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Performance Evaluation of the Thai Agricultural Cooperatives

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ABSTRACT

The aims of this research are to measure the efficiency of the Thai agricultural cooperatives and provide the policy recommendation for these firms. Due to the multiple business functions of agricultural cooperatives, DEA technique called Super SBM–O–V is employed to handle this problem. Data for all inputs and outputs from Cooperative Auditing Department (CAD) are collected for 77 DMUs, which are the representatives of 77 provinces in Thailand. In this case, Operating capital per member and total expenses per member were treated as input variables, since they represented amount of resources used for running the daily operations, while value of the main 5 businesses per member of agricultural cooperatives including (deposit, credit, trading, compilation of products and service and agricultural support) are used as the output variables, since all of these variables represented the value generated by cooperatives. The results showed that only 23 DMUs are operated on the efficiency frontier, while the rest of 54 DMUs are inefficient. The top 5 provinces that have the largest TE score consist of Chon Buri, Chanthaburi, Krabi, Amnat Charoen, and Phetchaburi, while the bottom 5 provinces with the lowest TE score include Trat, Nonthaburi, Loei, Nakhon Nayok, and Ang Thong. The average TE score of overall 77 provinces in Thailand is 0.6120. The computed slacks of inefficient DMUs provides useful information of how to improve the efficiency score of each DMU.

Keywords: Data Envelopment Analysis, Super SBM–O–V, Thai Agricultural Cooperatives, Efficiency

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Introduction

In Thailand, most of the studies exhibited that Agricultural cooperatives are among the main enterprises enabling the improvement and competency of the agricultural sector. They help agriculturists increase both quantity and quality of their products (Namwong and Janyasuprab, 2018). Members of agricultural cooperatives receive large benefit from the wide varieties functions of cooperatives such as interconnecting of members' products with the final consumers, raising members' bargaining power via negotiation, facilitating their members by providing personal loans, insurance and some logistics activities, acquiring the high–quality agricultural inputs from the suppliers, and distributing them to their members with the reasonable price (Faysse and Onsamrarn, 2018).

Moreover, most economists believe that the advantage of agricultural cooperatives over other business types arise from the modern principles of cooperatives namely, user–owner, user– control, and user – benefit principles (Jerker, 1996). Regarding to these principles, the people who own, control, finance and benefit from cooperatives are the members of cooperatives.

By contrast, agricultural cooperatives also encounter with some limitations. Due to the nature of agricultural products, where prices of most goods are quite sensitive to the quantity changes, cooperatives might lack ability to increase the products' prices of their members. In most cases, although establishment of cooperatives increase the market power of local farmers via introduction of a better production technology, reduction the handling or processing costs per unit, improvement related services and etc., cooperatives cannot restrict amount of members' supplies and have only a small influence on the demand side. As a result, lower agricultural products' prices remains the chronicle problem in Thailand. Secondly, the lack of managerial skill is another reason obstructing the growth of cooperatives. Since, the managing committees of cooperatives are elected from their members which make a living in the agricultural sectors, they may not have the experiences or skills in managing the business. Furthermore, the successful of agricultural cooperatives depends vastly on the availability of funds and credit, especially in the rural areas. The shortage of financial resources will be the main hindrance of cooperative expanding their business to cover activities such as providing production and consumption loans to members, selling agricultural equipment with reasonable price, assisting members to market their products, fringe benefits, offering welfare benefits to their members, and etc. Finally, the success of cooperatives requires member participation. However, the requirement of the large number of members to participate in decision-making process will lead to the delayed decision and the probability of conflicts among members.

According to the latest data of Cooperative Auditing Department (CAD), the total number of currently operating agricultural cooperatives in 2017 is 3,709 cooperatives. This is the largest number of all types of cooperatives in Thailand. Regarding this number, most of agricultural cooperatives (1,478 cooperatives, or about 40% of total number) are located in north-eastern region of Thailand followed by the northern (897 cooperatives, or about 24%) and the south regions (703 cooperatives, or about 19%), consecutively. The rest of cooperatives (571 cooperatives, or about 15%) are scattered in central, western, and eastern regions, and only 60 agricultural cooperatives are located in Bangkok metropolitan area. Analogous structure can be seen for the number of agricultural cooperative members.

Considering the overall performance of agricultural cooperatives, on the revenue side, operating capital of agricultural cooperatives are 255,378.46 million Baht in 2017 comparing with 238,535.98 million Baht in 2016 or increasing by 7.14%. Most of the operating capital comes from loans, share capital, and deposit of members. These three items are accounted for almost 90% of operating capital of agricultural cooperatives (See Table 1).

On the expenditure side, agricultural cooperatives spend most of their operating capital on loans and cash/deposits at financial institutions and other cooperatives. These two items take into account approximately 77–78% of operating capital both in 2016 and 2017, while the rest are spent on property, plant, and equipment, account receivables, other assets and inventory, consecutively (See Figure 1).

