



INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES



Efficiency Analysis of Malaysian General Insurance Companies Using Data Envelopment and Super-efficiency Approach

Jamilah Mohd Mahyideen, Nur Azlina Abd Aziz, Hafisah Yaakob, Nurhanani Aflizan Mohamad Rusli, Wan Normila Mohamad

To Link this Article: <http://dx.doi.org/10.6007/IJARBSS/v11-i10/11297> DOI:10.6007/IJARBSS/v11-i10/11297

Received: 05 August 2021, **Revised:** 22 August 2021, **Accepted:** 24 September 2021

Published Online: 07 October 2021

In-Text Citation: (Mahyideen et al., 2021)

To Cite this Article: Mahyideen, J. M., Aziz, N. A. A., Yaakob, H., Rusli, N. A. M., & Mohamad, W. N. (2021). Efficiency Analysis of Malaysian General Insurance Companies Using Data Envelopment and Super-efficiency Approach. *International Journal of Academic Research in Business and Social Sciences*, 11(10), 300–310.

Copyright: © 2021 The Author(s)

Published by Human Resource Management Academic Research Society (www.hrmars.com)

This article is published under the Creative Commons Attribution (CC BY 4.0) license. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this license may be seen at: <http://creativecommons.org/licenses/by/4.0/legalcode>

Vol. 11, No. 10, 2021, Pg. 300 - 310

<http://hrmars.com/index.php/pages/detail/IJARBSS>

JOURNAL HOMEPAGE

Full Terms & Conditions of access and use can be found at
<http://hrmars.com/index.php/pages/detail/publication-ethics>



INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES



www.hrmars.com

ISSN: 2222-6990

Efficiency Analysis of Malaysian General Insurance Companies Using Data Envelopment and Super-efficiency Approach

Jamilah Mohd Mahyideen¹, Nur Azlina Abd Aziz², Hafisah Yaakob³, Nurhanani Aflizan Mohamad Rusli⁴, Wan Normila Mohamad⁵

Faculty of Business and Management^{1,3,4,5}, Faculty of Computer and Mathematical Sciences²
Universiti Teknologi MARA, Seremban Campus, Negeri Sembilan, Malaysia
Email: nurhanani@uitm.edu.my

Abstract

Due to the phenomenal growth of the insurance sector, extensive research has been conducted to evaluate the insurers' efficiency at both domestic and international levels. Thus, this paper illustrates the applications of Data Envelopment Analysis (DEA) to measure the relative efficiency of 18 general insurance companies that were operating in Malaysia in the year 2018. The inputs included in this study are fees, commission, and management expenses while the outputs are net premium and generated investment income. The results reveal that the four general insurance companies can be identified as efficient units. The standard DEA method cannot discriminate efficient units. This study employs the super-efficiency DEA model to select the most efficient unit among them. This study makes a significant contribution to the financial industry especially for matters concerning insurance, as there is a lack of studies on exclusive efficiency analysis of general insurance companies in Malaysia. In addition, it has major implications for insurance decision makers, government agencies and emerging insurance markets. The information obtained from this study will benefit the insurance company's top management in devising viable strategies to enhance the efficiency of the company.

Keywords: DEA, Efficiency, Super-efficiency, General Insurance Companies

Introduction

Globally, the role of the insurance industry has become increasingly significant where it plays a vital role in stimulating the economy of a country. The industry is making impressive and remarkable progress. Malaysia's insurance sector is now expanding rapidly where it is identified as a key driver of the growth of the financial services sector. IMF (2014) reported that Malaysia's insurance sector accounted for 5.6% of the financial sector assets. Generally, there are two forms of insurance namely life and general insurance. General insurance offers non-life insurance products whereas life insurance covers the life of a person. Bank Negara Malaysia reported that at the end of 2016, there were 55 licensed

insurers and takaful operators in Malaysia, of which 44 are direct insurers (Bank Negara Malaysia, 2016). Among the direct insurers, 13 were life insurance companies, 19 were general insurance companies and 12 were composite insurance companies that provided both life and general products. The Malaysian local insurance market expanded by 4.9 per cent in 2019 where the life insurance industry's new business premiums increased by 14.19% to RM 11.8 billion in 2019 from RM10.3 billion in 2018 (LIAM, 2019). In contrast, the general insurance industry recorded a slight decrease of 0.8% (PIAM, 2019).

