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Efficiency of Cereal Production and Determinants of Cost Inefficiency in Natural Disaster-Prone Regions of Odisha (India)

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Abstract

Coastal districts in Odisha are one of the most vulnerable regions in India to climate-related natural disasters like cyclones and floods. They are some of the thickly populated zones of the state with agriculture as primary occupation for most rural households. The paper studies the technical efficiency of cereal production across the farm households and examines the factors contributing to inefficiency in the production process. It attempts to check the role of exogenous shocks like cyclones and floods in defining the observed cost inefficiency of the rural farmers. In doing so a cost efficiency approach is adopted and stochastic frontier analysis is carried out using primary household data. Based on the empirical analysis, and subject to the assumptions and the usual limitations of data, the findings suggest: (i) inputs like use of farm machinery and fertilizer significantly contribute to enhancement in farm output, (ii) most farmers operate at average levels of cost efficiency, and (iii) incidence of disaster events significantly contributes to cost inefficiency. From a policy perspective, the thrust should be on increasing the farm mechanisation and reducing the exposure to extreme events supplemented with efforts to augment the penetration risk diversification and reduction schemes.

Key words: Technical Efficiency, Stochastic Frontier Analysis, Extreme events, Natural disasters, Coastal Odisha.

I. Introduction

Developing countries like India have been characterized by soaring population, larger dependence on agriculture, higher incidence of poverty, huge economic inequality and rudimentary state of infrastructure. The problem is more glaring in rural than urban areas. The reliance of the rural households on climate sensitive factors like agriculture for their livelihood makes them susceptible to a greater extent to the risks of climate- induced natural disasters like cyclones and floods. Although the country has been following a balanced pattern of developmental interventions since the 1950s, backward regions continue to remain so with both inequalities among states and districts or regions within the States growing (Kurian, 2000; Audirac, 1997). Nonetheless, agriculture retains its importance in the economic, cultural and political landscape. The first phase of growth in agriculture started right after the independence of the country and the period 1947-64 witnessed national level interventions like establishment of fertilizer and pesticide factories, construction of large multi-purpose irrigation-cum-power projects, organisation of community development and national extension programmes and, above all, the starting of agricultural universities (Swaminathan, 2007). In the post-green revolution period, productivity growth in

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agriculture has been sustained through increased input use and, more recently, through more efficient use of inputs (Pingali & Heisey, 1999) and supplemented with intensive diversification. However, during the years after 2001 there was a departure from the trend observed since independence. The nation witnessed an agricultural decline creeping in at a time when international prices of major food grains were going up steeply (Swaminathan, 2007).

Additionally, during the last two decades a new aspect has emerged that compounds this problem: the possibility of adverse changes in rainfall, temperature and sea level as a result of global warming. The Inter-governmental Panel on Climate Change's (IPCC) fifth assessment report (AR5) has restored the earlier versions that the warming of earth's climate system is unequivocal, and since 1950s many of the observed changes are unprecedented over the millennium (IPCC, 2014). Specifically for India, Kavi Kumar and Parikh, (2001a, b) observe that the inter-annual variability in rainfall will have major impact on food grain production and also on the Indian economy as a whole. Further Mall et al. (2006) conclude that since agriculture is the backbone of Indian economy, a majority of people's livelihood is at risk in the current time period as well as in the foreseeable future. Again with respect to rice, Sinha and Swaminathan (1991) indicate that a 2°C increase in temperature could decrease rice yield by about 0.75 tonne per hectare in high-yield areas and by about 0.06 tonne per hectare in low-yield coastal regions. Studies also conclude that an increase in frequency and intensity of floods and droughts is likely to have adverse impact on occupational structure, food security, health, social infrastructure, etc., of the hotspots (Roy et al., 2005; NATCOM, 2004). It also emerges that in particular, households depending on agriculture for their basic livelihoods are the worst affected (Bhattacharya and Das, 2007).

Way back in 1798 Malthus in *An Essay on the Principle of Population* put forth a vision where he foresaw a time when population growth exceeding the land's potential to supply sufficient food resulting in societal self extinction. There are also a few historical examples existing that provide merit to this observation (Webster et al., 2000; Brander & Taylor, 1998). Although Malthus talks of the stabilization mechanisms based on resource constraints, it is important to recognize the potential roles of innovation and/or self-restraint over the short and medium run supplemented with the realization of impending scarcity over long run to usher in the required adjustments to meet the challenge. A similar process is being observed in India with population growth rates reaching newer heights and dismal performance of the agriculture and allied sector. A structural change is being noticed in agriculture in India with the rate of growth of agricultural output gradually declining in the recent years. The relative contribution of agriculture to the national output has been declining over time and so also is performance by crop categories. It is true that interventions initiated during the plan periods like reforms in industrial, financial and trade sectors contributed to the agricultural sector. However, recognition of the role of various non-price, institutional and organizational factors is essential for the sustainability of agricultural growth. For instance, the efficiency of production plays a determining role in output growth. Using existing resources in the best possible manner would yield the highest possible output for the given technological constraints (Shanmugan & Venkataramani, 2006). International and regional comparisons of efficiency would reveal that the level of efficiency displayed by Indian farmers is relatively low. Therefore, enhancement in technical efficiency would contribute directly to an increase in output and optimization of cost efficiency could direct the most favourable usage of existing resources given the constraints faced by developing economies like India.