Table 1 Operating Capital of the Thai Agricultural Cooperatives (Millions of Baht)

Operating Capital	2016	2017	% Change
Deposits of Member	61,850.93 (25.95%)	68,605.01 (26.86%)	10.92
Loans	75,540.33 (31.69%)	82,079.38 (32.14%)	8.66
Deposit of Others	15,430.60 (6.47%)	14,335.13 (5.61%)	-7.10
Other Liabilities	11,484.19 (4.82%)	11,807.51 (4.62%)	2.82
Share Capital	74,047.93 (31.07%)	78,551.43 (30.76%)	6.08
Total	238,353.98 (100.00%)	255,378.46 (100.00%)	7.14

Source: Cooperative Auditing Department (CAD)

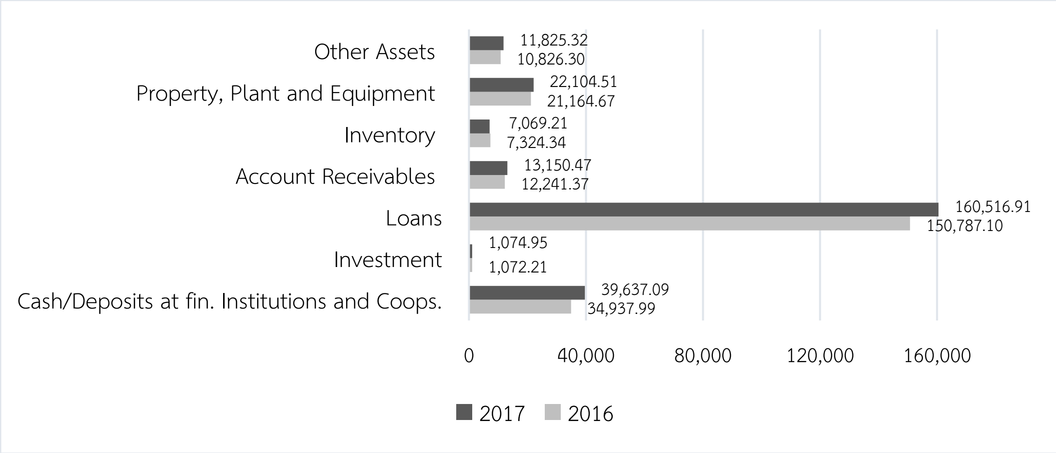

Figure 1 The Use of Funds by the Thai Agricultural Cooperatives

Moreover, agricultural cooperatives conducts 6 forms of businesses, namely (1) Credit Business (2) Deposit Business (3) Trading Business (4) Compilation of Product Business (5) Transformed Agricultural Products and Manufacturing Business, and (6) Service and Agricultural Support Business. The overall business value of the Thai agricultural cooperatives in 2017 equals to 295,228.29 million of Baht increasing from 290,408.73 million of Baht in 2016 (increased by 1.63%).

Figure 2 shows that the largest component of business value belongs to credit business. This activity accounts for 33.37% of the total business value in 2016 and decrease to 32.34% in 2017. The largest value of Credit business involves the loan to cooperative members. Most of the loan (about 85%) in 2016 and 2017 is in the form of short term and medium term loans (called emergency loan and ordinary loan). Only 15% of overall loan to cooperative member is in the form of long – term/special loan (See Figure 3).

