Farmers' Education and Farm Efficiency : A Non-Stochastic Frontier Production Approach

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Abstract

Importance of Human Capital has gained much of its importance in the sphere of production in general and agricultural production in particular due to the diffusion of modern technology. In dynamically growing and technically developing agriculture, differences in the farm productivity and farm efficiency (technical and allocative efficiency) are observed due to many exogenous and endogenous factors. Education, in general, and levels of formal schooling completed of the effective farm Household in particular seems to be statistically significant factor to contribute. In this paper, an attempt is made to analyze the effect of the levels of schooling of the Effective farm Household on the efficiency level in HYV Paddy production in Orissa's agriculture. The farm Specific efficiency level θ (theta) is estimated through the Non parametric. Data Envelopment Analysis (DEA) method. The obtained scores of (θ) for each Decision Making farm Unit (DMU) under the assumption of Variable Return to Scale (VRS) are regressed with the Average education of the Family, Experience of the DMU and education of the effective DMU. The levels of schooling of the DMU is also used as a dummy variable to estimate the significant change in the efficiency score of each DMU in response to the change in the levels of schooling of the DMU. The result suggests that education of the DMU has significant contribution on the efficiency score and more specifically the efficiency score of the DMU improves significantly for specific education dummy variable even though it shows negative effect on some other dummy.

Keywords: Technical efficiency, Constant returns to Scale, Variable Returns to Scale, Levels of schooling of the Effective DMU, Education of the family, Effective DMU, Education Dummy.

Introduction

Since its publication in the 1964, T.W. Schultz's book Transforming Traditional Agriculture has been enormously influential and extremely valuable (Schultz, 1964). The principal contributions of the book which, has made it clear to our understanding of developing country agriculture are: The first is Schultz's refutation of the not. n that farmer's in developing countries are poor because of cultural characteristics such as lack of work ethic; lack of an understanding of the idea of saving or general ignorance of how to make best use of their resources. In his 'Efficient but Poor' hypothesis, Schultz argued that low-income levels in developing country agriculture are a result of low productivity of the available factors of production, not of inefficiency in their allocation. The

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second contribution consists of the policy implication that is the outside experts (expert agents, farm managers, advisors) could not help farmers improve productivity merely by suggesting a reallocation of the available factors of production and that it was, therefore, important to invest in education to facilitate the diffusion of the new factor that could enhance productivity.

For empirical evidence to support his hypothesis, Schultz drew on two anthropological studies, SOL Tax's penny capitalism, a study on agricultural community of Panajachel, Guatemala, and W. David Hopper's Doctoral dissertation on the village of Senapur. India, Schultz argued that both of these traditional communities, farmers allocated their resource efficiently. The principal implication is that no appreciable increase in agricultural production is to be had by reallocating the factors at disposal of the farmers. If this is not possible, then what is necessary is the introduction of some new factors. He provided a supply and demand framework which new factors will be provided and adopted.

On the demand side, Schultz explained the differences in the acceptances of the new factors in terms of profitability. The determinants of the profitability were the cost of searching or learning inherent in the adoption of the new factors. The most efficient way in the long run to reduce search and learning cost is through formal schooling (Schultz, 1971). Simply increasing literacy rate has a pervasive value in reducing cost and improving the productivity of the economy. The knowledge that makes the transfer of the traditional agriculture possible is a form of capital which entails investment —investment not only in material inputs in which a part of this knowledge is embedded but importantly also investment in the farm people. Hence, the differences in the productivity as well as observed efficiency of the farmers may be attributed to the levels of formal schooling completed.

