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**Farm productivity and efficiency in rural Bangladesh:
The role of education revisited***

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*We have benefited from discussions with Stefan Dercon, Francis Teal and Sharada Weir.
However, usual disclaimers apply.

Abstract

This paper reassesses the debate over the role of education in farm production in Bangladesh using a large dataset on rice producing households from 141 villages. Average and stochastic production frontier functions are estimated to ascertain the effect of education on productivity and efficiency. A full set of proxies for farm education stock variables are incorporated to investigate the ‘internal’ as well as ‘external’ returns to education. The external effect is investigated in the context of rural neighbourhoods. Our analysis reveals that in addition to raising rice productivity and boosting potential output, household education significantly reduces production inefficiencies. However, we are unable to find any evidence of externality benefit of schooling – neighbour’s education does not matter in farm production. We discuss the implication of these findings for rural education programs in Bangladesh.

Key words: Agriculture, returns to education, stochastic production frontier, Bangladesh.

JEL classifications: I21, Q12, N5.

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1. Introduction

Acknowledging the importance of education in labour market success of individuals, governments all around the world routinely advocate further investment in education. However, a majority of the population in developing countries depends on agriculture for their livelihoods. Knowledge of market returns to education is less useful as a guide to increase educational investment in such agrarian societies. In theory, education is expected to improve productivity in all spheres of activities including agriculture. A positive return to education arises, for example, because educated farmers are better managers, adopt more modern farm inputs and prefer risky (high-return) production technologies. Despite such common beliefs regarding the benefits of schooling in farm activities, there is weak empirical evidence to advocate educational investment in agrarian societies.

The existing studies on the determinants of farm productivity and efficiency are largely inconclusive on the question of a positive return to education. For instance, Ali and Flinn (1989), Wang et al. (1996), and Seyoum et al. (1998) demonstrate significant role of farmers' education in raising farming efficiency in Pakistan Punjab, India, China, and Ethiopia, respectively. On the other hand, Battese and Coelli (1995) and Llewelyn and Williams (1996) fail to identify any significant impact of farmers' education on farming efficiency in India, and Java-Indonesia, respectively. Hasnah et al. (2004) rather report a significantly negative impact of education on technical efficiency in West Sumatra-Indonesia. Nevertheless, there is some agreement in the literature that education significantly influences adoption of technological innovations in agriculture (for example, Hossain et al. 1990, Weir and Knight 2004, Asfaw and Admassie 2004).

One reason for the differences in findings across studies lies in the cross-country variation in the nature of technology underlying agricultural production. An education effect is more likely to prevail in economies where farm production is modernizing as opposed to being traditional (Lockheed, Jamison and Lau 1980). Partly for this reason, studies using data from Asian countries tend to find a positive return to education in farm work while such effect is often lacking for Latin America and Africa (Philips 1994). Similar to other countries in Asia, Bangladesh agriculture has undergone significant modernization so that a positive return is also more likely for the Bangladeshi data.

Surprisingly, the majority of studies on returns to education in farm production in Bangladesh fails to find any significant impact. Given the modernisation of farm production following the ‘green revolution’, the current controversy surrounding the returns to education in Bangladesh is puzzling. For instance, Deb (1995), Wadud and White (2000), Coelli et al. (2002) and Rahman (2004) did not find any significant effect of education on production efficiency. The authors attributed this finding to the fact that education system in Bangladesh was not agriculturally orientated. The only study that reports a positive education effect on farm efficiency is Sharif and Dar (1996). However, findings of this study are difficult to generalise. The authors use a highly purposive sample which comprises of only 100 households selected from one Bangladeshi village.

A potential explanation for the failure of earlier research on farm production function using Bangladeshi data to detect an ‘education effect’ lies in the methodology. Most of the earlier literature employed empirical models that were underspecified in two ways. Almost all the studies focusing on internal returns to education preclude the possibility of centralized decision making in farm work (Yang 1998). Consequently, farm education stock is modelled either as education of the household-head or that of an average householder. Given that much of the farm work in agrarian societies is household (instead of individual) specific, such

proxies may contain little information and therefore, undermine the actual returns to education. Earlier research on Bangladesh by Deb (1995), Wadud and White (2000), and Rahman (2004) used farmer education as the sole measure of farm human capital. Second, the existing studies on farm production in Bangladesh and other developing countries exclusively centre on internal returns to schooling, ruling out presence of any externality effect of education in improving productivity and efficiency. Three exceptions are Appleton and Balihuta (1996), Knight et al. (2003) and Weir and Knight (Forthcoming).

Educational externalities arise as uneducated farmers learn from superior production choices of other educated farmers in the neighbourhood. A similar externality arises when educated farmers are early innovators and are copied by those with less schooling (Knight et al. 2003). Apart from such social learning, an externality effect could capture the possibility that uneducated farmers simply access basic literacy and numeracy skills of their educated neighbours. Partly motivated by such arguments, Appleton and Balihuta (1996) examine the effect of mean education of other farmers in the same enumeration area on agricultural productivity in Uganda. They conclude that externality benefit of education is sizable: mean primary schooling of neighbouring farmers enhances own farm's productivity. Weir and Knight (Forthcoming), on the other hand, explores the external effect on productivity and efficiency using Ethiopian data. Their analysis reveals significant externality benefit of education on productivity but no such benefit is found in improving technical efficiency. They conclude that education externalities affect adoption and spread of innovations, thereby, raising productivity in farming.

Similar education externalities could prevail in farm production in Bangladesh. In the dense and closely-knit society of rural Bangladesh characterized by an extremely low level of literacy, educational externality could serve as an important non-market determinant of farm-level productivity and efficiency. The scope for social interactions is widened by the way the

agricultural production system in Bangladesh is organized, particularly, rice production in irrigated areas. Although farmers commonly possess small parcels of land in various locations, each irrigated block of land used for rice production, known as the command area, hosts a large number of farmers who are effectively neighbours and have to grow rice at the same time, if not using the same varieties. Such social proximity could improve knowledge-sharing and generate positive externalities of one's education.

Given the perceived importance of education in raising productivity and efficiency in agriculture, the present study is set to examine two important issues in Bangladesh. First, we test for the internal effect of education. That is, whether household's own education raises farm productivity and efficiency. Second, we test for the presence of any external effect of education. It is examined whether in addition to household education, farm production is positively influenced by education of others in the residential neighbourhood. We do so by estimating the average production function as well as stochastic production frontier for rice cultivation in Bangladesh with controls for a host of farm inputs, education stock measures and villages-level determinants.

