Mathematical Sciences and Informatics Journal
Vol. 5, No. 1, May 2024, pp. 92-102
http://www.mijuitm.com.my DOI : 10.24191/mij.v5i1.974

Efficiency of Malaysian Life Insurance Company Using Two-stage DEA Method

Nur Diyana Awanis Razaly
Mathematical Sciences Studies, College of Computing, Informatics and Media, Universiti Teknologi MARA Negeri Sembilan Branch, Seremban Campus, Malaysia.
2022949729@student.uitm.edu.my

Nurul Nadia Saharuddin
Mathematical Sciences Studies, College of Computing, Informatics and Media, Universiti Teknologi MARA Negeri Sembilan Branch, Seremban Campus, Malaysia.
2022747973@student.uitm.edu.my

Muhamad Faris Iskandar Mohamad Fauzi
Mathematical Sciences Studies, College of Computing, Informatics and Media, Universiti Teknologi MARA Negeri Sembilan Branch, Seremban Campus, Malaysia.
2021494634@student.uitm.edu.my

Nur Rasyida Mohd Rashid
Mathematical Sciences Studies, College of Computing, Informatics and Media, Universiti Teknologi MARA Negeri Sembilan Branch, Seremban Campus, Malaysia.
syida@uitm.edu.my

Article Info

Article history:

Received Feb 10, 2024
Revised Apr 8, 2024
Accepted Apr 21, 2024

Keywords :

Efficiency
Traditional DEA
Two-Stage DEA
Life Insurance
CCR model

ABSTRACT

The insurance industry provides unique financial services for the growth and development of every country. The efficiency measurement in the insurance companies may increase the quality of their operations and assist in identifying the inefficacy stages for future improvements. This research intends to evaluate the efficiency of 12 life insurance companies in Malaysia by applying the Traditional Data Envelopment Analysis (DEA) method as well as the Two-Stage DEA method in the year 2021. Traditional DEA views the actions of decision-makers as a black box, overlooking the intermediate process which is unsuitable for network systems in the insurance industry. The production process of a life insurance company is divided into two sub-processes, which are operational and profitability stages, suitable to be evaluated by the Two-Stage DEA method. This method calculates the efficiency score of the decision-making units (DMUs) by equally considering the intermediate phases. The model was executed using Lingo 20.0 software yielding efficiency scores ranging from 0 to 1. The findings revealed that five companies performed efficiently throughout the whole production process under Traditional DEA. However, none of these five companies has an overall efficiency score of 1 under the Two-Stage DEA. This is because none of those companies are efficient in both sub-processes. This reveals the limitations of Traditional DEA thus offers valuable insights to Malaysian life insurance companies on the effectiveness of Two-Stage DEA in assessing operational and profitability efficiencies. This study aids companies identify areas for improvement and encourage benchmarking against efficient competitors.

Corresponding Author:
Nur Rasyida Mohd Rashi
Mathematical Sciences Studies, College of Computing, Informatics and Mathematics, Universiti Teknologi MARA (UiTM) Cawangan Negeri Sembilan, Kampus Seremban, Malaysia.
Email: syida@uitm.edu.my

PENERBIT PRESS
UNIVERSITI TEKNOLOGI MARA

1. Introduction

An insurance policy is defined as a contract in which the insurer guarantees financial help and security to the insured in return for a predetermined payment. The insurance industry has gained increasing importance worldwide, playing a crucial role in driving a country's economy. It has shown impressive progress, including the rapidly expanding insurance sector in Malaysia, which is recognised as a key contributor to the growth of the financial services sector [1]. Numerous studies have been conducted to understand insurance market activities and measure the efficiency of this industry in both developed and industrialized nations. It is crucial to evaluate the efficiency of the insurance companies to increase the quality of their activities and make future management improvements. Data Envelopment Analysis (DEA) is one of the mathematical models that uses linear programming models to rank, evaluate, categorise, and identify organisations' strengths and shortcomings, which also offers ways for improvement in the future [2]. Efficient units produce more or the same outputs with fewer inputs than inefficient ones. This approach is widely used because of its diverse findings to discover the best practices in decision-making units (DMUs) with numerous inputs and outputs. Thus, DEA has been implemented in numerous industries including in the measurement of efficiencies in manufacturing, banking, management, health, transportation and the insurance sector [3]. Nevertheless, the Traditional DEA perspective considers the system to be evaluated as a unified and interconnected process where the major limitation of Traditional DEA is its holistic approach, which fails to consider the individual performance of component processes when determining the relative efficiency of a group of production systems [4]. Another primary drawback indicates that the efficiency score may not accurately reflect the overall performance of a system's processes. Thus, Traditional DEA fails identify the specific process responsible for the inefficiency of an inefficient system. To determine the source of inefficiency, one could calculate the efficiency of each operation individually. However, the correlation between the efficiency of the system and the efficiencies of the individual processes remains undisclosed [5]. Traditional DEA perceives the actions of DMUs as a black box and disregards the intermediate measures. The Traditional DEA method may yield a high overall efficiency score, but it fails to accurately assess the efficiency of individual sub-processes [2]. Most of the systems representing DMUs are operating in two-stage networks with intermediate metrics. Thus, the extended model for DEA is the Two-Stage DEA, which can assess the overall efficiency and efficiency of each stage individually. The Two-Stage DEA model was used to partition the complex sector into two interrelated subsystems and quantify both subsystem and process efficiency [6].