Given this backdrop, the objective of the present study is to examine the efficiency of marginal, small and medium rural farmers in some of the worst disaster-prone regions. The study is with reference to three coastal districts in Odisha which have a high vulnerability to climate-induced disaster events like cyclones and floods where rice is the primary crop for the kharif season (July-October). In doing so, a cost efficiency approach is adopted and the performance of farmers is measured through a stochastic frontier analysis based on primary data collected from farm households. Subsequently, the determinants of cost inefficiency in production process are investigated by means of a Cobb-Douglas production function. Specifically controls are introduced to study the impact of climate-induced natural disasters like cyclones and floods on the cost inefficiency of farmers and to evaluate the role of crop insurance in mitigating the risk due to these events. Finally, variations in the distribution of cost efficiency are analyzed across regions, farm sizes and individual farmers. The study contributes to the existing literature on measuring technical efficiency of farmers across different agro-climatic zones and geographical settings. At the same time, it adds to the existing literature by investigating the role of climatic extremes in influencing the efficiency displayed by farm households.

II. Review of literature

Technical efficiency of agricultural production is defined as a farmer's ability to produce maximum output given a certain set of inputs and technology. The degree of technical inefficiency reflects a farmer's failure to attain the highest possible level of output given the sets of input and technology used where the highest level of output given a set of inputs is represented by the production frontier. One of the earlier definitions for technical efficiency says that it can also be defined as the farm’s ability to obtain the maximum output from a given set of resources (Farrell, 1957). Elaborating on this Mythili et al. (2000) state that technical efficiency of a farm is also defined as the ability and willingness of the farm to obtain the maximum possible output with a specified endowment of inputs (represented by a frontier production function), given the technology and environmental conditions surrounding the farm. Banik (1994) observes that a comparison of indices of technical efficiency of individual enterprises provides information on the relative as well as absolute levels of total factor productivity and also highlights this by adding that measurement as well as interpretation of the technical efficiency of the individual farms in the area under study is an important exercise to.

Application of this at a more disaggregated plane translates to the examination of technical efficiency at an individual farm household level and is also imperative from a policy point of view as the nature of farm households in developing nations like India is such that they face many constraints in their production process. The nature of these constraints varies at different stages of production and is also different across geographical regions as well as farmer classes and land holding sizes. Jayaraman and Murari (2014) stress this as they demonstrate that the earnings of the top 20 households are a multiple of the mean, while the earnings of the bottom 20 households are a fraction of the mean. In seven out of eight cases, the figure is negative for the bottom 20 households; that is to say, on an average, they ran at a loss from crop production. There are a number of empirical studies in literature which have attempted to measure technical efficiency through cross-section data with both parametric and non-parametric techniques. The deterministic and stochastic frontier approaches were used by Farrell (1957), Aigner and Chu (1986), Timmer (1971), Aigner et al. (1977) and Meeuen and Broeck (1977). For India, few studies also exist that measure technical efficiency of rice production using cross sectional data. Kalirajan (1981); Tadesse and Krishnamoorthy (1997); Kalirajan and Shand (1994) and Mythili and Shanmugam (2000) are some notable ones. While Kalirajan (1981) finds a significant positive relationship between access to extension services and technical efficiency for Tamil Nadu, Battese and Coelli (1992) find technical efficiency to be time invariant with constant returns to scale and a negative elasticity of bullock labour in Andhra Pradesh. Similarly, Tadesse and Krishnamoorty (1997) estimate mean technical efficiency to be 83 per cent with small and medium sized holdings operating at a higher level of technical efficiency than larger sized farms in Tamil Nadu. Supporting this, Mythili and Shanmugam (2000) estimate the mean technical efficiency to be 82 per cent with variation in this across the state. For central Gujarat, Narla and Zala (2010) report the mean technical efficiency to be close to 73 per cent for rice farms under irrigated conditions. For 12 major states in India, Shanmugam and Venkataramani (2006) find technical efficiency to be 79 per cent with literacy contributing positively and rural electrification being negatively related to mean technical efficiency.

Theoretical underpinnings

As discussed, the paper adopts a stochastic frontier function to study technical efficiency and economic efficiency of the farmers vulnerable to climatic shocks like cyclonic storms and floods in coastal Odisha. In fact, the stochastic production or cost frontier models were independently introduced by Aigner et al. (1977), and Meeusen and van den Broeck (1977). In the stochastic frontier approach the error term consists of two components. First is the random noise and the second is a residual term representing inefficiency and has been expanded and refined in numerous ways. Following Paudel and Matsuoka, (2009) it is assumed that a producer has a production function which is denoted as $f(x_j, \beta)$ and under the efficiency production approach, the j^{th} firm would produce:

$$q_j = f(x_j, \beta) \quad (1)$$

Where q_j is the scalar of output for producer j , x_j is the vector of inputs used by producer j, and β is the vector of technology parameters to be estimated. Stochastic frontier analysis assumes that each firm potentially produces less than it might due to the existence of a degree of inefficiency. Hence equation 1 is expressed as:

$$q_j = f(x_j, \beta)e_j \quad (2)$$

Here e_j is the level of efficiency for firm j, which must be in between (0 and 1). If $e_j = 1$, the firm is achieving optimal output given the technology attached to it. Since it is assumed that output should be strictly positive, the degree of technical efficiency is also assumed to be strictly positive. Output is also assumed to be subject to random shocks, i.e.

