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ARTICLES

Factors Affecting Cost Efficiencies of Rice Production of Indian States: A Stochastic Frontier Approach

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ABSTRACT

In this paper we have tried to estimate cost inefficiencies of rice production for twelve major rice producing states of India using farm level data at two points of time namely 2000 and 2013 using stochastic frontier cost function. After that we have tried to determine the determinants of cost inefficiencies. Our main objective is to examine whether there exists any relationship between cost inefficiencies and farm size. Further it has been checked whether the relationship is linear or non-linear. The study will enable us to know the factors affecting the cost inefficiencies at state level so that states can undertake proper measures to increase cost efficiency in rice production. Most important observation in this paper is that there exists non-linear relationship between cost inefficiency and farm size. Cost inefficiency is first increasing with the increase of farm size then it is decreasing. The cost inefficiency depends negatively on proportion of family labour, mechanisation, type of seed used, etc. The analysis will enable us to know the determinants of cost inefficiency and will guide various states to adopt suitable policies thereafter.

Keywords: Rice, Cost inefficiency, Stochastic frontier cost function, Mechanisation, Family labour Farm Size.

JEL: D24, N55, O13, C33, D20.

I

INTRODUCTION

The study attempts to examine how the states use the different factors of production for increasing their cost efficiency in paddy production and how it relates to farm size. The average farm sizes differ across different states of India so it is vital to examine inefficiency in terms of size classes of the farms and examine whether there is any relationship between cost inefficiency in case of rice production across the farm sizes.

There has been a long debate regarding farm size and productivity, but nobody has looked before into the relation between cost efficiency and farm size. Moreover the study has tried to examine whether the relationship between farm size and cost inefficiency is linear or not?

In this era of mechanisation, use of modern variety of seeds, modern fertiliser the present paper aims to look into the status of cost inefficiency of rice production in the twelve major rice producing states. The determinants of cost inefficiencies are then determined.

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In times of liberalisation when the government is reducing subsidies on agriculture, the farmers are turning to use more amounts of modern inputs then the question arises, is there any efficiency in cost? Are we not inefficiently using the inputs? These questions are examined in this paper. Rice is strategically very important crop. In the global scenario India holds an important position in terms of rice production. A large number of farmers are dependent on rice production for their livelihood. At the same time rice is one of the most important cereals in terms of consumption.

Cost efficiency across states in case of rice production for two distinct time periods namely 2000 and 2013-14 considering cost function has not been analysed in recent studies. The use of a cost function rather than a production function for estimating production parameters has several advantages. Moreover cost efficiency mainly confirms whether the optimum level of output is being produced at minimum cost by efficiently allocating the resources. Even if the farms are technically efficient, if the farms are not allocatively efficient the farms will be cost inefficient. So the main objective of the paper is to determine whether the farms are both technically and allocatively efficient. This is only possible only when farms are cost efficient. So here we will discuss efficiency by considering cost function. Here, cost inefficiency has been analysed for twelve states namely Andhra Pradesh, Assam, Bihar, Kerala, Madhya Pradesh, Punjab, Uttar Pradesh, West Bengal, Haryana, Karnataka, Tamil Nadu and Orissa based on farm level data. This study is useful to detect cost inefficiency of paddy production for different states.

This study proceeds as follow: Section II presents literature survey, in Section III there has been detailed description of methodology, concept of cost efficiency, sources of data used in the study while Section IV presents and discusses the analysis of efficiency results and the determinants of cost inefficiencies. The final section provides the concluding remarks.

II

LITERATURE REVIEW

The following section contains literature review of stochastic frontier modeling and efficiency measurement in brief. The purpose of this paper is to examine cost inefficiency of rice production for 12 major states of India using cost of cultivation data by employing stochastic frontier cost function. Detailed reviews on stochastic frontier analysis are outlined in Bauer (1990), Battese (1993), Lovell (1993). Many economists have used stochastic frontier model for estimation of technical efficiency. In case of Stochastic Frontier Analysis (SFA) Battese and Coelli (1993) model is used for estimation of technical efficiency. A few empirical studies provide the estimates of technical efficiencies for rice production. Kalirajan (1981), Shanmugam and Palanisamy (1993), Tadesse and Krishnamoorathy (1997) and Mythili and Shanmugam (2000), estimated the technical efficiency of rice farms in Tamil Nadu.

Datta and Joshi (1992) measured the technical efficiency (TE) of rice farms in Uttar Pradesh while Shanmugam (2002) measured the TE for raising rice crop in Karnataka. One common debate has been on the ability of small farmers to reap the benefits of new technology and to improve their efficiency. Pradhan and Mukherjee (2017) have estimated technical efficiency of agricultural production of India using stochastic frontier production function. In this study it has been observed farmers' age and education level, household size, household’s management in production, proportion of irrigated area covered by canals, availability of wells, yielding variety of lands, services provided by the government, agricultural expenditure by local government are the factors which significantly contribute to the efficiency in resource utilisation.

