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AN APPLICATION OF GREY SYSTEM THEORY AND DEA IN STRATEGIC ALLIANCE IN VIETNAMESE AGRICULTURAL INDUSTRY

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ABSTRACT. Collaboration is at the heart of every business success [1]. Indeed, every aspect of a business is dependent on a partnership one way or another. However, successful partnerships require a lot of factors and efforts from both sides in order to assure the necessary cooperation needed to harness the respective potency of each partner ([2]; [3]; [4]). Therefore, this study aims to develop tools which are Grey Theory and DEA models generate the effectiveness of enterprises in Vietnamese agricultural industry then offer an effective way to figure out the most suitable strategic partners. The most influenced enterprises are selected to collect realistic data from financial reports of Vietnam issued stock market in four consecutive financial years. The targeted decision making unit (DMU) has some potential partner for collaboration in the future, but they are also advised to stay away with some DMUs, which may make them even weaker after doing alliance. Although this research is specifically applied to the fertilizer industry, the proposed method could also be applied to other manufacturing industries.

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I. INTRODUCTION

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 ([5]; [6]). 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 ([7]; [8]). 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 [9]. We would recommend finding the alliance partners for companies to solve those existing problems by combining Data Envelopment Analysis (DEA) and 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 evaluatethe performance in firm's efficiency ranking [10].

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.

II. RESEACH METHODOLOGY

2.1 Grey Forecasting Model and Data Envelopment Analysis

In Grey System Theory, GM (n, m) denotes a Grey model, where n is the order of the difference equation and m is the number of variables ([11]; [12]). Although various existing types of Grey models can be applied for forecasting, most of researchers, lecturers have paid focused on GM (1, 1) models in their prediction method due to its computational efficiency ([13]; [14]). It should be noted that in real time applications, with the complex data sets, the reduction in the computing time is even more important than the rest of parameters ([15]; [16]; [17]; [18]).

GM (1, 1) is applied with the purpose of a forecasting for a series of time. And it can only been applied in non-negative data sequences, in this analysis, future values of the original data points can be predicted by Grey model because they are positive.

During recent years, some models have been presented to solve negative data in DEA models. However, they do not discriminate between efficient DMUs and only evaluate them as being efficient. In this part, we propose a model by which we discriminate between such DMUs it is "Slacks – based measure of efficiency" (SMB) introduced by Tone [19]. Then, we extend the "Slack – based measure of supper – efficiency" (Super – SBM) for DEA model with positive and negative inputs and outputs. In this model with n DMUs with the input and output matrices $X=\left(x_{ij}\right)\in R^{m\times n}$ and $Y=\left(Y_{ij}\right)\in R^{s\times n}$, respectively. λ is a non-negative vector in R^n. The vectors $S^-\in R^m$ and $S^+\in R^s$ indicate the input excess and output shortfall respectively. SBM model in fractional form is as follows [19]:

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

$$\text{s.t } x_0=X\lambda+s^-,\ y_0=Y\lambda-s^+,\ \lambda\geq 0,\ s^-\geq 0,\ s^+\geq 0.$$

Let an optimal solution for SBM be $(p^*,\lambda^*,s^{-*},s^{+*})$. *A* DMU (x_0,y_0) is SBM-efficient, if $p^*=1$. This condition is equivalent to $S^{-*}=0$ and $S^{+*}=0$, no input excesses and no output shortfalls in any optimal solution. SBM is non-radial and deals with input/output slacks directly. The SBM returns and efficiency measure between 0 and 1.

