AN INTEGRATED DATA ENVELOPMENT ANALYSIS (DEA) / FUZZY AHP/ASSURANCE REGION (AR) METHOD IN MEASURING EFFICIENCY OF LIFE INSURANCE COMPANIES IN MALAYSIA

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1. Introduction

Despite the challenging business environment caused by COVID-19, the insurance sector has continued to contribute to Malaysia's economic growth as one of the most significant and dominating financial services in the country (Drake, 2014). The largest threat to the insurance industry, according to Bank Negara Malaysia, is rising competition. Therefore, in order to remain competitive, the companies need to measure their performance and efficiency consistently. Data Envelopment Analysis (DEA) has been used widely in many applications in evaluating the efficiency of decision-making units (DMUs). The main advantage of the DEA method is it can handle multiple inputs and outputs simultaneously. However, there are some drawbacks that resulting from it, which are poor discrimination power and unrealistic weight such as zero weights which affects accuracy of the efficiency results (Bal et al., 2010). In this study, Data Envelopment Analysis (DEA) method is integrated with Fuzzy Analytic Hierarchy Process (Fuzzy AHP) and Assurance Region (AR) to overcome the drawbacks. Therefore, the aims of this study are to improve discrimination power and reduce zero weights assigned to inputs/outputs by adopting the integrated method DEA/Fuzzy AHP/AR and applies it in evaluating the efficiency of 12 life insurance companies in Malaysia.

Twelve life insurance companies were taken into assessment as a decision-making unit (DMUs). The secondary data sources are solely based on the published annual reports of the insurance firms' websites from 2017 to 2020, and the data were then normalized. Input-orientation DEA- BCC model was chosen, and the input variables selected in the study were operating expenses, equity share capital, and fee and commission expenses; meanwhile for the output's variables selected were net premium, net investment income and net incurred claims. Experts' opinions on the importance of inputs and outputs were considered while determining the weight for each variable, and the opinions were elicited using Fuzzy AHP. AR was used to impose the restrictions on input/output weights.

2. Methodology

Figure 1 shows the summarization of the methods used in conducting the study which is DEA is integrated with Fuzzy AHP and AR. There are 3 stages involved. Stage 1 is the development of a model where the objectives are defined, and the inputs and outputs are chosen. Stage 2 involves the application of Fuzzy AHP in computing the weights of inputs and outputs based on opinions from the experts. This is a crucial stage because it helps to overcome the drawbacks of DEA by obtaining weight that will be used in stage 3. Stage 3 is the last stage where the implementation of DEA/AR method and Fuzzy AHP method is conducted.