In very recent years Ghosh and Raychaudhuri (2015) have discussed both technical and cost efficiency of rice producing states using production and cost stochastic frontier. Kumbhakar and Bhattacharya (1992) have used a generated profit function by incorporating price distortions which came from imperfect market conditions, socio-political and institutional constraints along with technical and allocative inefficiencies using farm level data in the case of West Bengal for the year 1980-85. Goldman (2013) has carried out estimation of technical efficiencies of rice farms of West Bengal, Uttar Pradesh, Bihar and Tamil Nadu. Another study by Gautam *et al*. (2012) has estimated the technical, economic and allocative efficiencies of farmers using both cross section and panel data for the years 1982, 1994 and 2007 by employing production and cost frontier model.

Basu and Nandi (2014) have obtained technical efficiencies of rice producers dealing with farm level data. Lachaal *et al*. (2004) have studied efficiency of 46 agro based Tunisian farms and have observed that farm size affects the technical efficiency negatively where as skilled labour affects technical efficiency positively. Kalaitzandonakes *et al*. (1992) had estimated efficiency levels of a sample of Missouri grain farms by different techniques. They had observed that the relationship between farm size and technical efficiency does not exist. Mburu *et al*. (2014) have attempted to estimate the levels of technical, allocative and economic efficiencies among the sampled 130 large and small scale wheat producers in Nakuru district, in Kenya using stochastic frontier cost function. It has been observed that the number of years of school a farmer has had in formal education, distance to access extension advice, and the size of the farm have strong influence on the efficiency levels. The relatively high levels of technical efficiency among the small scale farmers defy the notion that wheat can only be efficiently produced by the large scale farmers. The relationship between farm size and land productivity has been widely debated in literature for decades and several reasons and explanations for the inverse relationship between farm size and land productivity have been put forward and tested. The first reason is imperfect factor markets including failures in the land market, credit market and insurance market.

There is another set of studies where Data Envelopment Analysis (DEA) has been used for finding out efficiency. Kumar *et al*. (2005) used data envelopment analysis to measure the technical efficiency of rice farms in Uttaranchal under irrigated conditions of North West Himalayan Range during the year 2004-2005. Ray and Ghosh (2013) used the non-parametric approach of DEA to obtain Pareto-Coopmans measures of technical efficiency of individual states over the years 1970-1971 to 2000-2001 in a multi output, multi input model of agricultural production. Laha and Kuri (2011) have examined allocative efficiency and its determinants in West Bengal agriculture by advocating cost minimisation principle using DEA. The type of tenurial contract, education level of head of the household, operated land, interlinkage of factor markets and availability of credit are some of the other factors, *inter alia* which are found to have significant influence on the level of allocative efficiency on agriculture in case of West Bengal.

Examples of frontier studies involving profit maximisation include Ali and Flinn (1989) in which a single – equation profit frontier has been estimated using the same methods as for production frontier. Bhatt and Bhat (2014) using field survey data of 461 farmers from Pulwama district of Jammu and Kashmir (India) for the year 2013-14 have estimated the technical efficiency by employing Non-parametric Data Envelopment Analysis. Farm size and productivity efficiency relationship was found to be non-linear, with efficiency first falling and then rising with size. Large farms tend to have higher net farm income per acre and are technically efficient compared to other small farm size categories.

Most frontier studies have focused only on technical efficiency even though it is by improving overall economic efficiency that the major gains in output could be achieved. The few studies reviewed above suggest there is still a gap in our understanding of the relationship between farm size and economic efficiency or in other words cost efficiency. This paper attempts to fill the gap by examining overall efficiency on rice production. We have observed that there is huge literature on frontier analysis but most of the studies are based on stochastic frontier production function dealing mainly with aggregate data. There are few studies dealing with stochastic frontier cost function and specifically involving with farm level data.

Cost efficiency will enable one to understand resource utilisation. Even if the farms are technically efficient but are inefficient in terms of allocation of inputs then they will be cost inefficient. The cost efficiency is product of technical efficiency and allocative efficiency. So this study has tried to examine the cost efficiency and the factors affecting cost efficiency. Particularly the role of farm size on the utilisation of the resources. Since most of the studies were based on aggregate data, the role of farm size affecting the cost efficiency cannot be captured. This is the first time a stochastic frontier Cobb Douglas form of cost function has been estimated to throw some light on the cost efficiency in case of rice production and then the effect of different factors have been discussed.

