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DETERMINING THE COMPARATIVE EFFICIENT UNITS OF INSURANCE INDUSTRIES THROUGH DEA

TSER-YIETH CHEN

DISCUSSION PAPER SERIES No.9704
September 1997

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Abstract

This paper employs data envelopment analysis (DEA) to measure the relative resource utilization efficiency of twenty-eight life insurance companies in Taiwan. We calculate the overall efficiency score, as well as the reference sets and dual weights of life insurance companies. The classification of reference sets, local leader and of the local economies of scale provides an operational framework that could be used to highlight the remedies for the inefficient companies. The estimated results show that nine life insurance companies are relatively efficient. The results also show that five out of these nine are foreign investor-owned. We also rated the top three life insurance companies which enjoy the highest levels of efficiency in the sample. Finally, we analyze dual weights and the reference units of the global leader and examine the local economies of scale to indicate the way to remedy the inefficient insurance companies.

Keywords: data envelopment analysis, performance evaluation, relative efficiency

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I. Introduction

In the mid-1980s, Taiwan began to open the insurance market and the first wave of nine foreign investor-owned life insurance companies entered in Taiwan's insurance market. There are Aetna, Georgia, Metropolitan, Pruco, Connecticut, American, Manufactures, Trans-America, and New York Life Insurance Company. Before that, Taiwan established seven domestic life insurance companies, Taiwan, First, Cathay, China, Nan-Shan, Kuo-Hua, and Shin-Kong Life Insurance Company. Thus, Taiwan had sixteen life insurance companies in total in 1991. In 1992, the government proclaimed a Promote Insurance Company Establishment Decree to open the insurance market further and invited domestic and foreign investors to participate in Taiwan's insurance market. They set up twelve new, investor-owned life insurance companies and there were twenty-eight life insurance companies in Taiwan in 1997. Of these, sixteen were categorized as old-established companies and the remaining twelve were newly-established ones. Meanwhile, fifteen were domestic investor-owned and thirteen foreign investor-owned. Along with the deregulation of Taiwan's life insurance market and the entrance of the foreign insurance companies in Taiwan, the life insurance market in Taiwan has become more competitive. It is definitively important to stock owners, investors, insurers, insurance company managers, and related regulators etc. to rank the overall efficiency of the individual life insurance companies and monitoring their business conditions. We can also discover the cost competition abilities of each company by investigating the content of the operating efficiency and finding out the efficiencies of adjacent competition opponents. This is an useful information to proceed a cost management of each company.

Concerning the efficiency evaluation literature in the insurance industry, parametric programming approaches have generally been concerned with the production or cost function base. Voluminous studies have focused on estimating the characteristics of the (translog) cost functions and measuring economies of scale and scope assuming all insurance companies were operating efficiently (Houston and Simon, 1970; Praetz, 1980; Pritchett and Myers, 1980; Weiss, 1986; Grace and Timme, 1992). Grace and Timme

(1992) argue that the estimated translog function represents the average behavior of firms in the sample, regression (econometric) procedures can be modified to orient the estimates to ward frontiers. In addition, some of the limited research on efficiency evaluation of insurance companies has conducted a variant of the case study or undertaken ratio analysis for parallel comparison among several insurance companies using a number of "performance indicators." (Pritchett and Myers, 1980) The main weakness of ratio analysis is that there is a lack of agreement on the relative importance of various types of inputs on outputs. When we adopt multiple measures (i.e., ratio analysis), we find that some insurance companies are better than average by certain measures, but poorer than average by others.

The most notable feature of this paper is that it uses a single input/output measure and conducts data envelopment analysis (DEA) to create a benchmark measure for the relative efficiency of twenty-eight life insurance companies in Taiwan. We take the role of resource manager and recognize that resources are scarce and we cannot afford to waste them. We then view efficiency /performance in terms of relative resource utilization efficiency which, simply put, is: how efficiently is a given life insurance company performing relative to other similar ones. As far as authors know, there is not any paper which uses the DEA method to evaluate the performance of insurance companies. This paper then extends the DEA approach to measure efficiency and apply it to insurance companies field:

II. DEA Method

The DEA method was first introduced by Charnes, Cooper and Rhodes (1978) who employed a mathematical planning model (CCR model) to create an efficiency frontier based on the concept of Pareto optimum. The basic idea of DEA is to identify the most efficient decision-making unit (DMU) among all DMUs. An efficient DMU is called a Pareto-optimal unit and is considered the standard for comparison of all other DMUs. The Pareto-optimal unit is one such that any change that makes some people better off makes others worse off. Conversely, a unit is Pareto nonoptimal if some people can be made better off without harming anyone else. The performance score of a non-optimal Pareto unit is always computed with respect to an optimal Pareto unit. Therefore, the DEA score is a relative number rather than absolute.