The top onehave the full effective status indicated by unity. According to super-SBM model by Tone [20], assuming that the DMU (x_0,y_0) is SBM-efficient, $p^*=1$, super-SBM model is as follows:

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

$$\text{s.t } \bar{x} \geq \sum_{j=1,\neq 0}^{n} \lambda_j x_j,\ \bar{y} \leq \sum_{j=1,\neq 0}^{n} \lambda_j x_j,\ \bar{y} \geq x_0 \text{ and } \bar{y} \leq y_0,\ \bar{y}\ \bar{y} \geq y_0, \lambda \geq 0.$$

Comparable to other DEA models, determine how to deal with negative outputs in model efficiency evaluation is fairly important [21]. But the properly role of negative data is effectiveness measurement, therefore DEA-Solver pro 4.1 Manuel had new change as below

Let us suppose $y_{ro} \leq 0$. it is defined $\bar{y}_r^+$ and y_{-r}^+ by

$$\bar{y}_r^+ = \max_{j=1,\ldots,n} \left\{ y_{rj} \middle| y_{rj} > 0 \right\},$$

$$\bar{y}_r^+ = \min_{j=1,\ldots,n} \left\{ y_{rj} \middle| y_{rj} > 0 \right\}.$$

(1) $\bar{y}_r^+ = y_{-r}^+ = 1$, the term is replaced by $s_r^+ / \dfrac{y_{-r}^+ \left(\bar{y}_r^+ - y_{-r}^+ \right)}{\bar{y}_r^+ - y_{r0}}$

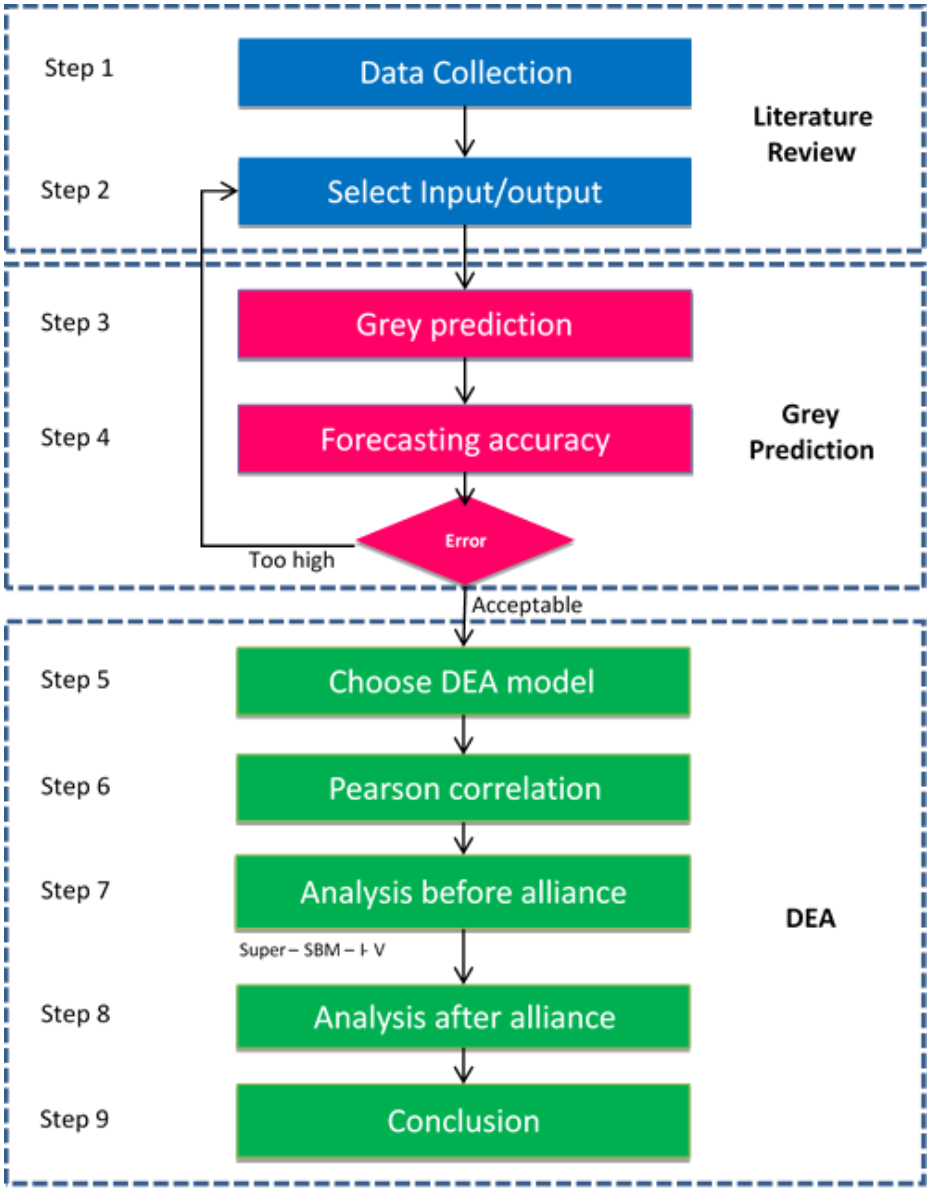
$$s_r^+ / \frac{\left(y_{-r}^+ \right)^2}{B\left(\bar{y}_r^+ - y_{r0} \right)},$$

