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A COMPARATIVE STUDY OF DETERMINANTS OF EFFICIENCY OF OKRA PRODUCTION FOR EXPORT IN THAILAND

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ABSTRACT

Farm size is the most widely used classification criterion in statistics and has a direct impact on the farm's technical efficiency (TE). The objectives of this research were (1) to compare the TE of okra production for export between marginal, small, medium, and large-scale farmers, and (2) to present the factors of the TE of okra production for export in Thailand to the marginal, small, medium, and large farmers. The data were collected in May and June 2017 from 250 okra farming households. This paper estimated TE by using a Stochastic Production Frontier Model and Tobit regression to investigate the factors influencing the TE. The results revealed that the marginal, small, medium, and large farmers' TE were ranked 67-98%, 36-95%, 32-96%, and 38-99%, respectively. The mean TEs were 0.87, 0.83, 0.79, and 0.75, respectively. Age was crucial factors that contributed to the TE of the marginal, small, and medium farmers. While education level was crucial factors that contributed to the TE of the marginal, and small farmers. Moreover, the findings indicated that the marginal farmers had the highest technical efficiency scores.

Keywords: Okra production, positive list, stochastic frontier analysis, technical efficiency, tobit regression.

1. INTRODUCTION

The vegetable business is one of the fastest growing in the food processing industry. It has the advantage of a large export market, including the Middle East, Malaysia, Japan, Korea, Thailand, and Europe (Muchira, 2017), with fresh vegetable exports to new importers- mainly ASEAN countries, especially Malaysia and Thailand (UNIDO and IDE-JETRO, 2013), which Thailand's vegetable export revenue was 1.4 billion dollars in 2016, out of an overall Asian Exporters revenue of 17.4 billion dollars (International Trade Centre, 2016).

Okra (*Abelmoschus esculentus* L. Moench) originated somewhere around Ethiopia, and was cultivated by the ancient Egyptians by the 12th century B.C., according to Singh *et al*. (2014), who believed the probable origin of okra is in Africa. It is being grown in most sub-tropical and tropical regions of the world (CBI Market Intelligence, 2016). It provides fiber, vitamins, and minerals can protect against cancer, improve digestion, and boost immunity (Organic Facts, 2018). In okra, no endogenous toxins or significant levels of antinutritional factors have been found. It is not capable of causing any disease in humans, or animals (ICAR, 2011). This cash crop takes only 90 days from planting to harvesting, with a daily picking for two months.

In Thailand, okra is one export vegetables that has been cultivated for decades. Nearly 98 percent of fresh pods were exported to Japan in 2002. Area under export cultivation was 4,128 rai with a total production of 4,374.62 tons. The average yield per rai was low at only 1,059.74 kilograms, out of a total of about 4,000 kgs per rai in 2016 (DoAE, 2016). An attention is required to identify the factors that lead to this productivity.

Thailand faced export problems from Japan, its major importer, when Japan suspended the importation of all okra following the promulgation of the Positive List System on May 29, 2006. Due to chemical residues in okra higher than Japan's standard, Thailand's export of fresh okra to Japan in 2007 decreased sharply from 2006 (Thai Custom, 2017). Because Thailand's okra had a much lower amount of chemical residue than China's, Japan applied more tolerant examination criteria to Thailand than to China, resulting in a lower examination rate (Jian *et al.*, 2017).

A decade after the suspension, the situation of okra exports to Japan has gradually improved in both quantity and value. Export quantity and value saw 34% increased from 2015 to 2016, which were 2,649,408 kilograms (kgs.) and 303,121,827 Baht (THB) (Thai Custom, 2017).

Okra farmers face high risks to obtain higher incomes from okra production, even though, the vegetable production industry has seen a significant rise in growth (Singh and Malhotra, 2012). TE of okra production is an important factor in production growth. TE is defined as the ability to produce a given level of output with a minimum quantity of inputs under a given technology. TE studies will be able to show the potential to raise productivity by improving efficiency of farms without increasing the resource base or developing new technology (Baree et al., 2011).

To date, there has been scant comparative research on technical efficiency of various farm sizes. Consequently, this study aimed to compare the technical efficiency of export okra farmers in Thailand's Suphan Buri, Nakhon Pathom, Ratchaburi, Ang Thong, and Ratchaburi provinces with 4 sizes of landholding: the marginal, small, medium, and large farmers, respectively.

