Farmers' Education—Cost Efficiency and Economies of Scale: Evidence from Orissa

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This paper empirically examines the cost efficiency of the effective heads of 200 farm households with respect to their education, experience and average education of their families. The parameters of stochastic frontier Cobb-Douglas cost function and inefficiency function have been simultaneously estimated. The results show that cost efficiencies of the farm households significantly improve with increase in the experience in farming and the level of education of the effective heads. About 75% of the variation in the total cost of production among the sample farms is due to variations in their cost efficiencies. The mean cost efficiency is estimated as 1.130, which implies that an average farm household incurs costs that are 13% above the minimum defined by the frontier and 78% of the farm households are in the range of 1.00-1.19. Hence, a majority of the farm households are fairly efficient in using cost minimizing inputs. The presence of economies of scale shows that the farm households experience diminishing but positive returns to scale. The study emphasizes the role of both the government and private agencies in introducing farm-oriented education at the school and college levels.

Introduction

Agriculture is a way of life which, for centuries, has shaped the thought, outlook, culture and economic life of the people of India. Agriculture, therefore, will continue to be the central to all strategies for planned socioeconomic development of the country. The rapid growth of agriculture is essential not only to achieve self-reliance at national level, but also for household food security and to bring about equity in distribution of income and wealth resulting in rapid reduction in the poverty levels. The share of agriculture in the Gross Domestic Product (GDP) has registered a steady decline from 36.4% in 1982-83 to 18.5% in 2006-07. Yet this sector continues to support more than half a billion people providing employment to 52% of the total workforce. The most important fact is that the overall growth rate of the economy is also largely determined by the performance of agriculture and allied sectors.

Orissa, one of the states of India, lies on the shores Bay of Bengal and is bordered by Andhra Pradesh, Jharkhand and West Bengal. Situated in the tropical savanna that is subject to cyclones,

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it has large rural population, which is mainly engaged in agriculture. Therefore, agricultural economy of the state is much dependent on the productivity of the land. Orissa has a geographical area of 15,540 thousand hectares; the net sown area covered under different crops for agricultural purposes accounts for 59.90 thousand hectares of which the gross irrigated land works out to 18.54 thousand hectares. Thus, the gross cropped area is of 82.75 thousand hectares. Some distinctive features of agriculture in Orissa, which have relevance to planning, are: the pressure of population on land and the inadequacy of irrigation. About 40% of the geographical area of the state has been exploited for agricultural use and it is highest in the coastal districts of Balasore, Bhadrak, Jajpur, Kendrapara, Jagatsinghpur, Cuttack, Puri, Khurda and Ganjam. The main crops include rice, oilseed, jute and sugarcane. Agriculture alone provides direct and indirect employment to around 65% of the total workforce of the state as per the 2001 census. Although the contribution of agriculture to the state income has significantly declined, the percentage of the workforce engaged in agriculture has remained somewhat unchanged. Although the net availability of foodgrain has increased from 393 g in 1951-52 to 521 g in 2001-02, it is much below the national average. Therefore, agricultural growth holds the key to the overall development of the state. One way to achieve sustainable agricultural development is to raise the productivity and efficiency of the land as well as of the people within the limits of the existing resources and available technology.

The famous 'poor but efficient' hypothesis advanced by Schultz (1964) generated a great deal of work designed to test the allocative or price efficiency of farmers (Hopper, 1965; Reddy, 1967; and Sahota, 1968). The empirical results suggest that not only is the adoption of new technology designed to enhance farm output and income, but also the efficiency with which the available technologies are used. Education of the farmers, experience of the farmer and education of the family are found to be statistically significant in contributing to the improvement in the efficiency level of the farmers.

Efficiency of farms with reference to maize cultivation in Nigeria, has been dealt in detail by Ogundari et al. (2006). A similar analysis has been made in this paper in the context of paddy cultivation in Orissa. The cost efficiency of the effective heads of the farm households in the Jajpur district of Orissa, has been empirically analyzed in this paper. It aims to provide a better understanding of small-scale farmers of the study area with a view to predict the allocative efficiency (a measure of farm's ability to produce at a given level of output using cost minimization input ratio) of the paddy farmers, using stochastic frontier cost function. It also investigates the economies of scale of the farmers.