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

2.2 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 Figure 1 as below:

FIGURE 1: **STUDY DEVELOPMENT**



III. APPLICABLE CASE RESULT AND ANALYSIS

3.1 Data Collection

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. The companies are listed in Table 1.

TABLE 1: **COMPANIES LIST**

Number order	Code	Companies
1	A	Petrovietnam Fertilizer and Chemicals
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
9	I	South-East PetroVietnam Fertilizer & Chemicals
10	K	Van Dien Fused Magnesium Phosphate
11	N	South-West PetroVietnam Fertilizer and

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: **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

Sources: Financial statements of companies

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 2, we take the total deposits of DMU_1 as an example to explain how to calculation. Other variables are calculated in the same way.

In this research, we use 5 periods of data (2012-2016) to forecast the input and output variables value in 2017 and 2018. Here, we select the fixed assets of company A as example to calculate in detail the procedure as following (Table 3 and Table 4).

TABLE 3: **INPUTS AND OUTPUTS DATA OF ALL DMUs 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

Source: Calculating by author

TABLE 4: **INPUTS AND OUTPUTS DATA OF ALL DMUS 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

Source: Calculating by author

3.2 Evaluating Process

Table 5 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 table 5 have a good reliability.

TABLE 5: **AVERAGE MAPE ERROR OF DMUs**

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

Source: Calculating by author

3.3 Alliance Setting-up Stages

DEA expects that the input and output factors must be metis tonicity ([22]; [23]). Prior to the procedure of DEA analysis, we have to ensure the connection between input and output factors and tonicity ([24]; [25]; [26]; [27]; [28]). Therefore, in this paper, we employ Pearson correlation analysis to see if our data fits the assumption of DEA. 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.

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.

TABLE 6: **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

Source: Calculating by author

Here, company Eis 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.

Finally, we use the software of DEA-Solver for calculation of Super-SBM-I-V model for 21 DMUs. Table 7 shows the score and ranking results of virtual alliance in 2018.

TABLE 7: **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

Source: Calculating by author

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:

First, the companies, which acquires brighter outcome after strategic alliance and also put their partnership more effectively, are the first prioritized candidate. Both corporationF and D helped the E to develop the result into a higher level after strategic alliance, which can be observed in Table 8.

TABLE 8: **THE FIRST PRIORITY IN ALLIANCE STRATEGY**

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

Source: Calculating by author

Second, the DMU which increases performance after strategic alliance while other DMU gets worst is the second priority. Total five companies in this group are shown in Table 9.

TABLE 9: **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

Source: Calculating by author

Thirdly, the DMUs which become 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 10 presented 3 companies in the group as below

TABLE 10: **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

Source: Calculating by author

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.