There are three major findings of our study. First, we find a positive effect of household head's education. However, the most educated individual in the household has the greatest influence so that, controlling for maximum schooling in the household, head's schooling does not impact farm production. Such internal returns to education arise through raising productivity, boosting potential output and reducing technical inefficiency. On the other hand, there is no evidence of an external effect of education on agricultural productivity. Neighbour's education does not matter in reducing production inefficiency either. Lastly, farm production is centralized so that even if the household-head is uneducated, productivity and potential output are augmented so long as an educated adult co-resides in the same household. The remaining part of the paper is organized as follows.

Section 2 discusses the study area, the methodology, empirical specifications of the production functions and the data. Section 3 discusses the results. Section 4 is conclusion.

2. Methodology

2.1 The study area

The farm households in this study belong to the Matlab thana¹ of Chandpur district in Bangladesh. The Matlab thana comprises of a total of 141 villages. Being criss-crossed by rivers, these villages remain sufficiently remote and well outside urban influence. Actual travel time between the capital city (Dhaka) and the Matlab thana is 5 hours. Therefore, villagers primarily rely on the local economy for their livelihoods. Agriculture constitutes the key source of earnings. Although in recent years, the study area has experienced some expansion of non-farm activities, farm sector remains the single largest employer of the rural workforce; primary economic activities are agriculture and fishing. Rice is the principal crop item in Matlab villages, in terms of its share in total cereal production. Being located in a low-lying area, the study villages are frequently flooded, particularly during the monsoon season. Hence, although unsuitable for homestead use, flood-plain land of Matlab villages is ideal for rice cultivation. The distribution of land, however, is not homogenous. About 50 per cent of the households are landless. Increasing population growth and density has also led to fragmentation of landholdings. Therefore, most of the farmers in the study area operate as smallholders or sharecroppers.

Similar to other regions of Bangladesh, the majority of adults in the study villages never went to school. This is despite a substantial labour market return to education in the Matlab villages – one year of additional schooling leads to 7 per cent gains in average earnings for wage workers (Berman and Stepanyan 2003). This is similar to the overall wage returns to education in Bangladesh (Asadullah 2005). No information on returns to farm work

is available, however. Therefore, it remains to be seen, whether a similar positive returns to education prevails in farm work in the Matlab villages.

Lastly, a key aspect of social organization in rural Bangladesh is the clustering of households in a unique residential neighbourhood commonly known as ‘bari’. Households belonging to the same neighbourhood maintain significant social ties which may have implications for farm production activities. Farmers might learn by observing (superior) input choices of their educated neighbours who are engaged in farm work. Alternatively, educated neighbours could simply share their literacy knowledge with uneducated farmers. Evidence of economic returns enjoyed by illiterate yet proximate (to literate householder) individuals is well-documented for Bangladeshi households (Basu et al. 2002). Our study extends these ideas in the context of farm production.

2.2 Modelling internal and external benefits of education on productivity and efficiency

Application of an average production function as well as the stochastic production frontier framework is appropriate to analyze internal and external benefits of education on productivity and efficiency. Two basic hypotheses are tested (distinguishing between internal and external effects): whether education affects (a) productivity as well as placement of the frontier (that is, influences production as well as increases potential output), and (b) deviations from the frontier (that is, affects production efficiency). The internal benefit of education on productivity and placement of the frontier is captured by specifying education at the household level as an independent variable in the average production function and in the stochastic production frontier function, respectively. The external benefit of education on productivity and placement of the frontier is captured by specifying neighbourhood level education as an independent variable in these models.

In this study, the degree of inefficiency in production is measured by the deviation from the frontier. Therefore, the internal and external effects of education on efficiency are

examined by placing household-level and neighbourhood-level education in the ‘inefficiency effects model’ in addition to variables representing farm and village characteristics to explain underlying causes of deviation from the frontier.

Stochastic production frontier approach, developed by Aigner et al., (1977) is utilized in this study. In this framework, the output (rice production) is treated as a stochastic production process and is defined as:

$$Q_i | f(x_i; A) \cdot \exp(\kappa_i) \quad (1)$$

where $x \subset R_2$ is a $(N \times J)$ matrix of the inputs, $Q \subset R_2$ is the $(N \times 1)$ vector of output, $f(.)$ is the best practice production frontier, A is the technology parameter vector, and i subscripts individual farm households, respectively.

The error term κ_i is composed of two components:

$$\kappa_i | v_i + u_i \quad (1a)$$

where the component v_i s are assumed to be identically and independently distributed $N(0, \omega_v^2)$ two sided random errors, independent of the u_i s, representing random shocks, such as exogenous factors, measurement errors, omitted explanatory variables, and statistical noise. The u_i s are non-negative random variables, associated with inefficiency in production, which are assumed to be independently distributed as truncations at 0 of the normal distribution with mean, $\sigma_i | \tau_0 + \frac{1}{d} \tau_d W_{di}$ and variance $\omega_u^2 (| N(\sigma_i, \omega_u^2) |)$, where W_{di} is the d th explanatory variable associated with inefficiencies of farm i and τ_0 and τ_d are the unknown parameters.

The production efficiency of the farm i is defined as:

$$EFF_i | E[\exp(4u_i) | \kappa_i] | E \left[\exp(4\tau_0 + \frac{4}{d} \tau_d W_{di}) | \kappa_i \right] \quad (2)$$

where E is the expectation operator. This is achieved by obtaining the expressions for the conditional expectation u_i upon the observed value of κ_i . The method of maximum likelihood is used to estimate the unknown parameters, with the stochastic production frontier and the inefficiency effects functions estimated simultaneously. The likelihood function is expressed in terms of the variance parameters, $\omega^2 \mid \omega_v^2, 2\omega_u^2$ and $\nu \mid \omega_u^2 / \omega^2$ (Battese and Coelli 1995).