One major challenge faced by the insurance industry is that there are many insurance companies in the market, which therefore creates intense competition among them. To remain competitive and sustainable, insurance companies need to operate at their highest level where they need to utilise their resources efficiently to produce outputs. Technological advances have revolutionised the way business is conducted. Therefore, it is very crucial for an insurance company to respond to development quickly, adapt to technological advances and make necessary changes in order to keep up with the industry's latest trend. According to Grmanová and Strunz (2017), this is only possible if the insurance company evaluates its efficiency relative to peer companies in the insurance industry. However, assessing the efficiency of insurance companies is a challenging task because they are complex units with multiple resources and outputs.

Data Envelopment Analysis (DEA) has been acknowledged as an effective technique to evaluate the relative efficiency of homogeneous decision-making units (DMUs) with multiple inputs and outputs (Cooper, Seiford & Tone, 2006), where it has been extensively implemented in many fields. The inefficient DMUs can be ranked based on their efficiency scores. However, it is not possible to rank efficient DMUs because all of them obtain an efficiency score that is equal to 100 per cent.

This study seeks to evaluate the relative efficiency and to rank 18 general insurance companies that were operating in Malaysia in the year 2018 by implementing the DEA and super-efficiency models. The results obtained are analysed and a general conclusion is presented in the last section of the paper.

Previous Studies on Efficiency in Insurance Sector

The DEA technique has been widely used for determining the efficiency of the insurance industry. Abd Karim (2015) highlighted that most research teams used non-parametric methods to measure efficiency in the study of the effectiveness of insurance companies. In addition, according to Kaffash & Marra (2017), DEA had been applied in many sectors such as banking, agriculture, transportation, healthcare, electricity, education and many other service industries.

The concept of efficiency analysis has been prevalent in the insurance literature (Berger & Humphrey, 1992). In the insurance industry, there is a widening body of literature regarding the efficiency of the insurance industry for both developed and developing countries. The efficiency analysis results have important consequences for insurance operators who are striving to boost operating efficiency. In addition, the awareness on insurance performance determinants helps policy makers to formulate strategies that further strengthen the stability of financial institutions and boost the efficacy of the monetary system as a whole (Saad et al., 2006).

According to Farrel (1957), a company's efficiency is comprised of three types of efficiency: technical efficiency, allocative efficiency and economic efficiency. Technical efficiency refers to a DMU's ability to maximize outputs given a set of inputs (output orientation) or to

minimize inputs given a fixed number of outputs (input orientation). On the other hand, allocative efficiency is a DMU's ability to optimize the use of inputs through price structure and production technology. The product of technical efficiency and allocative efficiency is known as economic efficiency or cost efficiency. A DMU which is both technically and allocatively efficient is identified as economically efficient. Al Amri (2015) highlighted that a company's production is said to be cost-effective if the company uses the lowest cost input or the lowest cost in producing output. Meanwhile, a company is technically inefficient if the use of inputs is disproportionate in comparison to its output volume. According to Cummins and Weiss (1993), there is technical inefficiency (input) if the current output rates can be achieved with less of all corresponding inputs. Allocative inefficiency (input) is present when the company is using inputs with different ratios. Consequently, the technical substitution rate (TSR) is not proportional to price inputs.

In the last decade, there were comprehensive analyses of the efficiency of the financial services market. However, prior research focused mainly on developed countries. Cummins and Weiss (1993) studied insurance efficiency, where the majority of their research was carried out in the United States. One of their studies was to study the property-liability insurers' technological and allocative performance, by considering 38 large companies, 134 medium-sized companies and 89 small companies. The findings showed that large insurers operated at an average efficiency level and were reasonably cost homogeneous. The findings also indicated minimal diseconomies for large insurers, and relatively large-scale economies for smaller insurers.

Meanwhile, a Multi-Stage Data Envelopment Analysis (DEA) was adopted by Eling and Schaper (2017) to identify the effects of evolving environments on the efficiency and results of European life insurance companies. A sample of 970 life insurance companies from 14 European countries were considered.

Nevertheless, many other insurance efficiency studies had recently been carried out in developing countries as well. Insurance efficiency and performance were also analyzed in developing countries. For example, there were studies conducted on the efficiency of general insurance companies in Indonesia (Amanti & Siregar, 2019) and on the cost efficiency, profitability and size of Thailand's insurance firms (Abd Karim, 2005).

