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The performance measurement of listed companies of the agribusiness sector on the stock exchange of Thailand

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Abstract: Listed companies in the agribusiness sector of the stock exchange play a key role in driving the economic system of Thailand. They have an important role in terms of being the producers of agricultural commodities by covering all products from the upstream to downstream. The performance measurements of listed companies contain important information for forecasting the trends of agricultural production and yield. The paper studied and considered much of the literature on the performance measurement of organizations to look for relative variables and the optimal methodology. The study used panel data from 2011–2014, which collected the listed annual companies' statements. The aim of the study was to employ the Slacks Based Measure context-dependent Data Envelopment Analysis (SBM context-dependent DEA) for evaluating the efficiency in Decision Making Units (DMUs). The SBM context-dependent DEA was used to measure the performance of listed companies by employing attractiveness and progress scores. The results showed that when a listed company has a higher attractiveness and lower progress score, it has a better performance than its competitors and does not need to improve its efficiency. Therefore, the empirical results of the study can help farmers and governments to realize the trends of agricultural productivity and also help the listed companies to understand the characteristics of their competitors, leading to improvements in their organizations.

Keywords: agribusiness sector, listed company, SBM context-dependent DEA, stock exchange, Thailand

Thailand has a long history in terms of the agricultural development. Agricultural products in Thailand are not only produced for the consumption within the country, but they are also produced for the export outside the country. In the history of the export sector, the value of agricultural products for export has been increasing every year and is still set to be a major source of export earnings for Thailand. Moreover, from the import-export statistics of agricultural products in Thailand, the findings showed that the export volumes of agricultural products had increased from 18 016 289.27 metric tons in 2012 to 19 690 489.94 metric tons in 2013 and increased to 25 597 579.52 metric tons in 2014, respectively. It can be stated that the volumes of agricultural products for export have been increasing every year (The Customs Department of Thailand 2014) because of the master plan for Thailand's agriculture which was approved by the government in early 1998. Moreover, Thailand has other aid for farmers, such as the agricultural project plans being identified and the key factors enhanced by the committee of the Deputy Agriculture Minister (Watanabe et al. 2009). The evolution of agricultural development has always been perceived by the government and the private agribusiness sector in Thailand as having elements from three main major areas consisting of (1) Crops (2) Livestock and (3) Aquaculture.

Currently, Thailand is a leader of the agribusiness sector in the ASEAN and has continually planned a further growth to become the number one producer on the Asia-Pacific continent. The Thai agribusiness

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sector has an influence on the market mechanisms of agricultural products. It has an important role, both directly and indirectly, in the employment and the living costs of the population of Thailand. The agribusiness sector has been one of the most important sectors of the economic system, with most businesses having concerns in agriculture, and most of the large agribusiness companies listed in the agro and food industry operate their businesses on the stock exchange of Thailand. In 2014, the values of the listed companies in the agro and food industry had a proportion that is increasing more than 25% when compared with other sectors (Stock exchange of Thailand 2014). However, farmers who produce agricultural products are facing the problem of the decline of product prices because they do not know about the trends of agricultural productivity and the yield of the agribusiness sector.

Thus, the objective of this study has focused on the performance measurement level of the listed companies in the agribusiness sector which is distinguished by the performance level and also demonstrated by the reference sets of the efficient Decision Making Units (DMUs) to make benchmarks for inefficient listed companies. Moreover, this study aims to realize the trends of agricultural production and the yield of the agribusiness sector by considering the production index of returns to scale. In a previous study, Nikoomaram et al. (2010) measured the performance of enterprises in the metal industry on the Tehran Stock Exchange by using the data envelopment analysis to analyse the financial variables of the performance assessment. The results of this study show the trend of significant relationships between three financial variables and the efficiency results of enterprises. In addition, Kadoya et al. (2008) identified investment strategies by using the DEA and mentioned that the book value of companies was a classic criterion of efficiency evaluation. It helps investors to know the trends of the market value and the performance of companies.

LITERATURE REVIEW

Currently, the operations' abilities of Thai listed companies are evaluated frequently by the performance measurement tools. Moreover, the measurement tools have been designed by the experts to report efficiently to the directors of the organizations. They support both public and private organizations. After reviewing the previous studies, it is clear that the performance measurement tools have been applied to many fields of modern society including hospitals, schools, universities, power plants, tax offices, manufacturing, bank branches, department stores and listed companies on the stock exchange, and so on.

According to social science, there are many varieties of techniques for measuring the performance, such as the Data Envelopment Analysis (DEA), the Analytic Hierarchy Process (AHP), the Grey Relation Analysis (GRA), the Financial Statement Analysis (FSA), and the Balanced Scorecard (Nikoomaram et al. 2010). Thus, this study will be focused on the DEA techniques by using variables and datasets from the FSA. The DEA was developed for the evaluation of the DMUs for the best relative efficiency by Charnes et al. (1978). The DEA is a nonparametric approach and mathematical programming technique which is used in the economics and social science for the evaluation of efficiency. The first step of the DEA starts by considering the input and output variables of each DMU and then all DMUs are evaluated by more holistic evaluation solutions helping to decide which different inputs to use to make several outputs. The DEA has been widely used to measure the efficiency and performance in many different fields, in both public and private organizations. It is becoming to be an important measurement tool in the area of research. In addition, the definition of performance measurement and assessment is examined by the previous literature. Helkiö and Ala-Risku (2012) stated that the performance measurement was one managerial tool which has been used to change and adjust important factors within an organization as its context evolves. Even though there are many pitfalls around the decision making using the performance measurement to induce strategically aligned actions in terms of the operation of organizations, Tangen (2005) mentioned that the use of the performance measurement was an effective way to increase the competitive advantage and profitability as well as encouraging productivity improvements for a company. These measurement tools can help managers to ensure that they can adopt a long-term perspective and allocate resources to improve their activities. Aliabadi et al. (2013) stated that the performance measures were used as a tool by external users for investing, financing, and benchmarking decisions. Moreover, they also have been used to measure the internal organization by managers and executives to grow, improve, reward, and learn. There are some observations that the performance of efficient DMUs

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is affected by the presence of inefficient DMUs. Thus, the context-dependent DEA approach is used to solve this problem by excluding the efficient DMUs from the future DEA runs (Izadikhah 2011).