2.3 The empirical model

The production structure of rice farmers in Bangladesh is specified using a single-output multi-input Cobb-Douglas production function and a stochastic production frontier, respectively. The general form of the production function and the stochastic production frontier for the i th farm is expressed, respectively as:

$$\ln Q_i \mid \eta_0 + 2 \sum_{j=1}^J \eta_j \ln X_{ji} + 2 \sum_{k=1}^K \zeta_k \ln E_{ki} + 2 \sum_{m=1}^M \lambda_m D_{mi} + 2 \kappa_i \quad (3)$$

$$\ln Q_i \mid \eta_0 + 2 \sum_{j=1}^J \eta_j \ln X_{ji} + 2 \sum_{k=1}^K \zeta_k \ln E_{ki} + 2 \sum_{m=1}^M \lambda_m D_{mi} + 2 \nu_i + 4 u_i \quad (4)$$

where

$$u_i \mid \tau_0 + 2 \sum_{d=1}^D \tau_d W_{di} + 2 \varpi_i \quad (4a)$$

where the dependent variable Q is the aggregate of rice output² produced (kg per farm) in all three seasons, ‘Aus’ (pre-monsoon), ‘Aman’ (monsoon) and ‘Boro’ (dry-winter); X ’s are the inputs of land cultivated (ha), total value of all purchased inputs³ (taka), total imputed value of all home supplied inputs⁴ (taka), and value of farm-capital assets used in rice production (taka); E ’s are the variables representing internal and external benefits of education; and D ’s are the village dummies; κ is the standard two-sided random error in eq (3); ν is the two-sided random error and u is the one-sided half-normal error in eq (4); and \ln is the natural logarithm; W ’s in eq. (4a) are the variables representing farm-specific characteristics to explain inefficiency and includes age of the farmer (years), tenurial status (1 if owner

operator, 0 otherwise), irrigation facilities of the village (1 if have facility in the village, 0 otherwise), level of infrastructural development at the village⁵ (number), non-agricultural income share⁶ (proportion of total household income obtained from non-agricultural sources), and variables representing internal and external effects of education; ϖ is the truncated random variable; ζ_k , η_0 , η_j , π_m , ι_0 , and ι_d are the parameters to be estimated.

The internal benefit of education is measured by two variables: (a) education level of the household-head (completed years of schooling), and (b) maximum education (completed years of schooling) among adult householders (aged 19 years and over)⁷. The external benefit of education is measured by the maximum years of schooling among adult neighbours⁸. Eight specifications were adopted using three types of education variables to examine internal and external effects of education on farm productivity and efficiency. The productivity effects were analyzed by placing these variables in the production function as well as the stochastic production frontier while the efficiency effects were analyzed by placing them in the inefficiency effects model.

Identification of neighbourhood externality as a causal effect is dubious if there are other determinants of farm productivity and efficiency that operate at the village level. If the omitted village determinants positively affect farm productivity and are positively correlated with our neighbourhood education measures, the estimate of education externality is likely to be upwards. We rule out this possibility by fully controlling for village fixed effects. This strategy ensures that our estimates of external returns to education are at least not driven by unaccounted village level observed and unobserved determinants of farm productivity. Nonetheless, we cannot rule out the possibility that a similar bias may prevail due to the omission of neighbourhood level unobserved correlates of farm productivity so that our estimates of externalities are likely to be upward biased⁹.

Lastly, exploring externality effects at bari (instead of village) level is appropriate as baris define the relevant social space in rural Bangladesh. The extant studies (for instance, Appleton and Balihuta 1996) investigate neighbourhood effect at the lowest administrative level which, in most cases, remains much broader than the social space relevant for farmers in rural areas. Appleton and Balihuta use enumeration area to define a neighbourhood in Uganda which on an average comprises of as many as 1000 households. It is not clear, a priori, how such administrative boundaries could capture the relevant social space for farmers. Geographical remoteness is likely to inhibit any economically meaningful social interaction. Weir and Knight (Forthcoming) is the only study that overcomes this problem by focusing on lower-level neighbourhoods (defined in terms of household clusters instead of some arbitrary administrative boundary) within each survey site in their Ethiopian study. Baris in our study resembles these rural neighbourhoods in Ethiopia. Therefore, throughout this study, we compare and contrast our estimates of externalities with that reported in Weir and Knight.

2.4 Data

Data for this study comes from the Matlab Health and Socio-economic Survey (MHSS). The survey was conducted in all villages of the Matlab thana in the year 1996. The dataset provides a rich description of the agricultural and non-agricultural profiles of the sample households and their asset portfolio along with complete information on personal characteristics of the householders. The sample households were selected in two steps. First, a random sample of 2678 residential neighbourhoods – baris – was selected from the entire Matlab thana. In the second step, households were sampled. If a bari had just one household, it was always selected. In case of multi-household baris, two households were selected at random from each of the sample baris. This led to a total sample of 4368 households¹⁰. Since

for each household, we know the identity of its bari and village of location, we can account for non-household (that is, external) determinants of agricultural productivity and efficiency using this dataset.

While all the households completed the module on farm production, only 56.5 per cent (2469 households) of them were engaged in agricultural production. After purging this sample of potential outliers, the final sample contains a total of 2357 rice producing households. Of these, the majority (85%) comes from multiple-household neighbourhoods where the mean number of households is six. For these households, the externality variable is a measure of education in the other (sampled) household in the neighbourhood. The remaining 352 households (15% of the sample), however, belong to single-household baris so that neighbourhood education is set to zero for these households.

3. Results

The summary statistics of the variables used appear in Table 1. A number of points can be noted from this Table. Farms in our sample are small, with an average size of 0.51 ha. 46 per cent of the household heads in our working sample never attended school so that the average level of household head's education is only 3 years. The maximum average level of adult education in the household is 5.8 years, and the maximum average level of neighbour's education is 6.7 years¹¹. Average age of the farmer is 49.2 years, 48 per cent of farmers are owner operators, 97 per cent of the villages have irrigation facilities¹². Lastly, 50 per cent of household-income is derived from non-agricultural sources.

[“Table 1” about here]

The Ordinary Least Squares (OLS) regression is used to estimate the parameters of the average production function models and Maximum Likelihood Estimation (MLE) procedure is used to estimate the parameters of the stochastic production frontier and inefficiency effects models jointly in a single stage¹³ using STATA Version 8 (Stata Corp 2003). All model specifications include four basic farm variables – land, purchased inputs, home supplied inputs, and farm capital assets used directly for rice production. Also, all model specifications control for village fixed-effects (to purge the data of the village-level unobserved determinants of farm output) unless mentioned otherwise. A test for the significance of fixed-effects in all specifications rejected the null hypothesis of ‘no influence’ at 1 per cent level of significance. This confirms that studies dealing with farmers’ decision making process at farm-level must dissociate the effects of village-level correlates, which has not been seen in studies using Bangladeshi data.

3.1 Productivity effects of education

Table 2 presents OLS estimates (with fixed effects) of extended Cobb-Douglas¹⁴ production functions incorporating alternative specifications of the education variables to account for internal and external benefits of education on rice production. OLS model implicitly assumes fully efficient rice farmers, an assumption that will be relaxed subsequently when we proceed to examine stochastic frontier production function for rice farming. Overall, these six specifications are able to explain 63-65 per cent of variation in rice production which is much higher than the explanatory power of the OLS models of average production function (with/without fixed-effects) reported in other studies¹⁵.