The present article is based on the analysis of the observed differences in the scale efficiency of the farmers owing to the differences in the levels average education of the family and the education of the effective farm household. The most important feature of this article is that a non-stochastic production frontier (Data Envelopment Analysis) has been employed to study the overall efficiency of the farm household (henceforth, called decision making Unit or DMU) and the causes attributed to the observed inefficiency. The efficiency of each DMU is then studied with respect to the Average education of the family of the DMU, years of education completed by the effective DMU and the experience of the DMU.[1] The entire article is divided into eight sections. First section covers the introduction. Section II presents a brief view about the role of education in production. Section III briefly presents the literature review. The

1 Even though the Stochastic DEA frontier coutd have been used, the author used the functional free Input oriented DEA to understand the farm-specific input use inefficiency.

methodology and methods of analysis is presented in section IV. Section V covers a brief discussion of the type and sources of data. Section VI is presented with the analysis of the result and the last section provide the conclusion of the study. The references of the study are presented at the end of the article.

The Role of Education in Farm Production

Many of the ways in which, education, to have a significant and a beneficial impact on the farm productivity grows out of Human Capital theory. Simply put, the theory maintains that formal schooling will enhance the ability of the farmers to work with the production inputs at their disposal and to produce more output with fewer inputs. Education contributes to this result by increasing the cognitive abilities of the farmers. In microeconomic theory of perfect competition, allocative ability as a source of return to a factor is ruled out. With Perfect and complete information, there is no room for the superior concept of superior alternative technology since in equilibrium all alternatives are equally good at the margin. In other words, in perfect information implies that the return to a factor is proportional to its marginal contribution to physical product. For education and some intangibles, it was not clear that the direct contribution to physical production accounts for the total revenue. There have been attempts to modify the competitive model to allow for 'entrepreneurial capacity', but the return to these factors is always considered as 'residual' which does not help for marginal analysis. As an alternative to computing marginal factor revenue as being proportional marginal physical product in which all other things remain constant is the implications of variations of an input (education) whose function, in part, is to vary the use of other inputs (Welch, 1970).

The productive value of education has its root in two distinct phenomena. Increased education simply may permit a worker to accomplish more with resources at hand. This 'Worker effect' is the marginal product of education as it is normally defined, that is the increased output per unit change in education holding other factor quantities constant.

On the other hand, increased education may enhance the worker's ability to acquire and decode information and cost and productive characteristics of other inputs. As such a change in education results in a change in other inputs Including perhaps the use of some new factors that otherwise would not have used. The return to education is therefore, considered as consist of two effects– 'worker effect and allocative effect'. In a pioneering study exploring the economic effects of education, Z. Grilliches (1964) used production function analysis to highlight the contribution of education in agricultural productivity. However, following Welch, the subsequent literature has not deemed it necessary to maintain the distinction between the innovative and allocative effect.

Prof. Choudhuri (1968) has made the first clear-cut distinction between worker and allocative effect by. Indeed, there have been many empirical tests of the effect of education on farm productivity. These generally have employed Cobb-Douglas production function. However, it has been shown that the engineering production function misses much of the education on production[2]. All the three measures- worker effect allocative effect and input selection effect can be measured by estimating engineering, gross sales and value added production function. A function with gross sales as the dependent variable will measure the allocative effect. A function with value added as the dependent variable and fixed inputs and education as the independent variables will estimate all the three effects (Pudasaini, 1983). But lack of information on the prices of inputs does not give a clear picture of the allocative effect. Another problem with the traditional production function approach is that it may obscure the effects on education by mixing all farms into estimation. Hence a frontier analysis whether parametric and non-parametric will yield more valuable information for knowing the effects of the levels of schooling on the level of efficiency on each farm household.

The nonparametric method initiated as Data Envelopment Analysis (DEA) by Charnes, Cooper and Rhodes (1971) builds on the individual firm evaluations of Farrell (1957), and extends the engineering ratio approach to efficiency measures from a single-input, single output efficiency analysis to multi-input and multi-output situations. In contrast ~to the parametric approach does not require any assumption about the functional form; the efficiency of a decision making unit (DMU) is measured relative to all other DMUs with the simple restriction that all the DMUs lie on or below the efficient frontier. Instead of trying to fit a regression plane through the center of the data, one floats a piece-wise linear surface to rest on top of the observations. Hence it uncovers the possibility of returns to scale and identification of the targets for improvement.

