Cost efficiency of principal crops in Bihar (India) -A stochastic frontier approach

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K. M. Singh
Dr Rajendra Prasad Central Agricultural University Pusa

Nasim Ahmad
Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur)

D.K.Sinha Sinha
Rajendra Agricultural University

Abhay Kumar
ICAR Research Complex for Eastern Region

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Cost efficiency of principal crops in Bihar (India) – A stochastic frontier approach

K M SINGH[1], NASIM AHMAD[2], D K SINHA[3], ABHAY KUMAR[4] and R K P SINGH[5]

Dr Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar 848 125, India

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ABSTRACT

In the present study, an attempt has been made to test the cost efficiency of cereal crops like paddy, wheat and maize separately in the state of Bihar using Stochastic Cost Frontier model. It has been tried to determine the determinants of cost inefficiencies. The study is also aimed to know the factors affecting the cost inefficiencies in production of major cereals of the state so as to ascertain proper steps to increase cost efficiency in production. Most important observation emerged that there existed non-linear relationship between cost inefficiency and farm category. Cost inefficiency first increased with the increase of farm size then it decreased. In case of paddy mechanization could negatively affect the cost inefficiency and proportion to family labour in total labour was found positive implying increase in cost inefficiency. But in wheat, family labour showed positive value, indicating thereby increase in cost inefficiency. In case of maize, coefficient of fertilizer use was observed positive indicating increase in cost inefficiency. Coefficients of land holding size were positive in all the crops for all categories of farms. This advocated non-linear relation between farm category and cost inefficiency which showed larger farms were less cost efficient. The cost inefficiency depends on proportion of family labour, mechanization, type of seed used. The result enables to identify the determinants of cost inefficiency, which will certainly guide the state to adopt suitable policies. Farmers may be made aware about rational allocation of resources to reduce cost and make farming cost efficient.

Key words: Cereals, Conservation, Cost frontier model, Cost inefficiency

Indian agriculture has witnessed many changes during the last century. It has fed millions of people which seemed impossible earlier. The soaring population, higher incidence of poverty, large economic inequality and rudimentary infrastructure are still the challenging task for the nation. The problem is more glaring in rural area where about 65 percent of people still depend on agriculture and allied sector (Patnaik *et. al.* 2015). No doubt, India has got self sufficiency in food grains production by producing 275.11 million tonnes of food grains in about 129.23 million ha of land with an average productivity of 2129 kg/ha in 2016-17, the conditions of the cultivators are still doleful.

Agriculture is, however, currently facing a dilemma. While it has made large strides in achieving the agricultural development goals of food security, availability and accessibility, it is still being challenged by pitiable conditions of the farming community. This situation has recently led to relook the developmental approach in the agriculture sector. The need for focusing on the welfare and prosperity of farmers has gained prominence. In this fresh approach, priority is to be accorded for making the agriculture and allied sector not only ecologically sustainable in the use of natural resources like soil and water, but also socio-economically sustainable to farmers in terms of prosperity, welfare and social security. Innovating managerial solutions to maximize farmers' income rather than relying solely on modern farming to raise productivity and production- is the clarion call of the day. Doubling the income of the farming community is much talked about among planner, policy makers, researcher and stakeholders of the nation (Anonymous 2017).

Development strategies in agriculture are partly guided by farm level performance. The farm level performance can be achieved by maximizing output with the given combination of various production technologies or minimizing production cost to produce optimal level of output. The later concept is known as cost efficiency. Cost efficiency is used as a tool to measure cultivator's ability to produce maximum output from optimum combinations of inputs. Further, the cost reduction seems to be more important to increase farmers' production profits in this context. Cost efficiency is explicitly input-oriented, which

[1]Professor of Agricultural Economics (m.krishna.singh@gmail.com), [2]Senior Technical Officer (Agricultural Economics), Corresponding author (nasim.rau@gmail.com), [3]Professor and Head, Department of Agricultural Economics, RPCAU, Pusa (dhruvkishor2014@gmail.com), [4]Principal Scientist (Agril. Statistics), ICAR-RCER, Patna (akumar1904@gmail.com), [5]Former Advisor, Farmer's Commission, Bihar (rkpsingh2k3@rediffmail.com)

indicates the ability to obtain predetermined output at minimum cost with respective input prices (Khai and Yabe 2011; Farrell 1957; Coelli *et al.* 2002 &2005; Battese 1992; Reinhard *et al.* 1999 & 2000). Cost minimization will make cultivators to fetch more income from the produce.

