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Research Article

Effect of Drought Condition on the Technical Efficiency of Rice Farms in Thailand

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Received: November 13, 2015; **Published:** June 29, 2016

Abstract

Rice is a major agricultural crop growing in Thailand and it is a mean of food security in small farm holders in Southeast Asia. Drought condition is a problem in rice production as it affects the land productivity and even collapse many fragile and unstable crop production systems in the world. Northeast part of Thailand which is affected by drought condition is not getting any irrigation infrastructures is the study site of this study. In this study, a survey data of the International Rice Research Institute (IRRI), collected in 2012 from the Nakhon Ratchasima province of Thailand were analyzed using stochastic frontier production method in Cobb-Douglas functional form. Results shows that, drought conditions in the rice growing farm community affect the rice production negatively and decline the efficiency of the rice farmers. We found that mean technical efficiency score of rice farmers in that area is around 0.41.

Keywords: *Rice Farms; Thailand; USDA; International Rice Research Institute*

Introduction

Rice is not only the staple in Thailand but it also has social and economic importance. Rice production has played important role in economy of Thailand because more than 3.71 million households in Thailand are engaged on rice farming (Office of Agricultural Economics, 2010). In 2014 the average yield of the rice farmland of Thailand is 2.85 t/ha (USDA, world rice statistics online query facility, 2015). Thailand is one of the largest rice exporter and fifth largest rice cultivator in the world (IRRI, 2015). Glutinous rice is famous rice in Thailand and this type of rice is deeply associated with the Thai tradition and culture. Rice cultivation is the mean of food security in small farm holders in Northeast of Thailand [1].

Now a days, drought is becoming a major problem in agricultural crop production by decreasing the land productivity and ultimately it affects food security. Negative impact of drought condition begun in the decade of 1980's in the world and it has been more problematic and widespread, particularly in the developing countries by collapsing many fragile and unstable crop production systems [2].

Different studies have shown that farmers of Thailand are producing rice below the level of potential output [3-7]. Agriculture and Agricultural Cooperatives Ministry of Thailand predicts that the emerging drought condition will affect 2.56-2.7 million hectares of the farmland in 58 provinces, among which 2.01 million hectares is in the Northeast part of Thailand, which is not effectively covered by national irrigation system. One-third of the land area and around half the rice land of Thailand is found in the Northeastern region of the country. However, average size of the rice farms is smaller than in other regions. Due to the topographic constraints, irrigation potential is limited and soil erosion and drought in the dry season is very common problem in Northeast Thailand. Drought condition is the challenging situation for rice growers in that region. So, it is necessary to find the impact of drought condition on rice production efficiency so as to impose some policies related to the adoption of drought mitigating technologies such as building the irrigation infrastructures, developing the drought tolerant rice varieties etc.

This study focused on the measurement of technical efficiency of rice farms of the Northeastern region of Thailand and point out the factors affecting technical efficiency of rice growers as regard of environmental factors. The score obtained from the production efficiency measures the production ability of a farm and figures out the difference in the actual and potential productivity of farm. This finding would be very helpful for planning and policy making to solve the problems associated with inefficiency of rice farming and improve the rice production so as to maintain well-being of Thai farmers.

Literature Review

In the production economics frontier models are widely used for technical efficiency estimation of crop farms along with the influences measurement of socio-economic factors on the efficiency. In South-East Asia, rice production efficiency studies have been conducted substantially in order to see the significant factors associated for creating gap in the production potential of farmland. Balcombe., *et al*.[8] estimated and explained technical efficiency of rice farmers in Bangladesh through the Bayesian analyses of frontier production model by providing the key insights into the distribution of technical efficiency and identification of important factors on rice growing. From the stochastic frontier production function and the inefficiency effect models, it was identified that age and education level of farmers, farm size and years of observation affect agricultural production inefficiency significantly in Kanzara and Sirapur villages of India [9]. Xu and Jeffrey (1998) used dual decomposition efficiency stochastic frontier model to see the difference in the efficiency of conventional rice farming and hybrid rice farming and found the significant differences in technical and allocative efficiency of conventional and hybrid rice production.

