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Measuring the relative efficiency of firms listed on Tehran Stock Exchange

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C H R O N I C L E

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A B S T R A C T

In this study, we provide six complementary models of data envelopment analysis to analyze the financial efficiency of chosen decision-making units for firms listed on Tehran Stock Exchange. For this purpose, we consider tapered modeling, the concept of accounting costs and economic costs and divide the whole process into the two sub-processes in modeling. After the modeling process, we choose the seventeen companies and thereby, provide a new method for analyzing the financial efficiency. The proposed method seems to be more appropriate than the methods proposed in the past and it can deliver better understanding of real-world cases. Finally, we understand that how this method works for analyzing the financial efficiency of organizations.

1. Introduction

During the past few years, there have been many studies on development of data envelopment analysis (DEA) for measuring the relative efficiency of financial firms. In fact, implementation of a DEA model of constant returns to scale has been widely used in issues of financial analysis (Tarawneh, 2006; Bojnec & Latruffe, 2008; Liu, 2008; Liu et al., 2013). However, applying this model to analyze financial performance is not enough because of two reasons. First, many processes consist of some sub-processes that neglecting these sub-processes and cannot give us a realistic model. Second, the large number of zeroes for DMU is inefficient and large differences in the weights of any information are worrisome. However, in most cases, paying attention to the apparent costs and paying attention to hidden costs as well as apparent costs is more important. Hence, this paper provides six complementary DEA models to analyze the financial efficiency in order to take advantage of models. Estelle et al. (2009) applied the Monte Carlo analysis to compare different DEA models measuring efficiency in the presence of the exogenous variables in a three-stage DEA models for incorporating exogenous inputs. They found that each of these methods had its own advantages depending on situations. Rahimi and Behmanesh (2012) considered 26 active companies in poultry field in order to improve the efficiency and found that the application of neural networks

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and decision trees for analyzing were more capable than using neural networks alone. Abolfathi (2013) analyzed financial statements of listed companies in Tehran Stock Exchange with a hybrid model of data envelopment analysis (DEA) and artificial neural network (ANN). According to Tsai and Chiou (2009), integrating the ANN and decision tree models provides not only higher rate of prediction accuracy but also important decision rules compared with using the ANN model alone. Sivatha Sindhu et al. (2012) provided a Intrusion Detection System (IDS) for detecting anomalies in networks. The essential part of building lightweight IDS depends on preprocessing of network data, detecting important features and in the design of efficient learning algorithm that classify normal and anomalous patterns. Malinov et al. (2001) developed a model for the analysis and prediction of the correlation between processing (heat treatment) parameters and mechanical properties in titanium alloys by applying ANN. Hamidi Zadeh et al. (2014) analyzed financial statements of listed companies in Tehran Stock Exchange with a hybrid model of data envelopment analysis (DEA) and ANN technique.

2. The proposed study

In DEA model, the relative efficiency of unit k (E_k) is measured as follows,

$$E_k = \max \sum_{r=1}^{s} u_r Y_{rk} / \sum_{i=1}^{m} v_i X_{ij}$$

subject to

$$\sum_{r=1}^{s} u_r Y_{rj} / \sum_{i=1}^{m} v_i X_{ij} \le 1,\ j = 1, \cdots, n$$

$$\sum_{p=1}^{q} w_p Z_{pj} / \sum_{i=1}^{m} v_i X_{ij} \le 1,\ j = 1, \cdots, n \qquad \text{Model (1)}$$

$$\sum_{r=1}^{s} u_r Y_{rj} / \sum_{p=1}^{q} w_p Z_{pj} \le 1,\ j = 1, \cdots, n$$

$$u_r, v_i, w_p \ge \varepsilon, r = 1, \cdots, s.$$

where Y and X represent output and input of different units for different units. Interested readers are referred to Abolfathi (2013) and Hamidi Zadeh et al. (2014). To resolve the problems associated with large differences in weights, we use tapered model from one decision-making unit to another.

$$Max\ \beta^T (By_0)$$

subject to

$$a^T (Ax_0) = 1$$

$$-a^t (AX) + \beta^T (BY) \le 0 \qquad \text{Model (2)}$$

$$a \ge 0, \beta \ge 0$$

Model (2) can be solved after applying the matrix α, β like constant returns to scale model.