2. MATERIALS AND METHODS

2.1 Study areas

Suphan Buri, Nakhon Pathom, Ratchaburi, Ang Thong, and Ratchaburi Provinces in Figure-1, were

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selected as the study area because they are in a major export okra production region in Thailand.

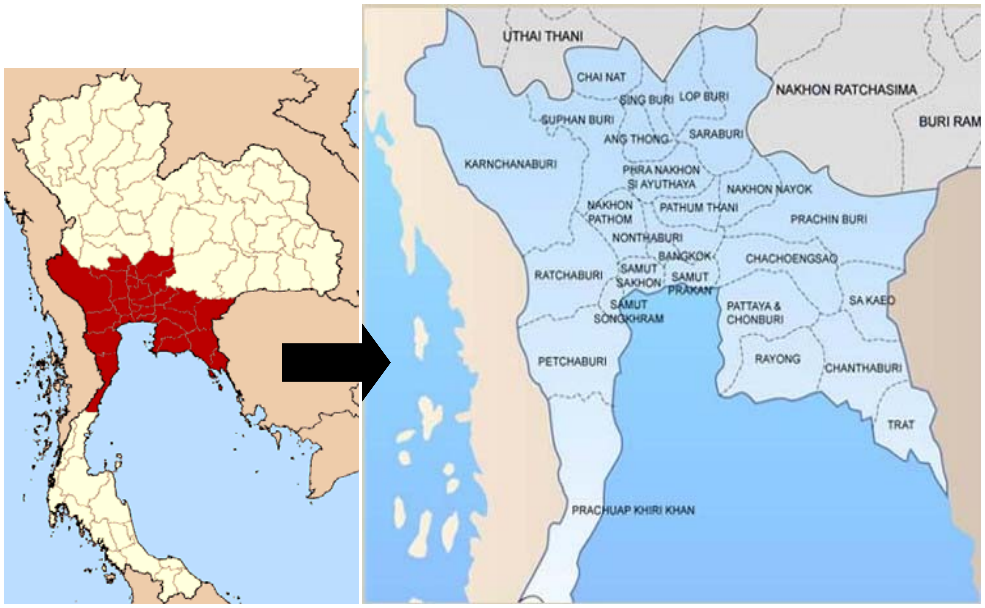

Figure-1. Primary Provinces for growing okra for export in Thailand.

2.2 Population and sample sizes

The population of this study was 670 households who were cultivating okra commercially in 2017 and registered with the Department of Agricultural Extension (DoAE) in Bangkok, Thailand in January-December, 2016 (DoAE, 2016).

The sample sizes of the four okra farmers categories showed in Table-1. Purposive sampling technique was used in collecting data from 250 households, according to 95% confidence level with a degree of variability of 5%, which represents a true population following a simplified formula provided by Yamane (Yamane, 1967) in equation 1 as follows:

$$n = \frac{N}{1 + N(e^2)} \qquad (1)$$

Where;

n is Sample size
N is Population size
e is Allowable error ($e = 5\%$).

2.3 Data collection

Primary data were collected from May to June 2017 using questionnaires and oral interviews conducted with selected okra farmers. Purposive sampling technique was applied for random sampling. The questionnaire comprised four parts. The first part consisted of the characteristics of the farmers. The second part addressed the costs and returns on production. The third part addressed the harvesting process. The fourth part asked for specific comments from the farmers.

The data included information on okra production such as: household labor (amount of work hours in production), quantity of inputs (seed, chemical fertilizer), labor cost (cost of harvesting and land cultivation in production), and farm size.

Data was also collected on household socioeconomic characteristics such as the farmers' age, gender, years of education, experience in okra production, and household size.

2.4 Data analysis

The study was based on primary data and was confined to four provinces in Thailand. The land area of okra production in rai (1 rai = 0.16 hectare) was used to standardize inputs in terms of quantities per rai.

The classification of okra farmers was based on their landholding sizes in okra production. Singh and Bagi (1980) classified farms as marginal, small, big, and large as holdings up to 7.5 acres, 7.5-15 acres, 15-30 acres, and above 30 acres, respectively, in Haryana District of India. Duraisamy (1992) classified farm households into marginal, small, medium, and big for landholding up to 2.5 acres, 2.5-5 acres, 5-10 acres, and above 10 acres, respectively, in Tamil Nadu. The definitions of farm size categories in terms of area should not be taken as uniform, without considering various other factors that affect agricultural productivity. When the associated parameters change, the land size of these categories may also change. In this study, the farmers were classified into 4 categories: marginal, small, medium, and large farmers, based on the size of their landholding according to FAO Vegetable IPM (2004), which indicated size classes in export okra production in Thailand. They are defined as follows:

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Marginal farmers <1.00 Rai
Small farmers = 1.00-1.99 Rai
Medium farmers = 2.00-2.99 Rai
Large farmers ≥ 3.00 Rai

Therefore, the 250 okra farmers in the samples were classified into 30 marginal, 164 small, 43 medium, and 13 large farmers based on farm size classes from FAO Vegetable IPM mentioned above.

