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9. ABSTRACT Attempts to formulate a rigorous test for the existence of the allocative efficiency effect of schooling by examining empirically the relationships between schoo attainment and the adoption of new grain varieties and schooling investment and technic change within a more general optimizing framework. Within this framework, the costs of allocative activities are taken into account and schooling is allowed to play a number of roles, including signalling, in raising earnings. The results are potentiall interesting in providing information on the impact of agricultural development programs on the distribution of rural incomes in the long and short run. A model of a farm hous which is subject to a constant flow of new agricultural technology is constructed in which the level of adoptive activity is endogenous and in which the stock of the household's allocative skills can be augmented through schooling investment. The effec of schooling on the degree of dynamic allocative efficiency is decomposed into allocative, worker and signalling effects. It is shown that the direction of the relationship between schooling and measured allocative efficiency as well as the response of schooling investment to the rate of technical change depnd crucially on the relative magnitudes of the individual schooling effects. Results based on household data collected in India during the green revolution period in which households were exposed in different degrees to continuous information about the new technologies are used to draw inferences concerning the productivity of schooling. The final section summarizes the results and inferences are drawn concerning the income-distributional consequences of the interactions between schooling and agricultural technical change.

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Schooling, Allocative Ability and the Green Revolution

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In recent years the assumption that schooling augments skills a central (but not critical) tenet of human capital theory, has come under attack, with the assertion that the well-established positive correlation between schooling and wage earnings may wholly reflect a more basic association between pre-school ability and productivity It has also been established that information based on wage earnings data is unlikely to enable researchers to distinguish whether schooling serves to enhance skills or as a means by which employers are informed of the level of innate abilities characterizing employees (signalling).[1]

At the same time, an emerging body of literature has focussed on defining alternative roles of schooling as a factor of production in environments in which it is assumed market signalling is much less relevant, chiefly agriculture. In particular, based on the work of Nelson and Phelps and Welch, the hypotheses that schooling enhances efficiency in allocative activities have been tested in a number of careful empirical studies in which positive correlations between farm earnings and the schooling of farm operators and between schooling and measures of proximity to the "optimal" utilization of one or more factor inputs in a dynamical setting have been found.[2] Two important conceptual flaws characterize this latter work, however, reducing its usefulness as evidence of a "true" productivity effect of schooling, unrelated to signalling. First, the correlations between schooling and measured (allocative) efficiency on farms

may again reflect a relationship between endowment ability and allocative productivity- more able (potential) farmers may tend to attend schoo longer for consumption, learning efficiency or other reasons without schooling necessarily contributing to managerial ability. Thus it appears necessary to supplement evidence on the association between schooling and farm earnings with information on schooling investment

Even with ability held constant, moreover, the empirical estimates of the gross schooling-efficiency relations cannot be interpreted as reflecting the actual association between schooling and allocative efficiency (whatever its basis) unless it is assumed that there are no other constraints on or costs to allocative decision-making or that neither "worker" (direct productivity, given resources) or signalling effects of schooling exist. To the extent that innovation and allocation require time[3] and goods, however, and education augments the returns to labor directly, either because there are worker effects of schooling or schooling raises the price of time due to signalling for "part-time" farmers, schooling attainment will be positively correlated with both the cost and ability to finance entrepreneurial activities as well as with entrepreneurial skills. Thus with a signifi proportion of farm owners in both developing and developed countries working off the farm,[4] it is possible that the existence of signalling (or worker) effects of schooling have distorted the observed relations... between schooling (assumed only to be a contributor to allocative skills) and measures of farm efficiency, although the direction of the "bias" is not obvious.

In this paper we attempt to formulate a rigorous test for the existence of the allocative efficiency effect of schooling by examining empirically the relationships between 1) schooling attainment and the adoption of new grain varieties and 2) schooling investment and technical change within a more general optimizing framework in which the costs of allocative activities are taken into account and schooling is allowed to play a number of roles, including signalling in raising earnings. The results are also potentially interesting in providing information on the impact of agricultural development programs on the distribution of rural incomes in the long and short run.

In section I a model of a farm household which is subject to a constant flow of new agricultural technology is constructed in which the level of adoptive activity is endogenous and in which the stock of the household's allocative skills can be augmented through schooling investment. The effect of schooling on the degree of dynamic allocative efficiency is decomposed into allocative, worker and signalling effects and it is shown that the direction of the relationship between schooling and measured allocative efficiency as well as the response of schooling investment to the rate of technica change depend crucially on the relative magnitudes of the individual schooling effects. In section 2, results based on household data collected in India during the "green revolution" period in which households were exposed in different degrees to continuous information about the new technologies are used to draw inferences concerning the

productivity of schooling. The data indicate that farms with more educated farm operators and more educated farm wives were more likely to have adopted new high-yielding grain varieties and that neglecting the value of time component of innovative activity significantly biases the schooling-adoption relationship, particularly for farm wives. The results also suggest that landowning households in districts with greater flows of information on new inputs tended to school their children more than otherwise similar farm households in other areas, even when the income effects of such information are taken into account, consistent with the hypothesis that schooling is perceived as aiding farm operators in coping with technical change but not wit the signalling hypothesis. In the final section the results are summarized and inferences are drawn concerning the income-distributional consequences of the interactions between schooling and agricultural te technical change.

1. The Model

a) Optimization

Consider a three-person agricultural household which owns a fixed stock of non-depreciating production assets (A) situated in a area characterized by a constant flow of new, productivity-enhancin innovations k per period. To utilize these innovations and expand output the household must combine the time of its members and purchased goods with the available (factor-neutral) technology. The relationship between the level of innovation v, assumed to be the same each period, and inputs is given by the linear homogeneous "innovation" production function (1).

$$(1) \quad v = v\,(T^{M}_{vj}, T^{F}_{vj}, T^{C}_{vj}, X_{vj}; H^{M}, H^{F}, E)$$

where T^{i}_{vj} is the jth period time input used in the innovating activity by household number i, X_{vj} is the goods input used in innovation in the jth period and the H^{i} are the endowment stocks of human capital owned by the adult household numbers. All arguments in (1) have positive first derivatives; in particular it is assumed that H^{M} and H^{F} contribute to dynamic innovative efficiency by increasing the productivity of the innovation inputs (allocative effect). E, the non-depreciating stock of human capital of the "child" in the household, contributes to innovative efficiency after the first period, during which the level of E is determined.

The continuous-time rate of increase in production μ is thus a function of the level of innovating activity, v, and k , the flow of available innovations per period, as described in (2):

$$(2) \quad \mu = \mu\,(v,k)$$

Farm output Q_j in each period is thus

$$(3) \quad Q_j = \Gamma_j\,(T^{M}_{fj}, T^{F}_{fj}, T^{C}_{fj}, A; H^{M}, H^{F}, E)\,Ke^{\mu j}$$

where Γ ( ) is a twice-differentiable, strictly concave production function, K is the initial level of efficiency or technology, and the T^{i}_{fj} are in the jth period time inputs of the family members. The stocks of human capital are assumed to contribute directly to output (worker effects).