Thus, this research aims to fill the gap in the current knowledge as there has been limited research on the Two-Stage production process for Malaysia's insurance sector by conducting a comprehensive analysis for the evaluation of the sector efficiency using Two-Stage DEA method which has been adapted from a previous study [4]. By considering the insurance industry operates in a two-stage process, the company is able increase the quality of their activities and conduct future management improvements for both sub system as well as overall efficiency. This study is structured as follows: the first section is an introduction. Meanwhile the second section provides a review of the literature. The third section discusses the methodology. The fourth section includes the analysis and discussion of the results, and the fifth section concludes and offers recommendations.

2. Literature Review

Current development in Malaysia has started to show deep interest and exertions on behalf of the DEA is a non-parametric method introduced by Charnes, Cooper and Rhodes [7], to assess the efficiency of DMUs in a single state by using multiple inputs to yield multiple outputs. Most of the previous studies only focused on measuring the efficiency of insurance companies using the Traditional DEA model. Those studies view the systems as one single system, ignoring the performance of their internal processes in measuring the relative efficiency of a set of production systems. The drawbacks include the fact that the efficiency score may not properly represent the aggregate performance of the processes in a system. Recently, DEA has been extended to examine the efficiency of the two-stage processes, where all the outputs from the first stage are the intermediate measure that act as the inputs to the second stage [8]. There are many studies dealings with network systems that include internal processes, where Henriques et al. [9] have divided a commercial bank production process into the stages of profitability and marketability. In a study by Seiford and Zhu [10], the network process determines the inputs of the bank production process, including employees, assets, and shareholders' equity, which are also the inputs of the first stage. Next, the outputs of the bank production process produce market value, total return on investments, and earning per share, which are also the outputs of the second stage. Two intermediate products, revenues, and profits are both the outputs of the first stage and the inputs of the second stage. On the other hand, the operation of water supply services can also be described as a two-stage network system, where the output of the water treatment process (stage 1) will also become the input to the water distribution process (stage 2). Applying the Two-Stage DEA model in this situation is therefore appropriate. Consequently, Ismail and Kamarudin [11] have applied an extended Two-Stage DEA to evaluate the performance of water supply services as well as to examine specific results for Malaysian water supply services that are not possible to obtain through traditional DEA approaches.

In addition, Kao and Hwang [4] have measured the efficiency of non-life insurance companies with Two-Stage DEA model in Taiwan where they divided the production process of the non-life insurance companies into two sub-processes which are the premium acquisition stage and the profit generation stage. The Two-Stage DEA model partially improves these deficiencies by initially measuring the overall efficiency of the system and then evaluating the first stage efficiency. The second stage efficiency was calculated by dividing the overall efficiency by the first stage efficiency. Almulhim [12] also evaluates the performance of the insurance market in Saudi Arabia employing a Two-Stage DEA to determine the effectiveness of the two production phases and identify the stage that serves as the leader. Moreover, Sinha [13] has conducted a study on the efficiency of Indian general insurance companies using a Two-Stage DEA model. Accordingly, these studies enable the researcher to estimate efficiency at the two substages, as well as the computation of the overall efficiency. Significantly, the findings emphasise on its importance to analyse efficiency at sub-aggregate levels while also considering contextual variables across different production stage.

Since the performance measurement of life insurance companies using the Two-Stage DEA model variation is either non-existent or just a few, the network model is applied for the Malaysian life insurance companies in this study. Two stages are involved in measuring the life insurance efficiency, which are the operational performance stage for stage 1 and the profitability stage for stage 2. The inputs and outputs in this study are influenced by literature on DEA applications in life insurance services.