IV. Recommendations and Conclusions

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 around600 companiesbut 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 makes "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 tolimit 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 alwaysexistent 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%, whichguarantee 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 21simulated 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. We observe the two companies 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 factled 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 & B, which are unnecessarily to be cared because there is no advantage for two alliances.

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APENDIX

INPUT AND OUTPUT FACTORS OF TARGET DMUs IN 2012

Companies	Fix Assets	Cost of goods sold	Operating cost	Net sales	Net profits	Operating profit
A	2,371,392	8,997,366	1,318,093	13,321,852	3,067,647	3,574,740
B	12,436,315	2,967,940	410,051	4,076,182	736,671	730,296
C	425,142	6,869,767	366,813	7,422,968	158,867	197,199
D	219,612	3,495,007	502,080	4,494,851	394,091	509,684
E	563,219	2,544,853	202,360	2,840,282	98,79	119,108
F	31,870	2,302,833	92,291	2,391,848	2,038	2,382
G	19,403	551,271	142,841	770,310	63,697	79,316
H	65,240	2,347,980	43,250	2,440,980	43,649	53,177
I	30,373	3,546,253	64,083	3,649,449	40,376	50,015
K	42,682	659,152	153,577	875,652	68,800	90,547
N	26,853	3,087,222	43,145	3,178,573	53,324	66,068

INPUT AND OUTPUT FACTORS OF TARGET DMUs IN 2013

Companies	Fix Assets	Cost of goods sold	Operating cost	Net sales	Net profits	Operating profit
A	2,368,444	7,011,191	1,194,639	10,363,418	2,179,191	2,586,225
B	11,209,745	5,065,121	830,907	6,263,118	531,710	495,135
C	466,150	5,895,935	379,110	6,585,110	261,684	318,832
D	173,294	3,668,449	531,103	4,768,477	446,820	580,370
E	537,410	2,343,321	185,888	2,638,857	115,398	140,514
F	57,542	1,861,569	57,992	1,939,946	21,348	25,760
G	17,316	579,585	112,844	735,370	40,451	46,074
H	61,656	2,447,841	48,183	2,542,168	36,380	48,519
I	44,993	3,218,254	76,630	3,336,440	31,409	42,486
K	76,255	731,509	145,336	959,652	80,543	105,472
N	23,564	2,811,818	44,765	2,890,025	30,394	40,606

INPUT AND OUTPUT FACTORS OF TARGET DMUs IN 2014

Companies	Fix Assets	Cost of goods sold	Operating cost	Net sales	Net profits	Operating profit
A	2,295,454	7,121,096	1,276,866	9,548,850	1,134,458	1,557,395
B	11,004,157	4,586,281	840,164	6,044,143	820,887	798,534
C	426,608	5,696,732	336,303	6,377,225	288,549	356,146
D	207,529	3,856,523	587,436	4,985,068	438,723	553,003
E	519,572	1,962,180	180,825	2,237,982	100,898	115,315
F	299,256	2,503,864	72,899	2,655,043	64,419	84,372
G	15,787	533,179	106,828	682,933	36,468	44,322
H	56,177	2,252,616	46,832	2,348,012	40,198	51,855
I	52,297	2,712,487	69,519	2,821,395	29,570	39,741
K	19,131	713,894	144,563	929,122	85,211	87,618
N	38,205	2,470,498	42,643	2,548,198	31,887	40,914

INPUT AND OUTPUT FACTORS OF TARGET DMUs IN 2015

Companies	Fix Assets	Cost of goods sold	Operating cost	Net sales	Net profits	Operating profit
A	1,853,676	6,612,424	1,355,133	9,764,947	1,522,461	1,855,678
B	9,848,606	3,950,628	1,145,494	5,582,239	712,460	712,527
C	652,335	5,278,378	425,014	6,037,884	280,234	337,002
D	191,584	3,673,450	590,926	4,651,235	306,285	391,334
E	159,206	2,118,099	141,198	2,337,950	86,046	99,837
F	171,237	3,319,407	113,278	3,516,965	77,278	93,609
G	11,508	427,693	83,221	532,533	17,638	21,653
H	50,728	2,369,227	51,944	2,452,136	27,958	34,392
I	50,050	2,562,297	78,202	2,673,131	27,286	33,264
K	17,974	722,029	164,166	956,801	65,183	81,636
N	34,790	2,519,510	46,905	2,600,069	32,042	37,566