$$q_j = f(x_j, \beta)e_j \exp(u_j) \quad (3)$$

Where u_j is the disturbance term used to represent inefficiency. Taking natural-logarithm in both side of the above equation:

$$ln(q_j) = ln\{f(x_j, \beta)\} + ln(e_j) + u_j \quad (4)$$

Now, assuming that there are k inputs, the production function is linear in logs and defining $u_j = ln(e_j)$ yields is expressed as

$$ln(q_j = \beta_0) + \sum_{j=1}^{k} \beta_i \, ln(x_{kj}) + v_j - u_j \quad (5)$$

Subtracting u_j from $ln(q_j)$ and imposing the restriction $u_j \geq 0$ implies that $0 \prec e_j \preccurlyeq 1$ as observed by Paudel and Matsuoka, (2009) and shown by Kumbhakar and Lovell (2000). Based on this foundation, for empirical analysis, Battese and Coelli (1995) model was used to specify a stochastic frontier cost function and to estimate all the parameters. Following, Paudel and Matsuoka (2009), this model is expressed as:

$$lnC_j = \hbar(P_j, Y_j; \alpha) + (V_j + U_j) \quad (6)$$

Where C_j represents the total cost of production, $\hbar$ is a Cobb-Douglas functional form, P_j is the vector of variable of input prices, Y_j is the value of the produced outputs and α is the parameter to be estimated. While the systematic component V_j represents the random disturbance costs due to the factor outside the scope of farmers, U_j is the one-sided disturbance used to represent cost inefficiency and is independent of V_j. The two error terms are proceeded by positive signs as inefficiencies are always assumed to increase cost.

In addition, the cost efficiency of an individual is defined in terms of ratio of the observed cost (C^b) to the corresponding minimum cost (C^{min}) given the available technology is expressed as:

$$Cost\ Efficiency\ (C_{EE}) = \frac{C^b}{C^{min}} = \frac{\hbar(P_j, Y_j; \alpha) + (V_j + U_j)}{\hbar(P_j, Y_j; \alpha) + (V_j)} = exp(U_j) \quad (7)$$

Where the observed cost C^b represents the actual production cost whereas the minimum cost C^{min} representing the frontier total production cost or the least total production cost level.

Empirical Specification

The study follows the stochastic frontier approach of Aigner et al. (1977), and Meeusen and van den Broeck (1977). The empirical model to be estimated is denoted by equation 8.

$$ln(Yield_j) = \alpha + \beta X_j + \varepsilon_j(V_j + U_j) \quad (8)$$

Where X_j represents the inputs used in the production process for the j^{th} farmer, the outcome variable is the total value of output produced per acre of land for the farmer. Similarly, V_j is the two sided independently and identically distributed (iid) random error component and U_j is the one sided inefficiency component. The farm specific technical efficiency (TE_j) and TIE_j) for the j^{th} farmer is estimated using the expectation of U_j conditional upon the random variableε_j. The efficiency and inefficiency components are depicted in equations 8 and 9.

$$TE_j = Exp[-U_j] so\ that\ 0 \leq TE_j \leq 1 \quad (9)$$

$$TIE_j = Exp[U_j] so\ that\ 0 \leq TE_j \leq 1 \quad (10)$$

Further, following Goldman (2013) the technical efficiency estimates obtained by equation 9 were mapped on to kernel density graphs to examine the distribution of technical efficiency in the sample. The one sample Kolmogorov-Smirnov test is used to test the normality of technical efficiency score distributions. In the next step examination of determinants of cost inefficiency is pursued using the functional form depicted in equation 11.

$$(U_j) = \gamma + \phi Z_j + \psi D_j + \eta_j \quad (11)$$

Here the outcome variable U_j is the inefficiency coefficients obtained from the estimation of equation 8. Z_j represents a vector of household specific characteristics, D_j is a vector that depicts the risk and coping with climate induced natural disasters. Finally, η_j is the well behaved error term.