3. Methodology

This section is divided into four sub-sections which are Section 3.1 explaining the inputs, outputs, intermediate variable use for this study. Section 3.2 explained the data description. Section 3.3 and Section 3.4 explained the mathematical model used for this study which are Traditional DEA and Two-Stage DEA.

3.1 Inputs, Outputs, and Intermediate Variable

The first stage which is the operational or premium stage utilises three inputs which are equity (x_1), net claims incurred (x_2), and general and administrative expenses (x_3). The output for stage 1 is direct written premium (z_1), Then, the direct written premium (z_1) which is also known as the intermediate variable along with another input which is reinsurance premium (z_2) will be used as input in stage 2 known as the profitability or investment stage. These inputs will produce two final outputs which are the net premium earned (y_1), investment and management fee income (y_2). The selection of inputs and outputs for both stages are based by literature on DEA application in the life insurance industry, as demonstrated by Almulhim [12].

3.2 Data Description

The information was taken from the 2021 annual financial reports published by each life insurance company, focusing on inputs, outputs, and intermediate variables. 12 life insurance companies in Malaysia are involved in this study. Table 1 shows the life insurance companiesas DMUs in the study, and Table 2 shows the input and output data for the life insurance companies in the year 2021.

Table 1. The life insurance companies as DMUs of the study

LIFE INSURANCE COMPANY	
A1	AiA Berhad
A2	Allianz Life Insurance Companies
A3	AmMetLife Insurance Berhad
A4	Tokio Marine Life Insurance
A5	Etiqa Life Insurance Berhad
A6	Gibraltar BSN Life Berhad
A7	Great Eastern Life Assurance (Malaysia) Berhad
A8	Hong Leong Assurance Berhad
A9	Manulife Insurance Berhad
A10	MSIG Insurance (Malaysia) Berhad
A11	Prudential Assurance Malaysia Berhad
A12	Zurich Life Insurance Malaysia Berhad

Table 2. Input and Output data for 2021

	Total Equity $(x1)$	**Net Benefit & Claims** $(x2)$	**General Administrative Expenses** $(x3)$	**Net Earned Premium** $(y1)$	**Investment & Management Fees** $(y2)$	**Direct Written Premium** $(z1)$	**Reinsurance Premium** $(z2)$
A1	5,030,342	5,803,189	2361331	8,555,533	1044998	9692298	1136765
A2	1,590,932	2,347,201	825217	3,116,698	252886	3259007	142,309
A3	624,842	367,681	186105	514,854	142263	591006	76152
A4	1,182,598	1,265,288	327589	1,514,333	395998	156133	46800
A5	1,573,215	1,496,819	259,734	1,897,389	128,095	1,936,388	38,999
A6	300,074	144,505	108669	187,742	119312	198746	11004
A7	4,229,277	6,036,152	1800395	9,443,679	69239	9674518	230839
A8	2,140,250	3,025,777	618,527	2,996,094	1,034,663	3,144,988	148,894
A9	629,384	924,350	297,530	946,911	1,299,502	1,013,803	66,892
A10	3,091,114	503,663	411,894	1,107,385	151,834	1,446,727	339,342
A11	2,103,152	5,456,633	2,482,882	7,771,909	1,064,970	7,963,238	191,329
A12	1,422,482	705,839	237777	835,758	250051	865379	29621

3.3 Traditional DEA

The Lingo 20.0 software was employed to execute the operational effectiveness of life insurance businesses operating within the Malaysian market. Units with a score below than 1 indicated inefficiency, whereas units with a score of 1 indicated efficiency. The efficiency score varied between 0 to 1. The ranking was determined based on the reference set and reference frequency. For Traditional DEA, this study utilised the Charnes, Cooper and Rhodes (CCR) model which was an output- oriented model that focused on maximising outputs without increasing any observed input values.

Shahroudi et al. [14] employed the Traditional DEA model to measure the efficiency of DMU k under the assumption of constant returns-to-scale (CRS). CRS in DEA represented the idea that when inputs were changed, the output changes proportionally. The mathematical model is defined as follows:

Model 1:

$$E_k = Max \sum_{r=1}^{s} u_r Y_{rk}$$

Subject to

$$\sum_{i=1}^{m} v_i X_{ik} = 1,$$

$$\sum_{r=1}^{s} u_r Y_{rj} - \sum_{i=1}^{m} v_i X_{ij} \leq 0, \;\; j = 1, \dots, n,$$

$$v_i, u_r \geq \varepsilon, i = 1, \dots m, \;\; r = 1, \dots, s. \qquad (1)$$

Where:
Ek: the relative efficiency of DMU k,
Xik , i = 1, … , m : ith input,
Yrk, r = 1, … , s : rth output,
vi : weight of input i, and
ur: weight of output r.