Table-1. Distribution of sample size in the study area.

Area	Marginal farmers	Small farmers	Medium farmers	Large farmers
Suphan Buri Province	21	107	27	8
Nakhon Pathom Province	8	43	6	1
Ratchaburi Province	1	11	4	-
Ang Thong Provinces	-	3	6	4
Total	30	164	43	13

Source: Computed from field survey data, 2017

Descriptive statistics including frequency, mean, and percentage were employed to describe the socioeconomic characteristics of the farmers.

A stochastic frontier analysis (SFA) was applied to estimate technical efficiency. Coelli and Walding (2006), who indicated this method is less invasive and provides greater incentives for efficiency improvements. A Cobb-Douglas form of SFA has been used in many observational studies, particularly those related to developing agriculture (Battese and Coelli, 1995).

The econometric specification in this study follows the Cobb-Douglas function form. Therefore, the specification of the okra farmers in the study area is given in equation 2 as follows:

$$\text{In } Y = b_0 + b_1 \text{In} X_{1i} + b_2 \text{In} X_{2i} + b_3 \text{In} X_{3i} + b_4 \text{In} X_{4i} + b_5 \text{In} X_{5i} + (Vi - Ui) \quad (2)$$

Where:

Y = Okra yield (kg/rai)
X_{1i} = Okra farm size (rai)
X_{2i} = Okra seed (kg/rai)
X_{3i} = Household labor (amount of work hours in okra production) (hour/rai)
X_{4i} = Chemical fertilizer (kg/rai)
X_{5i} = Labor cost (cost of harvesting and land cultivation cost) (THB/rai)
X_{6i} = Distance to sell center (Km)
V_i = Random errors caused by uncontrollable factors
U_i = Randomness inefficiency

Technical efficiency (TE_i) = exp ($-u_i$) of the ith firm is a non-negative random variable and follows a normal distribution truncated at zero. The mean technical efficiency input is an output variable, and X_s are input related variables, defined previously as technical inefficiency effects, μ_i is given by the efficiency model (Huq and Arshad, 2010).

Factors of okra TE were estimated by using the Tobit regression model. This approach has been used widely in efficiency literature (Nyagaka *et al*., 2010). The choice of diverse variables, although they have been found to have an effect on the level of efficiency among smallholder farmers. Tobit regression coefficients are presented as the following equation 3 as follows:

$$Y_i = \beta_0 + \beta_1 x_i + ... + \beta_k x_k + \varepsilon_i \quad (3)$$

Where:
X_{1i}, X_{2i}, X_{ki} = Independent variable 1 to k
$\beta_0 + \beta_1 + \beta_2 \ldots, \beta_k$ = unrecognized regression coefficient
E_i = Random error
i = 1, n

According to the literature, these independent variables can have either positive or negative effects on TE. This study mainly focused on 6 managerial and structural characteristic factors: gender, age, educational level, years of okra farming experience, household size (number of persons) in okra production, and hiring labor, which were included in equation 3.

3. RESULTS AND DISCUSSIONS

3.1 Demographic characteristics of okra farmers

Table-2 provides the demographic characteristics of the respondents in the study area, namely: gender, age, years of education, and years of experience in okra production. They were analyzed using descriptive statistics.

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Table-2. Characteristics of okra farmer in Thailand.