In Central Thailand, from the sample of 400 rice farms in crop year 2009/2010, it was estimated that the average technical efficiency of farmers was 51.86 percent ranging from 0.3 to 100 percent. This result indicated that most of the farms were operated at lower level of technical efficiency [10]. Similar study in Nepal suggested the variation of the level inefficiency among Nepalese farmers were due to the differences in the intensity of resources use such as seeds, labors, fertilizers and mechanical equipment [11]. In case of Pakistan Javed., *et al.* [12]uses the frontier production function and found that the technical efficiency of rice-wheat farming system is 0.83. Using the stochastic frontier production function, Brazdik [13] analyzed the technical efficiency of farm in West Java of Indonesia and pointed that land fragmentation was the main cause of technical inefficiency. The study done by Heriqbaldi (2014) using the similar approach found that land size, income and source of funding are the major determinants of technical efficiency in Indonesia.

Adoption of new rice varieties in Thailand during the years of 2006-2010 dramatically increased the rice productivity but there was some gap between the potential and actual average rice productivity [7]. The technology could be more efficient on the improved socio-economic characteristics and effective production management of farmers [6]. Rice growers who live in the irrigated area had higher production efficiency, which indicates that development of the irrigation facilities or adoption of drought tolerant rice varieties have the great contribution on the improvement of production efficiency of Thai rice farmers [7].

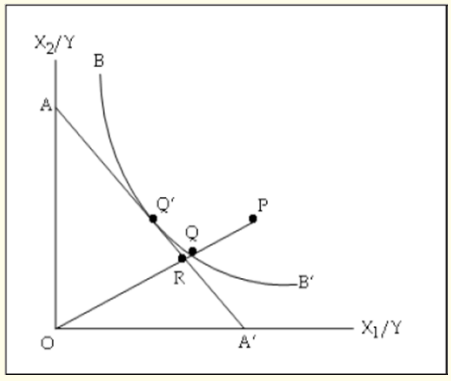
In Thailand, major studies based on the stochastic frontier production model focused on the glutinous rice as its compatibility with different cropping system, impact of modern varieties on the efficiency of rice production farms, production efficiency of jasmine rice etc. But very few studies have been found on the effect of natural and climatic factors on the efficiency of rice farming system.

Methodology

Technical Efficiency

The ability of a firm to obtain maximum output from a given set of inputs is the technical efficiency, which was first proposed by Farrel in 1957 [9]. Coelli, Rao and Battese explained the technical efficiency by using the example of a firm, which produces a single output (y) using tow inputs ($x_1$and x_2).

The technical efficiency to produce output at point 'P' is commonly measured as TE_i=OQ/OP , when firm uses certain amount of inputs. This is also written as 1- QP/OP (Figure1). The ratio is ranges from 0 to 1 indicating degree of technical inefficiency of the firm. This ratio provides the requirement of inputs for firm to be an efficient for the production.



Source: *Coelli, Rao, and Battese, 1998*

Figure 1: *Measurement of technical efficiency.*

Stochastic frontier analysis (SFA) is an important econometric approach for the measurement of production efficiency, which is first proposed by Aigner, Lovell and Schmidt in 1977 in an effort to link the gap between theory and empirical work. They suggested the new approach for estimating the production functions by specifying the error term, which is made up of two components; normal and one-sided distribution [14]. Furthermore, Meeusem and van den Broeck in the same year, 1977 has contribution on econometric modeling of production and the estimation of technical efficiency of firms as stochastic frontier production function [15]. The frontier production function can be explained as below:

$$y_i = x_i \beta + v_i - u_i, \text{ where } i=1,2,3,\ldots\ldots N$$

In this equation, y_i explains the output of firm, $x_i$denotes the vector of inputs used in the production process and β is the unknown parameter to be estimated. Here, error term is divided into two parts; v_i is the random error that farmers cannot control such as natural disaster and climate change, and u_i accounts for inefficiency. The error component v_i is assumed to follow a normal distribution $N(0,\sigma^2_v)$. Similarly, u_i is assumed to be normally distributed with mean, μ_i and variance σ^2_v, $[N(\mu_i,\sigma^2_v)]$, which is truncated at zero. The variance of the frontier error term is defined as, $\sigma^2=\sigma^2_v+\sigma^2_u$ and γ is the ratio of standard errors σ^2_υ and σ^2, $(\gamma=\sigma^2_u/\sigma^2)$ and this parameter determines efficiency of the firms. If the firm is fully efficient, the variance of u_i and the value of γ is zero in the model.