The idea of calculating DEA scores can be formulated as a fractional linear programming problem. We denote Y_{jn} as the n-th output of the j-th DMU and X_{jm} as the m-th input of the j-th DMU. If a DMU employs M inputs to produce N outputs, the score of j-th DMU, E_j, is a solution from the fractional linear programming problem (CCR model):

$$\underset{U_n V_m}{Max}\ E_j = \frac{\sum_{n=1}^{N} U_n Y_{jn}}{\sum_{m=1}^{M} V_m X_{jm}} \qquad m=1,2,\ldots.M \qquad n=1,2,\ldots.N$$

$$\text{s.t.} \qquad \frac{\sum_{n=1}^{N} U_n Y_{rn}}{\sum_{m=1}^{M} V_m X_{rm}} \le 1 \qquad r=1,2,\ldots j\ldots.R \quad U_n, V_m \ge 0$$

Where U_n and V_m give the weights associated with each output and input. We have generalized the usual input/output ratio measure of efficiency for a given life insurance company with fractional constraints. In the case of life insurance companies, the efficiency of a particular life insurance company is calculated by finding the ration of a weighted sum of a weighted sum of output to a weighted sum of inputs. Note that the former model can add $\sum_{r=1}^{R} \lambda_r = 1$ to the problem, which provides valuable information about the cost-benefit evaluation (BCC model):

$$Min \qquad TE = \theta_0 - \varepsilon\left(\sum_{m=1}^{M} S_{jm}^{-} + \sum_{n=1}^{N} S_{jn}^{+}\right)$$

$$\text{s.t.} \qquad \sum_{r=1}^{R} \lambda_r X_{rm} - \theta X_{jm} + S_{jm}^{-} = 0$$

$$\sum_{r=1}^{R} \lambda_r Y_{rn} - S_{jn}^{+} = Y_{jn}$$

$$\sum_{r=1}^{R} \lambda_r = 1 \qquad , \ \lambda_r \geq 0, \ S_{jm}^{-} \geq 0, S_{jn}^{+} \geq 0$$

Where θ_0 represents the maximum porportion of its input levels could be employed to procure its current output levels for the unit r_0. ε is a nonarchimedean quantity the value of which is very minute. We can use θ_0 to compute the potential improvement (reduction) for the inputs of each inefficient firms. For a specific firm J, the reduced values of any inputs can be obtained as:

$$X_{Jm}^{*} = \theta_J X_{Jm} - S_{Jm}^{-} \qquad m=1,2,\ldots\ldots M$$

Thus, the reduced input use for the firm J can be derived from its reference sets, say firm L and K. We have:

$$X_{Jm} = X_{Lm} \lambda_L + X_{Km} \lambda_K \qquad m=1,2,\ldots\ldots M$$

Where λ_L and λ_K and the corresponding dual weights of the firm J. We can observe the extent to each reference set contributes to the specific firm (J) and highlight the most influential firm to each inefficient DMU.

Concerning the choice of input and output items, an evaluation in this paper is conducted on the institution approach, views insurance as a number of activities, each producing a technical output (Grace and Timme, 1992). This approach views insurance company output as representing a resource-consuming activity. In accordance with this view, we specify three insurance company output measures, namely ordinary premium receipts, group premium receipts and investment. These outputs entail operating activities in terms of four inputs, namely counterman, salesman, assets, branch, and administrative expenses. The above items are the main consideration of the paper. In some cases, the appropriate output/input items can be acquired from insurance company administrators. Therefore, after communicating with insurance company managers, we divided personal insurance revenue into three parallel measures: first year premium receipts, renewal premium receipts, and accident & health premium receipts. These items were viewed as the revenue sources of a life insurance company. Basically, the perspectives of this evaluation are those of life insurance company managers (resource manager viewpoint) and of fee-payers (resource user viewpoint). The perspective of other constituencies is involved in relevant input/output measures, and tends to reveal the goals that those conducting the analysis consider important. Any important missing input/output will obviously bias the result of the DEA model. In fact, it is unlikely that there is worldwide agreement about what constitutes important input/output of an insurance company. We adopted measures referring to the institution approach school and adjusted them to fit our practical application. We finally decided upon the five output measures and four input items listed above. One argument is that it would be rather meaningful and useful to consider various combinations of input and output in measuring the efficiency of a life insurance company. However, it is very important when conducting DEA to resist the temptation to present results as an objective declaration of efficiency, irrespective of the adopted output and input.