If E_k = 1, then it shows that the DMU k was efficient and if E_k < 1, it indicates that the DMU k was inefficient. Model (1) was used to measure the overall efficiency while Model (2) and Model (3) were used to measure the efficiencies of first stage (E_k^1) and second stage (E_k^2). However, these models did not consider the interconnectedness of the internal processes and instead assessed the efficiency of each stage separately. Model (2) and Model (3) as in Kao and Hwang [4] are described as follows:

Model 2:

$$E_k^1 = Max \sum_{p=1}^{q} w_p Z_{pk}$$

Subject to,

$$\sum_{i=1}^{m} v_i X_{ik} = 1,$$

$$\sum_{p=1}^{q} w_p Z_{pk} - \sum_{i=1}^{m} v_i X_{ik} \leq 0, \;\; j = 1, \dots, n,$$

$$v_i, w_p \geq \varepsilon, \qquad i = 1, \dots m, \;\; p = 1, \dots, q. \qquad (2)$$

where:
v_i : weight given to input i,
w_p : weight given to intermediate p,
X_{ik} : data value i from DMUk and
Z_{pk} : is the intermediate data value p from DMUk.

Model 3: $$E_k^2 = Max \sum_{r=1}^{s} u_r Y_{rk}$$

Subject to,

$$\sum_{p=1}^{q} w_p Z_{pk} = 1,$$
$$\sum_{r=1}^{s} u_r Y_{rk} - \sum_{p=1}^{q} w_p Z_{pk} \le 0, \;\; j = 1, \dots, n,$$
$$w_p, u_r \ge \varepsilon, \qquad p = 1, \dots q, \;\; r = 1, \dots, s. \qquad (3)$$

where:
w_p: weight given to intermediate p,
u_r: weight given to output r,
Z_{pk}: the intermediate data value p from DMUk and
Y_{rk}: the data value output r from DMUk.

3.4 Two-Stage DEA

Kao and Hwang [4] considered Two-Stage network structure or process as shown in Figure 1. Each DMU j ($j = 1, 2, \cdots, n$) has m inputs $X_{ik}(i = 1, 2, \cdots, m)$ and q outputs $Z_{pk}(p = 1, 2, \cdots, q)$ in the first stage. These q outputs then will become the inputs to the second stage which also will be referred as the intermediate variable while the outputs from the second stage are $Y_{rk}(r = 1, 2, \cdots, s)$. The efficiency for the first stage was denoted as E_k^1 while the second stage was denoted as E_k^2 for each DMU j.

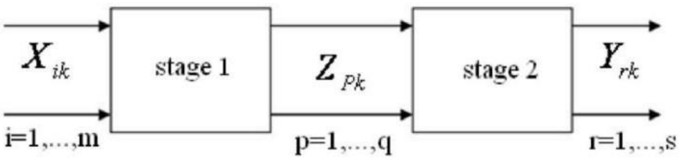

Figure 1. Two-Stage process of DMU k

As mentioned earlier, Kao and Hwang [4] presented two models, namely Model (2) and Model (3), which utilised identical data. The overall efficiency of the process, as well as the efficiencies of its two constituent sub-processes, were assessed individually. Consequently, a model must delineate the sequential relationship that exists between the overall process and the two sub-processes in order to establish a connection between the sub-processes and the overarching process. This concept led to the prompted of Model (4), which was implemented as follows:

Model 4: $$E_k = Max \sum_{r=1}^{s} u_r Y_{rk}$$

Subject to,

$$\sum_{i=1}^{m} v_i X_{ik} = 1,$$
$$\sum_{r=1}^{s} u_r Y_{rj} - \sum_{i=1}^{m} v_i X_{ij} \le 0, \qquad j = 1, \dots, n,$$
$$\sum_{p=1}^{q} w_p Z_{pj} - \sum_{i=1}^{m} v_i X_{ij} \le 0, \;\; j = 1, \dots, n,$$

$$\sum_{r=1}^{s} u_r Y_{rj} - \sum_{p=1}^{q} w_p Z_{pj} \leq 0, \quad j = 1, \dots, n,$$

$$v_i, w_{p,} u_r \geq \varepsilon, i = 1, \dots, m, p = 1, \dots., q, r = 1, \dots, s. \tag{4}$$

where:
v_i: weight given to input i,
w_p: weight given to intermediate p,
u_r: weight given to output r from DMUj,
X_{ij}: the data value i from DMUj,
Z_{pj}: the intermediate data value p from DMUj and
Y_{rj}: the data value output r from DMUj.