The household jointly maximizes a lifetime twice-differentiable utility funtion, which has as arguments the stock of child "schooling"

E and S, the standard of living composite commodity.[5]

(4) $U(S, E)$

The stock of child human capital is produced only in the first period according to the linear homogeneous schooling production function (5)

(5) $E = E(T_E^c, X_E)$

Where T_E^c is the time the child spends in school and X_E is the level of direct expenditures on schooling.

S is produced every period, such that

(6) $S_j = S(T_{sj}^m, T_{sj}^f, T_{sj}^c, X_{sj})$

where T_{sj}^i is the level of the time input of family member i spent in period j producing S and X_{sj} in the per-period level of goods expended in the production of S. Thus $S = \int_0^T e^{-rj} S_j \, dj$, where r is the discount rate and T is the horizon period limit.

It is assumed initially that the adults in the household spend some time, T_{wj}^i, in off-farm employment every period, earning wage rates W_i per unit of time. The child performs no market work in the first period but does contribute to farm production. Wage rates are assumed to be positive functions of schooling levels (non-farm worker and/or screening effects). With the total time available to each family member in each period given Ω^i, the horizon-period wealth constraint is (7):

$$(7) \quad F = \int e^{-rj} \left[\Gamma_j (\quad) e^{\mu j} + V + (\Omega^M - T_f^M) W_M + (\Omega^F - T_f^F) W_F \right] d$$

$$\int e^{-rj} (\Omega^C - T_f^C) W_C dj = \int e^{-rj} (\Pi_{sj} S + \Pi_{vj} v) dj + \Pi_{So} + \Pi_{vo} v + \Pi_E$$

where $\Pi_{vj} = x_{vj} P_v + t_{vj}^M W_M + t_{vj}^F W_F + t_{vj}^C W_C$; $\Pi_{vo} = x_{vo} P_v + t_{vo}^M W_M + t_{vo}^F W_F$,

$$\Pi_{so} = x_{so} P_s + t_{so}^M W_M + t_{so}^F W_F + t_{so}^C \Gamma_C, \quad \Pi_{sj} = t_{sj}^M W_M + t_{sj}^F W_F + t_{sj}^C W_C + x_{vj} P$$

$\Pi_E = x_E P_E + t_E^C \Gamma_C$ and x_v, x_s, x_E = marginal goods inputs in the production of V, E and S; P_v, P_s, P_E = price indices of the respective goods inputs; t_{vj}^i, t_{sj}^i, t_E^i = marginal time inputs of household number i in the production of V, S and E; Γ_C = the marginal product of child time in farm production in the first period.

The household chooses the optimal levels of the standard of living commodity, schooling and innovating activity for the planning period to maximize (4) subject to (7), given relations (1) through (3), (5) and (6) From the appropriate Lagrangean expression the necessary first order conditions, with corner solutions ruled out, can be written as

$$(8) \quad U_s/\lambda = \Pi_{so} + \int_1^T e^{-rj} \Pi_{sj} dj = \Pi_s^*$$

$$(9) \quad U_E/\lambda = \Pi_E + \int_1 e^{-rj} [v \delta \Pi_{vj}/\delta E - ((\Omega^C - T_F^C) - S t_s^C - v t_v^C) \delta W_C/\delta E$$

$$\Gamma_E K e^{\mu j}] dj = \Pi_E^*$$

$$(10) \quad \int_0^{\infty} r_j \left(\quad \right) K e^{(\mu - r)j} \mu_v j dj = \Pi_{vo} + \int_0^{\infty} e^{-rj} \Pi_{vj} dj = \Pi_v^{-}$$

where λ = Lagrangean multiplier

First-order condition (8) states that the value of the marginal utility of the non-schooling consumption commodity equals the sum of the per-unit direct and opportunity costs over the planning period, the shadow price of S , Π_s^*. Condition (9) indicates that the optimal level of schooling occurs at the point at which the value of the marginal utility of schooling equals the first period sum of marginal goods and child labor opportunity costs less the discounted future stream of net returns associated with the three roles of schooling. If all three schooling effects are operative an additional unit of schooling i) lowers the shadow price of the allocative activity ($v\delta\Pi_v^*/\delta E<o$), ii) increases future wage earnings due to the non-farm worker or signalling (wage) effect ($T_{Wj}^C \delta W_C/\delta E$) and iii) increases farm output directly if there is a worker effect of schooling (Γ_E , the marginal product of E,> o) but also iv) increases the child time cost in the production of S and in innovation if there is a wage effect.

Finally, condition (10) states that the discounted present value of the stream of gross income accruing to the household from an additional unit of "innovation" equals the present value of the time and goods resources used to produce that marginal increase. Expression (10) thus implies that there is an optimal level of dynamic production inefficiency if full efficiency is defined where the marginal product of a reallocation of resources is zero . Moreover, (10) implies that the alacrity with which farmers respond to changes in agricultural technology will differ across households, even if information is evenly distributed,

according to differences not only in skills but in preferences, prices and endowment resources.

b) Comparative Statics

To solve for the effects of endowment schooling on the level of innovation and for the effects of a change in the flow of innovations on schooling investment, equations (7) through (10) are totally differentiated with respect to the control variables. As in any utility-maximization model, the relationships between changes in control variables and exogenous parameters consists of substitution and income effects. However, in this model the effects of schooling on innovation and the response of schooling investment to changes in the flow of technology can be further subdivided into allocative, signalling and worker effects.

If there are only allocative effects of schooling, the relation between the schooling of adult household member i and innovation, given by (11), is likely to, but

$$(11) \qquad \left(\frac{dv}{dH^i}\right)_a = \left[\frac{\delta v}{\delta \Pi_v^*} - v\frac{\delta v}{\delta F}\right] \int_o^T e^{-rj} dj \; \frac{\delta H_v^*}{\delta_H i} > 0$$

does not necessarily, correspond to that assumed in the literature. The sign of the bracketed expression in (11) depends on the signs of the compensated own substitution term $\delta V/\delta \Pi_v^*$ and the "income" effect, $\delta v/\delta F$. While the own substitution effect is constrained by second order conditions to be negative, the sign of the income term corresponds to the sign of the income effect on E, η_E, since $\delta v/\delta F$ can be rewritten as:

$$(12)\quad \frac{\delta v}{\delta F} = \left| \int_0^T e^{-rj}\, \delta\Pi_v^*/\delta E dj \right| \frac{\delta v}{\delta H_{..}^*}\, \eta_E$$

If it is assumed that E is non-inferior, $\eta_E > o$, then if schooling contributes to allocative efficiency, $\delta\Pi_v^*/\delta E<0$, an increase in full income, by increasing the level of schooling investment, also lowers the cost of v and (11) will be unambiguously positive.[6]