Role of Education in Production

Many of the ways in which education can have a significant and beneficial impact on the farm productivity, grows out of human capital theory. In other words, the theory maintains that formal schooling enhances 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 concept of superior alternative technology since in equilibrium all alternatives are equally good at the margin. In other words, 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 whether 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 in marginal analysis.

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 the other factor quantities constant.

On the other hand, increased education may enhance the worker's ability to acquire the information about cost and productive characteristics of other inputs. As such, a change in education introduces of some new factors that were not used earlier (Welch, 1970). The return to education is, therefore, considered to consist of two effects: 'worker effect' and 'allocative effect'. In a pioneering study exploring the economic effects of education, Grilliches (1964) used production function analysis to highlight the contribution of education to agricultural productivity. However, following Welch (1970), the subsequent literature has not deemed it necessary to maintain the distinction between the innovative and allocative effect.

Choudhuri (1968) has made the first clear-cut distinction between worker and allocative effect. 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.[1] All the three measures—worker effect, allocative effect, and input selection effect—can be measured by estimating engineering, gross sales and value-added production functions. 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 of education by mixing all farms in the estimation process. Hence, a frontier analysis, whether parametric or nonparametric, will yield more valuable information on the effects of the level of schooling on the level of efficiency of each farm household.

Review of Empirical Studies

A number of empirical studies have been carried out in both developed and developing countries such as the US, Korea, China, Japan and India. Evidence from 13 low-income countries shows that farm productivity, on an average, increases by 8.7% as a result of the

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

farmer completing four years of elementary education (Lockheed *et al.*, 1980). Birkhaeuser *et al.* (1991) reviewed 47 studies from 17 countries and found that 33 studies show significant and positive extension effect. Past studies in India mainly focused on testing whether the resources (fixed and variable) were allocated efficiently in line with the allocative hypothesis of Schultz (1964), using the production function method (Hopper, 1965; Reddy, 1967; Sahota, 1968; and Saini, 1968) and later on applying the stochastic and deterministic frontier production function (Aigner *et al.*, 1977) and profit function methods (Kalirajan, 1981a and 1981b). However, only a few studies considered education as a factor of production and estimated its economic contribution using farm-level and district-level data (Choudhuri, 1979; and Sidhu, 1986). Research towards identifying and understanding the role of education can be categorized into two parts. First, the technical efficiency between two groups of farmers either educated or uneducated, or traditional or modern is investigated (Welch, 1970; Lockheed *et al.*, 1980; Moock, 1981; Pudasaini, 1983; Dhakal, 1987; and Azhar, 1991). In his study, Phillips (1994) used meta-analysis revised by Lockheed *et al.* (1980). While some studies examined the allocative efficiency of the production (Huffman, 1977; and Ram, 1980), some studies analyzed both technical and allocative efficiency (Welch, 1970; Ram, 1980; Pudasaini, 1982 and 1983; Duraiswamy, 1992 and 1994; and Mohapatra, 1998).

The pioneering work of Farrell (1957) on the measurement of efficiency and introduction of stochastic frontier models, independently proposed by Aigner *et al.* (1977) and Meeusen and van den Broeck (1977) and extended by Jondrow *et al.* (1982), was followed by a large number of empirical studies analyzing the technical, allocative and economic efficiency of the farms with special reference to education, age and experience of the farms using cross-sectional data (Kalirajan, 1981a, 1981b and 1991; Hwang and Bagi, 1984; Ali and Byerlee, 1991; Squires and Tabor, 1991; Bravo-Ureta and Pinheiro, 1997; Ajibefun *et al.*, 2002; and Ogundari *et al.*, 2006).