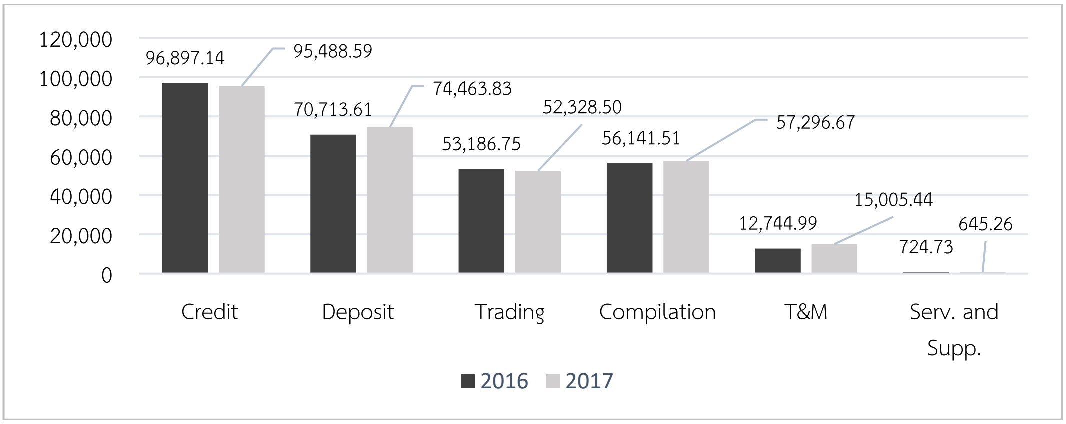

Figure 2 Business Value of Agricultural Cooperatives

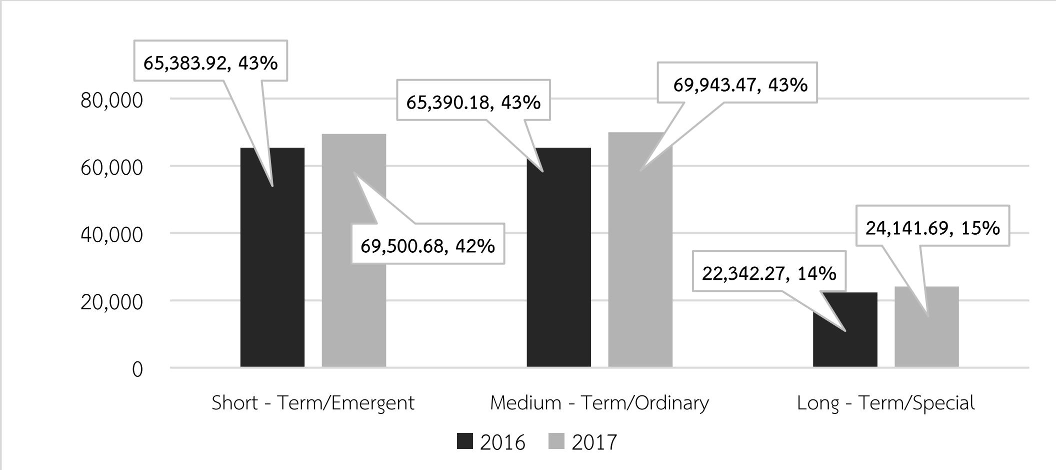

Figure 3 Loans to Agricultural–Cooperative Members

The second and the third largest businesses of agricultural cooperative are deposit business and compilation of product businesses, which account for 25% and 19% of total business value both in 2016 and 2017, while the smallest amount of business value pertains solely to service and agricultural support business (only 0.2% of total business value in both 2016 and 2017).

Operation results of agricultural cooperatives in 2017 reveals that about 70% of agricultural cooperatives gain the net profits. Their overall profits in 2017 equal to 3,983.64 million of baht increasing from the previous year by 17.35%. Finally, the 6 crucial financial ratios, namely current ratio, debt to equity ratio, total asset turnover, return on assets, return on equity, and profit margin indicate soundness and slightly improvement in management capacity of agricultural cooperatives in Thailand (See Table 2).

Table 2 Crucial Financial Ratios of the Thai Agricultural Cooperatives

Year	Current Ratio	D/E Ratio	Asset Turnover	ROA	ROE	Profit Margin
2016	1.00	2.22	0.62	1.46	4.71	2.36
2017	1.01	2.25	0.60	1.61	5.22	2.70

Source: Cooperative Auditing Department (CAD)

Research Objectives

The aforementioned discussion suggests that the overall performance of Thai agricultural cooperatives is quite impressive. However, some aspects are worthy to investigate including:

1. How do we measure and evaluate performance of the agricultural cooperatives that have multifunctional tasks?
2. Is there any difference in performance among agricultural cooperatives in each province of Thailand?
3. Are there any measures to improve the performance of agricultural cooperatives in Thailand?

As a result, the objectives of this study aim at measuring the performance of agricultural cooperatives in each province of Thailand by applying the method called Data Envelopment Analysis (DEA), since this methods has several advantages over the others, especially for the capacity to handle multiple input and output variables.

Literature Review

Farell (1957) classified the definition of economics efficiency into 2 concepts, namely allocative efficiency (AE) and technical efficiency (TE). By definition, AE refers to an ability of a firm to choose the suitable combination of its inputs under the constraint on the price of these inputs. On the other hand, TE can be measures in 2 ways. The output–oriented measure refers to an ability of a particular firm to increase quantities of its products given the quantities of inputs, while the input–oriented measure refers to a capability of a firm to reduce quantities of inputs by taking the quantities of outputs as given. By applying these concepts, Charnes, Cooper and Rhodes (1978) developed the traditional DEA model (called CCR) model to measure TE for the decision making units (DMUs) by using linear programming in order to assign the suitable weights for maximizing the virtual output to input ratio. Later, Banker et.al. (1984) introduced another traditional DEA model called BCC model by modifying CCR model in order to determine the returns to scale (RTS) characteristic of each DMU. Ever since, DEA became more popular as the tools to measure efficiency for DMUs in various industries such as banking sector (Jelena et al., 2014), healthcare (Stefko, Gavurova, and Kocisova, 2018), airline industry (Rai, 2013), education (Johnes, 2006), and etc. Moreover, DEA models have been adapted to serve wide varieties objectives related to efficiency measurement. For instance, Banker and Morey (1986) developed DEA model accounting for nondiscretionary input and output variables that could not be controlled by DMUs. In the same year, Banker and Morey (1986a) proposed DEA model involving categorical variables such as educational level, size of firms (small/medium/large) and etc. Charnes et.al. (1994) presented DEA model related to time series data called Window DEA. This technique aimed at investigating the change of DMU's efficiency during a period of time by using the moving average method. Caves et al. (1982) applied the concept of Farell's efficiency and distance function to develop the well-known Malmquist index. The index can be used to evaluate the productivity change of DMUs. Furthermore, the idea of super efficiency (SE) was first introduced by the studies of Banker and Gifford (1988) and Banker et al (1989). DEA Super Efficiency is a useful tool in wide varieties of its applications such as identifying the outliers, solving the problem of fully ranking the efficient DMUs, calculating efficiency stability region, and etc.

