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Abstract

Using the Cambodia Socio-Economic Survey (CSES) 2009, this study tested the cost efficiency of Cambodian rice farming households. The wet and dry season cases were examined separately; the results showed the evidence of cost inefficiency[1] among the wet season farming households, while among the dry season farming households, there was no significant evidence. When taking into account differences in agro-climatic zones, only wet season rice farming households in Tonle Sap and Plateau/Mountain zones were found to have cultivated inefficiently. There was no evidence of inefficiency among dry season rice farming households in all agro-climatic zones. The mean cost efficiency score of 1.2 and 1.3 were obtained respectively for Tonle Sap and Plateau/Mountain zones. If the efficiency score equals one, the farming households are cost efficient and if it is larger than one, the farming households are cost inefficient. The mean score of 1.2 and 1.3 indicates that, on average, wet season rice farming households in these two regions were operating on about 20% and 30% over the minimum cost frontier, i.e 20% or 30% of their resources respectively were wasted. The results of the factors affecting cost efficiency suggested that there should be an appropriate number of farmers cultivating in a plot of land. If too many farmers cultivate in a small plot of land, cost efficiency will drop. Cost efficiency can also be improved if farming households are able to increase their cultivated area given the same number of farmer member of household, or reduce the number of household members who cultivate rice.

Key Words: Cost Efficiency, Rice Production, Cambodia

1. Introduction

Eradicating poverty is one of the goals of the United Nations's MDG[2], and a policy priority of the Cambodian government. In Cambodia, although the impressive economic performance[3] in the last decade has reduced poverty significantly, the gap between rural and urban poverty has unfortunately been widened. In 2007, the poverty headcount ratio in the national poverty line was estimated to be 30.1%; however, the poverty headcount ratio in the rural poverty line was estimated to be 34.5% almost 3 times more than that of their urban counterpart which was estimated to be only 11.8%.[4] This striking fact suggests that poverty in Cambodia has become a rural phenomenon and economic growth in the last decades has been relatively biased against the rural poor. Thus, in order to reduce poverty,

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any poverty reduction policies must be directed to reducing poverty in the rural area. In order to reduce poverty in rural Cambodia, it is required that agricultural productivity be improved and other sources of non-farm income have to be established (Engvall *et al*. 2008).

It should be noticed that about 80% of the poor was estimated to be residing in a rural area in Cambodia, and 71% of them have been dependent solely on agriculture (largely rice production and livestock raising) for their livelihood (USDA 2010). Although, in particular, rice yield has increased gradually, rice industry is not adequately developed to be able to improve the welfare of farmers. Many farmers are practicing traditional cultivation and producing at a subsistent level. As cited in the report of the USDA (2010), the World Bank estimated that only 40% of the farmers are capable of producing marketable surplus. In addition, there are many constraints to the growth of Cambodian rice production because the fund for extension work and crop research are extremely limited, yield is low due to unavailability of good seeds, irrigation systems have been severely destroyed, and commercial farm credit is not accessible to farmers (USDA 2010; Ngo and Chan 2010; Chea et al. 2004). Therefore, although it appears that Cambodia has sufficient water, land and human resources (rural work forces), there are still many challenges to overcome to improve rice production, which is widely believed to be a direct means of lifting the rural farmers out of poverty.

In this regard, this study attempts to contribute to the formulation of policies to improve rice production in Cambodia as a policy instrument to reduce rural poverty. First, the study will examine whether or not rice farming households have been operating efficiently by separating the farming households according to their seasonal differences in rice cultivation, wet or dry season, and taking into account differences in agro-climatic zones. It should be noticed that Cambodian rice farming households may be less cost efficient compared to rice farming households in neighboring countries due to the fact that they still practice traditional cultivation, and they are relatively less accessible to modern infrastructure and inputs. However, it is not in the scope of this research, which will only compare the cost efficiency among Cambodian rice farming households; i.e comparing the inefficiency level to the most efficient Cambodian farming households. Then, factors affecting cost inefficiency will be explored. The study is divided into five sections. Following this introduction, the second section provides a background of Cambodian rice production and its role in the economy. Section 3 discusses the methodology used for the analysis. Section 4 presents the data source and the study's limitation. The empirical results are presented in section 5, where the farming households' cost efficiency hypothesis will be tested; then cost function are estimated, and after that, factors affecting cost inefficiency are explored. Finally, section 6 concludes the study and policy implications are suggested. We expect that the results will be applicable and supportive for current policy formulation.

2. Rice Production and its Role in the Cambodian Economy

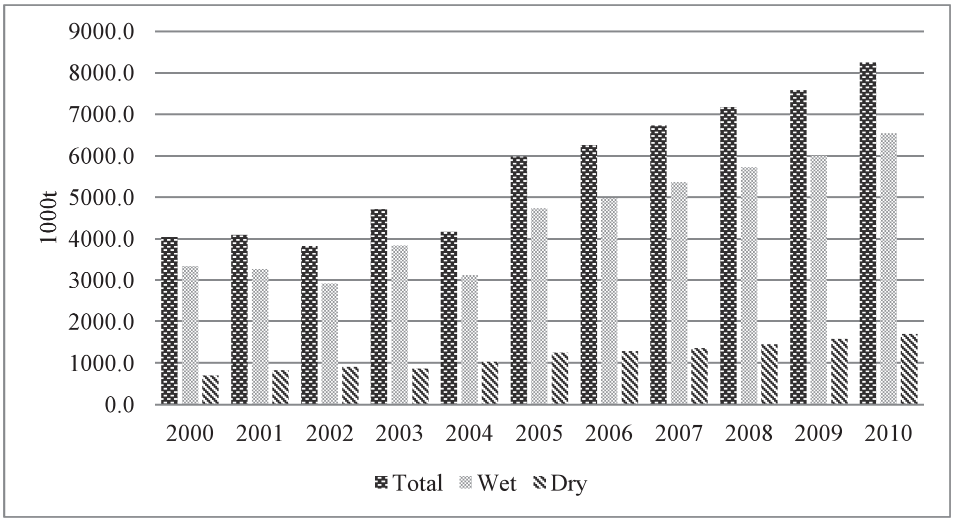
Rice is one of the most important staple foods for the Asian population in general. In Cambodia, in particular, rice is not just cultivated for consumption but it is also a main source of income generation for the rural population. Historically, farmers have been cultivating rice for more than 2000 years. After independence from France in the late 1953 and following the establishment of the modern state, in the 1960s, through export, rice had been one of the country's sources of foreign exchange.

