	6	2	0	0	—
4-6	M	—	49	56	48	28	21	34
	F	—	2	4	3	0	0	2
7-10	M	—	17	39	42	34	13	27
	F	—	1	2	1	0	0	1
10+	M	—	6	29	50	40	0	26
	F	—	5	8	36	0	0	10
Total	M	1	36	52	54	40	23	32
	F	—	6	8	8	4	1	4

*Based on Total Sample age above 5: Male = 5425, Female = 4917.