III. Study Area

The state of Odisha in eastern part of India consists of thirty districts being geographically located at the head of the Bay of Bengal and has a coastal stretch of approximately 480 km (Figure 1). A number of perennial rivers and their tributaries pass through the state. It is a multiple disaster -prone state with the risk of cyclones and floods being high every year in the coastal districts (Bahinipati & Patnaik, 2015; Bahinipati, 2014; Patnaik et al., 2013; IMD, 2008; Brenkert & Malone, 2005; Samal 2003). It is predominantly agrarian with agriculture and animal husbandry contributing 17.2 per cent (*Economic Survey, 2013*) to the Gross State Domestic Product. It provides employment and sustenance, directly or indirectly, to more than 60 per cent of the population, while forming the single largest employment sector of the state. Around 85 per cent of the state's 37 million people reside in rural areas, who depend largely on an undiversified agricultural economy. During 2000s, the growth rate in net state domestic product (NSDP) shows an upward trend. While it stood at 6.1 per cent per annum during 2000-01 to 2004-05, the value increased to 7.9 per cent per annum during 2005-06 to 2009-10. However, it sharply fell to 2.2 per cent during 2010-11. The average annual rates of growth in agriculture and allied activities in these periods have been 3.5 per cent, 3.9 per cent and 0.1 per cent respectively. The Human Development Index (HDI) for Odisha is one of the lowest HDI value (i.e., 0.404) with 11th rank among the Indian states in the year 2001 (GoO, 2004). Likewise, Suryanarayana et al. (2011) also find lower HDI value for the state, e.g., 0.296 with 19th rank among the Indian states for the year 2010. It is also observed that 32.59 per cent of people were below poverty line (BPL) during 2011-12 (GoI, 2013). Majority of households are dependent on climate sensitive sectors like agriculture for their basic livelihood and hence development in the field of agriculture holds the key to the economic development of the state.

Primary food grains produced in the state consist of cereals and pulses with very little change in the area under food grain production. Among cereals, rice is the principal food crop with gross cropped area being approximately 42 lakh hectares for the kharif crop and 3 lakh hectares being used in the rabi season. The kharif paddy accounts for 93 per cent of total paddy area in the state with 58 per cent of area being rain fed. Hence, the kharif paddy suffers from low productivity (1658 kg/ha as against 2393 kg/ha in rabi) with higher variability in productivity with the coefficient of variation for kharif paddy being 24 per cent as against 7 per cent for rabi paddy (Reddy, 2013). Mishra (2009) finds a negative growth rate for production of almost all the crops in the 1990s (Triennium Ending: TE 1993-94 to TE 2004-05) as compared with the 1980s (TE 1981-82 to TE 1992-93). In particular, the growth rate of paddy production, a staple food in Odisha, was negative in most of the districts during the 1990s (Mishra, 2009). It means that there is a declining trend both in terms of area cultivated and yield. For instance, the net sown area (NSA) declined to 5574 thousand ha in 2009 from 6304 thousand ha in 1990 (GoO, 2011). The compound annual growth rate (CAGR) was -1 per cent. A comparison with the national scenario reveals first, except 2010-11, the growth rate in agriculture and allied activities has been higher in Odisha than India. Second, though the share of agriculture and allied activities in NSDP of Odisha and that of India has been falling, the rate of decline is higher at the national level than in Odisha, indicating the predominance of agriculture in the state (Patra, 2013; Khan, 2012).

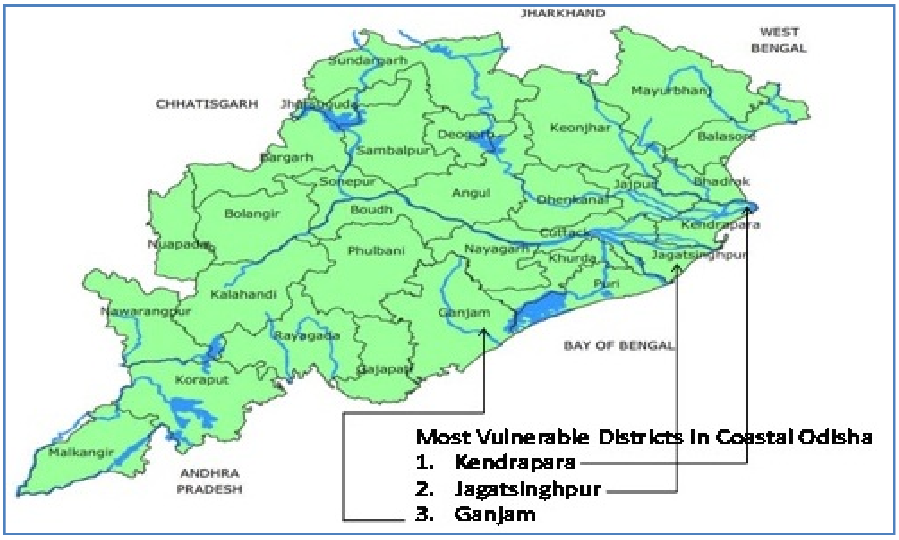

Figure 1: Map of Odisha and the location of the Districts for the Household Surveys
Source: Panchayati Raj Dept. Govt. of Odisha

The state has been experiencing a wide range of climatic extremes like cyclones and floods which have been disrupting economic growth and livelihood of the people who live in the fragility environment (Brenkert & Malone, 2005). It was estimated that the property lost was around Rs 105 crore during the 1970's, whereas it had increased seven times in the 1980's and more than 10 times in the 1990's (GoO, 2004: 163). Furthermore, during the first four years of the last decade, the climatic extreme events claimed more than 30,000 lives, which have not only become more frequent but also have hit areas that were never considered vulnerable so far (GoO, 2004). Historically, the districts Kendrapara and Jagatsinghpur have been the worst affected districts in terms of reported total casualties due to the incidence of climate extremes like cyclones and floods as compared with other coastal districts. Patnaik et al. (2013) conclude that Kendrapara, Jagatsinghpur and Puri districts are most vulnerable to cyclones and floods with Balasore, Bhadrak and Ganjam although vulnerable but to a lesser degree among the coastal districts.

