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A two-stage study of grey system theory and DEA in strategic alliance: An application in Vietnamese fertilizing industry

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ABSTRACT

Agriculture has been developed in Vietnam throughout the years, together with the fertilizing industry. In fact, among those fertilizing companies there is a need to form partnership. However, successful strategic alliances require special skills, considerations and efforts in order to assure the necessary cooperation needed to harness the respective potency of each partner. Grey Theory and DEA model were applied to calculate the effectiveness of enterprises in Vietnam fertilizer industry then offer an effective way to figure out the most suitable strategic partners. Seven companies in the fertilizer industry are selected to collect realistic data from financial reports of Vietnam issued stock market in four consecutive financial years (2012–2016). The Southern Fertilizers JSC was set to be the target decision making unit (DMU). Although this research is specifically applied to the fertilizer industry, the proposed method could also be applied to other manufacturing industries.

1. Introduction

Global fertilizer manufacturers play a vital role in agricultural crop production. Fertilizer use has opened up an increase in productivity of agricultural commodities adding to the farmer's ability to feed the planet. During the period 2004 - 2014, fertilizer demand consistently increased with CARG of 2.08%, which is also strongly segmented in terms of geography and fertilizer types. There are lots of components jointly determined the profitability of fertilizer companies such as fertilizer prices, crop prices, fertilizer demand, political and economic activity, exchange rates, prices of input raw materials, industry structure etc.

Asian still holds the largest consumption of fertilizer in the world which accounts for 59% of total world demand. Ranking as the second and third positions were Americas and Europe, with 23% and 13%, respectively of the whole need. Last but not least, Africa and Oceania remain the lowest proportion with a total of 5%. Considering national area, China, India and the US are the 3 largest fertilizer consumers with 28%, 14%, and 11% respectively. For a long time, fertilizer is one of the most significant tools for Vietnamese farmer to nurture their crops. Superphosphate technology invention has led to the beginning of chemical fertilizer industry, overhauling agriculture which substantially enhances the standard of crop yields. Nowadays, fertilizer sector plays an important role in the economic development of Vietnam, especially in 2014; net revenue of fertilizer enterprises reached the average percentage of more than 17%. This was thanks to new achievements in transforming production technologies of chemical fertilizers into the most advanced forms.

The fertilizer industry development relies on low labor costs, efficiency, large system of foreign exchange, an easy import and export procedures for exporters and the open policies for foreign investors. Currently, the fertilizer industry is facing more challenges such as how to maintain their competitiveness in today's fierce market, to diversify products, and divert from processing into other forms which can bring more advantages for the industry. In specific, there are three major problems: Equipment and modern technology selection, maintaining a stable and capable workforce and floating capital. The problems cannot be overcome when firms are doing individually. We would recommend finding the alliance partners for companies to solve those existing problems by combining Data Envelopment Analysis (DEA) and

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Grey Theory. Since errors in information are unavoidable, consequently, Grey theory and DEA Model are hired to forecast the business in the future and productively evaluate the performance in firm's efficiency ranking.

The purpose of this research is to provide an assessment model based on Grey theory GM (1, 1) and Data Envelopment Analysis (DEA) and suggest an appropriated establishment of partnership after many thoughtful considerations.

2. Research methodology

2.1. Definition of strategic alliance

In the last twenty years, Strategic alliance was considered to be one of the most indispensable issues of organizations. An alliance can be interpreted as an "inter-firm collaboration over a give economic space and time for the attainment of mutually defined goals" (Glaister and Buckley, 1996). In terms of definition, Buckley strongly emphasized a variety of important characteristics:

1. It covers only inter-firm agreements. An alliance operates across the frontiers and limitation of a firm.
2. Collaboration must be required for all ventures. Supplementary to this, there must be some input of resources from all the partners.
3. The alliance is defined on economic and geographical term. It can range from local to global, and also can be defined in actual time or until certain goals are accomplished.
4. An alliance will be defined by the achieving implementation of certain goals. It is not necessarily the case that all partners must be on the same wave length of the objectives.

A Strategic alliance is a voluntary, formal and cooperative arrangement between two or more organizations with the aim of prosecuting a set of agreement upon goal or supporting a critical business obligation while remaining independent organizations. Strategic alliance brings independent firms together to share resources in product design, production, marketing, or distribution (Chan et al., 1997).

2.2. Grey forecasting model

Grey system theory was initiated in 1982 by Deng (1982). The main task of grey system theory is to extract realistic governing laws of the system using available data. This process is known as the generation of the grey sequence. Grey model is suitable for forecasting the competitive environment where decision makers can refer only to a limited historical data (Nguyen and Tran, 2015).