The response of schooling investment to changes in k implied by the model under the assumption that schooling only increases allocative productivity, expression (13),

$$13)\quad \left(\frac{\delta E}{\delta k}\right)_a = -\frac{\delta E}{\delta \Pi_v^*} \left[\int_0^T \Gamma(\quad) K e^{(\mu-r)j} (j\mu_k \mu_v + \mu_{kv}) j dj \right]$$

$$+ \frac{\delta E}{\delta F} \left[\int_0^T \Gamma(\quad) K e^{(\mu-r)j}\ k j dj \right] > o$$

is also unambiguously positive with E assumed to be non-inferior and v and k complements in (2). The compensated cross effect of the shadow price of innovation on schooling investment $\delta E/\delta\Pi_v^*$ in (14), must be

$$(14)\quad \frac{\delta E}{\delta \Pi_v^*} = \frac{s}{\phi} \left| \int_1 e^{-rj} \delta\Pi_v^{*}/\delta E dj \right| = \frac{\delta v}{\delta \Pi_E^*} >$$

negative, since second-order conditions require that ϕ , the determinant of the bordered Hession, be negative, and, if there are diminishing retur to allocative activity, then the total income effect on E, given by (15) is positive, since an increase in E lowers the shadow price of v.

$$(15)\quad \frac{\delta E}{\delta F} = -\left|\int_0 \Gamma\,(\quad)K_e^{(\mu-r)j}\mu_{vv}\,dj\right| \qquad \eta_E > 0$$

Expression (15) also implies that the observed relationship between full income and schooling investment will be greater than the true income effect η_E if schooling contributes to allocative efficiency as a result of the dependency of the shadow price of E on the level of allocative production, v.

With only market wage or signalling effects of schooling operative, however, the relation between H^i and the level of allocat activity or efficiency is negative and the effect of a change in the flow of new technology on E cannot be signed. In this case the effect of a change in endowment schooling on v, given by (16), consists of negative own and cross compensated

$$(16)\quad \left(\frac{\delta v}{\delta H^i}\right)_{W-S}\left[\frac{\delta v}{\delta \Pi_E^*}\frac{\Pi_s}{\Pi_E^*}\int_0^T e^{-rj}t_s^i\,dj + \frac{\delta v}{\delta \Pi_v^*}\int_0^T e^{-rj}t_v^i\,dj + \left(\int_0^T e^{-}\right.\right.$$

$$\left.\left.[T_W^i - St_s^i - vt_v^i]dj\right)\frac{\delta v}{\delta F}\right]\frac{\delta W_i}{\delta H^i} <$$

and $$(17)\quad \frac{\delta v}{\delta \Pi_E^*} = \frac{\Pi_s^{-2}}{\phi}\left[\int_1^T e^{-rj}t_v^c\,\delta W_c/\delta E\,dj\right] = \frac{\delta E}{\delta \Pi_v^*} > 0$$

$$(18)\quad \frac{\delta v}{\delta F} = \left[\int_1^T e^{-re}t_v^c\,\delta W_c/\delta E\,dj\right]\frac{\delta v}{\Pi_v^*}\eta_E - \alpha s\frac{\delta v}{\delta \Pi_E^*}\frac{\delta W_c}{\delta E} < 0$$

where $\alpha_s = \dfrac{\Gamma_c t_s^c}{\Pi_s^*}$

substitution effects as well as a negative income effect: an income-compensated fall in the relative shadow price of schooling, expression (17), induced by the rise in the adult wage-cost component in the shadow price of S, increases the level of E and decreases the demand for v, since the post-school "child" wage cost in the production of innovation rises. Because a rise in schooling investment increases Π_v^*, the income effect on innovation, given by (18), is also negative if E is non-inferior. With the schooling of adults being directly and positively associated with the price of time component in the shadow price of innovation, all terms in the brackets in (16) are negative.

Similarly, when schooling only augments the wages of children due to signalling or worker effects but not allocative skills, an increase in the flow of new techniques, which increases the level of innovation, raises the shadow price of schooling and increases full income. Given non-inferiority, the net effect of k on E, given by (19), is ambiguous. Again, in the signalling case, the observed income effect ((20))

$$(19)\quad \left(\frac{\delta E}{\delta k}\right)_{W-S} = -\frac{\delta E}{\delta \Pi_v^*}\left[\int_0^T \Gamma(\quad) K e^{(\mu-r)j}(j\mu_k\mu_v+\mu_{kv})j\,dj\right]$$

$$+\ \frac{\delta E}{\delta F}\left[\int_0^T \Gamma(\quad) K e^{(\mu-r)j}\ kj\,dj\right] > 0$$

where

$$(20)\quad \frac{\delta E}{\delta F} = -\left[\int \Gamma(\quad)\ K^{(\mu-r)j}\ \mu_{vv}\,dj\right]\ \eta_E - \alpha_s\ \frac{\delta E}{\delta \Pi_E^*}\ \frac{\delta W_c}{\delta E}$$

overstates the true income effect, since a rise in E increases the shadow price of S by raising the value of the post-school child tim cost component.

If schooling only augments agricultural production through worker effects, the relation between innovation and endowment human capital, given by (21), becomes ambiguous but schooling investment

$$(21)\quad \left(\frac{dv}{dH^i}\right) = \frac{\delta v}{\delta \Pi_E^*}\left[\Pi_E^*\,(\alpha_E - \alpha_s)\,\frac{\delta \Gamma_E}{\delta H^i} - \int_o^T K_e^{(\mu-r)j}\,dj\,\frac{\delta \Gamma_E}{\delta H^i}\right]$$

$$\frac{\delta v}{\delta H_v^*}\left[\int_o^T e^{(\mu-r)j}\,K\Gamma_{H^i}\,\mu_v\,dj\right] + \frac{\delta v}{\delta F}\left[\int_o^T Ke^{(\mu-r)j}\,\Gamma_{H^i}\,dj - (st_s^c + Et_E^i)\,\frac{\delta \Gamma_c}{\delta_{H^i}}\right] \gtrless$$

$$(22)\quad \left(\frac{\delta E}{\delta k}\right) = -\frac{\delta E}{\delta \Pi_E^*}\left[\int_1^T e^{(\mu-r)j}\,K\Gamma_E\,\frac{\delta \mu}{\delta k}\right] - \frac{\delta E}{\delta \Pi_v^*}\left[\int_o^T e^{(\mu-r)j}\,K\Gamma_{H^i}\,\mu_v\,dj\right]$$

$$\frac{\delta E}{\delta F}\left[\int_o^T Ke^{(\mu-r)j}\,\Gamma_{H^i}\,dj - (st_s^c + Et_E^i)\,\frac{\delta \Gamma_c}{\delta_{H^i}}\right] \gtrless$$

her

$$(23)\quad \frac{\delta v}{\delta E^*} = \frac{\Pi_s^{*}}{\phi}\left[-\int_1^T Ke^{(\mu-r)j}\,\Gamma_E\,\mu_v\right] = \frac{\delta E}{\delta \Pi^*} < o$$

$$(24)\quad \frac{\delta v}{\delta F} = \left[-\int_1^T Ke^{(\mu-r)j}\,\Gamma_E\,\mu_v\,dj\right]\frac{\delta v}{\delta \Pi^*}\,\eta_E > o$$

investment responds positively to increases in the flow of available novel techniques if E is a 'normal' good (22). The ambiguity in the relationship between H^i and V is due the marginal value product of child time in farm production in period one increasing with increases in H^i so that the shadow price of E and S rise. As the first bracketed term in (21) indicates, if E is more (child) time-intensive than S ($\alpha_E > \alpha_s$), i.e., if opportunity costs dominate direct expenditures relatively more in schoolin than in the production of S, and if the marginal product of E in the post-school periods is insensitive to levels of H^i, then the positive income ($\eta_E > o$) and own substitution terms may be partly or wholly offset by the negative cross substitution term. The positive association of E with k, described in (24), arises because the induced increase in the level of adopted technology raises the future stream of returns from schooling in agricultural production, lowers the shadow price of V, which is complementary with E in this case, and increases income.