IV. Data and variables

To meet the objectives of the paper, primary household survey data were used. The three districts chosen for the primary survey were based on the vulnerability of the districts to natural disasters based on Patnaik et al, (2013). The district of Kendrapara was most vulnerable, while the second district (Jagatsinghpur) was lesser in terms of vulnerability. The third district chosen Ganjam was the least vulnerable to extreme events than the above two. Since a census survey of all the households in the studied area was not feasible, a sample survey was undertaken. The representative sample in each village represented around ten per cent of the total number of households in the village. The survey was undertaken as a part of another research analyzing the vulnerability of households in coastal Odisha to climatic aberrations and change. The sample size was 450 households spread across these three districts with 150 households in each district. For the survey, a single stage stratified sampling procedure was adopted based on the location of the villages (i.e., coastal region and non-coastal region). The coastal villages are defined as the ones that share their village boundary with the sea.

The present analysis covers only 372 households from this set which are engaged in agriculture. Out of the sample size of 372, there are 140 households from Kendrapara, while Jagatsinghpur accounts for 148 with the rest 84 households belonging to Ganjam district. The surveys were first undertaken in Kendrapara district, followed by Jagatsinghpur and Ganjam districts. It was ensured that the data collection is done after the farming season when the households are relatively free to participate in the surveys and record their responses to the questionnaire. In the studied area, the primary cropping season (the kharif season in local language) ends by late October. The next cropping season (rabi season) starts by November/December till March. Therefore, the time chosen for conducting the household surveys in the studied area coincides with the time period when the initial phase of cropping (planting of saplings) is over and households wait for the crop to grow before harvesting it in March. Another reason for choosing this time period is because the winter cropping season (rabi) is not the primary cropping season and many households also do not undertake cultivation for the winter crop in the studied area as compared with kharif, which is the primary cropping season. The questionnaire consisted of eight sections with a specific section devoted to the enquiry of agricultural production and input usage by the farmers which also forms the basis of investigation. Table 1 describes the variables used in the analysis and also presents the summary of statistics.

The outcome variable used in the cost of efficiency analysis is the monetary value of crop output produced per acre of land (YLD). From table 1, it can be observed that farmers in the study area produce approximately Rs. 12,400 worth of cereals per acre. However the distribution of this is highly skewed as represented by the standard deviation of the variable. The second analysis pertains to the determinants of the cost efficiency of farmers. Here the outcome variable is the cost estimates obtained from equation 8 through Battese and Coelli (1998) method. The mean cost efficiency of farmers in the study is approximately 0.7 (on a scale of 0 to 1). The independent variables used in the cost efficiency calculations refer to the cost of various inputs deployed in the production process. The variable LAB refers to the cost of labour used in production and included both hired labour and family labour used. The value of family labour is calculated on the basis of the number of labour days contributed by the household in the field and is approximated by using the market wage rate for agricultural labour. It is observed that farm households use Rs. 2,000 worth of labour in the production process. Similarly, SEED refers to the cost of seeds used for sowing and it is observed from table 1 that farmers on an average use Rs. 750 worth of seeds for production during the kharif season of 2012 in the study area. The usage of both organic manures and chemical fertilizers is evident in the region. While MANU represents the total value of organic manure used, FERTZ denoted the same for chemical fertilizers. In the sample it is observed that farmers are using approximately Rs. 300 worth of organic manures while the usage of chemical fertilizers stands at a high of Rs. 2,700 respectively per household. Likewise, the charges incurred for irrigation is captured by the variable IRIG and the use of farm machinery is denoted by the variable MACH. The charge for farm machinery is calculated at the rental value and stands at Rs. 1,800 for the sample. Similarly the farmers are also spending Rs. 1,100 towards providing irrigation for their crops in the field.

The next set of independent variables refers to the household level characteristics. While SIZE denoted the average household size, EDU refers to the number of years of education possessed by the head of the household and COAST a dummy where the reference group if the households are living in the coastal regions of the district. In the sample average family size is 4 members per household and average years of education of the head of the household 5 years respectively. Similarly, it emerges that 36 per cent of the households reside in coastal regions. The