This study has tried to examine whether there has been any change in the cost inefficiency after about a decade. Two time points have been taken into account namely 2000 and another 2013 for this purpose. The determinants of cost inefficiencies dealing with farm level data, mainly the condition of cost inefficiencies of the farms of different farm sizes are then examined. Our objective of the study is trying to answer the question whether it is the large farms or small farms that are most cost. Moreover it will be checked whether the relationship is linear or not. Besides the study has tried to find an answer whether mechanisation, use of modern variety of seeds, fertiliser uses is contributing to the enhancement of cost efficiency or not. Another age old debate of family labour use in the farm has been looked upon.

III

METHODOLOGY, CONCEPT OF EFFICIENCY AND DATA

There are certain advantages of using the 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 in case of cost function are prices which are exogenous in nature. In cost function, the explanatory variables, input prices are independent of each other so the problem of multicollinearity is not encountered. In case of cost of cultivation data provided by Ministry of Agriculture the prices of the inputs are not given, but the information on the cost of the each of the inputs and the amount of inputs used are usually given. From that data usually the per unit cost of each of the inputs have been derived. This imputed cost has been treated as the prices of the inputs. This method has been used by other studies also (Ghosh and Raychaudhuri, 2015). In case of labour both the hired labour as well as the family labour have been taken into consideration for deriving at the imputed cost of labour. Cost efficiency actually helps us to derive how efficiently each of the states 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, p.211). Even if the firms are technically efficient in terms of production in case of use of resource utilisation they may not be efficient. Allocative efficiency means that ratio of marginal products of the inputs are equal to ratio of their prices (see Coelli *et al*., 1998). If only technical efficiency is being looked upon then we cannot infer anything about allocative efficiency. In modern times when the resources are constrained we will have to look also on how the resources are being utilised, merely by looking into production side will not help us in answering the question on resource use efficiency. In this paper cost efficiency (economic efficiency) has been examined.

Allocative (or price) efficiency (AE) measures the farm's success in choosing the optimal input proportions, i.e., whether the ratio of marginal products for each pair of inputs is equal to the ratio of their market prices. In Farrell's framework, economic efficiency is a measure of overall performance and is equal to TE times AE (i.e., EE

= TE X AE). The large number of frontier models that have been developed based on Farrell's work can be classified into two basic types: parametric and non-parametric.

According to Farrell (1957), TE is associated with the ability to produce on the frontier isoquant, while AE refers to the ability to produce at a given level of output using the cost-minimising input ratios. Alternatively, technical inefficiency is related to deviations from the frontier isoquant, and allocative inefficiency reflects deviations from the minimum cost input ratios. Thus, economic efficiency (EE) or the cost efficiency (CE) is defined as the capacity of a firm to produce a predetermined quantity of output at minimum cost for a given level of technology (Kopp and Diewert, 1982). Productive units can be inefficient either by obtaining less than the maximum output available from a determined set of inputs (technical inefficiency) or by not purchasing the lowest priced set of inputs given their respective prices and marginal productivities (allocative efficiency). Efficiency measurement can be categorised as either input or output oriented: input-oriented technical efficiency evaluates how much input quantities can be reduced without changing the quantities produced while output-oriented measures of efficiency estimate the extent to which output quantities can be expanded without altering the input quantities used (Coelli, 1994). Efficiency estimation can best be demonstrated by relating both allocative and technical efficiency, Farrell's methodology has been applied widely while undergoing many refinements. So to be cost efficient the farms have to be both allocatively and technically efficient.

Here in this paper we tried to examine cost efficiency assuming parametric approach. A single equation for stochastic cost frontier function is represented by

$$Ci = C\ (Y, P_i, \beta) + v_i + u_i \qquad \text{….(1)}$$

where Y denotes the output, P_i, denotes price of the ith input, β is the parameter.

According to the above equation, we can see that the error term consist of two components, u_i an v_i .

v_i=random error due to statistical noise, weather, diseases etc. which are outside the control of the farmers.

These variables which are assumed to be $iid\ N(0, \sigma_v^2)$ and independent u_i.

u_i=randomness (technical inefficiency) due to farmers' socio-economic characteristics such as age, years spent in schools, farm size etc.

u_i are non-negative random variables which are assumed to account technical inefficiency are $iid\ N(0, \sigma_U^2)$.