Furthermore, there are several elements of financial statements and market ratios that are used to analyse performance. Financial statements are collected and reflect a company's financial results, financial condition and cash flow. They help a company to consider the capability of a business to generate cash, the uses of cash and also to identify the capability to pay back its debts. Meanwhile, they can also help companies to analyse the financial ratios from these statements that can indicate the critical factors of the business. Moreover, market ratio is a ratio of the current market price which is divided by the indicators of a company's ability. This ratio can be used to indicate the profits or assets held by the company. Thus, this paper has focused on the elements of financial statements for identifying the input and output variables. The elements of financial statements will consist of assets, liabilities, shareholders' equity, revenue and profit, respectively.

Upon review, the literature demonstrates the input and output variable as follows: Liu (2011) applied some elements of financial statements for the measurement of the performance of the Taiwanese financial holding companies. This study used employees, assets and shareholders' equity as inputs and also used revenues and profit as outputs. An asset is one of the economic resources that may be tangible or intangible in the business. An asset is owned goods, real estate or movable property which can help the owner to control and produce value, and also to hold the business' position in a positive economic value in a perfectly competitive market (Serifsoy 2007; Tan and Flores 2012). Liabilities are legal debts or obligations that a company obtains from a business partner or debtor during business operations. Liabilities are used as a financial tool for controlling both the inside and outside operations, and the expansion of the business. In addition, liabilities can be used to measure the performance of a business by identifying the period of time for paying debts which includes debts payable within one year or longer than in one year (Hoevenaars et al. 2008; Liu 2011). Shareholders' equity consists of two main sources. The first original source of shareholders' equity is money which is first invested in the company. The second source of shareholders' equity comes from the retained earnings of the company which are accrued over time during its operations (Ertuğruland and Karakaşoğlu 2009; Liu 2011; Tan et al. 2012). In addition, revenue is the income of the company which it receives as an achievement from its normal business activities, such as the activity of the sale of goods and services to customers (Chen and Zhu 2003; Hasan et al. 2003; Liu 2011). Finally, profit is the money the business makes after the calculation of income against all the expenses (Ertuğrul et al. 2009; Vaatanen and Karasoglu 2009).

METHODOLOGY

SBM context-dependent DEA

Tone (2001) introduced the original slacks-base measure (SBM) of efficiency in the DEA. The SBM model is a non-oriented model and non-radial in the DEA approach. This model was used to compute the ratio of production and yield by using the proportion of the feasible inputs reduction with the feasible output increase. Similar to the original model of the SBM, Färe and Lovell (1978) introduced the Russell measure model which was a non-oriented model that also considered the slacks of each input or output by allowing a decrease or increase at different rates. Thus, it can be stated that the Russell measure model has a similar concept to the original SBM model. Moreover, the SBM model implies the synchronized implementation of variable improvements from both input and output variables. It does not propose input and output variables to be enhanced uniformly or equipped proportionally, but rather it supports the maximum possible improvement. Moreover, the SBM efficiency model can also properly enhance all possible improvements by bringing them into the calculation of the objective function (Lozano and Gutiérrez 2011). In fact, the current research can be summarized as per the several other DEA research examples that deal with the feasible inputs and undesirable outputs. They mentioned that the undesirable outputs always decreased their quantity in the same proportion (Chang et al. 2014).

The context-dependent Data Envelopment Analysis (context-dependent DEA) was first developed by Seiford and Zhu (2003). The original model of the context-dependent DEA developed by using the frontiers of efficiency measurement, whereby the evaluation contexts were generated as a set of DMUs into different levels of efficient frontiers (Seiford and Zhu

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2003). Under the concept of the context-dependent DEA, all DMUs used would be distinguished by different performances, from inefficient to efficient levels. Each efficient frontier in a different performance level provides an evaluation context for estimating the assessment background of the DMUs. Thus, this model can be used to measure performance by considering the relative attractiveness of the decision-making unit's value and the relative progress value. Based on the same specific evaluation context, the attractiveness and progress value of the DMUs was indicated by the view of equal performance levels (Morita et al. 2005). Moreover, the combination of attractiveness and progress measures is used to further characterize the performance of the DMUs. Therefore, the concept of the context-dependent DEA model can be summarized as relative attractiveness with a higher value having the ability to generate a greater competitive advantage. In contrast, relative progressiveness with a higher value can indicate that the relative efficiency is worse.

Morita et al. (2005) generated a slack-based measure context-dependent data envelopment analysis. It has integrated the SBM model of Tone (2001) into a context-dependent DEA model which was introduced by Seiford and Zhu (2003). The context-dependent DEA is a model which has been developed by using a radial efficiency measure. It neglects the possibility of non-zero slack value. This model can analyse different frontier levels and more appropriate performance benchmarks for inefficient DMUs.

According to the literature review of SBM context-dependent DEA at this current time, it can be summarized as follows: Cheng et al. (2009) applied performance measurement as a benchmark by improving some models of slack-based measure context-dependent DEA for the hotel industry in Taiwan. This research's aims can be explained as follows: (1) Analyse operational performance of hotels; (2) Provide a reference path for hotel competitors. Cheng et al. (2010) applied the new model of slack-base measure context–dependent DEA approach in the case study of international tourism in Taiwan. The results showed that the tourist market differentiates five performance levels each with its own set of benchmark. In summary, a higher attractiveness score can be exhibited as a learning target. At the same performance level, the leading level can use the lower progress score to analyse the potential competitors.