Literature survey

A plenty of empirical studies have been made both in developed and developing countries such as USA, Korea, China, Japan and developing countries including India. Evidence from 13 low-income countries shows that farm productivity increases, on an average, by 8.7 per cent as a result of a farm completing four years of elementary education (Lockheed *et al.*, 1980). Bikhauser *et al.* (1991) reviewed Forty-seven studies from 17 countries and found that 33 studies show significant and positive extension effect. Past studies in India are mainly focused on testing whether resources (fixed and variable) are allocated efficiently in line with the allocative hypothesis of Schultz (1964) using produc-

2 Welch (1970) has shown that the engineering production function measures only the worker effect and neglects the allocative effect and input selection effect.

tion function method (Hopper, 1965; Reddy, 1967; Sahota, 1968; Saini, 1968 and others) and later on applying stochastic and deterministic frontier production function (Aigner, 1977) and profit function method (Kalirajan, 1981). However, only a few studies considered education as a factor of production and estimated its economic contribution using farm level and district level data (Chaudhuri, 1979; Sidhu, 1986). Research towards identifying and understanding the role of education can be categorized into two parts. In the first part, the technical efficiency part is investigated between two groups of farmers either educated or uneducated or traditional and modern farmers (Welch, 1970; Moock, 1981; Lockheed *et al.*, 1980; Pudasaini, 1983; Dhakal *et al.*, 1987; Azhar, 1991). In another study Phillip (1994) used Meta Analysis revised by Lockheed *et al.* (1980). The studies conducted to study allocative efficiency of the production are (Huffman, 1977; Ram, 1980). The studies used to analyze both technical and allocative efficiency are (Welch, 1970; Ram, 1980; Pudasaini, 1982, 1983; Duraiswamy, 1992, 1994; Mohapatra, 1998).

Empirical Model Specification

Data Envelopment Analysis (DEA) developed originally as a set of techniques for measuring the relative efficiency of a set of Decision Making Units (DMUs), when the price data for inputs are either unavailable or unknown. These techniques are non parametric in the sense that they are entirely based on the observed input out-put data. Various types of DEA models have been formulated which clarify the concepts of technical and allocative efficiency and their link with the concept of Pareto efficiency in economic theory.

The essential characteristics of the DEA model as originally formulated by Charnes, Cooper and Rhodes (1978), later referred to as CCR is the reduction of multi-output, multi-input situation for each DMU to that of a single (weighted combination) 'virtual' output and a single 'virtual' input. For a particular DMU this ratio provides a measure of efficiency, which can be compared with other DMU in the system. This comparison usually performed by a sequence of linear programming formulation yields a ranking of the different DMU in the system in a scale of relative efficiency from a lowest to a highest where the later is 100 per cent efficient. CCR model (1978) proposed a model of input orientation with constant returns to scale. The model with variable returns to Scale also has been proposed by Banker, Charnes and Cooper (1984).

The usual way to introduce DEA is via the ratio form. For each DMU, we would like to obtain a measure of ratio of all output over all inputs, such as $u'y_i/v'x_j$ where u is a M × 1 vector of output weight and v is a K × 1 vector of input weight. To select the optimal weight the mathematical program is

$$\text{Max}_{u,v}\ (u'y_i / v'x_i)$$

$s.t$

$u'y_i/v'x_j \leq 1 \quad j = 1, 2, 3..............,N$

$u, v \geq 0$ .... (1

To avoid infinite number of solutions the additional constraint to be imposed to the above system of equations is $v'x_i = 1$, which provides

$$\text{Max}_{\mu,v}\ (\mu' y_i)$$
$$\text{s.t } v'\ x_i = 1$$
$$\mu'\ y_j - v'x_j \leq 0,\ j = 1, 2, ..., N$$
$$\mu, v \geq 0 \quad (2)$$

The duality version of equation (2) can be specified as

$$\text{Min}_{\theta,\lambda}\theta$$
$$\text{s.t } -y_{i+}\ Y\lambda \geq 0$$
$$\theta x_{i-}\ X\lambda \geq 0$$
$$\lambda \geq 0 \quad (3)$$

Where, θ is a scalar and λ is an $N \times 1$ vector of constant. The value of θ will be the efficiency score of the i[th] DMU. The DMU having $\theta = 1$ is technically efficient (Farrell, 1957). However, the possibility of parallel shape of the frontier in both sides of the axes can be better explained with the use of input and output slack and radial movement. The multistage DEA is used to identify the efficient projected points which have input and output mixes which are as similar as to those inefficient points and that it is also invariant to unit measurement (Coeli, 1997).

