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Estimation of Farm Level Technical Efficiency in Small-scale Cocoa Production in Malaysia: A Data Envelopment Analysis Approach

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Abstract

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The continuous development of downstream cocoa activities in Malaysia has increased the demand for cocoa beans and provides opportunities for smallholder cocoa farmers to increase their income. However, declining output among smallholder cocoa farmers has resulted in the imbalance between the upstream and downstream cocoa activities in Malaysia. The decline in the production of cocoa beans is often associated with the reduction in the acreage of the crop. Although Malaysia's total cocoa hectarage has reduced since 1990s, the average production per hectare is also declining especially after 2001. Thus, this study investigates this issue by looking into the production efficiency among smallholder cocoa farmers in Malaysia. The technical efficiencies of cocoa farmers in Malaysia is estimated using data envelopment analysis. The study relies upon primary data gathered during the 2013 production season. Data are collected from a set of structured questionnaire administered on 375 smallholder cocoa farmers throughout Malaysia. Result of the analysis shows that the mean efficiency score is 0.526. In short, there existed inefficiency among the sampled farmers.

Keywords: Cocoa; technical efficiency; data envelopment analysis.

1. Introduction

In 1953, the first cocoa project in Malaysia started at Jerangau, covering 403 hectares of land (Malaysian Cocoa Board). Cocoa was traded commercially in Malaysia since 1960s and it is currently ranked fourth after palm oil, rubber and forestry products in the Malaysian agricultural sector. In 1990, Malaysia was the fourth largest cocoa producing countries in the world after Ivory Coast, Ghana and Brazil. However, in 2010, Malaysia was ranked 13th in the world. The decline of Malaysia's position as a major exporter of cocoa in the world was due to the reduction in the local production of cocoa beans. According to Malaysian Cocoa Board (MCB hereafter), small scale farmers prefer to grow oil palm and rubber trees instead of cocoa. The preference for oil palm and rubber trees is attributed to the simplicity in the plantation process.

Malaysia's raw cocoa beans production registered continuous decline since the mid 90's. Based on Table 1, domestic raw cocoa beans production achieved its peak in 1990 at 247,000 metric tons. A significant reduction in production occurs since 1995. Output dropped from 131,475 tons in 1995 to 70,262 tons in 2000. In 2014, only 2,665 tons were produced. In the cocoa grinding sector, production has increased from 103,540 tons in 1995 to 139,443 tons in 2000 and 244,423 tons in 2014. The continued growth in the cocoa grinding sector presents opportunities for farmers to increase raw cocoa beans output.

However, the recent data on raw cocoa beans output in Malaysia indicates that this industry which mostly operated by small-scale farmers are plagued with inefficiencies issues. The growing disparity between the upstream and downstream cocoa output despite efforts from governing bodies such as Malaysian Cocoa Board and Ministry of Agriculture justifies the need to investigate this issue further. Therefore, this study addresses this issue by estimating the technical efficiency of Malaysian smallholder cocoa farmers and determines the sources of technical inefficiencies of these farmers.

Table 1. Malaysia Cocoa Beans Production

Year	Raw beans(tonnes) (upstream sector)	Grinded beans (tonnes) (downstream sector)
1980	36,500	6,000
1985	108,000	27,000
1990	247,000	70,000
1995	131,475	103,540
2000	70,262	139,443
2005	27,964	258,647
2010	15,654	302,366
2014	2,665	244,423

Source: http://www.koko.gov.my/lkmbm/industry/statistic/p_cocoabean.cfm

The rest of the paper is organized as follows. Section 2 reviews the existing literatures on cocoa productivity. Section 3 presents the empirical model and data. Section 4 discusses the empirical results and section 5 concludes.

2. Literature Reviews

Most studies on production efficiency of smallholder cocoa farmers are concentrated in major cocoa producing countries such as Nigeria and Ghana (see Kolawole and Ojo, 2007; Amos, 2007; Taiwo et al., 2015; Binamu et al., 2008 and Aneani et al., 2011). In Malaysia, there is lack of research that investigates efficiencies of smallholder cocoa farmers. The only study was done by Othman in 1990 and only covers two states in the Peninsular Malaysia, namely Selangor and Perak.