Table 1: Definition and Summary of Variables used in the analysis

Variables	Definition	Mean	S.D.
YLD	Monetary value of crop output produced per acre of land (Rs./Acre)	12,367.06	25,545.39
LAB	Total value of labour used for agriculture both owned and hired (Rs.)	2118.01	2051.71
SEED	Value of seeds used in production (Rs.)	748.76	831.07
MANU	Value of organic manure used in production (Rs.)	298.12	451.18
FERTZ	Value of chemical fertilizer used in production (Rs.)	2667.99	3269.45
IRIG	Charges incurred for irrigating the land (Rs.)	1083.06	1812.27
MACH	Charges incurred for the deployment of machinery in the field (Rs.)	1762.64	1999.04
SIZE	Total members of the household	3.93	2.09
EDU	Number of years of education for the head of the household	4.74	3.64
COAST	Dummy for location of the household, Dummy =1 if the household resides in coastal region; Dummy = 0 otherwise	0.36	0.48
$CROP_{DAM}$	Crop Damage Dummy; Dummy = 0 if the household didn't suffer any damage to crops due to cyclones or floods during the previous year, 1 otherwise	0.79	0.40
$CROP_{INS}$	Crop Insurance Dummy; Dummy = 0 if no crop is insured, 1 otherwise	0.02	0.15
ELECTY	Dummy for access to electricity at farm field; Dummy = 0 if no access, 1 otherwise	0.76	0.43
SHG	Dummy depicting membership in self- help groups; Dummy = 0 if no access, 1 otherwise	0.48	0.50
LOAN	Dummy depicting presence of an outstanding loan in the household; Dummy = 0 if no prior loan, 1 otherwise	0.34	0.47
MIG	Migrant members in the household; Dummy = 1 if migrants are present in the households, 0 otherwise	0.36	0.71
LVST	Number of livestock possessed by the household	1.45	1.98
ACE	Average annual consumption expenditure for the entire household	31065.86	22709.92
CIE	Cost inefficiency by Battese and Coelli (1998) Method	0.43	0.30
CE	Cost efficiency by Battese and Coelli (1998) Method	0.704	0.115

impact of climatic shocks is included through the dummy variable $CROP_{DAM}$ and represents whether the households suffered any damage to their crops due to incidence of cyclones or floods. As a means of improving the ability of households to respond to flood, the households, the state and the national government are spearheading provision of crop insurance schemes to farmers for a few years till now. The variable $CROP_{INS}$ in the present study captures this aspect. However, it is observed that only 2 per cent in the present sample have insured their crops in the past with lack of awareness about the schemes being the primary reason for this low penetration. Similarly, ELECTY shows the access to electricity at the cultivation field of the farmer. Although government agencies have started crop insurance for select crops, most of the households are not educated about the benefits and the process of insurance. Similarly, a self-help group (SHG) is defined by the Reserve Bank of India as a registered or unregistered group of micro entrepreneurs having homogenous social and economic background voluntarily, coming together to save small amounts regularly, to mutually agree to contribute to a common fund and to meet their emergency needs on mutual help basis. Hence SHGs are financial intermediaries owned by the poor. These groups are usually started by pooling the voluntary savings of the members on a regular basis. These voluntary savings are pooled with resources from external banks to provide interest bearing loans (nominal interest rates) to their members during their time of need and hence such loans provide additional liquidity or purchasing power to the borrower for use in production, investment and consumption activities. In the present studied area a significant penetration of these groups is found as 58 per cent report being associated with a SHG. The penetration of SHG in the present sample is noticeable as almost half of the surveyed farmers have membership in some SHG. The variable LOAN depicts the presence of an outstanding loan for the household, with 34 per cent farmers in the sample reporting having the same. The presence of migrants is denoted by MIG and it is observed that in the sample approximately 36 per cent households have migrant members present in their family. Similar LVST represents the presence of livestock and the average livestock holding by the households is more than one livestock. Finally, the variable ACE represents the average annual consumption expenditure for the entire household.

V. Results and discussion

The production function estimates for the stochastic frontier estimation based on the specification presented in equation 8 are depicted in Table 2. Overall, based on the significance of the likelihood ration test for null hypothesis that the inefficiency parameter is zero is rejected. The correlation between the cost efficiency coefficients and residuals in Model 1 is -0.028 and turns insignificant. Hence the two step procedure adopted in the present analysis is justified. The value of γ is between zero and one with σ^2 being significant.

Table 2: Estimation results for the stochastic frontier model and determinants of technical efficiency

Variables	Model 1: Stochastic Frontier		Model 2: Determinants of Technical Efficiency	
	Coefficient	S.E.	Coefficient	S.E.
LAB	0.082*	0.042	-	-
MACH	0.068***	0.015	-	-
FERTZ	0.056**	0.024	-	-
MANU	0.015	0.022	-	-
SEED	0.036	0.049	-	-
IRIG	-0.015	0.013	-	-
SIZE	-	-	-0.013***	0.005
EDU	-	-	-0.003	0.003
COAST	-	-	-0.035	0.028
$CROP_{DAM}$	-	-	0.081**	0.047
$CROP_{INS}$	-	-	-0.079*	0.047
ELECTY	-	-	0.101***	0.033
SHG	-	-	-0.003	0.025
LOAN	-	-	-0.044***	0.025
MIG	-	-	-0.006	0.021
LVST	-	-	0.012***	0.004
ACE	-	-	0.078***	0.015
A	6.89***	0.349	-0.431	0.161
σ^2	0.619***	0.050	-	-
γ	0.641	0.082	-	-
Wald chi^2 / F	66.0***	-	5.24***	-
$\hat{u}$	-6.008	5.441	-	-
$\hat{u}^2$	0.419	0.323	-	-
R^2	-	-	0.112	-
Outcome Variable	ln(YLD)		CIE	
N	371		371	