The Constant Returns to Scale (CRS) is only applicable and appropriate when all the DMUs are operating at optimal scale. However, the imperfection in knowledge and dynamic changes may be the major factor for DMUs not operating at optimal scale. Banker, Charnes and Cooper (1984) have suggested an extension to the Variable returns to Scale (VRS). The use of VRS specification will permit the calculation of technical efficiency devoid of these scale efficiency. The modification made to the CRS model is by adding the convexity constraint: $N1'\lambda = 1$. The equation (3) can be modified as

$$\text{Min}_{\theta,\lambda}\theta$$
$$\text{s.t } -y_{i+}\ Y\lambda \geq 0$$
$$\theta x_{i-}\ X\lambda \geq 0$$
$$N1 - \lambda = 1$$
$$\lambda \geq 0 \quad (4)$$

This approach forms a convex hull of intersecting planes, which develop the data points more tightly than the CRS conical hull, and provides technical efficiency scores, which are greater than, or equal to those obtained using CRS model. Technical efficiency is calculated by running CRS and VRS separately.

The scale efficiency is obtained by dividing the CRS technical efficiency by the VRS technical efficiency. Equation (4) is used for calculating the efficiency parameter θ. Since Non-Stochastic Production function approach or DEA is a better method of estimating the efficiency of individual DMU, the present paper uses DEA method to estimate the value of θ for each DMU by including the major primary inputs such as Capital (in Rs.)[3], Net shown area under the crop, Labor Hour, Bullock Hour, fertilizers in kg, Pesticides in kg., Manures in kg. The parameter θ is estimated with VRS DEA model showing the efficiency of each DMU under consideration. The efficiency parameter is then regressed with the variables such as the Average Education of the Family (AEF), Experience of the effective farm (EXP) and the years of schooling completed by the effective DMU (EEH). The regression equation (5) is used to estimate the coefficient of the parameters.

$$\theta = \beta_0 + \beta_1 AEF + \beta_2 EXP + \beta_3 EEH + \delta_1 + \delta_2 + \delta_3 + \varepsilon \qquad (5)$$

In addition to this, the level of schooling is also grouped into three categories such as college education (11 to 13), High school education (8 to 10) and primary education (4 to 7) and used as a dummy variable δ_1, δ_2 and δ_3 respectively.

Type and Sources of data

The data used in this study are of primary nature and collected by the author in Orissa. **Korei** block of Jajpur district was selected and out of seven revenue villages five of the **Goleipur** panchayat have been surveyed. The villages have been selected with the objective that the farm households on an average, can, in no ways, be considered as traditional farmers. The farm households under the considerations have been surveyed personally with the help of ready-made questionnaire, which was framed both in English and Oriya script to enhance the understanding and self-study of the farm households. Besides this, some of the published books such as Economic Survey of Orissa and of the Jajpur district have been referred to for the additional and complementary information on the agricultural status of the state and the district. The area of study is chosen because of their geographical location i.e., the area is well connected to the national Highway 5 that connects Calcutta to Chennai. The area is also connected to the big markets such as Jajpur Road, Panikoili, Kuakhia and Chandikhole and the state head quarter Jajpur.

Two Hundreds of farm households have been surveyed to get detailed information regarding the inputs used, input prices, output (HYV paddy crops such as Swarna and IR-36, 1008 etc.), output prices, family background, educational status of the family as well as of the effective head of the household and

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3 The value of capital is calculated after taking the depreciation at 12% per annum. Six labor and six bullock hour are considered as a day labor and a day bullock

other socio-economic information. The entire questionnaire is divided into eleven headings covering the information on the socio-economic aspect, area under the crop, inputs (both Primary and secondary) used, education of the family as well as the farm household, experience, detail information on the cost of production, depreciation charges for the machine, sales revenue of the output.