INPUT AND OUTPUT FACTORS OF TARGET DMUs IN 2016

Companies	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

FORECASTING RESULTS FOR DMUs FROM 2013 TO 2016

DMUs	Fixed Assets	Cost of goods sold	Operating costs	Net sales	Net profits	Operating profit	Years
A	2,388,126.86	7,299,812.99	1,234,054.81	10,463,402.51	1,950,911.08	2,390,966.26	2013
	2,189,047.14	6,788,028.18	1,256,913.73	9,718,506.95	1,607,186.30	1,977,823.36	2014
	2,006,563.15	6,312,124.25	1,280,196.08	9,026,640.92	1,324,021.28	1,636,068.77	2015
	1,839,291.45	5,869,585.61	1,303,909.69	8,384,029.22	1,090,746.21	1,353,367.08	2016
B	11,486,844.53	5,080,520.13	846,388.72	6,380,816.98	649,771.36	616,742.81	2013
	10,583,070.02	4,516,601.37	908,876.29	5,902,217.90	664,610.90	644,613.17	2014
	9,750,403.67	4,015,275.49	975,977.22	5,459,516.59	679,789.36	673,742.99	2015
	8,983,250.76	3,569,594.91	1,048,032.10	5,050,020.50	695,314.46	704,189.16	2016
C	417,145.17	5,931,482.13	343,035.68	6,580,120.63	256,466.57	315,013.78	2013
	504,910.07	5,617,066.41	382,407.74	6,344,543.24	280,494.99	342,049.55	2014
	611,140.18	5,319,317.23	426,298.75	6,117,399.84	306,774.63	371,405.63	2015
	739,720.48	5,037,351.12	475,227.36	5,898,388.48	335,516.41	403,281.17	2016
D	184,995.92	3,826,074.99	553,820.83	4,994,870.56	486,537.02	627,238.47	2013

	189,288.48	3,676,682.18	563,175.00	4,716,012.59	366,273.13	467,820.04	2014
	193,680.64	3,533,122.56	572,687.15	4,452,722.96	275,736.48	348,919.26	2015
	198,174.71	3,395,168.36	582,359.97	4,204,132.48	207,578.99	260,238.22	2016
E	579,545.95	2,219,522.99	187,488.58	2,513,688.16	112,428.28	135,410.05	2013
	379,916.84	2,160,113.26	171,051.66	2,427,931.32	102,310.31	120,290.25	2014
	249,051.53	2,102,293.74	156,055.74	2,345,100.16	93,102.91	106,858.71	2015
	163,263.79	2,046,021.87	142,374.50	2,265,094.85	84,724.13	94,926.93	2016
F	139,782.22	1,880,837.64	39,532.09	1,989,414.54	45,174.60	56,854.20	2013
	175,054.39	2,472,442.74	66,606.59	2,608,910.65	44,489.72	55,683.47	2014
	219,227.03	3,250,133.33	112,223.73	3,421,315.50	43,815.23	54,536.84	2015
	274,546.03	4,272,441.36	189,082.87	4,486,700.12	43,150.96	53,413.83	2016
G	17,812.17	575,917.57	115,441.56	736,926.97	41,751.20	48,301.58	2013
	14,580.27	519,408.91	100,242.40	655,519.01	31,148.48	36,887.10	2014
	11,934.78	468,444.85	87,044.38	583,104.14	23,238.31	28,170.06	2015
	9,769.29	422,481.34	75,584.03	518,688.91	17,336.94	21,513.00	2016
H	61,718.53	2,468,162.45	45,368.49	2,563,400.06	39,247.53	51,926.86	2013
	55,948.66	2,312,659.2	49,477.75	2,404,278.59	34,290.40	44,241.91	2014