Based on the original SBM model, this model assumes there are n DMUs (DMUj = 1, 2, ..., n) with m non-negative input (x_{ij}, i = 1, 2, ..., m) and p *non-negative output* (y_{rj}, r = 1, 2, ..., s) for each DMU, respectively. Let us further assume that the slack variables $s_i^-, i = 1,2,\dots,m$ and $s_r^+, r = 1,2,\dots,s$ indicate the input excess and output shortfall and λ_j, i = 1, 2, ..., n is a non-negative value. Thus, the SBM model of Tone (2001) can be expressed as:

$$\text{Min } p = \left[1 - \frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{ik}}\right] / \left[1 + \frac{1}{s}\sum_{r=1}^{s}\frac{s_r^+}{y_{rk}}\right]$$

Subject to:

$$\sum_{j=1}^{n}\lambda_j x_{ij} + s_i^- = x_{ik} \quad i = 1,\dots,m \tag{1}$$

$$\sum_{j=1}^{n}\lambda_j y_{rj} - s_r^+ = y_{rk} \quad r = 1,\dots,s$$

$$\lambda_j \geq 0, j = 1, \dots, n, \; s_i^- \geq 0, i = 1, \dots, m, \; s_r^+ \geq 0, r = 1, \dots, s$$

The SBM efficiency score (p) is verified by a value between 0 and 1. If there is $p^* = 1$, it implies that the SBM model has no input excess and no output shortfall in the optimal solution, and the DMU is situated on the efficient frontier.

Based on the original concept of the context-dependent DEA model, there is $J^l = \{DMU_j = 1, \dots, n\}$ being the set of all n DMUs and $J^{l+1} = J^l - E^l$, where $E^l = \{DMUo \in J^l| = 1\}$. As per the combination of the SBM and context-dependent DEA model of Morita et al. (2005), it can be stated that the set of efficiency E^l was defined from the slack-based efficiency score between 0 and 1. Thus, the SBM context-dependent DEA model can obtain the equation from the following linear program:

$$\text{Min } p_k^l = \left[1 - \frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{ik}}\right] / \left[1 + \frac{1}{S}\sum_{r=1}^{S}\frac{s_r^+}{y_{rk}}\right]$$

Subject to:

$$\sum_{j\in J^l}\lambda_j x_{ij} + s_i^- = x_{ik} \quad i = 1,\dots,m \tag{2}$$

$$\sum_{j\in J^l}\lambda_j y_{rj} - s_r^+ = y_{rk} \quad r = 1,\dots,s$$

$$\lambda_j \geq 0, j \in J^l, \; s_i^- \geq 0, i = 1, \dots, m, \; s_r^+ \geq 0, r = 1, \dots, s$$

There is i^{th} input and r^{th} output of DMU$_j$ (j = 1, ..., n) which are denoted by x_{ij} (i = 1, ..., m) and y_{rj} (r = 1, ..., s), respectively. Moreover, λ_j will replace the weight assigned to DMU$_j$. According to the creation of its ideal benchmark, we can denote s_i^- and s_r^+ to replace the slack variables and they can be associ-

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ated with the first and second sets of constraints. Define p_k^l to replace the efficiency score of the SBM context-dependent DEA of DMU_k which has an achievement at performance level l, if the optimal value of $p_k^l = 1$.

As per the SBM context-dependent DEA model, there are four steps of achievement to reach the best-practice frontiers:

Step 1: Identifying $l = 1$ and assessing the overall DMUs sets, J^l, by using model (2) to calculate the first-level frontier DMUs, for generating set E^1.

Step 2: Excluding the inefficient DMUs from the future DEA runs. $J^{l+1} = J^l - E^l$.

Step 3: Starting the assessment of a new subset of DMUs, J^{l+1}, by using the same model to obtain the new set of DMUs E^{l+1}; it will arrive at being the new best-practice frontier.

Step 4: Letting $l = l+1$ and go to step 2.

Stopping rule: $J^{l+1} = \emptyset$, the algorithm will be stopped.

According to the reference set of DMU_o, the SBM context-dependent DEA model can generate the performance level "n" based upon the context "l" when $l < n$ is presented by the specific model as below:

$$R_n^{SBM}(l) = \{j \in J^l \mid \lambda_j > 0 \; in \; (2)\} \tag{3}$$

As per the identification of Morita et al. (2005), this model uses the calculation of the distance between the efficient DMU_0 and those at the leading performance level (E^l) by applying the super-efficiency of Tone (2002) into this model. Therefore, the attractiveness index can be obtained by the following linear programming:

$$\text{Min } \tau(A) = 1/m \sum_{i=1}^{m} \bar{x}_i / x_{ik}$$

Subject to:

$$1 = \frac{1}{s} \sum_{r=1}^{s} \bar{y}_r / y_{rk} \tag{4}$$

$$\bar{x}_i \geq \sum_{j \in E^l} \lambda_j x_{ij} \quad i = 1, \dots, m$$

$$\bar{y}_r \leq \sum_{j \in E^l} \lambda_j y_{rj} \quad r = 1, \dots, s$$

$$\lambda_j \geq 0, t > o, \; \bar{x}_i \geq t x_{ik}, 0 \leq \bar{y}_r \leq y_{rk}, j \in E^l$$

With the calculation of the relative attractiveness score, the score is more than 1. Thus, a higher value of Min $\tau(A)$ can indicate that the efficient DMU has an operations' performance higher than other DMUs in the same performance level.