III. Estimated Results

For the input and output described above, we calculated the efficiency rating E_k for 28 life insurance companies in Taiwan using the 1996 data. First, the mean overall efficiency score is not too high (0.782). It implies that the efficiency difference among 28 life insurance companies is quite large, because insurance companies need to be devoted to establishing a new relationship network and this may take a long time to build-up in order to cope with high competition in Taiwan and some newly-established insurance companies have not yet improved their efficiency. Among them, nine life insurance companies are relatively efficient (efficiency scores are equal to 1.00). This shows that the resource utilization of these nine life insurance companies is functioning well. Next, nineteen inefficient life insurance companies all had efficiency scores less than unity. Table 1 shows that inefficient firms can improve by decreasing resource input and increasing output. For example, the efficiency score of Kuo-Hua Life Insurance Company is 0.941; i.e., it can be interpreted that this firm has attained 94% efficiency. That is to say, the life insurance company has reached 94% of the level of output of efficient units with the same level of input. Note that the mean overall efficiency scores of the domestic investor-owned units (0.777) are roughly similar to that of foreign investor-owned units (0.787). It reveals relatively little difference of life insurance company operations may exist.

Table 1 Descriptive Statistics of Efficiency Scores

	Number of Units	Number of Efficient Units	Number of Inefficient Units	Mean of Efficiency Scores
All Samples	28	9	19	0.782
Ownership				
Domestic	15	4	11	0.776
Foreign	13	5	8	0.787
Firm Life				
old-aged	16	9	7	0.893
Newly-established	12	0	12	0.634
Firm Size				
Large-sized	8	3	5	0.885
Small-sized	20	6	14	0.741

Note: The cut-off point in the measurement of the firm life is six years and that of firm size is 4000 persons, respectively.

In order to interpret the contents of efficiency, more discrimination among the 9 efficient insurance companies was undertaken. We modified the method proposed by Charnes, Cooper and Thrall In order to interpret the contents of efficiency, more discrimination(1991) and used the frequency in the reference set to discriminate among them. A DMU which appears frequently in the reference set of other DMUs is likely to be a DMU which is efficient with respect to a large number of factors, and is probably a good example of a "well-rounded performer". Efficient units that appear seldom in the reference set of other DMUs are likely to possess a very uncommon input/output mix and are thus not suitable examples for other inefficient DMUs. So the frequency with which an efficient DMU shows up in the reference set of other DMUs is actually an indication of what may be called exemplary operating practices. When this frequency is low, one can usually safely conclude that the DMU is somewhat of an odd or peculiar unit as is well-pointed out in the above sentence. Table 2 shows that the 9 efficient life insurance companies can be categorized into three groups: (i) Taiwan Life and China Life Insurance Companies can be placed in the high frequency group. (ii) Cathay Life, Grorgia Life, Pruco Life, and New York Life Insurance Companies are in the middle robust group. (iii) Nan-Shan Life, Connecticut Life, and American Life Insurance Companies are classified in the low frequency group. Moreover, we divided the 19 inefficient life insurance companies into four subgroups using the level of efficient scores to isolate the worst life insurance companies among the inefficient ones. We choose the first 25th percentile of inefficient units as an example to describe how efficient units influence inefficient units. Please note that, we can divide the 28 insurance companies into two groups according to another dimension, that is, domestic investor-owned and foreign investor-owned companies when we report the results of efficiency score analysis. Because there are quite a few differences in administrative support and fund-rising regulation among life insurance companies based on the specific objectives of the regulators, we need to differentiate the unequal competing base among them.