The transformation of equation to the natural logarithm function shows

$$LnC_i = Ln\left(Y, P_{i,}\beta\right) + v_i + u_i \qquad \text{….(2)}$$

This cost function now defines u_i now defines how far the farm operates above the cost frontier. This cost function is identical to that of the model developed by

Schmidt and Lovell (1979). Schmidt and Lovell have noted that the log likelihood of the cost frontier is that of the production frontier except for a few sign changes. The log likelihood functions for the cost functions analogues to the Battese and Coell (1993, 1995) models were also obtained by making a simple sign changes. Frontier program will be used to estimate the cost frontier. It will calculate the predictions of individual farm cost efficiencies from the estimated stochastic frontier cost frontiers. The measure of cost efficiency relative to above cost function is

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

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

MLE has been applied for the estimation of the cost function. Maximum Likelihood Estimation (MLE) not only estimates parameters β_0, βi and μ, but also the two variances of vi and ui. The value 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 the total error variance.

Therefore the value of γ are between zero and one ($0 \leq \gamma \leq 1$).

$\gamma = \frac{\sigma_u^2}{\sigma_u^2+\sigma_v^2}$. After applying maximum likelihood method of estimation we have obtained β and cost inefficiency estimates γ and CE.
where γ parameter has value between zero and one.

$CE_i = \frac{Actual\ Cost}{Minimum\ cost}$ and this value is greater than 1 if the farms are cost inefficient. In this paper cost inefficiencies have been estimated across all farms across all states for the years namely 2000 and 2013 namely.

In this paper, the stochastic frontier Cobb-Douglas cost function used in this paper has been specified as follows:

$$Ln\ C = Ln\ \beta\ 0 + \beta y LnY + \beta\ 1LnPhl + \beta\ 2LnPbl + \beta\ 3LnPml + \beta\ 4LnPs + \beta\ 5LnPfer + vi + ui \quad \text{....(3)}$$

PHL= Price of human labour
PBL= Price of animal labour
PML= Price of machine labour
PSEED = Price of seed
PFER = Price of fertiliser

The estimates of the cost inefficiency have been regressed on other farm related variables.

The paper has tried to examine factors causing cost inefficiency. The factors that have been considered are, namely, mechanisation, proportion of family labour, type of seed used, and farm size. In order to examine non-linear relationship between cost inefficiency and farm size, square of farm size term has also been incorporated. In Indian agriculture farms use both the family labour as well as hired labour. The proportion of family labour that has been used in a particular farm may cause an effect on cost efficiency. Mechanisation is another important factor. Mechanisation may result in enhancement of productivity but at the same time it entails cost so whether machines have been efficiently utilised or not will be considered. The seeds are generally of two types namely traditional variety and modern variety. Type of seed used may be one of the factors influencing cost efficiency.

In case of stochastic frontier cost function, error components have a positive sign because inefficiency increases cost of production (Coelli *et al.*, 1998). We have estimated cost inefficiencies for each of the farm for each of the states, then separate regressions have been carried out to find out influence of each of the factors on the cost inefficiencies for each of the states separately.

The Cost Inefficiency model has been specified as follows:

$$\text{Cost Inefficiency} = \text{constant} + \delta 1\text{mechnisation} + \delta 2\text{family labour} + \delta 3\text{fer} + \delta 4\text{seed\_type} + \delta 5\text{farmsize} + \delta 6(farmsize)^2 + u \quad \text{….(4)}$$

where u is the random error term.

One of the age old debate of the agriculture is that there exist an inverse relation between farm size and productivity, here in this case we have wanted to examine the relation between the cost inefficiency and the farm size. Moreover to examine non-linear relationship in the equation 4 square of farm size has been taken as one of the explanatory variables. Apart from this role of family labour, mechanisation, use of fertiliser and seed type have also been examined. Actually mechanisation, use of fertiliser and use of modern variety of seeds are all indicators of modernisation of Indian agriculture. All these inputs use on the one hand may increase productivity but at the same time may increase the cost of the farm, so in this study we are trying to examine the effects of all these factors on the cost inefficiency of the farm production.

Source of Data

The basic farm level data of 2000 and 2013 has been collected from the reports of Comprehensive Scheme for Cost of Cultivation of Principal Crops by the Directorate of Economic and Statistics, Department of Agriculture, Co-operation and Farmer's Welfare, Ministry of Agriculture and Farmer's Welfare, Government of India. CACP provides different cost concepts. The state level data have been also collected from Economic Survey, India, The National Sample Survey Organization (NSSO), and Agriculture Census. The present study also considered five inputs like human labour, animal labour, machine labour, seed and fertiliser. And the reports mentioned above have been used as the source of the data. In the reports of the cost of cultivation the values of cost incurred on each of the inputs are given and also the amount of inputs used per hectare of land is given. From these two values implicit factor prices have been derived.