Ansah-Adu, Andoh and Abor (2012) implemented DEA to evaluate the cost efficiency of 30 insurance companies in Ghana. The input variables chosen in this study were total assets, total operating costs and total expenditure, while the output variables selected were profit or loss, net premiums and investment income. The findings showed that larger companies were more efficient than smaller companies. Market share was identified as the most important determinant of a company's efficiency.

The DEA method was also used by Amanti and Siregar (2019) to measure the efficiency of 70 General Insurance Companies in Indonesia. This research used two DEA models, namely CCR, which produces CRS (constant return to scale), and BCC, which produces VRS (variable return to scale), by concentrating on the orientation of outputs. Operational expenses and equity capital were chosen as inputs, while the output variables included underwriting and investment returns. According to the calculation of the efficiency scale, the number of efficient general insurance companies had decreased from 2014 to 2015.

In comparison, Abd Karim (2005) used a Stochastic Frontier Model to analyze the cost efficiency, profitability and size of Thailand's insurance firms. On average, the results reported that the firms were not efficient, with percentage ranging from 86 percent to 114 percent. The inefficiency and the age of the firm had no practical relationship. The test results showed

negative correlation with the ROE ratio indicated that on average, productive firms had higher returns on equity. Ghosh and Dey (2018) measured performance of the top ten general insurance companies in India using the DEA and super-efficiency method over the period of 2011 to 2017. The findings showed that five public sector general insurance companies were consistently efficient throughout the evaluation period.

Previously, two studies were conducted in 2018 and 2019 on the efficiency of Malaysian insurance companies. For example, the performance of Malaysian insurance companies was studied by Bao et al (2018). The researchers applied the DEA method to determine the performance of each insurance company in Malaysia. Overall, the results revealed that the performance of insurance companies in Malaysia varied from 2014 to 2015. Wang et al (2019) performed a study on the performance of insurance companies in Malaysia. They have detailed the study of the general insurance companies' efficiency in Malaysia. In contrast to Bao et al (2018); Wang et al (2019) used a combination of two decision-making processes involving various criteria based on the neutrosophic method, which is a process involving the analytical hierarchy of neutrosophic data (NDAHP) and Sequence Engineering Preference by Equity with Ideal Solutions (TOPSIS) - deviation method, which were both based on a single-value neutrosophic set (SVNS), to evaluate the efficiency of general insurance companies in Malaysia. The researchers argued that this approach is more holistic in assessing the efficiency of general insurance companies in Malaysia than the DEA and SFA methods used in previous studies.

Methodology and Data

DEA

This study applies the DEA method to measure the efficiency of Malaysian general insurance companies. It is a non-parametric and non-statistical approach in which no assumption concerning the functional form of the production functions is required (Johnes, 2006). The DEA was first presented by Farrel in 1957 and later extended by Charnes, Cooper and Rhodes in 1978, who introduced the most basic DEA model, which was the CCR model. It is a data-oriented deterministic technique which has been proven to be an effective method in analysing and evaluating the relative efficiencies of a set of homogeneous DMUs in many applications (Charnes, 1978). The DEA is computed based on how well a DMU utilises inputs (resources) and converts them into outputs, where the method can be applied to identify the best practical performance amongst DMUs in utilising resources. The DEA model is described as follows. Suppose that there are n DMUs to be evaluated with m inputs and s outputs, the i -th input and the r -th output produced by the j -th DMU are denoted by x_{ij} ($i = 1, \dots, m$) and y_{rj} ($r = 1, \dots, s$), respectively. Besides that, u_r and v_i denote the unknown output weights and input weights, respectively, and DMU_o represents the unit under evaluation. The relative efficiency of a DMU_o (where $o = 1, 2, \dots, n$) is computed by solving the following linear programming problem:

$$\text{Maximize } \theta_o = \sum_{r=1}^s u_r y_{ro} \quad (1)$$

subject to

$$\begin{aligned} \sum_{r=1}^m v_i x_{io} &= 1, \\ \sum_{r=1}^s u_r y_{rj} - \sum_{i=1}^m v_i x_{ij} &\leq 0; \quad j = 1, 2, \dots, n \\ u_r, v_i &\geq 0. \end{aligned}$$

where, the indices are represented as follows:

j : the DMUs, where $j = 1, 2, \dots, n$ (n DMUs);

i : input index, where $i = 1, 2, \dots, m$ (m inputs);

r : output index, where $r = 1, 2, \dots, s$ (s outputs);

x_{io} : the value of the i -th input for DMU_o ;

y_{ro} : the value of the r -th output for DMU_o ;

θ_o : relative efficiency to be computed for DMU_o ; and

u_r, v_i : unknown weight variables.