Although various existing types of grey models can be applied for forecasting, the most frequently used grey forecasting model is GM (1,1) due to its computational efficiency (Nguyen and Tran, 2017). In this study, GM (1, 1) was used to get the predicting results. This model is a time series forecasting model, encompassing a group of differential equations adapted for parameter variance, rather than a first order differential equation. Its difference equations have structures that vary with time rather than being general difference equations. Although it is not necessary to employ all the data from the original series to construct the GM (1, 1), the potency of the series must be more than four (Wang et al., 2015). In addition, the data must be taken at equal intervals and in consecutive order without bypassing any data. The GM (1, 1) model constructing process is described as following

Denote the variable primitive series $X^{(0)}$ as formula:

$$X^{(0)}=(X^{(0)}(1),X^{(0)}(2),...,X^{(0)}(n)),\ n\geq 4 \quad (1)$$

where $X^{(0)}$: a non-negative sequence; n: the number of data observed.

Accumulating Generation Operator (AGO) is one of the most important characteristics of grey theory with the aim at eliminating the uncertainty of the primitive data, and smoothing the randomness. The accumulated generating operation (AGO) formation of $X^{(0)}$ defined as:

$$X^{(1)}=(X^{(1)}(1),X^{(1)}(2),...,X^{(1)}(n)),,\ n\geq 4 \quad (2)$$

where

$$X^{(1)}(1)=X^{(0)}(1)$$
$$X^{(1)}(k)=\sum_{i=1}^{k} X^{(0)}(i), k=1,2,3,\dots,n \quad (3)$$

The generated mean sequence $Z^{(1)}$ of $X^{(1)}$ is defined as:

$$Z^{(1)}=(Z^{(1)}(1),Z^{(1)}(2),...,Z^{(1)}(n)),, \quad (4)$$

where $Z^{(1)}$ (k) is the mean value of adjacent data, i.e.,

$$Z^{(1)}(k)=\frac{1}{2}\left(X^{(1)}(k)+X^{(1)}(k+1)\right), k=2,3,\dots,n. \quad (5)$$

From the AGO sequence $X^{(1)}$, a GM (1,1) model which corresponds to the first order different equation $X^1(k)$ can be constructed as follows:

$$\frac{dX^1(k)}{dk}+aX^{(1)}(k)=b \quad (6)$$

where: parameters a and b are called the developing coefficient and grey input, respectively.

In practice, parameters a and b are not calculated directly from Eq. (6). Hence, the solution of above equation can be obtained using the least square method. That is

$$X^{(1)}(k+1)=\left(X^{(0)}(1)-\frac{b}{a}\right)e^{-ak}\frac{b}{a} \quad (7)$$

where $X^{(1)}$ (k+1) denotes the prediction X at time point k+1 and the coefficients $[a,b]^T$ can be obtained by the Ordinary Least Squares (OLS) method:

$$\begin{bmatrix} a \\ b \end{bmatrix} = \hat{\theta} = (B^T B)^{-1} B^T Y_N \quad (8)$$

and

$$Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \cdots\cdots\cdots \\ \cdots\cdots\cdots \\ x^{(0)}(n) \end{bmatrix} \quad (9)$$

$$B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \cdots\cdots\cdots & \vdots \\ \cdots\cdots\cdots & \vdots \\ -z^{(1)}(n) & 1 \end{bmatrix} \quad (10)$$

where: Y is called data series, B is called data matrix, and *[a, b]*^{T} is called parameter series.

We obtained $\hat{x}^{(1)}$ from Eq. (7). Let $\hat{x}^{(0)}$ be the fitted and predicted series

$$\hat{x}^{(0)} = X^{(0)}(1), \hat{x}^{(0)}(2), \ldots\ldots, \hat{x}^{(0)}(n)$$

where

$$\hat{x}^{(0)}(1) = \hat{x}^{(0)}(1)$$

Applying the inverse accumulated generation operation (IAGO). Namely

$$X^{(0)}(k+1) = \left(X^{(0)}(1) - \frac{b}{a}\right) e^{-ak}(1 - e^{a}) \quad (11)$$

The grey model prediction is a local curve fitting extrapolation scheme. At least four data sets are required by the predictor (7) to obtain a reasonably accurate prediction and all the process of Grey prediction was showed Fig. 1.