However, during the war, from the early 1970s to the early 1990s, almost all Cambodia's economic activities including the rice industry were severely undermined. In this period, domestic rice production was not enough to feed the people let alone exporting for foreign exchange.

In 1995, Cambodia was able to resume self-sufficiency in rice production, and started exporting the surplus to the world market. In the last 10 years, Cambodian rice production has increased gradually from roughly 4 million tonnes in 2000 to around 8 million tonnes in 2010 (Figure 1). In this period, both the wet and the dry season rice production, which are the two seasonal production of Cambodian rice, have shown gradual increase. With the increase in production, Cambodia is on the path to become one of the main rice exporting countries.

The increased production has been attributed to the expansion of harvested area, from 2.1 million hectare in 2000 to 2.8 million hectare in 2010, as well as improved yield, from a 1.9 tonnes per hectare in 2000 to 3 tonnes per hectare in 2010 (NIS 2011). Nevertheless, the improved yield is still relatively low compared to other rice producing countries in South-East Asia (Ngo & Chan 2011: 11).

Figure 1 Cambodian Rice Production from 2000 to 2010



Source: Statistical Year Book of Cambodia 2011

In Cambodia, there are 4 agro-climatic zones and rice cultivation in these 4 zones is different between wet season and dry season. Wet season cultivation is from May to December; farmers depend more on rainfall and cultivation are in general labor intensive with local varieties being planted. While in dry season, farmers usually cultivate in the plots at least having partial access to irrigation; high yielding varieties are used, and the plot are better managed; therefore, in general, yield in dry season is higher than that in wet season.

In the Agricultural Statistics published by Cambodia's Ministry of Agriculture, Forestry and Fisheries (MAFF), there are 5 types of wet season rice varieties[5]: early, medium, late, upland and floating rice. Wet season rice is the main production predominating about 69% of the total cultivated land or about 85% of the total cultivated land allocated for rice while the remaining 15% of the rice cultivated land is used for dry season production. Rice output from wet season production accounts for about 75% of the total rice production in Cambodia (Cheu 2011).

In summary, it is evident that rice is one of the key industries, and the source of income generation for many Cambodian poor farmers. Nonetheless, there are many factors attributing to the low productivity and efficiency, which obstruct farmers from gaining optimal benefit from rice production.

This study attempts to contribute to the literature on Cambodian rice industry as well as agricultural economics in general. We will test the hypothesis of whether or not Cambodian farmers are cost efficient, and explore factors affecting efficiency by employing the stochastic frontier model, which will be discussed in the following section.

3. Methodology

The stochastic frontier methodology based on the Cobb-Douglas cost function is employed to test whether or not rice farming households in Cambodia is cost efficient and to compute the inefficiency scores if inefficiency exists. These cost inefficiency scores are used as dependent variable in the inefficiency model and are thus regressed on households and farms' characteristics to explore the factors affecting cost inefficiency. These two stages of estimations, cost function and inefficiency model, are estimated in a single step procedure using STATA software package.

3.1. Stochastic Frontier Model

Stochastic frontier analysis was pioneered by Aigner, Lovell, & Schidt (1977), and Meeusen & Broek (1977); since then it has become one of the popular tools for empirical research in applied economics.

Following the specification in Coelli et al. (2005) and Hazarika & Alwang (2003), who used the cost frontier model in their study, the model is generally expressed as

$$c_i \geq c(p_{1i},\ p_{2i},\ \ldots,\ p_{Ni}, q_{1i}, q_{2i}, \ldots, q_{Mi}) \tag{1}$$

where c_i is the observed cost of producer i, p_{ni} is the n-th input price; q_{mi} is the m-output; and $c(.)$ is a cost function that is non-decreasing, linearly homogenous and concave in prices. The cost function $c(.)$ gives minimum cost of producing outputs $q_{1i}, q_{2i}, \ldots, q_{Mi}$ when a producer incurs prices $p_{1i}, p_{2i}, \ldots, p_{Ni}$.

To estimate this cost function, we have to specify the functional form of $c(.)$. If Cobb-Douglas type of cost function is specified, equation (1) becomes:

$$\ln c_i \geq \beta_0 + \sum_{n=1}^{N} \beta_n \ln p_{ni} + \sum_{m=1}^{M} \beta_m \ln q_{mi} + v_i \tag{2}$$

where v_i is a symmetric random variable and represents the error of approximation and other sources of statistical noises. Equivalently:

$$\ln c_i = \beta_0 + \sum_{n=1}^{N} \beta_n \ln p_{ni} + \sum_{m=1}^{M} \beta_m \ln q_{mi} + v_i - u_i \tag{3}$$

In equation (3), we have two composite error terms, v_i and u_i. v_i is assumed to be independently and identically distributed, which represents the variation in production cost due to uncontrollable factors such as weather shock or crop diseases.[6] u_i represents producer's cost efficiency relative to the stochastic cost frontier, which maybe resulted from the mismanagement or misallocation of resources. u_i is one-sided and negatively distributed. In other words, $u_i=0$ if production cost is at the minimum; if $u_i \geq 0$, cost efficiency is imperfect.

The objective of this study is to test the hypothesis of whether or not rice farming households are cost efficient. To achieve the objectives, the unrestricted and restricted forms, assuming $\sigma_{u_i}=0$, of equation (3) will be estimated. Then, the hypothesis testing will be applied by using the generalized likelihood-ratio statistics given as:

$$\lambda = -2\left[\ln\left\{ L(H_0) \right\} - \ln\left\{ L(H_A) \right\} \right] \tag{4}$$

where H_0 is the value of the likelihood function of the restricted model

H_A is the value of the likelihood function of the unrestricted model

This test follows the $\chi^2(1)$, the χ^2 distribution with one degree of freedom. If the hypothesis testing shows that the cost inefficiency exists, we can explore the determinants of cost inefficiency by estimating the following OLS equation as suggested by Hazarika & Alwang (2003):

$$u_i = \delta_0 + \sum_{k=1}^{n} \delta_k z_{ki} + \zeta_i \tag{5}$$

where z are independent variables which influence cost inefficiency.

