Journal of Islamic Accounting and Finance Research
ISSN 2715-0429 (print); 2714-8122 (online)
Vol. 4 No. 1 (2022), 155-182; DOI: https://dx.doi.org/10.21580/jiafr.2022.4.1.8792
Received 2021-08-03 Accepted 2022-04-10

Optimization of solvency margin in family Takaful and Life Insurance Institutions in Malaysia: Application of Data Envelopment Analysis

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Abstract

Purpose - The purpose of this paper is to present the findings of the study on optimizing solvency margin in family Takaful and life insurance institutions in Malaysia.

Method - The population of this study is family Takaful and life Insurance Institutions in Malaysia during the period 2010 - 2019. The selection of samples in this study uses the purposive sampling method and selected 11 family Takaful and 14 life Insurance Institutions. The data were analyzed using Data Envelopment Analysis.

Result - The results showed that for from 2010 to 2019, the family Takaful operators' efficiencies are improving, whilst the life insurers have become less efficient even though their efficiency score is higher than the family Takaful operators. In terms of the optimum size (i.e., scale), the results are reversed which means that the family Takaful operators are still not at the optimum size but once they reach there, they could improve their efficiency substantially. However, for both family Takaful operators and life insurers, 2019 seems to dip their efficiency in terms of pure technical and also scale.

Implication - The results of this research open a new way of measuring the efficiency of family takaful and life insurance not only in Malaysia but can be generalized to measure the efficiency level of family takaful and life insurance in general.

Originality - This research is the first study that used the combination of inputs and outputs specifically for the family Takaful and life insurance institutions in Malaysia.

Keywords: family takaful; life insurance; efficiency; solvency

Journal of Islamic Accounting and Finance Research

Introduction

In economic development, the insurance sector has a substantial role. Insurance provides financial protection to individuals and companies paying premiums (Alokla and Daynes, 2017). Thus, insurance is a protection for individuals or businesses against certain contingencies and delivery risk to the policyholders. Gustina & Abdullah (2012) state that in Malaysia, family *Takaful* grow rapidly in recent periods. Family *Takaful* and life insurance have almost the same principle, namely protecting against losses. Family *Takaful* is a type of insurance that uses sharia principles. According to Bank Negara Malaysia (2016), the growth of the insurance and *Takaful* sectors in Malaysia continued to show positive growth in 2016. An increase in premiums and contributions from 2015 showed an enhancement of 4.4% (RM 58.7 billion to RM 61.3 billion). The combination of insurance and *Takaful* assets also increased by 5.7% (RM 263.8 billion to RM 277 billion).

The increasing growth of insurance companies is upgrading business competition in this business sector. Therefore, insurance companies are required to be able to strategize appropriately and show their performance well. Improved insurance performance can be achieved through higher solvency margins. Thus, the insurance company becomes more stable and will eventually have a contribution to increase premium income (Shiu, 2004). The key indicator of an insurance company's financial stability is solvency. With good solvency, the insurers become stable and increase customer interest (Dof, 2008). Yakob et al. (2012) state that investment income is positively related to solvency. Abduh and Isma (2016) conclude that the cost of life insurance companies and investment income is positively related to solvency. Efficiency reflects the competitiveness of the industry in responding to the challenges it faces.

When measuring the efficiency of a financial institution, an important decision to be made is the choice of concept used (Baharin and Isa, 2013). Efficiency has been estimated using a number of efficiency concepts including production and cost. Efficiency avoids all forms of wastage with managed input and output relationships so that it can give good results. This study aims to assess solvency and efficiency by using the combination of input and outputs specifically for the family *Takaful* and life insurance institutions in Malaysia. Thus, by adopting an effective approach, it is hoped to optimize solvency margin and increase efficiency that describes the insurer's performance well.

Literature Review

The latest historical measure of microeconomic efficiency was initiated by Farrell (1957), who defined a modest measure of corporate efficiency that could explain multiple inputs. Farrell (1957) proposes that the efficiency of a particular enterprise consists of two components: the technical efficiency of the enterprise, that is the ability to maximize the output from a particular set of inputs, and the allocation efficiency of the enterprise, that is the ability to use these inputs optimally. I am considering each price condition. The combination of the two measurements provides a measure of cost or production efficiency. The proposal by Farrell (1957) that efficiency can be empirically measured via an idealized limit is quantity curve (or an equivalent perturbation of an econometric model) which forms the basis for the next analysis.

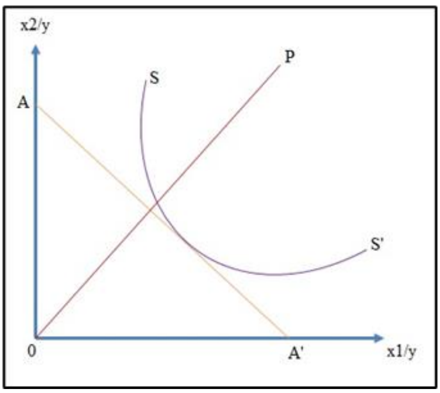


Figure 1. Allocative, Technical and Productive Efficiency (Farrel, 1957)

