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The Consequences of the Agricultural Productivity Growth for Rural Landless Households: Findings from Research Based on the Indian Green Revolution Experience

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There has been much debate over the extent to which economic growth reduces poverty and augments human development among the poor. This paper describes ongoing research using survey data on the Green Revolution experience in India that focuses on this issue. The research is based on a general-equilibrium model of labour markets for adults and children that differentiates households by whether they own land and incorporates a public sector that chooses the amount of school building. The empirical results suggest, consistent with the model, that expectations of improvements in agricultural productivity increase the schooling of children in landed households and reduce schooling in landless households, in part because of the operation of the child labour market, as landless child labour is used to replace landed child labour lost due to increased child school attendance in landed households. The results also show, however, that school construction in India was undertaken at higher levels in areas in which there were expectations of greater future productivity increases, and that the closer proximity of schools differentially benefited landless households. Thus school building policy in India tended to offset the adverse distributional consequences of agricultural technological change in the early stages of the Green Revolution. The allocation of schools, however, did not fully offset the incentives for landless households to reduce schooling investments. The perverse correlation between human development and income growth observed among the poor landless households in India at the initial stages of the Green Revolution, thus, was not due to lack of responsiveness of public resources but to the lack of a return to schooling in the non-farm sector.

In this paper I report on the research carried out by Andrew Foster and myself that has been examining the effects of the Indian Green Revolution, which substantially increased agricultural productivity in many areas of India, on income growth and schooling investment in *landless* rural households. The aim of this research is to shed light on the debate over whether promoting economic growth alone is sufficient for human development among households with initially low-levels of economic resources. Rural landless households are among the poorest of the poor, and how they have fared

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during a time when there was sustained economic growth in the agricultural sector may inform us about the relationship between income growth and human capital investment among the poor in general. The lessons we learn, moreover, may have relevance to Pakistan, which itself has benefited from the green revolution, has many poor rural landless households and many rural people with low levels of human capital.

The are two key features of our analysis of the experience of rural landless households. First, we employ a general-equilibrium approach in which there are both landed and landless households and these households interact. It is our view that it is not possible to understand what happens to landless households without also considering what happens to the landed. This is principally because households with land are the main employers of the individuals residing in rural landless households. Second, we focus on the role of the public sector in providing important resources for human development and recognise that the public sector responds, as well as households, to changes in opportunities and resource constraints. The endogenous presence of local public goods is another reason why we use a general-equilibrium framework. The presence and level of local public goods, such as schools and health centres that affect the well-being and human capital investments of the landless, depend in part on the preferences of landed households. Specifically, in our modelling landed and landless households interact via two labour markets—a market for child labour and a market for adult labour—and in local public schools. Access to schools is determined endogenously in the model by a centralised government authority determining where schools are built.

The model also incorporates the findings from Foster and Rosenzweig (1996) showing that rates of return to schooling among farmers in green-revolution India were highest in those regions experiencing substantial agricultural productivity growth. These findings are consistent with the view of T. W. Schultz and others that returns to schooling rise when there is new, useful (profitable) information to decode and exploit. A corollary of this is that for workers engaged exclusively in menial tasks—tasks like harvesting, weeding and sowing which are the principal agricultural activities of landless workers—increased schooling attainment has little effect on productivity, consistent with the empirical findings in Foster and Rosenzweig (1994) and Rosenzweig (1995). These results together imply that incentives to invest in schooling differ importantly by land ownership within the agricultural sector when there is an underdeveloped non-agricultural rural sector.

The general-equilibrium model is used to inform an empirical analysis that is based on unique panel data describing a representative sample of all rural Indian households over the first 15 years of the green revolution. Our empirical analysis exploits both the fact that we have baseline data at the onset of the green revolution and the enormous variability in productivity growth across India after the onset of the revolution due to differences in soil and water conditions.[1] Our preliminary estimates

[1]For example, crop productivity (measured by a Laspyeres-weighted index of output per acre of corn, rice, sorghum, and wheat) rose more than threefold in Karnataka state from 1961 through 1982, while in Kerala, crop productivity for these "Green Revolution" crops rose by just 10 percent over the same period.

based on these data show that agricultural productivity growth where it took place significantly increased agricultural wage rates, thus benefiting landless households, but also, in concert with changing expectations about future productivity advancements in agriculture, raised the price of land, benefiting landed households. Consistent with previous work we also find that higher expected future technology and increases in the number of schools raised schooling in landed households. However, while increased school availability also increased schooling in landless households we found that, consistent with the operation of a child labour market, high rates of expected technology, given school availability, substantially decreased schooling investment in landless households below what it otherwise would have been. Thus, we have a case in which income growth among the poor and the well-off is associated with both attenuated human development among the lowest-resource households and increased inequality in human development. We also find, however, that schools were allocated to areas in which agricultural technical change is expected by the local farmers to advance most rapidly, the more so the greater the proportion of households in an area that are farming households. This school building effect attenuated, but did not eliminate, the negative direct effect of advancing agricultural productivity on landless schooling operating through the child labour market. These results thus suggest that school building policy can substantially affect the distributional impacts of economic change. But uneven sectoral productivity growth—lack of opportunities in the non-agricultural sector in India—appears to be the real culprit behind the perverse relationship between human development and income growth among low-resource rural households—the rural landless.

1. MODEL

The Basic Set-up

In this section I outline the model we use that has guided our empirical work and which clarifies the complexities of the relationship between growth propelled by agricultural technical change and human capital investment among the rural landless. As noted, we need to model both landless households and landed households and the markets they operate in. We need also to have at least two periods in the model to reflect the fact that households are making investments—they allocate resources that only have future payoffs. Moreover, the payoffs are uncertain. Thus, we use a two-period general-equilibrium model in which the level of agricultural technology in the second period, which affects the returns to schooling in the rural sector, is stochastic. The two household types—landless households and landed households—have identical preferences and in the first period also are endowed with the same amount of adult labour and child labour. There is an adult labour market in which labour earns a return in the form of a wage. Landless adults are hired by landed households, which may also employ landed adults. Children participate, when not in school, in a child-intensive activity (e.g., herding) carried out in landed households. A competitively-determined wage is paid to hired children. Schooling is valued by parents in both landed and landless households for its own sake.[2] A key distinction in the model concerns the returns to schooling investment. In particular, it is assumed the schooling of hired adult workers does not augment their productivity while the schooling of landowners, who make input decisions, contributes to productivity in direct relation to the level of agricultural productivity. These assumptions capture the basic notion that schooling returns exist only where there are complex tasks to master [Rosenzweig (1995)].