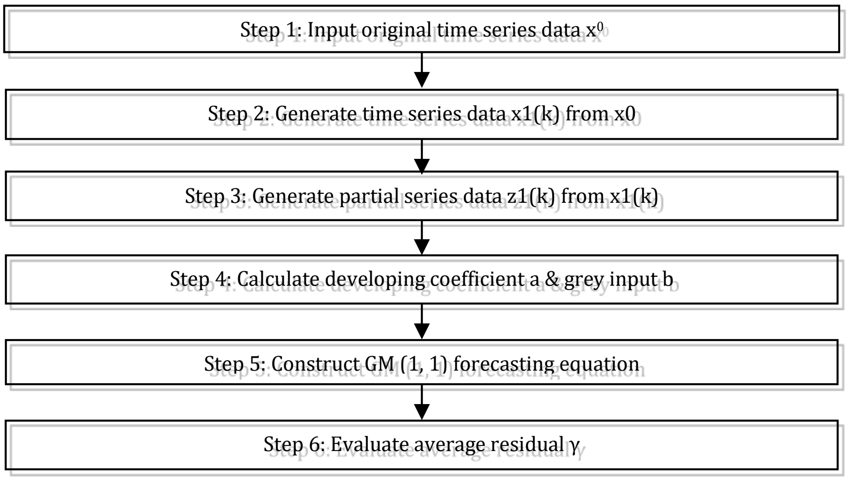

Fig. 1: The process of grey prediction

2.3. DEA models

As in many DEA models, it is crucial to consider how to deal with negative outputs in the evaluation of efficiency in SBM models too. However, negative data should have their duly role in measuring efficiency, hence a new scheme was introduced in DEA-Solver pro 4.1 Manuel and the scheme was changed as follows:

Let us suppose $y_{r0} \leq 0$ it is defined by $\overline{y_r^+}$ and $\underline{y_r^+}$

$$\overline{y_r^+} = \max_{j=1,\ldots n} \{y_{rj} | y_{rj} > 0\}, \quad (12)$$

$$\underline{y_r^+} = \min_{j=1,\ldots n} \{y_{rj} | y_{rj} > 0\} \quad (13)$$

If the output r has no positive elements, then it is defined as $\overline{y_r^+} = y_{-r}^+ = 1$. The term is replaced $\{s_r^+ | y_{r0}\}$ in the objective function in the following way. The value y_{r0} is never changed in the constraints.

(1) $\overline{y_r^+} = y_{-r}^+ = 1$,

the term is replaced by

$$s_r^+ / \frac{y_{-r}^+(\bar{y}_r^+ - y_{-r}^+)}{\bar{y}_r^+ - y_{r0}} \quad (14)$$

$$(2) s_r^+ / \frac{(y_{-r}^+)^2}{B(\bar{y}_r^+ - y_{r0})} \quad (15)$$

where B is a large positive number, (in DEA-Solver B=100).

In any case, the denominator is positive and strictly less than y_{-r}^+. Furthermore, it is inverse proportion to the distance $\bar{y}_r^+ - y_{r0}$. This scheme, therefore, concerns the magnitude of the non-positive output positively. The score obtained is units invariant, i.e., it is independent of the units of measurement used.

2.4. Development of research

In this study, Grey Theory and DEA model are combined in a group of methodical evaluation models. The development of research in this paper is implemented by the data information of Vietnamese Fertilizer Industry and also selected all related documentations as references. Then after subject confirming and proceeding industrial analysis, the development of this study is presented in Fig. 2. And each step is addressed afterward.

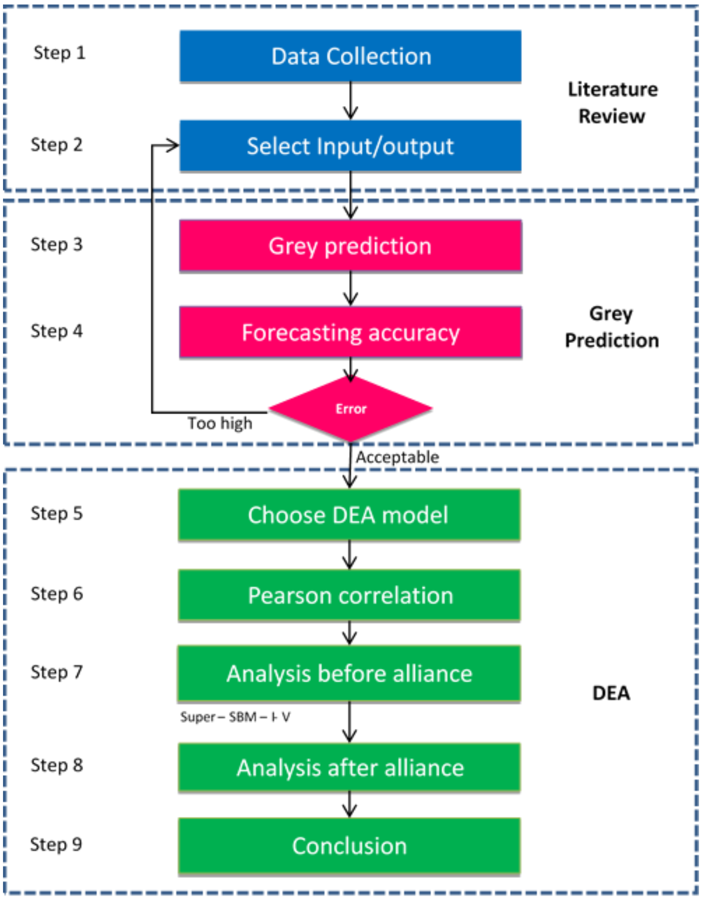

Fig. 2: Study development

Step 1: Data collection

The clarity of the data used in this study was collected from General statistics office of Vietnam. Then, the stock markets, including VietStock and CafeF which are among the reliable, well-known ones in Vietnam, record their realistic financial reports. From all of those sources, we collected all our DMUs from nominees in Vietnam Fertilizer data in which firms published their financial report in Vietnam stock market during 4 consecutive years (2012-2016). In this study, The Southern Fertilizers JSC was chosen as our target Company to incorporate with the rest of other DMUs to simulate the efficiency by applying the strategic alliance.