Characteristics	Marginal farmers (N = 30)		Small farmers (N = 164)		Medium farmers (N = 43)		Large farmers (N = 13)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Gender								
Male	18	60.0	72	43.9	20	46.5	7	53.8
Female	12	40.0	92	56.1	23	53.5	6	46.2
Age								
≤30 years	1	3.3	17	10.4	2	4.7	1	7.7
31-40 years	10	33.3	38	23.2	10	23.3	0	0.0
41-50 years	7	23.3	50	30.5	14	32.6	5	38.5
51-60 years	6	20.0	37	22.6	13	30.2	6	46.2
>60 years	6	20.0	22	13.4	4	9.3	1	7.7
Years of education								
0-6 years	9	30.0	71	43.3	29	67.4	11	84.6
9 years	4	13.3	26	15.9	3	7.0	1	7.7
12 years	16	53.3	66	40.2	9	20.9	1	7.7
14 years	1	3.3	1	0.6	2	4.7	-	-
Years of experience in okra production								
1-5 years	18	60.0	105	64.0	27	62.8	8	61.5
6-10 years	4	13.3	31	18.9	7	16.3	3	23.1
11-15 years	5	16.7	22	13.4	5	11.6	1	7.7
>15 years	3	10.0	6	3.7	4	9.3	1	7.7
Household size								
1-2 persons	22	73.3	141	86.0	35	81.4	11	84.6
3 persons	7	23.3	16	9.8	7	16.3	1	7.7
>3 persons	1	3.3	7	4.3	1	2.3	1	7.7
Farm type								
Garden grove	8	26.7	37	22.6	10	23.3	4	30.8
Ridge tillage	22	73.3	127	77.4	33	76.7	9	69.2

Source: Computed from field survey data, 2017
Note: 1 Rai = 0.16 ha

The results revealed the majority, 73.3%, 86.0%, 81.4%, and 84.6% of the marginal, small, medium, and large farmers, respectively, had 1-2 persons per household in okra production.

From the gender perspective, a total of 60.0%, and 53.8% of the marginal, and large okra farmers, respectively, were men. 56.1%, and 53.5% of the small, and medium okra farmers, respectively, were women.

By age classification, 33.3% of the marginal farmer respondents were between 31-40 years, 30.5%, and 32.6% of the small and medium farmer respondents, respectively, were 41-50 years, and 46.2% of the large farmer respondents were between 51-60 years.

Year of education, this study found that 53.3% of the marginal farmer respondents had 12-year education. 43.3%, 67.4%, and 84.6% of the small, medium, and large farmer respondents, respectively, had 6-year. Thus, more than 60% of the respondents in each category have had one form of formal education. Evidence indicates that Thai okra farmers have education background similar to those of UMOH (2006).

Experience in okra production, 60.0%, 64.0%, 62.8%, and 61.5% of the marginal, small, medium, and large farmer respondents, respectively, had 1-5 years' experience in okra production. 10.0%, 3.7%, 9.3%, and 7.7% of the marginal, small, medium, and large farmer respondents, respectively, had more than 15 years of experience.

For the farm type, 73.3%, 77.4%, 76.7%, and 69.2% of the marginal, small, medium, and large farmers, respectively, were ridge tillage.

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3.2 Efficiency scores estimators

Table-3 shows the marginal farmers' average okra yield was 2,731.67 kgs/rai. Their average farm size was 0.58 rai, and the average amount of seed was 0.29 kg/rai. The amount of chemical fertilizer used was 44.12 kgs/rai on average. The average labor cost was 2,710.00 THB. The average distance to sell center was 3.77 Km. In addition, 14.03 hours of labor were required.

Table-3. Descriptive statistic of the variables of technical efficiency variable.

Variables	Marginal farmers			Small farmers			Medium farmers			Large farmers		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Okra yield (kg/rai)	2,731.67	1,800.00	4,300.00	2,845.24	1,050.00	4,500.00	2,915.12	900.00	4,500.00	2,413.46	970.00	4,480.00
Okra farm size (rai)	0.58	0.25	0.75	1.12	1.00	1.75	2.03	2.00	2.50	3.96	3.00	8.00
Okra seed (kg/rai)	0.29	0.13	0.38	0.56	0.50	0.88	1.02	1.00	1.25	1.98	1.50	4.00
Household labor (hour/rai)	14.03	10.71	17.16	13.48	7.71	18.16	13.19	7.71	17.00	13.81	10.38	17.16
Chemical fertilizer (kg/rai)	44.12	15.00	67.50	89.31	30.00	135.00	172.71	60.00	225.00	375.00	240.00	720.00
Labor cost (THB. /rai)	2,710.00	1,230.00	3,830.00	2,641.28	1,230.00	3,830.00	2,846.28	1,230.00	3,830.00	2,645.38	1,230.00	3,830.00
Distance to sell center (Km)	3.77	0.00	10.00	3.77	0.00	10.00	4.16	0.00	10.00	4.92	0.50	10.00

Source: Computed from field survey data, 2017
Note: 1 Rai = 0.16 ha
1 US$ = 34.23 THB (as of the survey period May 19, 2016)

The small farmers' average okra yield was 2, 845.24 kgs/rai. Their average farm size was 1.12 rai, and the average amount of seed was 0.56 kg/rai. The amount of chemical fertilizer used was 89.31 kgs/rai on average. The average labor cost was 2,641.28 THB. The average distance to sell center was 3.77 Km. On average, 13.48 hours of labor were required.