The methodology is composed of estimating maximum likelihood of the restricted and unrestricted models of equation (3), testing the hypothesis of equation (4) and finally estimating OLS regression of equation (5). This procedure has been criticized because in the OLS regression, the assumption of identically distributed inefficiency effects was violated (Battese and Coelli 1995).

To correct this problem of assumption violation, Battese and Coelli (1995) combined to two steps of estimation into a single step, keeping the same the assumption of v_i, independently and identically distributed; nevertheless u_i, the cost inefficiency component, was alternately assumed to be independently, but not identically distributed as truncation (at 0) of the normal distribution, indicating that the mean cost inefficiency was assumed to be a function of variables z_i as specified in equation (5). This new method allows the estimation of the coefficients as well as the test of the hypothesis in a single step. This research follows the single step estimation procedure.

3.2 Empirical Model

Empirical studies using stochastic frontier model are diverse, from the field of agricultural economics to banking and tourism. In agriculture, studies using stochastic frontier cost function include the study of economic efficiency in Pakistani agriculture by Parikh *et al.* (1995), the studies of cost efficiency of small scale maize production in Nigeria by Dia *et al.* (2010) and Orgundari *et al*. (2006), the study of cost efficiency of maize production in Nepal by Paudel & Matsuoka (2009), and the study of cost efficiency of smallholder tobacco cultivators in Malawi by Hazarika & Alwang (2003). In the case of rice, there are several efficiency studies using production frontier model and data envelopment analysis such as the study of economic inefficiency of Nepalese rice farms by Dhungana et al. (2004) and rice farming households' efficiency in Bangladesh by Wadud & White (2000). There has been no study on rice efficiency using stochastic frontier cost model yet. Therefore, the study will contribute to the literature and shed light on how to increase rice production in Cambodia by the examining the extent to which it is possible to raise the efficiency of rice farming households with the existing resources and available technology.

In this study, the Cobb-Douglas stochastic cost frontier was applied and the specific empirical model was specified as follows:

$$\ln c_i = \beta_0 + \beta_1 \ln p_{1i} + \beta_2 \ln p_{2i} + \beta_3 \ln p_{3i} + \beta_4 \ln p_{4i} + \beta_5 \ln p_{5i} + \beta_6 \ln p_{6i} + \beta_7 \ln p_{7i} + \beta_8 \ln p_{8i} + \beta_9 \ln p_{9i} + \beta_{10} \ln p_{10i} + \beta_{11} \ln p_{11i} + \beta_{12} \ln q_i + (v_i + u_i) \quad (6)$$

where,

c_i : the total production cost of rice in Cambodian Riel (KHR)[7]/ha

p_{1i} : the cost of chemical fertilizers, insecticide, weedicide and fungicide in KHR/ha

p_{2i} : the cost of planting materials in KHR/ha

p_{3i} : the cost of animal manure in KHR/ha

p_{4i} : the cost of oil, gasoline and diesel in KHR/ha

p_{5i} : the cost of storable items in KHR/ha

p_{6i} : the cost of draft power, tractor in KHR/ha

p_{7i} : the cost of hired labor in KHR/ha
p_{8i} : the cost of irrigation in KHR/ha
p_{9i} : the cost of transportation in KHR/ha
p_{10i} : the cost of repair and maintenance in KHR/ha
p_{11i} : the cost of rent in KHR/ha
q_i : rice output in kg/ha

The choice of the Cobb-Douglas functional form is based upon the fact that the methodology requires the function to be self-dual as the case of the cost function which the analysis is based on.

Moreover, the inefficiency model (u_i) is specifically defined as:

$$u_i = \delta_0 + \delta_1 z_{1i} + \delta_2 z_{2i} + \delta_3 z_{3i} + \zeta_i \quad (7)$$

where,

u_i : cost inefficiency scores
z_{1i} : farmers per hectare
z_{2i} : age of the household head
z_{3i} : household head education

The single step estimation of the parameters of equation (6) and equation (7) are carried out using STATA software package.

4. Data and Limitation

Data applied in this study was obtained from the Cambodia Socio-Economic Survey (CSES) 2009. The Ministry of Planning's National Institute of Statistics (NIS) is responsible for conducting the survey and publishing its result. The survey was conducted from January to December, 2008. It is a nationwide survey covering the sample of 12000 households within 720 villages, which are divided into 12 monthly samples of 1000 households in 60 villages.

In this study, only rice farming households were selected for the analysis. Diversified farmers, i.e farmers producing rice and other crops, are not included in the data to be analysed to ensure that bias in sample selection is minimized. Data modification and filtering were performed to ensure that the unit of measurement of each variable is consistent with the study objective and the quality of data is satisfied. The description of data is provided in Table 1 in section 5.

As briefly mentioned in section 2, rice production in Cambodia is divided into wet season and dry season, and within wet season production, there are 5 different kinds of rice, namely, early, medium, late, upland and floating rice. However, in CSES 2009, only wet season and dry season rice were recorded. Therefore, in the analysis in the subsequent section, only wet season and dry season rice will be analyzed. This is one of the limitations of the study; the other limitation is that in applying cost function, price data of input is required. Nonetheless, since price data is not available, this study will follow the study of Paudel & Matsuoka (2009) by using the cost of input per harvested area as a proxy of input price.

5. Empirical Results and Discussion

5.1 Summary Statistics

The summary statistics of the variables used in estimating the stochastic frontier cost function and inefficiency model are presented in table 1. The table shows the mean, standard deviation, minimum and maximum value of each variable along with its contribution to the total cost for all cost variables.

The cost of rice cultivation was calculated in KHR. On average, in order to produce 2097.7 kg/ha of wet season rice, a total cost of 641611.7 KHR is required with a standard deviation of 402916.9 KHR. In dry season, to produce 3508.5 kg/ha of rice, the amount of 1209836.0 KHR is needed with a standard deviation of 535548.0 KHR. The big standard deviation of the total cost and other cost variables indicates that farmers operate on a different level of cost of production.