There are several studies applying DEA in the fields of cooperative. Magali and Pastory (2013) assessed TE score of the Rural Savings and Credits Cooperative Societies in Tanzania. They applied CCR DEA model to the secondary data of 37 savings and credit cooperative organizations (SACCOs) in Tanzania. The results exhibited that TE score of rural SACCOs varied both across and within the regions. The average TE scores of SACCOs in Morogoro, Dodoma and Kilimanjaro regions were 0.61999, 0.6028724 and 0.4649 consecutively. Moreover, the sources of inefficiency in every regions came from the high costs of operations. Othman et.al. (2014) studied the performance of 56 Malaysian cooperatives groups. By applying input-oriented BCC model under CRS and VRS assumptions with the Tobit regression model, they found that only 11% of cooperatives groups had the most efficient score. Furthermore, the Tobit regression model revealed that turnover, profit and equity were the variables that significantly affected TE score, while only turnover and equity were significantly variables influencing scale efficiency of all cooperatives groups. Akinsoyinu (2015) employed output-oriented CCR model to evaluate European financial cooperative sector. By gathering related data on cooperative banks within EU area during 2008–2013 (period of financial crisis in EU zone), the results showed that TE score of overall cooperative banks in EU zone were quite high, and there was no variation of TE score during the financial crisis. The scale efficiency of all DMUs ranged between 0.830–1.000 except for Portugal, which reflected the optimum scale of cooperative-banking operation in EU. Rapee and Peng (2016) attempted to measure operation efficiency of agricultural cooperatives in Thailand by using one of the DEA technique called Super SBM-DEA model under VRS assumption. This model had an advantage in solving the problem of indistinguishability among the efficient DMUs. The result showed that approximately 20% of Thai Agricultural cooperatives in 2012 were operate on the efficient frontier. Linh, et.al. (2017) used 2015 data to estimate the value of technical efficiency of 45 agricultural cooperatives in

Dong Thap province of Vietnam. In this study, they applied both DEA and regression analysis and separated their analysis into 3 stages. The first stage used the standard input–oriented BCC model to estimate TE score. In the second stage, they regressed TE score obtaining from the first stage and other independent variable including the management inefficiency, technical training, statistical noise and environmental variables on slack data and then used the estimated slack values from regression equation to adjust the input values. Finally, in the third stage, they ran another input–oriented BCC model by using the adjusted input data to estimated TE score. The result showed that technical training and infrastructure index were significant variables affecting TE of cooperatives. Moreover, TE scores from the third stage of all DMUs were slightly improve. Finally, Krasachat and Chimkul (2009) determined factors influencing Thai agricultural cooperatives' technical efficiency. By applying DEA with financial statement's data of agricultural cooperatives, the results showed that there existed positive relationship between efficiency scores (pure, technical and scale efficiency) and the ratio of loans to assets. Conversely, there existed the negative relationship between these efficiency scores and total debts to equity ratio.

Research Methodology

DEA Model

To determine the TE score of Thai agricultural cooperatives, this study employed the DEA model called super–efficiency output–oriented SBM model with variable returns to scale assumption (Super SBM–O–V) proposed by Tone (2002). A Super SBM–O–V model was developed based on the concept of a slack based measure of efficiency called SBM model, which proposed by Tone (1999) as follows:

$$\min \rho = \frac{1-\frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{i0}}{1+\frac{1}{s}\sum_{r=1}^{s} s_r^+ / y_{r0}}$$

Subject to

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = x_{i0}, \quad i=1,2,\ldots, m$$

$$\sum_{j=1}^{n} y_{ij}\lambda_j - s_r^+ = y_{i0}, \quad r=1,2,\ldots, s$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda, s^+, s^- \geq 0 \qquad (1)$$

where, ρ = efficiency index, s^+= input excess, s^-= output short fall, λ = the vector of weights of the DMU_j ($\lambda > 0$), and x_{ij}, y_{ij} were the inputs and outputs of DMU_j, respectively. The nonlinear programming represented by system of equations (1) gave the TE score of DMU_0 between 0 and 1 ($0 < \rho^* \leq 1$). Moreover, a DMU was efficient if $\rho^*= 1$ and also $s^+$and s^- took the value of zero. The main advantages of SBM model were unit invariant and monotone decreasing. By unit invariant, this implied that the measure of TE was invariant with respect to units of data, whereas monotone decreasing referred to the value of TE kept decreasing when both input and output slacks were increased.

By using the same concept as efficiency index (ρ), a Super – SBM model was developed in order to solve the problem of ranking efficient DMUs. Since, the efficient DMUs under SBM model were all represented by the TE score of 1 with zero value of slacks, this tool could not be classified among the efficient DMUs. The idea of Super–SBM model relied on the omission of all efficient DMUs from the computation of the efficient frontier. Then, the process used the remaining DMUs to construct the new efficient frontier and applied the concept of distant function to measure the distance from the omitted efficient DMU to the new efficient frontier as follows:

$$\min \delta = \frac{\frac{1}{m}\sum_{i=1}^{m}\bar{x}_i/x_{i0}}{\frac{1}{s}\sum_{r=1}^{s}\bar{y}_r/y_{r0}}$$

Subject to

$$\sum_{j=1,j\neq 0}^{n} x_{ij}\lambda_j+s_i^- =\bar{x}_i, \quad i=1,2,\ldots, m$$

$$\sum_{j=1,j\neq 0}^{n} y_{ij}\lambda_j-s_r^+ =\bar{y}_r, \quad r=1,2,\ldots, s$$

$$\sum_{j=1,j\neq 0}^{n} \lambda_j=1$$

$$\bar{x}_i \geq x_{i0},\ \bar{y}_r \leq y_{i0},\ \lambda,\ s^+,\ s^- \geq 0 \qquad (2)$$

Both the numerator and the denominator of equation (2) could be defined as a weighted distance in the input and output space from the omitted efficient DMU_0 (x_0, y_0) to the nearest virtual DMU ($\bar{x}$, $\bar{y}$) on the new efficient frontier, respectively.