[“Table 2” about here]

All basic farm variables significantly influence rice production and the estimates are robust irrespective of model specifications. The effect of land is dominant as expected. Output elasticity of land varies from 0.65 to 0.71 implying that a 1 per cent increase in land area will increase rice production by 0.65 to 0.71 per cent. Since, Cobb-Douglas model is used, sum of coefficients of all basic farm variables provides a direct estimate of the ‘returns to scale’ in rice production. The sum varies from 0.83 to 0.87 indicating decreasing returns to scale. Appleton and Balihuta (1996) and Weir and Knight (2004) also reported decreasing returns to scale in cereal production for Ugandan and Ethiopian farmers respectively. Given widespread reporting of scale inefficiency among farmers in developing countries, estimates of ‘decreasing returns to scale’ seems consistent with expectation.

The internal (household-level) benefits of education in rice production are first explored in neighbourhood fixed-effects models (1) and (2) in Table 2. The motivation underlying joint control for head’s schooling and that of other householders (Model 2) is that production decisions are likely to be collectively made when farm size is small. The distinction between farm managers and workers is marginal in such a setting. While contributions of all may matter, the highest educated in the household is likely to play the lead role. We find that the effect of household education is 6.4%, comparable to the labour market returns to education in the study villages. Household-head’s education has no effect, however.

To explore the external (neighbourhood-level) benefits, we re-estimate the production functions with village fixed effects and an additional control for neighbour’s education (Models 4-8, Table 2). Model (4) proxies for farm education using head’s schooling only. Model (5) additionally controls for maximum education among other householders. Model (6) jointly controls for head’s schooling and maximum education in the neighbourhood. Lastly, Model (7) includes all three measures of education.

We find that an additional year of household-head's education increases rice production by 4 per cent (Model 3). But controlling for maximum adult education in the household, head's education has no impact (Models 4 and 6). This finding confirms our earlier conjecture that farm production within the household is a centralized activity so that the most educated household member plays the key role in decision making¹⁶. The external benefit of education, measured by neighbour's education level is weak (Models 3 and 4). When specified jointly with household head's education, one year of additional schooling at the neighbourhood level increases rice production by 3 per cent ($p < 0.10$) and is similar to the estimate of Weir and Knight (2004) for Ethiopian cereal farmers. However, additionally controlling for maximum schooling among other householders, the neighbourhood effect disappears. We also re-estimated the regressions with alternative measures of neighbour's education (e.g. mean education of adults or education of the head in the neighbouring household). However, our results remained unchanged.

In the next stage we relax the assumption of fully efficient rice farmers and estimate stochastic production frontier models to allow for farm-specific inefficiencies. The predicted farm specific inefficiencies are then modelled as a function of selected farm and village level characteristics. In all specifications, both the stochastic production frontier and inefficiency effects models are estimated simultaneously. These results are summarized in Table 3.

["Table 3" about here]

The influence of basic farm variables on potential rice output is robust and mirrors those obtained from the average production function models. The first four models in Table 3 provide alternative specifications to account for internal and external benefits of education on the placement of the rice production frontier. A positive significant coefficient on the relevant variable will establish the evidence of its influence on upward shift of the rice production

frontier. Once again, we find strong evidence of internal benefits of education in shifting the rice production frontier outward. The level and magnitude of influence mirrors those obtained in the average production function estimation results reported in Table 2. An additional year of schooling of household head or adult members within the household will shift the rice production frontier by 3–7 per cent. However, when head's education and that of other adult householders are controlled simultaneously, coefficient on the former becomes insignificant. This is consistent with the argument of centralized planning. To sum, the most educated member raises farm output not only through boosting average output, but also by shifting the production frontier. The finding of a positive effect of formal education on potential output is at contrast with Weir and Knight (Forthcoming) (who using Ethiopian data found no such effects).

Turning to the external benefit of education on shifting the rice production frontier, however, evidence is still weak. When included alongside the head's education, an additional year of schooling in the neighbourhood seems to shift the rice production frontier by 3 per cent ($p < 0.10$). But with additional control for maximum education of adult householder, neighbourhood education has no impact.

Our earlier finding that maximum education of the householder, instead of that of the household head, matters most in farm production suggests that educated householders are substitutes for one another. In order to formally test for this possibility, we also estimated average production function and stochastic frontier production functions for a sub-sample of households where the household heads are uneducated¹⁷. Reassuringly, we find robust internal benefits of education (adult household education) on rice productivity and placement of the rice production frontier. The externality effect of neighbourhood education remains absent. Therefore, households where uneducated heads co-reside with educated adult

members still experience significant gains in rice production. This finding has important policy implications which we discuss later in the paper.

Next, to detect any non-linearity in returns to household head's education on rice productivity and placement of the frontier, we categorized his/her education into three levels: up to primary level, up to secondary level, above secondary level (details are in Table 1). The results are presented in Appendix Table A, Models 1-4. We find that influence of education on rice productivity and placement of the frontier kicks in only when head's education passes the primary level and reaches up to secondary level¹⁸. Tertiary level education, perhaps drives the household head away from rice production allowing him/her to engage in off-farm and non-agricultural activities, which presumably provides higher income as compared to rice farming. However, controlling for maximum schooling in the household, head's education once again has no impact.

3.2 Efficiency effects of education

Given robust internal benefits of education in rice productivity and placement of the production frontier and missing external benefits of education in the same, we next investigate the influence of education on technical efficiency. Prior to the discussion of these effects, we briefly highlight the farm-specific efficiency scores presented in Table 4. The mean efficiency level varies between 71 to 73 per cent across specifications indicating that rice production can be increased up to 27 to 29 per cent by improving technical efficiency alone with no additional use of resources. The minimum efficiency level is 12 per cent while the maximum is 94 per cent. The results are similar to those reported by Wadud and White (2000) and Coelli et al. (2002) for Bangladesh.

[“Table 4” about here]

Models 5 through 8 in Table 3 present the results of 4 alternative specifications of internal and external effects of education on technical efficiency. Five variables representing farm characteristics and selected village-level characteristics are used to explain farm-specific technical inefficiency in addition to variables representing internal and external effects of education (for details, see lower panel of Table 1). Non-agricultural income share seems to be the dominant variable in explaining technical efficiency. The significant positive sign on this coefficient points towards a situation where households with higher opportunity to engage in non-agricultural activities fail to pay high attention to their rice production activities and therefore, are highly inefficient. The result is similar and consistent with findings of Ali and Flinn (1989), Wang et al. (1996) and Rahman (2003). Rice producers also benefit significantly from better infrastructure¹⁹. Underdeveloped infrastructure has negative effects on technical efficiency, as farmers may not have the required inputs to use at the correct time, or not at all. This result corroborates the findings of Ali and Flinn (1989), Coelli et al. (2002) and Rahman (2003), indicating that farmers in remote villages are less efficient after accounting for other correlates of efficiency. Weak evidence that owner operators are relatively efficient than the tenants is also found.