As per the improvement of Cheng et al. (2010), the calculation of the distance between inefficient DMU_o, and those at the lagging performance level (E^1) can be measured relative to the concept of progress by the following linear programming:

$$\text{Min } \tau(P) = 1/s \sum_{r=1}^{s} \bar{y}_r / y_{rk}$$

Subject to:

$$1 = \frac{1}{m} \sum_{i=1}^{m} \bar{x}_i / x_{ik} \tag{5}$$

$$\bar{x}_i \leq \sum_{j \in E^l} \lambda_j x_{ij} \quad i = 1, \dots, m$$

$$\bar{y}_r \geq \sum_{j \in E^l} \lambda_j y_{rj} \quad r = 1, \dots, s$$

$$\lambda_j \geq 0, t > 0, \; \bar{y}_r \geq t y_{rk}, 0 \leq \bar{x}_i \leq x_{ik}, j \in E^l$$

This model has inverted the super-efficiency of model (4). The progress score is less than 1. Thus, a lower value of min $\tau(P)$ indicates that the inefficient DMU has a better practice than other DMUs in the same performance level.

Data selection

This study selects secondary data from the companies' financial statements and operations' statistics from 14 listed companies on the Thai stock exchange covering 2011–2014. The screening procedures of input and output variables are used as considerations in this paper. As per the previous studies of input and output selection of Dyson et al. (2001) and Zhou et al. (2008), it can be summarized that there are three screening steps as follows: first step, establish a list of inputs and outputs that relate to this paper; second step, a list of inputs and outputs will be examined by the statistical analysis in terms of correlation; third step, consider the numbers of DMUs' rules regarding its numbers being larger than the products and its number of DMUs being at least two times larger than the amount of the number of inputs and outputs. As per the data set of the listed companies in Table 1, the number of DMUs can be calculated from the number of listed companies multiplied by four years, and then the number of DMUs is 56. Thus, the number of suitable DMUs for using

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Table 1. Data set of 14 listed companies in the agribusiness sector on the stock exchange

Number	Listed company name	Initial
1	Asian Sea foods Cold Storage Public Company Limited	ASIAN
2	Kiang Huat Sea Gull Trading Frozen Food Public Company Limited	CHOTI
3	Chiangmai Frozen Foods Public Company Limited	CM
4	Chumporn Palm Oil Industry Public Company Limited	CPI
5	Eternal Energy	EE
6	GFPT Public Company Limited	GFPT
7	Lee Feed Mill Public Company Limited	LEE
8	Patum Rice Mill and Granary Public Company Limited	PRG
9	Sri Trang Agro-Industry Public Company Limited	STA
10	Thai Luxe Enterprises Public Company Limited	TLUXE
11	Thai Rubber Latex Corporation (Thailand) Public Company Limited	TRUBB
12	Thai Wah Starch Public Company Limited	TWS
13	United Palm Oil Industry Public Company Limited	UPOIC
14	Univanich Palm Oil Public Company Limited	UVAN

Source: Stock Exchange of Thailand (2014)

in this paper is two times larger than the amount of the number of inputs and outputs. The descriptive statistics of input and output items are demonstrated in Table 2. The results in this study exhibit that the distribution of the data selection is ensured by the arithmetic mean and standard division.

In addition, Table 3 shows the correlation coefficients among the input and output variables that are conducted to test the statistical relationship. The results show that they have strong correlations among the independent variables. The reasoning shows that most correlation coefficients are more than 0.80. Moreover, the finding of a positive correlation is discovered between the feasible input and output variables which denote that when some inputs have an increase in value, this will lead to the increase of value in some outputs. Thus, these variables are consistent with the hypothesis of constant returns to scale.

Table 2. Descriptive statistics for 56 DMUs of the 14 listed companies

Variable	Maximum	Minimum	Mean	Std. dev.
Input items				
Asset	44 320.10	1 168.66	6 596.39	9 755.58
Liabilities	24 253.80	3.98	2 939.60	5 285.83
Shareholders' Equity	20 491.67	1 038.09	3 625.59	4 679.39
Output items				
Revenue	135 039.83	32.56	12 331.21	25 921.36
Profit	1 811.60	0.0001	375.87	503.64

Source: Author's calculations

Table 3. Correlation coefficients among input and output variables

	Asset	Liabilities	Shareholders' Equity	Revenue	Profit
Asset	1				
Liabilities	0.979	1			
Shareholders' Equity	0.974	0.908	1		
Revenue	0.956	0.954	0.911	1	
Profit	0.637	0.557	0.693	0.596	1

Source: Author's calculations

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Table 4. DMUs for each performance level (CRS model)

Performance level	Group of DMUs
First level performance DMUs (E^1)	DMU09, DMU12, DMU14, DMU19, DMU25
Second level performance DMUs (E^2)	DMU02, DMU11, DMU13, DMU23, DMU28, DMU39
Third level performance DMUs (E^3)	DMU01, DMU16, DMU26, DMU27, DMU37, DMU42, DMU53
Fourth level performance DMUs (E^4)	DMU06, DMU10, DMU15, DMU21, DMU29, DMU33, DMU41, DMU44, DMU48, DMU51, DMU56
Fifth level performance DMUs (E^5)	DMU03, DMU04, DMU07, DMU17, DMU24, DMU30, DMU31, DMU34, DMU43, DMU54, DMU55
Sixth level performance DMUs (E^6)	DMU35, DMU38, DMU40, DMU45, DMU46
Seventh level performance DMUs (E^7)	DMU18, DMU20, DMU32, DMU49
Eighth level performance DMUs (E^8)	DMU22, DMU47, DMU50, DMU52
Ninth level performance DMUs (E^9)	DMU05, DMU36
Tenth level performance DMUs (E^{10})	DMU08

Source: Author's calculations

EMPIRICAL ANALYSIS

This section collects the panel data of the 14 listed companies from 2011–2014 which is used for the analysis by the SBM context-dependent DEA model. This study applies the software of the DEA approach to distinguish the performance levels of the DMUs as the first step. The second step determines the reference sets of the listed companies in the agribusiness sector under standard performance. The third step measures the attractiveness and progress score in each performance level of the DMUs.