Methodology

Farrell (1957) distinguishes between technical and allocative efficiency (or price efficiency) as a measure of production efficiency through the use of frontier production and cost functions, respectively. He defined Technical Efficiency (*TE*) as the ability of a farm to produce a given level of output with minimum quantity of inputs under certain technology, and Allocative Efficiency (*AE*) as ability of a farm to choose optimal input levels at given factor prices. In Farrell's framework, Economic Efficiency (*EE*) is a measure of overall performance and is equal to the product of *TE* and *AE* ($EE = TE * AE$). However, Farrell's methodology has been applied to a wider range of studies with many refinements and improvements. Such refinements and improvements are the development of stochastic frontier model that enables one to measure farm-level efficiency using the maximum-likelihood estimation. The stochastic frontier model incorporates a composed error structure with two-sided symmetry and one-sided component. The one-sided component reflects inefficiency, while the two-sided component captures the random effects outside the control of production unit including measurement errors and other statistical noise typical of empirical relationship.

The economic application of stochastic frontier model is to measure the technical and allocative efficiency. The production technology can be represented in the form of cost function. The cost function represents the dual approach in that technology is seen as a constant towards the optimizing behavior of firms (Chambers, 1983). In the context of cost function, any error in optimization is taken to translate into higher cost for the producers. However, the stochastic nature of production frontier would still imply that the theoretical minimum cost function would be stochastic.

The cost function can be used simultaneously to predict both technical and allocative efficiency of a farm (Coelli, 1995). Also, it can be used to acquire all the economically relevant information about farm-level technology as it is generally positive, non-decreasing, concave, continuous and homogeneous degree (one) in the input prices (Chambers, 1983). In this study, Battesse and Coelli's (1995) model is used to specify a stochastic frontier cost function with behavior inefficiency component, to estimate all parameters together in one-step maximum likelihood estimation. The model is implicitly expressed as:

$$\ln C_i = g(Y_i, P_i : \alpha) + (v_i + \upsilon_i)$$

where C_i represents the total cost of production of the i^{th} farm household, g is a suitable functional form such as Cobb-Douglas, P_i is a vector variable of input prices, Y_i is the output of High-Yielding Variety (HYV) paddy (Swarna) (in kg), and α is the parameter to be estimated. The systematic component, v_i, represents random disturbances cost due to factors outside the scope of the farmers. It is assumed to be identically and normally distributed with zero mean and constant variance, $N(0, \sigma_v^2)$. υ_i is the one-sided disturbance term used to represent cost inefficiency and is independent of v_i. Thus, $v_i = 0$ for a farm whose cost lies on the frontier, $\upsilon_i > 0$ for farms whose cost lies above the frontier; and $\upsilon_i < 0$ for farms whose cost lies below the frontier. υ_i is identically and independently distributed as $N(0, \sigma_v^2)$. The two error terms are preceded by positive signs because inefficiencies are always assumed to increase the cost. Cost efficiency (C_{EE}) of an individual farm is defined in terms of the ratio of observed cost (C_{OB}) to the corresponding minimum cost (C_{MIN}), given the available technology.

$$(C_{EE}) = (C_{OB})/\ (C_{MIN}) = \{g(Y_i, P_i : \alpha) + (v_i + \upsilon_i)/g(Y_i, P_i : \alpha) + (v_i)\} = \exp(v_i)$$

(C_{EE}) takes the value of 1 or higher than 1 defining cost efficient farms. Following the adoption of Battesse and Coelli's (1995) framework for the analysis of data, the explicit Cobb-Douglas functional form for the HYV paddy data of the study area is therefore specified as follows:

$$\ln C_i = \alpha_0 + \alpha_1 \ln Y_{1i} + \alpha_2 \ln P_{1i} + \alpha_3 \ln P_{2i} + \alpha_4 \ln P_{3i} + \alpha_5 \ln P_{4i} + (v_i + \upsilon_i)$$