Bihar is endowed with bountiful natural resources of fertile soil, abundant groundwater and varied climatic conditions and sizeable working population. However, the declining trend in area and by and large, stagnant productivity scenario exist in almost all major crops in the state of Bihar. This sluggish growth performance of Bihar agriculture may be due to failure in tapping the proper resource use efficiency of different scarce inputs. The percentage of population employed in agricultural production system in the state is estimated at 77%, which is much higher than the national average but agriculture contributes nearly 19% to the GDP of the state. Although the area under cultivation is shrinking, there is tremendous scope for income generation by improving productivity through optimization of resource use (Sinha *et al*. 2016)

The gross and net sown area in the state is estimated at 79.77 lakh ha and 52.52 lakh ha, respectively. The intensity of cropping is 142 which need to be stepped up. At present, the problems/crises those faced by the farming community are stagnating growth in agricultural production and productivity, rising average cost of production, declining net income in farming, sizeable input subsidy amount, excessive use of water and land resources leading to deterioration of overall environment and ecological balance (Raju *et al.* 2015) The ongoing agricultural scenario warrants sustainability in agricultural production and natural resource base (Singh *et al.* 2014).

In the present study, an attempt has been made to investigate how different farming groups use the different inputs so as to enhance their cost efficiency in the production of major cereal crops like paddy, wheat and maize in the state of Bihar where about 91% of the farmers are marginal. Hence, it is of utmost importance to see whether there is any relationship between cost efficiency and farm size categories in the state in the production of paddy, wheat and maize.

The use of cost function for estimating production factor has several advantages. Cost efficiency mainly points out whether the optimum level of output is being produced at minimum cost by efficient allocation of inputs. Even though, the farms are technically efficient, the farms are not allocatively efficient, thus the farm will be cost inefficient. The main focus of the investigation is to examine whether the farms are both technically and allocatively efficient, this is only possible when farms are cost efficient. In this investigation, cost efficiency has been analyzed for different size group of farms growing cereal crops like paddy, wheat and maize in the state.

MATERIALS AND METHODS

The plot level data of comprehensive cost of cultivation scheme for major cereal crops grown during the year 2013-14 in the state of Bihar have been used. The data is available at the website of Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Govt. of India. The sample farms were categorized into three size groups as marginal farms (<1 ha), small farms (1-2 ha) and medium farms (2-4 ha) for paddy and wheat. Large farms were very few; hence, this category of farms was not included in analysis. Since, there was less number of category wise observations for maize crops; hence, the analysis was followed for the state as a whole.

There are certain advantages of using cost function. In case of cost function there is no necessity to impose the homogeneity condition since cost function is always homogeneous of degree zero in terms of prices. The explanatory variables, input prices are independent of each other therefore; the problem of multicollinearity is not encountered. Cost efficiency actually helps us to derive how efficiently each of the farm sizes are using their resources. Cost efficiency is a product of allocative efficiency and technical efficiency for the Cobb-Douglas form of cost function (Coelli *et al.* 1998). Even if the firms are technically efficient in terms of production in case of resource utilization they may not be efficient. Allocative efficiency means that ratio of marginal products of the inputs are equal to their prices. If only technical efficiency is being considered then we cannot infer anything about allocative efficiency. In recent times when the resources are limited we will have to look also on how the resources are being utilized, simply looking into production side will not help us in answering the question on resource use efficiency. In this investigation, cost efficiency has been examined.

Efficiency measurement can be categorized as either input or output oriented, input oriented technical efficiency estimates that how much input can be reduced without changing the quantities produced while output oriented measures of efficiency evaluates the extent to which output quantities can be expanded without changing the input quantities use. Efficiency estimation can best be demonstrated by relating both allocative and technical efficiency, Farrell's methodology has been applied widely with many refinements. So to be the best cost efficient, the farms have to be both technically and allocatively efficient.