Turning to our variables of interest, we find weak evidence of external benefits of education on improving technical efficiency (Models 7 and 8). The coefficient on the neighbour's education variable is significant in Model 7 only. Once we additionally control for adult education within the household, neighbourhood education becomes insignificant (Model 8).

Similar results follow when the household head's education is categorized into levels (see Models 5 through 8, Appendix Table A). Beyond secondary schooling, head's education

does not matter in reducing production inefficiencies (Model 5). Once, again, the external returns to education are absent net of education of adult householders.

4. Conclusions and policy implications

Like other developing countries, Bangladesh is characterized by low human capital investment. Returns to additional investment are high; schooling is vital to labour productivity. Yet earlier studies eschewed the positive role of education in farm work arguing that formal schooling in Bangladesh is not agriculture-oriented and hence makes little contribution to improving farm productivity and efficiency. To the extent, schooling raises literacy and numeracy skills and ability to process agricultural information, an education effect can exist independent of school curriculum design. Returns to such skills are particularly magnified in a modernizing agriculture sector, where access to advanced technology complements human capital stock (Rosensweig, 1995). This study therefore reassessed the puzzle over low returns to schooling in farm work in Bangladesh using a large dataset on rural rice producing households spread over 141 villages.

Three sets of results follow from our empirical analysis. First, the results espouse existence of internal benefits of education in rice production: education matters in raising productivity, boosting potential output and improving efficiency. This is consistent with the fact that farm work in Bangladesh involves modern varieties of seeds and inputs. There are several implications of such a positive education effect. First, similar to labour market returns to education, schooling is relevant even in an agrarian setting where wage work opportunities may be limited. This, therefore, questions the commonly held view that household investment in children's schooling in agrarian societies is discouraged by a lack of return to education in farm work. Second, the finding that proximity to an educated adult in the household boosts farm productivity implies that not all farmers who are uneducated are equally worse-off in

farm work. Earlier studies (for example, Sharif and Dar, 1996a, b) on the effect of education on rice production inefficiency in Bangladesh probably overstate the efficiency loss suffered by less educated farmers in rural Bangladesh. Given the evidence of a centralized production regime, public policy should therefore aim at targeting farm households where all members are uneducated. How this can be achieved, nevertheless, remains unclear. If the education effect merely reflects the effect of basic literacy and numeracy skills, then a well-designed adult literacy programs could serve as a potential intervention. Providing literacy training to one adult householder would suffice. On the other hand, if education captures the effect of farm-specific lessons acquired during one's school years, adult literacy programs may not be sufficient.

Our data supports the relative importance of basic education over higher education in agriculture. Household head's education, when decomposed by levels of education shows that having primary and secondary education over and above zero year of education has a significant impact on productivity (Appendix Table A; Model 1). Farmers who complete secondary schooling also enjoy significant efficiency gains (Appendix Table A; Model 5) suggesting that basic literacy skill, usually attained during primary and secondary schooling is more relevant in farm production than tertiary education.

The third important finding relates to education externalities. The absence of a 'neighbourhood education effect' in farm production is at contrast with other studies that have tested for similar effects using developing country data (for example, Weir and Knight Forthcoming). The precise reason for this discrepancy is not clear. One possibility is that educational spill-over effects on potential output arise through adoption of HYV varieties/technologies. But adoption rate is higher in Bangladesh (including the study villages) compared to Ethiopian villages so that returns to education in the form of 'learning-from-others' is likely to be less in Bangladesh²⁰.

In conclusion, evidence of significant household education effect is consistent with the fact that farmers in Bangladesh operate in a modernizing environment (for example, one where there are changes in technology and infrastructure) compared to other regions such as Africa and Latin America where farm production is largely traditional. Despite such returns, distribution of education stock is sparse in rural Bangladesh. A vast majority of the farming population remains uneducated or live in isolation of other educated individuals (in own household or in the residential neighbourhood). Consequently, only a fraction of them succeed in appropriating returns from advanced technology in farm work. Lack of education (or access to it) then partly explains why Bangladesh agriculture has not been able to fully exploit the available technologies. In spite of modernization, total factor productivity growth in agriculture has declined at an annual rate of 0.23 per cent per year for the period 1961–1992 mainly owing to dramatically falling efficiency despite strong technological progress (Coelli et al. 2003). Current policy initiatives of the government to expand educational opportunities in rural areas of the country are therefore well-placed and promise significant long-run returns in terms of bolstering agricultural productivity.

Footnotes

1. Thana is the second lowest unit of local government in Bangladesh.
2. We have aggregated the volume of rice produced over all three seasons covering a crop year. This is because our main focus is to determine the internal and external benefits of education on overall rice production (the main staple and dominant crop in Bangladeshi farming) which is unlikely to differ across seasons for the same household. The main difference one usually obtains in parameter estimates of basic production inputs is across varieties of rice produced, as the input mix as well as use rates differ to a large extent between production of traditional and modern rice varieties. Unfortunately, our data do not distinguish between the varieties of rice produced in each season. In this specification, we implicitly assume that the production function of both traditional and modern rice is same.
3. Purchased inputs include seeds/seedlings, fertilizers, pesticides, irrigation, hired labour, and hired animal power services.
4. Home supplied inputs include all family labour, animal power services, manures, and seeds.
5. The index of underdevelopment of infrastructure is constructed using a cost-of-access approach. A total of six infrastructural indicators are used. These are: local market, bank, thana (sub-district) headquarter, bus stop, boat station, and telephone office (for details of construction procedure see Ahmed and Hossain, 1990).
6. The non-agricultural income share is composed of earnings from selling labour (permanent, seasonal as well as daily labour), revenues from household assets other than farm, non-farm assets and livestock, and earnings from primary and secondary non-agricultural sources.