Among the various factors of production, in wet season, the cost of chemical fertilizer, insecticide, weedicide, and fungicide accounts for the highest share (33.5%) of the total cost of production followed by the cost of draft power or tractor (18.5%), the cost of planting materials (14.5%), the cost of hired labor (12.7%), and the cost of animal manure (10.9%). These five types of factor costs represent 90.1% of the total cost of rice production incurred by Cambodian farmers. The other six different types of cost account for only 9.9% of the total cost. In dry season, the highest share of cost is also the cost of chemical fertilizer, insecticide, weedicide and fungicide, which is 27.4% of the total cost followed by the cost of planting materials (19.5%), the cost of draft power or tractor (15.6%), the cost of oil, gas and diesel (13.1%), and the cost of hired labor (10.4%). These five types of factor cost represent 86.0% of the total cost. The other six different types of cost account for the other 14.0%. The notable difference between wet season and dry season production is the use of oil, gas and diesel. In dry season, farmers spend much more on oil, gas and diesel than in wet season.

The socio-eocnomic and demographic characteristics of the farmers, which are used to examine their effects on inefficiency level, are also reported in the table. It includes the ratio of farmers to harvested area, age and education of the household heads. On average, there are 2.4 farmers per households for wet season rice farmers and 2.2 for dry season rice farmers. The small standard deviation of 1.2 for both seasons indicates that the number of farm laborers is not much different. The average age of the farm head household is 41.7 and 44.3 years old for wet season and dry season rice farmers respectively, indicating that they are largely middle aged; however, the standard deviation of 11.4 and 14.5 are quite big, suggesting that there are varieties of age groups among the farming household heads. With an average number of years of schooling of 5.6 years for wet season and 5.8

Table 1 Summary Statistics

Variable	Unit	Wet season rice Mean	Std. deviation	Min	Max	% of total cost	N^0 of Obs	Dry season rice Mean	Std. deviation	Min	Max	% of total cost	N^0 of Obs
Total cost	KHR/ha	641611.7	402916.9	16666.7	2091667.0		3168	1209836.0	535548.0	88000.0	2100000.0		346.0
Cost of chemical	KHR/ha	215174.2	238043.0	0.0	1635000.0	33.5	3168	330938.6	278649.8	0.0	1587500.0	27.4	346.0
Cost of planting material	KHR/ha	92725.1	80824.2	100.0	1060000.0	14.5	3168	236234.2	154692.2	25000.0	1080000.0	19.5	346.0
Cost of animal manure	KHR/ha	70124.2	107961.6	0.0	1666667.0	10.9	3168	20991.9	62533.5	0.0	625000.0	1.7	346.0
Cost of oil gasoline diesel	KHR/ha	11643.5	45865.5	0.0	799999.9	1.8	3168	159085.2	180720.7	0.0	999999.9	13.1	346.0
Cost of storable items	KHR/ha	19678.1	34254.3	0.0	600000.0	3.1	3168	39559.3	52680.3	0.0	733333.3	3.3	346.0
Cost of draft power/tractor	KHR/ha	118664.4	166587.0	0.0	1333333.0	18.5	3168	189315.1	174552.7	0.0	1000000.0	15.6	346.0
Cost of labor	KHR/ha	81684.4	133437.0	0.0	1428572.0	12.7	3168	126254.2	178945.6	0.0	999999.9	10.4	346.0
Cost of irrigation	KHR/ha	5090.5	31724.6	0.0	666666.7	0.8	3168	36019.6	102011.7	0.0	600000.0	3.0	346.0
Cost of transportation	KHR/ha	14399.6	35245.6	0.0	500000.0	2.2	3168	48875.6	66378.9	0.0	330000.0	4.0	346.0
Cost of repair and maintenance	KHR/ha	6581.3	34530.4	0.0	766666.6	1.0	3168	1836.4	15924.4	0.0	250000.0	0.2	346.0
Cost of rent	KHR/ha	5236.0	39801.7	0.0	700000.0	0.8	3168	18378.4	90245.7	0.0	833333.3	1.5	346.0
Rice output	kg/ha	2097.7	950.0	971.9	6800.0		3168	3508.5	1747.7	381.0	10000.0		346.0
Harvested area	ha	1.1	1.2	0.0	26.0		3168	1.1	1.1	0.1	7.5		346.0
Number of farmers in the household	person	2.4	1.2	0.0	9.0		3168	2.2	1.2	0.0	6.0		346.0
Age of household head	year	41.7	11.4	15.0	69.0		3168	44.3	14.5	20.0	85.0		346.0
Household head education	year	5.6	2.6	0.0	18.0		2434	5.8	2.6	0.0	14.0		275.0

Note: Cost of oil, gas and diesel included only those used for rice production; household expenditure for oil, gas and diesel was excluded. Family labor plays important role in Cambodia's rice production. Cost of labor in CSES 2009 includes hired labor in kind and in cash; thus, this is of the limitation in that family labor has not been incorporated.

Source: CSES, 2009

years for dry season rice farmers, and with the same standard deviation of 2.6, many farm household heads are not highly educated.

The results of the estimation of equation (6) and (7) are presented in the following sub-section. The maximum-likelihood (ML) estimates of the parameters of the frontier cost function and inefficiency model were obtained using STATA software package in two stages. In the first stage, the inefficiency evidence was tested; if evidence of inefficiency is not found, the frontier cost function becomes OSL cost function. If there is evidence of cost inefficiency, in the second stage, the inefficiency is regressed on socio-economic variables in order to explore the relationship among those variables and the cost efficiency. These two stages of estimation were carried out in a single step.

5.2 Estimates of the Stochastic Frontier Cost Function Parameters

The results showed only evidence of cost inefficiency among farming households in wet season, while no evidence of cost inefficiency among farming households in dry season. When taking into account differences in agro-climatic zones, there still no evidence of inefficiency found in the case of dry season. Surprisingly, in wet season, there was evidence of inefficiency only among farming households in Tonle Sap and Plateau/Mountain zones, but there was no evidence of cost inefficiency among farming households in Plain and Coast zones. This section presents the interpretation of the result of regions where the evidence of inefficiency were found only, in table 2 below; otherwise, the results are reported in the appendices.