The medium farmers' average okra yield was 2,915.12 kgs/rai. Their average farm size was 2.03 rai, and the average amount of seed was 1.02 kg/rai. The amount of chemical fertilizer used was 172.71 kgs/rai on average. The average labor cost was 2, 846.28 THB. The average distance to sell center was 4.16 Km. In addition, 13.19 hours of labor were required.

The large farmers' average okra yield was 2,413.46 kgs/rai. Their average farm size was 3.96 rai, and the average amount of seed was 1.98 kg/rai. The amount of chemical fertilizer used was 375.00 kgs/rai on average. The average labor cost was 2,645.38 THB. The average distance to sell center was 4.92 Km. On average, 13.81 hours of labor were required.

Table-4 presents the distribution of the TE results from the marginal, small, medium, and large farmers, respectively. Estimates of TE among the marginal farmers varied between 67 and 96%. Their average TE level was 87%. Moreover, the findings revealed that 90% of the marginal farmers had economic efficiency scores above 80%, which means the average technical inefficiency of the marginal farmers was 13% of the samples.

The results show that the small farmers had a TE between 36 and 95%. Their mean TE was 83%, which was lower than the marginal farmers. Thus, the average technical inefficiency was 17% of the samples of the small farmers. Additionally, 76% had economic efficiency scores above 80%.

The medium farmers had a TE between 32 and 96%. Their mean TE was 79%, which was lower than the marginal and small farmers. 63% had economic efficiency scores above 80%. Means the average technical inefficiency was 21% of the samples of the medium farmers.

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Tabl-4. Distribution of technical efficiency of okra production in Thailand.

Efficiency level	Marginal farmers		Small farmers		Medium farmers		Large farmers	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
≤ 0.60	0	0.00	12	7.32	7	16.28	4	30.77
0.61 - 0.70	1	3.33	8	4.88	4	9.30	0	0.00
0.71 - 0.80	2	6.67	20	12.20	5	11.63	2	15.38
0.81 - 0.90	15	50.00	86	52.44	17	39.53	3	23.08
> 0.91	12	40.00	38	23.17	10	23.26	4	30.77
Total	30	100.00	164	100.00	43	100.00	13	100.00
Mean efficiency (%)	0.8747		0.8287		0.7867		0.7511	
Minimum (%)	0.6696		0.3649		0.3206		0.3833	
Maximum (%)	0.9571		0.9526		0.9555		0.9927	

Source: Computed from field survey data, 2017

Then, the large farmers had a TE between 38 and 99%. Their mean TE was 75%, which was the lowest. Thus, the average technical inefficiency was 25% of the samples of the large farmers. In addition, 54% of the large farmers had economic efficiency scores above 80%.

The results of maximum likelihood estimates (MLE) of the stochastic frontier analysis are shown in Table-5. The result revealed that the coefficients of okra seed (β_2) were significant with a positive sign at the 1% level of probability of the marginal, small, medium, and large farmers.

Table-5. Maximum Likelihood Estimates (MLE) of frontier production.

Variables	Parameters	Marginal farmers		Small farmers		Medium farmers		Large farmers	
		Coefficients	t-value	Coefficients	t-value	Coefficients	t-value	Coefficients	t-value
Production function Constant	β_0	442.50***	38.67	-1,307.90	-2,105.98	4,775.43***	4,639.19	5,750.07***	5,905.17
ln (Okra farm size) (rai)	β_1	-649.74	-39.96	1,897.95***	2,761.06	-6,880.99	-8,741.66	-8,265.63	-9,808.27
ln (Okra seedling) (kg. /rai)	β_2	650.03***	39.91	1,898.58***	2,780.24	6,880.48***	8,524.36	8,267.43***	9,939.21
ln (Household labourers) (hour/rai)	β_3	-0.65	-2.40	-0.04	-0.30	-0.35	-1.70	-0.80	-2.13
ln (Chemical fertilizer) (kg. /rai)	β_4	0.33*	2.76	0.06	0.80	0.31*	2.73	-2.12	-3.23
ln (Labour cost) (THB. /rai)	β_5	0.04	0.40	-0.01	-0.26	0.14	1.19	-0.01	-0.02
ln (Distance to sell center) (Km.)	β_6	-0.02	-0.41	0.05	1.79	0.16*	2.86	0.12*	2.73
Variance parameters									
Total variance	δ^2	0.08	0.35	3.03	0.60	1.95	0.17	0.22	1.68
Variance ratio	γ	0.80	1.42	0.99***	59.26	0.99***	24.57	1.00***	1,474.07
Log likelihood function		10.22		-8.78		-1.71		0.028	
LR test of the one-sided error		0.47		13.98***		8.54***		7.16***	

