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PRODUCTION EFFICIENCY AND ITS DETERMINANTS OF CASSAVA FARMS IN MAHA SARAKHAM, THAILAND

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ABSTRACT

This study sought to analyse technical efficiency and its determinants for cassava farms in Maha Sarakham province, using three-step sampling. The data collection was done in January to February, 2019. The 108 farmers in the sample were categorized into three groups depending on their farm size (small, medium, or large). For the production efficiency analysis, a stochastic frontier model was used in combination with a fractional regression model. The study showed that cassava farms in Maha Sarakham have a technical efficiency level of 61%; the large farms have the highest level of technical efficiency. The determinants of technical efficiency were household labor, farm size, age at which cassava is harvested, and communication with government extension service. The study recommends the following: 1) gathering cassava farmers together on larger plots to increase farmers' production efficiency, as a result of economies of scale; 2) the development of small machines for cassava planting to relieve the shortage of labor; and 3) direct contact with agricultural support officials to increase cassava production efficiency more than the provision of cassava training courses.

Keywords: farm size, machinery labor, production function, technical efficiency, stochastic frontier model

INTRODUCTION

Cassava is the fourth most important key economic crop in Thailand, in terms of planted area, coming behind rice, *Pará* rubber, and sugar cane. The area of Thailand planted with cassava has gradually increased since 1970, and is approximately 1.43 million hectares in 2016(Arthey et al. 2018). Moreover, cassava exports provided national income more than 80 billion baht annually and Thailand is also the largest cassava exporter of the world (OAE 2016). Demand for cassava products in the world market has doubled over the past 20 years, with increased demand not only for cassava chips and pellets but also for ethanol produced from cassava (Piyachomkwan and Tanticharoen, 2011).However, the average Thai cassava yields have tended to decrease, and they are lower than the yields in other key cassava exporting countries including India, Cambodia, and Indonesia (OAE 2018a). Increasing cassava productivity is the key to meet the rising demand that the significant factor which affects towards the agricultural yield productivity of developing countries. However, although Thailand agricultural production sector had shifted themselves from small batch production for living to commercial production by using modern technology such as cultivar development, using fertilizer and agricultural machineries but this changing process was the result of government investment in large infrastructure and human resource development as a part of National Economic and Social Development plan (Ebers et al. 2017).The consequence was, Thailand had become the largest cassava exporter in the world, however, small farmers in rural area still had to suffer from resource constraints including land and labor shortage.

In Maha Sarakham province, most cassava producers are small farmers with an average planted area of around two hectares. They produce 20 tons per hectare, which is lower than neighbouring farmers in areas such as Kalasin (22 tons per hectare), Khon Kaen (21.25 tons per hectare), or even Nakhon Ratchasima (23.13 tons per hectare) (OAE 2018b). Furthermore, most cassava farmers in Maha Sarakham province focus on using human labor in the production processes (even for the growing and harvesting processes) rather than machine labor. The machinery use for crop establishment and harvesting is wildly used in the Central region of Thailand, the most farmer access to the machinery was large-scale farmer (Arthey et al. 2018). This has caused many resource constraints compared with cassava farmers in other areas, and the farmers did not gain any benefits from advances in technology because of the low level of acceptance and distribution of modern technology, mechanical operations are limited to land preparation and harvesting, most farmers do not have machinery of their own due to the prohibitive acquisition cost, but entrepreneurial farmers, commonly operating on >8ha, with better access to finance, will purchase machinery and then offer contracting services to others at a contracting charge. Thus, increasing the yield without increasing the production factors or changing the technology can be achieved by improving the production efficiency; technical efficiency analysis is a significant tool for understanding the factors that are associated with efficiency improvement (Coelli et al. 2002). Research on efficiency and cassava production efficiency level were studied widespread in Africa countries which were the cassava growing and consumption countries of the world (Ogundari and Ojo 2007; Udoh and Etim 2007; Raphael 2008; Oladeebo and Oluwaranti 2012). All of these studies applied parametric approach, i.e., Stochastic Production Frontier approach with relatively smaller sample size ranging from 100–200 farmers. Although parametric approach requires assumption of the nature of production technology and behavior of the market, it is well known that this approach has certain advantage of accommodating statistical noise (Ogundari and Ojo 2007). Studies on the cassava value chain and supply chain were conducted (Suvittawatt et al. 2014: Arthey et al. 2018) and the factors determining demand, supply, and price of cassava were studied (Chaisinboon and Chontanawat 2011). However, there are no studies about cassava production efficiency in Thailand. Therefore, the study results will allow comparison of the cassava production efficiency levels in the various production areas in Maha Sarakham province, and specify the factors that affect production efficiency, which can be applied as guidelines for sustainably developing cassava production policies in Thailand.