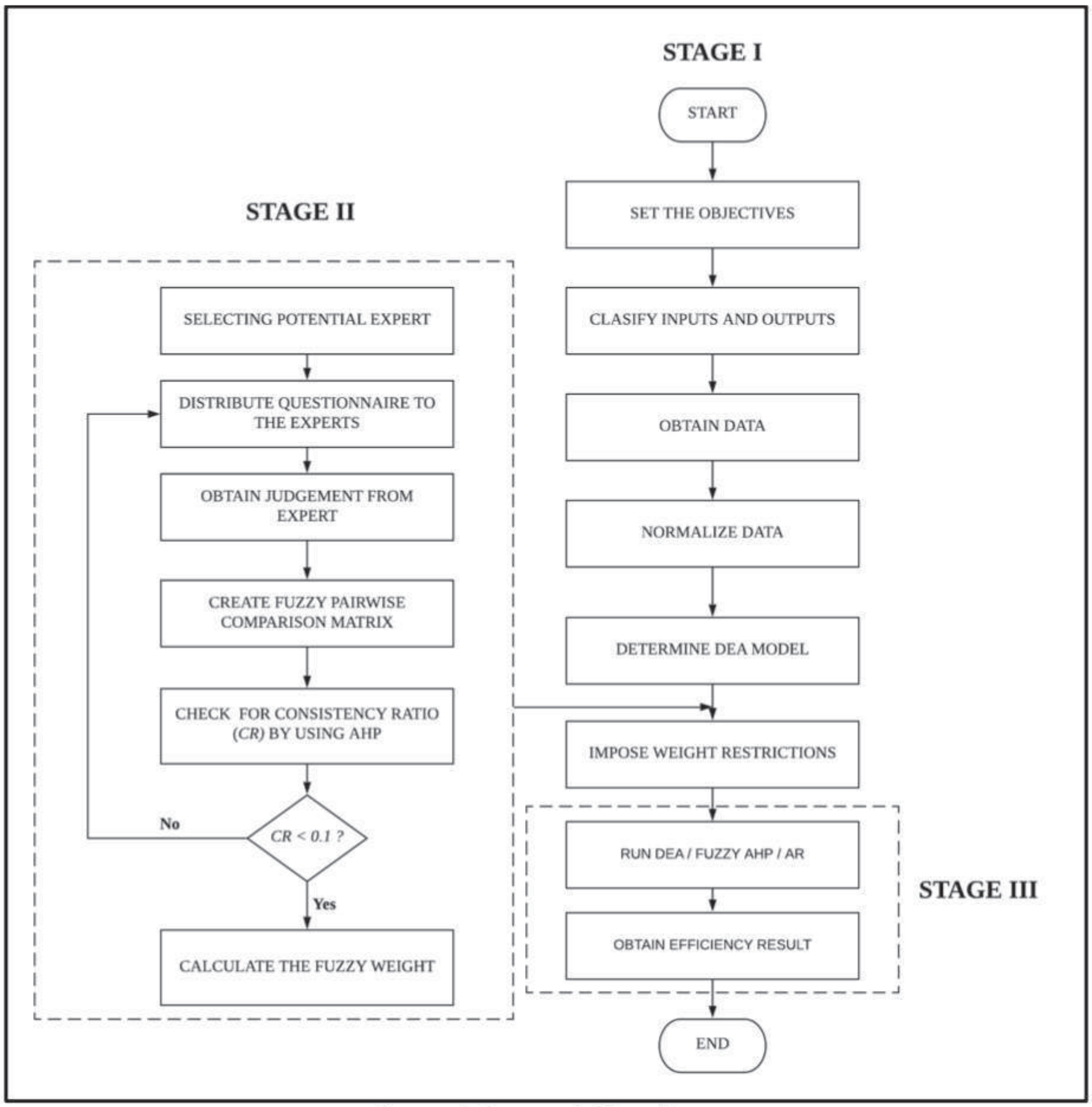

Figure 1. Research Flowchart

The input-oriented BCC model is chosen in order to minimize the usage of inputs by DMUs where the output quantity is fixed. The DEA/AR and Fuzzy AHP model are employed to reduce weight flexibility in standard DEA as it helps in solving the drawbacks of DEA and which were mentioned before. Fuzzy AHP is applied to obtain weights for inputs and outputs. Below is the extended analysis method by Cheng (1997) that is used to compute the fuzzy weights:

$$S_i = \sum_{j=1}^{m} M_{ij} \left(\sum_{i=1}^{n} \sum_{j=1}^{m} M_{ij} \right)^{-1} \tag{1}$$

$$\sum_{j=1}^{m} M_{ij} = \left(\sum_{j=1}^{m} l_{ij}, \sum_{j=1}^{m} m_{ij}, \sum_{j=1}^{m} u_{ij} \right), i = 1,2,\ldots,n$$

$$\sum_{j=1}^{n} \sum_{j=1}^{m} M_{ij} = \left(\sum_{i=1}^{n} \sum_{j=1}^{m} l_{ij}, \sum_{i=1}^{n} \sum_{j=1}^{m} m_{ij}, \sum_{i=1}^{n} \sum_{j=1}^{m} u_{ij} \right)$$