The main points of the discussion by Farrell (1957) are shown in Figure 1. The two inputs x1 and x2 are used to generate a single output y, assuming diminishing returns (CRS) over a certain scale. A fully efficient company SS isoquant curve (indicating an alternative combination of inputs that can be used to produce a particular level of output) allows you to measure technical efficiency. For a particular company that uses the inputs defined at point P to generate units of production, production efficiency is from the "optimal" or "best practice" institution where a single institution exists in the production function. Derived as a distance, this fictitious "best practice" agency is defined with reference to all agencies in the sample. For production and cost features, assumptions are made about all transferable production technologies and the fixed goal of maximizing performance and minimizing costs. The production function assumes that the output level of an individual institution depends on the number of inputs spent in production, random errors, and other additional variables that describe the environment and unique circumstances of the individual institution is. Therefore, the scope of production efficiency is limited to considering the inputs that can be reduced in order to produce a certain amount of production. This form of efficiency is commonly referred to as productive or technical efficiency. The derivation of production functions has been criticized for both the difficulty of providing adequate data and the limited definition of efficiency. Cost-effectiveness estimates how the production costs of an individual institution differ from the production costs of a best-practice institution or company that operates under similar conditions and achieves the same results. This measurement is defined with reference to a cost function constructed from the observations of all sampled institutions. The cost function is that the total production cost of an individual institution is the price of variable inputs such as capital and labor, the amount or value of output produced, random errors, and other additional variables that take into account the environment and specific circumstances. It is supposed to depend on it. Of individual institutions, you can use the cost function to measure the lowest cost share of an input in terms of input price. This framework allows you to consider both production efficiency and the optimal share of inputs in the form of input prices or allocation efficiencies. Farrell's concept of efficiency uses the concept of cost-effectiveness in this study because it is difficult to provide good data and limited variable inputs. This concept of efficiency is used for three reasons. First, it would be preferable to consider efficiency in the broadest sense, including both productivity and allocation efficiency. Second, there is a wealth of subjective information that both Malaysian and global financial institutions are emphasizing tighter cost controls. A Salomon study suggests that cost control has become a major strategic issue for finance as a whole (Molyneux et al., 1996). Finally, most econometric studies of financial institutions to date use the concept of cost efficiency. Therefore, using the concept of profitability improves the degree of comparability of the analysis.

Frontier efficiency methods have been applied to all significant lines of business as well as a wide range of countries. In addition, frontier efficiency methods have been used to investigate various economical problems. This includes risk management, market structures, organizational forms, and mergers. However, the same economic crisis results often differ across countries, activities, periods, and methods considered in different studies.

According to a study conducted by Eling and Luhnen (2010) on 95 past studies, 63 published articles and 32 working papers applied the frontier efficiency analysis to the insurance industry in 45 countries and used various methods to measure efficiency. These methods are separated into two approaches, specifically the parametric and the nonparametric approaches. The most used parametric approaches are the Stochastic Frontier Approach (composed error), Distribution Free Approach (different written error), and the Thick Frontier Approach, whereas for the nonparametric, the most commonly used are the Data Envelopment Analysis (DEA) and the Free Disposable Hull (Cummins et al., 1999; Cummins and Zi, 1998).

Among the methods, the two main ones that have been widely used in the literature to measure the efficiency of the insurance industry are Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) (Md. Saad, 2012).

A number of recent studies have sought to apply various techniques to estimate efficiency of family *Takaful* and life insurance institutions. Despite the considerable development of the family *Takaful* and life insurance institutions, there have seen very limited studies done focusing on the cost and optimized the efficiency using the stochastic frontier analysis (SFA) studies that compared the efficiency with conventional life insurance. Studies on these family *Takaful* is still lacking although several studies have been experienced on conventional life insurance, particularly in the US and Europe (Gustina and Abdullah, 2012).

The SFA which is also known as the Econometric Frontier Approach was proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and Broeck (1977). This technique specifies a practical shape for cost, earnings, or manufacturing courting amongst inputs, outputs, and environmental elements and lets in for random mistakes (Berger and Humphrey, 1997). The capabilities are used to estimate an organization's gap from the optimizing envelope (Seale Jr., 2000). In different words, the devices that deviate from the frontier won't be beneath neath control. Therefore, those research endorse that we must upload similarly random mistakes to the non-terrible random variable to version this inefficiency.

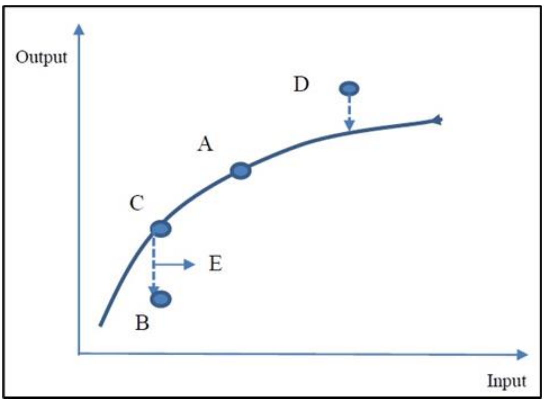


Figure 2. The Stochastic Production Frontier (Aigner et al. 1977: Meeusen and Broeck, 1977)

The primary benefit of this SFA technique is its capability to deal with technical inefficiency and any random shocks or dimension mistakes, which would have encouraged the established variables. This is the manufacturing output. This technique calls for a particular distributional shape for technical inefficiency and the ultimate random mistakes. Furthermore, to deal with technical inefficiency one by one, a rule of technological alternate is likewise required, with inside the shape of an era characteristic. It is usually assumed that technical inefficiency, which is non-terrible, follows a truncated ordinary, half-ordinary, or gamma distribution (Smith and Street, 2005). However, those are restrictive assumptions and can gift a first-rate undertaking to the effectiveness of this technique. For example, if the technological characteristic is misspecified, the cap potential of the method to split the results of technical inefficiency and the results of the ultimate random mistakes may be eliminated.

Figure 2 shows the case of a stochastic production curve using a simple production function. Point D is a technically efficient DMU with a positive stochastic part. Random errors do not include inefficiencies, and favorable external shocks contribute to higher output. On the other hand, point B is an inefficient case where the DMU operates at a technically inadequate point. Unlike the deterministic approach, the line segment BC can now be divided into BE and EC, corresponding to technical inefficiencies and the rest of the random error, respectively.