Table 2 shows that all the independent variables' estimated coefficients are in conformity with the prior expectation but the cost of irrigation and the cost of repair and maintenance were not significant in Tonle Sap zone. In Plateau/Mountain zone, the coefficients of the cost of storable items and the cost of transportation were found to have no significant correlation with the total production cost. The coefficients of all the input cost and output that are positive and significant suggest that the cost function monotonically increases with the input prices.

Since the Cobb-Douglas type of cost function was applied to estimate the stochastic frontier cost function, the coefficient of the cost function serves as the cost elasticity of the production. Therefore, interpreting the result of the Cambodia's wet season case, a 1% increase in the cost of chemical fertilizer, insecticide, weedicide and fungicide will increase the total production cost by approximately 0.054%. A 1% increase in the cost of planting materials will increase the total production cost by 0.328% . A 1% increase in the cost of animal manure will increase the total production cost by around 0.030% . An increase of 1% in the cost of oil gasoline diesel will increase the total production cost by around 0.015%. A 1% increase in the cost of storable items will increase the total production cost by around 0.004%. An increase of 1% in the cost of draft power/tractor will increase the total production cost by around 0.037%. A 1% increase in the cost of hired labor will increase the total production cost by around 0.026%. A 1% increase in the cost of irrigation will increase the total production cost

Table 2 Maximum-likelihood Estimates of Parameters of the Cobb-Douglas Frontier Cost Function for Wet Season Production, 2009

		Cambodia	Tonle Sap	Plateau/Mountain
Variable	Parameters	Estimates		
General Model				
Constant	β_0	4.101***	4.714***	4.101***
		(5.379)	(0.327)	(0.436)
Cost of chemical	β_1	0.054***	0.046***	0.052***
		(0.001)	(0.003)	(0.004)
Cost of planting material	β_2	0.328***	0.426***	0.399***
		(0.013)	(0.023)	(0.031)
Cost of animal manure	β_3	0.030***	0.023***	0.031***
		(0.002)	(0.003)	(0.004)
Cost of oil gasoline diesel	β_4	0.015***	0.008*	0.031**
		(0.002)	(0.004)	(0.006)
Cost of storable items	β_5	0.004**	0.008*	0.002
		(0.002)	(0.003)	(0.005)
Cost of draft power/tractor	β_6	0.037***	0.030***	0.043***
		(0.001)	(0.003)	(0.004)
Cost of hired labor	β_7	0.026***	0.024***	0.028***
		(0.001)	(0.002)	(0.004)
Cost of irrigation	β_8	0.017***	0.006	0.019**
		(0.003)	(0.008)	(0.009)
Cost of transportation	β_9	0.005***	0.014***	0.008
		(0.002)	(0.003)	(0.005)
Cost of repair and maintenance	β_{10}	0.009***	0.005	0.023**
		(0.002)	(0.004)	(0.009)
Cost of rent	β_{11}	0.022***	0.029***	0.044***
		(0.004)	(0.006)	(0.046)
Rice output	β_{12}	0.358***	0.290***	0.404***
		(0.019)	(0.036)	(0.046)
Inefficiency Model				
Constant	δ_0	−3.059***	−2.920***	−2.752***
		(0.448)	(0.741)	(1.001)
Farmers per hectare	δ_1	0.062***	0.042*	0.073*
		(0.016)	(0.023)	(0.041)
Household head education	δ_3	0.019	0.069	0.041
		(0.033)	(0.062)	(0.079)
Age of household head	δ_4	−0.019**	−0.027*	−0.022
		(0.009)	(0.015)	(0.019)
Diagnostic Statistics				
log-likelihood		−1861.342	−386.212	−274.127
σ_u^2		−3.360***	−3.319***	−2.908***
		(0.216)	(0.314)	(0.311)
$\sigma^2 = \sigma_u^2 + \sigma_v^2$		0.190	0.146	0.194
$\lambda = \sigma_u / \sigma_v$		0.472	0.573	0.625
Likelihood ratio test H_0: $\sigma_u^2 = 0$		12.960***	7.720***	10.210***
Number of observations		3168	851	461

Note: Figures in parentheses are value of SE.
***, ** & * indicate significant at 1%, 5% and 10% respectively.
Source: Author

by around 0.017%. An increase of 1% in the cost of transportation will increase the total production cost by around 0.005%. A 1% increase in the cost of repair and maintenance will increase the total production cost by around 0.009%. An increase of 1% in the cost of rent will increase the total production cost by around 0.022%. An increase of 1% in the total output will increase the total production cost by around 0.358% . One of the important coefficients, the cost elasticity of rice output, which has the second largest value, is in the range of the estimated values from the literature. In the case of maize production in Nepal, Paudel & Matsuoka (2009) found that output contributed around 0.21% of the total cost which is equal to the estimated value of 0.21% in the study of small scale maize production in Adamawa state, Nigeria, by Dia *et al*. (2010). Another study of small scale maize production in Ondo state, Nigeria, by Ogundari *et al*. (2006) found that output would contribute to 0.48% of the total cost of production, which is the largest value among the studies applying the Cobb-Douglas cost function.

The interpretation of the result of the Tonle Sap and Plateau/Mountainous regions follows the same fashion.

5.3 Cost Efficiency Analysis

The table 2 above shows the statistical evidences of cost inefficiency among wet season rice farming households in general, and wet season rice farming households in Tonle Sap and Plateau/Mountain zones in particular. In addition, the efficiency score of each rice farming household can be generated to examine how far from the cost frontier they are producing. If the efficiency scores equal unity, the rice farming households are cost efficient. If the score is greater than unity, the farming households are not efficient; the greater the cost efficiency is, the more inefficient the level the farming households are operating at. The predicted cost efficiency scores range from 1.1 to 3.5 for the sample of wet season rice farming households in general. In the case of Tonle Sap zone, the efficiency score range from 1.1 to 3.2, and from 1.1 to 5.0 in the cease of Plateau/Mountain zone (Table 3).