where C_i represents the total cost of production (in Rs.), Y_i stands for the total paddy output (in kg) produced by the i^{th} farm household, P_{1i} is the price of the labor hired by the i^{th} farm household, P_{2i} refers to the price of manures used, P_{3i} refers to the price of fertilizer, and P_{4i} refers to the price of pesticides used.[2] The choice of the Cobb-Douglas functional form is based on the fact that the function is self-dual as in the case of cost function on which the present analysis is based. The inefficiency model (U_i)[3] is defined by:

$$U_i = \delta_0 + \delta_1 EF + \delta_2 EX + \delta_3 EDU + D_1 EDU + D_2 EDU + D_3 EDU + \epsilon$$

where *EF* refers to the average education of the family, *EX* represents the experience of the effective head of the household, *EDU* refers to the levels of formal schooling years completed by the effective head of the farm household,[4] D_1 refers to education dummy for college level education, D_2 represents the higher secondary education dummy, and D_3 represents the primary and higher primary schooling dummy. These exogenous social variables are included to examine their impact on the cost efficiency of the farmers. The δ_is and D_is are the scalar parameters to be estimated. The variance of the random error, σ_v^2, and the cost inefficiency error, σ_u^2, and the overall variance of the model, σ^2 are related as: $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$, where γ measures the total variation of the total cost from the frontier, which can be attributed to cost inefficiency (Battesse and Corra, 1977). The estimates for all the parameters are simultaneously obtained using the program FRONTIER 4.1 (Coelli, 1996). The test for the presence of cost inefficiency using generalized likelihood ratio statistics, λ, obtained by $\lambda = -2\ln(H_o/H_a)$. If the null hypothesis is true, then λ has approximately a mixed chi-square distribution with degrees of freedom equal to the number of parameters excluded in the unrestricted model.

Data

This study employs primary data. Information on the socioeconomic profile, area under cultivation of paddy, total volume of production, input costs, quantities of different inputs used have been collected by interviewing 200 farm households of Goleipur Panchayat of Korei Block of Jajpur district of Orissa. A structured questionnaire was made to obtain the required information. The sample farm households have been selected on the basis of the purposive sampling technique. The specific study area has been selected because of the fact that the area is well-connected to NH-5 that connects Puri to Kolkata. Secondly, the area is situated near the river Kharashrota, a tributary of Brahmani. Hence, multiple cropping patterns are the general characteristics of the study area. Thirdly, all the big markets are connected to the area through the national highway. The well-connected area makes the farm people more dynamic and, hence, agriculture is said to be heading towards commercialization.

2 The cost of land, capital, bullock labor and family labor are considered as fixed cost. Irrespective of the production, most of the farm households spend specific and fixed amount on these inputs.

3 In this cost function, U_i now defines how far the farm operates above the cost frontier. If allocative efficiency is assumed, then U_i is closely related to the cost of technical inefficiency. If this assumption is not made, the interpretation of U_i in a cost function is less clear, with both technical and allocative inefficiencies involved. Thus, we shall refer to efficiencies measured relative to a cost frontier as 'cost' efficiencies in this study. The exact interpretation of these cost efficiencies will depend upon the particular application.

4 While collecting the sample, it has been observed that the head of the farm household, most often, is not the real cultivator. Hence, the family member who cultivates the farm takes the major decision regarding farm production. Hence, he is designated by the term 'effective head of the household'.

Analysis of the Results

Table 1 presents the summary statistics of the variables used in the frontier estimation. The mean value of the total cost of production (*C*) is Rs. 19,170 with a standard deviation of Rs. 6,352.92. The large standard deviation of total costs implies that the farms are operating at different scales of production. The mean value of the hired labor cost is Rs. 12,249.90 with a standard deviation of Rs. 3,756.06. It is 63.9% of the total cost of paddy production signifying the importance of hired labor. The positive attitude towards children's education makes the use of hired labor more prominent and significant.

Table 1: Summary Statistics of Variables in the Stochastic Frontier Model

(in Rs.)