In this investigation, it has been tried to examine the cost efficiency assuming parametric approach. For each farm size group, cost efficiencies were computed using Stochastic Cost Frontier model (Error Component Model) having the parametric model:

$$C_i = C(Y, P_i, \beta) + v_i + u_i$$

where Y is output (production), P_i represents price of i^{th} input used and β is parameter, v_i and u_i are two error terms. v_i is the random error which are beyond the control of the cultivator like, weather, diseases etc. u_i is error due to socio-economic condition of the cultivators which is technical inefficiency and is non-negative. The log transformed form of the above equation is as follows:

$$LnC_i = Ln(Y, P_i, \beta) + v_i + u_i$$

This cost function defines u_i that is how far the farms operate above the cost frontier (Schmidt and Lovell 1979). They have pointed out that the log likelihood of the cost frontier is that of production frontier except for a few sign changes. The log likelihood functions identical to the Battese and Coelli (1995) model were obtained by simply changing sign. Frontier 4.1 program was used to estimate the cost frontier. It will calculate the predictions of individual farm cost efficiencies from estimated stochastic cost frontier. The measure of cost efficiency relative to the above cost function is given as

$$CE_i = \frac{E(C_i^* / u_i, P_i}{E(C_i^* / u_i = 0, P_i)}$$

C_i^* will be equal to exp (C_i) when the dependent variable is in log. The value of CE_i ranges from one to infinity. More the value of CE_i, less efficient will be the farm. Since the numerator contains inefficiency term u but, the denominator does not contain inefficiency term.

Maximum Likelihood Estimate (MLE) has been applied for estimation of the cost function. MLE not only estimates parameters β_0, β_i and μ but also the two variances of v_i and u_i. These values of variances can be used to measure the value of γ which is the contribution of the technical and cost efficiency of the total residual effect. Γ is the ratio between the variance of u and total error variance. Therefore, the values of γ are between 0 and one ($0 \leq \gamma \leq 1$).

$$\gamma = \frac{\sigma_{\mathbf{u}}^2}{\sigma_{\mathbf{u}}^2 + \sigma_{\mathbf{v}}^2}$$

Using MLE method, the value of β and cost inefficiency estimates γ and CE were obtained.

$$CE_i = \frac{\text{Actual cost}}{\text{Minimum cost}}$$

and the value is ≥ 1 if the farms are cost inefficient. Following stochastic frontier Cobb-Douglas cost function has been used in the study:

$$LnC = Ln\beta_0 + \beta_y LnY + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + \beta_6 LnX_6 + v_i + u_i$$

where, X_1= human labour cost (in ₹), X_2= animal labour cost (in ₹), X_3= Machine labour cost (in ₹), X_4= irrigation cost (in ₹), X_5 = seed cost (in ₹), X_6 = fertilizer cost (in ₹).

The estimates of cost efficiency have been regressed on other farm related variables to examine factors causing cost inefficiency. The factors that have been taken into the analysis are proportion of family labour to total human labour, seed type, farm size, fertilizer quantity used and mechanization index. In order to examine non-linear relationship between cost inefficiency and farm size, square of farm size term has also been incorporated in the model.The proportion of family labour that has been used in particular farm may influence the cost efficiency. Mechanization and fertilizer use may enhance the productivity but at the same time they entail cost so whether the machinery and fertilizers have been efficiently utilized or not will be taken care off. The seeds are of two type traditional and improved variety. Type of seed may be one of the factors influencing cost efficiency.

In case of stochastic frontier cost production function, error component have a positive sign as inefficiency enhances production cost (Colli *et al.* 1998). Since, inefficiencies for each of the crop for each size groups had been calculated individually then separate regression analysis had been carried out to determine influence of each of the factors on the cost inefficiency for each crops for each of the farm size separately. The cost inefficiency model is described as follows:

Cost inefficiency

= a + θ_1 Proportion of family labour + θ_2 seed type + θ_3 farm size + θ_4 fertilizer + θ_5 mechanization + θ_6 square of farm size + u

where, u is the random error term.