In the general wet season sample, the mean cost efficiency score was estimated to be 1.2 indicating that, on average, wet season rice farming households incurred cost that was roughly 20% over the minimum cost defined by the frontier. In other words, about 20% of the cost incurred was lost or wasted if compared to the best practice farming households facing the same production technology. In Tonle Sap and Plateau/Mountain zones, the interpretation follows the same fashion.

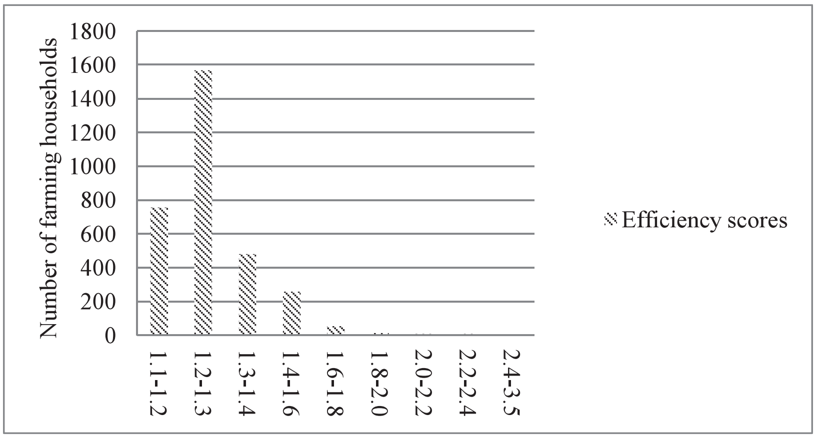
Figure 2, Figure 3 and Figure 4 show the distribution of cost efficiencies. We can see that many rice farming households in all cases were operating close to the cost frontier, households having efficiency scores ranging from 1.1 to 1.3 represent 73.5% of all farming households in the whole sample of wet season, while the figure is 72.5% in Plateau/Mountain but less than 55% in Tonle Sap zone, which indicate that rice farming households in the latter is the most cost inefficient.

Table 3 Cost Efficiency Scores of Wet Season Rice Farming Households

Efficiency Scores	Number of Farming Households			% of Farming Households		
	Cambodia	Tonle Sap	Plateau/Mountain	Cambodia	Tonle Sap	Plateau/Mountain
1.1–1.2	758	228	57	23.9	26.8	12.4
1.2–1.3	1571	389	196	49.6	45.7	42.5
1.3–1.4	482	129	111	15.2	15.2	24.1
1.4–1.6	260	74	59	8.2	8.7	12.8
1.6–1.8	55	11	24	1.7	1.3	5.2
1.8–2.0	16	14	3	0.5	1.6	0.7
2.0–5.0	26	6	11	0.8	0.7	2.4
Total	3168	851	461	100.0	100.0	100.0
Mean	1.2	1.2	1.3			
Std. Deviation	0.2	0.2	0.3			
Min	1.1	1.1	1.1			
Max	3.5	3.2	5.0			

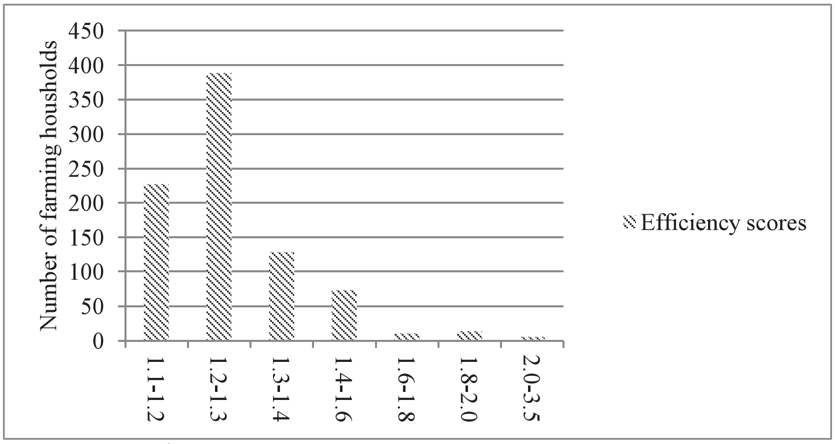
Source: Author

Figure 2 Distribution of Cost Efficiencies (Cambodia)



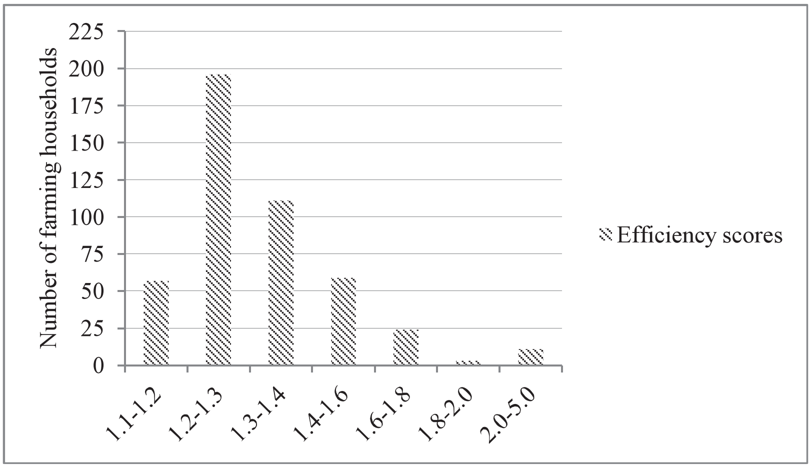
Source: Author

Figure 3 Distribution of Cost Efficiencies (Tonle Sap)



Source: Author

Figure 4 Distribution of Cost Efficiencies (Plateau/Mountain)



Source: Author

5.4 Factors Affecting Cost Inefficiency

The lower part of Table 2 presents the result of the inefficiency model. In this model, the dependent variable is the inefficiency score and the explanatory variables are the farm characteristics and socio-economic status of the farming households. Those explanatory variables are the ratio of farmers to harvested area, household head education and age of household head.