Variable	Mean	Standard Deviation	Maximum	Minimum	% of Total Cost
Total Cost (*C*)	19,170	6,352.92	47,676	7,568	
Total Output (*Y*)	33,436	10,811.62	70,560	13,800	
Cost of Labor	12,249.9	3,756.06	24,960	5,760	63.9
Cost of Manure	354.136	120.93	848	67.2	1.847
Cost of Fertilizer	5,112.5	2,980.43	37,500	5,000	27
Cost of Pesticides	56.257	29.67	360	18	0.3
Cost of Tractor Hours	1,397.25	719.85	4,200	300	7.28
Average Education of the Family*	8.270	2.514	10	4	
Experience*	12.315	2.59	15	7	
Education of the Effective Head*	8.13	2.35	13	3	

Note: * Figures are in number of years.

The second important component of the total cost is the cost of fertilizer. The mean cost of fertilizer is Rs. 5,112.50 with Rs. 2,980.83 as the standard deviation. It has a 27% share in the total cost. Some farmers revealed that they generally compete with each other with respect to the use of fertilizers, however the soil quality is more fertile. The last important component is the cost of tractor hours. Even though the farmers maintain a full-fledged bullock-driven plough system, use of tractors is more frequent for two reasons: the time of cultivation is very less and the quality of cultivation is far better than that under the traditional methods. Thus, tractor ownership in each district has increased. It is also opined that frequent cultivation of land by tractor improves the quality of the soil.

The variables that are included in the inefficiency model are: average education of the family of the farm household (*EF*), experience of the effective head of the household (*EX*), years of schooling completed by the effective head of the household (*EDU*), and the three educational dummies D_1, D_2 and D_3 for college education, higher-secondary and primary and upper primary schooling of the effective head, respectively. The descriptive statistics of these variables are reported in Table 1.

Another important fact is that some farmers consider manures more effective than fertilizers and so use more manures instead of fertilizers.

The results of the maximum-likelihood estimates of the parameters—the value of output, price of labor, price of manure, price of fertilizer and price of tractor hours—of the stochastic cost frontier are presented in Table 2. The positive and significant input price coefficients indicate the monotonicity of the cost function with input prices. Since the amount of the cost of pesticides is very negligible, it has no significant imp..ct on the total cost. The result of presence of economies of scale among paddy farmers computed as inverse coefficient of cost elasticity with respect to paddy output (in kg), as the only output in the analysis, shows that economies of scale prevails among the sampled farms judging by the fact that E_s computed is greater than 1, i.e., E_s = 1.107. The economic implication of this value is that the sample farms despite being small scale in nature expand their production capacities in order to decrease their cost to the lowest minimum irrespective of their size of operation which shows that the farms are experiencing diminishing but positive return to scale (Stage II of production), since returns to scale and economies of scale are similar measures (Chambers, 1983). This proves the 'poor-but-efficient-hypothesis' advocated by Schultz (1964).

Table 2: Maximum-Likelihood Estimates of Parameters of Cobb-Douglas Frontier Function for the HYV Paddy Farmers in Orissa

Parameters of Variables	Estimate of Parameters	*t*-value of Parameters
β_0 (Constant)	0.20410	2.1890**
β_1 (Output)	0.90310	10.6100***
β_2 (Labor Price)	0.36010	15.5100***
β_3 (Price of Manure)	0.05980	7.2100***
β_4 (Price of Fertilizer)	0.31250	4.1970***
β_5 (Price of Pesticide)	0.09890	1.0140
β_6 (Price of Tractor Hours)	0.32381	3.3468***
δ_0 (Constant of Inefficiency)	–0.22400	0.4294
δ_1 (Average Education of Family)	0.00889	1.7000
δ_2 (Experience of the Effective Head)	–0.07510	17.0700***
δ_3 (Education of the Effective Head)	–0.03080	2.2150**
δ_4 Education Dummy1	–0.07040	2. 3940**
δ_5 Education Dummy 2	–0.03780	7.5400***
δ_6 Education Dummy 3	–0.11570	0.2226
σ^2	0.13340	8.2240***
γ	0.75400	7.4860***
Log Likelihood Ratio Test	154.09200	

Note: ** and *** denote 5% and 1% significance levels, respectively.