All households in the first period earn income, choose how much time to allocate their children to school, and consume. Income in landed households is obtained from the wage labour of both children and adults, the profits from agricultural production using adult labour, and the child-intensive activity. Income in landless households arises solely from the wage labour of both adults and children. The agricultural production function is assumed to have two inputs - land and adult manual labour—and to be multiplicative in the technology level and family human capital so that higher technology increases the returns to family human capital in landed households. Hired and family adult farm manual labour are assumed to be perfect substitutes.

In the first period a social planner also allocates funds to villages to build schools. Schools are public goods that must accommodate all village children, and all school costs are due to travel time and opportunity costs. Thus, the building of a school in a village lowers the cost of schooling identically for all households, regardless of their landholding status. In the second period the first-period children are adults, the new technology is realised and the households again earn income and consume, with landed households hiring labour and producing and landless households selling labour.

Partial-equilibrium Schooling Decisions in Landless and Landed Households

The partial-equilibrium decision rules for landless households in the model are quite simple, in part because we shut down the capital market to reflect the difficulties of borrowing in poor, rural setting. This makes the model both simple and more realistic. Thus, school enrolment decisions for landless households depend only on the child wage, the adult wage in the first period and on the stock (proximity) of local schools. There are no effects of variation in expected second-period wages or technology on the human capital investment made by landless because there is no capital market and no second period labour-market return to human capital investment for the landless.

The model yields straightforward predictions for landless schooling decisions: First, the (partial-equilibrium) effect of building schools would increase landless schooling investment if wage rates were unaffected by school building. Second,

[2] Alternatively, we could allow child schooling to earn a return outside of agriculture that is the same for both landless and landed households. Doing so would not change the main points of the analysis.

whether an increase in the child wage increases or decreases child human capital in landless households depends on whether the higher opportunity cost of child time is offset by the higher earnings per child. If income effects are weak, increases in the demand for child labour, brought about, say, by increased seed productivity, reduces child schooling for landless households.

The comparative statics from the partial-equilibrium problem for landed households are also straightforward. In particular, we show that the effect of an increase in child wages on landed household human capital investment, given expected second-period technology, wages, schools, and second-period labour usage, is unambiguously negative, reflecting the negative effect of a higher opportunity cost of child time and the fact that increases in child wages reduce the income of landed households, who are net hirers of child labour. In contrast, increases in expected second period adult wages given technology, schooling, and second-period labour usage unambiguously increase human capital investment in landed households because landed households, who are also net hirers of adult labour, expect to suffer a loss in the second period if second-period wages rise. This induces them to shift resources from the first to the second period. Given the absence of credit markets such a transfer of resources can only be accomplished by increasing human capital investment. Finally, the wage-constant effect of an increase in expected second-period technology on human capital investments in landed households has two components: an increase in expected future technology raises the return to schooling investment, which induces more schooling, but also increases second-period income, which induces households to want to increase their consumption in the first-period by cutting back on schooling.

General-equilibrium Effects

Because changes in agricultural technology have no direct effect on the returns to hired-worker schooling investments, whether and how a change in expected technology affects landless schooling decisions depends on how such changes affect (i) the demand for child labour, and thus child wages, and (ii) the stock of schools, which will in turn depend on the decisions of the landed households that employ labour and decisions by the school authority. To assess the spillover effects of agricultural technical change on landless-household schooling investment thus requires assessing general-equilibrium effects, in particular the operation of child and adult labour markets. In order to determine the general-equilibrium effects of increasing the number of schools and the level of agricultural technology on schooling investment, by land status, it is necessary to solve for equilibrium wages, the wage levels that equate the supply of and demand for adult and child labour. To simplify, we have fixed adult labour supply in the model; it is given by the number of adults. The supply of child labour, however, depends on the optimal schooling decisions in both the landed and landless households, because more time spent by children in school means a reduction in child labour supply. Moreover, changes in the allocation of children's time in school in landed households affect the demand for hired landless children as substitute child workers and thus the opportunity cost of schooling for the landless.

We first solve the general-equilibrium model taking as given the supply of schools, combining the human capital demand functions for the two types of households, the equilibrium conditions for the three wages, and expressions for labour supply. This yields human capital demand functions that condition only on aggregate village-level conditions, inclusive of the number of local schools. There are two key implications from the general-equilibrium analysis. First, the general-equilibrium effect of an increase in expected agricultural technology on the schooling investments in landed households is more positive than the partial-equilibrium effect because the general-equilibrium effect contains both the direct partial-equilibrium technology effect and the second-period wage effect, which is positive. The intuition is that if technology is expected to improve, second-period wages will also be expected to increase (given the fixity of labour supply), which will further induce landed households to transfer resources to the second period.

The second major implication of the model is that the general-equilibrium effect of a change in expected agricultural technology on the schooling decisions of the landless is not zero, as suggested by the partial-equilibrium analysis. Indeed, the effect is opposite in sign to the general-equilibrium effect in landed households—if landed households increase schooling investments in response to anticipated increases in technology then landless households will be decreasing their schooling investment. The reason is that if higher future technology induces greater human capital investment on the part of landed households this raises the equilibrium child wage which increases the opportunity cost of schooling in landless households and thus lowers their human capital investments.

In general, because of the operation of the child and adult labour markets all of the characteristics of landed households, inclusive of the level of agricultural technology, affect the schooling decisions in landless households. For example, in the partial-equilibrium model of the landless households, the schooling of parents has no effect on either income or preferences and therefore increases in parental schooling in landless households have no effect on landless schooling investment. However, taking into account the operation of the labour market, the schooling of parents in landed households affects the schooling of landless children because the schooling of landed-household parents in the first period affects the demand for both adult and child labourers. In particular, under reasonable assumptions, the general-equilibrium model suggests that although increases in parental schooling in landed households will be unambiguously associated with increased schooling investment in landed households, the increase will be less in landless households and landless-household schooling investment may even decrease. The intuition is that an increase in the schooling of adults in landed households increases landed-household income which leads to more time being allocated to schooling among landed children. The latter effect raises the demand for substitute child labour and thus increases the child wage, which increases the opportunity cost of schooling for landless children. Offsetting this is the fact that if landed farmers are more schooled, manual labour is also more productive so that the demand for adult hired labour also increases, leading to higher incomes in landless households. It is thus an empirical question whether on net the effect of the schooling of landed-household adults affects landless schooling investment negatively or positively.