Performance level of the DMUs

Based on identifying the returns to scale, the SBM context-dependent DEA has two choices of models in order to calculate the optimal result. In this study, the SBM context-dependent DEA is used to analyse the data set of both constant returns to scale (CRS) and variable returns to scale (VRS) for exploring the optimal model. By using Model (1), based on the CRS and VRS models, it can separate the 56 DMUs of the 14 listed companies into 10 and six performance levels in Table 4 and Table 5, respectively. As per the application of the CRS and VRS models from the performance level results in Table 4 and 5, this study can make the decision to use the performance level through the CRS model because this model can apply both the technical and scale efficiency into the performance measurement. Meanwhile, the VRS model ignores the scale efficiency and only focuses on the pure technical efficiency. For instance, the DMU05 is a rather more inefficient company than the other companies (see Table 4). This DMU05 has been ranked in the ninth performance level of the CRS model. In contrast, the DMU 05 is the most efficient listed company in the VRS model because the DMU10 obtains a higher efficiency score (Table 5).

Table 5. DMUs for each performance level (VRS model)

Performance level	Group of DMUs
First level performance DMUs (E^1)	DMU02, DMU03, DMU05, DMU09, DMU10, DMU12, DMU13, DMU14, DMU19, DMU25, DMU27, DMU28, DMU37, DMU47, DMU48
Second level performance DMUs (E^2)	DMU11, DMU16, DMU17, DMU23, DMU26, DMU31, DMU33, DMU34, DMU39, DMU41, DMU44, DMU45
Third level performance DMUs (E^3)	DMU01, DMU06, DMU21, DMU24, DMU26, DMU30, DMU42, DMU51, DMU52, DMU53, DMU55
Fourth level performance DMUs (E^4)	DMU04, DMU07, DMU15, DMU20, DMU29, DMU38, DMU40, DMU46, DMU54, DMU56
Fifth level performance DMUs (E^5)	DMU18, DMU35, DMU43, DMU49, DMU50
Sixth level performance DMUs (E^6)	DMU08, DMU22, DNU32, DMU36

Source: Author's calculations

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Reference set

This section exhibits the reference sets of the listed companies in the agribusiness sector under the standard performance measurement which is analysed by the benchmark structure (Table 6). As a concept of the benchmark target sets, it can be used by a given company to improve its overall performance by referring to another listed company which has a higher performance score. For example, the C36 is in level 7, and it has reference sets including the C09 and C12 at level 1. When the C36 needs to improve performance, it can refer to the reference set at level 1. This can guide resource allocation, strategy and policy, both inside and outside of the company.

Table 6. The reference sets and benchmark targets of the 14 listed companies

Company code	Company name	Level	RTS	$R_k^{SBM}(1)$	$R_k^{SBM}(2)$	$R_k^{SBM}(3)$
C01	ASIAN*	3	Increasing	STA*	TWS*	
C02	CHOTI*	2	Increasing	STA*	TWS*	UVAN*
C03	CM*	5	Increasing	UVAN*		
C04	CPI*	5		STA*	TWS*	
C05	EE*	9	Increasing	UVAN*		
C06	GFPT*	4	Decreasing	STA*	TWS*	
C07	LEE*	5	Increasing	UVAN*		
C08	PRG*	10	Decreasing	STA*	TWS*	
C09	STA*	1	Constant	STA*		
C10	TLUXE*	4	Increasing	STA*	TWS*	
C11	TRUBB*	2	Increasing	STA*	TWS*	TRUBB**
C12	TWS*	1	Constant	TWS*		
C13	UPOIC*	2	Increasing	UVAN*		
C14	UVAN*	1	Constant	UVAN*		
C15	ASIAN**	4	Increasing	STA*		
C16	CHOTI**	3	Increasing	STA*	TWS*	
C17	CM**	5	Increasing	UVAN*		
C18	CPI**	7	Increasing	STA*	TWS*	
C19	EE**	1	Constant	EE**		
C20	GFPT**	7	Increasing	STA*		
C21	LEE**	4	Increasing	UVAN*		
C22	PRG**	8	Decreasing	STA*	TWS*	
C23	STA**	2	Decreasing	STA*	TWS*	
C24	TLUXE**	5	Increasing	STA*	TWS*	
C25	TRUBB**	1	Constant	TRUBB**		
C26	TWS**	3	Increasing	UVAN*		
C27	UPOIC**	3	Increasing	UVAN*		
C28	UVAN**	2	Increasing	UVAN*		
C29	ASIAN***	4	Increasing	STA*		
C30	CHOTI***	5	Increasing	STA*	TWS*	
C31	CM***	5	Increasing	UVAN*		
C32	CPI***	7	Increasing	STA*	TWS*	
C33	EE***	4	Increasing	UVAN*		
C34	GFPT***	5	Decreasing	STA*	TWS*	
C35	LEE***	6	Increasing	UVAN*		
C36	PRG***	9		STA*	TWS*	
C37	STA***	3	Decreasing	STA*	TWS*	
C38	TLUXE***	6	Increasing	STA*	TWS*	
C39	TRUBB***	2	Increasing	STA*	TRUBB**	
C40	TWS***	6	Increasing	UVAN*		
C41	UPOIC***	4	Increasing	STA*	TWS*	
C42	UVAN***	3	Increasing	UVAN*		
C43	ASIAN****	5	Increasing	STA*		
C44	CHOTI****	4	Increasing	STA*	TWS*	
C45	CM****	6	Increasing	UVAN*		
C46	CPI****	6	Increasing	STA*	TWS*	
C47	EE****	8	Increasing	UVAN*		

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Continued Table 6

Company code	Company name	Level	RTS	$R_k^{SBM}(1)$	$R_k^{SBM}(2)$	$R_k^{SBM}(3)$
C48	GFPT****	4	Decreasing	STA*	TWS*	
C49	LEE****	7	Increasing	UVAN*		
C50	PRG****	8	Decreasing	STA*	TWS*	
C51	STA****	4	Decreasing	STA*	TWS*	
C52	TLUXE****	8	Increasing	STA*	TWS*	
C53	TRUBB****	3	Increasing	STA*		
C54	TWS****	5	Increasing	UVAN*		
C55	UPOIC****	5	Increasing	STA*	TWS*	
C56	UVAN****	4	Decreasing	TWS*	UVAN*	