Tone (2002) verified that TE score for the efficient DMU computed from equation (2) could be either equal or greater than 1, while the inefficient DMU would have the TE value lower than 1. For the output oriented super – SBM model (Super SBM–O–V), equation (2) could be transformed by dealing only with the weighted distance in the output space, and keeping inputs as usual. As a result, equation (2) could be written as:

$$\min \delta = \frac{1}{\frac{1}{s}\sum_{r=1}^{s}\bar{y}_r / y_{r0}}$$

Subject to

$$\sum_{j=1,j\neq 0}^{n} x_{ij}\lambda_j + s_i^- = \bar{x}_i, \quad i=1,2,\ldots, m$$

$$\sum_{j=1,j\neq 0}^{n} y_{ij}\lambda_j - s_r^+ = \bar{y}_r, \quad r=1,2,\ldots, s$$

$$\sum_{j=1,j\neq 0}^{n} \lambda_j = 1$$

$$\bar{x}_i = x_{i0},\ 0 \leq \bar{y}_r \leq y_{i0}$$

$$\lambda,\ s^+,\ s^- \geq 0 \qquad (3)$$

Details on DMUs

In this study, the latest data in 2017 collected from Cooperative Auditing Department (CAD), Ministry of Agriculture and Cooperatives of Thailand are utilized to determine the efficiency score of Thai agricultural cooperatives. Data for all inputs and outputs are collected for 77 DMUs, which are the representatives of 77 provinces in Thailand. In this case, the related data on provincial level were used to represent the operation of cooperatives in each province. The details of each DMU are shown in Table 3.

Table 3 Names of All DMUs under Consideration

Metropolitan Area					
DMU_1	Bangkok				
North Region (9 Provinces)					
DMU_2	Chiang Rai	DMU_3	Chiang Mai	DMU_4	Nan
DMU_5	Phayao	DMU_6	Phrae	DMU_7	Mae Hong Son
DMU_8	Lampang	DMU_9	Lamphun	DMU_{10}	Uttaradit
Northeastern Region (20 Provinces)					
DMU_{11}	Kalasin	DMU_{12}	Khon Kaen	DMU_{13}	Chaiyaphum
DMU_{14}	Nakhon Phanom	DMU_{15}	Nakhon Ratshasima	DMU_{16}	Buengkan
DMU_{17}	Buri Ram	DMU_{18}	Maha Sarakham	DMU_{19}	Mukdahan
DMU_{20}	Yasothon	DMU_{21}	Roi Et	DMU_{22}	Loei
DMU_{23}	Si Sa Ket	DMU_{24}	Sakon Nakhon	DMU_{25}	Surin
DMU_{26}	Nong Khai	DMU_{27}	Nong Bua Lam Phu	DMU_{28}	Amnat Charoen

Table 3 (Continued)

Metropolitan Area					
Central Region (21 Provinces)					
DMU_{29}	Udon Thani	DMU_{30}	Ubon Ratchathani		
DMU_{31}	Kamphaeng Phet	DMU_{32}	Chai Nat	DMU_{33}	Nakhon Nayok
DMU_{34}	Nakhon Phratom	DMU_{35}	Nakhon Sawan	DMU_{36}	Nonthaburi
DMU_{37}	Pathum Thani	DMU_{38}	Ayutthaya	DMU_{39}	Phichit
DMU_{40}	Phitsanulok	DMU_{41}	Phetchabun	DMU_{42}	Lop Buri
DMU_{43}	Samut Prakan	DMU_{44}	Samut Songkhram	DMU_{45}	Samut Sakhon
DMU_{46}	Sing Buri	DMU_{47}	Sukho Thai	DMU_{48}	Suphan Buri
DMU_{49}	Saraburi	DMU_{50}	Ang Thong	DMU_{51}	Uthai Thani
Eastern Region (7 Provinces)					
DMU_{52}	Chanthaburi	DMU_{53}	Chachoengsao	DMU_{54}	Chon Buri
DMU_{55}	Trat	DMU_{56}	Prachin Buri	DMU_{57}	Rayong
DMU_{58}	Sa Kaeo				
Western Region (5 Provinces)					
DMU_{59}	Kanchanaburi	DMU_{60}	Tak	DMU_{61}	Prachuap Khiri Khan
DMU_{62}	Phetchaburi	DMU_{63}	Ratchaburi		
Southern Region (14 Provinces)					
DMU_{64}	Krabi	DMU_{65}	Chumphon	DMU_{66}	Trang
DMU_{67}	Nakhon Si Thammarat	DMU_{68}	Narathiwat	DMU_{69}	Pattani
DMU_{70}	Phangnga	DMU_{71}	Phatthalung	DMU_{72}	Phuket
DMU_{73}	Yala	DMU_{74}	Ranong	DMU_{75}	Songkhla
DMU_{76}	Satun	DMU_{77}	Surat Thani		

Source: Author’s Conclusion

Input and Output Selection

Since, the main objective of most agricultural cooperatives is to enhance members to realize economic benefit that they are unable to achieve, if they run business alone, the outputs of cooperatives should be based on the business volume of cooperatives, which come from the main business activities of agricultural cooperatives. Consequently, the output variables in this study consist of 4 variables including the value of credit business (y_1), deposit business (y_2), trading business (y_3), and compilation of products business (y_4). Unlike previous studies, profits of cooperatives were not selected to be the output variable, because the main objective of cooperatives are not the profit maximization, but to improve the well – beings of their members.