Step 2: Select inputs/outputs

Inputs and outputs are main impacting factors to the efficiency of DEA model and instantaneously help the target DMU to find the proper alliance partners, consequently we should have a thoughtful consideration. In this research, six (06) inputs/outputs used are defined as below:

- **Fixed assets:** Fixed assets are composed of land, property equipment.
- **Cost of goods sold Capital**: capital is the amount of cash and other assets owned by a business. These business assets include accounts receivable, equipment, and land/buildings of the business.
- **Operating costs** are the expenses which are related to the operation of a business, or to the operation of a device, component, and piece of equipment or facility. They are the cost of resources used by an organization just to maintain its existence.
- **Net sales:** The amount of sales generated by a company after the deduction of returns, allowances for damaged or missing goods and any discounts allowed.
- **Net profits** is calculated by subtracting a company's total expenses from total revenue, thus showing what the company has earned (or lost) in a given period of time (usually one year)
- **Operating profit:** A measure of a company's earning power from ongoing operations, equal to earnings before deduction of interest payments and income taxes.

Step 3: Grey prediction

Based on GM (1; 1), Grey Prediction has been designed to forecast the results on 2017. However, error in prediction is unavoidable. Hence, the MAPE (Mean absolute percent error) is employed to measure the accuracy values in statistics. The smaller values of MAPE demonstrate that the forecasting values are more reasonable

Step 4: Forecasting accuracy

Forecasting method is implemented to predict future results using the present uncompleted information. It is not easy to believe that predictions will viably be accurate at the vast majority of time. Hence, the MAPE will be implemented to quantify the forecasting accuracy. In case of high forecasting error, we have to reselect the information sources.

Step 5: Choose the DEA model

In this research, the Super-SBM-I-V is utilized to indicate how proficiency can be accommodated each effective unit compared to different DMUs.

Step 6: Pearson correlation

DEA is used incompetency estimation for decision-making units by developing a comparative effectiveness score through the change of the multiple foundation data into a ratio of a single virtual output to a single virtual input. Subsequently, correlation testing for collected input and output is quite important. In this examination, we utilize the Pearson Correlation Coefficient Test.

Step 7: Analysis before alliance

Main purpose of this step is to point out the effectiveness of each decision-making unit by applying the model in the inspected data of 2016 to discover a firm as target one for computing the proficiency of virtual alliance in the forecasting value of 2017.

SBM models show in fragmentary shape is as per the following (Tone, 2001):

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

Step 8: Analysis after alliance

We set up all the predicted factors in 2017 and sum the factors of 11 DMUs with the forecasting value of the target Company. Then we get final DMUs for comparing, after that using the supper-SBM-I-V model to analysis all the combination for each DMU, and finally provide our suggestion.

Step 9: Summary

If a company is non-proficient before strategic alliance, but after strategic alliance, it gets better results, then we recommend strategic alliance is a better choice. Contrarily, if a enterprises is efficient before strategic alliance, but get worst after strategic alliance then we do not recommend strategic alliance because it exist possible risks.

3. Applicable case result and analysis

3.1. DMUs collection

After searching in Vietnam Fertilizer Industry, we find out 11 companies which are collected from Vietnam issued stock market during 2012-2016 as our DMUs. The synopsis is shown in the following Table 1.

Table 1: Companies list

Number order	Code	Companies
1	A	Petrovietnam Fertilizer and Chemicals Corporation
2	B	Petrovietnam Ca Mau Fertilizer JSC
3	C	BinhDien Fertilizer JSC
4	D	Lam Thao Fertilizers and Chemicals JSC
5	E	The Southern Fertilizers JSC
6	F	Quang Binh Import and Export JSC
7	G	NinhBinh Phosphate Fertilizer JSC
8	H	Central PetroVietnam Fertilizer And Chemicals JSC
9	I	South-East PetroVietnam Fertilizer and Chemicals JSC
10	K	Van Dien Fused Magnesium Phosphate Fertilizer JSC
11	N	South-West PetroVietnam Fertilizer and Chemicals JSC

3.2. Input/ output variables selecting

To apply the research on Grey Forecasting model and DEA literature review, three main participations are selected as fixed assets, cost of goods sold, operating costs which are essential to the sources of fertilizer industry. And we select the net sales, operating profit, net profits as our output factors owing to the essential index to analyze the company's financial effectiveness. We show the realistic data of 2016 which are gained from the financial statement that they are selected at Vietnam issued stock market website with the Vietnam currency unit (Table 2).