Model (4) was implemented to calculate the overall efficiency. After executing Model (4), the overall efficiency and internal process efficiency were obtained as well as the coefficients of u_r^*, v_i^*, w_p^*.

$$E_k = \frac{\sum_{r=1}^{s} u_r^* Y_{rk}}{\sum_{i=1}^{m} v_r^* X_{ik}}, \quad E_k^1 = \frac{\sum_{p=1}^{q} w_p^* Z_{pk}}{\sum_{i=1}^{m} v_r^* X_{ik}}, \quad E_k^2 = \frac{\sum_{r=1}^{s} u_r^* Y_{rk}}{\sum_{i=1}^{m} w_r^* Z_{pk}}$$

From model (4), the optimal coefficients solved may not be unique. Therefore, the decomposition of $E_k = E_K^1 \times E_k^2$ may also not be unique. This makes the comparison of E_K^1 or $E_k^2$for all DMUs lacks a common basis. To solve the problem, the set of coefficients that produces the largest E^1 must be calculated while maintaining the overall efficiency score at E_k that has been calculated from Model (4) as above. Therefore, Kao and Hwang [7] introduced Model (5) which is defined as follows:

Model 5:
$$E_k^1 = Max \sum_{p=1}^{q} w_p Z_{pk}$$

Subject to,

$$\sum_{i=1}^{m} v_i X_{ik} = 1,$$

$$\sum_{r=1}^{s} u_r Y_{rk} - E_k \sum_{i=1}^{m} v_i X_{ik} = 0, \quad j = 1, \dots, n,$$

$$\sum_{r=1}^{s} u_r Y_{rj} - \sum_{i=1}^{m} v_i X_{ij} \leq 0, \quad j = 1, \dots, n,$$

$$\sum_{p=1}^{q} w_p Z_{pj} - \sum_{i=1}^{m} v_i X_{ij} \leq 0, \quad j = 1, \dots, n,$$

$$\sum_{r=1}^{s} u_r Y_{rj} - \sum_{p=1}^{q} w_p Z_{pj} \leq 0, \quad j = 1, \dots, n,$$

$$u_r, v_{i,} w_r \geq \varepsilon, \quad r = 1, \dots, s, \quad i = 1, \dots, m, \quad p = 1, \dots, q. \tag{5}$$

where:
v_i: weight given to input i,
w_p: weight given to intermediate p,
u_r: weight given to output r from DMUj,
X_{ij}: the data value i from DMUj,
Z_{pj}: the intermediate data value p from DMUj and

Y_{rj}: the data value output r from DMUj.

4. Results and Discussion

This paper evaluated the efficiencies of the life insurance companies relationally by employing the application of Two-Stage DEA model. The efficiency of the first stage measures the performance of the operational processes of the insurance companies labelled as E_k^1 while the efficiency of the second stage measures the performance in generating profit from the premiums labelled as E_k^2. Firstly, the overall efficiency Ek of Traditional DEA was calculated using Model (1). Then, the efficiency of the first stage E_k^1 in the Traditional DEA model was measured using Model (2). Finally, the efficiency of the second stage E_k^2 of Traditional DEA was estimated using Model (3). However, the application of measuring efficiencies using Traditional DEA did not consider the interconnection process or sequential relationship that exists between the overall process and the two sub-processes. Therefore, the Two-Stage DEA model developed by Kao and Hwang [4] had been used to advance this study.

The Two-Stage DEA model measured the overall efficiency as well as stage one E_k^1 for operational performance while stage two E_k^2 for measuring the performance in profitability process. Thus, the overall efficiency Ek of Two-Stage DEA was calculated using Model (4). Meanwhile, the efficiency of the first stage Ek in Two-Stage DEA model was calculated using Model (5). Then, the efficiency of the second stage E_k^2 of Two-Stage DEA was assessed using $E_k^2 = \frac{E\mathrm{k}}{E_k^1}$. Table 3 displayed the efficiency results for 2021. The Traditional DEA model has been a cornerstone in assessing efficiency by considering a single-stage process, while the Two-Stage DEA model extends this methodology by incorporating additional stages to account for complexities in the production process.