IV

ANALYSIS

The data used for our analysis consist of sample farms collected from each state. We have worked with farm level data collected from the cost of cultivation, of the Ministry of Agriculture and Farmer's welfare.[1] For two respective years 2000 and 2013 we have sample of farms from each of the states. We have tried to classify the farms of this sample data into farms of different size classes. The Table 1 below

TABLE 1. NUMBER OF FARMS IN THE COST OF CULTIVATION SAMPLE SURVEY IN THE RESPECTIVE YEARS

States (1)	Number of farms in 2000 (2)	Number of farms in 2013 (3)
West Bengal	2520	2394
Punjab	462	545
Assam	1336	982
Bihar	1409	1027
Uttar Pradesh	1033	956
Andhra Pradesh	948	926
Kerala	870	832
Orissa	2125	1732
Tamil Nadu	1143	739
Haryana	176	485
Karnataka	235	113
Madhya Pradesh	421	146

contains the number of rice producing farms collected from each state. Table 2 represents the percentage of each type of farms according to size classes.

From the above Table 2 it is observed that in West Bengal the marginal holdings constitute 97 per cent of total farms. In Punjab and Haryana the percentage of farms under marginal class is below 40 per cent while in Haryana 10 per cent of the farms are under the medium class where as for Karnataka it is only 5.5 per cent during 2000. Thus it is observed that the number of marginal holding have increased in 2013, where as in Haryana, percentage of marginal farmers have declined in the sample.

TABLE 2. DISTRIBUTION OF SAMPLE ACCORDING TO SIZE CLASSES ACROSS DIFFERENT STATES

(*per cent*)

	Marginal (0-1 Hec)		Small (1 Hec-2Hec)		Semi-Medium (2 Hec-4Hec)		Medium (4 Hec-9Hec)		Large (> 10 Hectare)	
States	2000	2013	2000	2013	2000	2013	2000	2013	2000	2013
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Andhra Pradesh	58.1		28		10.4		3.4		0.1	
Assam	77.9	80.5	16.8	16.8	4.7	2.5	0.6	0.1		
Bihar	68.3	68.2	27.3	26.4	4.3	5.5				
Haryana	35.2	27.6	30.7	25.9	23.3	30.8	10.2	13.5	0.6	2.2
Karnataka	63.4	49.6	23.4	30.1	7.2	14.2	5.5	6.2		
Kerala	82.5	73.3	10.9	14.9	5.1	8.25	1.5	2.9	0.7	
Madhya Pradesh	31.8	39	40.1	48.6	26.6	12.3	1.4			
Orissa	84.6	89	13.3	10.2	2.1	0.8	0.1			
Punjab	37.9	44.8	31.4	29	23.4	19.6	7.4	6.4		0.2
Tamil Nadu	73.8	63.5	17.8	23.7	6.9	10	1.5	2.8		
Uttar Pradesh	79.8	80.5	16.7	14.7	3.4	4.1	0.2	0.6		
West Bengal	97.2	98.2	2.2	1.8						

Source: Author’s calculation using cost of cultivation data, Ministry of Agriculture.

This section presents the trend of input use for rice cultivation and efficiency measurement for paddy production. Cost of cultivation provides data on values of rice cultivation as well as total cost per hectare of land. The unit price of inputs like human labour, animal labour, machine labour, seed and fertiliser have been obtained. So, for calculation of efficiency we have taken log value of total cost, output and log value of prices of the inputs. The value of inefficiency has been obtained by using the stochastic frontier analysis (Error Component Model). From the analysis the twelve states have been ranked according to their efficiency. And we get a comparison between 2000 and 2013-14. The mean value of inefficiency for the states considered. (See Appendix Table-A-1A and Table-A-1B for the coefficients of the stochastic frontier cost function for two years namely 2000 and 2013).

From Tables 3 and 4, it is observed that cost efficiency has declined in case of West Bengal, Punjab, Assam for the year 2013. Some states like Madhya Pradesh, Karnataka have improved their position in terms of cost efficiency. Here we have obtained the ranking of states for two years namely 2000 and 2013. Accordingly to the rank of efficiency for 2000 West Bengal is most cost efficient whereas Punjab, Assam, Andhra Pradesh Bihar, Uttar Pradesh, Kerala, are in good position. Whereas cost inefficiency is high for Orissa, Tamil Nadu, Haryana, Karnataka for 2000 and Madhya Pradesh is in the worst situation in 2000, Madhya Pradesh is most cost inefficient.