On the other hands, like ordinary business, agricultural cooperatives require cash for running the daily operations. Consequently, the variables that could be used as the input variables in this study consist of amount of operating capital (x_1) and total expenses (x_2). Moreover, to reduce the effect of the difference in the size of cooperatives in each province, all input and output data are divided by the number of cooperative's members. As a result, all variables are measured in terms of Thai Baht per member. Table 4 – 6 shows the detailed of input and output variables, descriptive statistics, and correlation matrix of these variables, respectively.

Table 4 Details on Input and Output variables

Input variables (x_i)	**Output Variables (y_i)**
▪ Operating capital per member (x_1) ▪ Total expenses per member (x_2)	▪ Value of deposit business per member (y_1) ▪ Value of credit business per member (y_2) ▪ Value of trading business per member (y_3) ▪ Value of compilation of products business per member (y_4) ▪ Value of service and agricultural support business per member (y_5)

Source: Author's Conclusion

Table 5 Descriptive Statistics on Input and Output Data (Baht per Member)

	x_1	x_2	y_1	y_2	y_3	y_4	y_5
Max	349,411.30	170,883.32	139,328.83	188,264.08	67,984.74	136,328.77	1,097.01
Min	17,875.77	4,828.22	1,509.43	1,154.71	1,333.24	0.00	0.00
Average	101,461.89	36,374.47	29,775.74	38,518.59	18,106.67	10,964.86	120.89
S.D.	54,541.47	27,567.55	22,506.15	26,840.46	13,715.74	19,732.83	230.07

Source: Author's Calculation

Table 6 Correlation Matrix of Input and Output variables

	x_1	x_2	y_1	y_2	y_3	y_4	y_5
x_1	1.0000						
x_2	0.2271	1.0000					
y_1	0.8304	0.2006	1.0000				
y_2	0.8376	0.2044	0.8238	1.0000			
y_3	0.4270	0.6409	0.3608	0.3577	1.0000		
y_4	-0.0612	0.8548	-0.0219	-0.0217	0.1749	1.0000	
y_5	0.0274	0.3055	-0.0678	0.0170	0.1929	0.2449	1.0000

Source: Author's Calculation

It is worth noting that number of input and output variables in this study satisfied the following criteria

$$n \geq \max\{m \times s,\ 3(m+s)\} \tag{4}$$

where, n is the minimum suitable number of DMUs, m and s are the number of input and output variables, consecutively. Equation (4) was suggested by Cooper et al. (2006) in order to avoid the problem of discriminating power in DEA model.

Results

The TE score of Thai cooperatives classified by geographical province using the super - SBM DEA Model under the output – oriented assumption with variable returns to scale (Super SBM – O – V) are shown in Table 7. The top 5 provinces that have the largest TE score consist of Chon Buri, Chanthaburi, Krabi, Amnat Charoen, and Phetchaburi, while the bottom 5 provinces with the lowest TE score include Trat, Nonthaburi, Loei, Nakhon Nayok, and Ang Thong. The average TE score of all 77 provinces in Thailand is 0.6120. There are only 23 DMUs operating on the efficient frontier. By contrast, the rest of 54 agricultural cooperatives (approximately 70%) operated inefficiently.

When considering the average TE score by region, the results show that the highest average TE score belongs to eastern region with average score of 0.8305 followed by western (0.7118), southern (0.6520), northeastern (0.5846), central (0.5391), and northern regions (0.5124), respectively.

Table 7 Computed TE Score and Rank of Thai Agricultural Cooperatives

DMU	Score	Rank	DMU	Score	Rank	DMU	Score	Rank
1	1.000	24	27	0.997	29	53	1.050	12
2	0.132	61	28	1.181	4	54	1.377	1
3	0.847	33	29	1.035	14	55	0.002	77
4	0.008	68	30	0.062	65	56	0.651	36
5	1.004	22	31	0.264	55	57	1.104	9
6	0.004	71	32	0.520	44	58	0.414	47
7	0.552	42	33	0.003	74	59	0.230	57
8	1.011	19	34	1.013	18	60	0.045	66
9	0.030	67	35	0.629	38	61	1.111	8
10	1.025	15	36	0.002	76	62	1.177	5
11	0.139	60	37	1.014	17	63	0.996	30
12	0.536	43	38	0.344	52	64	1.198	3
13	0.636	37	39	0.619	39	65	0.556	41
14	0.007	69	40	0.069	64	66	0.312	54
15	0.858	32	41	0.489	45	67	0.801	34
16	1.000	26	42	0.004	70	68	1.000	25
17	1.005	20	43	0.992	31	69	1.000	23
18	0.161	59	44	0.999	28	70	0.228	58
19	1.139	6	45	1.046	13	71	0.087	63
20	0.366	50	46	0.408	48	72	1.128	7
21	0.464	46	47	1.080	10	73	1.023	16
22	0.003	75	48	0.245	56	74	0.999	27
23	0.321	53	49	1.004	21	75	0.122	62
24	0.377	49	50	0.003	73	76	0.003	72
25	0.347	51	51	0.575	40	77	0.670	35
26	1.058	11	52	1.216	2			
Overall Average TE								**0.6120**