3. Methodology

Data of the research were extracted from financial statements for selected companies in Tehran Stock Exchange of the first six months of 2013. For selecting companies, first we classified sixty-two companies in terms of return on equity ratio, and then applied DEA constant returns to scale model and remove underperforming units and put the remaining units in the same group. Then again, we used the model of constant returns to scale and remove the units whose efficiencies were less than fifty percent and eventually we have got seventeen firms. We consider the whole process with two sub-processes and inputs of the research DEA model are as follows: administrative costs, general and sales (c_1), financial cost (c_3), and amortization expense (c_2). (This cost is not included in the final three models). Outputs of DEA models are operating profit (p_1) and net profit (p_2). Intermediate sizes in the second and the third as well as the fifth and the sixth models which are used, including net sales (i_1) and net other incomes (i_2). The reason for choosing these two as an intermediate measure is that the efficient management of a company is looking to gain more money from the lower cost and more profit from lower income. We have calculated the efficiency of the process with constant returns to scale model and used Lingo software for modeling.

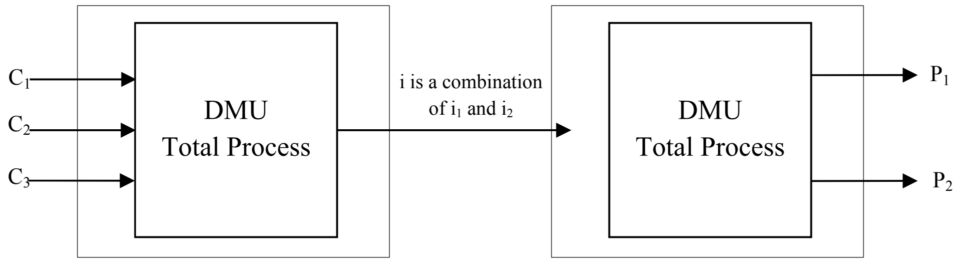

Fig. 1. Related to the second and third models

We provide the fourth model with using model (2) and thus, calculated the total efficiency of the whole process with using the ratio method of tampered. To calculate the matrices *A*, *B* in model (2), first from the previous research we consider seven cases as *A*, *B* and after trial and error, we chose a case from these seven cases where our goals include reducing the large differences in the weights of one information item to another. Independently for model six, we consider constant returns to scale DEA models for the deployment of the first and second sub-processes and then apply the matrices A, B_1 constant returns to scale model of first sub-process and applying the matrices B_1, B to the second sub-process of constant returns to scale. We have created independent tapered hybrid model and solved it with Lingo software. B_1 matrix has been calculated such as matrices *A, B*, to create the fifth model and named it tapered-communication model. Also, we established tapered model related to two sub-processes with using matrices *A, B,* B_1 and multiplied them respectively by inputs, outputs and middle-sized of two sub-processes. In this situation, creating communication model is similar to creating a communication model from the query of constant returns to scale model of the first and second sub-processes. Thus, the fifth model was created by combining tapered and communication model. Now we write the first two models related to the efficiency of the whole and other related efficiency of second sub-process in Lingo software and after calculating whole efficiency and efficiency of second sub-process, we may achieve the efficiency of first sub-process by dividing them. Table 1 is related to the inputs and outputs and intermediate sizes of the first three basic DEA models.

Table 1
Data from the first three models

DMU	Name	Depreciation expense	General administrative and selling expenses	financial cost	Operating Profit	Net Income	Net sales	Net other income
DMU_1	Torbatjam sugar	764	1140	18080	19068	19336	140902	19623
DMU_2	Iran Porcelain Clay	1235	11739	58	110727	94977	187102	8712
DMU_3	Kharg Petrochemical	17299	1261507	0	3537766	2827501	6828246	731104
DMU_4	Mobarakeh	101	2903	0	3586	4281	30237	1591
DMU_5	Lavan Petrochemical	57405	135242	0	1964832	1528469	2764910	7619
DMU_6	Soliran	122	3725	12	8080	11236	30204	3470
DMU_7	Tehran drugs	1231	15176	1096	41045	90959	242578	2193
DMU_8	Urban Baghmisheh	299	31600	11458	648139	642137	1047904	5456
DMU_9	Petrochemical Fanavaran	42214	610338	7236	2998326	3460226	4272081	1281937
DMU_{10}	Mapna	1156	18964	1420	72614	78727	397028	7523
DMU_{11}	Pars Khazar	238	6608	17319	77392	131128	662496	84891
DMU_{12}	National Development	356686	37418	127611	1349417	1194141	1386845	0
DMU_{13}	Tuka Rail	511	19194	31456	209082	156983	665237	24871
DMU_{14}	Alborz	11764	26964	0	128724	145126	148602	23488
DMU_{15}	Magsal Agri	1207	6592	2865	67284	67677	176610	3374
DMU_{16}	Pasargad	1356	12095	141025	336296	197460	348391	2169
DMU_{17}	Amir Kabir Steel	9399	15637	13610	217129	156980	730611	21238

