Technical Efficiency and Factors Influencing Technical Efficiency of Agricultural Cooperatives in Nonthaburi Province of Thailand

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Abstract

For over 60 years, Nonthaburi province has been one of the main agricultural production areas in Thailand. Agricultural Cooperatives also play a key role in farmer's assembly. Because of externality, the number of agricultural cooperatives in Nonthaburi province has been declined. Nowadays, there are only 8 agricultural cooperatives that still perform their own business. Two research objectives were set as 1) to analyze the technical efficiency of agricultural cooperatives and 2) to analyze factors influencing the technical efficiency of agricultural cooperatives in the Nonthaburi province, Thailand. The population numbers of agricultural cooperatives were considered as 8 individuals. The purposive technique was applied as the sampling technique. With the purposive sampling of agricultural cooperatives who had their financial status and business operational performance of positive numbers and performed continuously, it turned out of 5 agricultural cooperatives as sample size. The time-series data were collected from 1990 to 2021 while the cross-sectional data were collected from 5 cooperatives. So, the total number of observations was clarified as 180 observations. The technical efficiency analysis was applying the 3-state Data Envelopment Analysis (3-stage DEA). While the factors influencing the technical efficiency were utilized the Ordered Probit Model.

Findings were: 1) all 4 out of 5 agricultural cooperatives operated their own business with Technical efficiency, and 2) the factors that influenced the cooperatives' technical efficiency were cooperatives' capitals and operating capitals. Both cooperatives and members would have the managing strategy to meet the technical efficiency include the plans for a brush up their capitals and increase their operating capitals. Also, they would encourage members to save more since members' saving is the main source of funding for their investment.

Keywords: *Technical Efficiency, Agricultural Cooperatives, DEA, Ordered Probit Model.*

1. Introduction

Thailand is a country with an economic background from an agricultural country. The value of agricultural products in the country is $2,895,743$ million baht or 14.6 percent of Gross Domestic Product (GDP) and has $22.-35$ million workers in the agricultural sector. Agricultural products produced by farmers and agricultural cooperative members fluctuate to the natural environment, such as rainfall, climate. And even the fertility of the soil affects the number of products produced. (Cooperative Auditing Department, 2021).

Moreover, the volatility of the number of goods produced also affects the income volatility, which inevitably affects the agricultural occupation, resulting in higher production costs of agricultural products. As a result, agricultural producers need capital to produce agricultural products more. It can be seen that the financial organization that is the main body in assisting farmers and members of the cooperative finance is the Bank for Agriculture and Agricultural Cooperatives. Supply of inputs trading of agricultural produce Including educating farmers and members of agricultural cooperatives. Agricultural cooperatives are considered important at the community level, as agricultural cooperatives are considered a form of unification of people with a common purpose in solving community problems in self-help. Helping fellow members and helping communities and society. (Cooperative Promotion Department, 2021).

From past to present, Nonthaburi province is one of the agricultural production areas in Thailand located in the northwest of Bangkok on the Chao Phraya River known as a metropolitan area functioning as the urbanized as the capital of Thailand. (Figure 1.) (www.distantias.com, 2021).

Figure 1. The Location of Nonthaburi Province, Thailand, 2021.
Source: www.distantias.com/distance-from-bangkok-thailand-to-nonthaburi-thailand.htm

Like other agricultural production areas in Thailand, in Nonthaburi province, the agricultural cooperatives have been established and found that farmers and members of agricultural cooperatives in Nonthaburi province still have a crucial role for farmers. However, farmers in Nonthaburi province earn an average monthly income of 6,750 baht per person or 81,000 baht per year (National Statistical Office, 2021). The government assistance is still substantial. On the other hand, the financial performance of such organizations differs, but most are low, and it is worth noting since many groups of organizations, including agricultural cooperatives, have abolished. According to statistics from the Cooperative Auditing Department, it was found that from 1990 to 2021, the number of agricultural cooperatives and farmer groups in Nonthaburi province tended to decline. (Cooperative Auditing Department, 2021).

In the past, Nonthaburi province was the main agricultural production area. Since Nonthaburi was one of the famous fruit, flower, rice, and other agricultural product that produced to serve consumers in Bangkok and surroundings. Over 50 years, the number of farmers who produced agricultural products in Nonthaburi has been declined continuously because the urban expansion from Bangkok to suburb led to the land use of agriculture change dramatically. The agricultural land has been changed to a residential area because of the expansion of Bangkok's metropolitan. Agricultural land use was threatened to others. Some farmers in Nonthaburi province still live in the agricultural sector serving themselves as an agricultural career. Most farmers left not only their farmland but also their traditional career led to the number of agricultural cooperatives in Nonthaburi province declined as the obvious phenomena.