Studies in Nigeria generally find consistent results on technical efficiency among cocoa farmers. Damian et al. (2012) estimated technical efficiency involving 200 cocoa farmers from Ikom Agricultural Zone in the state of Nigeria. The effects of some selected socio-economic characteristics of the farmers on the efficiency indices were also estimated. Result of the analysis showed that farmers were experiencing decreasing but positive returns to scale in the use of the farm resources. The result also confirmed that the cocoa farmers in that area were technically inefficient. The study observed that there is enough room to improve efficiency with the farmers' current resource base and available technology and concluded that policies that would directly affect these identified variables should be pursued. In a study by Ogundari and Aladejimokun (2006) involving 240 cocoa farmers in Ondo, Nigeria, they found that farmers are efficient in allocating their resources. Furthermore, Amos (2007) in his study showed that farmers in Nigeria were experiencing increasing returns to scale in the use of the farm resources. The study nevertheless found that cocoa farmers in that area were technically inefficient. The efficiency level ranged between 0.11 and 0.91 with a mean of 0.72.

Binam et al. (2008) examine the technical efficiency and productivity potential of cocoa farmers in West and Central Africa. Separate stochastic frontier models were estimated for farmers in Cameroon, Ghana, Nigeria, and Côte to obtain alternative estimates for the technical efficiencies of farmers in the different countries. The study found that the productivity potential ratio plays an important part in explaining the ability of cocoa farmers in one country to compete with other farmers from different countries at the regional level. This ratio provides an estimate of the technology gap between the country and the region as a whole.

Richman (2010) investigates the determinants of technical efficiency using a balanced longitudinal (panel) data on Ghanaian cocoa farmers for the period 2001 to 2006. The average efficiency was found to be 44.2%. This study recommends that effort aimed at raising productivity and efficiency must concentrate on reducing if not eliminating farm level problems and intensification of fertilizer usage. It is further recommended that farmers be given some education on maintenance practices. In Indonesia, Hanani et al. (2013) investigated the production efficiency of 98 cocoa farmers at Sigi, Indonesia. The study found that the average level of production efficiency among cocoa farmers in Indonesia is 0.8096. The results showed the level of technology adoption on cocoa farming was still low.

3. Data and Method

This study uses cross-section data for the production year 2013. The data for this study is collected through a cross sectional survey of cocoa farmers in the West and East Malaysia involving 375 smallholder cocoa farmers using simple cluster random sampling. Information are gathered using face-to-face interview via structured questionnaire designed for collecting information on output, inputs, prices of variables, and some important socio economic variables about the farmers.

3.1 Analytical Techniques

In order to estimate the production efficiency for smallholder cocoa farmers in Malaysia, the study uses Data Envelopment Analysis method (DEA hereafter). DEA method is a non-parametric approach which was introduced by Charnes, Cooper and Rhodes (1978) based on the model of production efficiency that spearheaded by Farell (1957). DEA construct a piecewise linear production surface using linear programs and computes an efficiency score for each decision making unit (DMU) along the lines suggested by Farell (1957). DEA is very versatile and can accommodate multiple inputs and multiple outputs. DEA also does not require any parametric specification and thus is not susceptible to specification error. In contrast, the DEA approach is sensitive to outliers that might exaggerate the actual frontier because it takes no account of the possible influence of measurement error and other noise in the data.

3.2 Model Specification

In DEA, efficiency is measured by the ratio of output with input. Mathematical form of this calculation can be solved as follows:

$$\frac{\sum_{j=1}^{s} u_i\ y_{iq}}{\sum_{j=1}^{m} v_j\ x_{jq}} \quad (1)$$

subject to,

$$\frac{\sum_{j=1}^{s} u_i\ y_{iq}}{\sum_{j=1}^{m} v_j\ x_{jq}} \leq 1 \qquad k = 1,2,3,\ldots\ldots,\text{n} \quad (2)$$

u_i=1,2,3,…….,n
v_j=1,2,3,…….,n

where:
v_j is the weights to be determined for input j;
m is the number of inputs;
u_i is the weights to be determined for output i;
s is the number of outputs and
n is the number of entities.