Source: Computed from field survey data, 2017
***Significant at $p \leq 0.01$, * Significant at $p \leq 0.10$

The coefficients of the farm size (β_1) were significant with a positive sign at the 1% level of probability of the small farmers, with the values 2,761.06. This indicated that the yields of the small farmers can be explained by 1, 897.95% increase in their farm size.

The coefficients of the chemical fertilizer (β_4) were significant with a positive sign at the 10% level of probability of the marginal, and medium farmers, with the values 2.76, and 2.73, respectively. This indicated that the yields of the marginal, and medium farmers, can be explained by 33%, and 31% increase in chemical fertilizer use, respectively.

The coefficients of distance to sell center (β_6) were significant with a positive sign at the 10% level of probability of the medium, and large farmers, with the values 2.86, and 2.73, respectively. This indicated that the yields of the medium, and large farmers, can be explained by 16%, and 12% increase in distance to sell center, respectively

The estimates of sigma square (δ^2) of the marginal, small, medium, and large farmers were 0.08 (t-value 0.35), 3.03 (t-value 0.60), 1.95 (t-value 0.17), and 0.22 (t-value 1.68), respectively. This indicated the goodness of fit and correctness of the specified assumption of the composite error term distribution (Okoye *et al.*, 2007).

The values of gamma (γ) of the marginal, small, medium, and large farmers were 0.80, 0.99, 0.99, and 1.00, respectively. This demonstrated that 80% of the yields of the marginal farmers', 99% of the small farmers', 99% of the medium farmers', and 100% of the large farmers' variation in okra production was due to differences in their efficiency, which were significant with a positive sign at the 1% level of probability of the small, medium, and large farmers, respectively.

Okra farm size (β_1), measured in rai. The coefficient of farm size had a negative sign for the marginal, medium, and large farmers. By increasing farm size in okra production per household per crop, the output level will likely decrease. This result is similar to Bhatt and Bhat (2014). Additionally, Duffy (2009), who indicated that one of the major drawbacks is the changing nature of farming as the farm size grows. As a farm gets larger, the composition and complexity of the farming operations are altered. On the contrary, the coefficient of farm size had a positive sign for small farmers. By increasing farm size in okra production per household per crop, the output level will likely increase, which this result in line with Mittenzwei and Britz (2018); Anyiro et al. (2013), who found that an increase in farm size led to an increase in efficiency.

Okra seed (β_2), measured in kilograms/rai. The coefficient of okra seed had a positive sign for the marginal, small, medium, and large farmers. By increasing the amount of seed in production per household per crop, the output level will likely increase. This is in line with the findings of Bala *et al*. (2015); AL-Bahadely and AL-Ukeili (2018), who indicated that seeds had the greatest impact on production. On the other hand, this result is contrary to Rahman *et al.* (2012); Baree *et al.* (2011), who indicated that the coefficient of seed was negative and insignificant for small and large farms, and was positive and significant for medium farms.

Household labor (β_3), measured in hour/rai. The coefficient of household labor had a negative sign for the marginal, small, medium, and large farmers. It indicated that the efficiency will likely decrease when household labor is increased, a finding is similar to Baree et al. (2011); Rahman et al. (2012), who showed the importance of labor in farming. On the other hand, this result is contrary to UMOH (2006).

Chemical fertilizer (β_4), measured in kilogram/rai. The coefficient of chemical fertilizer had a positive sign for the marginal, small, and medium farmers. By increasing chemical fertilizer in okra production per household per crop, the output level will likely increase. This result is in line with the findings of Rahman et al. (2012); Anyiro *et al.* (2013). On the contrary, the coefficient of chemical fertilizer had a negative sign for the large farmers. By increasing chemical fertilizer in okra production per household per crop, the output level will likely decrease, which is similar to Helfand and Levine (2004).