RESULTS AND DISCUSSION

The data used in this investigation of sample farms were taken from cost of cultivation survey data for the state of Bihar for the crop year 2013-14. Table 1 contains total sample size and farm size-wise distribution of crops under study. In case of paddy, the marginal, small and medium farms constituted about 69.33%, 22.30% and 8.37%. Almost similar trends were observed in case of wheat. In Bihar, about 91% farms are marginal.

ML estimates of farm-size specific stochastic frontier cost function model for cereal growing farms

The cost inefficiency has been obtained by applying stochastic frontier model (error component). The coefficients of stochastic cost function for different farm sizes and overall are presented in Table 2.

ML estimates of paddy

In case of paddy, the generalized likelihood ratio (LR) statistic for testing hypothesis for the absence of inefficiency effects in the Cobb-Douglas stochastic cost frontier were 5.84, 3.80, 2.97 and 11.95, respectively for marginal, small, medium and overall farms. The calculated LR statistics were statistically significant in all the cases, indicating that the null hypothesis that there were no cost efficiency effects in Cobb-Douglas stochastic cost function was rejected. The estimates of γ values of 0.624, 0.491, 0.564 and 0.709, respectively were estimated for marginal, small, medium and overall farms. The levels of γ values in the present study

Table 1 Distribution of sample according to size categories

Crops	Number of farms	Marginal (0-1 ha) (%)	Small (1-2 ha)(%)	Medium (2-4 ha)(%)
Paddy	1027	69.33	22.30	8.37
Wheat	1027	65.14	26.97	4.97
Maize	124	-	-	-

Table 2 Maximum Likelihood Estimates of the stochastic cost frontier for different size groups of farms

Farm category	Factors	Paddy		Wheat		Maize	
		Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Marginal	Constant	-0.574E+01*	0.208E+00	-0.551E+01*	0.143E+00	-	-
	LnX_1	0.682E+00*	0.380E-01	0.558E+00*	0.402E-01	-	-
	LnX_2	-0.420E-01*	0.151E-01	-0.555E-01*	0.617E-02	-	-
	LnX_3	-0.231E-01***	0.179E-01	0.278E-01*	0.944E-02	-	-
	LnX_4	-0.744E-01*	0.560E-02	-0.142E-01*	0.551E-02	-	-
	LnX_5	0.165E+00*	0.378E-01	0.899E-01*	0.336E-01	-	-
	LnX_6	0.205E+00*	0.270E-01	0.337E+00*	0.230E-01	-	-
	σ^2	0.147E+00	0.359E-01	0.117E+00	0.112E-01	-	-
	γ	0.642E+00	0.109E+00	0.832E+00	0.448E-01	-	-
	Log likelihood	-0.187E+03		0.402E+02		-	-
	LR test of the one sided error		5.84	79.06			
Small	Constant	-0.517E+01*	0.565E+00	-0.711E+00	0.589E+00	-	-
	LnX_1	0.509E+00*	0.902E-01	0.538E-01	0.931E-01	-	-
	LnX_2	0.363E-01	0.324E-01	-0.174E-01*	0.122E-01	-	-
	LnX_3	0.984E-01*	0.379E-01	-0.101E-01	0.119E-01	-	-
	LnX_4	-0.798E-01*	0.905E-02	-0.258E-01	0.851E-02	-	-
	LnX_5	0.101E+00***	0.776E-01	0.153E+00**	0.703E-01	-	-
	LnX_6	0.288E+00*	0.472E-01	0.279E+00*	0.465E-01	-	-
	σ^2	0.134E+00	0.392E-01	0.171E+00	0.166E-01	-	-
	γ	0.491E+00	0.356E+00	0.987E+00	0.668E-02	-	-
	Log likelihood	-0.775E+02		0.213E+02		-	-
	LR test of the one sided error		3.80	27.90			
Medium	Constant	-0.456E+01*	0.656E+00	-0.376E+01*	0.155E+01	-	-
	LnX_1	0.559E+00*	0.121E+00	0.347E-02	0.116E+00	-	-
	LnX_2	-	-	0.148E-01***	0.748E-02	-	-
	LnX_3	0.296E-01**	0.185E-01	-0.347E-01**	0.162E-01	-	-
	LnX_4	-0.427E-01	0.426E-01	-0.166E-01***	0.102E-01	-	-
	LnX_5	0.159E+00***	0.107E+00	0.829E+00*	0.549E-01	-	-
	LnX_6	0.984E-01	0.101E+00	0.978E-01**	0.517E-01	-	-
	σ^2	0.152E+00	0.68E-01	0.663E-01	0.693E-02	-	-
	γ	0.564E+00	0.407E+00	0.999E+00	0.219E-02	-	-
	Log likelihood	-0.216E+02		0.334E+02		-	-
	LR test of the one sided error		2.97	33.36			
Overall	Constant	-0.573E+01*	0.147E+00	-0.561E+01	0.112E+00	-0.424E+01*	0.471E+00
	LnX_1	0.647E+00*	0.318E-01	0.509E+00	0.338E-01	0.704E-01	0.104E+00
	LnX_2	-0.114E-01	0.105E-01	-0.525E-01	0.576E-02	-	-
	LnX_3	0.177E-01***	0.112E-01	0.148E-01	0.728E-02	0.543E-01**	0.315E-01
	LnX_4	-0.777E-01*	0.474E-02	-0.171E-01	0.449E-02	0.717E-01*	0.129E-01
	LnX_5	0.143E+00*	0.298E-01	0.175E+00	0.297E-01	0.328E+00*	0.416E-01
	LnX_6	0.235E+00*	0.221E-01	0.336E+00	0.199E-01	0.432E+00*	0.592E-01
	σ^2	0.196E+00	0.192E-01	0.140E+00	0.901E-02	0.106E+00	0.419E-01
	γ	0.709E+00	0.658E-01	0.889E+00	0.199E-01	0.306E+00	0.467E+00
	Log likelihood	-0.304E+03		0.204E+02		-0.236E+02	
	LR test of the one sided error		11.95	58.52	0.06		