*2011,**2012,***2013,****2014; RTS is returns to scale and is the benchmark target of DMU_k

Source: Author's calculations

Attractiveness and progress scores

The results in Table 7 show the attractiveness and progress scores of 14 listed companies in the agribusiness sector during the period 2011–2014. In this study, 56 DMUs of 14 listed companies are distinguishing different performance levels in the SBM context-dependent DEA approach. As per the concept of the SBM context-dependent DEA, the higher attractiveness score of a listed company represents a long distance between the efficient DMUs and those with a lagging performance level. This concept can be explained thus: a listed company observed with a higher attractiveness score has a better performance than the other listed companies and also indicates that it does not have close competitors at the same level. Meanwhile, the lower progress score represents a short distance between the inefficient DMUs which comes from the leading level. It means that a listed company needs to improve its inputs and then has the best chance to go to be the leader of the business at the same level.

As per the attractiveness score of the listed companies in level E^1 to E^{10}, the C19 and C12 have a higher attractiveness score when level 2 to level 10 are used to consider the score as an evaluation context. In addition, the C09 has the lowest attractiveness score when level 1 through level 7 are used to consider the score as an evaluation context at the same level E^1.

In level E^2, the C13 has a higher attractiveness score when levels 1 through 10 are used to consider the score. In contrast, the C23 and C02 have a lower attractiveness score when levels 4 through 10 are used to consider the score at the same level E^2. Therefore, the C13 has the best performance of listed companies in level E^2, whereas the C23 and C02 are the worst performers in this level. According to the above scenario, there are listed companies in levels E^3 through E^9 that can be used to consider the ranking in terms of a higher attractiveness and lower progress scores. In level E^3, the C27 has a higher attractiveness score when compared with level 4 through level 10 and has a lower progress score when level 1 and level 2 are used as a comparison. Thus, the C27 is the best performer in this level. In level E^4, the C33 has a higher attractiveness score when levels 5 to 10 are used as a comparison. In contrast, C21 has a lower progress score when levels 1 through 4 are used to consider the score. In level E^5, the C55 has a lower attractiveness score when levels 8 through 10 are used as a comparison and has a higher progress score when levels 1 through 4 are used to consider the score. In level E^6, the C38 and C46 have a lower attractiveness score when levels 7 through 10 are used as a comparison and have a higher progress score when levels 1 through 5 are used to consider the score. In level E^7, the C20 and C32 have a higher progress score when levels 1 through 6 are used as a comparison. In contrast, the C20 and C32 have a lower progress score when levels 8 through 9 are used to consider the score. In level E^8, the C22 and C50 have a higher progress score when levels 1 through 7 are used as a comparison. In contrast, the C22 and C50 have a lower attractiveness score when levels 1 through 4 are used to consider the score. In level E^9, C36 is in level 1 through level 6 and has the highest progress score. In contrast, the C05 has a higher attractiveness score when level 10 is used as a comparison. Moreover, in level E^{10}, which is the last performance level, the C08 is in level 1 through level 9 and has the highest progress score when compared with the progress scores of level E^2 through level E^9. Therefore, the C08 is the worst performing in this measurement concept.

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Table 7. Attractiveness and progress scores of fifty-seven DMUs of the agribusiness sector