Now the numbers of agricultural cooperative in Nonthaburi province still have only 8 individuals. The technical efficiency and factors that influenced the technical efficiency are necessary to study to oversee the outcomes of agricultural cooperatives in Nonthaburi province performed their own business. To make the agricultural cooperatives' members confident as the owners of their cooperatives. Theoretically, technical efficiency is to evaluate the effectiveness of inputs used to generate an output (Economics Help, 2021). Following the concept of how agricultural cooperatives are performing the maximum output from the minimum amount of inputs such as operational capitals ad technology. As a researcher, the question of technical efficiency and factors influencing the technical efficiency of agricultural cooperatives in Nonthaburi province cope my attention, Also, the research results will provide good answers to set up the recommendations and suggestions for agricultural cooperatives in the Nonthaburi province area and other agricultural cooperatives in Thailand. (Nonthaburi Provincial Cooperatives Office.,2021).

Due to the research objectives and research outcomes of measurement the technical efficiency and find out the factors that influenced the technical efficiency to provide the answers of 1) what agricultural cooperatives in Nonthaburi province met the requirement of technical efficiency and in case some agricultural cooperatives performed their own business with technical inefficiency what factors would they increase for their management process to acquire the technical efficiency. It is beneficial for agricultural cooperatives to adjust themselves at least to immanence agriculture career and agricultural cooperatives as a part of Nonthaburi province. In terms of literature review, there were some studies of technical efficiency both business and cooperatives such as Onnwan, D., et al. (2021). Studied the measurement of technical efficiency

in the northern region of Thailand. Similarly, the study of Uraporn, Ng. (2020). Focusing factors affecting the success of agricultural cooperatives in the upper north region of Thailand. In the recent study of W. Krasachat & K. Chimmkul. (2020). who studied performance measurement of agricultural cooperatives in Thailand applying the accounting-based Data Envelopment Analysis (DEA). There was a recent study by Skevas, T. & Grashuis, J. (2020). who studied the technical efficiency and spatial spillovers expressing the evidence from grain marketing cooperatives in the US Midwest. Since there were a certain number of the technical efficiency of agricultural cooperatives. For the last 10 years, there were no research works of agricultural cooperatives in Nonthaburi, Thailand. Even Nonthaburi is closed to Bangkok and also the agricultural production area. It is very interesting to establish the measurement of technical efficiency and factors that influenced the technical efficiency of agricultural cooperatives in Nonthaburi province of Thailand. These research outcomes would be beneficial for agricultural cooperatives and other government agencies such as the department of cooperative promotion to take some ideas for further guidance of agricultural cooperatives in Nonthaburi province.

2. Objectives

2.1 To analyze the technical efficiency of agricultural cooperatives in the Nonthaburi province, Thailand

2.2 To analyze factors influencing the technical efficiency of agricultural cooperatives in the Nonthaburi province, Thailand

3. Materials and Methods

The population numbers of agricultural cooperatives were considered as 8 individuals who still have their business operation from 1990 to 2021. The purposive technique was applied as the sampling with 2 conditions of purposive technique 1) all outcome of agricultural business cooperatives are positive, and 2) all agricultural cooperatives still continuously operate their own business from 1990 to 2021. To meet these 2 purposive conditions, it turned out of 5 agricultural cooperatives as sample size. (Guzman, I. and Arcas, N. ,2008). (Maltz, Alan C., 2000). (Onnwan, D., et al.,2021).

The secondary data were collected from the database of the Cooperative Auditing Department from 1990 to 2021 accounted for 32 years of 5 samples. The cooperative's financial status was collected which was composed of assets, debts, and capital. Also, the cooperatives' business operation outcome was collected included income, expenditures, profits, and operation capitals. .(Guzman, I. and Arcas, N. ,2008). (Maltz, Alan C., 2000). (Onnwan, D., et al.,2021). Following the studies of Maltz, Alan C., (2000), and Onnwan, D., et al., (2021), they applied both financial status and business operational performance in terms of money unit to identify the cooperatives inputs and outputs.