The model thus implies that on farms in which some family members participate in the labor market 1) a positive relation between schooling endowment and level of allocative efficiency will only be observed if the allocative or farm worker effects of schooling dominate signalling (or labor-market worker effects) but 2) a negative correlation between educatio and allocative efficiency does not imply that schooling does not augment allocative skills since the existence of signalling or market worker effects may "bias" <u>downward</u> the gross school endowment-efficiency relation if such effects are ignored. The model also implies that 3) while an <u>income compensated</u> increase in the flow of economically-relevant agricultural techniques will raise schooling investment levels only if allocative and/or

farm workers effects dominate signalling effects, the sign of the un-compensated relation between schooling investment and the flow of techn gy may be positive even if schooling serves only as a "signal" to the employ ers of part-time farmers.

Implications can also be drawn from a similar model in which no work is performed off the farm. In that case if there are allocative as well as (farm) worker effects of education, a rise in endowment schooling raises the opportunity value of time in innovating activities, just as would signalling, as well as efficiency in innovation and income; worker and allocative effects are thus offsetting. Moreover, on full-time farms an increase in non-earnings wealth also raises the value of the farmer's time, since the demand for consumption time (leisure) rises, thus raising the shadow price of innovation. Similarly, while the model implies that farm size (A) is associated positively with the returns to the adoption of new production techniques, it is also positively correlated with the valu of the (full-time) farmer's time in agricultural production and thus the time-value component in the shadow price of innovation.[7] Thus in a populatio in which all farmers are full-time even if there are imperfect capital markets such that land size and non-earnings wealth are important determinan of the ability to finance the adoption of agricultural techniques, the relationships between farm size, wealth and allocative efficiency or adoptio cannot be predicted, nor can the direction of the association between schooling and innovation if worker effects are important.

The major implication of these results is that by examining empiri cally both the cet. par. relation between schooling and a measure of allocative

or adoptive efficiency and the partial association between schooling investment and a measure of the (expected) flow of innovations, a test for the existence of productivity-enhancing schooling effects is established which could be applied to data from population in which workers both earn wages (and thus "signal") and make production decisions, such as is characteristic of most farm populations. Thus, if a positive association between schooling and farm efficiency is found, based on data from such populations, the result would imply both that signalling was not the dominant effect of schooling and that an observed income-compensated positive correlation between schooling investment and technical change was due to the perception that schooling augmented agricultural productivity; schooling and ability would thus not be merely proxies for each other. Estimates of either the schooling-efficiency or school investment-technical change relations would not by themselves necessarily indicate a direct productivity role of education, particularly if wage rate data are not available or not used.

Finally, the model implies that innovation is a function of income and prices. In particular, wage rates play a central role in determining the optimal level of innovation for the large proportion of farmers who derive some income off the farm, as they reflect the value of time component in the shadow price of innovation. Given a strong correlation between wage rates and schooling, due, perhaps, to signalling, it would appear that the exclusion of wage rate variables from econometric specifications of the schooling "efficiency" relation would result in specification error, imbounded most seriously in the schooling coefficient. The gross association between wage rates and innovation or efficiency cannot be predicted, however, since a rise in wages would have offsetting income and substitution effects.

2. Empirical Application

a) Determinants of Innovation - HYV Adoption

In this section, the innovation-schooling model is applied to data from the third round of a national sample survey of 5115 rural households in India, collected in three rounds between 1968 and 1971 by the National Council of Applied Economic Research. These data are unique in providing information on a large number of socioeconomic characteristics of rural families, including landless households, as well as production information for farm households. Moreover, households in the survey were exposed differentially to information about new agricultural practices, chiefly related to new grain varieties associated with the "green revolution", due to the implementation beginning in the early 1960's of a geographically selective governmental program, the Intensive Agricultural District Program, (IADP), in which one district from each Indian State was chosen to receive on a continuing basis technical assistance and assured supplies of credit and fertilizer. In terms of the model, households in these program districts thus were subject to a greater flow of informati on new techniques and faced lower prices in terms of the goods inp utilized in innovation.

will be concerned first with the association between schooling and innovation, utilizing information on the adoption of high-yielding grain varieties (HYV) as a proxy for the degree of dynamic innovative efficiency. Specifically, we seek answers to four questions: 1) Are the schooling levels of farm operators and their wives positively associated with adoption, as is implied by the allocative efficiency

hypothesis; controlling for the costs of innovation? 2) With half of the heads of farm households in the sample (and 26 percent of their wives) working off the farm, is the estimated association between schooling and HYV significantly altered when wage rates are included in the adoption function to capture time costs and possible signalling effects? 3) Do the relations between wage rates and adoption suggest that the value of time is an important cost to farmers in allocative activities? 4) Did the IADP program succeed in inducing farmers to adopt new grain varieties? The answer to this latter question is not only of interest to policy-makers but is important because the existence of the program will be used as a basis for testing the hypothesis that schooling investment responds to differential rates of flows in new inputs, in the next section.

Because the measure of adoptive efficiency is dichotomous, taking on the value of one if high-yielding varieties are used and 0 if not, we assume that the probability of using the new grains in the ith farm household P_i is determined according to the logistic function

$$(25) \quad P_i = (1 + e^{-a - \Sigma b_i X_i + \varepsilon_i})$$

where the X_i are independent variables assumed to influence adoption and a and b are the parameters to be estimated. Equation (25) can be transformed into a linear equation in the X_i by solving for the

natural logarithm of the odds ratio.

$$(26) \quad L = \ln(P_i/(1 - P_i)) = a + \Sigma b_i X_i + \varepsilon_i$$

The parameters in (24) can be estimated using maximum likelihood techniques and will have desirable asymptotic properties

The estimating equation determining the level of innovation, as measured by HYV use is thus:

$$(27) \quad L = a+b_1 EDH+b_2 EDW+b_3 LAND+b_4 NEARN+b_5 ELEC+b_6 BANK+b_7 AES$$
$$+b_8 IADP+\Sigma_{i=9}^{11} b_i WAGE_i+\varepsilon$$

where EDH, EDW are the schooling attainment levels of the farm head and spouse;[8] LAND is net cropped area; NEARN is household non-earnings income; ELEC, BANK, AES and IADP are dummy variables which take on the value of one if the village in which the family resides is electrified, contains a bank or credit union, contains an agricultural extension program, or if the family resides in an IADP district, respectively; the WAGEi are the predicted daily wage rates of the head and spouse and the district-level daily child wage rate in agriculture, computed from Agricultural Wages in India, 1971. Th

adult wages were computed from auxiliary regressions in which the daily wages of farm heads (wives) who reported wage earnings were regressed against own schooling attainment, age, age squared, distance from farm to village, the sex-specific district-level agricultural wage rate, village size and dummy variables representing the presence of factories or small scale industry in the village.[9]