The ratio of farmers to harvested area is significant in all the 3 cases. The positive coefficient indicates that, on the one the hand, if there are more farmers per harvested area, the households will be less efficient. In this case, if one unit of this variable is added, the efficiency score will increase by 0.062 in Cambodia's case, 0.043 in Tonle Sap case and 0.073 in Plateau/Mountain case (the larger the efficiency score, the more inefficient the farming households are). The logic is that many Cambodian farming households own a small plot of land, and there are not many off-farm employment opportunities; therefore, if a lot of farmers work in the same plot, the plot becomes crowded and farmers cannot work efficiently. In the case of Nepali maize production, Paudel & Matsuoka (2009) found a negative but not significant relationship between family size and cost efficiency. They explained that farmers with a larger family size rely on family labor so the cost inefficiency will be reduced.

On the other hand, if the harvested area is increased, assuming that the number of farmers in the household stays the same, the farm household will be more efficient suggesting the merit of large scale production. This finding is consistent with the studies by Dia *et al*. (2010) in the case of Nigerian maize production, and Paudel & Matsuoka (2009) in the case of Nepali maize production.

Age of household head had a negative relationship with efficiency score but significant only in the general wet season[8] and Tonle Sap sample. Age of farmer can be a proxy of farming experiences; hence, if farmer become older or more experienced, the efficiency will improve. This result refutes the finding by Paudel and Matsuoka (2009) for the cost efficiency of maize farms in Nepal and Ojo (2003) for the study of efficiency of poultry egg production in Nigeria. They found the positive coefficient of age and interpreted that young farmers have greater access to extension services, and are likely to have better knowledge about the cost of production since they are relatively better educated than senior farmers.

The education level of the household head was not found to affect farm efficiency in this study. In the study of the effects of farmers' formal education on Cambodian rice production, Cheu (2011) found only primary education completion, up to 6 years of schooling, significantly affected wet rice production but was no significant evidence in dry season case. Yu & Fan (2011), in their Cambodia rice production function estimation, also found inconclusive evidence with regards to the effect of farmers' education on rice production. In the literature, the effects of education on cost efficiency are inconclusive. In the studies of Pakistani agriculture by Parikh et al. (1995), and Nepali maize production by Paudel & Matsuoka (2009), education was found to significantly improve cost efficiency. Nonetheless, in the studies of maize production in Nigeria by Ogundari *et al.* (2006) and Dia *et al*. (2010), the opposite results were obtained. In agricultural sectors, it is difficult to assess the impact of formal education on production, since highly educated famers may not necessarily be more efficient than lower educated farmers. Many scholars suggest variables such as training on agricultural technique as a proxy of education rather than years of schooling, but this information is not available in the CSES 2009.

6. Conclusions and Policy Implications

This study applies the stochastic frontier cost function to examine the cost efficiency among

Cambodian rice farming households, and to explore the factors affecting cost inefficiency. A Cobb-Douglas functional form was used. It was found that cost inefficiency prevails among wet season rice farming households in Cambodia's Tonle Sap and Plateau/Mountain agro-climatic zones. The estimated coefficients of almost all input cost are in conformity with the prior expectation, except the cost of repair and maintenance that was not significant in Tonle Sap agro-climatic zone and the cost of transportation that was not significant in Plateau/Mountain agro-climatic zone.

On the effects of socio-economic status and farm characteristics on cost inefficiency, the ratio of farmers to harvested area were found to significantly affect cost inefficiency in all cases. Age of household head was significant only in general wet season and Tonle Sap cases while head household education level was not significant in any case.

Based on the findings, several implications can be suggested. First and foremost, because inefficient farming households concentrated in Tonle Sap and Plateau/Mountain zones, farm efficiency in these two agro-climatic zones must be improved so that farmers can save input cost as well as produce more output given the same level of input cost. Tonle Sap zone plays important role in rice production, especially the up market fragrant rice such as Jasmine rice. From the finding, to increase farm efficiency, the ratio of famers to harvested area should be reduced. The reduction in this ratio can be achieved by creating more diverse sources of income generation in the rural area, including both on-farm and off-farm job opportunities, so that farming households can divide their labor for working in rice cultivation and other rural sectors. In other words, this finding also suggests disguised unemployment in rural areas. In this regard, the government and the private sector should cooperate to create new industries and provide more jobs to rural people so that disguised unemployment can be remedied and efficiency of rice cultivation can be improved. There are many possibilities to create jobs in rural areas such as creating value added of the farm products or food for work program. In addition, creating more jobs in urban and semi-urban also reduced disguised unemployment in rural areas for farmers may migrate to work during off-season. Moreover, rural and agriculture usually function as a buffer for unemployment but if disguised unemployment exists, this role is limited; hence, disguised unemployment needs to be remedied.

Otherwise, the harvested area should be increased to reap the scale merit. One way to increase cultivated area is that the government distributes the unused or uncultivated land to households possessing smaller plots of land. Thus far, the data on unused land is not yet widely available; however, there is evidence that there is unused land. Cambodia's total cultivated land has expanded from 2.3 million hectares in 2004 to around 3 million hectares in 2011 from the land which has been cleared from degraded forests or demining (Sobrado et al. 2013). In addition, with the aim of boosting the agricultural sector, the Cambodian government, in fact, has formulated policies to distribute land to the poor and the landless rural households since 2003 according the sub-decree[9] No. 19 dated March 19, 2003. However, even with the support of development partners, the effectiveness of this policy was limited due to the complicacy of the implementation. Bickel & Löhr (2011) mentioned that in 7299 villages in 16 Cambodian provinces, the landless rural households could be provided with an average of one hectare of farmland provided that the village would identify 14.5 hectares of land for pro poor purposes. When data is widely available, the issues of land distribution and its effect on agricultural efficiency should be a topic for future research.

Distributing unused land is not the only remedy. Creating farming cooperatives so that small holding households can cooperate with each other in cultivating rice is also one of the means to garner the benefit of larger scales of cultivation. Creating cooperative may be easier said than done but it has been proved successful in many Asian countries including Japan. Besides, since many farming households cultivate rice once a year, it is possible to increase the cropping period as a means of increasing cultivated areas. This policy involves constructing infrastructure such as water reservoir and irrigation system so that farming households will be able to cultivate in dry season.