Endogenous Public School Allocations and Schooling Investment

With endogenous school allocations, the effects of expected advances in agricultural technology that lead to economic growth on the schooling of landless-household children will also depend on how changes in expectations about future technology affect the allocation of schools. Increased schooling availability can offset the reduction in landless-household schooling investment that is induced by an increase in the demand for child labour when future agricultural technology is expected to improve. The model indicates that the general-equilibrium effect of an exogenous increase in the stock of schools on school investment in landless households is positive, but it is less than the partial-equilibrium effect because withdrawals of landed households from the labour market to attend school increase the child wage and thus raise the opportunity cost of schooling for landless children.

Whether an increase in anticipated future agricultural technology in a locality does in fact increase school allocations to that locality is not obvious. This will depend in part on the objective function of the planner. We have explored a number of alternatives, including planner objective functions incorporating income, income inequality, and the level and inequality in schooling. It is difficult to obtain clear predictions; however, in all cases the fractions of village populations that are landless matter for the placement of schools. Because technology only has a direct impact on the income and returns to schooling for landed households, the magnitude of the response of schools to anticipated technology advances is decreasing to zero in the share of landless households. This is most clear in the case where the planner is maximising the sum of second-period village incomes. In that case, schools will be allocated to where technology is expected to be the most advanced, because schooling has the highest return in those localities, but the positive expected technology effect in a village will be smaller the higher the proportion of landless households located there. This is because advancing agricultural technology always benefits the income of the landed more than the landless.

2. DATA

Our theoretical analysis suggests that a great deal of information is needed to carry out a useful empirical analysis identifying how agricultural technical change affects the incomes and the schooling decisions of rural landless households. In particular, our model suggests that we need information on wage rates, on agricultural income, on assets, on schooling levels for adults and enrolment rates for children distinguished by the landholding class of households, and on school construction for at least two time periods.

We were able to carry out the analysis because of the availability of information from a unique data set constructed from data files produced by the Indian National Council of Applied Economic Research (NCAER) from six rural Indian surveys carried out in the crop years 1968-69, 1969-70,1970-71, 1981-82, and 1999-2000. The first set of three survey rounds from the Additional Rural Incomes Survey (ARIS) provides information on over 4500 households located in 261 villages in 100 districts in India. These sample households are meant to be representative of all households residing in rural areas of India in the initial year of the survey excluding households residing in Andaman and Nicobar and Lakshadwip Islands. The most detailed information from the initial set of three surveys is available for the 1970-71 crop year and covers 4,27 households in 259 villages. The 1981-82 survey, the Rural Economic and Demographic Survey (REDS), was of a subset of the households in the 1970-71 ARIS survey plus a randomly-chosen set of households in the same set of villages, excluding the state of Assam, providing information on 4,596 households in 250 villages. 248 of these are the same villages as in the ARIS. Finally, in1999 a village-level survey (REDS99) was carried out in the same set of original ARIS villages, this time excluding villages in the states of Jammu and Kashmir. Among other data, the survey obtained information on the schools in each of the villages, including information on when they were constructed.

The existence of comparable household surveys at two points in time separated by 11 years enables the construction of a panel data set at the lowest administrative level, the village, for 245 villages that can be used to assess the effects of the changing economic circumstances on incomes and household and school allocations. There are three other key features of the data: First, the first survey took place in the initial years of the Indian green revolution, when rates of agricultural productivity growth began to increase substantially in many areas of India. Second, two-thirds of the households surveyed in 1981-82 were the same as those in 1970-71. This merged household panel, the original 1968-71 panel and information on profits, inputs and capital stocks were used by Behrman *et al*. (1999) based on methodology developed in Foster and Rosenzweig (1996) to estimate rates of technical change for each of the villages between the two survey dates and between 1968 and 1971. Third, in each survey there is information provided at the individual household or village level on daily agricultural wage rates, the prices of irrigated and unirrigated land, as well as information on crop prices, crop- and seed-specific output and planted area by land type that permit the construction of yield rates for high-yielding variety crops on the two types of land.

We aggregated the household survey data to the village level by landownership status to form two panel data sets in order to estimate the determinants of changes in school enrolment rates in landed and landless households. In particular, we chose households with children aged 10 through 14 years of age and constructed the proportions of children in that age group who were attending school in each village separately for households owning land and for landless households in the two survey years using sample weights. We also constructed weighted, village-level aggregates of the schooling and wealth of the parents of the children in this age group for each of the two land groups at each survey date. Slightly over 30 percent of children 10-14 resided in landless households in 1971. 37 percent of the children in this age group in the landless households were attending school, compared with 41 percent in landless households in that year.

The data indicate that in both 1971 and 1982 a significant proportion of the primary school-age children who were not attending school participated in the labour market. In landless households 34.9 percent of the non-attendee children aged 10-14 worked for wages. Although only 8.3 percent of the non-attending 10-14 year-olds in landed households worked for wages off the farm, an additional 28 percent of these landed children worked as “family” workers. In 1982, 30.3 percent of landless children aged 10-14 who were not attending school worked as wage workers, compared with 22.4 percent in landed households. In the latter, however, 38.6 percent of the children not in school worked as family labourers.

A challenge in assessing empirically the determinants of schooling is that school decisions are based on expectations about the future, and future technology in particular. The data set we used, and indeed, most data sets, however, do not provide direct information on expectations or measures of technical change. We thus reformulated the model in terms of observable that reflect these expectations. In particular, we exploited the idea that land prices capitalise the expected discounted stream of future returns on land. Thus, land prices reflect both current and expected future technology. With production technology characterised as Cobb-Douglas, we show it is possible to identify future technology effects using information only on current land prices and land yields. Given current land yields, higher current land prices are positively correlated with expectations of future productivity advances. Conversely, given current land prices, areas with higher yields are characterised by lower expectations of future productivity increases.