On the basis of the analysis of the previous section, schooling levels and HYV adoption should be positively correlated if schooling's contribution to farm productivity through allocative effects dominates worker effects on full-time farms and all the relevant costs of and constraints on innovation are held constant, including wage rates (which capture "signalling" effects). The rationale for the inclusion of the other variables is as follows: The coefficient of BANK, included to capture the effects of imperfections in capital markets in rural India (assumed to be perfect in the model) would be expected to display a positive sign, given that investments in irrigation and fertilizer are necessary for HYV use. It would also be expected that the coefficient of NEARN would be positive, as wealthier farmers would have lower finance costs, although the model also suggests that the value of time in full-time farm households is positively associated with wealth. Similarly, the greater is LAND the lower credit costs, the higher the return to investments in new technology but the higher are time input costs on full-time farms.[10] ELEC is another proxy for the price of the inputs used in innovation; Singh has noted that electricity, available to only a third of the households in the sample, is an important input for

irrigation systems; thus this variable should be positively associated with adoption.

AES and IADP, the two program variables, might be expected to have opposite effects on the adoption of high-yielding varieties. The agricultural extension programs had been in existence in India for several decades prior to the introduction of the high-yielding grains and thus may be associated with more traditional techniques. Farmers in villages with extension programs might have invested heavily in or be more efficient at traditional practices and thus may be less likely to switch to a new technology. The IADP program, however, was designed to increase use of non-traditional methods and had been in existence for at most ten years at the time of the survey and would be expected to significantly raise levels of HYV use.

Because the selection of the IADP districts was not random, however, but was based on an identification of areas already "developed" and to some extent industrialized the coefficient of IADP may not represent the impact of the program. Rather the IADP dummy may merely pick up district-level differences in otherwise unmeasured "modern" characteristics and attitudes. To assess the impact of the IADP program on adoption it is thus necessary to hold constant the level of development at the time of its introduction. To do this, the IADP dummy was regressed against variables representing the characteristics of 68 of the 88 districts represented in the sample obtained from 1961 census sources, including 12 of the 14 IADP districts. These regressions, estimated using linear and logit models are presented in Table 1, where LAND = average landholdings

Table 1

OLS and LOGIT Coefficient Estimates: Identification of IAPD Districts, 1961 District Data

Independent Variable	OLS	LOGIT	
LAND	-.010	-.297	-.112
	(1.97)	(1.97)	(0.99)
DIST	.011	.165	...
	(2.87)	(2.58)	
NLAND	.002	.0596	.0285
	(0.55)	(1.05)	(0.70)
IRR	.002	.0208	.0132
	(0.97)	(0.72)	(0.55)
PROD	-.002	-.0280	-.0176
	(1.50)	(1.69)	(1.41)
FACTRY	.906	8.830	7.046
	(2.95)	(2.52)	(2.56)
SCALE	.060	.682	.361
	(4.43)	(2.95)	(2.69)
LITM	.002	.0508	.0742
	(0.34)	(0.45)	(0.79)
LITF	.015	.208	.0723
	(1.11)	(1.04)	(0.48)
ENRM	.003	.098	.041
	(0.59)	(1.12)	(0.75)
ENRF	-.010	-.197	-.088
	(1.15)	(1.51)	(0.94)
Consta	-1.195	23.51	-8.28
		(2.59)	(1.83)
R^2	.264		
χ^2		32.56	21.49
n	68	68	68

(acres), DIST= the Kusnets ratio of landholding inequality, NLAND proportion of households without land, IRR= percentage of land irrigated, PROD= rupee value of production per acre, FACTRY= number of factories per household, SCALE= proportion of factories employing 10 or more workers, LITM (F)= male (female) literacy rate, rural population aged 15-44, ENRM (F)= male (female) school enrollment rate (5-14). The results suggest that districts with large factories and characterized by greater landholding inequality, but not higher levels of agricultural productivity, were selected for the program. The IADP districts also appear to be characterized by marginally higher levels of irrigation and literacy rates, but by lower average holdings of land. While these results, giving the "real", i.e., not official intended, basis for inclusion in the program, could be interpreted in a number of ways, it is only necessary for the purposes at hand that the set of 1961 variables chosen accurately capture the initial conditions in IADP districts. The residuals computed from the linear estimates, orthogonal to the 1961 district characteristics, may thus better reflect the "value added" of the program.

The sub-sample of households used for the estimation of (26) thus consists of cultivating households residing in the 68 districts for which there is data on the 1961 district characteristics and in which the head was aged 20 to 65, a total of 1082 households. Table 2 reports the maximum likelihood logit coefficients of the adoption regressions. In the first column, wage rate variables

Table 2

Maximum Likelihood LOGIT Coefficient Estimates: Use of High Yielding Varieties, Landed Households

Independent Variables	1	2	3	
EDH	.198 (3.27)[a]	.087 (1.63)	.092 (1.61)	
EDW	.094 (1.20)	.201 (2.05)	.213 (2.17)	
EDH1				1.506 (3.52)
EDH2				.185 (0.56)
EDH3				.671 (2.16)
EDH4				.738 (2.09)
EDW1				-.070 (0.13)
EDW2				.611 (2.86)
EDW3				.139 (0.29)
EDW4				-.018 (0.02)
LAND	.025 (3.99)	.028 (4.26)	.026 (4.04)	.027 (3.80)
WAGEM	...	.097 (5.81)	.097 (5.93)	.080 (4.73)
WAGEF	...	-.187 (4.39)	-.187 (4.50)	-.097 (2.31)
WAGEC	...	.491 (3.40)	.486 (3.41)	.298 (1.93)
NEARN x 10^{-3}	.452 (2.47)	.454 (2.32)	.455 (2.31)	.218 (1.95)
ELEC	1.139 (6.37)	.931 (4.85)	1.010 (5.21)	.840 (3.93)
BANK	1.108 (5.77)	1.038 (5.24)	1.090 (5.45)	1.147 (4.94)
AES	-.318 (1.91)	-.300 (1.76)	-.296 (1.74)	...
IADP	.517 (2.86)	.739 (3.83)	...	...
RES-IA	...	....	1.002 (4.11)	.951 (3.46)
Constant	-3.219 (13.30)	-3.625 (11.82)	-3.547 (11.73)	-3.954 (10.11)
χ^2	155.14	198.77	201.38	178.70
n	1082	1082	1082	836*

[a]Asymptotic t-ratios in parentheses

*Random sample from 1082 households

are omitted and IADP rather than the residual program measure is used, but the other determinants of innovation are included. The schooling coefficients in that specification suggest that only the schooling acquired by the male head contributes to dynamic farm efficiency, as the coefficient of EDH, but not EDW, is statistically significant and positive. Ability to finance investments appears to be a significant constraint on adoption of HYV as BANK, NEARN, and LAND display positive coefficients, although LAND is also positively associated with the returns to adoption. The coefficient of ELEC displays the expected positive sign as does IADP; the presence of extension programs, however, appears to impede HYV use.