Next, we used the reference sets and dual weights to find the influence of the reference unit of each inefficient life insurance company. This information is quite important for the manager to illustrate the method to remedy inefficient firms (Oral and Yolalan ; 1990). The reference sets and dual weights of grouped inefficient firms are shown in Table 3. We choose the first 25th percentile of inefficient units as an example to describe how efficient units influence inefficient units. The entry in each cell shows the dual weights between each reference unit and the inefficient units. Therefore, the "contribution" of each reference unit to an inefficient unit is shown in its own column and then the magnitude of the dual weights can be read easily. Hung-Fu Life Insurance Company, for instance, is influenced by Taiwan, Cathay, and Pruco Life Insurance Company. Here we find that Taiwan Life Insurance Company influences all the inefficient insurance companies in Table 3(a) and can be viewed as a local leader. Conversely, Connecticut Life Insurance Company does not act as a reference for any of the selected inefficient units. Connecticut Life Insurance Company is not a wider efficient, which is not similar to the regular efficient insurance companies and possesses its own peculiarities and specialties. Also, the magnitudes of dual weights can be considered as showing the amount of technical weight that is attributed by each reference unit in the composition of the efficient (hypothetical) unit. For example, Kuo-Hua Life Insurance Company has 7,166 persons (salesmen), NT$1,865 million dollars (administrative expenses) and the derived efficiency score E_k=0.941. In addition, the dual weights 1.11, 0.99, and 0.24, can be obtained. We have:

$$7166 \times 0.941 = 6743 \doteqdot 4063 \times 1.11 + 1999 \times 0.99 + 1124 \times 0.24 = 6759 \quad \text{or}$$

$$1865 \times 0.941 = 1755 \doteqdot 622 \times 1.11 + 986 \times 0.99 + 380 \times 0.24 = 1758$$

where (4,063, 622), (1,999, 986), and (1,124, 380) are the salesmen and the administrative expense of Taiwan, China, Georgia Life Insurance Company respectively. Please note that the dual weight of reference unit 1.11 is larger than that of 0.99 and 0.24, indicating Taiwan Life Insurance Company plays a stronger role in determining the idea efficiency level of life insurance companies.

In addition, we can judge the local returns to scale of an inefficient life insurance company by using the magnitude of dual weights. From Boussofican et al. (1991), if the sums of the dual weights of a given unit is larger than 1, it can be attributed to decreasing returns to scale (DRS) unit. On the other hand, an increasing returns to scale (IRS) unit is judged when the total of its dual weights is less than unity. In Table 3(a), we find that Metropolitan, Hung-Fu, Kuo-Hua, and Shin-Kong Life Insurance Companies have dual weights which are greater than one and we can say that they operate at decreasing returns to scale. While, Mercury Life Insurance Company is placed in the IRS unit group. This implies that we can improve the average productivity of inefficient units by reallocating resources from those DRS units to IRS units, if the potential redistribution of resources can be operated. Note that a more thorough analysis can be obtained from a describing the inputs and outputs to the selected units, additional normalized scale is usually needed to employed to analyze the behavior of those efficient and inefficient units.

Table 2 Classification of Life Insurance Companies

Classification		Domestic investor-owned	Foreign investor-owned
Efficient Units (E_k=1)	High Reference Set Frequency Count	Taiwan (16) China (14)	—
	Middle Reference Set Frequency Count	—	Georgia (9) New York (9) Pruco (8)
	Low Reference Set requency Count	Cathay (4) Nan-Shan (2)	American (2) Connecticut (1)
Inefficient Units (E_k<1)	25th percentile	Mercury (0.969) Hung-Fu (0.961) Kuo-Hua (0.941) Shin-Kong (0.797)	Metropolitan (0.964)
	50th percentile	Eagle (0.793) Shin-Fu (0.666)	Zurich (0.773) Aetna (0.770) Republic-Vanguard (0.669)
	75th percentile	Chin-Fon (0.601) Fubon (0.5981) Chung-Shing (0.586)	Trans-America (0.643) Manufactures (0.571)
	100th percentile	Shinung (0.404) Global (0.337)	Investors (0.489) Integrity (0.358)
Average	Total (0.782)	Domestic (0.776)	Foreign (0.787)

Note: The figures in parentheses are the efficiency score (inefficiency units); or the frequency of showing in the reference set (efficiency units).

Table 3 Grouped Inefficient Units and their Reference Units

(a) The first 25th percentile of inefficient units

Inefficient Units \ Efficient Units	1. Taiwan	4. China	17. Georgia	24. New York	19. Pruco	3. Cathay	5. Nan-Shan	Total
10. Mercury	0.55		0.001				0.08	0.63
18. Metropolitan	0.07	0.001		0.004	1.19			1.27*
14. Hung-Fu	0.40				0.91	0.001		1.31*
7. Shin-Kong	2.54	1.17				0.30		4.01*

Note: The figures in cells (i,j) are the dual weights for some inefficient units; "*" means a decreasing return of scale (DRS) unit.