The scenario is bit different for the year 2013. In this year Haryana and Tamil Nadu are in lead position, they are most cost efficient states. Though in 2000 Madhya Pradesh was in last position but in 2013 Madhya Pradesh is relatively cost efficient. According to rank of mean inefficiency for 2013 Madhya Pradesh is in fourth position, West Bengal takes fifth position, i.e., the situation for West Bengal have

TABLE 3. RANK OF COST INEFFICIENCY OF RESPECTIVE STATES FOR THE YEAR 2000

RANK OF IN COST *INEFFICIENCY -2000	
States (1)	Cost inefficiency (2)
West Bengal	1.26E+00
Punjab	1.31E+00
Assam	1.32E+00
Bihar	1.33E+00
Uttar Pradesh	1.33E+00
Andhra Pradesh	1.37E+00
Kerala	1.39E+00
Orissa	1.39E+00
Tamil Nadu	1.41E+00
Haryana	1.48E+00
Karnataka	1.52E+00
Madhya Pradesh	1.61

*Lower value indicates more cost efficiency.

TABLE 4. RANK OF DIFFERENT STATES IN TERMS OF COST INEFFICIENCY FOR THE YEAR 2013

Rank of cost inefficiency-2013	
States (1)	Cost Inefficiency (2)
Haryana	1.00E+00
Tamil Nadu	1.00E+00
Karnataka	1.06E+00
Madhya Pradesh	1.23E+00
West Bengal	1.26E+00
Punjab	1.26E+00
Assam	1.30E+00
Uttar Pradesh	1.32E+00
Bihar	1.33E+00
Andhra Pradesh	1.34E+00
Kerala	1.34E+00
Orissa	1.39E+00

*Lower value indicates more efficiency.

deteriorated in 2013-14. Punjab, Assam, Uttar Pradesh, Bihar are in moderate position. But Andhra Pradesh and Kerala are relatively more cost inefficient in 2013, and Orissa is most cost inefficient state in this year. Here, cost inefficiency is defined as lower the value of cost inefficiency more efficient is the state, that is better is the state in terms of efficiency.

Cost efficiency depends both on allocative and technical efficiency. Technical efficiency is declining in West Bengal over time (Ghosh and Raichaudhuri, 2015). This may have contributed to the fall of the cost efficiency in West Bengal. Another reason that may be cited for decline of cost efficiency in West Bengal is the deterioration of the agricultural growth of rice. Chand *et al*. (2012) has categorised all the rice producing states into three categories, high producing state (if the growth rate is above 4 per cent), medium rice producing state if the growth rate is between 2 per cent to 4 per cent and the low rice producing state if the growth rate is below 2 per cent. West Bengal falls in the third category. We have tried to examine the cause of cost inefficiencies and the next set of econometric analysis will throw light in this regard. The reason of decline in the position of Punjab may be also due to decline in technical efficiency. From the study of Ghosh and Raichaudhuri (2015) it has been observed that technical efficiency is increasing in Tamil Nadu over time, and technical efficiency is declining over time for the states like Assam, Punjab and Bihar. May be due to deterioration of the technical efficiency over time is contributing to the fall in the cost efficiency in these states. The same study has shown that cost efficiency is increasing for MP overtime. This has resulted in the change in ranking of the different states over two different time periods.

Now, to examine the determinants of cost inefficiency we have regressed cost inefficiency on farm size, square of farm size, type of seed used (crop_dummy=1 if farm has used modern variety and 0 if the farm has used traditional seed), ratio of family labour to total human labour, ratio of machine labour to total labour (stands for mechanisation) and fertiliser use for the year 2000 for all the states taken together. The correlation between proportion of family labour and farm size has been computed. Although the correlations are negative but none of the correlations are greater than 0.5 so there will be no problem of multicollinearity. The correlation coefficients have been presented in the Appendix Table A-2A and Table A-2B for the year 2000 and 2013 respectively. Twelve separate regressions have been carried out for each of the states for determining factors affecting cost inefficiency for each of the states. The regression coefficients of the Equation 4 for the year 2000 have been represented in the Appendix Table A-3.

The regression results represented by Table A3 have been discussed here. It has been observed that use all the modern inputs namely modern type of seed, mechanisation leads to reduction of cost inefficiency. In a study by Bhatt and Bhat (2014) have shown that the technical efficiency improves with the increase of modern type of seed. Our result supports the view that cost inefficiency declines with the use of modern type of seed. At the same time higher proportion of family labour leads to reduction of cost inefficiency at aggregate level India. When higher proportion of family labour is utilised for farming may be farmers are very diligent compared to the case when labour is being hired. So the cost inefficiency gets reduced when higher proportion of family labour is being used. But the farm size affects cost inefficiency positively. This indicates larger farms are less efficient. But the square of farm size influences the cost inefficiency negatively. This indicates as the farm size increases the cost inefficiency increases but after certain level it improves. There is a non-linear relationship between cost inefficiency and farm size. The results revealed that efficiency decreases up to a certain level then it increases with increase in farm size. In many studies like by the study by Bhatt and Bhat (2014) it has been observed that technical efficiency is higher for farms of smaller sizes than others. But the square of farm size is positively related to technical efficiency. It may be argued that farmers with small farms use the land diligently, which reduces the loss in soil fertility level hence making them more productive. Results implied that large farmers were technically efficient. Large farmers generally cultivate land by using new methods/techniques of production which may thereby affecting productivity and increasing cost inefficiency initially but latter on they become cost efficient. As using the modern technology entails cost. In other words, when a farm is relatively small, farmers combine their resources better but increase in farm size up to certain level decreases cost efficiency. But beyond a level again large farms become cost efficient. Tchale (2009) concluded that farm size was inversely related to efficiency. Studies by Bravo-Ureta and Pinheiro, 1997 do not agree with these findings.