Source: Author's Calculation

Table 8 shows the computed slacks for 54 inefficient DMUs. The value of input and output slacks (s_i^- and s_r^+) can be interpreted as the amounts of input reduction and output increment that inefficient DMUs should adjust in order to make them operate on the efficient frontier. This information provides the policy recommendation for each inefficient DMU. For instance, an input slack in variable x_1 of DMU_{36} (Nonthaburi) is equal to 59,301.9 Baht per member, while output slacks in variables y_2, y_4 and y_5 of the same DMU are equal to 40,502.3, 5405.3, and 841.2 Baht per member, respectively. This means that Nonthaburi cooperatives can reduce amount of operating capital per member (x_1) by 59,301.9 Baht per member, and should increase the values of credit business per member (y_2), compilation of products business per member (y_4), and service and agricultural support business per member (y_5) by 40,502.3, 5405.3, and 841.2 Baht in order to be efficient DMU.

Table 8 The Computed Slacks of 54 inefficient DMUs

DMU	TE Score	s_1^-	s_2^-	s_1^+	s_2^+	s_3^+	s_4^+	s_5^+
3	0.8471	0.0	0.0	0.0	4,441.7	0.0	1,322.1	39.5
4	0.0075	0.0	0.0	0.0	0.0	0.0	0.0	364.6
6	0.0039	0.0	0.0	0.0	2,461.3	0.0	0.0	450.7
7	0.5523	0.0	0.0	0.0	1,925.8	0.0	1,553.8	15.9
9	0.0299	0.0	0.0	0.0	0.0	0.0	0.0	504.8
11	0.1388	0.0	0.0	385.4	0.0	0.0	0.0	507.7
12	0.5357	0.0	0.0	18,117.4	0.0	0.0	1,538.4	246.0
13	0.6361	0.0	0.0	11,974.4	0.0	0.0	0.0	214.7
14	0.0074	0.0	0.0	2,699.9	1,195.6	1,990.2	0.0	240.6
15	0.8583	0.0	0.0	11,663.5	0.0	4,437.6	0.0	83.6
16	0.9998	0.0	0.0	0.1	0.0	0.0	0.0	0.0
18	0.1613	479.8	0.0	8,028.5	0.0	0.0	1,216.8	916.5
20	0.3665	0.0	0.0	13,654.8	0.0	0.0	132.4	298.7
21	0.4642	0.0	0.0	16,870.7	13,853.6	3,348.1	5,900.8	813.3
22	0.0025	0.0	0.0	8,771.9	0.0	0.0	465.6	705.1
23	0.3209	12,627.7	0.0	10,630.6	0.0	5,959.1	3,199.0	898.2
24	0.3770	0.0	0.0	0.0	1,410.4	0.0	11,779.1	320.4
25	0.3472	0.0	0.0	30,252.3	0.0	1,107.7	0.0	132.7

Table 8 (Continued)

DMU	TE Score	s_1^-	s_2^-	s_1^+	s_2^+	s_3^+	s_4^+	s_5^+
27	0.9968	0.0	0.0	0.7	0.0	0.0	0.1	0.0
30	0.0621	0.0	0.0	2,891.1	0.0	0.0	0.0	343.2
31	0.2636	0.0	0.0	639.4	0.0	0.0	0.0	417.1
32	0.5196	0.0	0.0	13,849.1	0.0	0.0	0.0	396.5
33	0.0026	16,316.7	0.0	6,510.2	0.0	0.0	0.0	689.5
35	0.6286	0.0	0.0	14,560.8	0.0	0.0	5,013.7	108.7
36	0.0020	59,301.9	0.0	0.0	40,502.3	0.0	5,405.3	841.2
38	0.3442	10,170.8	0.0	19,489.8	20,107.0	0.0	5,454.6	0.0
39	0.6193	0.0	0.0	0.0	716.7	0.0	0.0	630.7
40	0.0686	0.0	0.0	0.0	0.0	0.0	0.0	512.6
41	0.4891	0.0	0.0	4,982.8	0.0	0.0	0.0	410.7
42	0.0044	0.0	0.0	5,755.4	0.0	0.0	961.3	405.5
43	0.9925	1.8	0.0	0.3	0.0	0.0	0.1	0.0
44	0.9986	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	0.4082	26,165.7	0.0	14,325.6	0.0	0.0	0.0	273.5
48	0.2449	0.0	0.0	0.0	0.0	0.0	0.0	658.0
50	0.0027	0.0	0.0	7,802.3	9,022.1	0.0	0.0	671.4
51	0.5754	0.0	0.0	0.0	0.0	0.0	4,401.1	201.8
55	0.0020	0.0	0.0	0.0	5,251.5	0.0	6,825.0	891.6
56	0.6513	0.0	0.0	20,131.7	20,298.4	0.0	625.8	423.1
57	1.1042	0.0	0.0	18,477.0	0.0	11,242.6	0.0	0.0
58	0.4138	0.0	0.0	356.8	0.0	0.0	0.0	246.1
59	0.2303	0.0	0.0	25,116.2	0.0	0.0	0.0	187.2
60	0.0453	0.0	0.0	0.0	0.0	0.0	0.0	506.7
63	0.9964	0.0	0.0	0.0	512.8	0.0	0.0	0.0
65	0.5557	0.0	0.0	0.0	10,246.2	6,058.6	0.0	461.0
66	0.3123	0.0	0.0	0.0	43,915.7	0.0	3,640.2	481.7
67	0.8015	11,894.0	0.0	6,012.2	2,779.6	0.0	0.0	263.0
68	0.9998	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	0.2279	0.0	0.0	1,809.4	0.0	952.1	0.0	292.4