*,** & *** indicate significant at 1%, 5% and 10% level of probability

indicate that inefficiencies in individual farms explained high proportion variations in cost of paddy cultivation. The statistical significance of γ values also indicates that the stochastic cost frontier models were significantly different from the OLS models in which there were no random errors in the cost function.

In case of marginal farms for paddy cultivation, the coefficients of animal labour cost, machine labour cost and irrigation cost were negative and significant indicating that these factors would increase the cost inefficiency in case of marginal farms in cultivation of paddy. It may be due to poor economic conditions of marginal farmers, who were not able to afford the cost of machine labour and irrigation. Keeping animals only for cultivation is also a costly affair for the marginal farmers. In case of small and medium farm size groups only coefficient of irrigation charge was found negatively resulting thereby enhancement in cost inefficiency.

For overall condition, the coefficient of animal labour charge was negative and irrigation charge was estimated negatively significant. Very few farmers are using animals labour for crop production in the state and having animals only for cultivation purposes is a costly affair and farm operations using animal labour is also time consuming. The coefficient of irrigation charge was also estimated negatively significant. Irrigation is mostly done through diesel pumps, which is also costlier.

ML estimates of wheat

In case of wheat, the LR statistic for testing the null hypothesis for absence of inefficiency effects in Cobb-Douglas stochastic frontier cost function was also 27.90, 58.52, 33.36 and 79.06 in case of marginal, small, medium and overall farms groups. These statistics were significant implying that the null hypothesis that there were no cost efficiency effects rejected. The estimates of γ values of 0.832, 0.987, 0.999 and 0.889 for marginal, small, medium and overall groups were very high and significant, indicating that the frontier model was different from OLS model. The high values of γ imply that inefficiency effects in individual farms explain a very high proportion of variation in cost of wheat cultivation in all the farm sizes under investigation.