Method of Analysis

The Table-1 shows the information on type of returns to scale and scale efficiency of the DMUs. The DMUs are classified on the basis of returns to scale. For example DMU 1 and 2 are on the IRS and DMU 3 is on CRS part of the Frontier. 66 per cent of the total samples DMU are operating on the IRS part of the frontier, whereas, 15.5 per cent and 18.5 per cent are operating on the DRS and CRS part of the frontier.

The information shows that the most of the DMUs are operating with increasing returns to scale, which means the possibility of increasinr the out-put, and productivity is more if the farmers will adopt modem farm techniques. Hence, the possibility of growth in population and its direct linkage with in-creasing food grain demand and price escalation can be prevented to certain extent, if institutional support and attention will be given to the farm produc-tion. One of the interesting evidence it shows that most of the DMUs operat-ing in the IRS range of the frontier are from the range of 7 years of schooling to 10 years of schooling. Table-2 shows the farm and its peer count. Most of the farms completing 8 to 10 years of schooling are becoming the peer farms for the other. It means the farms having higher levels of formal schooling adopt more modernized and scientific techniques that are also imitated by other

Table-1: Scale Efficiency of the DMUs.

DMU on IRS	DMU on DRS	DMU on CRS
1,2,4,6,9,10,14,16,20,21,23,32,34,36,37, 38,39,40,41,44,45,47 ,48,50,53,55,56,58, 61,63,64,67,68,69,70,71,72,73,76,77,78, 82,83.84,85,86,87,88,89,90,91,95,97 ,100, 101,104,105,108,109,110,113,114,115,116, 117,119,120,122,123,124,125,126,127,129, 130,131,132,133,134,135,136,137,139,140, 143,144,145,146,148,149,150,151,152,154, 155,156,157,158,159,161,162,163,164,167, 169,170,172,173,174,175, 176,177, 178,180, 182,184,185,186,187.	12,15,18,19,28,30, 42,49,52,54,57,5 9,60,62,68,75,79, 80,81,92,94,98,10 3, 107, Ill, 112,138, 141, 142,153,171.	3,5,7,8,11,13,11, 22,24,25, 26,27,29,31, 33,35,43,46,51,6 6,74,93,96, 99,102,106, 118,121,128, 147,160,165,166, 168,181, 183,188.

Table-3: Estimates of the Regression Coefficients.

Name of the variable	Beta Coefficient	Beta Coefficient	Beta Coefficient	Beta Coefficient	Mean (S.D)
Column 1	2	3	4	5	6
Constant	0.551 (10.033)**	0.679 (10.343)**	0.465 (7.509)**	0.823 (19.746)**	0.8372# (0.17454)**
AEF	–0.006 (1.376)	0.017 (3.405)**	0.024 (5.654)**	0.003 (0.936)	8.230 (2.5057)
EXP	–0.005 (1.392)	(–0.0007) (.018)	0.006 (1.408)	0.004 (1.370)	12.205 (2.6548)
EEH	0.053 (11.179)**				8.235 (2.4185)
Dummy 1		0.089 (2.613*			0.18 (0.381)
Dummy 2			0.156 (6.867)**		0.67 (0.471)
Dummy 3				–0.383 (17.295)**	0.15 (0.358)
R^2	0.457	0.141	0.272	(0.648)	
F value	54.988	10.703	25.822	120.270	
N	200	200	200	200	

** Shows level of significance at 1%;

* Shows 5% level of significance.

The bracketed value' shows the t-value of the estimated parameter.