DEA, which is used in the study, is a nonparametric frontier analysis based on a production frontier generated without the need to parameterize the production function. This means that the production function may remain unknown, and there is no need to define its distributional properties either. The nonparametric methods are based on linear programming analysis, and they consider any deviation from the frontier as actual inefficiency (Alrashidi, 2015). One such non-parametric analysis is the Data Envelopment Analysis (DEA) or the mathematical programming approach which was introduced by Charnes, Cooper and Rhodes in 1978 and draws upon the efficiency concept in Farrell (1957) as can be seen in Figure 1. This method has been widely used to analyse and to study the productivity and/or efficiency of various fields like the education and academic industry, the financial industry, the logistics business, telecommunications, and other science and technology industries. The method has also been used for the insurance industry specifically the conventional life insurance industry. However, applications of the method in studies relating to family *Takaful* industry are less common.

DEA uses linear programming to measure the relationship of produced goods and services (outputs) to assigned resources (inputs). DEA determines the efficiency score as an optimization result. According to Charnes et al. (1978), DEA estimates efficiency under the assumption of constant returns to scale (DEA – CCR), while Banker et al. (1984), DEA – BCC assumed variable returns to scale and can be used to decompose cost efficiency into its single components—technical, pure technical, allocative, and scale efficiency.

DEA is a nonparametric approach that uses linear programming to construct an efficient boundary line that captures all combinations between a firm's inputs and outputs in a sample (Leong et al., 2003). The nonparametric approach does not account for errors as it does not imply a specific functional form for evaluating efficiency. The efficient combination of input and output is in the frontier (best practice), while the inefficient combination will be less than that. This is determined by the most efficient companies in the industry (Eling and Luhnen, 2010). DEA measures the relative performance of companies by comparing sets of inputs and outputs and developing benchmarks related to industry best practices based on the idea that widespread use can lead to increased productivity across industries (Barros et al., 2005). Performance indicators are typically standardized from 0 to 1, with the most (least) efficient companies assigned a value of 1 (0). The difference between the value assigned to the company and the value of 1 can be interpreted as the company's improvement potential in terms of performance (Cooper et al., 2007). Thus, this method is a benchmarking method in the sense that "best practice" companies are at the forefront and "catch" other underperforming companies (Neal, 2004). Previous insurance industry performance studies using DEA provided data for understanding the performance of the insurance industry in specific countries, such as studies analyzing insurance in the domestic market, such as the case of Berger et al. (1997), Cummins et al. (1999), Miador et al. (2000) and the insurance industry in Cummins and Weiss (2002), Cummins et al. (2010) and other countries such as Malaysia, Japan, Italy, UK, Australia, Spain, and Germany by Md Saad (2012), Fukuyama (1997), Cummins et al. (1996), Diacon (2001), Worthington and Hurley (2002), Cummins and RubioMisas (2001), and Mahlberg and Url (2010). In addition, Rees and Kessner (2000) and Diacon et al. (2002) analyzed the insurance industry in Da-Jang and conducted a study comparing the performance of insurance companies internationally in Europe.

Charnes et al. (1978) draw the DEA to the limits of excellence without specifying a manufacturing technique. Unlike traditional analytic methods that look for intermediate paths through a set of data waypoints, DEA directly identifies the best practice boundaries in the data. Using nonparametric linear programming techniques, DEA considers all inputs and outputs and differences in skill, capacity, competition, and demographics and then compares the individual to best practices (efficiency). According to Ali and Seyford (1993), DEA is a well-established nonparametric performance measure and has been widely used in more than 400 management science performance studies over the past decade.

Research Methods

For this study, the researcher uses the DEA, a non-parametric method in order to measure the family Takaful operators' and life insurers' efficiency in optimizing their solvency margin. These analyses were done using the computer software DEAP, which was developed by the University of New England, Australia.

As this study is exploring the optimization of solvency for family Takaful and life insurance in Malaysia, the generalized input-oriented Malmquist index, developed by Fare et al. (1989) are acknowledged in this study. The Malmquist index is built using the Data Envelope Approach (DEA) and evaluated using the DEAP version 2.1 of Coelli (1996). The Malmquist index was chosen because it has many desirable properties for this particular study. Not only do DEAs require input or output prices when plotting, but they are also instrumental in situations where this method is not available or does not exist at all by the public, nor does it require behavioral assumptions such as cost minimization or profit maximization. The producer's goals are different, unknown, or unattainable. It was first demonstrated by Fare et al. (1989) using the Malmquist geometric mean exponential formula. Forsund (1991) derived the decomposition of the simple version of the Malmquist productivity index into technical and efficiency change.

Consistent with Fare et al. (1994), this study uses an enhanced decomposition of the Malmquist index, decomposing the efficiency change component, calculated relative to constant turns to scale technology, into a pure efficiency component (computed relative to the variable returns to scale (VRS) technology) and a scale efficiency change component which captures changes in the deviation between the VRS and constant returns to scale (CRS) technology. The subset of pure efficiency change measures the relative ability of operators to convert inputs into outputs, while scale efficiency measures the extent to which the operators can take advantage of returns to scale by altering its size in the direction of the optimal scale.

Both the econometric and mathematical programming approaches have their advantages and disadvantages and there is no consensus as to which method is superior (Cummins and Zi, 1998; Hussels and Ward, 2006). In line with the study's objectives to assess solvency and efficiency of family Takaful operators and life insurers, the selected inputs included fees and commission expenses, underwriting risk and operating leverage. These inputs are the most pertinent to the objective of this research and have also been mentioned in DEA literature related to family Takaful and life insurance.