The theoretical analysis suggests that equation 1 is misspecified since wage rates are omitted. The results displayed column 2, indicate that while inclusion of the wage rates does not change the magnitudes of most of the adoption coefficients, the coefficients of the schooling variables are altered significantly. Indeed, with wage rates included the hypothesis that the schooling farm wives had no affect on adoption, accepted with wage rates excluded, is now rejected at the 1 percent level while the coeffic: of male schooling becomes barely significant. Moreover, while it is not surprising to find that two of the three wage rates coeffic: display positive signs, given the importance of financing capacity indicated by the BANK and NEARN coefficients, the negative female wage coefficient indicates that for women the substitution effect, the existence of which is predicated on time being an important cos

of innovation, dominates the income (credit) effect. These results thus indicate not only the importance of resource costs and time value in determining the level of adoption but that ignoring the latter cost importantly affects empirical results focussing on the relation between schooling and adoptive efficiency.[11]

In the third specification, the replacement of the IADP dummy variable by the residual measure doe not alter the conclusion that the IADP program did induce greater rates of adoption of HYV. In the final specification, the singulate school level variables are replace by dummy variables representing levels of schooling, where EDH (W)1= completed primary education or below, but some schooling, EDH (W)2= above primary but below matriculation, EDH (W)3= matriculation or its equivalent, EDH (W)4= college graduate or above. These variables are employed to insure that the "schooling" effects obtained do not merely represent returns to literacy and to identify the most important levels of schooling.

The schooling dummy results, estimated on a random sub-sample of households from the 1082 household sample in order to conform to program constraints, indicate that for males all but the schooling levels above primary but below matriculation contribute to innovatic with the initial schooling years providing the greatest effect- the results suggest that the probability that a farm has adopted HYV is 28 percent higher if the farm operator has received some primary education than if he is totally unschooled, controlling for the wage effects of schooling. Moreover, farms with wives who have attained schooling levels beyond primary are 11 percent more likely to have adopted the new grain varieties.[12]

b) Determinants of Schooling Investment

The results described in the previous section suggest that the level of innovation on Indian farms, measured by the adoption of high-yielding varieties, is positively associated with the schooling levels of the farmer and wife, given wage rates and other variables representing costs and constraints on allocative activities. As demonstrated in the theoretical section, this result implies that allocative efficiency but not screening is responsible for the observed relationship between education and innovatio but does not rule out the possibility of schooling attainment being a proxy for endowment entrepreneurial ability. In this section, we test this latter proposition by ascertaining if farm households in areas characterized by more intensive exposure to new farm inputs, i.e., in IADP distric respond by increasing schooling investment, as would be true if the allocative efficiency effect of schooling were recognized. We also exploit another dimension of the data by simultaneously examining school investment behavior in landless households, who would not be expected to derive direct benefits from improved allocative skills in the presence of technical change.

To investigate the determinants of household schooling investment using micro data, it is necessary to construct a measure of schooling investment which simultaneously takes into account differences in the size and age structure of households and the problem that not all children will have completed their schooling at the time of the survey. As one measure, based on child schooling attainment, we first compute the mean schooling levels by single years of age for boys and girls aged 5-14 in the total sample and use this schooling-age gradient to standardize the schooling levels of children within each household. The measure used, which

represents relative schooling intensity, EDI, computed separately for boys and girls, is given by (28):

$$(28) \quad EDI_{kj} = \sum_{i=1}^{n_j} \frac{ED_{ixkj}}{\overline{ED}_{ixk}} \qquad k = m,f, x = 5 \ldots 14$$

where $\overline{ED}_{ixk}$ = the mean population schooling level of children of sex k aged x.

ED_{ixkj} = the actual level of schooling attainment of child i of sex k aged x in household j.

h_j = the total number of children aged 5-14 in household j.

EDI will be less (more) than one if a family schools any child (or all children) below (above) average levels, independent of age, sex-composition and number of children. The measure will be biased (towar one) by the presence of any children who have not completed school but will reflect the higher school investment levels of the household if these children are already at levels higher than the "norm" for their age group.

EDI is first regressed against the same set of variables as use in the HYV functions except that a dummy variable representing the existence of an educational institution in the village, EDINST, is add and farm-related variable are omitted in the landless sample. The subsamples are also composed of households with either male or female children aged 5-14. The list of regressors and their means are giver in Table 3. While we are primarily concerned here with the coefficier of IADP, or the residual variant IADP-RES, as it reflects the effect c the level of exposure to technical change or schooling investment, the model also provides some guidance with respect to the effects of some

Table 3

Variable Means by Presence of Male, Female Children Aged 5-14, in Landed and Landless Households

Variable Name	Landed		Landless	
	Male Children	Female Children	Male Children	Female Children
EDIND	1.19	0.91	1.12	0.94
EDH	2.47	2.39	2.07	2.05
EDW	0.42	0.44	0.56	0.61
LAND	11.31	11.40	-	-
WAGEM	12.91	12.36	17.31	8.13
WAGEF	6.59	6.48	7.90	8.23
WAGEC	1.23	1.25	1.18	1.18
NEARN	95.65	87.58	55.15	9.71
ELEC	0.32	0.32	-	-
BANK	0.64	0.66	0.62	0.65
FACTR	0.09	0.07	0.13	0.14
EDINS	0.93	0.92	0.92	0.91
AES	0.51	0.51	-	-
IADP	0.25	0.24	0.22	0.25
RES-I	0.04	0.04	0.01	0.02
n	615	596	264	242

of the other independent variables. In particular, it suggests that if children contribute to farm production or work off the farm, variables such as land size and the child wage rate may be negatively associated with EDI. The analysis also suggests that the income effect on child schooling, from (15), measured by the coefficient of NEARN, will be biased upward in farm households if schooling contributes to allocative efficiency on the farm.