MATERIALS AND METHODS

Study area. Maha Sarakham province is in the central area of northeastern region of Thailand with planted area of approximately 528,000 hectares. The terrain is quite flat with undulated plains and rough highlands with no mountains, and there are fields alternating with sparse forest. Most areas are 130 – 230 meters above sea level with sandy loam soil. The climate is tropical monsoon with rainfall altered with dry air, averaged monthly rainfall is 118.1 mm with maximum rainfall of 414.9 mm in May. Average temperature is 27.91 ºC with the highest temperature of 39.3 ºC in April and the lowest temperature of15.0 ºC in January. Relative humidity is approximately 73.55% (Maha Sarakham provincial office 2019).

Data and sampling. Population in this study is 9,883 cassava farmers in Maha Sarakham Province (OAE 2018b). This research is an empirical study using cross-sectional data of Kasetsart 50 variety cassava growing of 108 farmers in Maha Sarakham Province in 2017 to 2018 crop year. Specifying sample size by using 10 percent of sample size deviation with the formula as shown in equation (1) (Vanitsuppavong 2003).

$$n = \frac{N}{1+Ne^2} \tag{1}$$

n = desired size of sample group
N = population size
e = acceptable sampling deviation

Given value in the formula as shown in equation (2) will attain a cassava farmer size of98.998peopleas shown in equation (2)

$$n = \frac{9{,}883}{1+9{,}883\ (0.10)^2} = 98.998 \qquad (2)$$

The sampling process was done in three stages, as follows. First, the three districts with the greatest planted areas were selected. The second step was to select the sub-districts in each district that had the greatest planted area, in such a way that the selected sub-districts had at least 30 cassava farmers (each sample group must have at least 30 farmers in order to meet the requirements of a normal sample distribution); if more than one sub-district met this condition, the sub-district was considered to be the geographical representative of that district; and if more than one sub-district still met this condition, a random sampling method was used to select only one sub-district in the sampling process. Third, random sampling was used, with each cassava farmer having equal probability of being selected (Ebers et al. 2017). The farmers in the sample were divided into groups according to the size of the area planted with cassava, as follows:1) small-scale farmer (cassava planted area less than 0.8 hectares); 2) medium-scale farmer (cassava planted area 0.8-1.6 hectares); and 3) large-scale farmer (cassava planted area more than 1.6 hectares). Households in the sample that did not grow cassava in the crop year 2017/18 or were unable to provide information about production factors and yields were excluded.

Therefore, specifying the study target district for three districts for three planted area sizes was performed in order to equalize the sample for district and planted area size in each group evenly. The sample in this study contained 108 farmers, with 36 samples in each of the large, medium, and small farm groups.

Empirical model and data analysis. Production efficiency refers to potential yield that the production unit can provide under current available production factor that the production efficiency is used to evaluate the economic performance of business unit with limited resource and production efficiency also refers to technical efficiency and resource allocation performance. Farrell (1957) proposed the production efficiency measurement by using output-oriented model which is the ratio between the yield performances with the potential yield (Fig. 1). However, practically, we were unable to recognize efficient production function of production unit, so we need to estimate the production function in order to evaluate the production efficiency of cassava farmers in Maha Sarakham Province.