The first model has not used the mid-sized. Table 2 consists of inputs/outputs and intermediate size for three final models but in model four, we have not intermediate size. We put matrices *A, B, B1* before Table 2.

Table 2
Summarizes the data for the fourth, fifth and sixth models

DMU	Name	C_1	C_3	M	P_1	P_2
DMU_1	Torbatjam sugar	5660	37300	145807.75	23902	57740
DMU_2	Iran Porcelain Clay	11753.5	11855	189280	134471.25	300681
DMU_3	Kharg Petrochemical	1261507	1261507	7011022	4244641.25	9192768
DMU_4	Mobarakeh	2903	2903	30634.75	4656.25	12148
DMU_5	Lavan Petrochemical	135242	135242	2766814.75	2346949.25	5021770
DMU_6	Soliran	3728	3749	31071.5	10889	30552
DMU_7	Tehran drugs	15450	17368	243126.25	63784.75	222963
DMU_8	Urban Baghmisheh	34464.5	54516	1049268	808673.25	1932413
DMU_9	Petrochemical Fanavaran	612147	624810	4592565.25	3863382.5	9918778
DMU_{10}	Mapna	19319	21804	398908.75	92295.75	230068
DMU_{11}	Pars Khazar	10937.75	41246	683718.75	110174	339648
DMU_{12}	National Development	69320.75	292640	1386845	1647952.25	3737699
DMU_{13}	Tuka Rail	27058	82106	671454.75	248327.75	523048
DMU_{14}	Alborz	26964	26964	154474	165005.5	418976
DMU_{15}	Magsal Agri	7308.25	12322	177453.5	84203.25	202638
DMU_{16}	Pasargad	47351.25	294145	348933.25	385661	731216
DMU_{17}	Amir Kabir Steel	19039.5	42857	735920.5	256374	531089

Table 3 and Table 4, respectively, resulting from the resolution of the efficiency from three primary and three final models.

Table 3
Efficiency of all models for applying to the proposed method for three primary models

DMU	Name	e Model 1	e Model 2	e_1 Model 2	e_2 Model 2	e_1 Model 3	e_2 Model 3
DMU_1	Torbatjam sugar	80.29	14.82	100	14.82	100	14.82
DMU_2	Iran Porcelain Clay	100	60	100	60	100	60.82
DMU_3	Kharg Petrochemical	100	53	100	53	100	53.25
DMU_4	Mobarakeh	54.49	15	100	15.7	100	15.74
DMU_5	Lavan Petrochemical	100	72	100	73	100	73.03
DMU_6	Soliran	84.5	32	100	39	100	39.06
DMU_7	Tehran drugs	59.82	32	74	43	76	43.22
DMU_8	Urban Baghmisheh	100	70	100	70	100	70.85
DMU_9	Petrochemical Fanavaran	90.93	48	65.9	75	100	82.94
DMU_{10}	Mapna	46.54	22	100	22	100	22.66
DMU_{11}	Pars Khazar	97.5	20	100	20	100	20.73
DMU_{12}	National Development	100	36	36	100	36	100.00
DMU_{13}	Tuka Rail	51.04	15.75	48	32	48	32.30
DMU_{14}	Alborz	47.62	30	30	100	100	100.00
DMU_{15}	Magsal Agri	50	33	76	43	76	43.79
DMU_{16}	Pasargad	100	28	28	99	28	99.21
DMU_{17}	Amir Kabir Steel	64.05	29	96	30	96	30.54