Panel data statistical model was utilized as the data analysis. To meet its acquirement, both time series and cross-sectional data were collected. For the times series data, the financial status and the cooperative business operation data were collected from 1990 to 2021 accounted for 32 years while the cross-sectional data were collected from 5 agricultural cooperatives. The total number of observations was 160 observations collected.

The technical efficiency analysis of agricultural cooperatives in Nonthaburi province was applying the 3-state Data Envelopment Analysis (3-stage DEA). The efficiency of the production unit can be assessed as follows. .(Guzman, I. and Arcas, N. ,2008). (Maltz, Alan C., 2000). (Onnwan, D., et al.,2021).

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \quad\text{---}(1)$$

According to equation (1), the outputs were defined as the total amount of income and profit of agricultural cooperatives while the inputs were defined as the total amount of assets debts, capital, expenditures, and operation capitals respectively.

Theoretically, the popular method of benchmarking technique to measure the performance of agricultural cooperatives' business operations. This is a comparison of the efficiency value calculated in each production unit. The benchmark is the best practice compared to the total number of units as a study unit. the

technical efficiency can be assessed as follows: (Paradi, J.C., & Scahffnit, C.,2004). .(Guzman, I. and Arcas, N. ,2008). (Uraporn, Ng.,2020).

$$\text{Technical efficiency} = \frac{\sum_{j}^{n} \mu_r\, y_{rj}}{\sum_{i}^{m} \omega_i\, x_{ij}} \; ; \; i=l, \dots, m,\; r=l, \dots, s,\; j=l, \dots, n \text{ ----------------(2)}$$

Where: x_{ij} is the number of inputs ith of production j

  y_{rj} is the number of output at r of production j.

  μ_r is the weight of the product r.

  ω_i is the weight of the input i

  n   is the number of production units

  s   is the number of output

  m   is the number of inputs

The analysis of factors influencing the technical efficiency of agricultural cooperatives in Nonthaburi province was utilized the Ordered Probit Model which can be expressed as follow: (Rangkakulnuwat, P. ,2021). (Worthington, A.C.,2004). .(Guzman, I. and Arcas, N. ,2008).

$$\mathbf{Y_i} = \sum_{i=1}^{n} \sum_{j=1}^{j} x\mathbf{ij} + \mathbf{e}$$

Where: Y_i = The Technical Efficiency Score of Agricultural Cooperatives i

  X_{ij} = Variables describing the efficiency of agricultural cooperatives

  α = Coefficients

  e = term of error

Also, the technical efficiency scores of agricultural cooperatives i. were obtained from equation (2), the technical efficiency score ranged from 0.00 to 1.00 while the variables describing the efficiency of agricultural cooperatives were defined as the total amount of income, profit, assets debts, capital, expenditures, and operation capitals respectively.

4. Results and Discussion

The Financial Status of Agricultural Cooperatives in Nonthaburi Province from 1990 to 2021 could be expressed as table 1 below:

Table 1. Financial Status of Agricultural Cooperatives in Nonthaburi Province from 1990 to 2021

(Unit = $)

Agricultural cooperatives	Assets ($)	Capital ($)	Liabilities ($)
Bang Bua Thong Agricultural Cooperative Limited	20,991,367.39	16,210,901.66	4,780,465.73
Pak Kret Agricultural Cooperative Limited	6,387,715.13	3,154,317.61	3,233,397.53
Sainoi Agricultural Cooperative Limited	6,387,715.13	3,154,317.61	3,233,397.53
Bangyai Agricultural Cooperatives Limited	7,067,119.80	4,859,203.37	2,207,916.43
Muang Nonthaburi Agricultural Cooperative Limited	1,342,485.37	608,749.70	733,735.67
Maximum Value	20,991,367.39	16,210,901.66	4,780,465.73

Minimum Value	1,342,485.37	608,749.70	733,735.67
Average	8,435,280.57	5,597,497.99	2,837,782.58
Standard Deviation	7,386,135.19	6,124,036.39	1,492,546.90

Source: Calculated from the database of the Cooperative Auditing Department, 2021.

From Table 1. showing the financial status of the five agricultural cooperatives of Nonthaburi Province, it was found that Bang Bua Thong Agricultural Cooperatives Limited had the highest assets, liabilities, and operating capital. With assets, liabilities, and operating capital at $20,991,367.39, $16,210,901.66, and $4,780,465.73 respectively, and Muang Nonthaburi Agricultural Cooperative Limited had the lowest assets, liabilities, and operating capital. With assets, liabilities and operating capital at $1,342,485.37, $608,749.70, and$733,735.67 respectively. All five agricultural cooperatives in Nonthaburi province had the average of assets, liabilities and operating capital at $8,435,280.57, $5,597,497.99, and $2,837,782.58, respectively, with standard deviations of assets, liabilities and operating capital at $7,386,135.19, $6,124,036.39, and $1,492,546.90 respectively.