The MLE estimate of different farm sizes of wheat indicated that coefficient of animal labour charge was negative reflecting the decline in use of animal labour in farming. Coefficient of machine labour cost was found negative in small and medium farm sizes indicating that use of machine will increase the production cost as a large number of farmers do not have their own machineries and they hire them which increases the cost of production. Hence, the cost inefficiency in wheat would increase. The same situation was observed in irrigation charges in all size groups of wheat farms. The irrigation is done by diesel pump set which is more costly as compared to electric pump sets. Hence, the cost of production of wheat went up causing cost inefficiency.

ML estimates of maize

In case of maize the LR statistic was estimated to be highly insignificant (0. 06) implying that the null hypothesis for absence of inefficiency effect was accepted. The γ values was also low (0.306), indicating that inefficiency effects explained was less proportion of variation in cost of maize production. This implies that the frontier model was not significantly different from the OLS model. The coefficients of the variables taken into the model had positive and significant effects. Use of animal labour was not found in any farm sizes in the sample.

Determinants of cost inefficiency in cereal crops

Table 3 presents the farm size wise cost efficiencies of the crops. From the table it may be observed that in case of paddy cost inefficiencies were found 21.4%, 14.5%, 28.4% and 38.3% for marginal, small, medium and overall farm sizes. The small farms were comparatively efficient. It may be due to efficient allocation of inputs and their price combination on small farms as compared to marginal and medium resulting in increase in cost inefficiency. The results indicated that 21.4%, 14.5%, 28.4% and 38.3% cost can be minimized by optimal allocation of human labour cost, machine labour cost, seed cost, irrigation charges and fertilizer cost by marginal, small, medium and overall farms in the state.

In case of wheat medium farms were found more cost efficient than that of marginal and small. Findings indicate that medium farmers generally cultivate wheat more efficiently using modern technologies like high yielding variety, use of machinery and other inputs which may increase the yield but increase cost inefficiency. The cost of wheat cultivation can be minimized by 30.4%, 42.8% 21.8% and 35.5%, respectively by allocating right combination of inputs keeping the prevailing market prices of these inputs in consideration. The results of cost inefficiency in maize pointed out that maize cultivation was more cost efficient as compared to paddy and wheat. The average efficiency score for maize was estimated 1.162, indicating that 16.2% cost can be minimized by optimal allocation of human labour cost, machine labour cost, seed cost, fertilizer cost and irrigation charges. The poor socio-economic conditions of farmers and their lack of knowledge about modern technologies of cultivation and preference of purchasing inputs from local markets resulted in high cost inefficiency

Table 3 Cost inefficiencies of different size groups during 2013-14 for major cereal crops

Farm size	Cost inefficiency		
	Paddy	Wheat	Maize
Marginal (0-1 ha)	1.214	1.304	-
Small (1-2 ha)	1.145	1.428	-
Medium (2-4 ha)	1.284	1.218	-
Overall	1.383	1.355	1.162

*Lower value denotes more efficient

on these farms. Wheat and *rabi* maize (for which Bihar is one of the leading state) requires irrigation and use of machinery which resulted in more cost of production.

To determine the factors influencing the cost efficiency, regression analysis was carried out for different farm sizes for individual crops like paddy, wheat and maize. The results of the findings are presented in Table 4.

It has been noticed that modern cultivation practices like use of modern seeds and mechanization resulted in increase in cost inefficiency. Bhatt and Bhatt (2014) suggested that technical efficiency goes up with the use of high yielding quality seeds. Technically efficient farmers may be more cost efficient as compared to technically inefficient ones.

Factors influencing cost efficiency of paddy

In case of paddy, coefficients of seed type and mechanization were found negative and significant which leads to reduction in cost inefficiency of the marginal size group. In case of small farms, fertilizer use and mechanization were found negative and in medium farms the coefficient of proportion of family labour and seed type and mechanization were obtained negative. The reason may be that marginal farmers were resource poor, and in marginal land mechanization is costly. The small farmers were using less fertilizers and mechanization was poor which may be one of the reasons for cost inefficiency. Medium farmers have used more hired labour and lack of quality seed and lack of mechanization caused cost inefficiency. In case of overall farm sizes, coefficient of fertilizer use and mechanization were found negative indicating that fertilizers are underutilized in the state. Farm size influenced the cost inefficiency positively in all farm size groups. This addresses with increase in farm size, cost efficiency decreases. But the effect of square of land holding size on the cost inefficiency was recorded negative in all classes of farm except marginal. This finding suggested that with