The estimated coefficients of the explanatory variables in the model are also presented in Table 2. The results pertaining to cost inefficiencies are of interest and have important implication. The average education of the family shows a positive, but insignificant effect on cost inefficiency. The implication is that more educated family gives least importance to the farming practice and performs it for fulfilling the family need of foodgrains. The experience and the years of schooling of the effective head show negative and statistically significant effect on cost efficiency. More experience enables the farmer to utilize the latest available technology that helps in reducing the cost of production.

With regard to the years of schooling of the effective head used as a dummy variable, it was found that the farmers with college level and high school level of education make significant contribution in reducing the cost inefficiency. The implication is that the adaptiveness of decoding and diffusing the information regarding input prices, input quality, timely use of inputs, understanding the use of different fertilizers and pesticides by the farmers who have higher education becomes stronger. However, the farmers having primary and upper primary schooling have no significant contribution in reducing cost inefficiency. Choudhuri has articulated this idea as 'lapses into illiteracy'. According to Nelson-Phelps-Schuitz hypothesis, the effect of education is supposed to differ overtime and as time passes new technological diffusions are made in the field of agriculture, the knowledge either from primary or higher primary schooling is totally outdated to grasp and implement them.

The log likelihood ratio test for the parameters of the stochastic cost function shows that the null hypothesis that there is no difference between OLS and stochastic frontier model is rejected. The estimated γ of the model is 0.754 and is significant at 1% level. Hence, it indicates that about 75% of the variation in the total cost of production among the sample farmers is due to the variations in their cost efficiencies.

Table 3 shows the cost efficiency frequency distribution of the HYV paddy farmers as estimated from $C_{EE} = \exp(u_i)$. The mean cost efficiency of the farms is estimated as 1.130 implying that an average effective farm in the sample area has costs that are about 13% above the minimum defined by the frontier. The higher the value of C_{EE}, the more inefficient the HYV paddy farm. However, the percentage of frequencies of the predicted cost efficiency between

Table 3: Frequency Distribution of Cost Efficiency

Class Interval (C_{EE})	Frequencies	Percentage
1.00-1.09	88	44.0
1.10-1.19	68	34.0
1.20-1.29	38	19.0
1.30-1.39	3	1.5
1.40-1.49	3	1.5
1.50-1.59	0	0

1 and 1.09 is 78% and for the interval 1.2-1.29 is 19%. The rest is between 1.30 and 1.49. Hence, a majority of the effective farm households are fairly efficient in producing a given level of output using the cost minimizing input ratio, which reflects the farmers' tendency to minimize the resource wastage associated with the production process from the perspective of cost.

Conclusion

This study measures the cost efficiency in the HYV paddy production using a stochastic frontier cost function. A Cobb-Douglas functional form is used to impose the assumption that returns to scale and economies of scale are equivalent measures if, and only if, the production function is homothetic. The outcome of the analysis shows that about 78% of the farms included in the sample operate close to the frontier level of cost, achieving about 13% or lower in terms of cost difference in comparison to the best practiced technology. The cost efficiency is significantly improved by the level of education and experience of the effective head of the household.

In conclusion, it can be argued that greater emphasis should be given to the introduction of farming-related concepts in the course curriculum at high school and college level education. Since, formal education makes the students more inclined towards industry and service sector, the participation in farming becomes an optional or sometimes unattractive occupation. Hence, initiatives, both at government and private level, for reorientation of the educational system should be taken so that it can give much priority to agriculture. As far as the State of Orissa is concerned, the research institutions such as Central Rice Research Institute (CRRI) and Orissa University of Agriculture and Technology (OUAT) could play an important role in bridging the gap between laboratory research and field application by the farmers. Therefore, formal education with special reference to farm management will definitely help in bringing a sea change in the agrarian economy of Orissa. ○

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