Table 4 reports the schooling equation coefficients for male and female children in the farm households. In the first-column specifications the IADP variable, which was found to be positively associated with HYV adoption, has the expected positive sign here and is significant at the one percent level. As discussed in the previous section, however, IADP, being a regional dummy variable, may reflect other characteristics of the district which may be correlated with unmeasured determin nts of household schooling investment, such as attitudes towards schooling. To check the robustness of this result, we add the district-level sex-specific school enrollment rates in 1961--ENRM61, ENRF61. These variables should reflect the schooling "environment" in existence in the district prior to the introduction of the IADP program and thus should "net out" those characteristics from the IADP coefficient. The "effects" of the "own" sex-specific enrollment rates are indeed significantly and positively correlated with the household-level schooling measure, but the IADP coefficient remains virtually unchanged in the presence of these variables. In the third specification, IADP is replaced by IADP-RES, which nets out all the 1961 district characteristics listed as regressors in Table 1; this measure also displays a positive and

Table 4

Instrumental Variables Regression Coefficients: Male and Female Schooling Attainment Indices, Children Aged 5-14, Landed Households

Independent Variables	Male Children			Female Children		
EDH	.279 (8.72)[a]	.273 (8.53)	.283 (8.91)	.213 (7.25)	.207 (7.14)	.223 (7.62)
EDW	.203 (4.44)	.210 (4.50)	.208 (4.58)	.193 (5.07)	.159 (4.10)	.201 (5.24)
LAND	-.0054 (1.77)	-.0052 (1.55)	-.0061 (1.98)	-.0034 (1.13)	-.0005 (0.17)	-.0045 (1.47)
WAGEM[b]	-.0060 (1.11)	-.0041 (0.69)	-.0052 (0.95)	.0070 (1.34)	-.0029 (0.51)	.0086 (1.62)
WAGEF[b]	-.0024 (0.21)	-.0035 (0.30)	-.0042 (0.36)	-.018 (1.71)	-.016 (1.52)	-.022 (2.11)
WAGEC	-.012 (0.23)	-.038 (0.69)	-.016 (0.30)	.0081 (0.17)	-.083 (1.63)	-.0076 (0.16)
NEARN x 10	.107 (1.78)	.091 (1.52)	.103 (1.72)	.060 (1.00)	.085 (1.41)	.049 (0.82)
BANK	.091 (1.21)	.082 (1.07)	.091 (1.21)	.101 (1.40)	.076 (1.06)	.102 (1.41)
EDINST	.230 (1.55)	.171 (1.13)	.250 (1.69)	.154 (1.18)	.194 (1.45)	.196 (1.49)
FACTRY	.056 (0.44)	.072 (0.56)	.052 (0.40)	.262 (1.98)	.177 (1.34)	.274 (2.06)
AES	.087 (1.13)	.060 (0.77)	.091 (1.19)	.044 (0.61)	.076 (1.02)	.057 (0.77)
IADP	.223 (2.47)	.226 (2.48)	...	.485 (5.58)	.451 (5.21)	...
RES-IADP	...	...	.269 (2.47)	...	...	.509 (6.88)
ENRM61	...	.009 (1.84)	...	...	-.0081 (1.80)	...
ENRF61	...	-.007 (1.72)	...	...	.013 (3.27)	...
Constant	.199	-.104	.226	.013	.125	.065
$\bar{R}^2$	.258	.260	.258	.311	.327	.303
SEE	.876	.875	.876	.808	.799	.812
F	18.80	16.40	18.80	21.66	20.28	20.92
n	615	615	615	596	596	596

[a] t-values in parentheses

[b] Instrumental variable. See text.

significant coefficient.

Of the other variables, the negative coefficients of LAND and WAGEC suggest that the value of child time is an important cost of schooling. Moreover, the greater absolute magnitude of these coefficients in the male schooling equations is suggestive of a greater reliance o the part of farm families on the farm work of male children than of female children. Given the relative importance of males in farm production, the significantly greater NEARN coefficient in the male schooling equation is consistent with the schooling-innovation efficiency relationship being greater for male children, resulting in a larger upward bias in the "income" coefficient, since it is unlikely that the true income effect on female schooling is less than that on male education

In Table 5, the landless equations indicate that exposure to technical change, controlling for the wage (income) effects of such change, does not evoke any significant schooling investment response from landless families, as would be the case if hired workers were no expected to participate in decisions relating to allocation or innovation. While the IADP variable in positive and statistically significant in the landless males equation (specification 1), when the pre-program district characteristics are purged from the reginal dummy, the "effect" of the program vanishes (columns 2 and 3), unlike in the farm households sample.

The positive schooling investment response on the part of farm families and the lack of such observed behavior in the non-farm rural population is supportive of the view that the increased benefits of schooling to decision-makers associated with more rapid exposure to

Table 5

Instrumental Variables Regression Coefficients
Male and Female Schooling Attainment Indices,
Children Aged 5-14, Landless Households

Independent Variables	Male Children			Female Children		
EDH	.318 (8.16)[a]	.303 (7.77)	.333 (8.54)	.357 (6.55)	.355 (6.47)	.360 (6.55)
EDW	.051 (1.30)	.063 (1.29)	.058 (1.16)	.095 (1.35)	.093 (1.32)	.095 (1.36)
WAGEM[b]	-.0027 (0.43)	-.012 (1.72)	-.0025 (0.39)	-.0030 (0.33)	.0003 (0.04)	-.0029 (0.32)
WAGEF[b]	.0128 (0.92)	.0093 (0.67)	.0104 (0.74)	.046 (2.43)	.046 (2.42)	.045 (2.40)
WAGEC	-.111 (1.56)	-.035 (0.48)	-.134 (1.89)	-.163 (1.62)	-.181 (1.72)	-.173 (1.75)
NEARN x 10^{-3}	.056 (0.31)	.122 (0.68)	.032 (0.18)	.114 (0.38)	.131 (0.44)	.135 (0.47)
BANK	.017 (0.17)	.106 (1.04)	.0021 (0.02)	-.223 (1.53)	-.202 (1.34)	-.218 (1.50)
EDINST	.057 (0.31)	.297 (1.42)	.088 (0.47)	.203 (0.84)	.281 (0.99)	.191 (0.80)
FACTRY	-.145 (1.00)	-.046 (0.31)	-.122 (0.81)	.0009 (0.004)	-.0082 (0.04)	.013 (0.06)
IADP	.267 (2.13)	.077 (0.56)	...	.090 (0.53)	.149 (0.76)	...
RES-IADP[b]	...	...	.133 (0.82)	...	...	.043 (0.19)
ENRM61	...	.013 (1.60)	...	...	-.0009 (0.08)	...
ENRF61	...	-.0018 (0.29)	...	...	-.0014 (0.15)	...
Constant	.428	-.518	.454	.331	.488	.346
$\bar{R}^2$	.379	.403	.370	.384	.379	.383
SEE	.747	.733	.753	1.030	1.033	1.030
F	17.08	15.79	16.45	15.99	13.27	15.96
n	264	264	264	242	242	242

[a]t-values in parenthesi

[b]Instrumental variable. See tex

new agricultural technologies, indicated in the previous section, are perceived by farm households. However, two alternative interpretations remain. First, the IADP coefficient may wholly reflect an income effect as farms in IADP districts benefit from the more efficient technology and lower input-prices, which if schooling is a non-inferior commodity would result in a greater levels of schooling, as indicated in the theoretical section, without schooling necessarily augmenting allocative efficiency. Second, the technologies associated with the "green revolut may have resulted in a substitution away from labor inputs leading to higher rates of schooling as a possible means by which children can improve their chances of leaving the agricultural sector (through screening).[13] With respect to the latter hypothesis, regressions with agricultural wages as the dependent variable run on a set of personal and village-level characteristics as well as the IADP-RES variable indicate that wage rates were 17 percent higher for male agricultural workers and 9 percent higher for females in IADP districts.[14] The gree revolution technology thus appears to be labor-using.