Table 4 Factors influencing cost inefficiency of paddy cultivation

Farm category	Factors	Paddy		Wheat		Maize	
		Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Marginal	Constant	3.189*	0.358	1.329	0.132	-	-
	Proportion of family labour	0.183	0.217	0.149*	0.048	-	-
	Seed type	-1.530*	0.268	-0.174	0.111	-	-
	Fertilizer (kg)	0.001	0.002	-0.004*	0.001	-	-
	Land holding size (ha)	1.381**	0.599	0.917*	0.238	-	-
	Mechanization	-18.703***	9.692	0.276	0.313	-	-
	Square of land holding size	0.813**	0.342	-0.243	0.223	-	-
Small	Constant	1.138*	0.038	0.007	0.935	-	-
	Proportion of family labour	0.022	0.028	0.302**	0.153	-	-
	Seed type	0.001**	0.001	0.231	0.184	-	-
	Fertilizer (kg)	-0.0004*	0.0001	-0.003*	0.001	-	-
	Land holding size (ha)	0.091**	0.044	1.709	1.440	-	-
	Mechanization	-3.331*	0.734	0.585	0.571	-	-
	Square of land holding size	-0.039**	0.016	-0.391	0.565	-	-
Medium	Constant	1.380	0.124	8.767	9.911	-	-
	Proportion of family labour	0.294	0.540	0.839	0.526	-	-
	Seed type	-0.003	0.002	-0.108	0.228	-	-
	Fertilizer (kg)	0.0001	0.0003	-0.001**	0.001	-	-
	Land holding size (ha)	0.010	0.047	-6.070	8.194	-	-
	Mechanization	-2.477	2.816	-2.549	1.693	-	-
	Square of land holding size	-0.620	1.234	1.346	1.650	-	-
Overall	Constant	1.288*	0.059	1.356	0.129	0.046	0.028
	Proportion of family labour	0.002	0.040	0.169*	0.047	0.113*	0.018
	Seed type	0.110*	0.047	-0.168	0.119	-6.78E-06	0.0001
	Fertilizer (kg)	-0.0002	0.0002	-0.003*	0.001	0.052***	0.031
	Land holding size (ha)	0.048	0.065	0.412*	0.073	-0.803*	0.215
	Mechanization	-3.370**	1.530	0.315	0.274	-0.003	0.010
	Square of land holding size	-0.005	0.025	0.007	0.027	1.031	0.033

*, ** & *** Significant at 1%, 5% & 10% level of probability

increase in farm size cost inefficiency also goes up but after certain level it improves. The relationship between farm size and cost inefficiency is non-linear. The findings indicated that cost efficiency decreases up to a certain level then it increase with increase in farm size. This finding is in conformity with the results of Bhatt and Bhatt (2014) who found in their study that technical efficiency was more in smaller farm classes than that of others. They also pointed out that square of farm size was positively related with the technical efficiency. It may be concluded that cultivator with small farms size uses the land and other resources assiduously. Coefficient of fertilizer use for all classes of farm was observed negatively related with cost inefficiency indicating use of fertilizer will enhance the productivity but it will also push up the production cost. Coefficient of mechanization in paddy cultivation was found negative in all size classes. Hence, it may be inferred that mechanization decreases the cost inefficiency in all farm sizes. It may be due to saving in labour cost and mechanized farms enhances the technical efficiency leading to produce optimal level of output with right combination of input prices.