		1					
	50,718.19	2,166,953.24	53,959.20	2,255,034.49	29,959.38	37,694.30	2015
	45,976.70	2,030,427.28	58,846.56	2,115,054.62	26,175.39	32,115.70	2016
I	50,042.98	3,196,925.43	75,310.21	3,315,225.38	31,905.42	43,767.33	2013
	46,980.56	2,791,367.29	74,115.19	2,902,910.81	29,065.35	37,687.57	2014
	44,105.56	2,437,257.76	72,939.13	2,541,875.81	26,478.10	32,452.35	2015
	41,406.49	2,128,070.15	71,781.73	2,225,742.73	24,121.15	27,944.36	2016
K	69,034.53	732,010.20	140,824.91	957,559.67	87,542.56	106,627.95	2013
	32,660.79	719,943.09	151,388.03	944,591.68	73,706.82	88,350.10	2014
	15,452.08	708,074.91	162,743.48	931,799.31	62,057.77	73,205.39	2015
	7,310.51	696,402.38	174,950.69	919,180.19	52,249.80	60,656.74	2016
N	29,289.43	2,782,729.96	41,666.27	2,859,617.14	31,582.90	41,514.28	2013
	31,086.36	2,576,154.47	45,397.65	2,655,768.12	30,924.88	39,474.13	2014
	32,993.53	2,384,914.07	49,463.20	2,466,450.57	30,280.56	37,534.24	2015
	35,017.71	2,207,870.38	53,892.83	2,290,628.60	29,649.67	35,689.69	2016

MAPE CALCULATING FOR DMUs FROM 2013 TO 2016

DMUs	Fixed Assets	Cost of goods sold	Operating costs	Net sales	Net profits	Operating profit	Year
A	0.831046126	4.116590049	3.299390862	0.9647832	10.475444	7.549951686	2013
	4.635547643	4.677198847	1.562597015	1.7767265	41.669969	26.99561505	2014
	8.247781831	4.541447342	5.529857586	7.5607792	13.034141	11.83444692	2015
	3.726061535	6.161022481	4.436678796	5.7950103	6.3556301	2.29920229	2016
B	2.471952086	0.304022899	1.863231306	1.8792393	22.204088	24.56053657	2013
	3.82661733	1.519305739	8.178437474	2.3481426	19.037468	19.27542536	2014
	0.997119035	1.636385084	14.7985746	2.1984442	4.5856106	5.443163906	2015
	2.61404069	0.720707464	8.795346636	2.8481595	11.367918	11.29747875	2016
C	10.51267363	0.60290911	9.515527255	0.0757674	1.9937899	1.197563902	2013
	18.35457038	1.398443681	13.70928726	0.5124762	2.7912122	3.95805446	2014
	6.314979658	0.775602403	0.302283726	1.3169487	9.4708804	10.20873198	2015
	0.324004609	0.029151344	3.000373581	0.7492704	4.1655485	4.223307378	2016
D	6.75264103	4.296802082	4.277481516	4.747712	8.8888184	8.075619689	2013
	8.789383771	4.663289108	4.129982405	5.3972264	16.513808	15.40370719	2014
	1.094371267	3.82004489	3.086485535	4.2679427	9.9738885	10.83849993	2015
	2.283723542	5.001840549	3.51078815	6.0401502	50.256233	51.57800809	2016
E	7.840559703	5.283015274	0.861046281	4.7432974	2.5734587	3.632341309	2013
	26.87888539	10.08741602	5.404861424	8.4875268	1.3997435	4.314484942	2014
	56.43350477	0.746200265	10.52263082	0.3058301	8.201324	7.033176797	2015
	8.56315681	2.806428744	4.772587155	3.1332679	6.4741546	7.397391298	2016
F	142.9220754	1.035075386	31.83182459	2.5499955	111.61045	120.707288	2013
	41.50346437	1.25491082	8.631675732	1.7375368	30.936956	34.00243411	2014
	28.02549984	2.086929224	0.93069136	2.7196603	43.301808	41.73974439	2015
	0.686175888	0.645496541	15.75161309	0.1906421	218.19896	220.0349318	2016
G	2.865376084	0.632767883	2.30190748	0.2117258	3.2142614	4.834787255	2013
	7.643815581	2.58263864	6.164671664	4.0141558	14.586828	16.7747376	2014