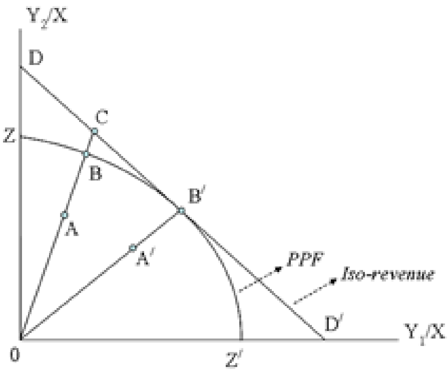

Fig. 1. Technical and allocative efficiency : output-orientated measure
(Source : Kumbhaker and Lovell, 2000)

The research prototype of Farrell (1957) referred to the concept of overall technical efficiency, price-based performance, and production efficiency by using the model of Stochastic Frontier (SF), which suits this study because farmers in developing countries must grow crops under the environmental uncertainty at risk. Moreover, SF model uses parametric approach analysis method which is able to eliminate statistical noise better than non-parametric approach (Ogundari and Ojo 2007). This study measures technical efficiency according to the guideline of Kumbhakar and Lovell (2001) by using SF model as shown in equation (3)

$$y = f(x; \beta) \cdot \exp\{v - u\} \tag{3}$$

The estimating equations for the production frontier are:

$$lnY_i = \beta_0 + \beta_1 \ln(SEED_i) + \beta_2 \ln(FERT_i) + \beta_3 \ln(FLAB_i)\, \beta_4 \ln(MACH_i) + \beta_6\, DMANURE_i + V_i + U_i \tag{4}$$

Where Y_i is cassava production (kilogram)

x_i represents production factor vectors in cassava production as follows; cultivar amount (SEED: kilogram); fertilizer amount (FERT: kilogram); human labor amount (HLAB: hour); machine labor(MACH: hour), and dummy variable represents for farmers using manure (DMANURE: 1=applied manure, 0=otherwise) (Table 1)

β is an estimation required parameter

v is the production deviation and uncontrollable risks for farmers that agricultural production also contains production risks which are climate changes, plant diseases, and pests.

While randomized variable u is the deviation from farmers' inefficiency including inefficiencies in term of technical and resource management of farmers and hired labors, the application of stochastic frontier model of Aigner et al. (1977) assumes u_i to have half-normal distribution. Model assumption has the distribution in this form because there is an assumption that most of farmers had the efficiency close to the maximum production efficiency. The model used in this study defines the production equation in form of Cobb-Douglas (CD), the advantages of using CD production equation among others is not only the appropriate usage with multi-production factor but there are also the potential to manage various production size including the simplicity to handle the econometrics estimation issues such as serial correlation, hetroscidasticity and multicolinearity as well (Murthy 2002).

Stochastic frontier production function model analysis used the maximum likelihood estimation approach to estimate the value of u_i and technical efficiency (TE_i) (Equation 5 to 7) (Kumbhakar and Lovell 2001).

$$E(u_i / \varepsilon_i) = \mu_* \left[\frac{\phi(-\mu_{*i} / \sigma_*)}{1 - \varphi(-u_{*i} / \sigma_*} \right] \tag{5}$$

Where $u_{*i} = -\frac{(\sum \beta^* \varepsilon_i)\sigma_v^2}{\sigma \int_v^2 + \sigma_u^2 \beta^2}$ and $\sigma_* = \frac{\sigma_u \sigma_v}{\sqrt{\sigma_v^2 + \sigma_u^2 \beta^2}}$

Once u_i has been estimated, the minimum square error predictor of technical efficiency is explained by (6)

$$E(exp\{u_i\} / \varepsilon_i) = E(exp\{-u_i \beta\} / \varepsilon_i) \tag{6}$$

Since the technical efficiency of each firm (TE_i) is equal toexp(-u_i) this can lead to the determination of technical efficiency of each firm from the equation (7)

$$TE_i = \exp(-E(u_i / \varepsilon_i)) \tag{7}$$

Table 1. Variables, definition and description.