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{ij} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} u_{ij}}, \frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} m_{ij}}, \frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} l_{ij}} \right)$$

$$S_j = (l_j, m_j, u_j) \geq S_i = (l_i, m_i, u_i) \tag{2}$$

$$V(S_j \geq S_i) = height(S_i \cap S_j) = \begin{cases} 1 & if\ m_j \geq m_i \\ 0 & if\ l_i \geq u_j \\ \dfrac{l_i - u_j}{(m_j - u_j) - (m_i - l_i)} & otherwise \end{cases}$$

$$\begin{aligned} & V(S \geq S_1, S_2, S_3, \ldots, S_k) \ for\ i = 1,2,3,\ldots,k \\ & = V[(S \geq S_1)\ and\ (S \geq S_2)\ and \cdots (S \geq S_k)] \\ & = min\ V(S \geq S_i)\ for\ i = 1,2,3,\cdots,k \end{aligned} \tag{3}$$

Let $d'(A_i) = min\ V(S \geq S_i)\ for\ i = 1,2,3,\cdots,k$

$$W' = [d'(A_1), d'(A_2), \cdots, d'(A_n)]^T$$

$$W = [d(A_1), d(A_2), \cdots, d(A_n)]^T$$

The weights obtained using Fuzzy AHP are then used in AR to define both upper and lower limits on the ratio of input and output weights. Below are the AR restrictions that are used to reduce the weight flexibility in standard DEA.

$$u_r \geq a_r u_t, \quad r < t \quad r,t = 1,\ldots,s, \tag{4}$$

$$u_r \leq b_r u_t, \quad r < t \quad r,t = 1,\ldots,s, \tag{5}$$

$$v_i \geq a_i k, \quad i < k \quad i,k = 1,\ldots,m, \tag{6}$$

$$v_i \leq \beta_r v_k, \quad i < k \quad i,k = 1,\ldots,m, \tag{7}$$

The model used in this study after additional constraints is as follows:

$$Max\ h_o = \sum_{r=1}^{s} u_r y_{ro} - u_o \tag{8}$$

Subject to

$$\sum_{i=1}^{m} v_i v_{io} = 1 \tag{9}$$

$$\sum_{r=1}^{s} u_r y_{rj} - u_o - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \tag{10}$$

$$A_{p,q} \leq \frac{v_p}{v_q} \leq B_{p,q} \quad ; p \neq q \tag{11}$$

$$a_{p,q} \le \frac{u_p}{u_q} \le b_{p,q} \quad ; p \neq q \tag{12}$$

$$u_r, v_i \ge 0 \tag{13}$$

where

x_{io} : the value of ith input for DMU_o

y_{io} : the value of ith output for DMU_o

v_i : weight for inputs

u_r : weight for outputs

The efficiency result is executed by using EMS Software.

3. Results and Discussions

DEA used to calculate the relative efficiency of a decision-making unit (DMUs) based on the multiple inputs and outputs. DEA allows to compare the objectives, inputs and outputs, issue comprehensive indexes, and be able to hold numerous inputs and outputs at the same time (Zbranek, 2013). However, the drawback of DEA are poor discrimination power and unrealistic weight. Poor discrimination power happens when the number of inputs and outputs is greater than the number of DMUs. This leads to too many DMUs identified as efficient and the input and output might appear as zero values (Bal et al., 2010). Yet, unrealistic weight happens when certain DMUs are stated as efficient because of the uttermost or zero values of input and output weights.