Company List	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Level 9	Level 10
Level E^1		#	#	#	#	#	#	#	#	#
C09 STA*		1.260(4)	1.593(5)	1.833(5)	2.247(5)	2.668(5)	3.016(5)	5.777(5)	18.718(5)	24.341(5)
C12 TWS*		2.320(2)	2.677(2)	4.324(2)	5.836(2)	8.433(2)	11.985(2)	25.988(2)	31.687(2)	71.204(2)
C14 UVAN*		1.425(3)	1.643(3)	2.525(3)	3.371(3)	4.908(3)	6.732(3)	17.849(3)	21.764(4)	48.904(3)
C19 EE**		3.254(1)	3.554(1)	4.942(1)	7.278(1)	12.333(1)	16.907(1)	51.676(1)	63.008(1)	141.583(1)
C25 TRUBB**		1.171(5)	1.606(4)	2.356(4)	2.677(4)	4.091(4)	4.091(4)	7.113(4)	28.701(3)	37.322(4)
Level E^2	##		#	#	#	#	#	#	#	#
C02 CHOTI*	0.927(4)		1.275(5)	1.432(5)	1.541(6)	2.040(5)	2.900(5)	6.513(4)	11.333(6)	16.026(6)
C11 TRUBB*	0.969(5)		1.467(1)	2.070(3)	2.361(3)	3.360(4)	3.663(3)	6.972(3)	23.574(2)	30.655(4)
C13 UPOIC*	0.649(1)		1.154(6)	2.190(2)	2.626(1)	3.826(1)	5.199(1)	15.512(2)	18.914(4)	42.501(2)
C23 STA**	0.864(2)		1.307(3)	1.401(6)	1.758(5)	1.989(6)	2.303(6)	4.456(6)	13.367(5)	17.383(5)
C28 UVAN**	0.977(6)		1.290(4)	2.237(1)	2.372(2)	3.790(2)	5.196(2)	15.882(1)	19.364(3)	43.513(1)
C39 TRUBB***	0.870(3)		1.372(2)	2.012(4)	2.286(4)	3.494(3)	3.494(4)	6.076(5)	24.513(1)	31.877(3)
Level E^3	##	##		#	#	#	#	#	#	#
C01 ASIAN*	0.681(2)	0.788(2)		1.384(4)	1.529(4)	2.249(4)	2.643(3)	5.201(4)	13.556(4)	17.628(5)
C16 CHOTI**	0.789(5)	0.866(6)		1.217(7)	1.274(7)	1.662(6)	2.234(6)	4.162(7)	7.471(7)	9.140(7)
C26 TWS**	0.844(7)	0.864(5)		1.227(6)	1.324(6)	1.639(7)	2.247(5)	7.460(3)	12.019(5)	18.817(4)
C27 UPOIC**	0.705(4)	0.925(7)		2.050(1)	2.295(1)	3.470(1)	4.757(1)	14.540(1)	17.729(2)	39.837(1)
C37 STA***	0.652(1)	0.826(3)		1.232(5)	1.415(5)	1.877(5)	2.197(7)	4.305(6)	11.653(6)	15.153(6)
C42 UVAN***	0.809(6)	0.839(4)		1.568(2)	1.700(2)	2.656(2)	3.641(2)	11.164(2)	13.568(3)	30.488(2)
C53 TRUBB****	0.692(3)	0.749(1)		1.467(3)	1.666(3)	2.547(3)	2.547(4)	4.429(5)	17.868(1)	23.235(3)
Level E^4	##	##	##		#	#	#	#	#	#
C06 GFPT*	0.485(4)	0.717(6)	0.852(6)		1.058(11)	2.036(3)	2.893(3)	4.680(4)	6.062(9)	10.377(8)
C10 TLUXE*	0.607(7)	0.726(8)	0.876(8)		1.089(9)	1.607(8)	2.284(6)	4.055(6)	6.242(8)	8.193(10)
C15 ASIAN**	0.548(6)	0.617(3)	0.833(5)		1.156(5)	1.722(7)	1.724(9)	3.196(8)	12.084(3)	15.714(4)
C21 LEE**	0.716(11)	0.810(11)	0.984(11)		1.118(7)	1.308(10)	1.794(7)	5.834(3)	10.433(4)	14.031(5)
C29 ASIAN***	0.536(5)	0.594(1)	0.809(3)		1.136(6)	1.736(6)	1.736(8)	3.019(10)	12.182(2)	15.842(3)
C33 EE***	0.430(2)	0.685(4)	0.749(2)		1.533(1)	2.598(1)	3.561(1)	10.884(1)	13.271(1)	29.821(1)
C41 UPOIC***	0.355(1)	0.597(2)	0.673(1)		1.217(4)	2.004(4)	2.849(4)	3.991(7)	4.263(11)	10.216(9)
C44 CHOTI****	0.674(10)	0.739(9)	0.859(7)		1.076(10)	1.254(11)	1.338(11)	1.453(11)	6.477(7)	7.933(11)
C48 GFPT****	0.466(3)	0.696(5)	0.816(4)		1.114(8)	2.064(2)	2.933(2)	4.535(5)	5.299(10)	10.521(7)
C51 STA****	0.655(9)	0.755(10)	0.973(10)		1.281(3)	1.398(9)	1.618(10)	3.129(9)	9.432(5)	12.265(6)
C56 UVAN****	0.616(8)	0.720(7)	0.885(9)		1.383(2)	1.975(5)	2.759(5)	7.124(2)	8.824(6)	19.361(2)
Level E^5	##	##	##	##		#	#	#	#	#
C03 CM*	0.686(11)	0.702(7)	0.812(6)	0.958(6)		1.065(11)	1.124(11)	4.253(6)	9.429(3)	12.886(5)
C04 CPI*	0.498(4)	0.637(5)	0.770(5)	0.911(3)		1.445(6)	1.728(7)	3.467(8)	7.488(7)	9.737(8)
C07 LEE*	0.630(8)	0.712(10)	0.866(10)	0.936(4)		1.404(7)	1.925(5)	5.850(3)	9.171(4)	15.024(3)
C17 CM**	0.571(5)	0.584(3)	0.699(2)	0.999(10)		1.695(2)	2.323(3)	7.145(1)	8.684(5)	19.453(1)
C24 TLUXE**	0.628(7)	0.706(8)	0.830(8)	0.980(9)		1.404(8)	1.798(6)	3.487(7)	6.104(9)	7.937(11)
C30 CHOTI***	0.639(9)	0.712(9)	0.850(9)	0.958(7)		1.215(9)	1.321(10)	1.856(11)	6.406(8)	8.330(10)
C31 CM***	0.617(6)	0.632(4)	0.742(4)	0.966(8)		1.480(5)	2.029(4)	6.319(2)	8.589(6)	16.993(2)
C34 GFPT***	0.449(2)	0.702(6)	0.820(7)	0.999(11)		2.043(1)	2.903(1)	4.629(5)	5.813(10)	10.414(7)
C43 ASIAN****	0.484(3)	0.543(2)	0.734(3)	0.886(2)		1.528(4)	1.528(8)	2.657(10)	10.722(1)	13.943(4)
C54 TWS****	0.646(10)	0.748(11)	0.909(11)	0.937(5)		1.132(10)	1.509(9)	4.887(4)	9.455(2)	12.141(6)
C55 UPOIC****	0.296(1)	0.501(1)	0.567(1)	0.834(1)		1.678(3)	2.385(2)	3.342(9)	3.570(11)	8.555(9)
Level E^6	##	##	##	##	##		#	#	#	#
C35 LEE***	0.630(4)	0.688(5)	0.829(5)	0.880(4)	0.971(5)		1.307(2)	4.752(2)	9.116(1)	11.840(2)
C38 TLUXE***	0.536(2)	0.589(2)	0.682(1)	0.800(2)	0.853(1)		1.070(4)	1.680(5)	5.003(5)	6.177(5)
C40 TWS***	0.610(3)	0.678(4)	0.815(4)	0.851(3)	0.945(2)		1.421(1)	4.839(1)	8.850(3)	11.480(3)
C45 CM****	0.644(5)	0.659(3)	0.763(3)	0.899(5)	0.948(3)		1.056(5)	3.991(3)	8.940(2)	12.100(1)
C46 CPI****	0.505(1)	0.580(1)	0.743(2)	0.770(1)	0.966(4)		1.151(3)	2.210(4)	7.017(4)	9.124(4)
Level E^7	##	##	##	##	##	##		#	#	#
C18 CPI**	0.444(3)	0.512(3)	0.661(3)	0.680(2)	0.868(3)	0.914(1)		1.905(2)	6.41(4)	8.336(4)
C20 GFPT**	0.371(1)	0.463(1)	0.588(1)	0.679(1)	0.827(1)	1.000(4)		1.854(3)	7.02(2)	9.123(2)
C32 CPI***	0.415(2)	0.487(2)	0.633(2)	0.680(3)	0.855(2)	0.939(2)		1.722(4)	6.59(3)	8.571(3)
C49 LEE****	0.610(4)	0.666(4)	0.804(4)	0.852(4)	0.938(4)	0.970(3)		4.006(1)	8.83(1)	11.463(1)
Level E^8	##	##	##	##	##	##	##		#	#
C22 PRG**	0.135(2)	0.164(2)	0.197(2)	0.233(1)	0.296(1)	0.447(1)	0.635(1)		1.405(3)	2.709(4)
C47 EE****	0.529(4)	0.542(4)	0.627(3)	0.739(4)	0.772(3)	0.822(3)	0.868(3)		1.980(2)	9.946(1)
C50 PRG****	0.103(1)	0.155(1)	0.176(1)	0.253(2)	0.321(2)	0.502(2)	0.714(2)		1.219(4)	2.740(3)
C52 TLUXE****	0.493(3)	0.536(3)	0.648(4)	0.732(3)	0.793(4)	0.908(4)	0.961(4)		5.223(1)	6.452(2)
Level E^9	##	##	##	##	##	##	##	##		#
C05 EE*	0.307(2)	0.314(2)	0.363(2)	0.428(2)	0.447(2)	0.476(2)	0.503(1)	0.658(1)		5.764(1)
C36 PRG***	0.111(1)	0.153(1)	0.181(1)	0.236(1)	0.294(1)	0.470(1)	0.668(2)	0.982(2)		2.396(2)
Level E^{10}	##	##	##	##	##	##	##	##	##	
C08 PRG*	0.087(1)	0.098(1)	0.115(1)	0.136(1)	0.145(1)	0.196(1)	0.279(1)	0.497(1)	0.818(1)	