Variables	Variable definition	Unit/description
Production function		
Seed	Total amount of seed use	Kg.
Chemical fertilizer	Total amount of chemical fertilizer used	Kg.
Labor use	Total labor use	Hour
Machinery hour	Total machinery hour	Hour
Manure applied	Dummy for manure applied	1 if applied manure, 0 otherwise
Technical Efficiency Model		
Farmer's characteristics		
Gender	Gender of key laborer	1 = male, 0 = female
Age	Age of key laborer	Years
Education	Education level of key laborer	1 = uneducated, 2 = primary school, 3 = secondary school, 4 = high school, and 5 = diploma or higher
Non-agricultural income	Non-agricultural income of farm household	Thai Baht/year
Farm physical characteristics		
Labor force	Agricultural labor amount	Person
Distant from farm to home	Average distant from cassava farm to home	Km.
Medium farm size	Dummy of medium farm size	1 if farm size between 0.8-1.5 ha, 0 otherwise
Large farm size	Dummy of large farm size	2 if farm size more than 1.5 ha, 0 otherwise
Crop culture and management		
Cultivar age	Cultivar age use for cassava production	Months
Soil care	Dummy of soil care	1 if applied soil care practice, 0 otherwise
Weeding	Number of weeding times	Times
Pesticide applied	Dummy of pesticide applied	1 if applied pesticide, 0 otherwise
Hormone applied	Dummy of hormone applied	1 if applied hormone, 0 otherwise
Harvested age	The harvesting period (from planting until harvesting)	Months
Communication and government extension		
Credit access	Dummy of credit access	1 if the farmer access credit, 0 otherwise
Cassava registered	Dummy of cassava registered	1 if the farmer registered at Agricultural Extension service system, 0 otherwise
Training attend	Dummy of training attend	1 if the farmer attends the cassava production training course, 0 otherwise
Government extension	Dummy of government extension	1 if the farmer contacts with government extension staff, 0 otherwise
Mobile phone applied	Dummy of mobile phone applied	1 if the farmer has mobile phone, 0 otherwise
Agricultural enterprise member	Dummy of agricultural enterprise member	1 if the farmer was the member of agricultural enterprise, 0 otherwise

For the second process to define production efficiency, due to the range of efficiency level from Stochastic Frontier Analysis (SFA) between 0 to 1, fractional regression model was used because it suits for the data analysis that the data was divided partly such as farmers' cassava production efficiency level in this study (Papke and Wooldridge 2008; Ramalho et al. 2011; Gelan and Muriithi 2012). The value estimation approach in this study is QMLE (Quasi-maximum likelihood estimate) by using STATAversion 15. There are 4determinant of technical efficiency which are used as the study variables as follows; 1) Farmer's characteristics (gender, age, education, and household income), 2) Farm physical characteristics (labor force, distant from farm to home, and farm size), 3) Cultural practice and crops management (cultivar age, soil care, weeding times, pesticide applied, hormone applied, cassava harvested age), and 4) Communication and government extension (credit access, cassava training attend, agricultural government extension communication, mobile phone applied in access cassava growing knowledge source, cassava farmer registration, and agricultural enterprise membership) (Table 1). These variables are defined by referring from previous literature review (Coelli et al. 2002; Songsrirote and Singhapreecha 2007;Srisompun et al. 2012; Rahman and Awerije 2015; Ebers et al. 2017).

RESULTS AND DISCUSSION

Farmer's and farm characteristics. The average age of the farmers was 59.81 years old; 71.30% of the main labor force was male. The main occupation was farming on their own farm. Most farmers graduated from primary school and relied on agricultural income. The average household income was 236,477 THB/year, the income from non-agricultural sector was 148,972 THB/year or 61 per cent of total household income. Compared to other production systems, cassava production is labor intensive especially during harvest; therefore, the key factor should be the number of household laborers, as most cassava processes use household labor more than hired labor; thus, household labor shortage should be a significant factor affecting the production efficiency. From the observation, the average number of household laborers was 3 people per household. The distance between the homestead and crop fields may have a negative effect because it makes it harder to transport bulky inputs that improve soil quality (Eber et al. 2017). The average distance from cassava farmer's field to homestead was 3.03 km. Regarding the plantation size, the farmers had an average plantation area of 5.04 hectares, of which an average of 1.81 hectares were used for cassava production or 35.85 per cent of household cultivated area.For crop culture and management, we found that the average cultivars age was 8.12 months, around 85 per cent used cultivar age more than 8 months. The most farmers around 83 per cent harvesting cassava product after planting date, the average harvesting period was 8.81 months. The most farmer applied hand weeding; the average weeding times was 2.40 time per crop, only 7 per cent of total farmer applied chemical herbicide but haft of them applied plant hormone to accelerating the growth of plant. As for the social communication, we found that the most farmers were registered in the government crop system and half of them used to attend the cassava production training program.