Factors influencing cost efficiency of wheat

Coefficient of proportion of family labour to total labour was found positive and significant in all classes of farms except in marginal farms, where it was insignificant which accelerates cost inefficiency of wheat production, i.e. it will reduce the cost efficiency. When higher proportion of family labour is utilized for cultivation it will be more cost effective than that of hired labour. Seed type in all size groups except small size farm has negative addressing use of modern quality seeds enhance the cost efficiency in cultivation of wheat. In case of small farm size cultivators may not be using quality seeds, or seed was underutilized leading to decrease cost efficiency. Farm size affected the cost inefficiency positively in all size groups except medium farm size. This advocated non-linear relation between farm size and cost inefficiency in case of all classes except medium size group. This shows larger farms are less cost efficient. But the effect of square of land holding size on the cost inefficiency was recorded positive in medium and overall farm size and negative in case of marginal and small. This finding suggested that with increase in farm size cost inefficiency also goes up in case of medium and overall size groups of wheat cultivating farms. But in case of marginal and small it exhibited linear relation that is with increase in farm size cost inefficiency decreases. The findings indicated that cost efficiency decreases up to a certain level then it increase with increase in farm size in case of medium and overall size groups of wheat cultivating farms. It may be concluded that cultivator with marginal and small farms were technically inefficient in case of wheat cultivation. Coefficient of fertilizer use for all classes of farm size was observed negatively related with cost inefficiency indicating use of fertilizer will enhance the productivity but it will also accelerate the cost of production of wheat. Coefficient of mechanization in wheat farming was computed positive in all size classes. Hence, it may be pointed out that mechanization decreases the cost inefficiency in all farm sizes. The reason may be saving in hired labour cost and mechanized farms may enhance the technical efficiency leading to higher production.

Factors influencing cost efficiency of maize

Coefficient of proportion of family labour to total labour in case of maize was computed positive and significant indicating farmers used more family labour thus reducing cost inefficiency. Coefficient of fertilizer use was computed positively significant in maize. The farmers might have used more fertilizers causing increase in inefficiency. Farm size affected the cost inefficiency negatively. This advocated non-linear relation between farm size and cost inefficiency. This shows increase in farm size accelerate cost efficiency. But the effect of square of land holding size on the cost inefficiency was recorded positive. This finding suggested that with increase in farm size cost inefficiency also goes up but after certain level it improves. There is non-linear relation between farm size and cost inefficiency. Coefficient of mechanization in maize farming was computed negative. Hence, it may be pointed out that mechanization increase the cost inefficiency. The reason may be mechanization of small farms may not be cost effective thereby enhancing the cost inefficiency.

In the present study, attempts have been made to investigate how the different farming groups use the different inputs for production for increasing their cost efficiency in the production of major cereal crops like paddy, wheat and maize in the state of Bihar.

The cost inefficiency has been obtained by applying stochastic frontier model (error component). The results depicted that coefficients of irrigation in all the farm categories in case of paddy and wheat cultivation were assessed negative indicating that cost efficiency would increase with decrease in cost of irrigation. From the result it was observed that in case of paddy small farms were found more cost efficient than that of others farms. But in case of wheat medium farms size was found more cost efficient than that of marginal and small. The results of cost inefficiency in case of maize pointed out that maize farms were more cost efficient as compared paddy to and wheat.

Coefficient of proportion of family farm labour to total farm labour was found positive and significant in all classes of farms except in marginal farms in case of wheat. Seed type in all size groups except small size farm was found negative. Farm category affected the cost inefficiency positively in all size groups except medium farms. This advocated non-linear relation between farm size and cost inefficiency. Coefficient of fertilizer use for all classes of farm size was observed negatively related with cost inefficiency indicating use of fertilizer will enhance the productivity but it will also accelerate the cost of production of wheat. Coefficient of mechanization in wheat farming was computed positive in all size classes, indicating that mechanization decreases the cost inefficiency in all farm sizes. Coefficient of proportion of family labour to total labour in case of maize was computed positive and significant indicating farmers used more family labour which reduces cost inefficiency.

The investigation pointed out that there was non- linear relationship between cost inefficiency and farm category. The other factors which affected the cost inefficiencies in cereal crops production in the state like proportion of family labour, seed type, use of fertilizers and mechanization were also examined. The study will enable the policy makers to know the factors affecting the cost inefficiencies in state level for production of major cereals so that state may undertake proper policies to increase cost efficiency in production. The observant result may aware cultivators to know the determinants of cost inefficiency and guide farmers to adopt suitable measures to overcome cost inefficiencies thereafter.

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