Labor cost (β_5), measured in THB./rai. The coefficient of labor cost had a positive sign for the marginal, and medium farmers. By increasing labor cost in okra production per household per crop, the output level will likely increase. This result is similar to Iwala *et al.* (2006), who indicated that the total cost of harvesting and processing was positive with technical efficiency. In contract, the coefficient of labor cost had a negative sign for the small and large farmers. By increasing labor cost in okra production per household per crop, the output level will likely decrease. Quora (2017) made similar statements that agriculture is rather lean and labor-efficient now, in comparison with other labor-intensive sectors.

Distance to sell center (β_6), measured in Km. The coefficient of distance to sell center had a positive sign for the small, medium, and large farmers. By increasing distance to sell center in okra production per household per crop, the output level will likely increase. On the other hand, the coefficient of distance to sell center had a negative sign for the marginal farmers. By increasing distance to sell center in okra production per household per crop, the output level will likely decrease.

3.3 Factors affecting technical efficiency

Table-6 displays the results of Tobit regression analysis of factors affecting the TE of okra production. The TE scores were analyzed against gender, the age of okra farmers, the education level of okra farmers, years of experience in okra production, household size, hired labor, and farm type.

The results revealed that age of the farmers was significant with a positive sign at the 1% level of level of probability of the marginal, small, and medium farmers. Their education level was significant with a positive sign at the 1% level of probability of the marginal, and small farmers.

Gender showed a positive effect on efficiency scores for the small farmer, and it showed a negative effect on efficiency scores for the marginal, medium, and large farmers. The results indicate that an increase in male okra farmer on small farm will increase the efficiency of okra production by 2.3%. This result is similar with [33], who indicated that male farmers are more likely to be efficient than their female counterparts. An increase in female okra farmers of the marginal, medium, and large farmers will increase the efficiency of okra production by 0.3%, 4.2%, and 5.9%, respectively. This result confirmed the finding of Nyariki (2011), who found that female headed households were more efficient in the use of the limited resources that they controlled.

Table-6. Factors affecting the technical efficiency of okra production.

Economic Efficiency	Marginal farmers		Small farmers		Medium farmers		Large farmers	
	Coefficient	P>|t|	Coefficient	P>|t|	Coefficient	P>|t|	Coefficient	P>|t|
Gender (male = 1, female = 0)	-0.003	0.915	0.023	0.228	-0.042	0.431	-0.059	0.749
ln age of okra farmer (years)	0.148***	0.000	0.173***	0.000	0.162***	0.000	-0.004	0.982
ln education educational level (years)	0.114***	0.008	0.064***	0.006	0.077	0.256	0.507	0.174
ln years of okra farming experience (years)	0.003	0.808	0.005	0.611	0.003	0.910	-0.014	0.899
ln household size (person)	0.043	0.223	0.006	0.845	-0.009	0.927	-0.115	0.620
Hired labour (yes = 1, no = 0)	0.021	0.466	0.010	0.633	0.067	0.192	0.143	0.574
Farm type (garden grove = 1, ridge tillage = 0)	0.035	0.274	0.043	0.064	-0.002	0.967	-0.367	0.139
Log likelihood	38.179		118.139		22.064		3.096	
AIC	-2.079		-1.355		-0.701		0.601	

Source: Computed from field survey data, 2017
***Significant at p≤0.01

Age of okra farmer showed a positive effect on efficiency scores for the marginal, small, and medium farmers. The results indicate that an increase in age of okra farmers will increase the efficiency of okra production by 14.8%, 17.3%, and 16.2% of the marginal, small, and medium farmers, respectively. Similarly, Rahman *et al.* (2012), who stated that the older farmers were technically more efficient than the younger farmers. On the contrary, it showed a negative effect on efficiency scores for the large farmers. The results indicate that an increase in age of okra farmers will decrease the efficiency of okra production by 0.4%. Huq and Arshad (2010); Bhatt and Bhat (2014), who found that older farmers were less technically efficient than their younger counterparts.

Education level showed a positive effect on efficiency scores for the marginal, small, medium, and large farmers. The results indicate that an increase in the education level will increase the efficiency of okra production by 11.4%, 6.4%, 7.7%, and 50.7% of the marginal, small, medium, and large farmers, respectively. This result was contrary to Rahman *et al.* (2012); Anyiro *et al.* (2013), who found a negative relationship between education and economic efficiency.