7. We only focus on householder (farm) workers. Information on workers hired from outside the household is unavailable and hence not accounted for in our analysis.
8. As discussed later in the paper, we also experiment with other measures of neighbourhood education such as mean education of adults in the neighbouring household and education of the head of the neighbouring household.
9. For a comprehensive discussion of the issue of identification of neighbourhood effect, see Durlauf (2004).
10. Further details on the MHSS are available in Rahman et al. (2001).
11. The neighbourhood variable is constructed by excluding all members of the index household.
12. This, however, does not guarantee that all farmers within the village have full access to irrigation.
13. The single-stage approach is considered superior against the conventionally used two-stage approach wherein the first stage involves estimation of the stochastic production frontier and the prediction of inefficiency effects under the assumption that these inefficiency effects are identically distributed with one-sided error terms. The second stage involves the specification of a regression model for predicted inefficiency effects, which contradicts the assumption of an identically distributed one-sided error term in the stochastic frontier (Battese and Coelli, 1995).
14. The rationale behind using Cobb-Douglas specification as opposed to a more flexible Translog specification is that we are specifying our models with 139 village dummies to control for village level correlates of productivity and efficiency. This leaves our variable list to vary from 144 to 149 variables in production frontier models alone. Other studies with similar specification also used Cobb-Douglas specification, for example Weir and Knight (Forthcoming).

15. For example, Weir and Knight (Forthcoming) report adjusted R^2 of 0.55 for the OLS models of cereal output with site fixed effects. The better-off fit of our models perhaps owes to control for large number of village dummies.
16. The choice of maximum education could be problematic if it proxies access to non-farm cash income, rather than direct access to skill learned at school. We tested for this by additionally controlling for non-farm income of the household. However, it didn't drive out the effect of maximum household education.
17. The results are not reported here but available from the authors upon request.
18. This finding is consistent with the experience of other Asian countries for which a positive education effect on technology adoption is documented only if farmers have more than four years of schooling (Philips, 1994).
19. The infrastructure index is defined as the level of underdevelopment of infrastructure. Hence, a positive coefficient on this variable indicates positive effect on efficiency.
20. The differences in results, however, could also reflect the possibility that the existing evidences on externalities are exaggerated. Recent research on human capital externalities in the labour market context suggests that naïve estimates of educational externalities are upward-biased; correcting for the endogeneity of education, there is little evidence in support of externalities (Acemoglu and Angrist 2000). Although a similar analysis is yet to be attempted for agricultural production, it is difficult to rule out the prospect of a spurious externality effect in farm activities.

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Table 1: Summary statistics of variables

| Variables | Description | Full Sample | | Uneducated-head Sample | |
|--|--|-------------|-----------|------------------------|-----------|
| | | Mean | Std. Dev. | Mean | Std. Dev. |
| <i>Farm variables</i> | | | | | |
| Rice output | Unit of measurement: kg | 1615.79 | 1888.73 | 1355.45 | 1448.98 |
| Area cultivated | Unit of measurement: hectare | 0.51 | 0.65 | 0.44 | 0.60 |
| Purchased inputs | Unit of measurement: Taka ^a | 4133.43 | 4315.82 | 3472.54 | 3396.45 |
| Home supplied inputs | Unit of measurement: Taka ^a | 306.40 | 861.29 | 275.85 | 705.09 |
| Value of farm capital assets | Unit of measurement: Taka ^a | 1001.51 | 5963.08 | 435.34 | 2830.56 |
| <i>Education variables</i> | | | | | |
| Household head's education | Years of schooling completed | 3.07 | 3.66 | 0 | 1 |
| Primary education (grade 1 – 5) | Dummy (1 if head's education is grade 1–5, 0 otherwise) | 0.31 | 0.36 | 0 | 1 |
| Secondary education (grade 6 – 10) | Dummy (1 if head's education is grade 6–10, 0 otherwise) | 0.18 | 0.38 | 0 | 1 |
| Higher secondary and above (grade 11+) | Dummy (1 if head's education is grade >10, 0 otherwise) | 0.04 | 0.21 | 0 | 1 |
| Adult education in household | Maximum years of schooling completed (among adults) | 5.78 | 4.11 | 3.45 | 3.87 |
| Neighbour's education | Maximum years of schooling completed (among adults) | 6.73 | 3.97 | 4.98 | 4.03 |
| <i>Other variables</i> | | | | | |
| Age of the farmer | Years | 49.17 | 13.13 | 49.67 | 13.27 |
| Household head is female | Dummy (1 if head is female, 0 otherwise) | 0.08 | 0.28 | 0 | 1 |
| Tenurial status | Dummy (1 if owner operator, 0 otherwise) | 0.48 | 0.50 | 0.39 | 0.49 |
| Irrigation facilities in village | Dummy (1 if have irrigation, 0 otherwise) | 0.97 | 0.16 | 0.98 | 0.15 |
| Infrastructure index | Aggregate index of village-level facilities | 4.20 | 4.70 | 4.22 | 4.70 |
| Non-agricultural income share | Unit of measurement: Proportion | 0.50 | 0.43 | 0.49 | 0.44 |
| N | | 2357 | | 1104 | |

Note: ^a = Exchange rate, 1 USD = Taka 48.06 in 1998/99 (BBS, 2001)

Table 2: Estimates of average production function (Dependent variable: Natural log of rice produced)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|----------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| Constant | 2.832 (21.89)** | 2.815 (21.77)** | 2.91 (40.42)** | 2.879 (39.65)** | 2.885 (39.28)** | 2.876 (39.16)** |
| <i>Farm variables</i> | | | | | | |
| ln Land | 0.712 (26.01)** | 0.703 (25.44)** | 0.661 (45.96)** | 0.655 (45.12)** | 0.658 (45.55)** | 0.654 (45.07)** |
| ln Purchased inputs | 0.122 (6.06)** | 0.118 (5.87)** | 0.134 (12.13)** | 0.134 (12.06)** | 0.135 (12.14)** | 0.134 (12.06)** |
| ln Home supplied inputs | 0.023 (3.25)** | 0.021 (2.96)** | 0.021 (4.98)** | 0.02 (4.81)** | 0.021 (4.95)** | 0.02 (4.81)** |
| ln Farm assets | 0.012 (1.73)+ | 0.012 (1.69)+ | 0.019 (4.40)** | 0.018 (4.25)** | 0.018 (4.28)** | 0.018 (4.23)** |
| <i>Education variables</i> | | | | | | |
| ln Head's education | -0.011 (0.47) | -0.031 (1.24) | 0.037 (2.90)** | 0.014 (0.92) | 0.026 (1.87)+ | 0.013 (0.86) |
| ln Adult education in HH | - | 0.064 (2.00)* | - | 0.054 (3.05)** | - | 0.052 (2.51)* |
| ln Neighbour's education | - | - | - | - | 0.027 (1.75)+ | 0.005 (0.26) |
| Adjusted R ² | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| F test | 321.89 | 270.22 | 1081.95 | 906.55 | 902.98 | 776.73 |
| Village fixed effects | No | No | Yes | Yes | Yes | Yes |
| Neighborhood fixed effects | Yes | Yes | No | No | No | No |
| N | 2357 | 2357 | 2357 | 2357 | 2357 | 2357 |

Notes: (1) Absolute value of t statistics in parentheses (2) + significant at 10 per cent; * significant at 5 per cent; ** significant at 1 per cent.