The above model assumes a constant return to scale (CRS) where an increase in the inputs will yield a proportional increase in the outputs. The model is known as the multiplier input-oriented CCR model and this model will be employed in this study. The first constraint ensures that the values of the efficiency ratio are confined to 1. As such, a finite number of optimal solutions are guaranteed based on the formulation above. The values of θ satisfy $0 \leq \theta \leq 100\%$, where DMU_o is identified as an efficient unit if $\theta = 100$ percent; otherwise, it is considered as inefficient.

Data

This study chose two inputs and two outputs measures to evaluate the efficiency of Malaysian general insurance companies in the year 2018. The inputs consisted of fees, commission, and management expenses, which represented the amount paid by the company. These inputs were chosen because both the expenses provided a substantial impact on the performance of the insurance company. Besides, the outputs chosen for the present study were net premium and generated investment income, which were the two significant revenues for an insurance and a takaful company (Shieh, Hu & Ang, 2020).

The sample of the present study was comprised of 18 general insurance companies in Malaysia. These companies were AIA General Berhad, AIG Malaysia Insurance Berhad, AXA Affin General Insurance Berhad, AmGeneral Insurance Berhad, Berjaya Sompo Insurance Berhad, Chubb Insurance Malaysia Berhad, Etiqa General Insurance Berhad, Great Eastern General Insurance (Malaysia) Berhad, Liberty Insurance Berhad, Lonpac Insurance Berhad, MSIG Insurance (Malaysia) Berhad, Pacific Insurance Berhad, Progressive Insurance Berhad, QBE Insurance (Malaysia) Berhad, RHB Insurance Berhad, Tokio Marine Insurance (Malaysia) Berhad, Tune Insurance Malaysia Berhad, Zurich General Insurance Malaysia Berhad, Allianz Life Insurance Malaysia Berhad, AIA Berhad, AXA Affin Life Insurance Berhad, Great Eastern Life Assurance (Malaysia Berhad), Manulife Insurance Berhad, MCIS Insurance Berhad, Prudential Assurance Malaysia Berhad, Sun Life Malaysia Assurance Berhad, Tokio Marine Life

Insurance Malaysia Berhad, Gibraltar BSN Life Berhad, Zurich Life Insurance Malaysia Berhad, Hong Leong Assurance Berhad, AmMetLife Assurance Berhad, HSBC Amanah Takaful Berhad, Prudential BSN Takaful Berhad, Sun Life Malaysia Takaful Berhad, Zurich Takaful Malaysia Berhad, AIA Public Takaful Berhad, Etiqa Family Takaful Berhad, AmMetLife Takaful Berhad, Great Eastern Takaful, and Hong Leong MSIG Takaful Berhad. The data were obtained from the companies' annual reports. Figure 1 shows the model of the study.

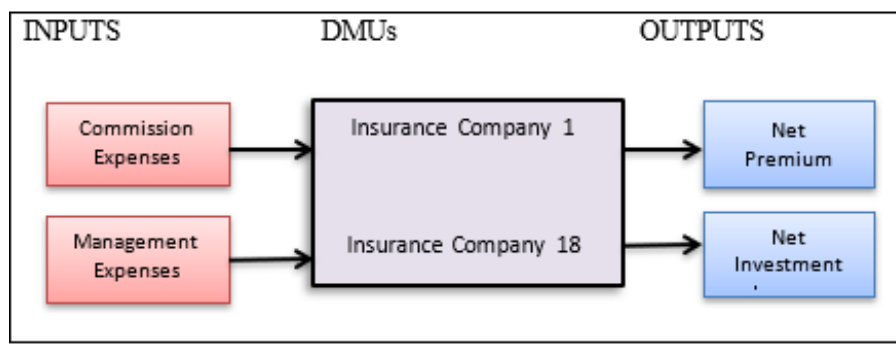


Figure 1: Model of the study

Super-efficiency

The scores obtained in the standard DEA model indicate how efficient a DMU performed in utilizing inputs to produce outputs, as compared to its peers. The DMUs can be ranked based on the values of their efficiency scores. However, one flaw of this model is it fails to rank efficient DMUs or inefficient DMUs that obtained similar scores. Super-efficiency DEA model is a method introduced by Andersen and Petersen (1993) for ranking efficient units in DEA. This model is used for differentiating efficient insurance companies. It is based upon the idea of omitting a unit and assessing this unit through the remaining units. The efficiency scores of inefficient DMUs remain the same but the scores of efficient units are higher than 100 per