Years of okra farming experience showed a positive effect on efficiency scores for the marginal, small, and medium farmer, and it showed a negative effect on efficiency scores for the large farmers. The results indicate that an increase in years of okra farming experience will increase the efficiency of okra production by 0.3%, 0.5%, and 0.3% of the marginal, small, and medium farmers, respectively, similar with Taraka *et al*. (2012), who mentioned that more experienced farmers tend to be more efficient than those who are less experienced. However, an increase in years of okra farming experience will decrease the efficiency of okra production by 1.4% of the large farmers. This result confirmed the finding of Karunarathna (2014).

Household size in okra production (number of people) showed a positive effect on efficiency scores for the marginal and small farmers, and it showed a negative effect on efficiency scores for the medium and large farmers. The results indicate that an increase in household size in okra production will increase the efficiency of okra production by 4.3%, and 0.6% of the marginal, and small farmers, respectively. This result confirmed the finding of Mbanasor and Kalu (2008); Bhatt and Bhat (2014), who found that the household size was positively correlated with technical efficiency. On the other hand, an increase in household size in okra production will decrease the efficiency of okra production by 0.9%, and 11.5% of the medium, and large farmers, respectively.

Hired labor showed a positive effect on efficiency scores for the marginal, small, medium, and large farmers. The results indicate that an increase in hiring labor in okra production will increase the efficiency of okra production by 2.1%, 1.0%, 6.7%, and 14.3 of the marginal, small, medium, and large farmers, respectively, similar with Lowder et al. (2016), who also found that seasonal hired workers provide an important source of labor for forms.

Farm type showed a positive effect on efficiency scores for the marginal and small farmers, and it showed a negative effect on efficiency scores for the medium and large farmers. The results indicate that an increase in Garden Grove in okra production will increase the efficiency of okra production by 3.5%, and 4.3% of the marginal, and small farmers. An increase in ridge tillage in okra production of the medium and large farmers will increase the efficiency of okra production by 0.2%, and 36.7% of the medium, and large farmers.

4. CONCLUSIONS

This case study provides information on how to estimate the efficiency of the export okra production under four okra farmer size categories; the marginal, small, medium, and large.

The medium farmers spent the highest labor cost on average (2,846.28 THB./rai), whereas the large farmers used the highest average amounts of seed, and chemical fertilizer, 1.98 kg./rai, and 375 kgs./rai, respectively.

The study assessed technical efficiency (TE) of export okra production in Thailand by attempting to compare the TE of okra production between the marginal, small, medium, and large farmers. The results demonstrated that the TE varies across farm size groups, with marginal farmers having the highest average TE (87.5%). This study also found that increasing of household size for medium and large farmers, tended to decrease the production efficiencies, while increased hired labor for the marginal, small, medium, and large farmers tended to increase the production efficiencies. Additionally, older okra farmers are experienced and are efficient for the marginal, small, and medium farmers.

The models of the technical efficiency in the stochastic frontier production function consisted of 'okra farm size', 'okra seed', 'household labor', 'chemical fertilizer, 'labor cost', and 'distance to sell center'. Technical efficiency of the marginal, small, medium, and large farmers increased as okra farmers' formal education increased, which had a significant positive impact at 1% level of probability of the marginal, and small farmers. Therefore, education should be one of the top priorities to develop the necessary human capital for sustainable development for the marginal, small, medium, and large farmers.

The highly significant value of the gamma of the small, medium, and large farmers showed that there were technical inefficiency effects on export okra production in the study area. This means that about 99%, 99%, and 100% of the differences between the observed output and maximum production frontier output of the small, medium, and large farmers, respectively, were caused by differences in farmers' levels of technical efficiency (Huq and Arshad, 2010).

SIGNIFICANT STATEMENTS

This research investigated technical efficiency of okra production for export in Thailand between the marginal, small, medium, and large farmers. The study indicated that the mean TE of the marginal farmers (0.87) was the highest, while the average TE of the large farmers (0.75) was the lowest. It means the TE of okra production for export in Thailand in the selected area tended to decrease with increased farm size. This is because okra plants demand much attention from farmers, especially while maintaining and harvesting. If okra farmers can't attend adequately, the TE will decrease, which can be seen from the decreased of okra yields. This suggests that small farm size is efficient in okra production. Conversely, there is disadvantage to larger farm size in okra production for export in Thailand.

Furthermore, using the Tobit regression model, this study offered suggestions on how to improve the TE of okra farmers.

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