Specification of Model

In this study, production frontier estimation is done by means of Cobb-Douglas function, which is widely used in econometrics. The Cobb-Douglas production function was introduced by Charles W. Cobb and Paul H. Douglas. The assumption of Cobb-Douglas production function is written as below:

$$f(L,K)=AL^{\alpha}K^{\beta}$$

Since, this function is a power function with the three parameters, the production is estimated in the log-linear function where, logarithm of the variables are used in the linear fashion. In the above function, A is a scaling factor and α and β are the elasticities of output to corresponding two inputs, which are used for the production process. For this study, a Cobb-Douglas functional form of the production function is created as done by Schmidt and Lovell (1979) and Battese and Coelli (1988). The production function in a log-linear form written as below:

$$\ln y_i=\beta_0+\beta_1 \ln x_1+\beta_2 \ln x_2+\beta_3 \ln x_3+ \beta_4 \ln x_4+ \beta_5 \ln x_5+ v-u$$

Where, y_i is the total rice production, the x_i's are the major inputs used for the rice production. Here, v is the random statistical noise, and u represents technical efficiency and is always greater or equal to zero. The technical efficiency of firm is estimated by using the equation;

$$TE_i=\exp(-\hat{u}_i), \text{ where } 0<TE_i<1.$$

Data and Variables

Data, which were collected by International Rice Research Institute (IRRI) as a baseline study of autonomous adaptation against drought among Thai rice farmers was used for this study. Data were cross-sectional and were collected from 204 rice farmers resided in Nakhon Ratchasima, North-East province of Thailand. However, due to lack of production data for some farmers, among 204 only 197 rice farmers were included in this study. Two sets of variables were selected, first is the total rice production and its associated input factors (total land, amount of seeds and fertilizers, capital cost, labor-days). Another sets include the determinant variables like demographic characteristics of farmers, farm characteristics, and access to new rice varieties. A summary of variables related to rice production; inputs and household specific socio-demographic information are listed in table 1.

Results and Discussions

Table 1 shows that, in Nakhon Ratchasima province of Thailand, typical farm household involving rice planting has on an average 4.5 4-hectare land and average production of rice is about 8.6 ton per year. For the 204 sampled rice farmers, 21% of the farm households were affected from drought in their community during the period of sampled year 2012. Since the sampled area (part of North-East Thailand) is topographically difficult for irrigation facilities, it would be very interesting to study how the drought condition and those demographic characters of rice growers affect the efficiency of rice farmers in this area. In addition, on an average a sampled household with household members 4.07 have 54.48 years old male head and 77% of those families are male dominated. The sampled data suggests that household head earned on an average 5.3 years of formal schooling. Among them, 20% farmers have access for new rice varieties to grow on their farms.

Variables	Description	Mean	Standard Deviation
Production	Total rice production(Kg)	8609.94	6896.69
Land	Total land (ha)	4.54	4.59
Labordays	Total man days used	6.33	3.58
Capital	Fuel cost and rental cost (Baht)	17,612.64	10,784.34
Seed	Total seed used (Kg)	441.29	295.1
Male	=1 if head of household is male ;0 otherwise	0.77	0.42
Age	Age of head of household (Years)	54.48	11.04
Family size	Number of family members in household	4.07	1.69
Education	Number of years of education of head of household	5.30	2.71
Drought	=1 if community faced drought; 0 otherwise	0.21	0.40
Newricevarieties	=1 if farmer is access to new rice varieties; otherwise 0	0.20	0.40

Table1: *Variables and descriptive statistics (Source: IRRI, 2012).*

Variables	Parameter estimates	Standard errors
Production frontier estimates		
Land	0.825***	0.075
Labordays	0.428***	0.024
Capital	0.0142***	0.003
Seed	-0.126***	0.031
constant	-35.30***	0.0572
Inefficiency parameters		
Male	0.293	0.222
Age	-0.0311***	0.011
Education	0.174**	0.081
Drought	0.297*	0.179
Newricevarieties	-0.216	0.207
constant	1.107	0.747

Table 2: *Parameter estimates generated by frontier production function specifications for rice farming in Northeast area of Thailand (dependent variable= log total rice production, in kilogram).*

(*), (**) and (***) indicate that the value of the statistic is significant at 1, 5 and 10 percent respectively