$$\text{Maximize } \theta_o = \sum_{r=1}^s u_r y_{ro} \quad (2)$$

subject to

$$\begin{aligned} \sum_{r=1}^m v_i x_{io} &= 1, \\ \sum_{r=1}^s u_r y_{rj} - \sum_{i=1}^m v_i x_{ij} &\leq 0; \quad \forall j \neq o \\ u_r, v_i &\geq 0. \end{aligned}$$

cent. The mathematical model of super-efficiency with CCR model is:

Results and Discussions

Relative efficiency and super-efficiency scores were obtained using Efficiency Measurement System Software (EMS), which was developed by Scheele (2000). This software has all the features needed to conduct this study. Results of efficiency scores from the input oriented CCR model based on 18 Malaysian general insurance companies are presented in Table 1. The efficiency scores varied from 52.66 percent to 100 percent. The efficiency scores signify the efficiency of an insurance company in utilizing inputs to attain its desired output level as compared to its peers. A higher efficiency score indicates that the DMU is more efficient. It is

interesting to highlight that in 2018, four insurance companies obtained an efficiency of 100 percent; hence, they can be identified as the best performing units. The companies were AmGeneral Insurance Berhad, Etiqa General Insurance Berhad, Liberty Insurance Berhad and MSIG Insurance (Malaysia) Berhad. The rest were inefficient units. To achieve efficiency, the inefficient companies should emulate the practices and strategies adopted by AmGeneral Insurance Berhad, Etiqa General Insurance Berhad, Liberty Insurance Berhad and MSIG Insurance (Malaysia) Berhad to transform their inputs to outputs. However, since these 4 DMUs were equally efficient, the ranking of efficient DMUs was impossible using the standard DEA method. Therefore, the super-efficiency model was used to segregate the efficient companies. The efficiency scores were estimated by removing the data on the efficient DMU from the reference set and re-evaluating their efficiency.

Table 1: CCR–DEA Results

Name	Insurance Companies	Efficiency
DMU1	AIA General Berhad - 13 month	65.01
DMU2	AIG Malaysia Insurance Berhad	89.78
DMU3	AXA Affin General Insurance Berhad	98.23
DMU4	AmGeneral Insurance Berhad	100
DMU5	Berjaya Sompo Insurance Berhad	87.44
DMU6	Chubb Insurance Malaysia Berhad	68.17
DMU7	Etiqa General Insurance Berhad	100
DMU8	Great Eastern General Insurance (Malaysia) Berhad	62.9
DMU9	Liberty Insurance Berhad	100
DMU10	Lonpac Insurance Berhad	92.26
DMU11	MSIG Insurance (Malaysia) Berhad	100
DMU12	Pacific Insurance Berhad	58.84
DMU13	Progressive Insurance Berhad	85.79
DMU14	QBE Insurance (Malaysia) Berhad	76.48
DMU15	RHB Insurance Berhad	85.62
DMU16	Tokio Marine Insurance (Malaysia) Berhad	94.9
DMU17	Tune Insurance Malaysia Berhad	52.66
DMU18	Zurich General Insurance Malaysia Berhad	86.2