*2011, **2012, ***2013, ****year 2014, #Attractiveness score, ##Progress score. The numbers in parenthesis () explain the ranking of performance which is viewed from the higher efficiency score starting from 1, to the lower efficiency score *n*

Source: Author's calculations

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Returns to scale of listed companies in the agribusiness sector

The descriptive statistics of returns to scale can provide useful information for the agribusiness sector in general. As per the empirical results in Table 5 and 6, the returns to scale are used to explain the trends and direction of agribusinesses' productivity. Figure 1 shows that 71% of the total observations operate under increasing returns to scale, 20% display decreasing returns to scale, and 13% show constant returns to scale. As per the evaluation results, they can indicate that the listed companies in the agribusiness sector still have the opportunity to develop efficiency by increasing their productivity scale.

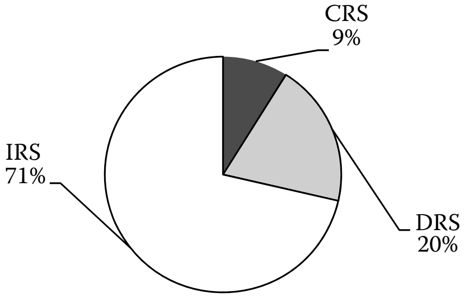

Figure 1. Returns to scale of agribusiness sector

Source: Author's calculations

CONCLUSIONS

Listed companies in the agribusiness sector of the stock exchange of Thailand have an important role in terms of the production of agricultural products. These listed companies are the largest players for driving this part of the economic system. The performance measurements of the listed companies are important tools for indicating the trends and yield of agricultural production. This study selects secondary data from the companies' financial statements and operations' statistics. A panel data of 56 DMUs has been considered and employed for the analysis.

Based on the consistency of input and output variables, the correlation coefficients among the input and output variables have been considered. In this study, the finding of positive correlations has been discovered between the feasible input and output variables. This finding can indicate that when the values of some inputs are increased, this will lead to the increase of value in some outputs. Therefore, these variables are consistent with the hypothesis of constant returns to scale.

Moreover, this study has proposed the SBM context-dependent DEA model to distinguish the performance level and to benchmark the listed companies. As per the results, the reference sets in this study are composed of the best performances of listed companies during a period of four years. The reference sets are used as benchmarks of inefficiency in the listed companies which have the possibility of making all the optimal enhancements by proposing improvement targets with reference to the efficient listed companies.

In addition, the SBM context-dependent DEA model has been used to measure the performance of each of the listed companies by adopting the super-efficiency model in terms of attractiveness and progress. Based on the scope of the attractiveness and progress score, the higher attractiveness scores of the listed companies represent a long distance between the efficient DMUs, and the lower progress scores represent a short distance between the inefficient DMUs. This concept can indicate that if a listed company has a higher attractiveness and lower progress score, it will have a better performance than its competitors and does not need to improve its efficiency. As per the results of the attractiveness and progress scores of all the listed companies, the finding of this study can state that most of the highly efficient listed companies transact their business in relation to the tapioca, palm oil and ethanol industries. Moreover, the returns to scale are used to explain the trends and direction of productivity. As per the evaluation results, they can indicate that the listed companies in the agribusiness sector can build up efficiency by increasing their productivity scale.

Therefore, the empirical results from this study can help the farmers and government to realize the trends of the Thai agricultural productivity and can develop plans and policies for them in the future. Moreover, these results can help the listed companies to realize the performance level and benchmarks leading to improvements in their organizations. They can use this knowledge to develop the strategy and policy for facing the competitor environment as well as to understand the characteristics of their competitors.

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