The comparison of these two models offers valuable insights into the robustness of efficiency assessments, especially in the context of the life insurance industry. Thus, the major factor of each of the 5 model as mention above lies in the input and output variable that are interconnected in the whole process. The result also depends on the input and output used in the model. The input and output that has been chosen are influenced by the previous study on the insurance companies' efficiency measurement. The efficiency scores measure using the Traditional DEA were displayed in the second, third, and fourth columns. The fifth, sixth, and seventh columns showed the efficiency scores using the Two-Stage DEA method and its rank stated in the columns.

Table 3. Efficiency result for 2021

Insurance companies	**Traditional DEA Model**			**Two-Stage DEA Model**		
	$\boldsymbol{E_k}$ **Model (1)**	$\boldsymbol{E_k^1}$ **Model (2)**	$\boldsymbol{E_k^2}$ **Model (3)**	$\boldsymbol{E_k}$ **Model (4)**	$\boldsymbol{E_k^1}$ **Model (5)**	$\boldsymbol{E_k^2 = \frac{E_k}{E_k^1}}$
A1	0.9698 (6)	1.0000 (1)	0.2202 (11)	0.2201 (9)	1.0000 (1)	0.2201 (10)
A2	0.8788 (11)	0.8781 (7)	0.5581 (10)	0.2536 (6)	0.4691 (9)	0.5406 (5)
A3	0.9082 (9)	0.8641 (8)	0.2099 (12)	0.1606 (10)	0.7662 (3)	0.2096 (11)
A4	0.8948 (10)	0.2482 (12)	1.0000 (1)	0.2455 (7)	0.2462 (12)	0.9972 (1)
A5	1.0000 (1)	1.0000 (1)	1.0000 (1)	0.3030 (4)	0.5868 (6)	0.5164 (7)
A6	0.9202 (8)	0.7067 (11)	0.7367 (9)	0.2396 (8)	0.5938 (5)	0.4035 (9)
A7	1.0000 (1)	1.0000 (1)	0.8907 (6)	0.3107 (3)	0.3526 (11)	0.8812 (4)
A8	0.9404 (7)	0.9114 (6)	0.6502 (8)	0.2885 (5)	0.5414 (7)	0.5329 (6)
A9	1.0000 (1)	0.7486 (9)	1.0000 (1)	0.6872 (1)	0.6912 (4)	0.9942 (2)
A10	1.0000 (1)	1.0000 (1)	0.9985 (4)	0.0998 (12)	1.0000 (1)	0.0998 (12)
A11	1.0000 (1)	1.0000 (1)	0.9534 (5)	0.4784 (2)	0.5396 (8)	0.8866 (3)
A12	0.8183 (12)	0.7234 (10)	0.8446 (7)	0.1556 (11)	0.3580 (10)	0.4346 (8)

In 2021, Table 3 indicated that five companies which were Etiqa Life Insurance Berhad (A5), Great Eastern Life Assurance (Malaysia Berhad) (A7), Manulife Insurance Berhad (A9), MSIG Insurance (Malaysia) Berhad (A10) and Prudential Assurance Malaysia Berhad (A11) performed efficiently throughout the production process when using Traditional DEA. However, none of these five companies achieved an overall efficiency score of 1 in the Two-Stage DEA analysis. This was because none of those companies were efficient in both none of those companies were efficient in both sub-processes. For instance, MSIG Insurance (Malaysia) Berhad (A10) was only efficient in stage one but inefficient in stage two. Therefore, these companies were inefficient for the overall process. The companies are expected to be efficient in both stages in order to achieve efficient scores in the overall process. This indicates that the Traditional DEA model does not consider the sub-processes and intermediate variables in the mathematical model. In addition, the ranking for the overall process of MSIG Insurance (Malaysia) Berhad (A10) differed significantly between the two models. This company ranked high in Traditional DEA but was positioned 12th rank in the Two-Stage DEA. This is due to the company’s inefficiency in both stages under Two-Stage DEA model.

In conclusion, by comparing the efficiency ranking of the overall processes obtained from the Traditional DEA model and the Two-Stage DEA model, it was found that most of these companies were efficient in the overall process under Traditional DEA model but inefficient for the overall process in the Two-Stage DEA model. In comparison with previous studies, the findings of this study are aligned with existing literature conducted by Lychev et al. [15]. The results of the studies have demonstrated that the Two-Stage DEA model provides more accurate efficiency scores than the Traditional DEA model. Moreover, the Two-Stage DEA model offers valuable insights into the efficiency of each stage within a system, thus assisting decision-makers to improve the overall efficiency of the system [8]. This is due to the presence of constraints and intermediate variables in the Two-Stage DEA model list. Thus, the result of efficiency calculated by the Two-Stage DEA model is more reliable as it considers the sub-processes and intermediate variables.