Table 2: Input and output factors of companies in fertilizer industry in 2016

Company	Input (Units: Volume million, $thousand)			Input (Units: Volume million, $thousand)		
	Fix assets	Cost of Goods sold	Operating Cost	Net sales	Net profits	Operating profit
A	1,910,477	5,528,946	1,248,517	7,924,787	1,164,775	1,385,216
B	8,754,407	3,595,508	963,306	4,910,171	624,340	632,709
C	742,125	5,038,820	489,927	5,942,917	350,100	421,064
D	193,750	3,233,437	562,608	3,964,661	138,150	171,686
E	150,386	2,105,100	149,510	2,338,362	90,589	102,510
F	272,675	4,300,199	224,435	4,495,270	13,561	16,690
G	9,559	447,691	75,801	546,139	19,334	23,145
H	45,939	1,910,249	60,932	1,997,252	25,168	31,289
I	35,167	2,071,763	69,801	2,165,958	23,353	26,457
K	16,853	689,058	176,225	907,609	44,432	54,398
N	31,797	2,153,810	56,339	2,237,995	28,117	35,149

3.3. Variables calculation – Forecast inputs/ Outputs by GM (1, 1)

The Grey Model (1, 1) is utilized to predict the input and output factors values for each decision making unit in 2016 and 2017. In the Table 3, we take the total deposits of DMU_1 as an example to explain how to calculation. Other variables are calculated in the same way.

We have a result by apply GM(1,1) of all DMU_s in 2017 and 2018 was shown in Tables 4 and 5, respectively.

Table 3: Inputs and outputs factors of company a during 2012-2016

Company A	Inputs Factor ($ thousands)			Outputs Factor ($ thousands)
	Fixed Assets	Cost of goods sold	Operating costs	Net sales
2012	2,371,392	8,997,366	1,318,093	13,321,852
2013	2,368,444	7,011,191	1,194,639	10,363,418
2014	2,295,454	7,121,096	1,276,866	9,548,850
2015	1,853,676	6,612,424	1,355,133	9,764,947
2016	1,910,477	5,528,946	1,248,517	7,924,787

Table 4: Inputs and outputs data of all DMU_s in 2017

Company	Fixed Assets	Cost of goods sold	Operating costs	Net sales	Net profits	Operating profit
A	1,685,963.90	5,458,073.04	1,328,062.56	7,787,165.42	898,571.13	1,119,514.35
B	8,276,456.74	3,173,383.20	1,125,406.69	4,671,239.04	711,194.13	736,011.19
C	895,353.32	4,770,331.45	529,771.77	5,687,218.04	366,951.03	437,892.40
D	202,773.07	3,262,600.72	592,196.17	3,969,420.53	156,268.90	194,096.28
E	107,026.31	1,991,256.22	129,892.69	2,187,819.01	77,099.39	84,327.45
F	343,824.05	5,616,309.67	318,580.84	5,883,841.46	42,496.76	52,313.94
G	7,996.72	381,027.75	65,632.55	461,389.60	12,934.22	16,429.11
H	41,678.48	1,902,502.95	64,176.59	1,983,763.92	22,869.33	27,362.72
I	38,872.59	1,858,105.71	70,642.69	1,948,927.11	21,974.00	24,062.58
K	3,458.66	684,922.27	188,073.55	906,731.96	43,991.94	50,259.14
N	37,166.07	2,043,969.49	58,719.15	2,127,340.18	29,031.92	33,935.78

Table 5: Inputs and outputs data of all DMU_s in 2018

Company	Fixed Assets	Cost of goods sold	Operating costs	Net sales	Net profits	Operating profit
A	1,545,418.09	5,075,411.34	1,352,662.83	7,232,792.69	740,254.75	926,069.79
B	7,625,272.64	2,821,149.52	1,208,493.72	4,320,868.44	727,436.45	769,271.25
C	1,083,730.40	4,517,465.95	590,576.54	5,483,607.79	401,330.76	475,474.11
D	207,478.12	3,135,209.31	602,198.50	3,747,812.28	117,641.82	144,764.92
E	70,160.26	1,937,956.48	118,505.13	2,113,179.50	70,160.84	74,911.50
F	430,583.44	7,382,882.89	536,768.63	7,716,047.30	41,852.48	51,236.70
G	6,545.77	343,641.55	56,991.30	410,420.12	9,649.57	12,546.64
H	37,782.09	1,782,638.32	69,989.40	1,860,623.01	19,980.84	23,313.15
I	36,493.75	1,622,388.64	69,521.73	1,706,539.05	20,017.98	20,720.02
K	1,636.32	673,631.40	202,180.74	894,452.32	37,039.20	41,643.87
N	39,446.23	1,892,235.76	63,977.69	1,975,691.83	28,427.04	32,268.06

3.4. Accuracy checking

Evaluating the results of the forecasts is very important. The forecasting accuracy not only reflects choosing right method but also directly affects to the results of decision. In this study, The MAPE (Means absolute percentage error) was used to evaluate the accuracy of forecasting and shown as follows (Table 6).