Production frontier model and technical efficiency score. The analysis starts with the estimation of the stochastic production frontier model under the Cobb–Douglas production function. Table2 shows the estimation for the coefficients of the stochastic production frontier model; we found that a common estimation value provides a satisfactory statistical result, with all the variable coefficients in the stochastic production linear equation being positive. Each of the variable coefficients can explain the elasticities in the production factor. From the study results, we found that all the input factors have a positive effect on the cassava yield, which is less than one, as expected. This implies that all the input factors except the labor force have a significantly non-zero effect on the cassava yield at a confidence level of more than 95%. Moreover, the results show that using chemical fertilizers is the key factor for cassava plants, with a coefficient of elasticity of 0.357, which means that, if the other factors are held constant, a 1 per cent change in chemical fertilizer usage affects the cassava yield by 0.357. Moreover, labor force factors, the cultivar and human labor have elasticities of, respectively, 0.269, 0.169 and 0.069. The study results in Table 2 show that the human labor coefficient is not significantly different from zero compared with the other input factors. The explanation for this is most of the human labor was used for planting and harvesting, while machine labor was used for the tillage and maintenance processes, so using human labor may not directly affect the cassava yield. Each of the estimated production factor coefficients can be used not only to explain the production elasticities, but also together the sum of all the coefficients can be used to explain the return to scale for the cassava production process. From Table 2, it can be seen that the sum of all the input factor coefficients is 0.864 (= 0.357+0.169+0.069+0.269), which is less than one. That means if all the production factors were used by 1 per cent more, the cassava yield would increase by 0.864 per cent. This could be interpreted as saying that the cassava production of the farmers in Maha Sarakham province has decreasing returns to scale. Furthermore, the coefficient of the dummy variable for whether manure was applied was 0.141, which differs significantly from zero at the confidence level of 90%; this shows that farmers who use manure for their cassava plants combined with a chemical fertilizer would have a higher yield than farmers who do not use manure.The underlying reason could be because manure contains not only NPK but also other plant nutrients and improves the soil condition that can increase nutrient uptake compared to mineral fertilizers alone (Adekiya and Agbede 2016; Amanullah et al. 2007).

Table 2. Maximum-likelihood estimates of the stochastic production frontier model.

Variables	**Mean**	**Std. Err.**	**Estimation result from SF Model**		
			Coefficient	**P-value**	
Seed (Kg.)	161.154	13.748	0.169	0.053	*
Chemical fertilizer(Kg.)	62.121	3.100	0.357	0.000	***
Labor use (hour)	91.623	6.021	0.069	0.410	ns
Machinery hour (hour)	3.896	0.442	0.269	0.003	***
Dummy (1 if applied manure, 0 otherwise)	0.519	0.048	0.141	0.100	*
Ln sigma V^2			-2.96184	0.000	***
Ln sigma U^2			-0.631101	0.070	*
Log likelihood = -71.152			probability χ^2 = 0.001**		

Note: * = significant at p<0.1; ** = significant at p<0.05; *** = significant at p<0.01

Sample size=108 households compose of 1) small-scaled farm (less than 0.8 hectares) = 36 households, 2) medium-scaled farm (0.8-1.6 hectares)=36 households,3) large-scaled farm (more than 1.6 hectares) = 36 households,

The results of the efficiency estimates using SFA are presented in Table 3, classified by farm size categories. The mean level of technical efficiency is 61%, with a significant difference across farm size categories. The implication is that there is substantial scope for boosting cassava production by reallocating resources to optimal levels, given the input prices. A clear and consistent size–efficiency relationship is observed with productivity, with large farms showing the highest levels of technical efficiency. The percentage of DMUs defines the frontier, with a higher share of large farms defining the frontier. Although some of the small farms define the frontier, their share is relatively small. Therefore, based on the results in Table 4, it can be concluded that a consistent size–efficiency relationship exists for cassava production for these sample farms of Maha Sarakham, Thailand. The efficiency measures presented in Table 3 are quite comparable to those reported for the production of other crops in Thailand, where rice technical efficiency was in the range of 58-71% (Songsrirote and Singhapreecha 2007; Srisompun et al. 2012; Srisompun et al. 2019). While technical efficiency of para-rubber is 67-69% (Rungsuriyawiboon 2010). However, as mentioned earlier, their estimates of cassava technical efficiency quite limited in Thailand.