To test the importance of the income effect associated with technical change or schooling investment in farm households, the schooling equations were rerun using two-stage least squares, treating gross household income net of non-earnings income as an endogenous variable. These results are reported in Table 6. In these equations the IADP-RES variable coefficient retains its positive sign and level of significan Moreover, while farm gross income has a negative effect on schooling, reflecting the time value substitution effect, the non-earnings income coefficient reflecting both the pure income and schooling-efficiency effects, is positive, in accord with the presumptions of the model.

Table 6

Two Stage Least Squares Regression Coefficients: Male and Female Schooling Attainment Indices, Children Aged 5-14

Landed Households

Independent Variables	Male Children		Female Children	
EDH	.288	.294	.248	.231
	(9.01)[a]	(8.91)	(8.44)	(7.53)
EDW	.201	.235	.189	.210
	(5.29)	(5.27)	(5.76)	(5.53)
GINCx10^{-4}[b]	-.267	-.252	-.213	-.203
	(2.60)	(2.12)	(1.54)	(1.46)
NEARNx10^{-3}	.115	.119	.070	.056
	(1.91)	(1.98)	(1.17)	(0.80)
BANK	.110	.102	.114	.100
	(1.49)	(1.38)	(1.59)	(1.39)
EDINST	.227	.247	.179	.193
	(1.57)	(1.70)	(1.37)	(1.47)
FACTRY	.084	.087	.266	.269
	(0.67)	(0.69)	(2.02)	(2.19)
AES	.057	.079	.052	.065
	(0.76)	(1.04)	(0.73)	(0.89)
RES-IAI	.326	.270	.527	.522
	(3.20)	(2.51)	(5.34)	(5.02)
WAGEM		-.002		.010
		(0.36)		(1.99)
WAGEF		-.009		-.023
		(0.76)		(2.17)
WAGEC		-.017		-.006
		(0.35)		(0.12)
Constan	.177	.222	.020	.067
SEE	.873	.873	.814	.812

[a] t-value in parentheses

[b] Endogenous variable

Conclusions

By the formulation of a model of the farm household in which the levels of farm efficiency or innovation and schooling investment are behavioral variables, a two-dimensional test for the existence of allocative efficiency effects of schooling in agricultural populations is established in which signalling can be distinguished from productivity augmenting effects of schooling. Empirical results based on an econometric analysis of high-yielding variety seed adoption and schooling investment in rural Indian households derived from the theoretical framework are supportive of the hypotheses that schooling contributes to innovative efficiency and that farm household school investment, consequently, responds positively to increases in the flow of new agricultural inputs. Moreover, the results indicate that variables which condition the behavior of the farm operator(s) must be incorporated into analyses of production relations in agriculture to obtain unbiased estimates of the parameters characterizing those relations and thus call into question prior estimates of schooling-efficiency effects which ignore such variables.

The results obtained also suggest that agricultural development programs, such as the Indian IADP, can succeed, where implemented, in accelerating the modernization of agricultural, raising farm earnings as well as agricultural wage rates, and indicate a complementarity between agricultural investment and schooling as inputs in the development process. However, the differential in the school investment response

to flows of new techniques between farm households and rural non-farm families due to the allocative returns from schooling investment only accruing to decision-makers means that earnings inequality between landed and landless families may grow each generation if agricultural technical change persists, unless the returns to schooling also rise in the non-farm sector.

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Footnotes

1. See Spence, Riley and Lazear.

2. Schultz summarizes this literature. Notable examples are Fane and Huffman, who utilize aggregate U.S. farm data.

3. Two aspects of innovation time are search, where the individual obtains information on the prices and production characteristics of new inputs, and experimentation, including the monitoring of input performance

4. Approximately half of U.S. farm operators reported off-farm earnings in 1964 according to the 1964 Census of Agriculture. About the same proportion of Indian farmers were employed off their farms in 1970-71. See section 2, below.

5. We abstract from the interrelationships between the quantity and quality of children and, perhaps more importantly, from uncertainty and risk.

6. The reason that the innovation-income effect exists only if η_E is non-zero is that perfect capital markets are assumed. The effects of capital market imperfections are discussed in section 2.

7. Fane and Huffman both explicitly consider only the correlation between the returns to allocative efficiency and farm scale, ignoring the value of time effect. Neither find a significant positive association between size and efficiency; indeed, Fane's measures of farm scale and cost efficiency are significantly negatively correlated. The model formulated here presents a consistent explanation for these results

8. These variables take on the value of 1 if the individual receive primary schooling or below only, but some education, 2 if the schooling level was above primary but below matriculation, 3 if the individual had a matriculation diploma, and 4 if the individual at minimum attended college. Converting these measures to year equivalents did not alter the qualitative results. The use of a dummy variable specification is reported below.

9. The imputed wage rates will only be rough approximations to the price of time of farm family members who do not work off the farm. Indeed, the theoretical analysis suggests that the effects of almost al the variables on HYV will differ according to the off-farm participatio status of the farmer(s). We are only concerned here, however, with the average relationship between farm characteristics, schooling and innova tion in a heterogeneous population composed of both participants and non-participants and how these relationships are altered by considera-tion of variables associated with the costs of innovative and schooling activities.

10. The ambiguity characterizing the relationship between farm siz and innovation is reflected in the empirical literature on agricultural innovation. For example Singh finds a positive association between far acreage and an index of modernization, based on farm-level data from the Jaunpur district in India, while Mangahas, as reported in Nerlove and Press, finds a significant negative effect of farm size on HYV adop-tion in the Philippines. Neither study employs wage rate data; both ignore the schooling of the farm wife.

11. The wage rate results are insensitive to the functional form chosen for the instrumental wage equation--the use of a log-linear specification, however, resulted in marginally higher standard errors.

12. The effect of a unit change in any independent variable X_i on the probability of HYV adoption can be approximated from the LOGIT para-meter estimates by the formula $\frac{\delta P_i}{\delta X_i} = b_i\ (\bar{P}_i)\ (1-\bar{P}_i)$ where $\bar{P}_i$ is the sample mean proportion of HYV users (25).

13. The "biased"nature of technical change in U.S. agriculture subverts the interpretation of a positive farm population school enroll-ment-technical change relationship, reported in Rosenzweig, as reflectin allocative effects of schooling.

14. These equations are:

$$\ln W_M = .822 + \underset{(.016)}{.093EDH} - \underset{(.016)}{.0008AGE} + \underset{(.006)}{.040POPVIL} + \underset{(.069)}{.225FACTRY}$$

$$+ \underset{(.055)}{.117WEATHER} + \underset{(.072)}{.172\ IADP\text{-}RES} \qquad \bar{R}^2 = .255 \qquad S.E.E = .410$$

$$\ln W_F = .191 + \underset{(.034)}{.058EDW} + \underset{(.016)}{.011AGE} + \underset{(.007)}{.057POPVIL} + \underset{(.079)}{.266\ FACTRY}$$

$$+ \underset{(.063)}{.031WEATHER} + \underset{(.061)}{.092IADP\text{-}RES} \qquad \bar{R}^2 = .232 \qquad S.E.E = .372$$

where AGE = age, in years, POPVIL = total population of village,
WEATHER = crops not adversely (1) or adversely (0) affected