Table 6: Average MAPE error of DMU_S

Company	Fixed Assets	Cost of goods sold	Operating costs	Net sales	Net profits	Operating profit	Average MAPE of DMUs
A	4.36	4.87	3.71	4.02	17.88	12.17	7.84
C	2.48	1.05	8.41	2.32	14.30	15.14	7.28
D	8.88	0.70	6.63	0.66	4.61	4.90	4.40
E	4.73	4.45	3.75	5.11	21.41	21.47	10.15
F	24.93	4.73	5.39	4.17	4.66	5.59	7.28
G	53.28	1.26	14.29	1.80	101.01	104.12	45.96
H	4.10	4.59	3.34	4.69	14.97	14.69	7.73
I	0.15	4.58	4.70	4.29	8.43	8.49	4.40
K	12.75	2.79	4.48	2.80	2.38	4.06	4.88
N	37.71	0.98	2.35	1.44	11.15	5.94	9.93

Table 6 indicated that the forecasting value of DMU_s are good because most of MAPE of DMU less than 10% and the MAPE average of all thirty commercial banks is 10.48% (less than 20%) which confirm GM (1, 1) model suitable in this case study. Therefore, this means the results in Tables 5 and 6 have a good reliability.

3.5. DEA model choosing

The standard of typical DEA models cannot be utilized with non-positive information. Lately, a horde of models has been proposed to manage negative collected information. Nevertheless, almost all these models assess the quantity of DMUs as efficiency and allocate to them an effectiveness measure of unity, yet make no mention of the necessities of one unit over the others. In this paper, the Super-SBM is utilized to demonstrate that a proficiency positioning can be accommodated each productive unit in contrast with different DMUs.

3.6. Pearson correlation

DEA expects that the input and output factors must be metis tonicity. Prior to the procedure of DEA analysis, we have to ensure the connection between input and output factors and tonicity. Therefore, in this paper, we employ Pearson correlation analysis to see if our data fits the assumption of DEA. Tables 7 to 11 show that all of correlation coefficient between input and output variables are high than 0.6, which exhibits a highly positive correlation and well complies with the prerequisite condition of the DEA model.

3.7. Analysis before alliance

Here, we run the software of Super-SBM-I-V by choosing the realistic data of 2016 to rank the companies' effectiveness before alliances. The empirical results are obtained in the below Table 12.

Table 7: Correlation of input and output data in 2012

Pearson correlation	Input factors			Output factors		
	Fixed Assets	Cost of goods sold	Operating costs	Net sales	Net profits	Operating profit
Fixed Assets	1	0.09395	0.26897	0.16311	0.29144	0.25233
Cost of goods sold	0.09395	1	0.79538	0.97511	0.75289	0.75831
Operating costs	0.26897	0.79538	1	0.90450	0.95828	0.96219
Net sales	0.16311	0.97511	0.90450	1	0.87804	0.88236
Net profits	0.29144	0.75289	0.95828	0.87804	1	0.99866
operating profit	0.25233	0.75831	0.96219	0.88236	0.99866	1

Table 8: Correlation of input and output data in 2013

Pearson correlation	Input factors			Output factors		
	Fixed Assets	Cost of goods sold	Operating costs	Net sales	Net profits	Operating profit
Fixed Assets	1	0.43838	0.60034	0.43634	0.29447	0.23822
Cost of goods sold	0.43838	1	0.81097	0.97730	0.74020	0.72800
Operating costs	0.60034	0.81097	1	0.90132	0.90766	0.88905
Net sales	0.43634	0.97730	0.90132	1	0.86282	0.85262
Net profits	0.29447	0.74020	0.90766	0.86282	1	0.99815
operating profit	0.23822	0.72800	0.88905	0.85262	0.99815	1

Table 9: Correlation of input and output data in 2014

Pearson correlation	Input factors			Output factors		
	Fixed Assets	Cost of goods sold	Operating costs	Net sales	Net profits	Operating profit
Fixed Assets	1	0.38587	0.57252	0.43958	0.63379	0.49251
Cost of goods sold	0.38587	1	0.81383	0.98803	0.82596	0.84110
Operating costs	0.57252	0.81383	1	0.89337	0.99430	0.98927
Net sales	0.43958	0.98803	0.89337	1	0.90032	0.91271
Net profits	0.63379	0.82596	0.99430	0.90032	1	0.98430
operating profit	0.49251	0.84110	0.98927	0.91271	0.98430	1