The Business Operational Performance of Agricultural Cooperatives in Nonthaburi Province from 1990 to 2021 could be expressed as Table 2 below:

Table 2. The Business Operational Performance of Agricultural Cooperatives in Nonthaburi Province from 1990 to 2021

(Unit = $)

Agricultural cooperatives	Income($)	Expenses($)	Profit (Loss) ($)	Operating Capital($)
Bang Bua Thong Agricultural Cooperative Limited	20,483,679.58	18,480,685.04	2,002,994.54	92,836,297.05
Pak Kret Agricultural Cooperative Limited	59,598,374.82	49,308,655.71	10,289,719.11	625,888,260.80
Sainoi Agricultural Cooperative Limited	53,553,431.58	49,800,424.19	3,753,007.39	185,082,221.84
Bangyai Agricultural Cooperatives Limited	42,891,325.65	37,995,138.06	4,896,187.60	197,050,140.63
Muang Nonthaburi Agricultural Cooperative Limited	4,431,770.12	3,932,922.93	498,847.18	40,219,009.59
Maximum Value	59,598,374.82	49,800,424.19	10,289,719.10	625,888,260.75
Minimum Value	4,431,770.11	3,932,922.93	498,847.19	40,219,009.59
Average	36,191,716.34	31,903,565.19	4,288,151.16	228,215,185.98
Standard Deviation	23,182,009.11	20,142,446.09	3,750,189.01	231,649,300.05

Source: Calculated from the database of the Cooperative Auditing Department, 2021.

From Table 2, The Business Operational Performance of Agricultural Cooperatives in Nonthaburi Province, All five found that Pak Kret agricultural cooperatives have the highest operating performance with levels of income, expenses, profit and operating capital at the $59,598,374.82, $49,308,655.71, $10,289,719.11, and $625,888,260.80, respectively. Muang Nonthaburi Agricultural Cooperative Limited had the lowest performance. The level of income, expenditures, profits and operating capital at the level of $4,431,770.12, $3,932,922.93, $498,847.18 and $40,219,009.59, respectively. The results of operations of the five agricultural cooperatives in Nonthaburi province had an average of income, expenditures, profit and capital. Operating at the level $36,191,716.34, $31,903,565.19, $4,288,151.16, $228,215,185.98, respectively, with standard deviation of income, expenses, profit and operating capital at the $23,182,009.11, $20,142,446.09, $3,750,189.01, $231,649,300.05, respectively.

The Technical Efficiency of the 5 agricultural cooperatives in Nonthaburi Province, Thailand could e be expressed in Table 3 below:

Table 3. The Technical Efficiency of the 5 agricultural cooperatives in Nonthaburi Province, Thailand

Agricultural Cooperatives of Nonthaburi Province	crste	vrste	scale	Explanation
Bang Bua Thong Agricultural Cooperative Limited	1.00	1.00	1.00	-
Pak Kret Agricultural Cooperative Limited	1.00	1.00	1.00	-
Sainoi Agricultural Cooperative Limited	1.00	1.00	1.00	-
Bangyai Agricultural Cooperatives Limited	1.00	1.00	1.00	-
Muang Nonthaburi Agricultural Cooperative Limited	0.90	1.00	0.90	irs
Average	1.00	1.00	1.00	1.00

Source: Calculated from the database of the Cooperative Auditing Department, 2021.
crste = technical efficiency from CRS DEA
vrste = technical efficiency from VRS DEA
scale = scale efficiency = crste/vrste

From Table 3, the results of the Technical Efficiency of the 5 agricultural cooperatives in Nonthaburi Province, it was found that 4 out of 5 agricultural cooperatives in Nonthaburi province had the technical efficiency with the value of 1.00 which were 1) Bang Bua Thong Agricultural Cooperative Ltd., 2) Pak Kret Agricultural Cooperative Ltd., 3) Sai Noi Agricultural Cooperative Ltd., and 4) Bangyai Agricultural Cooperative Ltd. Muang Nonthaburi Agricultural Cooperatives Ltd. was the only which had the technical efficiency score equal to 0.90 meaning that this agricultural cooperative had to improve themselves to meet the requirement of technical efficiency. By doing that, the result from Data Envelopment (DEA) expressed in table 3 showed some suggestions which was IRS (Increasing return to Scale). This meant that when Muang Nonthaburi Agricultural Cooperatives Ltd. increased their input usage by 1 percent for their business operation then their outputs would be increased greater than 1 percent. It is the way to increase its technical efficiency. By doing that, Muang Nonthaburi Agricultural Cooperatives Ltd. would increase their input usage such as assets, debts, capital, expenditures, and operation capitals respectively.