Although the results showed no significant effects of educational level on efficiencies in this study, and inclusive results from the literature, it is widely believed that education improves efficiencies, in particular, education in the form of training in agricultural technique, suggesting the importance of extension works, which have been almost non existent in Cambodia. From the descriptive statistics, many farmers have only primary education; therefore, extension work should be accessible to these groups of farmers.

Notes

1 For ease of explanation, inefficiency and efficiency maybe used interchangeably. In interpreting inefficiency model, for instance, the term inefficiency will be used frequently.

2 There are 8 goals of Millennium Development Goals (MDG) set forth at the onset of the millennium; one of which is to “eradicate extreme poverty and hunger”.

3 The growth of Cambodian GDP averaging 8.0% from 2000 to 2011 (ADB Key Indicators for Asia and the Pacific 2012).

4 World Bank’s World Development Indicator online data base. Available at http://data.worldbank.org/data-catalog/world-development-indicators. Last accessed April 17, 2013.

5 In CSES 2009, only wet season and dry season rice were recorded. Therefore, in the analytical section, only the broadly-classified wet season and dry season production will be examined.

6 In the normal year, output is not affected by weather. Therefore, v_i and q_i will not be correlated.

7 Cambodian currency is the Riel and abbreviated as KHR. Based the February, 2014 exchange rate, one USD is about 4000 KHR.

8. General wet season sample is the sample of wet season rice farming households in all agro-climatic zones.

9. The sub-decree is available at http://www.cambodiainvestment.gov.kh/sub-decree-146-on-economic-land-concessions_051227.html. Last accessed, April 3, 2014.

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Appendix A: Maximum-likelihood Estimates of Parameters of the Cobb-Douglas Frontier Cost Function for Wet Season Production (Plain and Coast Zones), 2009

		Plain	Coast
Variable	Parameters	Estimates	
General Model			
Constant	β_0	6.609***	5.299***
		(2.451)	(0.698)
Cost of chemical	β_1	0.048***	0.071***
		(0.003)	(0.006)
Cost of planting material	β_2	0.279***	0.273***
		(0.022)	(0.048)
Cost of animal manure	β_3	0.023***	0.018***
		(0.003)	(0.006)
Cost of oil gasoline diesel	β_4	0.018***	0.016*
		(0.003)	(0.009)
Cost of storable items	β_5	0.000	0.029***
		(0.003)	(0.007)
Cost of draft power/tractor	β_6	0.034***	0.027***
		(0.002)	(0.005)
Cost of hired labor	β_7	0.019***	0.031***
		(0.002)	(0.009)
Cost of irrigation	β_8	0.010***	0.014
		(0.004)	(0.009)
Cost of transportation	β_9	0.003	0.024***
		(0.003)	(0.006)
Cost of repair and maintenance	β_{10}	0.005*	0.018*
		(0.003)	(0.011)
Cost of rent	β_{11}	0.009*	0.009
		(0.006)	(0.012)
Rice output	β_{12}	0.338***	0.420***
		(0.033)	(0.082)
Diagnostic Statistics			
log-likelihood		−529.033	−129.477
σ_u^2		−13.446	−3.937***
		(506.615)	(1.376)
$\sigma^2=\sigma_u^2+\sigma_v^2$		0.159	0.165
$\lambda=\sigma_u/\sigma_v$		0.003	0.366
Likelihood ratio test H_0: $\sigma_u^2=0$		0.000	0.190
Number of observations		1056	250

Note: Figures in parentheses are value of SE.
***, ** & * indicate significant at 1%, 5% and 10% respectively.
Source: Author

Appendix B: Maximum-likelihood Estimates of Parameters of the Cobb-Douglas Frontier Cost Function for Dry Season Production, 2009

		Cambodia	Plain	Tonle Sap
Variable	Parameters		Estimates	
General Model				
Constant	β_0	6.849**	7.253**	6.155***
		(3.022)	(2.963)	(0.925)
Cost of chemical	β_1	0.031***	0.020**	0.037***
		(0.005)	(0.008)	(0.010)
Cost of planting material	β_2	0.325***	0.326***	0.456***
		(0.031)	(0.041)	(0.072)
Cost of animal manure	β_3	0.011**	0.012**	0.015
		(0.004)	(0.005)	(0.013)
Cost of oil gasoline diesel	β_4	0.023***	0.023***	0.042***
		(0.004)	(0.005)	(0.008)
Cost of storable items	β_5	0.022***	0.024***	−0.015
		(0.005)	(0.006)	(0.019)
Cost of draft power/tractor	β_6	0.024***	0.021***	0.020**
		(0.004)	(0.005)	(0.008)
Cost of hired labor	β_7	0.015***	0.018***	0.015**
		(0.003)	(0.004)	(0.007)
Cost of irrigation	β_8	0.024***	0.024***	0.012
		(0.005)	(0.006)	(0.017)
Cost of transportation	β_9	0.009**	0.009**	0.001
		(0.004)	(0.005)	(0.008)
Cost of repair and maintenance	β_{10}	0.011	0.022*	−0.024
		(0.011)	(0.013)	(0.020)
Cost of rent	β_{11}	0.015**	0.014*	0.024
		(0.006)	(0.008)	(0.038)
Rice output	β_{12}	0.233***	0.195***	0.142
		(0.037)	(0.047)	(0.094)
Diagnostic Statistics				
log-likelihood		−124.056	−85.351	−4.032
σ_u^2		−14.646	−15.340	−6.429
		(11394.460)	(15697.320)	(15.695)
$\sigma^2=\sigma_u^2+\sigma_v^2$		0.001	0.124	0.069
$\lambda=\sigma_u/\sigma_v$		0.002	0.001	0.154
Likelihood ratio test H_0: $\sigma_u^2=0$		0.000	0.000	0.003
Number of observations		346	277	47

Note: The Plateau/Mountain and coast zones do not have sufficient observation for the estimation. Figures in parentheses are value of SE. ***, ** & * indicate significant at 1%, 5% and 10% respectively.
Source: Author