The non-linear relationship between farm size and cost inefficiency holds for almost all states at individual level except for West Bengal where there is no relationship between cost inefficiency and farm size neither linear not non linear. In West Bengal use of fertiliser is leading to enhancement of cost inefficiency. Another important observation is that in Punjab, farm size is negatively affecting the cost inefficiency. In Punjab just opposite scenario is being visible large farms are more cost efficient than the smaller ones and the square of farm size is insignificant indicating that non linear relation does not hold in Punjab. Moreover in Punjab use of family labour, mechanisation and fertiliser use all are leading to enhancement of cost inefficiency. So we can say that the resources are not being efficiently utilised. May be as the sizes of the farms in Punjab are proportionately larger than the other states , Table 2 indicates that more than 40 per cent of the farms are more than 2 hectares, use of family labour will not be effective in those cases. Moreover mechanisation is also not effective may be in terms of cost. In another two large rice producing states like Andhra Pradesh and Karnataka results are slightly different. In Andhra Pradesh and Karnataka there is nether linear nor non linear relationship between farm size and cost inefficiency. In Andhra Pradesh more use of family labour is leading to higher cost inefficiency. In Andhra Pradesh large scale mechanisation has been adopted and technology is much more improved (Ghosh and Raychaudhuri, 2015) so use of family labour is not viable option for increasing cost efficiency. In Tamil Nadu too use of higher proportion of family labour is leading to cost inefficiency.

Similar exercise has been carried out for the year 2013. The results have been presented in the Table A4. The results depict that at aggregate level taking all the states together there exists non linear relationship between farm size and cost inefficiency. The larger the farm size more is the cost inefficiency but the square of the farm size is affecting negatively the cost inefficiency. This indicates initially may be the small farms are cost efficient but later on this efficiency gets diminished. This non linear relationship between farm size and cost inefficiency holds more or less for all the states. Even for Punjab, Karnataka and West Bengal this non linear relationship holds. This indicates over time all the states are almost behaving in the similar way. Moreover the result denotes up to certain level for the small farms the cost inefficiency will be low but after a level the cost efficiency will improve in favour of large farms. In case of Andhra Pradesh linear relationship exists between farm size and cost inefficiency. At all India level the proportion of family labour use, mechanisation, modern variety of seed, mechanisation, use of fertiliser are all affecting the cost inefficiency negatively. This means that use of modern inputs like mechanisation, modern variety of seeds, use of fertiliser all lead to reduction of cost inefficiency. At the same time use of higher proportion of family labour also leads to reduction of cost inefficiency. But there are few deviations from the all India result as for example in West Bengal, Uttar Pradesh, Karnataka, Tamil Nadu fertiliser use is leading to enhancement of cost inefficiency. May be the fertiliser use is not optimally utilised. In West Bengal and Tamil Nadu use of higher proportion of family labour is leading to increase of cost inefficiency. In Orissa also in the year 2013 the results are different from all India level, non of the factors are significant apart from fertiliser use, but use of fertiliser is leading to reduction of cost inefficiency and leading to increase of efficiency in Orissa. From the above results we can get an India about the determinants of cost inefficiency across different states of India. Moreover the non linear relationship confirms that even though the small farms at initial level may be cost efficient over time large farms will be more cost efficient. Modernisation of production like use of machine labour, use of modern variety of seeds will all lead to enhancement of cost efficiency. So the states should undertake special measures to distribute modern variety of seeds, should make the farmers aware about the processes of mechanisation and should facilitate the process of mechanisation so that farmers can benefit in terms of cost efficiency.