(b) The 50th percentile of inefficient units

Efficient Units / Inefficient Units	1. Taiwan	4. China	17. Georgia	24. New York	19. Pruco	21. American	3. Cathay	20. Connecticut	Total
15. Eagle		0.06			0.37	0.69			1.12*
28. Zurich		0.002	0.001					0.02	0.02
16. Aetna	0.61	0.001	0.63	0.87	3.78				5.89*
25.Republic-Vanguard	0.05		0.02		0.52		0.001		0.59
12. Shin-Fu	0.08	0.001			0.03				0.11

(c) The 75th percentile of inefficient units

Efficient Units / Inefficient Units	1. Taiwan	4. China	17. Georgia	24. New York	19. Pruco	3. Cathay	Total
23.Trans-America	0.07	0.001	0.08	0.66	0.04		0.85
2.Chin-Fon	0.11	0.08	0.12	0.27			0.58
8.Fubon	0.61			0.32		0.001	0.93
13.Chung-Shing	0.27				0.61	0.001	0.88
22.Manufactures	0.06	0.001		0.28			0.34

(d) The 100th percentile of inefficient units

Efficient Units / Inefficient Units	1. Taiwan	4. China	17. Georgia	24. New York	5. Nan Shan	21. American	Total
27.Investors		0.003				0.11	0.11
11.Shinung	0.17	0.001		0.42			0.59
26.Integrity	0.05	0.001	0.004	0.05			0.11
9.Global	0.13		0.001		0.001		0.13

Note: same as above.

IV. Discussions

The results show that nine life insurance companies are relatively efficient, and Taiwan Life, China Life, and Georgia Life Insurance Company are the top three life insurance companies and greatly surpass the robustness of the inefficient firms. Of the 19 inefficient life insurance companies, one can identify the reference units and of the global leader to provide an useful guidelines to remedy their inefficiency. In addition, by examining the local economies of scale, we can also highlight the treatment for the specific decreasing returns of scale units. Analyzing such results could help the decision-maker to better understand the implications of a DEA assessing results Noted that we can also understand the internal capability of life insurance companies when we analyze the company resource and its utilization efficiency. This result can be used as a foundation of a company to establish its particular competition ability in the cost-benefit perspective. It will enable to find out many competitive opponents by grouping some companies with similar operating efficiencies, especially in the short-run period, that the resource does not change in a big range. The resource manager can then use this information to set up an appropriate cost competition strategy.

We can extend our analysis into the relationship efficiency and market share. The figure of correlation coefficient (0.36) can show the correlation extent between efficiency scores and market share, which is measured by the premium receipts on insurance contracts. We employ the business strategy matrix derived by Boston Consulting Group (BCG Matrix) to illustrate the individual evidence between the relationship between life insurance company operating efficiency and market share (see Table 4). It has been observed that seven of twenty-eight firms are in the "super stars" group which is characterized by high efficiency and high market share and the super stars firms are all old-established ones. On the other hand, eleven of twenty-eight firms are characterized by low efficiency and low market share and are placed in the "problem child" group and half of foreign life insurance companies are categorized as being in the problem child group. This result is based on the concept of relative comparison. We then conclude that eleven problem child firms should rearrange input to improve their performance and we need conduct the further research in the near future.

Table 4 The Efficiency-Market Share Matrix of Twenty-eight Firms

Efficiency (DEA Score)	Market Share: low			Market Share: high
high		**Question Marks**		**Super Stars**
	Hung-Fu	*Metropolitan*	Taiwan	*Georgia*
		Pruco	China	
		Connecticut	Cathay	
		American	Nan-shan	
		New York	Kuo-Hua	
			Mercury	
low		**Problem Child**		**Money Ox**
	Global	*Trans-America*	Chin-Fon	*Aetna*
	Shinung	*Manufactures*	Shin-Kong	
	Shin-Fu	*Republic-Vanguard*	Fubon	
	Chung-Shing	*Integrity*		
	Eagle	*Investors*		
		Zurich		

Note ： The foreign investor-owned life insurance companies are shown in italics.

However, there are two issues we encountered in the study. First, output measures do not include quality-type indicators, e.g., service quality and equipment quality, due to limited data. These issues will become less critical as we gain experience. Furthermore, since evaluation of life insurance companies usually contains on-site visits, more in-depth research is needed to combine visits (qualitative) and DEA measurement (quantitative). It is worth finding a new method to solve this issue to save company staff and budget utilization costs.

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