Fees and Commission Expenses: As there are Takaful operators that employ the Wakalah model in their operations, it is important to see how this input will affect the sustainability of the risk fund. Other studies that included fees and commission expenses in their analysis are Antonio et al. (2013), Md Saad and Idris (2011) and Md Saad et al. (2006).

Underwriting Risk: The underwriting risk can be observed by looking at the Combined Ratio which is derived from the benefits paid out over premium earned. It is important to see how this risk will affect the sustainability of the risk fund. Other studies that included underwriting risk in their analysis are Yakob et al. (2014a) and Yakob et al. (2014b).

Operating Leverage: Operating leverage can be defined as the net premiums written plus net liabilities over the policyholders' surplus. Other studies that included operating leverage in their analysis are Yakob et al. (2014a) and Yakob et al. (2014b).

These input data were extracted from annual reports of all the Takaful operators and insurers from 2010 until 2019. However, as data extracted from the annual reports were found not compatible for entry into the DEAP software, some adjustments were required (Sarkis, 2002). Thus, the inputs are obtained by calculation as per following formulae tabulated in Table 1.

For the purpose of this study, an excel spreadsheet was designed to be able to compute the required inputs after extracting the data from the annual reports to minimize human error before using these inputs to be entered into the DEAP software.

Table 1. Derivation of Input Measures from Annual Report Data

No	Input	Formula
1	Fees and Commission Expenses (FeesCommExp)	$\frac{Fees\ \&\ Commission\ Expenses}{Net\ Premium}$
2	Net Operating Leverage (NetLev)	$\frac{Net\ Premium}{Net\ Assets} + \frac{Total\ Liabilities}{Total\ Assets}$
3	Combined Ratio (CombRatio)	$\frac{Benefits\ Paid}{Net\ Premium}$

The two outputs chosen for this study which are solvency margin and net profit margin are explained below:

Solvency Margin: Solvency margin is an important output for this study as it is mainly how sustainability of the risk fund can be observed. For the *Takaful* and insurance industry, the solvency margin can be defined as net assets over net contributions (or premiums). Studies that have used solvency margin in their analysis include Sinha (2016), Yakob et al. (2014) and Lim, Oh and Zhu (2014).

Net Profit Margin: It is also important to observe net profit margin as a healthy figure would usually mean that the business would be sustainable in the long-run. Studies that have used net profit margin in their analysis include Lim, Oh and Zhu (2014), Batchimeg (2017) and Novickyt˙ and Droždz (2018).

This study utilizes data in the form of three inputs and two outputs to investigate efficiency of family Takaful and life insurance in Malaysia. The inputs are fees and commission expenses, net operating leverage and underwriting risk and the outputs are solvency margin and net profit margin. Data on inputs and outputs are collected from period of 2010 to 2019 (10 years). Initially, this research wanted to study the efficiency in terms of the solvency of family Takaful operators and life insurers after the IFSA 2013 had taken into effect. However, seeing that 5 years of data might be insufficient, the period was extended to 2010 when it was the earliest year of annual reports being made available online. Eventually, the selection was finalised based on data availability, and the selected inputs and outputs for the DEA application are presented in Table 2.

Table 2. Selected DEA Model Inputs and Outputs for the Research

Input	Output
Fees and Commission Expenses	Solvency Margin
Underwriting Risk	Net Profit Margin
Operating Leverage	

Results and Discussion

The results of the corresponding DEA frontier analysis provide an overview of the development of the family Takaful or life insurance sector in terms of sustainability. Consequently, the results may show how the efficiency scores of the obtained samples by the institutions changed during the period under consideration, and how the different institutions operate relatively to others.

Institutions with an efficiency score equal to 1 is considered to be the most efficient among the institutions. Institutions with efficiency scores less than 1 are deemed to be inefficient relatively. Table 3 shows the overall Technical Efficiency Scores (DEA – CCR Model) for family Takaful operators and life insurers 2010 – 2019. From the table, it can be observed that the overall technical efficiency of Great Eastern (GE) Takaful is the most efficient with an efficiency score of 0.899 whereas the least efficient is Syarikat Takaful Malaysia Berhad (STMB) with an efficiency score of 0.069. The most efficient life insurer is Great Eastern (GE) Life with an efficiency score of 0.897 and the most efficient family Takaful operator is from the same holding company, that is the Great Eastern Takaful with an efficiency score of 0.899. The least efficient life insurer is Etiqa Life Insurance Berhad with an efficiency score of 0.215 whereas the least efficient family Takaful is also the least efficient in the entire life or family segment which is Syarikat Takaful Malaysia Berhad (STMB) with an efficiency score of 0.069. However, it is mentioned that under the DEA – CCR model, the size of the DMUs is not accounted, thus the results from the DEA – BCC are considered.

Pure Technical Efficiency

As stated earlier, it is found that by considering the DEA – CCR model with the CRS assumption, the size of each DMU is not taken into account when assessing technical efficiency. Therefore, it seems that the CRS would be a too realistic assumption. When there is inefficiency, the DEA – CCR model is not capable of pinpointing whether the inefficiency is due to technical or scale inefficiency. Nevertheless, unlike the DEA – CCR which measures the overall technical efficiency, the DEA – BCC model has the capacity to decompose technical from scale efficiency and able to identify the most productive scale size for each DMU. Due to this reason, the DEA – BCC is a better model especially when providing policy recommendations such as the performance measures to encourage operations of the most productive scale size or the adjustment of performance outcomes in order to be able to control the scale differences.