Factors Influenced the Technical Efficiency of Agricultural Cooperatives in Nonthaburi Province, Thailand could be expressed in Table4 below:

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Table 4: Factors Influenced the Technical Efficiency of Agricultural Cooperatives in Nonthaburi Province, Thailand

Factors Influenced the Technical Efficiency	Coefficient	T statistics	P-value
Assets	0.000000001653	0.650	0.823852192
Debt	0.000000006451	0.245	0.902385219
Capital	**0.00000000798**	**2.789**	**0.007704623**
Income	0.0000000201	0.845	0.402385219
Expenses	-0.0000000139	-0.583	0.562607521
Profit	0.0000000101	0.635	0.802385219
Operating capital	**0.00000000131**	**2.509**	**0.029323722**
F statistics	10.976**		
R^2	0.493853787		

Source: Calculation by Ordered Probit Model.
** Statistically Significant level at 99 percent.

From Table 4, the research results found that all seven factors that are expected to influence the technical efficiency of agricultural cooperatives in Nonthaburi province are assets, debts, capital, income, expenses, profit, and operating capital. Capital and operating capital of agricultural cooperatives in Nonthaburi province affect directly the technical efficiency with the coefficient equal to 0.00000000798, and 0.00000000131 at 99 and 95 percent of statistically significant level respectively. The technical efficiency of both factors was positive, indicating that the capital and operating capital of agricultural cooperatives in Nonthaburi province had a similar effect on the technical efficiency of the cooperatives. In other words, when the capital and operating capital increase, it is reflected in the increase in the technical efficiency of the cooperatives. (Paradi, J.C., & Scahffnit, C., 2004). (Rangkakulnuwat, P.,2021).

In other words, the research results of table 4 would confirm that what factors influenced the technical efficiency exactly. So the research results of Tables 3 and 4 would be combined to find out the way to increase agricultural cooperatives in case they had the technical efficiency score smaller than 1. For example, Muang Nonthaburi Agricultural Cooperatives Ltd. who had its technical efficiency score of 0.90 that has to improve its technical efficiency by increasing the usage of inputs. Combining the research results from Tables 3 and 4, it was explained that the way to increase technical efficiency of Muang Nonthaburi Agricultural Cooperatives Ltd. According to table 3, it expressed that capitals and operating capitals were only 2 factors that directly influenced technical efficiency. Theoretically, Muang Nonthaburi Agricultural Cooperatives Ltd. would increase the usage of capital and operating capitals to increase its technical efficiency. Muang Nonthaburi Agricultural Cooperatives Ltd. would make it in cooperates with the cooperatives' members to increase their capitals as well as their saving.

In sum, All 5 agricultural cooperatives in Nonthaburi province, Thailand expressed technical efficiency meaning that all of them operated their business performance in the good shape. For over 60 years, Nonthaburi has been an important agricultural production area in Thailand. Besides, the research results expressed 2 factors of business performance which were capital and operating capital had a positive influence on technical efficiency. The encouragement of capital and operating capital would be the way to bust up the technical efficiency. Due to the results, agricultural cooperatives would have the strategy to encourage agricultural cooperatives' members to accumulate their capital. Cooperatives can bust internal capital. To do that the cooperatives and cooperatives' members would have the plan to increase both of their savings, capital,

as well as operating capital since all of them, are the source of fundings for investment. (Onnwan, D., et al.,2021). (Paradi, J.C., & Scahffnit, C., 2004).