Table 3. Technical efficiency scores of cassava production in Maha Sarakham, Thailand

Variables	Small farm (< 0.8 Ha)	Medium farm (0.8-1.5 Ha)	Large farm (> 1.5 Ha)	Total
	Percentage			
Efficiency range				
Up to 50%	44.44	22.22	16.67	27.78
51-60%	22.22	13.89	22.22	19.44
61-70%	11.11	19.44	11.11	13.89
71-80%	11.11	16.67	25.00	17.59
More than 80%	11.11	27.78	25.00	21.30
Efficiency measure				
Mean score	0.54	0.63	0.65	0.61
Standard deviation	0.18	0.21	0.19	0.20
Minimum	0.19	0.16	0.26	0.16
Maximum	0.90	0.92	0.87	0.92

Determinants of technical inefficiency. The chi square value indicates that the model can explain the changes in the dependent variable with statistical significance at the 99% confidence level. There are five determinants of production efficiency with statistical significance as labor force, medium farm size, large farm size and dummy of contact with government agent (Table 4).

Table 4. Determinant of technical efficiency of cassava production in Maha Sarakham, Thailand.

Variables	Mean	Std. Err.	Coeff.	Std. Err.	P>z	
Farmer's characteristics						
Gender	1.287	0.454	-0.038	0.118	0.751	
Age	59.806	10.330	-0.003	0.006	0.596	
Education	2.0185	0.927	-0.078	0.058	0.180	
Non-agricultural income	148971.537	183039.400	0.000	0.000	0.489	
Farm physical characteristics						
Labor force	3.000	1.230	0.085	0.047	0.071	*
Distant from farm to home	3.003	2.042	0.017	0.021	0.409	
Dummy of medium farm size	0.333	0.474	-0.368	0.213	0.084	*
Dummy of large farm size	0.333	0.499	0.278	0.124	0.025	**
Crop culture and management						
Cultivar age	8.120	1.345	-0.051	0.045	0.256	
Dummy of soil care	0.130	0.354	0.164	0.152	0.280	
Weeding times	2.398	0.820	-0.007	0.053	0.888	
Dummy of pesticide applied	1.868	0.190	-0.194	0.333	0.561	
Dummy of hormone applied	0.407	0.798	0.033	0.058	0.566	
Harvested age	8.806	1.710	0.055	0.033	0.090	*
Communication						
Dummy of credit access	0.167	0.374	0.042	0.052	0.422	
Dummy of cassava registered	0.898	0.333	0.124	0.145	0.392	
Dummy of training attend	0.556	0.499	0.037	0.116	0.752	
Dummy of government extension	0.120	0.327	0.278	0.152	0.068	*
Dummy of mobile phone applied	0.241	0.430	-0.139	0.130	0.282	
Dummy of agricultural enterprise	0.676	0.639	0.034	0.069	0.618	
Constant			0.379	0.634	0.550	
Pseudo log likelihood			-68.9124			
Chi-squared			77.120			

Note: * = significant at p<0.1; ** = significant at p<0.05

Considering the technical efficiency determinant related to the farmer's characteristics, including gender, age, education, and non-agricultural income, this relates to farming experience: skilled or experienced farmers might have more efficiency and practical knowledge, or better management (Ahmed et al. 2002). However, young farmers tend to be more advanced, because their technology acceptance level is greater than that of older farmers. Education level may increase production efficiency, because educated farmers may be more efficient: they are able to access external agricultural information to improve their yields or to make more precise decisions (Piya et al. 2012). Households with a male leader may have better production performance because, historically, male farmers had better access to institutional support or resources (Nguyen 2012). However, the inefficiency equation estimation found that none of the three variables was related with statistical significance to changes in the farmer's technical efficiency. Non-agricultural income would increase income but may also decrease production efficiency because farmers who are performing other activities may have less time to plant cassava, causing their production efficiency to decrease (Villano and Fleming 2006; Srisompun et al. 2013), or the farmer can invest more capital for cassava production (Taiwo 2008). However, the coefficient estimation of non-agricultural income result found that it did not affect the changes in technical efficiency with statistical significance. This may be because most of the farmers in the study area grow rice as their primary crop, while cassava is a supplementary crop that does not require much attention. Labor was mostly for tillage, planting and harvesting, for which most farmers tend to use hired labor rather than household labor so their non-agricultural activities do not affect the technical efficiency level. The number of household members is the only variable in this group that has a positive influence on the changes in technical efficiency. This reflects the fact that cassava planting by Maha Sarakham farmers is labor-intensive; large households with more household labor can allocate more labor to cassava production and gain benefits of the proficiency in the various skills (Abdulai and Eberlin 2001).