Note: (i) Correlation between Estimated Cost Efficiency Coefficients and Residuals in Model 1 is -0.028 (insignificant); (ii) ***p<0.01, **p<0.05 and *p<0.10

Table 2 shows that two variable turn out to be significant in the estimation of the exponential cost frontier. The variable MACH denoting the amount of farm machinery is positively related to the outcome variable yield. This implies that a one per cent change in this variable will translate to six per cent increase in the output of the crops produced. Similarly, the use of fertilizer also exhibits a positive relationship with the outcome variable. The coefficient value suggests that one per cent increase in fertilizer consumption could augment the crop output by five per cent. Although the coefficient for labour is positive, it is significant only at ten per cent level. The one sample Kolmogorov-Smirnov test was used to check the normality of the estimated efficiency coefficients obtained through equation 8. The results are depicted in Figure 2. Here it is observed that at 5 per cent level the distribution of technical efficiency scores is statistically different from normal distribution.

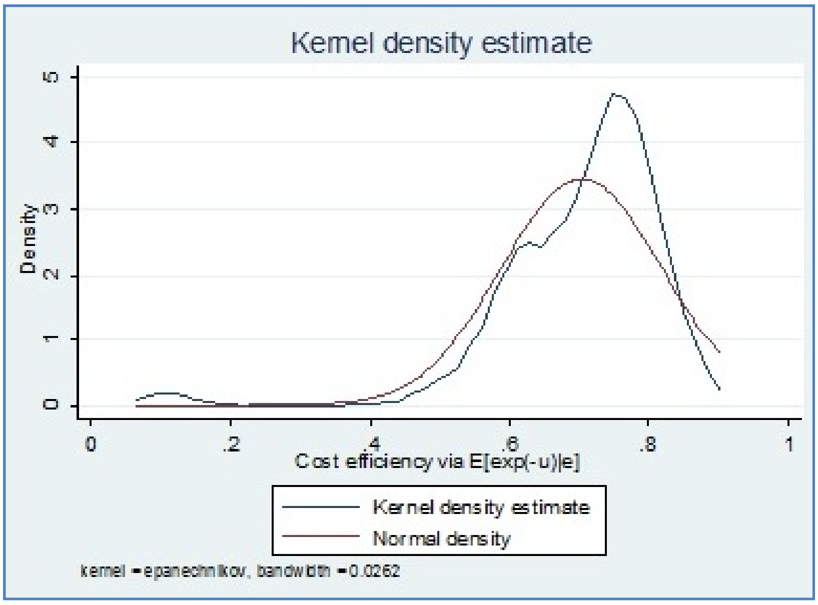

Figure 2: Kernel Density estimates of the cost efficiency estimates.

The subsequent analysis is an attempt to examine the determinants of the cost inefficiency at the household level using an ordinary least squares estimation by adopting. In doing cost inefficiency estimates obtained from equation 10 were on a set of household specific variables. The results are presented in Table 2 (columns 4 and 5). From the results it is observed that seven variables in total turn out to be significant in the analysis with the expected signs. It is found that household size is negatively associated with cost inefficiency of farmers. This implies that larger sized households are more inefficient in the sample. This could be due to the large scale usage of family labour in the production process disregarding the quality and skill of labour in the studied area although the contribution of this to the diminution of cost efficiency is by one per cent. The variables capturing the impact of climatic shocks like cyclones and floods also turn up significant with the relevant signs. While suffering damage to crops negatively contributes to efficiency in the farm production process, crop insurance acts as a buffer to the losses and positively contributes to the efficiency of farm production process. This is an important observation as the penetration of crop insurance in the sample as well as the studied area is miniscule. However, the results signify that those having access to crop insurance have benefitted out of the same which contributes positively to enhancement in efficiency. On similar lines, it is observed that not having access in electricity contributes to cost inefficiency for farmers in the studied area. Two other variables are found to be significant and positively associated with the presence of cost efficiency of the farmers. While the presence of livestock increases cost inefficiency, similar is also the observation about higher income households. More importantly, loans play a crucial role in reducing the inefficiency of farmers since most of them in the sample are either marginal or small and medium farmers. These groups of households in the studied area as well as more generally in India face funds and credit constrains for taking up agriculture. The coefficient for loan obtained in the estimation highlights that if the farmers are able to overcome these constraints, the potential reduction in cost efficiency could be up to 8 per cent of the total cost.

In the next step the pattern of estimated cost efficiency is further analyzed and decomposed. The results are presented in Table 3. It is observed from it that there is a difference in the cost efficiency levels across the three districts. The farmers in district Kendrapara are the most efficient, followed by farmers in Ganjam and Jagatsinghpur. While the mean efficiency in Kendrapara is approximately 74.8 per cent, that in Ganjam is close to 70 per cent and in

Jagatsinghpur the lowest at 66.4 per cent. Similarly, the mean efficiency levels vary across coastal and non-coastal regions. While the average cost efficiency for households residing in the coastal regions across these three districts is 71.3 per cent, that in non-coastal it stands lower at 69.8 per cent. Further, the cost efficiency estimates are cross tabulated with the land holding size of the household. In the sample only three classes of farmers are present: (i) marginal farmers (having land holding size below one hectare), (ii) small farmers (land holding size between one and two hectares), and (iii) medium farmers (includes semi-medium with landholdings above two hectares and below eight hectares.