Table 4
Efficiency of all models for applying to the proposed method for three final models

DMU	Name	e Model 4	e Model 5	e_1 Model 5	e_2 Model 5	e_1 Model 6	e_2 Model 6
DMU_1	Torbatjam sugar	18.19	5.76	41.4	13.9	41.21	14.64
DMU_2	Iran Porcelain Clay	68.38	46.7	78.2	59.7	78.15	59.79
DMU_3	Kharg Petrochemical	19.63	13.8	26.5	52	27.15	50.95
DMU_4	Mobarakeh	11.27	23.8	51.6	46.1	51.58	14.62
DMU_5	Lavan Petrochemical	100	71.3	100	71.3	100	71.38
DMU_6	Soliran	21.96	40.5	40.5	100	40.55	36.25
DMU_7	Tehran drugs	35.05	17.1	69.5	24.6	69.66	33.81
DMU_8	Urban Baghmisheh	100	65.6	100	65.6	100	68.13
DMU_9	Petrochemical Fanavaran	42.68	26.2	36	72.7	36.5	79.63
DMU_{10}	Mapna	28.82	18.1	91.4	19.8	91.1	21.29
DMU_{11}	Pars Khazar	55.38	14.6	100	14.6	100	18.32
DMU_{12}	National Development	100	32	32	100	32	100
DMU_{13}	Tuka Rail	38.83	14.9	47.9	31.1	47.98	31.12
DMU_{14}	Alborz	41.85	25.8	28	92.1	28	100
DMU_{15}	Magsal Agri	49.45	30.7	75.9	40.4	75.95	42.23
DMU_{16}	Pasargad	34.26	10.9	11.7	93	11.79	93.01
DMU_{17}	Amir Kabir Steel	57.2	28.1	95.9	29.3	96.04	29.32

In Table 3, as it shown, most companies failed to reach 100% efficiency in communication model (i.e. the second model) of the second sub-process.

In addition, companies like sugar Torbatjam, despite having an acceptable efficiency in terms of DEA models in first sub-process, but were not successful in second sub-process. This means that if the company had better efficiency in the second sub-process, it could also achieve higher efficiency in the first model. Other case is about overall efficiency in the first model and overall efficiency in the second model. Their numbers are significantly different from that and it's so important that we describe it in the result. In Table 4, some decision-making units in terms of efficiency compared with the first model for efficiency of tapered models (i.e. the fourth model) are in a better position in terms of ranking. However, some decision-making units are not in terms of this point of view. Pars Khazar is an example of a company that has been in a better position and Soliran is an example of a company that has been in a worse position.

4. Conclusion and Discussion

Overall efficiency in a communication model is in fact multiplication of efficiency of the first and second sub-processes. In addition, there is no logical connection between the efficiency of constant returns to scale model of the first model and the efficiency of the communication model in the second model. With calculating the coefficient of determination with rate of 36 percent, there is not a strong correlation between the efficiency of the whole model of constant returns to scale and whole efficiency of communication model. It must be said that each of these performance represents different things. With the first model, we can identify the week companies and with the second model, we can identify weaknesses in the efficiency of first and second sub-processes. Equality answers of the second and third models together for efficiency of first and second sub-processes and equity of solutions of the fifth and sixth models of the same sub-processes indicates that for validation of answers obtained from the second and fifth model, we can use the answer of the third and sixth models and vice versa. Efficiency of second sub-process for the fifth and sixth models are 65.6 and 68.13, respectively. The second reason is that there are larger difference arises from having a great efficiency for one or both sub-processes. Another problem is that the efficiency of second sub-process in the second, third, fifth and sixth models are not suitable for some decision-making units. This is due to their lack of ability to convert the interest to income. Another case is that the overall efficiency in the fourth model (i.e. the tapered model) for decision-making unit from overall efficiency of the first model (i.e. the model of constant returns to scale) is so low. Because the matrix is applied to α, β to tapered model is like limitations and limitation make the bad answer for model.
Finally, it must be said that the use of each of these models for the analysis of financial efficiency is like that some people go to the dark room with an elephant in there and each one of them conclude one thing with touching different parts of elephant but the results for detecting the elephant is insufficient. Therefore, by putting together solutions from these models together with the skills and expertise to analyze it, we can have a better understanding of the financial efficiency.

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