Large farms have a positive effect on the technical efficiency level. This effect has statistical significance, and arises from the use of production machinery and other factors that cause economies of scale (Hansson 2008). Distance from the farm to farmers' home did not affect production efficiency because most of the farms in the study area are small farms with constraints on their access to input factors, so distance does not affect the transportation of large input factors to the farm (Ebers et al. 2017). Proper crop culture and management can increase the yield significantly (Ashraf and Saeed 2006). From the estimation of the coefficient in the equation, it was found that the cassava harvesting age has a statistically significant positive influence on technical efficiency. Cassava harvesting age is associated with the quantity and quality of the cassava yield, especially the starch content in the cassava roots (Ngeve 2003), which affects price and farmer income. Cassava should be harvested between 8 and 18 months, which gives a starch percentage higher than 20%, and 12-month cassava has the best fresh root and starch percentage (National Bureau of Agricultural Commodity and Food Standards 2010). However, other variables in this group did not affect the farmers' technical efficiency.

The last factor is associated with communication and government departments. The variables used in the estimation formula were access to credit, registration of the cassava farmer, training attended, contact with government agriculture academics, mobile usage to access data, and membership of an agricultural enterprise. Participating in a political organization or social institute can boost production efficiency because of the opportunity for better access to information about efficient production and input factors (Hellin et al. 2009). In particular, farmer institutes can support their members and elevate the price bargaining power with production factor suppliers, especially landlords and buyers (Levins, 2002). The Thai government has a policy tool to continuously assist cassava farmers such as emergency loan program for cassava farmers, a project for enhancing drip irrigation for cassava plantation, large-scale cassava farming, training program on both cassava production and marketing (Office of Agricultural Economics 2018c). However, the estimation of the variable coefficient in this group found that access to agricultural credit did not affect the production efficiency. This is because cassava is the household supplemental crop and farmers use input factors to increase yield less than they should, and invest as necessary in smaller amounts of chemical fertilizer. This makes the average yield lower than in other provinces. For government departments and communication with farmers' groups, it was found that registration of the cassava farmer and attending training about cassava plants did not affect the production efficiency level with statistical significance, while government communication has a positive relationship with farmer efficiency.

CONCLUSIONS

Cassava farmers in Maha Sarakham province are small farmers with resource constraints and a low level of access to modern technology. The estimation of the technical efficiency level of the farmers in the area of study shows that cassava is produced by these farmers at less than maximum efficiency and that, using the technology and production factors that are currently available, farmers can boost their production efficiency by 39% by improving the physical characteristics of their farms, their cultivation practices and crop management, and their communication and contact with government departments. There are three key suggestions from the study in terms of policy:

1. Larger farms show a better performance than smaller ones, and, therefore, gathering cassava farmers together to plant cassava over large areas will increase the production efficiency of the cassava, with benefit from economy of scale.

2. The cassava yield in Maha Sarakham province is highly affected by the labor-intensive production methods, with household labor having a strong influence on the farmer's efficiency level, so the development of small agricultural machinery for cassava plants is necessary to relieve the issue of the shortage of labor for cassava planting.

3. Official communication from government has a positive relationship with farmers' efficiency. However, attending training on cassava growing did not affect the farmers' efficiency level, which reflects the fact that the training curriculum for farmers may not meet the demands or issues that the farmers face, and nor did registration of farmers improve the production efficiency. However, direct communication with government agriculture academics may support the improvement of farmers' efficiency.

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