Referring to Table 4 of Pure Technical Efficiency Scores for Family Takaful Operators and Life Insurers 2010 – 2019, it can be seen that out of the 25 institutions included in the study, only Great Eastern Life is found to be pure technically efficient as only it has an average pure technical efficiency APTE of 1. Since only 1 institution has an APTE of 1, observation will also be made for institutions having APTE more than 0.90. They are MCIS Zurich with APTE of 0.991, Great Eastern Takaful with APTE 0.958, SunLife Takaful with APTE 0.945, Allianz Life with APTE 0.913 and Prudential with APTE of 0.901. These institutions are defined as best practice or efficient frontier and thus form the reference set for inefficient institutions. These institutions' resource utilization is optimum specifically for Great Eastern Life and almost optimum for the other 4 institutions which are MCIS Zurich, Great Eastern Takaful, SunLife Takaful, Allianz Life and Prudential. In DEA terminology, these institutions are called peers and set an example for good operating practices for inefficient institutions to emulate.

As seen in the Table 4, the remaining 19 institutions have an APTE scores of less than 0.90 which means that they are technically inefficient. The results, thus, indicate a presence of marked deviations of the institutions from the best practice frontier. These inefficient institutions can be improved by reducing their efficiency inputs. APTE scores among the inefficient institutions are as follows in descending mean scores:

0.896 for Zurich Takaful,

0.893 for Axa Affin Life,

0.839 for Hong Leong Assurance,

0.800 for Prudential BSN Takaful,

0.767 for Tokio Marine Life,

0.756 for Hong Leong MSIG Takaful,

0.746 for Manulife,

0.733 for AIA Public Takaful,

0.715 for Zurich Life,

0.688 for AmMetLife,

0.675 for AIA,

0.654 for AmMetLife Takaful,

0.634 for Gibraltar,

0.471for Etiqa Life,

0.437 for Takaful Ikhlas

0.334 for Etiqa Takaful,

0.304 for Sun Life,

0.120 for Syarikat Takaful Malaysia Berhad

0.104 for FWD.

Out of these 19 inefficient institutions, the lowest is FWD Takaful with an efficiency score of 0.104 and the highest is Zurich Takaful with efficiency score of 0.896. This implies that FWD Takaful and Axa Affin Life can potentially reduce their current input levels by 89.6 percent and 10.4 percent respectively while leaving their output levels unchanged. This interpretation of APTE scores can be extended for other inefficient institutions in the sample. As a whole, it is observed that APTIE levels ranged from 10.4 percent to 89.6 percent among the inefficient institutions.

Scale Efficiency

Scale efficiency expresses how close an observed DMU is to the most productive scale size. The Technical Efficiency is obtained from the Overall

Technical Efficiency (OTE) scores under the DEA – CCR model which does not take into account of the scale effect whereas the Pure Technical Efficiency (PTE) is obtained from the scores obtained under the DEA – BCC model which has the variable returns-to-scale factorized. The relationship as observed from the formula above, depicts the sources of inefficiency, whether it is caused by inefficient operation or by the disadvantageous conditions displayed by the scale efficiency (SE) or by both.

Table 5 shows the Average Efficiency Scores for family Takaful and Life Insurance Institutions. The institutions which are almost scale efficient are: Allianz Life with ASE of 0.916, Axa Affin Life with ASE of 0.926, Sun Life with ASE of 0.902, Great Eastern Takaful with ASE 0.932 and Sun Life Takaful with ASE 0.939. These institutions can scale their inputs and outputs in a linear manner with minimal increment or decrement in efficiency.

For the scale inefficient institutions there are situations like FWD Takaful which has a low APTE score of 0.104 and a relatively high ASE score among the inefficient institutions of 0.834. This means that the overall inefficiency of FWD Takaful with AOTE of 0.078 is caused by inefficient operations rather than scale inefficiency. On the other hand, there are also situations like Prudential BSN Takaful which has a highly efficient APTE score of 0.800 and a low ASE score of 0.322. This can be interpreted to mean that the inefficiency of Prudential BSN Takaful is due to the inappropriateness of scale which overall will cause its efficiency to be low with AOTE score of 0.230.

Why Are Some Institutions on or Close to the DEA Frontier while Others Are Not?

As mentioned earlier, according to Charnes et al. (1978), the DEA frontier is the best-practice frontier and not the production frontier. This frontier is characterised as an excessive factor technique that assumes that if a company can produce a sure degree of output using precise enter levels, any other company of identical scale need to be able to do the same. The maximum green manufacturers can shape a `composite producer', permitting the computation of an green answer for each degree of enter or output. Where there may be no real corresponding company, 'digital manufacturers' are recognized to make comparisons (Berg, 2010). Thus, institutions on or close to the frontier are efficient or close to being efficient whereas institutions not on the frontier are less efficient.

Through the current research, Table 4 shows that out of the 25 institutions and 206 observations over the study period of 2010 until 2019, there are 93 instances where institutions appeared to be fully efficient, which means that their efficiency scores are equal to 100%. These institutions in each year together define the best practice frontier, and thus form the reference set. These can be supported by previous empirical studies for example by the one by Saad et al. (2006) and Ismail et al. (2017).

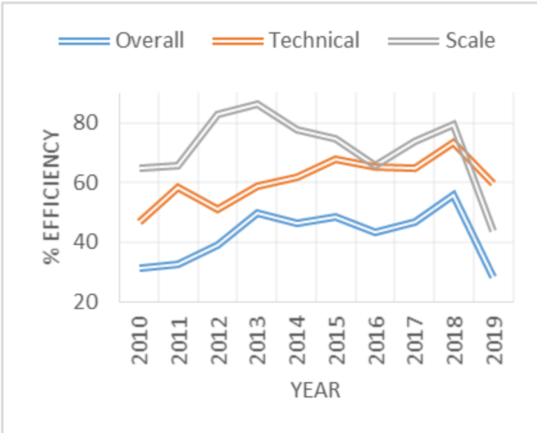
Efficiency between Family Takaful and Life Insurance

The relative efficiencies of institutions with varied types are also of importance and relevance, as *Takaful* operators and life insurers operate differently due to their different business modelling. The performance of these two different types institutions in terms of efficiency is presented in Figure 3 and their comparison is illustrated in Table 6.