5. Conclusion

As a researcher, I would like to make my conclusion that there were 4 out of 5 agricultural cooperatives in Nonthaburi province that met the requirement of technical efficiency expressing by the technical efficiency score of 1.00. There was only 1 agricultural cooperative in Nonthaburi province that had its technical efficiency score smaller than 1.00 which was Muang Nonthaburi Agricultural Cooperatives Ltd. With the results of technical efficiency and factors that influenced the technical efficiency, Muang Nonthaburi Agricultural Cooperatives Ltd. would have its opportunity to enhance technical efficiency by increasing 2 inputs usage which was capitals and operating capitals. This was consistent with the study of W. Krasachat and K. Chimkul who studies the performance measurement of agricultural cooperatives in Thailand (W. Krasachat and K. Chimkul, 2020).

For 4 agricultural cooperatives who obtained the technical efficiency score of 1.00 expressing their full technical efficiency. Theoretically, they operated their business with technical efficiency meaning that all of the managerial factors, assets, debts, expense, capital, and operating capital in the efficiency and effectiveness. Capitals and operating capitals were 2 factors that influenced the technical efficiency of agricultural cooperatives in Nonthaburi province. With the suggestion that cooperatives' members would realize that both of capitals and operating capitals would be the factors influencing technical efficiency. Cooperatives and their members would make their cooperation to increase cooperatives' capital as well as the operating capital to meet the standard of technical efficiency directly. (Onnwan, D., et al.,2021). (Paradi, J.C., & Scahffnit, C., 2004). (Worthington, A.C., 2004). The research results were also consistent with the studies of Skevas, T. & Grashuis, J. (2020) who studied the technical efficiency and spillovers: evidence from grain marketing cooperatives in the US Midwest (Skevas, T. & Grashuis, J., 2020).

6. Acknowledgements

7. References

Cooperative Auditing Department. (2021). Performance Evaluation of Agricultural Cooperatives. Retrieved January 12, 2021 from http// www. cad.ac.th.203.154.183.18/ewt/statistic/main.php?

Cooperative Promotion Department. (2021). Technical Efficiency of Agricultural Cooperatives in Thailand. Retrieved January 12, 2021 from http// www.cpd.ac.th /statistic/main.php?03.154.183.18/ewt/statistic/main.php?

Economics Help. (2021). Technical Efficiency Definition. Retrieved February 10, 2021 from http// https://www.economicshelp.org/blog/glossary/technical-efficiency/

Guzman, I. and Arcas, N. (2008). The Usefulness of Accounting Information in the Measurement of Technical Efficiency in Agricultural Cooperatives. *Annals of public and cooperative Economics*. 79 , (2): 107 – 131.

Maltz, Alan C. (2000). Defining and Measuring Organizational Success: A Multidimensional Framework. A Doctoral dissertation of Business Administration. Stevens Institute of Technology.

Map of Nonthaburi Province. (2021). February 10, 2021, from http//www.distantias.com/distance-from-bangkok-thailand-to-nonthaburi-thailand.htm

Nonthaburi Provincial Cooperatives Office. (2021). Agricultural Cooperatives in Nonthaburi. Retrieved February 10, 2021 from http// web.cpd.go.th/nonthaburi/index.php/2019-11-25-08-31-14/2019-11-25-09-56-27/qty-coop

Onnwan, D., et al. (2021). Factors affecting the success of community businesses in Thailand, Sub-Project, and Factors affecting the success of community businesses in the Northern Region. Research report of Rajamangala Institute of Technology. Retrieved January 2, 2021 from http// www.rmutt.ac.th.

Paradi, J.C., & Scahffnit, C. (2004). Commercial Branch Performance Evaluation and Results Communication in a Canadian Bank – a DEA Application. *European Journal of Operation Research*. 156, (2): 719 – 735.

Rangkakulnuwat, P. (2021). Technical Performance of Thai Commercial Banks. *Academic Journal University of the Thai Chamber of Commerce*. 27, (1): 129-138.

Skevas, T. & Grashuis, J. (2020). Technical efficiency and spatial spillovers: Evidence from grain marketing cooperatives in the US Midwest. Agribusiness, *36*,111–126.

Uraporn, Ng. (2020). Factors Affecting Success of Agricultural Cooperatives in the Upper North Region. A thesis for the degree of Master of Agricultural Economics. Chiang Mai University.

W. Krasachat & K. Chimmkul. (2020). Performance Measurement of Agricultural Cooperatives in Thailand: An Accounting Based Data Envelopment Analysis. Productivity, Efficiency, and Economic Growth in the Asia-Pacific Region. New York: Springer Publisher.

Worthington, A.C. (2004). Determinants of Merger and Acquisition Activity in Australian Cooperative Deposit-taking Institutions. *Journal of Business Research*. 57, (10): 47-57.