Source: Authors

Table 2 depicts the ranking orders obtained from the super-efficiency method. The super-efficiency scores for efficient units were more than 100 percent while the scores for inefficient units were less than 100 percent. The results of the analysis show that Etiqa General Insurance Berhad was identified as the most efficient general insurance company when compared to its peers. It had the highest efficiency score of 146.29 percent, thus obtaining the number 1 ranking. This indicates that Etiqa General Insurance Berhad had efficiently utilised its resources to produce outputs. This is probably due to its remarkable performance in 2018 as the company won three prestigious awards, namely “Malaysia’s Insurance Company of the Year for General Insurance” award, which was received in Hong Kong, “Best Takaful Company” award that was received in London, and “Malaysia’s Best Islamic Takaful Institution” award, which was received in Malaysia (The Star, 19 July 2018). This finding is consistent with the finding obtained by Bao, Ramlan, Mohamad and Yassin (2018) and Yusof (2020), where they found that Etiqa General Insurance Berhad earned top ranking in 2014, 2015, 2016 and 2017. The second place in the ranking was AmGeneral Insurance Berhad, with a technical efficiency score of 119.86 percent. Liberty Insurance Berhad was in the third place in the ranking with 110.94 percent technical efficiency score, while the fourth place in the ranking was DMU11, MSIG Insurance (Malaysia) Berhad, with 109.73 percent technical efficiency score. Meanwhile, Tune Insurance (Malaysia) Berhad was regarded as the least efficient where it had a technical efficiency score of 52.66 percent, thus obtaining the lowest rank. The inefficient companies can enhance their performance by emulating the best practices of efficient companies, namely AmGeneral Insurance Berhad, Etiqa General Insurance Berhad, Liberty Insurance Berhad and MSIG Insurance (Malaysia) Berhad.

Table 2 : Super Efficiency DEA Results

Name	Insurance Companies	Super efficiency	Ranking
DMU7	Etiqa General Insurance Berhad	146.29	1
DMU4	AmGeneral Insurance Berhad	119.86	2
DMU9	Liberty Insurance Berhad	110.94	3
DMU11	MSIG Insurance (Malaysia) Berhad	109.73	4
DMU3	AXA Affin General Insurance Berhad	98.23	5
DMU16	Tokio Marine Insurance (Malaysia) Berhad	94.9	6
DMU10	Lonpac Insurance Berhad	92.26	7
DMU2	AIG Malaysia Insurance Berhad	89.78	8
DMU5	Berjaya Sompo Insurance Berhad	87.44	9
DMU18	Zurich General Insurance Malaysia Berhad	86.2	10
DMU13	Progressive Insurance Berhad	85.79	11
DMU15	RHB Insurance Berhad	85.62	12
DMU14	QBE Insurance (Malaysia) Berhad	76.48	13
DMU6	Chubb Insurance Malaysia Berhad	68.17	14
DMU1	AIA General Berhad - 13 month	65.01	15
DMU8	Great Eastern General Insurance (Malaysia) Berhad	62.9	16
DMU12	Pacific Insurance Berhad	58.84	17
DMU17	Tune Insurance Malaysia Berhad	52.66	18

Source: Authors

Conclusion and Recommendations

This study employed DEA to measure the relative efficiency of 18 general insurance companies in Malaysia. The significance of the study stems from the need of measuring efficiency in insurance sector due to challenges, competition faced by the insurance companies. The empirical results show that four general insurance companies were found to be efficient, namely AmGeneral Insurance Berhad, Etiqa General Insurance Berhad, Liberty Insurance Berhad and MSIG Insurance (Malaysia) Berhad. Since DEA cannot segregate efficient DMUs, super-efficiency was implemented to rank the efficient units. Etiqa General Insurance Berhad was identified as the most efficient company. It can be regarded as the industry leader. This study will benefit inefficient companies whereby they can improve their efficiencies by adopting strategies and practices from efficient companies. The information will allow those involved in the management of insurance companies to redefine policies, company practices, and to devise viable strategies to enhance the insurance companies to be more competitive, innovative and diversified with the ability to operate on an efficient frontier. It is recommended for future research to apply these models on a panel data in order to assess the efficiency changes of the companies over time, hence providing more and better information related to the performance of the companies.