Table 10: Correlation of input and output data in 2015

Pearson correlation	Input factors			Output factors		
	Fixed Assets	Cost of goods sold	Operating costs	Net sales	Net profits	Operating profit
Fixed Assets	1	0.31576	0.68236	0.39465	0.47405	0.39970
Cost of goods sold	0.31576	1	0.75479	0.97607	0.78617	0.78974
Operating costs	0.68236	0.75479	1	0.86743	0.94363	0.91982
Net sales	0.39465	0.97607	0.86743	1	0.89980	0.90063
Net profits	0.47405	0.78617	0.94363	0.89980	1	0.99655
operating profit	0.39970	0.78974	0.91982	0.90063	0.99655	1

Table 11: Correlation of input and output data in 2016

Pearson correlation	Input factors			Output factors		
	Fixed Assets	Cost of goods sold	Operating costs	Net sales	Net profits	Operating profit
Fixed Assets	1	0.31838	0.65085	0.40448	0.55128	0.48808
Cost of goods sold	0.31838	1	0.73151	0.97624	0.69616	0.70380
Operating costs	0.65085	0.73151	1	0.85443	0.94726	0.93483
Net sales	0.40448	0.97624	0.85443	1	0.83111	0.83669
Net profits	0.55128	0.69616	0.94726	0.83111	1	0.99723
operating profit	0.48808	0.70380	0.93483	0.83669	0.99723	1

3.8. Analysis after alliance

Here, company E is chosen as target Company for alliance considering to the outcome of data ranking of 2016 before strategic alliance by reason of couple of reasons. Firstly, company E acquired the point less than 1 all of the period from 2012 - 2016, implying that they did not have good business performance. Subsequently, they should boldly develop their effectiveness by alliance model. Secondly, company E is in major position in the fertilizer industry. To implement our empirical research, we combine E with the rest of DMUs to reach 21 virtual alliances.

Table 12: Efficiency, ranking before strategic alliances

Rank	DMU	Score
1	G	1.875656
2	K	1.703822
3	F	1.377278
4	N	1.321511
5	D	1.268671
6	C	1.213142
7	A	1
8	I	0.94212
9	E	0.937486
10	H	0.86823
11	B	0.612298

Finally, we use the software of DEA-Solver for calculation of Super-SBM-I-V model for 21 DMUs. Table shows the score and ranking results of virtual alliance in 2018 (Table 13).

Table 13: Performance ranking of virtual alliance

Rank	DMU	Score	Group
1	K	4.44656	
2	G	1.887691	
3	E + F	1.675027	1
4	N	1.189458	
5	E + D	1.178774	1
6	B	1.127153	
7	E + K	1.11175	2
8	A	1.098635	
9	E + N	1.090146	2
10	E	1.076125	
11	E + C	1.053355	2
12	C	1.012596	
13	D	1.006937	
14	E + A	1	2
15	E + G	0.991406	2
16	E + I	0.976105	3
17	E + H	0.967737	3
18	I	0.932377	
19	H	0.918227	
20	F	0.902863	
21	E + B	0.681111	3

3.9. Summary

In this examination, enterprise E is established as the objective enterprise which was positioned as the ten in comparison to the other 11 DMUs in 2016.The Southern Fertilizer JSC (SFG) takes a hand in manufacturing, sale of fertilizer and other chemical products. The Company's main products include Nitrogen-Phosphorous-Potassium (NPK) fertilizer, organic NPK fertilizer, solid and liquid Yogen fertilizer, Phosphorous fertilizer, sulfuric acid and agricultural organic minerals among others. The Southern Fertilizer JSC looks for strategic alliances. As indicated by the positioning of virtual cooperation, the examinations of observational outcomes split into three gatherings and translate as underneath:

- **Group 1:** The companies, which acquires brighter outcome after strategic alliance and also put their partnership more effectively, are the first prioritized candidate. Both corporation F and D helped the E to develop the result into a higher level after strategic alliance, which can be observed in Table 14.

Table 14: The first priority in alliance strategy

Rank	DMU	Score	Group
3	E+F	1.675027	1
5	E+D	1.178774	1

- **Group 2**: The DMU which increases performance after strategic alliance while other DMU gets worst is the second priority. Total 05 companies in this group are shown in Table 15.

Table 15: The second priority in alliance strategy

Rank	DMU	Score	Group
7	E + K	1.11175	2
9	E + N	1.090146	2
11	E + C	1.053355	2
14	E + A	1	2
15	E + G	0.991406	2

- **Group 3:** The DMU which becomes worse and worse after strategic alliances are not suggested in this study. It is unnecessary to put in any effort for partnership because no advantages between both candidates and target candidates. Table 16 presented 3 companies in the group as below

Table 16: The third priority in alliance strategy

Rank	DMU	Score	Group
16	E + I	0.976105	3
17	E + H	0.967737	3
21	E + B	0.681111	3

The importance of strategic alliance has been consistently emphasized as the key factors of business survival in the era of globalization. It helps companies to reduce risk and easily penetrate into the market. However, it is a big challenge to have a successful strategic alliance. Application of a strategic alliance can give rise to less than competitiveness or cause large enterprises to become even larger and small enterprises even smaller.