Table 3: Estimates of stochastic production frontier (Dependent variable: Natural log of rice produced)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| <i><u>Production frontier model</u></i> | | | | | | | | |
| Constant | 3.691 (11.00)** | 3.636 (10.84)** | 3.659 (10.91)** | 3.636 (10.83)** | 3.710 (10.92)** | 3.749 (11.23)** | 3.735 (10.99)** | 3.752 (11.20)** |
| <i><u>Farm variables</u></i> | | | | | | | | |
| In Land | 0.665 (47.63)** | 0.657 (46.75)** | 0.662 (47.31)** | 0.657 (46.73)** | 0.665 (46.67)** | 0.657 (45.27)** | 0.660 (45.97)** | 0.657 (45.28)** |
| In Purchased inputs | 0.114 (11.52)** | 0.112 (11.48)** | 0.114 (11.56)** | 0.112 (11.47)** | 0.113 (11.36)** | 0.112 (11.20)** | 0.113 (11.34)** | 0.112 (11.22)** |
| In Home supplied inputs | 0.020 (5.11)** | 0.019 (4.90)** | 0.019 (5.08)** | 0.019 (4.90)** | 0.019 (5.07)** | 0.019 (4.88)** | 0.019 (5.02)** | 0.019 (4.89)** |
| In Farm assets | 0.016 (4.07)** | 0.015 (3.89)** | 0.015 (3.93)** | 0.015 (3.88)** | 0.016 (4.13)** | 0.015 (3.95)** | 0.015 (3.99)** | 0.015 (3.92)** |
| <i><u>Education variables</u></i> | | | | | | | | |
| In Head's education | 0.039 (3.20)** | 0.011 (0.77) | 0.027 (2.05)* | 0.011 (0.75) | | | | |
| In Adult education in HH | | 0.063 (3.80)** | | 0.063 (3.27)** | | | | |
| In Neighbour's education | | | 0.028 (1.94)+ | 0.001 (0.04) | | | | |
| <i><u>Model diagnostics</u></i> | | | | | | | | |
| Log Likelihood | -1695.00 | -1687.83 | -1693.13 | -1687.83 | -1696.36 | -1690.08 | -1692.07 | -1689.52 |
| Wald ² | 6460.96 | 6529.81 | 6476.50 | 6529.27 | 6123.43 | 5699.03 | 5954.83 | 5703.94 |
| Prob > ² | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.822 (13.20)** | 0.821 (13.60)** | 0.825 (13.24)** | 0.821 (13.55)** | 0.792 (12.18)** | 0.747 (10.67)** | 0.774 (11.42)** | 0.748 (10.64)** |
| ² | 0.830 (2.94)** | 0.807 (3.07)** | 0.839 (2.89)** | 0.808 (3.06)** | 0.709 (3.41)** | 0.576 (4.01)** | 0.652 (3.62)** | 0.579 (3.96)** |
| <i><u>Inefficiency effects model</u></i> | | | | | | | | |
| Constant | -2.942 (1.78)+ | -3.018 (1.86)+ | -3.055 (1.78)+ | -3.020 (1.86)+ | -2.212 (1.78)+ | -1.470 (1.71)+ | -1.867 (1.75)+ | -1.478 (1.70)+ |
| Age | 0.002 | 0.005 | 0.004 | 0.005 | 0.003 | 0.006 | 0.005 | 0.006 |

| | | | | | | | | |
|-------------------------|----------|----------|----------|----------|----------|----------|----------|----------|
| | (0.48) | (1.02) | (0.72) | (1.02) | (0.63) | (1.71)+ | (1.29) | (1.73)+ |
| Head is female | 0.347 | 0.402 | 0.379 | 0.402 | 0.280 | 0.283 | 0.310 | 0.293 |
| | (1.42) | (1.68)+ | (1.51) | (1.68)+ | (1.43) | (1.84)+ | (1.70)+ | (1.87)+ |
| Tenurial status | 0.146 | 0.157 | 0.160 | 0.157 | 0.145 | 0.140 | 0.152 | 0.143 |
| | (1.04) | (1.15) | (1.10) | (1.15) | (1.23) | (1.54) | (1.41) | (1.56) |
| Irrigation | 0.770 | 0.809 | 0.774 | 0.809 | 0.662 | 0.467 | 0.579 | 0.479 |
| | (0.77) | (0.82) | (0.76) | (0.82) | (0.80) | (0.79) | (0.81) | (0.80) |
| Village infrastructure | 0.049 | 0.046 | 0.049 | 0.046 | 0.043 | 0.038 | 0.040 | 0.037 |
| | (2.06)* | (2.04)* | (2.03)* | (2.04)* | (2.12)* | (2.33)* | (2.17)* | (2.31)* |
| Non-agril. income share | 1.011 | 0.987 | 1.014 | 0.987 | 0.891 | 0.730 | 0.847 | 0.740 |
| | (3.12)** | (3.24)** | (3.09)** | (3.23)** | (3.48)** | (3.82)** | (3.53)** | (3.74)** |
| Head's education | | | | | -0.050 | -0.004 | -0.021 | -0.002 |
| | | | | | (2.15)* | (0.21) | (1.04) | (0.09) |
| Adult HH education | | | | | | -0.057 | | -0.046 |
| | | | | | | (2.74)** | | (2.08)* |
| Neighbour's education | | | | | | | -0.045 | -0.017 |
| | | | | | | | (2.23)* | (0.99) |
| N | 2357 | 2357 | 2357 | 2357 | 2357 | 2357 | 2357 | 2357 |

Note: (1) Absolute value of z statistics in parentheses (2) + significant at 10 per cent; * significant at 5 per cent; ** significant at 1 per cent (3) All specifications include 139 villages dummies in the production frontier model.