	3.708543236	9.52829413	4.594251804	9.4963393	31.751415	30.09770429	2015
	2.199958954	5.631039699	0.286241911	5.0262094	10.329263	7.051216505	2016
H	0.101422786	0.830178572	5.841293482	0.8351949	7.8821559	7.023767879	2013
	0.40646951	2.665488071	5.64944064	2.3963502	14.696244	14.6814982	2014
	0.019338597	8.537542344	3.87956054	8.0379518	7.1585402	9.601931657	2015
	0.08207085	6.291236393	3.422569495	5.8982354	4.0026662	2.64214953	2016
I	11.22391796	0.662737159	1.72228776	0.6358459	1.5804908	3.015896799	2013
	10.16585478	2.908042972	6.611411841	2.8892025	1.7066201	5.167039374	2014
	11.87701298	4.879966566	6.729845073	4.9101668	2.9608697	2.440034955	2015
	17.7424437	2.717837439	2.837677776	2.7601978	3.2892842	5.621788834	2016
K	9.468852659	0.068515274	3.103902509	0.2180303	8.6904612	1.095976026	2013
	70.72182241	0.847337559	4.721148677	1.6649781	13.500811	0.835561257	2014
	14.03090946	1.932621349	0.866510581	2.6130502	4.7945484	10.32707351	2015
	56.62193163	1.065858078	0.723112981	1.2749086	17.594975	11.50545964	2016
N	24.29736247	1.034492368	6.922215208	1.0521661	3.9116337	2.236813993	2013
	18.63274851	4.27672745	6.459803005	4.2214194	3.0172939	3.519253898	2014
	5.163756206	5.342147014	5.453997959	5.1390339	5.4972881	0.084534393	2015
	10.12896285	2.50998816	4.341881054	2.3518195	5.451032	1.538273265	2016

MAPE RESULTS FOR DMUs FROM 2013 TO 2016

DMUs	Fixed Assets	Cost of goods sold	Operating costs	Net sales	Net profits	Operating profit	Average MAPE of DMUs
A	4.36010928	4.87406468	3.70713106	4.02432479	17.88379591	12.16980399	7.83653829
B	2.47743229	1.04510530	8.40889750	2.31849642	14.29877108	15.14415115	7.28214229
C	8.87655707	0.70152663	6.63186796	0.66361569	4.60535774	4.89691443	4.39597325
D	4.73002990	4.44549416	3.75118440	5.11325783	21.40818698	21.47395873	10.15368533
E	24.92902667	4.73076508	5.39028142	4.16748058	4.66217019	5.59434859	7.28214229
G	4.10442346	4.59368509	3.33676821	4.68710757	14.97044169	14.68961141	7.73033957
H	0.15232544	4.58111134	4.69821604	4.29193307	8.43490155	8.48733682	4.39597325
I	12.75230736	2.79214603	4.47530561	2.79885326	2.38431622	4.06118999	4.87735308
K	37.71087904	0.97858307	2.35366869	1.44274180	11.14519889	5.94101761	9.92868152
N	14.55570751	3.29083875	5.79447431	3.19110971	4.46931193	1.84471889	5.52436018