In equation (1), x and y are for inputs and outputs respectively. μ is denoted for output weights and v for input weights and μ and v will be calculated for efficiency maximization subject to constraints in equation (2). If maximize score = 1, it means that DMUk is efficient and efficiency is achieved. On the contrary, if maximize score is <1, DMUk is considered inefficient and efficiency is not achieved. DMUk is relatively inefficient if it is possible to expand its outputs without increasing any of its inputs. Table 2 provides list of inputs and output employ in the DEA analysis:

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Table 2. Summary definitions of inputs and output in the DEA analysis

Variable	Measurement unit	Description of variable
Output		
Dry cocoa beans	Kilogram (kg)	Quantity of dry cocoa beans produced
Input		
Land	Hectares	Size of land for cocoa plantation
Labor	No. of people	Quantity of labor working at cocoa farm
Fertilizer	Kilogram	Quantity of fertilizer used
Pesticides	Liter	Quantity of pesticide used
Cocoa tree	No. of trees	Quantity of cocoa trees planted

4. Results and Discussion

This section discusses the findings of technical efficiency derived from equation (1). Estimation for DEA is carried out using DEAP program version 2.1. The study applies the maximizing output method under the Constant Return to Scale (CRS) and Variable Return to Scale (VRS) assumptions.

Table 3 shows the summary statistics for 375 respondents who participated in this study. Results show that the average cocoa beans produced by respondents in 2013 are around 1,049 kg. From the input side, the average size of cocoa farms is 1.32 hectares whereby the landowners themselves do most of the plantations. Additionally, most of the respondents use around 720 kg of fertilizers and 14.4 liters of pesticides respectively.

Table 3. Summary statistics of input and output in cocoa production

Variable	Mean	Std. Dev.	Minimum	Maximum
Output:				
Dry cocoa beans (kg)	1049	1296	20	12000
Input:				
Land (hectare)	1.32	1.157	0.1	10
Labor (no. of)	1.78	1.016	1	8
Fertilizer (kg)	720	738	50	7500
Pesticides (Liter)	14.4	24.7	1	348
Tree (no. of)	1193	1149	30	10000

Source: Authors' calculation

Table 4 provides results from DEA analysis. It shows efficiency index for smallholder cocoa farmers in Malaysia for the production year 2013. More than 85 percent of cocoa smallholders in Malaysia have efficiency score less than one for both technical efficiency measures under CRS and VRS. It reveals that majority of cocoa farmers do not produce at the optimum level of output under the existing technology and inputs combination. The number of efficient farmers measured under CRS is lower than that of VRS. In total there are 18 efficient farmers measured under CRS compared to 39 and 55 farmers respectively under VRS. Differences exist because the technical efficiency index of cocoa farmers estimated under CRS is based upon the assumption that farmers will maximize output from the currently available resources.

However, this assumption is not relevant for cocoa farmers who do not produce at optimum level due to inefficient use of resources. This justifies the higher percentage of inefficient farmers estimated under CRS than VRS. For efficiency measured under VRS, the index can be observed from two aspects; Pure Technical Efficiency (PTE) and Scale Efficiency (SE).The average efficiency score under VRS' PTE and SE estimates are 0.526 and 0.925 respectively. These results represent around 86% of cocoa farmers who recorded efficiency score less than 1. This finding is consistent with Kachroo et al. (2013) study on corn growers in India. They found that 85 percent of all corn growers are inefficient due to poor management of input resources.

Table 4. Mean Technical Efficiency Score of Smallholder Cocoa Farmers

	CRS	VRS	
	TE	PTE	SE
Minimum Score	0.057	0.009	0.016
Standard Deviation	0.124	0.281	0.299
Mean Score	0.483	0.526	0.925
Efficiency Score = 1			
No. of farmers	18	39	55
	(4.8%)	(10.4%)	14.7%)
Efficiency score<1			
No. of farmers	357	336	320
	(95.2%)	(89.6%)	(85.3%)
Total	375	375	375

Source: Authors' calculation
Note: TE: Technical Efficiency; PTE: Pure Technical Efficiency; SE: Scale Efficiency

5. Conclusion

Technical efficiency is an important determinant of competitiveness especially for smallholder cocoa farmers in Malaysia. The results of this study show that most of the cocoa farmers in Malaysia are technically inefficient due to poor management and usage of inputs. Based on the findings, the Malaysian Cocoa Board should engage the farmers with activities and programs that could help improve their technical efficiency. The low efficiency scores obtained from the DEA analysis show that smallholder cocoa farmers need to be efficient if they wish to remain competitive in the industry. Achieving this objective however requires strong commitments from cocoa farmers and all agencies involved. Relevant agencies should pursue policies that would directly affect the efficiency of the cocoa farmers vigorously.

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