4. Research conclusion and further study

4.1. Research conclusion

At this moment, more and more competition dramatically arises in fertilizer industry. According to the Viet Nam Fertilizer Association, the domestic fertilizer industry has experienced a growth in output, but lacking of competitive ability. The industry still continues to widely apply the usage of old-fashioned production technology while the world's fertilizer industry uses many modern technologies to reduce production costs. In long term, local fertilizer factories will lose their market shares or even have to dissolve if they do not embrace new creation advancement in technology. Although the industry counts around 600 companies but most of them are small-medium sized. Products made in Vietnam are low-to-medium quality. Supplementary to this, like any existing market, one of the essential challenges is operating the management of the supply chain, in-depth understanding the import requirements and ensuring that the product can be delivered to the customer and/or consumer. Input/ output factors fluctuate in different periods, which make "business future" in uncertain success. Therefore, in this research, we propose a new methodology which combines the GM (1, 1) model and DEA model to find the right alliance partners for Target Company under several inputs and outputs.

Many related subjects of strategic alliance have been already done research by many scholars and experts. However, this study provides firms with a method to limit the possibilities of risks, creates the mode of penetration. But how strategic alliance opens up for firms to be roaring successful is the enormous challenge.

This research concentrates on the connection between key collusion and firms' execution of Vietnamese Fertilizer by using GM (1, 1) model and DEA model. This study reaches some conclusions through a series of literature reviews and empirical results.

1. The GM(1, 1) model helps the enterprises to predict what will happen in the future regarding particular elements: fixed assets, cost of goods sold, operating costs, net profits, operating profit ,which are important to the firm's efficiency in doing business based on the realistic data and information in the past time. However, there are always existent errors in predicting processes, thus the MAPE is utilized to ensure whatever collection of inputs or outputs is almost precise or not. In this examination, the range of MAPE values from 2% to 20%, which guarantee that GM (1, 1) delivers high accurateness.

2. This study shows that the DEA model is based on the resource-based theory. The Super-SBM model was used to assess the11 firms separately and calculate the operational performance of 21 simulated decision making units for strategic alliances. Thanks to this methodology, we can simply divide 11 candidates into three groups.

In this study, company E, among famous fertilizer companies in Vietnam, is an objective company for strategic alliance with the others 10 firms. In chapter 4, we observe the two companies (Table 14) which are the best candidates because profits are generated for both sides: target company E and 2 candidate companies due to the effective alliance. This fact led to the outstanding efforts from both: collaborative innovation agreement and renewal products. The second priority is a group of companies with five companies and Target Company should carefully consider when implementing alliance because they can get the risk after strategic alliances. The third group includes companies: E, H and B, which are unnecessarily to be cared because there is no advantage for two alliances.

4.2. Further study

Although the paper shows that GM (1, 1) is a very flexible and easy model to predict what would happen in the future business. Also, DEA is an efficient tool to measure the firms' performance. However, we still cannot deny some restrictions about these two methods for further studies.

- More variables of inputs/ outputs can be discussed carefully and more difference can be assessed in the future research to make sure that factors are important to the industry and useful to evaluate the firms' performance.
- Different DEA models can also be tested to find out some more changes and important issues.
- Other industries can be assessed by this proposed model in the future research.

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References

Chan SH, Kensinger JW, Keown AJ, and Martin JD (1997). Do strategic alliances create value?. Journal of Financial Economics, 46(2): 199-221.

Deng JL (1982). Control problems of grey systems. Systems and Control Letters, 1(5): 288-294.

Glaister KW and Buckley PJ (1996). Strategic motives for international alliance formation. Journal of Management Studies, 33(3): 301-332.

Nguyen NT and Tran TT (2015). Mathematical development and evaluation of forecasting models for accuracy of inflation in developing countries: A case of Vietnam. Discrete Dynamics in Nature and Society, 2015: Article ID 858157, 14 pages. https://doi.org/10.1155/2015/858157

Nguyen NT and Tran TT (2017). A novel integration of DEA, GM (1, 1) and neural network in strategic alliance for the Indian electricity organizations. The Journal of Grey System, 29(2): 80-102.

Tone K (2001). A slacks-based measure of efficiency in data envelopment analysis. European Journal of Operational Research, 130(3), 498-509.

Wang CN, Nguyen NT, and Tran TT (2015). Integrated DEA models and grey system theory to evaluate past-to-future performance: A case of Indian electricity industry. The Scientific World Journal, 2015: Article ID 638710, 17 pages. https://doi.org/10.1155/2015/638710