V

CONCLUSION

In this paper we have tried to examine the cost inefficiency of rice production of major rice producing states of India. We have observed the cost inefficiencies for 12 states (like Andhra Pradesh, Assam, Bihar, Kerala, Madhya Pradesh, Punjab, Uttar Pradesh, West Bengal, Karnataka, Haryana, Tamil Nadu and Orissa) and for two distinct year 2000 and 2013. When we have ranked the states over two distinct years we get different results. Some states performed better in 2000 but not in 2013 from the view point of cost efficiency. West Bengal has been found to be most cost efficient for the year 2000 and for the year 2013 Haryana is the most cost efficient. In West Bengal the cost efficiency declined may due to the fact that state has failed to use the resources efficiently and may be due to fall in the growth of rice. Cost efficiency depends both on technical efficiency and allocative efficiency. The deterioration of technical efficiency of West Bengal has contributed to fall of cost efficiency. An important observation of the study is that there exists non linear relationship between farm size and cost inefficiency. Initially the small farms will more cost efficient than the large ones but the rate of change of cost inefficiency with the rate of change of farm size is negative. So after certain level the inverse relationship between farm size and cost efficiency does not hold. The most striking feature is that use of modern inputs and mechanisation are contributing to enhancement of cost efficiency. So the government must take special initiatives to make the modern variety of seeds available to the farmers. The farmers should be made aware of the gains of using the mechanisation, modern variety of seeds. The states should take special steps at the grass root level to provide knowledge about the modern techniques of farming, should make available credit, seeds etc. so that farms can take advantage and be cost efficient.

NOTE

1. Directorate of the Economics and Statistics collect data for sample of farmers. The detail of the sampling technique and the sampling units can be obtained from the website http://eands.dacnet.nic.in/Plot-Level-Summary-Data.htm.

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APPENDIX

TABLE A-1A. THE FINAL MLE ESTIMATES OF THE STOCHASTIC FRONTIER COST FUNCTION FOR THE YEAR 2000

(1)	Coefficient (2)	Standard error (3)	t-ratio (4)
constant	5.56E+00	3.10E-02	1.79E+02
LnY	7.60E-01	4.09E-03	1.86E+02
LnPHL	3.21E-01	1.07E-02	2.99E+01
LnPAL	3.77E-02	3.72E-03	1.01E+01
LnML	5.88E-03	1.80E-03	3.26E+00
LnPSEED	-1.34E-02	4.36E-03	-3.08E+00
LnPFER	4.25E-03	5.08E-03	8.36E-01
sigma-squared	2.27E-01	7.15E-03	3.18E+01
Gamma	3.50E-01	3.44E-02	1.02E+01
mu is restricted to zero			
eta is restricted to zero			
log likelihood Function	-0.7	2.42E+09	

TABLE A-1B. THE MAXIMUM LIKELIHOOD ESTIMATES OF THE STOCHASTIC COST FRONTIER FOR THE YEAR 2013

The maximum likelihood estimates : (1)	Coefficient (2)	Standard (3)	t-ratio (4)
constant	6.43E+00	7.95E-02	8.08E+01
LnY	6.52E-01	3.43E-03	1.90E+02
LnPHL	3.32E-01	1.01E-02	3.29E+01
LnPAL	1.61E-02	2.08E-03	7.73E+00
LnML	2.00E-02	1.48E-03	1.35E+01
LnPSEED	6.77E-02	2.32E-03	2.91E+01
LnPFER	2.23E-02	4.48E-03	4.97E+00
sigma-squared	0.15311244	2.07E-03	7.38E+01
Gamma	1.25E-04	4.95E-03	2.52E-02
mu is restricted to be zero			
eta is restricted to be zero			
log likelihood	function = -0.5	6.19E+10	

TABLE A-2A. CORRELATION COEFFICIENT BETWEEN FARM SIZE AND PROPORTION OF FAMILY LABOUR FOR THE YEAR 2000

(1)	(2)
Andhra Pradesh	- 0.442
Assam	- 0.331
Bihar	- 0.413
Kerala	- 0.218
Madhya Pradesh	- 0.445
Punjab	- 0.339
Uttar Pradesh	- 0.406
West Bengal	- 0.137
Karnataka	- 0.451
Haryana	- 0.268
Tamil Nadu	- 0.384
Orissa	- 0.345
India	- 0.321

TABLE A-2B. CORRELATION COEFFICIENT BETWEEN FARM SIZE AND PROPORTION OF FAMILY LABOUR FOR THE YEAR 2013

(1)	(2)
Andhra Pradesh	- 0.381
Assam	- 0.375
Bihar	- 0.566
Kerala	- 0.202
Madhya Pradesh	- 0.463
Punjab	- 0.34
Uttar Pradesh	- 0.384
West Bengal	- 0.342
Karnataka	- 0.368
Haryana	- 0.483
Tamil Nadu	- 0.521
Orissa	- 0.437
India	- 0.266