5. Conclusion

The study intended to evaluate the efficiency of 12 life insurance firms in Malaysia for the year 2021 using Traditional and Two-Stage DEA models. The Two-Stage DEA model examined operational and profitability stages, drawing from literature on DEA in the life insurance industry. The inputs in the first stage included total equity, net benefits and claims, and general administrative expenses, producing the direct written premium output. The output, along with reinsurance premium input also acted as intermediate variables that were used in the second stage to produce net premium earned and investment or administrative income outputs. The data was obtained from the annual reports available on the firms' official websites for the year 2021. The results of this study showed that the chosen DEA model, Two-Stage DEA was considered appropriate due to its consideration of the interconnection process or sequential relationship that exists between the overall and the two sub-processes.

The primary objective of this study was to evaluate the efficiency using the Traditional DEA, a method that involved only a single process or so called black-box analysis. Upon implementing the overall process, five life insurance companies were considered efficient in the overall efficiency. Nevertheless, due to the omission of sub-processes and intermediate variables in the Traditional DEA model’s inventory of variables, the outcome generated was unreliable and unfair when attempting to assess the operational and profitability efficiency of life insurance companies. Since this model accounted for intermediate and sub-processes variables, the efficacy was determined using the Two-Stage DEA model. Those companies that are efficient for the overall process were inefficient in both stage 1 and stage 2.

The implementation of the Two-Stage model in this study showed that the performance results of life insurance businesses differed from those obtained using the Traditional DEA. By employing the Traditional DEA method, efficient results were not able to be obtained in the overall stage as well as in the first and second stages. Therefore, it may be inferred that the Two-Stage DEA accurately described the physical relationship between the overall process and its sub-processes, yielding dependable outcomes in efficiency measurement.

Finally, future research should focus on measuring the efficiency of other insurance businesses, including Islamic insurance, auto insurance, health insurance, and others. Furthermore, it is recommended that future researchers should consider extending the scope of this Two-Stage DEA model by including multiple stages connected in a series whereby the overall efficiency of the process is determined by multiplying the efficiencies of its sub-processes. Moreover, researchers should consider examining the effectiveness of other activities beyond profitability or operations, including risk management, customer satisfaction, regulatory compliance, or employee engagement. It is practical to apply the hybrid DEA method with another mathematical model such as the Fuzzy DEA method and Goal Programming. Future research should also consider undesirable input or undesirable output in the insurance industry for their efficiency measurement model.

Acknowledgements

The authors gratefully acknowledge the Universiti Teknologi MARA Negeri Sembilan Branch, Seremban Campus, Malaysia for the support given to this project.

Conflict of Interest

This study has no conflict of interest with the subject matter, or materials discussed in this manuscript.

References

[1] J. M. Mahyideen, N. A. A. Aziz, H. Yaakob, N. A. M. Rusli, and W. N. Mohamad, "Efficiency Analysis of Malaysian General Insurance Companies Using Data Envelopment and Super-efficiency Approach," Int. J. Acad. Res. Bus. Soc. Sci., vol. 11, no. 10, pp. 300-310, 2021. doi: 10.6007/IJARBSS/v11-i10/11297.

[2] T. Zhao, R. Pei, and J. Pan, "The evolution and determinants of Chinese propertyinsurance companies' profitability: A DEA-based perspective," *J. Manage. Sci. Eng.*, vol. 6, no. 4, pp. 449-466, 2021. doi: 10.1016/j.jmse.2021.09.005.

[3] A. Amirteimoori, B.K. Sahoo, V. Charles, and S. Mehdizadeh, "An introduction to data envelopment analysis," *Stochastic Benchmarking: Theory and Applications*, pp. 13-29, 2022. doi: 10.1007/978-3-030-89869-4_2.

[4] Kao and S.-N. Hwang, "Efficiency decomposition in two-stage data envelopment analysis:An application to non-life insurance companies in Taiwan," *European Journal of Operational Research*, vol. 185, no. 1, pp. 418-429, 2008. doi: 10.1016/j.ejor.2006.11.041.