Table 4: Technical efficiency scores of rice farmers

| Model specifications | Mean | Standard deviation | Minimum | Maximum |
|-----------------------------|-------------|---------------------------|----------------|----------------|
| Model 1 | 0.728 | 0.133 | 0.123 | 0.944 |
| Model 2 | 0.727 | 0.134 | 0.123 | 0.943 |
| Model 3 | 0.729 | 0.133 | 0.123 | 0.944 |
| Model 4 | 0.727 | 0.134 | 0.123 | 0.943 |
| Model 5 | 0.722 | 0.134 | 0.133 | 0.942 |
| Model 6 | 0.713 | 0.136 | 0.134 | 0.942 |
| Model 7 | 0.720 | 0.135 | 0.132 | 0.941 |
| Model 8 | 0.713 | 0.136 | 0.133 | 0.942 |

Note: Technical efficiency scores correspond to Table 3.

Appendix Table A: Alternative estimates of stochastic production frontier (Dependent variable: Natural log of rice produced)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| <i><u>Production frontier model</u></i> | | | | | | | | |
| Constant | 3.688 (10.98)** | 3.626 (10.81)** | 3.650 (10.88)** | 3.624 (10.80)** | 3.696 (10.86)** | 3.744 (11.24)** | 3.727 (10.97)** | 3.748 (11.21)** |
| <i><u>Farm variables</u></i> | | | | | | | | |
| ln Land | 0.667 (47.86)** | 0.657 (46.79)** | 0.664 (47.46)** | 0.657 (46.80)** | 0.667 (47.10)** | 0.657 (45.49)** | 0.662 (46.31)** | 0.657 (45.49)** |
| ln Purchased inputs | 0.113 (11.47)** | 0.112 (11.46)** | 0.113 (11.53)** | 0.112 (11.46)** | 0.113 (11.39)** | 0.112 (11.21)** | 0.113 (11.36)** | 0.112 (11.23)** |
| ln Home supplied inputs | 0.020 (5.12)** | 0.019 (4.89)** | 0.019 (5.08)** | 0.019 (4.89)** | 0.020 (5.13)** | 0.019 (4.88)** | 0.019 (5.05)** | 0.019 (4.89)** |
| ln Farm assets | 0.016 (4.03)** | 0.015 (3.87)** | 0.015 (3.89)** | 0.015 (3.86)** | 0.016 (4.10)** | 0.015 (3.93)** | 0.015 (3.96)** | 0.015 (3.90)** |
| <i><u>Education variables</u></i> | | | | | | | | |
| Primary education (grade 1-5) | 0.042 (1.73)+ | 0.004 (0.16) | 0.026 (1.00) | 0.004 (0.14) | | | | |
| Secondary education (grade 6-10) | 0.067 (2.26)* | 0.006 (0.17) | 0.042 (1.31) | 0.005 (0.15) | | | | |
| Higher secondary and above (grade 11+) | 0.075 (1.38) | -0.004 (0.07) | 0.042 (0.75) | -0.005 (0.08) | | | | |
| ln Adult education in HH | | 0.069 (4.18)** | | 0.068 (3.51)** | | | | |
| ln Neighbour's education | | | 0.033 (2.27)* | 0.003 (0.15) | | | | |
| <i><u>Model diagnostics</u></i> | | | | | | | | |
| Log Likelihood | -1696.78 | -1688.10 | -1694.21 | -1688.09 | -1696.69 | -1688.69 | -1691.56 | -1688.13 |
| Wald ² | 6454.24 | 6530.14 | 6475.66 | 6533.24 | 6192.15 | 5723.25 | 5996.17 | 5727.56 |
| Prob > ² | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.825 (13.55)** | 0.822 (13.43)** | 0.822 (13.43)** | 0.822 (13.75)** | 0.807 (12.44)** | 0.747 (10.61)** | 0.781 (11.57)** | 0.748 (10.59)** |

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|--|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|-------------------|-------------------|
| 2 | 0.840 (2.95)** | 0.270 (0.64) | 0.270 (0.64) | 0.264 (0.62) | 0.767 (3.13)** | 0.575 (3.98)** | 0.672 (3.49)** | 0.577 (3.95)** |
| <u>Inefficiency effects model</u> | | | | | | | | |
| Constant | -2.962 (1.80)+ | -3.042 (1.85)+ | -3.094 (1.80)+ | -3.049 (1.88)+ | -2.575 (1.78)+ | -1.474 (1.72)+ | -1.994 (1.77)+ | -1.469 (1.71)+ |
| Age | 0.003 (0.54) | 0.006 (1.12) | 0.004 (0.82) | 0.006 (1.13) | 0.003 (0.72) | 0.007 (1.87)+ | 0.006 (1.41) | 0.007 (1.89)+ |
| Head is female | 0.363 (1.47) | 0.421 (1.73)+ | 0.400 (1.57) | 0.422 (1.74)+ | 0.307 (1.40) | 0.297 (1.91)+ | 0.333 (1.73)+ | 0.306 (1.94)+ |
| Tenurial status | 0.129 (0.92) | 0.144 (1.06) | 0.147 (1.02) | 0.145 (1.07) | 0.136 (1.05) | 0.127 (1.41) | 0.139 (1.26) | 0.129 (1.43) |
| Irrigation | 0.766 (0.78) | 0.806 (0.82) | 0.768 (0.76) | 0.806 (0.82) | 0.736 (0.80) | 0.475 (0.81) | 0.609 (0.82) | 0.484 (0.82) |
| Village infrastructure | 0.049 (2.05)* | 0.045 (2.02)* | 0.049 (2.02)* | 0.045 (2.03)* | 0.047 (2.17)* | 0.039 (2.46)* | 0.042 (2.26)* | 0.039 (2.44)* |
| Non-agricultural income share | 1.013 (3.13)** | 0.984 (3.18)** | 1.017 (3.11)** | 0.985 (3.24)** | 0.955 (3.22)** | 0.713 (3.78)** | 0.861 (3.42)** | 0.721 (3.72)** |
| Primary education (grade 1-5) | | | | | -0.256 (1.52) | -0.034 (0.33) | -0.101 (0.78) | -0.023 (0.22) |
| Secondary education (grade 6-10) | | | | | -0.424 (1.85)+ | -0.020 (0.13) | -0.157 (0.88) | -0.004 (0.02) |
| Higher secondary and above (grade 11+) | | | | | -0.173 (0.62) | 0.322 (1.32) | 0.150 (0.57) | 0.340 (1.37) |
| Adult HH education | | | | | | -0.064 (2.94)** | | -0.052 (2.33)* |
| Neighbour's education | | | | | | | -0.051 (2.35)* | -0.017 (1.00) |
| N | 2357 | 2357 | 2357 | 2357 | 2357 | 2357 | 2357 | 2357 |

Note: (1) Absolute value of z statistics in parentheses (2) + significant at 10 per cent; * significant at 5 per cent; ** significant at 1 per cent (3) All specifications include 139 villages dummies in the production frontier model.