We computed from the data village-specific yield rates for the high-yielding seed varieties of the four major green revolution crops—wheat, rice, corn and sorghum—on irrigated land for 1971 and 1982. We aggregated the total output in each of the years for these crop/seeds using 1971 prices and sample weights and divided by the weighted sum of the irrigated area devoted to these crops for each village and survey year. The 1982 survey data provides information at the village level on the prices of irrigated and unirrigated land. The 1971 survey provides information on the value and quantity of owned land, by irrigation status, for each household. We constructed the village median price of irrigated land for 1971 from the weighted household-level data, and deflated the 1982 village-level irrigated land prices to 1971 equivalents using the rural consumer price index. The measures of the village-specific rates of technical change over the period 1971-82 and the land price and yield data were appended to the two village-specific data sets describing schooling investments in landless and landed households.

The 1999 REDS school building histories provide the dates of establishment for all schools located within10 kilometres of the villages classified by whether they were public, private, aided, or parochial and by schooling level—primary, middle, secondary, and upper secondary. It is thus possible to examine the determinants of school building over the 1971-82 survey span as well as for the decade subsequent to the 1981-82 survey round, relating comparable intervals of school investment to initial village conditions. In Foster and Rosenzweig (2001a) we carried out investigations of the accuracy of recall data pertaining to village infrastructure based on comparisons of the overlapping years for the histories of electrification that were obtained in the 1970-71 and 1981-82 surveys. The results, to the extent that they carry over to the similarly-obtained school histories, suggest that the school building histories accurately reflect the true changes in school availability over the survey period.[3]

For the analyses of school placement, we looked at the determinants of changes in the spatial allocation of secondary, inclusive of upper secondary, schools. We look at secondary schools because even in the 1960s primary schools were nearly universal in India—by 1971 primary schools were located within 90 percent of the sample villages. The relevant margin is at the secondary school level. In 1971, only 41 percent of villages were proximate to a secondary school. However there was considerable school building—by 1981 secondary school village coverage had reached 57 percent and coverage increased to 73 percent by 1991. As documented in detail in Foster and Rosenzweig (2001), the school establishment histories also indicate that there were large inter-state disparities in the presence of rural secondary schools 1971, but show as well that there have been substantial variations in state-wide school investments since then.

Table 1 provides the means and standard deviations for daily agricultural male wages, irrigated land prices, and the constructed village-level variables for the 1970-71 and 1981-82 survey rounds, where all money values are in 1971 rupees. The data indicate that over the 11-year period output per acre of HYV crops approximately doubled. During this time agricultural wage rates rose by slightly over 20 percent in real terms. Landless households engaged in the agricultural sector thus clearly benefited from the green revolution. The growth in wages is more impressive considering that over the same period the number of adults in the villages more than doubled. Higher wage rates benefit the landless relative to the larger landed households who are net importers of labour. However, owners of land also

[3]There is one caveat: if there are schools that have been destroyed over the period, these would not be reflected in a school-building history based on schools in existence in the villages in 1999.

benefited—the price of land more than doubled over the period, presumably reflecting population pressures, productivity growth and expectations of future productivity growth. Indeed, the greater increase in the real price of irrigated land compared to productivity growth, given the rise in labour costs, suggests that expectations of future growth rose more than did real output.

Table 1

Means and Standard Deviations of Key Variables, by Survey Year

Variable	1971	1982
Daily Male Agricultural Wage Rates, 1971 Rupees	2.63	3.16
	(1.01)	(1.46)
Price of Irrigated Land, 1971 Rupees	4405	10848
	(3581)	(9713)
Per-acre Yield Index Using 1971 Prices, HYV Crops	289.3	586.0
	(257.0)	(348.5)
Primary School Enrolment Rate, Children 10–14—Landed	.408	.503
	(.302)	(.359)
Primary School Enrolment Rate, Children 10–14—Landless	.367	.401
	(.373)	(.385)
Number of Secondary Schools Built in Subsequent 11 Years	.157	.170
	(.371)	(.382)
Number of Secondary Schools	.410	.568
	(.630)	(.703)
Wealth Per Farm Household, 1971 Rupees	13647	12091
	(12947)	(10060)
Proportion of Landed Households with a Primary-Schooled Male	.449	.421
	(.326)	(.365)
Proportion of Landless Households with a Primary-Schooled Male	.171	.269
	(.321)	(.383)
Total Number of Adults in Village	835	1831
	(1092)	(1209)
Total Number of Child Workers in Village, Ages 10–14	18.3	62.7
	(47.8)	(119)
Proportion Children 10–14 who are Boys—Landed Households	.541	.533
	(.231)	(.285)
Proportion Children 10-14 who are Boys—Landless Households	.575	.506
	(.316)	(.378)

To properly assess the net gains to farm households, comparable information on farm profits is required for both survey rounds. Unfortunately, because in the 1970-71 survey round information on family labour allocated to farm production was not coded, it is not possible to construct the relevant measure of profits in that crop year, which requires netting out the value of family labour. Nor can wealth per household be used to assess the gains for landed households, as household wealth is affected by the size of household landholdings, which decrease over time as households divide [Foster and Rosenzweig (2001)].

The data show that inequality in schooling investment by land class did evidently increase in the initial stages of the green revolution. As noted, in 1971 the average primary school enrolment rate among children in landed households was about 11 percent higher than that in landless households. In the subsequent 11 years, enrolment rates for both sets of households increased, but at a faster rate in landed households, so that by 1982 the disparity in enrolment rates between landed and landless households had increased to over 25 percent. Over the same period the number of secondary schools built between 1971 and 1982 represented a 38 percent increase in the stock of secondary schools, with school building continuing in the next 11 years at similar rate.

3. OUTPUT GROWTH, POPULATION GROWTH AND WAGE CHANGES

We first investigated how changes in output brought about by agricultural technical change, the increase in the number of potential adult workers and changes in work participation by children affect agricultural wages. In particular, we estimated the following wage equation:

$$ln\,wage_{jt} = \gamma_F F_{jt} + \gamma_T T_{jt} + \gamma_l l_{jt} + v_j + e_{jt}, \quad \ldots \quad \ldots \quad \ldots \qquad (1)$$

where $ln\,wage_{jt}$ is the log of the male agricultural wage at time t in village j, F_{jt} = the log of total output at time t in village j, T_{jt} = the log of the total number of adults at time t in village j, l_{jt} = the log of the total number of child labourers aged 10-14 in village j at time t, v_j = village-specific time-invariant unobservable, and e_{jt} is a village-specific time-varying wage shock.[4] Estimation of (1) by OLS would produce biased estimates of the parameters. First, there may be semi-permanent characteristics of areas, captured by v_j, that make wages higher or lower, such as trade unions or monopsony. Because higher wages would lower output, there would be a negative correlation between the error term and output, which would impart a negative bias to γ_F. Or, areas may differ substantially in soil productivity, which will affect labour and land productivity and thus wages and output jointly. Thus would induce a positive spurious association between wages and output. To correct for this we estimate (1) in differenced form:

[4]The γ coefficients in (1) for F and T would be equal to one if the technology were strictly Cobb-Douglas.

$$\Delta ln\, wage_{jt} = \gamma_F \Delta F_{jt} + \gamma_T \Delta T_{jt} + \gamma_l \Delta l_{jt} + \Delta e_{jt}, \qquad \ldots \qquad \ldots \qquad (2)$$

where the Δ is a difference operator denoting that the variable is the change between 1971 and 1982. The differenced transitory wage shocks that remain in (2) would still induce bias in γ_F. For example, good weather in a given year in a particular village may jointly boost wage and output. Another source of bias is that children's labour supply may respond to variation in adult wages, as in the model via income effects. To eliminate these sources of bias, we used instrumental variables. We instrumented the change in log output and the change in the labour-force participation of children using the estimated village-level technical change measure for the interval 1971-82. In addition to this variable, we made use of the fact that the Indian government introduced at the initial stages of the green revolution two programmes—the Intensive Agricultural District Programme (IADP) and the Intensive Agricultural Advancement District Programme (IAADP)—in selected districts, roughly one in each state. The programmes were designed to provide more assured supplies of credit and fertiliser. As part of the ARIS sampling design, moreover, households residing in these programme districts were oversampled (as reflected in the sample weights), so that roughly a third of the households (villages) are represented in each programme area. We also use as instruments the initial, 1971, total gross cropped area in the village, average wealth and the proportion of households with a primary schooled male. These variables should also have influenced output growth over the period. We added to the list of instruments the 1971 number of secondary schools in the village and the change in the ratio of boys to girls in the households between 1971 and 1982. These variable should have influenced the change in schools and labour-force participation rates by children.

Table 2 reports in the first and second columns the first-stage estimates of the change in the log of total village-level agricultural output and the total number of child workers, respectively. These estimates suggest that, as expected, areas experiencing higher rates of technical change and with the IADP experienced greater output growth, for given initial conditions. Child labour-force participation, however, evidently declined in such areas, perhaps reflecting increased child schooling, as we investigate below. In the third column the two-stage least squares (TSLS) estimates of the difference log wage Equation (2) are reported. The predicted change in the log of farm output has a statistically significant positive effect on wages. The point estimate of γ_F suggests that an exogenous doubling of farm output would raise adult male wage rates by 18 percent Augmenting agricultural productivity thus does benefit landless workers. The estimates also suggest, however, that a doubling of the adult population would lower wages by 14 percent. Finally, in the fourth column we added the number of child workers. The estimates suggest that there is some substitutability between child and adult workers, but the effect is small—a 10 percent in crease in child participation rates would only depress adult wages by just over a half a percent, although the estimated effect is not measured precisely.

Table 2

Farm Output Growth, Population Growth, and Wages

Dependent Variable	ΔLog Total Farm Output	ΔLog Total Child Workers	ΔLog Daily Male Agricultural Wage	
Est. Procedure	OLS	OLS	TSLS	TSLS
ΔLog Total Farm Output[a]	–	–	.178 (4.83)[b]	.198 (4.82)
ΔLog Total Child Workers[a]	–	–	–	– .0581 (1.53)
ΔLog Total Adults	–	–	–.142 (2.44)	–.127 (2.03)
Estimated Technical Change	.0431 (1.95)	–.0481 (1.31)		
IAADP	.569 (2.48)	–.712 (1.80)		
Proportion of Farm Households with Primary School Person	.489 (1.49)	1.51 (2.90)		
Log Wealth in 1971	–.491 (3.34)	–.324 (1.34)		
Log gca in 1971	–.124 (0.97)	.635 (2.92)		
Number of Secondary Schools in 1971	–.0243 (0.14)	.269 (0.91)		
ΔRatio Boys/Girls	.112 (0.41)	.772 (1.65)		

[a]Endogenous variable.
[b]Absolute value of *t*-statistic in parentheses.

4. SCHOOL ENROLMENT, LAND PRICES AND EXPECTED FUTURE YIELDS

The results in Table 2 indicate that productivity increases in agricultural production brought about by improvements in seeds and perhaps increased inputs were in part captured by landless households in the form of wage increases. To assess how the green revolution affected human capital investments in landless households requires, as noted, that we assess how changing expectations about future growth in landed households, as reflected in changing land prices net of current yields, influenced their schooling investment decisions.

In this section I report the estimates we obtained of linear approximations to the general-equilibrium relationships determining the school enrolment rates of 10–14 year-olds in landless and landed households. In particular, the equations we estimated are of the form

$$h_{kjt} = \alpha_k^{\,1}\, y_{jt} + \alpha_k^{\,2}\, p_{Ajt} + \alpha_k^{\,3}\, A_{jt} + \alpha_k^{\,4}\, h_{hjt} + \alpha_k^{\,5}\, Ssubjt + \alpha_k^{\,6}\, \lambda_{jt} + \mu_j + \varepsilon_{kjt}\,, \quad (3)$$

where the subscripts j and t again denote village location and time, respectively; the subscript k denotes whether the household is landed or landless; y_{jt} is the crop yield index in village j at time t; p_{jt} is the village- and time-specific land price; A_{jt} is the total value of productive assets in landed households; h_{jt} is a dummy variable taking the value of one if any adult in the household completed primary school (parent's schooling); S_{jt} is a dummy variable taking on the value of one if there is a secondary school in the village at time t; λ_{jt} is the fraction of rural households in village j at time t that are landless; μ_i captures unobserved time-invariant characteristics of villages, including second moments of the technology distribution and preferences for schooling; and ε_{jt} denotes an i.i.d. mean-zero taste shock.