The results demonstrate that family *Takaful* operators have experienced an increase in the average overall and pure technical efficiency from 2010 (AOTE= 31.3%; APTE= 46.8%) to 2018 (AOTE= 55.7%, APTE= 73.4%). However, in 2019, the performance of family Takaful falls to AOTE score of 28.4% and APTE score of 59.8%. For the life insurers, performance seems to be decreasing throughout from 74.6% in 2010 to 31.5% in 2019 for AOTE and 82.5% in 2010 to 69.3% in 2019 for APTE. It can be said that by year 2019, the family *Takaful* operators are closely at par with life insurers in terms of the average pure technical efficiency. A clear demonstration can be observed from Figure 4.

Significance of Results

In order to test the significance of the results obtained, a t-test was carried out on the data and the results are shown in Table 7. At $\alpha = 5\%$, with p-value less than 0.05, the results are significant. Thus, life insurance is more efficient than family Takaful.



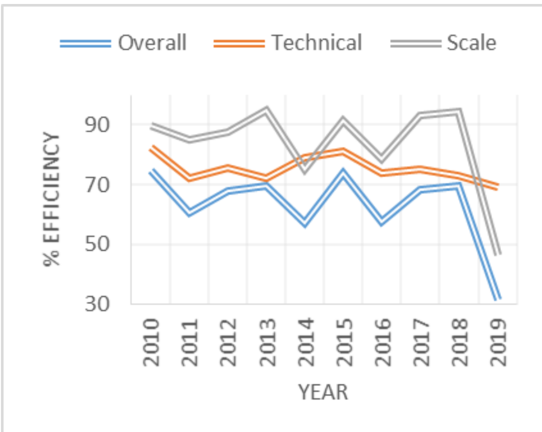


Figure 3 Efficiency of Family *Takaful* Operators and Life Insurers

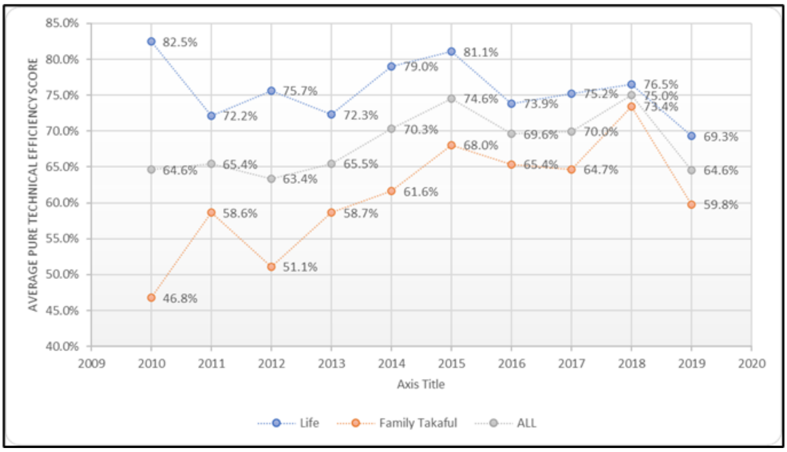


Figure 4 Pure Technical Efficiency between Family Takaful and Life Insurance

Table 3. Overall Technical Efficiency Scores (DEA – CCR Model) for Family *Takaful* Operators and Life Insurers, 2010 – 2019

Years / Institution	AIA (L1)	Allianz (L2)	AmMet Life (L3)	Axa Affin (L4)	Etiqa (L5)	Gibraltar (L6)	GE Life (L7)	Hong Leong (L8)	Manu life (L9)	MCIS (L10)	Prudential (L11)	Sun Life (L12)	TM Life (L13)	Zurich (L14)
2010	-	1.000	0.753	1.000	-	-	-	0.383	-	0.520	-	0.312	1.000	1.000
2011	0.454	1.000	0.547	1.000	0.179	-	0.949	0.547	0.509	0.522	-	0.286	0.883	0.390
2012	1.000	1.000	0.537	1.000	0.299	0.399	1.000	1.000	0.403	0.631	0.925	0.379	0.526	0.605
2013	0.451	1.000	0.507	0.763	0.303	0.478	1.000	1.000	0.753	1.000	0.980	0.173	0.943	0.415
2014	0.331	1.000	0.444	0.688	0.135	1.000	1.000	0.293	0.566	0.737	0.814	0.086	0.568	0.365
2015	0.659	1.000	0.754	0.774	0.302	0.751	1.000	0.846	0.977	0.785	0.625	0.219	0.637	1.000
2016	0.436	0.899	1.000	0.593	0.156	0.596	1.000	0.593	0.508	0.817	0.557	0.125	0.546	0.231
2017	0.677	1.000	0.317	0.817	-	0.295	1.000	0.906	0.694	1.000	1.000	0.267	0.605	0.328
2018	0.676	0.760	1.000	1.000	0.294	0.523	1.000	0.750	1.000	1.000	1.000	0.199	0.564	0.445
2019	0.682	0.103	0.084	0.671	0.051	0.188	0.126	0.090	0.445	0.172	0.320	1.000	0.429	0.049
Mean	**0.596**	**0.876**	**0.594**	**0.831**	**0.215**	**0.529**	**0.897**	**0.641**	**0.651**	**0.718**	**0.778**	**0.305**	**0.670**	**0.483**