Table 8 (Continued)

DMU	TE Score	s_1^-	s_2^-	s_1^+	s_2^+	s_3^+	s_4^+	s_5^+
71	0.0870	27,447.9	0.0	0.0	0.0	0.0	0.0	216.2
74	0.9991	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	0.1219	33,801.6	0.0	0.0	14,395.9	0.0	9.2	288.5
76	0.0029	0.0	0.0	0.0	6,101.4	0.0	1,808.8	609.4
77	0.6698	0.0	0.0	0.0	3,329.6	672.5	0.0	551.9

Source: Author's Calculation

Finally, the result confirmed that Thai agricultural cooperatives in 2018 were inefficiently operated due to poor cost management and low–level of business-value creation. This results were consistent with Magali and Pastory (2013) and Rapee and Peng (2016) which showed that the main sources of the inefficient aspects came from the high costs of operations.

Conclusion and Discussion

In this study, the Super SBM–O–V DEA model is employed to measure the technical efficiency of Thai cooperatives by provinces. There are several distinct advantages of using Super SBM–O–V model over the traditional DEA model. Firstly, advantages of Super SBM–O–V model come from the fact that objective function of this model focuses directly on slacks (input excesses and output shortfalls) rather than using the input–output ratio as defined in the traditional model such as BCC or CCR model, therefore the model has two important properties, which are unit invariant and monotone with respect to slacks. For the unit–invariant property, this refers to the TE scores measured by this model are unvarying with respect to the change of the units of data, while the monotone property, this refers to the resulted TE scores of this model are monotone decreasing in slacks. Secondly, by combining the technique called super efficiency with SBM model, the Super SBM–O–V model can solve the problem of ranking the efficient DMUs and the problem of truncated TE score, which limits the range of TE score between 0 and 1.

The estimated results from Super SBM–O–V model showed that only 23 DMUs are operated on the efficiency frontier, while the rest of 54 DMUs are inefficient. On one hand, agricultural cooperative operations in the provinces such as Chon Buri, Chanthaburi, Krabi, Amnat Charoen, and Phetchaburi are ranked in the top 5 largest TE scores. On the other hand, cooperative operations in Trat, Nonthaburi, Loei, Nakhon Nayok, and Ang Thong provinces are categorized in the group of lowest TE scores. The overall average TE score of cooperative operations in 77 provinces equals to 0.6120, and the region with the highest average TE score is eastern region with average score of 0.830. Finally, the computed slacks of inefficient DMUs provides useful information of how to improve the efficiency of each DMU by reducing expenses and operating cost of cooperatives and increasing the business values of all cooperatives' activities. In practice, to reduce costs and increase values of cooperatives businesses, there are wide varieties of policies that cooperatives should pursue including:

1. to enhance the professional operation and effective administration of president, committees, manager, and officers in order to create trust and faith in the cooperative system and augment the confidence of members
2. to encourage Thai agricultural cooperatives to participate in markets for high–valued products such as processed food, organic food, high – quality products and etc
3. to create business networking with numerous firms and organizations with specialized skills and knowledge such as universities, private companies, and government sector
4. to enhance agricultural cooperatives to use suitable logistic system in order to reduce inventory and transportation costs

Finally, the limitation of this study depends on the use of secondary data reported by Cooperative Auditing Department (CAD), which displays only the main financial variables such as assets, liabilities, profits, and business values of agricultural cooperatives, thus it lacks the details on financial data for each of cooperatives. For further studies, the choices of DEA model should be the main concern, since there are wide varieties of DEA models to measure the performance of DMUs when dealing with the problems such as the undesirable output, the negative output and input variables, the uncontrollable input and output data, the productivity change overtime, the categorical variables, and etc. The suggestion here is that researchers should employ the appropriate model matching with objectives, or limitation of data. Moreover, not only the choices among DEA model, but also the choices between parametric and non–parametric model should be the focal point of consideration. Stochastic frontier analysis is the example of non–parametric model used to estimate efficiency score. It has the advantages over DEA analysis in the extent to which it can perform hypothesis test related to efficiency score that could not be found in DEA analysis.

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