Because parental human capital reflects investments made in the village in previous periods, OLS estimation of (3) given the unobservability of the fixed preference factors embedded in μ will in general yield biased estimates of the coefficients. Moreover, cross-sectional variation in land prices may reflect variations in such permanent qualities as location, inclusive of proximity to cities or even attractiveness, rather than just expectations of future changes in agricultural technology and current crop yields. To address these problems one can estimate (3) in cross-time differences:

$$\Delta h_{kjt} = \alpha_k^{\,1}\, \Delta y_{jt} + \alpha_k^{\,2}\, \Delta p_{Ajt} + \alpha_k^{\,3}\, \Delta A_{jt} + \alpha_k^{\,4}\, \Delta h_{hjt} + \alpha_k^{\,5}\, \Delta S_{jt} + \Delta \varepsilon_{kjt} \quad \ldots \quad (4)$$

so that the fixed unobservables are swept out.

There are two additional problems, however. First, because an exogenous (say, taste- or income-driven) shock to the demand for schooling in period t will, given the model, result in, among other things a higher level of parental schooling and possibly a higher level of wealth A in period t+1, there will be a correlation between the differenced regressors in (4) and the differenced residual. To eliminate this correlation, we employed instrumental variables, using the initial values of the variables in (3), including the survey information on pre-1971inherited assets and the period-t adult schooling, which will be uncorrelated with the differenced residuals given the assumption of i.i.d. taste shocks, as instruments.[5] A second estimation problem is that land prices are likely to measure expectations of future profitability with error and the yield variables too may be error-ridden. We thus also used instrumental-variables estimation to deal with these problems, adding to the list of instruments the technical change and pre-1971 programme variables used to estimate the yield forecast equation.

[5]We used the information on inherited assets rather than the 1971 wealth level as an instrument because it is likely that wealth, as in most surveys, is measured with error. We assumed that the correlation between the measurement error in the inherited wealth variable and the measurement error in the 1971-82 wealth change variable is substantially less than that between the error in the initial wealth level and the change in wealth.

The first column of Table 3 reports the fixed-effects instrumental-variables (FE-IV) estimates of the determinants of school enrolment in the landed households that we obtained. The estimates indicate that, for given current yields, in villages in which land prices are higher, school enrolment rates in landed households are also higher, consistent with the hypothesis that expectations of future higher levels of technology raise the returns to landed schooling investments. In addition, adding a secondary school increases school enrolment for 10–14 year-olds in the landed households, for given expectations and yield levels. The point estimates indicate that increasing expectations of future productivity such that land prices doubled would raise the school enrolment rates in landed households by 14 percent What does this say about the amount of technical change? We showed that if the technology is Cobb-Douglas these estimates would imply given a discount rate of 3 percent a rate of growth in agricultural technology over the next 11 years of 7.4 percent per year. Adding a school raises enrolment by 68 percent, although that estimate is not very precise. Finally, increases in the total wealth of the landed households appears on net to depress landed child school enrolment, consistent with most wealth being land wealth and with the opportunity cost effect of schooling outweighing the second-period schooling gains.

Table 3

FE-IV Estimates: Determinants of School Enrolment Among 10-14 Year-Olds, by Land Ownership

	Landed	Landless	
Log of Land Price	.143	–.342	–.330
	(2.52)[a]	(2.40)	(2.26)
Log of Yield	.0441	–.168	–.168
	(1.02)	(2.66)	(2.64)
Number of Secondary Schools	.278	.455	.472
	(1.46)	(2.03)	(2.05)
Total Wealth	–.104	–	–
	(1.75)	.0324	.0301
		(0.57)	(0.52)
Proportion of Landed Households with a Primary-Schooled Male	.0918	–.184	–.170
	(0.93)	(1.42)	(1.27)
Proportion of Landless Households with a Primary-Schooled Male	–	–	–
			.0766
			(0.43)
Proportion of 10-14 Year Olds Male	.0732	.348	.343
	(0.95)	(3.62)	(3.50)
N	382	222	222

[a]Absolute value of asymptotic *t*-ratio in parentheses.

The estimates of the determinants of schooling enrolment for landless households, based on the same specification, are given in the second column. As expected given the operation of a child labour market and the effects of anticipated technical change on landed schooling seen in column one, increases in expected future productivity reduce schooling enrolment in the landless households, and the effect is strong—the same doubling of land prices induced by an expected rise in agricultural productivity reduces landless schooling enrolment by over 90 percent For given expectations about future productivity, increases in current yields also lower landless schooling. These effects, however, are more than offset by building a school, which evidently would more than double landless enrolment in the same technology regime.

Finally, given yields and land prices, an increase in the schooling of farmers appears to also reduce the schooling investment made by landless households. This effect also operates through the child labour market, but requires care in interpretation given the inclusion of the yield and land price variables in the specification—among farm households with the same yields, assets and land prices, those with more productive (schooled) farmers must have poorer land quality and thus must expect higher future levels of technology growth. If so, we should expect to observe more schooling investment in the farm households and less in the landless households, which is what the columns one and two estimates indicate, although the effects are imprecise. In contrast, the schooling of the landless household adults should have no effect, given our assumption of the absence of schooling returns for the landless, on landless schooling investment. This is confirmed in the column-three specification, in which the schooling of the landless adults is included in the landless enrolment equation—the coefficient for landless adult schooling is less than half of that of the schooling of the landed-household adults, is small in magnitude and not statistically significantly different from zero by any conventional standard.

5. THE DETERMINANTS OF SCHOOL BUILDING

The estimates in Table 3 suggest that the gap between landless and landed schooling widens with increased agricultural technical change and that there is an absolute decline in landless schooling investment where the landed are increasing their schooling in response to technological advances, in the absence of offsetting forces. One offsetting factor is school building. The net effect of technical change on schooling investment in landless households depends therefore on how changes in expected technology impact on school construction. The first column of Table 4 reports estimates of the determinants of school building. Basically, the equation estimated is the same as (4), except that the (level) dependent variable is the number of schools built in the subsequent 11-year interval. The estimates were obtained using the same estimation procedure as was used to estimate the enrolment equations. These estimates indicate

Table 4

FE-IV Estimates: Determinants of School Building

	(1)	(2)	(3)
Log of Land Price[a]	.163	.439	.387
	(2.37)[b]	(2.53)	(2.56)
Log of Land Price X Proportion of Households Landless[a]	–	–.388	–.320
		(1.92)	(1.70)
Log of Yield[a]	.00790	–.227	–.196
	(0.17)	(1.59)	(1.45)
Log of Yield X Proportion of Households Landless[a]	–	.527	.439
		(2.00)	(1.70)
Number of Secondary Schools[a]	–.779	–.665	–571
	(3.12)	(2.03)	(1.75)
Total Wealth[a]	– .00357	–.141	–.102
	(0.07)	(1.10)	(0.96)
Proportion of Landed Households with a Primary-Schooled Male[a]	–.439	–.571	–.503
	(4.07)	(2.99)	(2.75)
Proportion of Landless Households with a Primary-Schooled Male[a]	–	–	–.407
			(1.59)
N	410	410	410

[a]Instrumented variable. See text.
[b]Absolute value of asymptotic *t*-ratio in parentheses.

that schools were built where agricultural productivity was evidently expected to increase in the future. On average, the parameter estimates suggest that a doubling of land prices, for given current productivity, results in .16 schools being built in the subsequent 11 years, which represents more than a doubling in the average rate at which schools were actually built between 1971 and 1982.