References

- Abd Karim, M. Z. (2005). Cost efficiency and profitability in Thailand's life insurance industry: a stochastic cost frontier approach. *International Journal of Applied Econometrics and Quantitative Studies*, 2, 19-36.
- Al-Amri, K. (2015). Takaful insurance efficiency in the GCC countries. *Humanomics*. 31 (3), 344-353.
- Amanti, P. G., & Siregar, A. A. (2019) The Efficiency of General Insurance Companies in Indonesia. In *12th International Conference on Business and Management Research (ICBMR 2018)* (pp. 314-320). Atlantis Press.
- Andersen, P., & Petersen, N. C. (1993). A procedure for ranking efficient units in data envelopment analysis. *Management Science*, 39(10), 1261-1264.
- Ansah-Adu, K., Andoh, C., & Abor, J. (2012). Evaluating the cost efficiency of insurance companies in Ghana. *The Journal of Risk Finance*, 13 (1) (2012), 61-76.
- Bao, N. J., Ramlan, R., Mohamad, F., & Yassin, A. M. (2018). Performance of Malaysian insurance companies using data envelopment analysis. *Indonesian Journal of Electrical Engineering and Computer Science*, 11(3), 1147-1151.
- Berger, A. N., & Humphrey, D. B. (1992). Measurement and efficiency issues in commercial banking. In *Output measurement in the service sectors* (pp. 245-300). University of Chicago Press.
- Bank Negara Malaysia. (2016). Insurance and Takaful Sector. <https://www.bnm.gov.my/documents/20124/856371/cp03.pdf>
- Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2(6), 429-444.
- Cooper, W. W., Seiford, L. M., & Tone, K. (2006). *Introduction to data envelopment analysis and its uses: with DEA-solver software and references*. Springer Science & Business Media.
- Cummins, J. D., & Weiss, M. A. (1993). Measuring cost efficiency in the property-liability insurance industry. *Journal of Banking & Finance*, 17(2-3), 463-481.

- Eling, M., & Schaper, P. (2017). Under pressure: how the business environment affects productivity and efficiency of European life insurance companies. *European Journal of Operational Research*, 258(3), 1082-1094.
- Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of The Royal Statistical Society, Série A*, 120(3), 253-290.
- Ghosh, A., & Dey, M. (2018). Performance Measure of Indian General Insurance Companies Using DEA and Super Efficiency Model. *Journal of Economics & Business Research*, 24(1).
- Grmanová, E., & Strunz, H. (2017). Efficiency of insurance companies: 99Application of DEA and Tobit analyses. *Journal of International Studies*, 10(3), 250-263
- IMF (2014). Malaysia: Publication of Financial Sector Assessment Program Documentation— Detailed Assessment of Observance of Insurance Core Principles. <https://www.imf.org/external/pubs/ft/scr/2014/cr1498.pdf>
- Johnes, J. (2006). Data envelopment analysis and its application to the measurement of efficiency in higher education. *Economics of Education Review*, 25(3), 273-288. doi: 10.1016/j.econedurev.2005.02.005
- Kaffash, S., & Marra, M. (2017). Data envelopment analysis in financial services: a citations network analysis of banks, insurance companies and money market funds. *Annals of Operations Research*, 253(1), 307-344.
- LIAM (2019). Annual Report 2019. https://www.liam.org.my/pdf/AnnualReport2019_LIAM.pdf
- PIAM (2019). Annual Report 2019. https://piam.org.my/wp-content/uploads/2021/04/3b_PIAM_people-at-the-heart.pdf
- Saad, N. M., Majid, M. S. A., Yusof, R. M., Duasa, J., & Rahman, A. A. (2006). Measuring efficiency of insurance and Takaful companies in Malaysia using data envelopment analysis (DEA). *Review of Islamic Economics*, 10(2), 5.
- Scheel, H. (2000). *EMS: Efficiency Measurement System Users Manual, Version 1.3*, Universität Dortmund, Dortmund, Germany. <http://www.wiso.uni-dortmund.de/LSFG/OR/scheel/ems/>.
- Shieh, H. S., Hu, J. L., & Ang, Y. Z. (2020). Efficiency of Life Insurance Companies: An Empirical Study in Mainland China and Taiwan. *SAGE Open*, 10(1).
- Wang, Z. L., Kim, J., Selvachandran, G., Smarandache, F., Abdel-Basset, M., Thong, P. H., & Ismail, M. (2019). Decision Making Methods for Evaluation of Efficiency of General Insurance Companies in Malaysia: A Comparative Study. *IEEE Access*, 7, 160637-160649.
- Yusof, N. A. M. (2020). Analysing the technical efficiency of general takaful industry in malaysia: a non-parametric approach. *Platform: A Journal of Management and Humanities*, 3(1), 2-14.
- Yunus. (2018). Malaysia. Governor's remarks at the Malaysian Insurance Institute (MII) Summit-Innovation in a Disruptive Era. *Governor's remarks at the Malaysian Insurance Institute (MII) Summit*.