Table 3: Distribution of Cost Efficiency across the sample

District Name / Category	Mean efficiency	S.E.	Distribution of cost efficiency	No. of farmers	Percentage of farmers
District					
Kendrapada	0.748	0.007	0-50 per cent	15	4.0
Jagatsinghpur	0.664	0.011	51-60 per cent	44	11.8
Ganjam	0.699	0.009	61-70 per cent	97	26.1
Type of village					
Non-coastal village	0.698	0.008	71-80 per cent	165	44.4
Coastal village	0.713	0.007	81-90 per cent	51	13.7
Landholding size					
Marginal	0.684	0.006			
Small	0.788	0.006	Total	371	100
Medium	0.796	0.022			

Table 3 shows that efficiency of farmers is increasing as the land holding sizes grows. One possible reason for this being economies of scale coming into effect and displaying increasing returns as we move from the category of marginal to small farmer. The cost efficiency of farmers is increased by a margin of ten per cent between these categories. However, moving upper in the ladder from small to medium farmer the increase in efficiency rate is only one per cent, displaying the limits to the economies of scale. Here as the farm sizes grow, the corresponding increase in efficiency level is to the tune of 10 per cent. Similarly, the right side of the Table 3 displays the distribution of farmers over ranges of cost efficiency. A majority of the farmers in the sample operate between 60-80 per cent levels of efficiency. There are some households operating at below 50 per cent level of efficiency. Although they are relatively few in number, they still account for 4 per cent of the total sample. Most of the farmers operate between 70 to 80 per cent level of efficiency in terms of cost of different inputs used in the production process accounting for 44 per cent of the total sample. The share of households engaged in farming with 61-70 per cent level of cost efficiency accounts for approximately 26 per cent of the sample households. Likewise, close to 12 per cent of the farmers in the sample operate at 51-60 per cent level of efficiency. The most efficient farmers in the sample are the ones operating with a cost efficiency level between 81-90 per cent and account for approximately 14 per cent of the sample.

VI. Summary and conclusion

This paper attempts to analyze the production performance of agricultural households that generate a large proportion of their income through farm-based activities. The primary objective is to understand the factors that affect the technical efficiency of households in an environment characterized by a high incidence of climate-related natural disasters like cyclones and floods. An attempt was also made to understand the impact of these shocks on cost efficiency of the farmers in one of the most disaster-prone regions of rural India. The analysis undertaken suggests firstly, that the yield from the agricultural farms is highly responsive to the usage of inputs like farm machinery and fertilizers. Although the adoption of labour in the production process contributed to the enhancement of farm output, rate of augmentation is quite low. Secondly, most farmers operate at average levels of cost efficiency with none of the households crossing the 90 per cent level. The level of efficiency is also associated with the size of the land holdings and although the cost efficiency increases with the augmentation of land holding size, there are limits to this growth with rise following a pattern of rise but with a diminishing rate. It also emerges that farm households in coastal regions are more efficient than the non-coastal ones. Thirdly, a number of significant determinants for the estimated cost efficiency levels also emerge. Family size of the households contributes negatively to the observed level of inefficiency and so also is the role of access to loans. Importantly, the incidence of disaster events diminishes the cost efficiency exhibited by the farmers. Although the penetration of crop insurance is low, farmers having access to it benefit from it.

There is scope for improvement in the resource usage across different farmer classes as well as across regions to enhance the cost efficiency. The results call for a thrust in agricultural policy related to increasing farm mechanisation as one of the ways to increase the yield of cereal production as observed by Swaminathan (2007). Similar is the case of fertilizer usage where the objective of the state should be on promoting optimal usage of fertilizer in the production process. The farmers are operating way below the efficient frontier levels which leaves scope for achieving potential gains in output through improvements in production management and enhancement in technical efficiency which should also be the focus of policy makers. Efforts should be undertaken to reduce the risks and exposure of agriculture to the incidence of climate-induced natural disasters which in turn could contribute to enhance the technical efficiency of the farmers. Equally important is to educate the farmers about the crop insurance schemes as they could contribute in reducing the post-disaster crop losses.

The paper analyzes the level of technical efficiency and its determinants in production of cereals in one multiple disaster-prone region. However, it is based on static analysis of studying farming practices over a spatial scale and is restrictive in this sense. Future research could address come of these shortcomings by analyzing and monitoring technical efficiency for a bigger basket of crops and also including a temporal scale in the analytical framework. This would also facilitate examining changing agricultural contexts to evaluate and inform productive policy actions. Nonetheless, given the changing nature of requirement of population, shifts in food security position, fluctuating prices of agricultural commodities and emerging challenge due to climate change on agriculture, widespread improvements in technical efficiency provides a way to confront and tackle the pressures.

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