The responsiveness of school building in a village to changes in expectations about future farm productivity appears to be significantly related to the proportion of landless in the village, as seen in the estimates reported in the second column of Table 4 in which the log of the land price is interacted with the proportion of landless households. In particular, as is consistent with school allocation rules that maximise total incomes, more schools are evidently built in response to an increase in anticipated productivity in villages with few landless households compared with villages with many households who have no land. The point estimates suggest that if almost all of the households in a village are landless, school building is almost totally unresponsive to agricultural change. In contrast, if almost all households are farm households, an increase in expected local increases in future agricultural productivity that results in a doubling of land prices would increase the number of schools built over the next 11 years by almost one-half of a school on average, which is 2.5 times the average rate.

The estimate in column three suggest that for the average village in which 30 percent of the households dot not own land, the number of schools built in response to a doubling of land prices associated with increased expectations of improved agricultural technology is .32. The estimates from column three of Table 3 suggest that this increase in school availability would raise landless schooling enrolments by almost 41 percent (.15/.367). This would cut the direct negative effect of the rising land price on landless school enrolment by almost half. Put another way, ignoring the endogenous response of school building to spatial differences in expectations about future agricultural technical change would lead to a substantial overestimate of the negative impact of agricultural technical change on the disparities between landless and landed schooling investment.

6. CONCLUSION

While there has been much debate over to what extent economic growth reduces poverty and augments human development among the poor, few micro-level empirical studies have explored the underlying mechanisms by which economic growth affects the distribution of human resource investments across households differentiated by income or wealth levels. This fact is likely due not only to the limited availability of longitudinal data that permits the examination of these relationships at units of analysis below that of the country or state, but also to the methodological difficulties that arise in attempts to account for general-equilibrium effects that are likely to importantly influence the distributional and human development effects of growth.

In this paper I have described ongoing research with Andrew Foster using data on the green revolution experience in India that provides one example of how human development among the poorest households and its distribution can be worsened in an environment in which there is significant poverty reduction. The research also demonstrates the necessity of looking at the markets linking households defined by land status, the allocation of public goods, and the utility of the general-equilibrium approach. Indeed, the partial equilibrium-responses of schooling investment in landless and landless households to prospects of agricultural technical change are straight-forward. Because there is no market return to schooling for landless households, expected improvements in agricultural technology only increase schooling in landed households, thus increasing school inequality. From a general-equilibrium perspective, however, two additional factors come into play: the market for child labour and school construction. The operation of the market for child labour worsens the distributional impact of agricultural productivity on school investment across landless and landed households, as landless child labour is used to replace landed child labour lost due to increased child school attendance in landed households.

Our results also show, however, that school construction in India was undertaken at higher levels in areas in which there were expectations of greater future productivity increases and that the closer proximity of schools differentially benefited landless households. Thus school building policy in India tended to offset the adverse distributional consequences of agricultural technological change in the early stages of the green revolution. The allocation of schools, however, did not fully offset the incentives for landless households to reduce schooling investments. The perverse correlation between human development and income growth observed among the poor landless households in India at the initial stages of the green revolution thus was not due to lack of responsiveness of public resources but to the lack of a return to schooling in the non-farm sector. One lesson is that unless the green revolution is also accompanied by nonfarm productivity change and growth it is unlikely that human development among the rural landless will increase at the same pace as among the landed in the foreseeable future.

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Comments

1.

The paper presented by Rosenzweig is rich in content. This, and the short time available to the reviewer, makes the prospect of commenting on it somewhat daunting. In addition, some typographical errors and misnumbered equations in the paper add to the reviewer's difficulties. Having said all this, the paper appears to be very good. It is professional in its presentation, careful in model formulation, specification and estimation, and restrained in the interpretation of its results.

Even so, there are a few questions that remain unanswered. The most important is whether the conclusions drawn reflect the properties of the model or the data? The model specification seems to preclude a number of conclusions. One of these specifications, for example, is that returns to schooling are mainly for the landed and not for the landless. Yet the paper suggests that this conclusion emerges from the data. There is a need for a more careful separation of assumptions and results.

Another problem relates to model specification and estimation. The author assumes that ordinary least squares estimates are biased in most cases. Therefore, they adopt a variety of *ad hoc* procedures, such as first differencing, two-stage least squares, instrumental variables, etc. As is well known, recourse to these procedures is not without problems. If the existence of biases is known, then there should be a way to accommodate them in the stochastic specification of the equation, which may provide a simpler choice of estimation procedures.

There also seems to be a problem with the discussion leading up to Equation 7. In the demand for human capital equation the stock of schools appears as an explanatory variable. If this is the reduced form of three or four equations, then the equation seems plausible. Otherwise, if it reflects the assumption that the demand for schooling depends on the supply of schooling, then this may lead to an identification problem. Along with this, the paper reports results on a large number of variables such as output, workers, wages, crop yields (1982), enrolment rate, and school buildings, etc. Such a large number of explanatory variables seem extraneous for the purposes of the paper, and it may be possible to formulate a more parsimonious specification that is sufficient for the tasks of the model.

Although such minor problems exist, the paper contributes significantly to the field of policy planning. An important policy question that the paper raises is whether it is sufficient to raise the incomes of the poor so that they can finance their expenditure on education and health, or whether this should be supplemented by targeted interventions designed to raise enrolment rates, say, by making primary schooling compulsory. The first option may be a plausible policy stance to take within liberal economic theory but the data set shows that a rise in income can be accompanied by a fall in enrolment rates. This is a fairly significant finding as it raises questions about the effect of the manner of growth on incentive structures. This is because the growth path can alter the incentives to invest in education by the poor. However, it is unclear whether this finding is a feature of the data or the model. This should be clarified in the revised version.