[5] A. Ghasemi and A. Elham, "Efficient multi-stage aerodynamic topology optimization usingan operator-based analytical differentiation," *Structural and Multidisciplinary Optimization*,vol. 65, no. 4, p. 130, 2022. doi: 10.1007/s00158-022-03208-x

[6] Z. Zuo, H. Guo, Y. Li, and J. Cheng, "A two-stage DEA evaluation of Chinese mining industry technological innovation efficiency and eco-efficiency," *Environmental Impact Assessment Review*, vol. 94, p. 106762, 2022. doi: 10.1016/j.eiar.2022.106762.

[7] A. Charnes, W.W. Cooper, and E. Rhodes, "Measuring the efficiency of decision-making units," *European Journal of Operational Research*, vol. 2, no. 6, pp. 429-444, 1978. doi:10.1016/0377-2217(78)90138-8.

[8] A. Rani, K. Taneja, and H. Taneja, "Life insurance-based recommendation system for effective information computing," *Int. J. Inf. Retr. Res.*, vol. 11, no. 2, pp. 1-14, 2021. doi: 10.4018/IJIRR.2021040101.

[9] I. C. Henriques, V. A. Sobreiro, H. Kimura, and E. B. Mariano, "Two-stage DEA in banks: Terminological controversies and future directions," *Expert Systems with Applications*, vol. 161, p. 113632, 2020. doi: 10.1016/j.eswa.2020.113632.

[10] L. Seiford and J. Zhu, "Profitability and Marketability of the Top 55 U.S. Commercial Banks," *Manage. Sci.*, vol. 45, no. 9, pp. 1270-1288, 1999. doi: 10.1287/mnsc.45.9.1270.

[11] W. R. Ismail and N. Kamarudin, "Modified Russell Network Model For DeterminingMalaysia Water Supply Services Performance," *J. Qual. Meas. Anal.*, vol. 16, no. 2, pp. 231-241, 2020.

[12] T. Almulhim, "Analysis of takaful vs. conventional insurance firms' efficiency: Two-stage DEA of Saudi Arabia's insurance market," *Cogent Bus. Manage.*, vol. 6, no. 1, p. 1633807,2019. doi: 10.1080/23311975.2019.1633807.

[13] R. P. Sinha, "Two-stage data envelopment analysis efficiency of Indian general insurance companies," *Global Business Review*, pp. 09721509211047645, 2021. doi: 10.1177/09721509211047645.

[14] K. Shahroudi, G. Mohammadi, and M. Taleghani, "Application of two-stage DEA techniquefor efficiencies measuring of private insurance companies in Iran," *Int. J. Appl. Oper. Res.-An Open Access J.*, vol. 1, no. 3, pp. 91-105, 2011.

[15] A. V. Lychev, S. V. Ratner, and V. E. Krivonozhko, "Two-stage data envelopment analysis models with negative system outputs for the efficiency evaluation of government financial policies," *Mathematics*, vol. 11, no. 24, p. 4873, 2023. doi: 10.3390/math11244873.

Biography of all authors

Picture	Biography	Authorship contribution
	Name: Nur Diyana Awanis Razaly is currently studying at Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban in the field of Bachelor of Science (Hons.) Management Mathematics & Bachelor of Business Administration (Hons.) Business Economics. Other than that, the author also holds a Diploma in Actuarial Science.	Handling data application from the insurance companies' websites. The author presented idea, performed the analysis and drafted the manuscript
	Name: Nurul Nadia Saharuddin is currently studying Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban in the field of Bachelor of Science (Hons.) Management Mathematics & Bachelor of Business Administration (Hons.) Business Economics. Other than that, the author also holds a Diploma in Actuarial Science.	Handling data application from the insurance companies' websites. The author formulated the presented idea, performed the analysis and drafted the manuscript.
	Name: Muhamad Faris Iskandar Mohamad Fauzi is currently studying at Is currently studying Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban in the field of Bachelor of Science (Hons.) Management Mathematics & Bachelor of Business Administration (Hons.) Business Economics. In addition, the writer is a graduate from Kedah Engineering Matriculation College.	Handling data application from the insurance companies' websites. The author formulated the presented idea, performed the analysis and drafted the manuscript.
	Nur Rasyida Mohd Rashid is a senior lecturer in Mathematical Sciences Studies, College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban. The author earned bachelor's degree from Univeristi Islam Antarabangsa, Malaysia (UIAM) and a master's degree from Universiti Kebangsaan Malaysia (UKM).	The author supervised the starting findings of this work from the implementation of the research, analysis of the results and to the writing of the manuscript.