Years / Institution	AIA Public *Takaful* (T1)	AmMetLife *Takaful* (T2)	Etiqa *Takaful* (T3)	FWD *Takaful* (T4)	GE *Takaful* (T5)	Hong Leong MSIG *Takaful* (T6)	Prudential BSN *Takaful* (T7)	Sun Life *Takaful* (T8)	STMB (T9)	*Takaful* Ikhlas (T10)	Zurich *Takaful* (T11)	Mean
2010	-	-	-	-	-	0.022	0.380	-	0.049	0.128	0.988	**0.580**
2011	0.073	-	0.141	-	-	0.514	0.323	0.869	0.054	0.110	0.532	**0.494**
2012	0.410	0.310	0.127	-	1.000	0.501	0.464	0.379	0.067	0.141	0.533	**0.568**
2013	0.390	1.000	0.132	0.072	1.000	0.326	0.378	0.826	0.105	0.272	1.000	**0.611**
2014	0.420	0.301	0.082	0.062	1.000	0.466	0.143	1.000	0.051	0.587	1.000	**0.526**
2015	1.000	1.000	0.094	0.097	0.505	0.362	0.178	1.000	0.101	0.282	0.726	**0.627**
2016	1.000	0.321	0.065	0.055	0.759	0.800	0.107	1.000	0.076	0.158	0.412	**0.512**
2017	1.000	0.440	0.114	0.047	0.929	0.691	0.139	1.000	0.085	0.270	0.409	**0.585**
2018	1.000	0.471	0.125	0.159	1.000	1.000	0.170	1.000	0.094	0.153	0.956	**0.654**
2019	0.273	0.055	0.027	0.052	1.000	0.341	0.013	1.000	0.012	0.130	0.224	**0.301**
Mean	**0.618**	**0.487**	**0.101**	**0.078**	**0.899**	**0.502**	**0.230**	**0.897**	**0.069**	**0.223**	**0.678**	**0.543**

Table 4. Pure Technical Efficiency Scores for Family *Takaful* Operators and Life Insurers, 2010 – 2019

Years	AIA (L1)	Allianz (L2)	AmMetLife (L3)	Axa Affin (L4)	Etiqa (L5)	Gibraltar (L6)	GE Life (L7)	Hong Leong (L8)	Manulife (L9)	MCIS (L10)	Prudential (L11)	Sun Life (L12)	TM Life (L13)	Zurich (L14)	LI Mean
2010	-	1.000	0.753	1.000	-	-	-	0.500	-	1.000	-	0.346	1.000	1.000	0.825
2011	0.525	1.000	0.572	1.000	0.176	-	1.000	0.607	1.000	1.000	-	0.296	1.000	0.485	0.722
2012	1.000	1.000	0.540	1.000	0.408	0.523	1.000	1.000	0.455	1.000	0.947	0.223	0.809	0.688	0.757
2013	0.497	1.000	0.510	0.843	0.303	0.486	1.000	1.000	0.765	1.000	1.000	0.217	0.995	0.509	0.723
2014	0.393	1.000	1.000	0.699	1.000	1.000	1.000	1.000	0.594	1.000	1.000	0.095	0.734	0.549	0.790
2015	0.680	1.000	1.000	0.841	0.342	1.000	1.000	1.000	0.995	0.910	0.703	0.227	0.651	1.000	0.811
2016	0.618	0.920	1.000	0.728	0.239	1.000	1.000	0.915	0.579	1.000	0.559	0.147	0.635	1.000	0.739
2017	0.677	1.000	0.323	0.910	-	0.295	1.000	1.000	0.703	1.000	1.000	0.268	0.605	1.000	0.752
2018	0.688	0.861	1.000	1.000	0.300	0.530	1.000	0.750	1.000	1.000	1.000	0.225	0.577	0.784	0.765
2019	1.000	0.349	0.185	0.910	1.000	0.235	1.000	0.613	0.621	1.000	1.000	1.000	0.659	0.135	0.693
Mean	0.675	0.913	0.688	0.893	0.471	0.634	1.000	0.839	0.746	0.991	0.901	0.304	0.767	0.715	0.758

Years	AIA Public *Takaful* (T1)	AmMetLife *Takaful* (T2)	Etiqa *Takaful* (T3)	FWD *Takaful* (T4)	GE *Takaful* (T5)	Hong Leong MSIG *Takaful* (T6)	Prudential BSN *Takaful* (T7)	Sun Life *Takaful* (T8)	STMB (T9)	*Takaful* Ikhlas (T10)	Zurich *Takaful* (T11)	FTO Mean	Overall Mean
2010	-	-	-	-	-	0.043	1.000	-	0.059	0.237	1.000	0.468	0.688
2011	0.074	-	0.208	-	-	1.000	1.000	1.000	0.059	0.350	1.000	0.586	0.668
2012	0.410	0.768	0.128	-	1.000	1.000	0.468	0.501	0.081	0.151	0.606	0.511	0.654
2013	0.614	1.000	0.132	0.075	1.000	0.397	0.768	1.000	0.106	0.360	1.000	0.587	0.663
2014	0.502	0.302	0.212	0.066	1.000	0.641	1.000	1.000	0.055	1.000	1.000	0.616	0.714
2015	1.000	1.000	0.108	0.099	0.660	1.000	1.000	1.000	0.129	0.489	1.000	0.680	0.753
2016	1.000	0.959	0.102	0.062	1.000	1.000	1.000	1.000	0.211	0.236	0.620	0.654	0.701
2017	1.000	0.513	1.000	0.050	1.000	1.000	0.345	1.000	0.092	0.379	0.735	0.647	0.704
2018	1.000	0.630	1.000	0.183	1.000	1.000	1.000	1.000	0.099	0.166	1.000	0.734	0.752
2019	1.000	0.059	0.120	0.194	1.000	0.477	0.420	1.000	0.308	1.000	1.000	0.598	0.651
Mean	0.733	0.654	0.334	0.104	0.958	0.756	0.800	0.945	0.120	0.437	0.896	0.691	0.691