Finally, the findings of the paper raise interesting questions on whether raising human development (as specified in the paper) may lead to a decline in the incomes of the poor, and if there is in fact a trade-off between incomes and school enrolment of the poor. On this, the paper's results on income equality may provide additional insight. It may be possible that when the income of the poor rises, income inequality also diminishes. If this is true, then from a policy perspective there is a trade-off between making the poor richer or making them more educated. *Some guidelines as to how these differences should be resolved in practice should be helpful in policy-making*.

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2.

It is an interesting but difficult paper. Based on a panel data set relating to the peak period of Green Revolution in India, 1968–82, the author has examined the complex relationship between economic growth and human development as manifested through various levels of schooling across different groups of rural households. The author attempt to understand and highlight how and to what extent economic growth affects resources and incentives for households in human development.

Constructing a general equilibrium model, incorporating landless as well as landed households, the author analyses the effects of Green Revolution on the income growth and investment in schooling in India through the use of surveys data on rural households during the first 15 years of the Green Revolution. The author reports that rates of return to schooling among Indian farmers in the wake of green revolution were highest in the regions experiencing substantial agri. productivity growth. Nevertheless, increased schooling has had no bearing on the productivity of those exclusively engaged in menial activity. The author argue that returns to education primarily stem from increased skills in decoding information and decision-making under changing circumstances. To understand how advances in agri. productivity impact on the rural landless it is necessary to understand the behaviour of both landed and landless households, who interact in labour markets and in the political spheres, the author argue.

Based in the results of their analysis the author conclude that incentives to invest in schooling differ by land ownership. The important questions in this context however, arise: are the landowners a homogenous group within and across villages? What is the impact of varying land ownership levels on patterns of schooling? Neither landless nor landed households in Indian setting are a homogenous lot. Among the landed households there are vast variations in the size of land ownership as well as in tenurial arrangements having direct impact on income and consumption patterns as well as households' investment in schooling. A number of rural households who are not owners of land but operate farms owned by others have also benefited from the green revolution technology. I am sure the author is aware of these differences but should have thrown some light on these dimensions. Similarly, the landless households are not a uniform lot in the Indian rural landscape, dotted by considerable differences of caste, race, culture etc. Had the analysis addressed the impact of such variables on the investments in child schooling and human capital we should have been that much wiser.

As the children in landed and landless households may compete in labour market, changes in time that children from landed households allocate to schooling may have implications on the demand for labour supplied by the children from landless households. Increased return to schooling among farm households may result in greater school construction affecting schooling investment in landless households.

The analysis show: Increased agri. productivity/resulted in higher wage rates thus benefiting landless households. As a sequel to higher productivity, prices of land also rose. Increase in the number of schools raised schooling in landed households while increased availability of schools increased schooling in landless households. However schooling investment in landless households decreased. Thus income growth among the poor and the well off is associated with both decreased human development among the lowest resource households and increased inequality in human development. Higher allocation of schools to areas with rapid agri. technical change as concluded by the author, however, may not lend itself to simple analysis. There are a number of other factors such as the social and political considerations and the kind of leadership of the region which impact on such decisions. Allocation of schools to areas in which agri. technical change expected to advance more rapidly may be an important observation. But more so the greater the proportion of households in the area that are farming households may be an important observation. But what about the distribution of land among these households?—The building of schools may be promoted in the areas having more even distribution of land. Areas dominated by feudal landlords having skewed distribution of land may in fact lag behind in terms of school buildings as the feudal lords may be less interested in promoting schooling in their area as it may adversely affect the supply of labour to their farms.

Negative direct effect of advancing agri. productivity on schooling of landless, operating through the child labour market needs further probing. It assumes/implies that all landless seek employment on farm as wage labourers. Nevertheless a large number of rural landless households i.e. artisans and craftsmen may not be seeking wage labour employment on farms and schooling may be helpful in increasing their productivity as well.

Green Revolution by raising labour wages and the opportunity cost of child labour in the process reduced incentives for child schooling in the landless households. Should it imply that lower wage rates in the rural areas, other things being equal, should promote child schooling. I do not think so. Lower wages would also imply lower household income and higher poverty which can hardly be thought of promoting child schooling.

Increase in domestic production of food grains spared resources for school building at the national level having positive impact. Real prices of cereals in the aftermath of rapid spread of green revolution technology have declined in many countries. Thus, increasing availability of food grains at lower prices resulting from Green Revolution must have had positive impact on human capital. However, these aspects have not been addressed in the paper. These are positive spillovers of the green revolution technology and need to be incorporated in the analysis. As a result of the widespread use of green revolution technology India has been transformed from a food deficit to a surplus country holding large stocks of food grains.

Essence of this paper is to understand the process of development and social and economic consequences of technical change. Without introducing technical change it may be well nigh impossible to raise agricultural productivity and without raising farm productivity increase in farm production is not sustainable. Arable land and water resources in developing countries are facing intense competition from non farm uses and at the same time demand for commodities on account of burgeoning population and rising incomes is on the rise. In the short run there is not much scope for augmenting land resources predicted on the development of water resources. In the long run also development of water resource, if technically and politically possible, requires substantial investments. Thus, it is imperative to develop and promote the use of improved technology encompassing technical change, which also requires continuous investments in research and development as well as in human capital to raise farm productivity.

Economic development certainly entails social as well as economic costs but it does enhance the opportunities for choice. In our quest for raising productivity in agriculture, the dominant sector of low income countries, we are bound to come up with certain side effects/social consequences and problems. These problems and social consequences can be successfully decoded through investment in human resources and research and development efforts in return. Without raising farm productivity in developing countries, for which there is vast scope, problems of poverty alleviation and food security cannot be addressed.

Schooling related spillovers between landed and landless households affects the distributional impacts of economic change and social policy. Uneven productivity growth across sectors is the root cause of perverse relationship between human development and income growth among low resource households.

Since these data sets were collected, 20–30 years ago, both the rural and urban sectors have experienced profound social and economic changes. Accordingly there is a need for revisiting the rural scene to update the data set to analyse the current trends in agricultural development as well as human resource.

Before closing I would like to thank the Pakistan Society of Development Economists for their kind invitation to discuss an interesting paper, for which the author deserve our compliments.

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