\# Shows the mean and the standard deviation of the dependent variable.

ate dose of the fertilizer with appropriate soil and their understanding helps in persuading and influencing the effective farm household to adopt it. While collecting the data it was realized that some farmers who, are simply literate and none of their family members are also having high school education, are dead against the use of the tractors as it may plough the land into dipper level which may cause damage to the soil quality and, hence, it will be just barren after a few years. The statistically insignificant but negative value of the EXP implies that those farmers had enough experience they feel themselves efficient with the farm techniques that they have been using through out their life. When new information or new farm techniques are diffused into the farm level, they are not ready to accept it easily in viewing that it may have serious consequences on the productivity, cost of production and soil quality. In column 4 of

Table-4: Kruskal-Wallis Test

Range of the Variable	k^2 (Chi-Square) (Degrees of Freedom)		Assymp. Significance
5-7	38.777	(2)	0000
5-8	43.208	(3)	0000
5-9	44.084	(4)	0000
5-10	52.092	(5)	0000
8-13	12.254	(2)	0.031
8-10	31.162	(2)	0.205
9-10	0.507	(1)	0.476
10-13	6.921	(3)	0.074
10-12	6.528	(2)	0.038
11-12	0.754	(1)	0.385
4-13	91.301	(9)	0000

Table-5: Two Related Sample Test.

Variables	Z-value (2-tailed Test)	Sing Test
Dummy1 & Dummy2	–2.347	–1.96
Dummy1 & Dummy2	–4.860	–5.388
Dummy2 & Dummy3	–4.860	–5.388

the Table-5, the result of the regression equation (5) with Education dummy 2 (from 8 years of schooling to 10 years of schooling) is presented and the coefficient of AEF and Dummy 2 are statistically significant at 1% level of significance. 'But when e is regressed with AEF, EXP and Dummy 3, it shows that the coefficient of the dummy 3 is negative and statistically significant. It means the average education of 4 to 7 years of schooling does not help the farm household to adopt and implement successfully the new information available to him. Whenever, with temptation he does imitate the new techniques adopted by the other farms, the outcome goes against his favor. Hence, his level of efficiency becomes negative. From the result, it can be inferred that higher secondary and college levels of schooling of the effective household has a positive and significant contribution to the efficiency level of the farm. However, primary and upper primary schooling contributes negatively to the efficiency of the farm. Ever since, Chaudhuri has re-articulated this idea as "lapses back into illiteracy". According to Nelson-Philps-Schultz hypothesis, the effect of education is supposed to differ over time, as the time passes and new technological diffusions are made in the field of agriculture, the knowledge either from primary schooling or from higher primary schooling is totally outdated to grasp and implement that into practice

In order to know the threshold effect of the different years of education both within the group and between the groups, Kruskal Wallis (K-test) and Wilcoxon (W-test) are conducted. The K test result (shown in Table-4) shows that there are no significant differences of schooling of 11 to 12 and 12 to 13 and even from 11 to 13 years of schooling. The difference between 10 and 13 years of schooling is significant. Similarly, the difference between high school and Upper primary education is highly significant showing the role of high school education on the efficiency of the farm DMU; even the differences within the group are not significant. At the primary levels, efficiency contribution of each years of schooling is significantly different showing that the contribution increases with each year of schooling even the primary schooling has negative effect.

Similarly the differences in the efficiency level of the three groups are tested with the help of Mann Whitney (U) and Wilcox on (W) tests and Sign test. The results in the Table-5 in terms of Z value show that all these three groups (classified as primary level, high school level and college level) efficiency levels are statistically significant.

In concluding the result, it can be argued that even though, the Government of India including the state Governments have made several efforts for Sarva Siksha Abhiyan i.e., Education For All, no major improvement in the sphere of rural education has occurred. This is due to the fact that the present course pattern has nothing to do with the occupation and life of the rural people and as a matter of fact, people think that after completion of education, it will be again essential to engage in the agricultural field. Secondly, lack of infrastructure facilities in the schools especially in the primary level and negligible public investment .- makes the schooling meaningless to the rural farmers. The most important fact is that the institutions providing practical oriented education with much significance to the rural farmer are totally funded by the private agencies; hence, it becomes a practical impossibility for the rural people including the farmers.

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