Table 5. Average Efficiency Scores for Family *Takaful* and Life Insurance Institutions

Code	Institution	AOTE Score	APTE Score	ASE Score
L1	AIA	0.596	0.675	0.884
L2	Allianz Life	0.876	0.913	0.916
L3	AmMetLife	0.594	0.688	0.858
L4	Axa Affin Life	0.831	0.893	0.926
L5	Etiqa Life	0.215	0.471	0.654
L6	Gibraltar BSN Life	0.529	0.634	0.860
L7	Great Eastern Life	0.897	1.000	0.897
L8	Hong Leong Assurance	0.641	0.839	0.751
L9	Manulife	0.651	0.746	0.877
L10	MCIS	0.718	0.991	0.726
L11	Prudential Assurance	0.778	0.901	0.872
L12	Sun Life	0.305	0.304	0.902
L13	Tokio Marine Life	0.670	0.767	0.872
L14	Zurich Life	0.483	0.715	0.665
T1	AIA Public Takaful	0.618	0.733	0.860
T2	AmMetLife Takaful	0.487	0.654	0.783
T3	Etiqa Family Takaful	0.101	0.334	0.578
T4	FWD Takaful	0.078	0.104	0.834
T5	Great Eastern Takaful	0.899	0.958	0.932
T6	Hong Leong MSIG Takaful	0.502	0.756	0.665

T7	Prudential BSN Takaful	0.230	0.800	0.322
T8	Sun Life Takaful	0.897	0.945	0.939
T9	Syarikat Takaful Malaysia	0.069	0.120	0.753
T10	Takaful Ikhlas	0.223	0.437	0.614
T11	Zurich Takaful	0.678	0.896	0.753

Table 6. Annual Mean Efficiency Scores – Family Takaful versus Life Insurance

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Family *Takaful*	No	5	8	10	11	11	11	11	11	11	11
	AOTE	31.3	32.7	39.3	50.0	46.5	48.6	43.2	46.6	55.7	28.4
	APTE	46.8	58.2	51.1	58.7	61.6	68.0	65.4	64.7	73.4	59.8
	ASE	65.0	65.7	82.8	86.1	77.7	74.8	65.7	73.8	79.5	43.9
Life Insurance	No	8	12	14	14	14	14	14	13	14	14
	AOTE	74.6	60.6	67.8	69.8	57.3	73.8	57.6	68.5	69.5	31.5
	APTE	82.5	72.4	75.7	72.3	79.0	81.1	73.9	75.2	73.2	69.3
	ASE	89.8	85.1	87.5	95.1	75.4	91.4	78.8	93.1	94.6	46.5

Table 7. Reported T-test Results for Family *Takaful* versus Life Insurance, 2010 – 2019

t-Test Two-Sample Assuming Unequal Variance

	Family Takaful	Life
Mean	0.608138409	0.757708104
Variance	0.00610017	0.001716981
Observation	10	10
Hypothesized Mean Difference	0	
df	14	
t Stat	-5.349576	
P(T<=t) one-tail	5.12664E-05	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	0.000102533	
t Critical two-tail	2.144786688	

At $\alpha = 5\%$, with p-value less than 0.05, the results are significant. Thus, life insurance is more efficient than family *Takaful*.

Conclusion

When comparing between the family *Takaful* and life insurance, it is found that for family *Takaful* operators there is an increase in the average pure technical efficiency from the year 2010 of 46.8% to the year 2018 of 73.4%. The average pure technical efficiency however dropped to 59.8% in 2019 bringing down the overall average pure technical efficiency score for the period 2010 to 2019 to 69.1%. For life insurers, the average pure technical efficiency scores seem to be decreasing from 82.5% in the 2010 to 69.3% in the year 2019. Therefore, it can be seen that for the period from the year 2010 to 2019, the family *Takaful* operators' efficiencies seems to be improving, whilst the life insurers have become less efficient even though their efficiency score is higher than the family *Takaful* operators. However, in terms of the optimum size (i.e., scale), the results are reversed. This means that the family *Takaful* operators are still not at the optimum size but once they reach there, this could improve their efficiency substantially. However, for both family *Takaful* operators and life insurers, 2019 seems to dip their efficiency in terms of pure technical and also scale.

The results gained from the DEA – BCC model revealed that the average overall technical efficiency of all institutions attained is 54.3% during the research period of 10 years based on the inputs and outputs selected. Therefore, there are possibilities for increasing the level of technical efficiency by 45.7%. Nevertheless, the results demonstrate a steady increase in the mean up to the year 2018 being the highest level of 65.4% but then dropped significantly to 30.1%. Over this duration, out of 25 institutions, the number of efficient institutions increased from 4 to 10 from 2010 to 2018 and then dropped to 3 in 2019. The standard deviation of the overall technical efficiency is negatively correlated with the average overall technical efficiency over the period 2010 to 2019.

The empirical findings from the research have answered the uncertainty into whether there is empirical evidence to support the assumption that expenses and risks associated with family *Takaful* or life insurance can be lowered while improving the solvency and sustainability of the institution at the same time. The results have implied that in order to achieve a high level of performance, the inputs of fees and commission expenses, net leverage and underwriting risk have to be reduced. However, the reduction of each input variable varies from one year to another. The overall conclusion of the study is that the assessment of the of the solvency in *Takaful* and life insurance can be optimized if an effective method of which modelled professional practice and instituted deeper meaning and fair justification to operators and participants as a whole.

This research opens up a new way of measuring family *Takaful* and life insurance efficiency. Although the methodologies developed in this study are specific to the assessment of family *Takaful* and life insurance in Malaysia, they could be generalised to measure the levels of family *Takaful* and life insurance efficiency in general.

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