Technical Efficiency (%)	Numbers of Farmers	Percentage
1-10	4	3.98
11-20	18	8.96
21-30	44	21.89
31-40	43	21.39
41-50	39	19.40
51-60	19	9.45
61-70	8	3.98
71-80	7	3.49
81-90	6	2.99
91-100	9	4.48
Total	197	100

Table 3: *Frequency distribution of technical efficiency*

Stochastic frontier production approach augmented for inefficiency was simultaneously estimated using the maximum likelihood method. We specified for the Cobb-Douglas production function and the parameter estimates generated by the frontier production function specifications for the rice farming in Northeast area of Thailand were listed in table 2. The result showed that in 1% level of significance, total production of rice increased by 0.825% when farmers increase their land by 1%. Similarly, in that area if farmer increase number of labor days by 1%, the total production of rice increases by 0.428% at 1% level of significance. In addition to that, capital cost which includes both the rental cost of machinery and fuel cost; is also significantly affect the total production of rice. The result shows that, increase in capital cost by 1% leads to increase production by 0.014% at 1% level of significance. Interestingly, the coefficient for the amount of seed used is negative and significant at 1% level of significance suggesting that increasing the amount of seed by 1% leads to decrease in the total production by 0.13%. It is possible because using higher amount of seed decrease the enough plant to plant space leading to the decrease in the total production of rice.

The coefficient of age is negative and is significant for the technical inefficiency at 1% level. That means farmers with more age are likely to be efficient compare to the young farmers. In rice farming societies farmers with more age are more experience and they have good knowledge of the practice and management of paddy farms [9,16,17]. However, the result suggests that more educated farmers are less efficient on rice production. Positive sign of education and significant at 5% level for inefficiency measurement tells that educated persons in the farming societies are involved more in off-farm activities and less active on farming. Due to this reason, those people in farming society may not achieve enough level of efficiency for the rice production. People with more education are attracted in other different welfare rather than farming.

Drought conditions in the community affect the rice production negatively and reduce the productivity of land. Negative sign of drought for the inefficiency at 10% significance level indicates that rice farmers facing drought condition are less efficient. The sign is expected because the area of sampled rice farmers has no enough irrigation facilities and if weather becomes unfavorable that means more drought during rice growing season, production of rice would sharply decline.

Technical efficiency of a given firm gives the firm's ability to produce maximum level of output from given bundles of inputs. The mean technical efficiency of our sampled famers is 41.21% indicating that a lot of rice farmers are inefficient in the North-Eastern part of Thailand. However, Taraka., *et al*. [10]2010 found that rice farmers in Central part of Thailand are about 51.86% efficient. Table 3 shows the distribution of farmers with different technical efficiency scores. In the Central part of Thailand farmers have proper access to irrigation facilities and faces less drought condition during the major rice-growing season. But the Northeastern part of Thailand is drought prone and farmers in that area do not have not enough irrigation facilities to grow rice. Due to this reason, rice farmers in that part are less efficient in comparison to other parts.

Conclusion

This study has shown that the technical efficiency of rice farmers of in the Northeast part of Thailand is still low even if different kinds of production technology are developed for rice farming. Under the current technologies rice yield can be increased by improving the socioeconomic characteristics and production management of farmers in Thailand [6]. Besides that, technical efficiency of rice production can be increased through the adoption of current environmental condition such as excessive drought and flooding condition and cultural practices [18]. Our study attempted to see the effect of drought condition on the technical efficiency of Thai farmers and found that drought condition significantly affects in the technical efficiency of rice production. Farmers facing drought condition are less efficient in the Northeast part of Thailand.

Previous studies showed that the technical efficiency score of rice production in Thailand is different among the different production environments. Most of these studies indicated that farmers living in irrigated area have higher technical efficiency score than other area [7]. Those study already proved that proper irrigation system is very important input factor for the rice production along with fertilizers and seeds. However, if certain places where irrigation facility is not enough and are facing certain natural drought condition, it is better to adopt certain rice varieties which are drought tolerant. From this study our estimated average technical efficiency score of rice farmers of North-East part of Thailand is about 41%, which is lower than the previous studies and it is reflected that those Thai farmers still had opportunity to increase their production efficiency. Age and drought condition were found to be the significant determinants which affect the efficiency levels of rice growers in North-East Thailand. Hence, in future, those findings might be helpful for formulating policies and other technical foundations to improve rice production in that area.

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Volume 3 Issue 3 June 2016