Table 1. Weight distribution of input and output using DEA and DEA/Fuzzy AHP/AR for year 2020

	DEA							DEA/Fuzzy AHP/AR						
	$v1$	$v2$	$v3$	$u1$	$u2$	$u3$	Efficiency	$v1$	$v2$	$v3$	$u1$	$u2$	$u3$	Efficiency
DMU1	0	0.16	0.84	1.00	0	0	0.7675	0.41	0.11	0.48	0.76	0.16	0.09	0.6588
DMU2	0.28	0.06	0.65	1.00	0	0	1.0000	0.55	0.21	0.25	0.68	0.23	0.09	0.6706
DMU3	0.37	0	0.63	0.84	0	0.16	0.9008	0.50	0.32	0.18	0.39	0.07	0.54	0.4684
DMU4	0	0	1.00	0	0	1.00	1.0000	0.61	0.25	0.14	0.21	0.13	0.66	0.6830
DMU5	0.74	0.26	0	0	1.00	0	1.0000	0.53	0.09	0.38	0.26	0.70	0.04	1.0000
DMU6	0.92	0.08	0	0	0	1	1.0000	0.60	0.05	0.35	0.29	0.14	0.57	1.0000
DMU7	0	0.12	0.88	1.00	0	0	0.9644	0.59	0.07	0.34	0.38	0.09	0.53	0.6302
DMU8	0.38	0	0.62	1.00	0	0	1.0000	0.45	0.28	0.28	0.41	0.07	0.53	0.6003
DMU9	0.29	0.01	0.7	0.82	0	0.18	1.0000	0.47	0.13	0.40	0.36	0.11	0.53	0.8698
DMU10	0.41	0	0.59	0	0.93	0.07	0.8920	0.51	0.24	0.25	0.16	0.46	0.38	0.6152
DMU11	0	1.00	0	0	0	1.00	1.0000	0.44	0.06	0.50	0.40	0.08	0.52	0.7732
EMU12	0	0.15	0.85	0.7	0.3	0	0.7301	0.48	0.11	0.41	0.40	0.55	0.05	0.6240

Table 1 presents the comparison result of the implementation of DEA and DEA/Fuzzy AHP/AR for the year 2020. By using DEA in Table 1, seven out of 12 DMUs were identified as efficient units which results from poor discrimination power since it has too many DMUs were identified as efficient unit. The hybrid method enabled to decrease the number of efficient units from seven units to twi units. To explain on the unrealistic weight, IC04 represent Gilbratar BSN Life Insurance were identified as efficient unit. There are 4 variables identified as zero weight which is v_1, v_2, u_1 and u_2. Therefore, the score obtained was only based on one input that is fee and commission expenses and one output that is net incurred claim. Operating expenses, equity share capital, net premium and net investment income were not considered in calculating the efficiency score. However, when the hybrid method was applied it becomes inefficient as the efficiency score unit does not equals to one when all the input and output weight were considered in calculating the efficiency of the insurance company. The integrated method of DEA/Fuzzy AHP/AR has improved the discrimination power and eliminates zero weights for four consecutive years.

4. Conclusion

This study deduces the following main objectives which are to improve discrimination power in standard Data Envelopment Analysis (DEA) and to reduce zero weights by integrating DEA with Fuzzy Analytic Hierarchy Process (Fuzzy AHP) and Assurance Region (AR). The hybrid method was applied to measure efficiency of 12 life insurance companies in Malaysia. It was shown that the methos has successfully eliminated zero weights and improved discrimination power. This shows that the results obtained were more accurate and realistic since all the inputs and outputs chosen were considered in the efficiency assessment. Thus, among the 12 life insurance companies that were observed, it can be seen that Great Eastern Life Insurance (Malaysia) Berhad succeeded in being efficient for four consecutive years from 2017 to 2020. Based on the Great Eastern official website, the insurance company has received many awards in many categories and one of them is the CSR Malaysia Award 2020 because Great Eastern was recognized as the most outstanding Malaysian corporation in terms of corporate sustainability and social responsibility. Great Eastern was also awarded with the BrandLaureate brand of the year for the insurance category and was honored for its brand leadership, commitment, and innovation in product development and customer engagement. Consequently, it is clear that Great Eastern is one of the most efficient insurance companies in Malaysia. Other than that, this study actually helps the decision makers such as the top management in planning a strategic and efficient plan by turning inefficiencies units to more efficient and stressing on more important inputs or outputs that have the greater impact for the selected DMUs. By doing so, the performance of the company can easily be monitored.

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