Evaluate operational performance and scale efficiency in non- life insurance companies in Egypt

By

Dr. Dina Talaat Hamdy Neel

Lecturer of Insurance, mathematics and statistics

Faculty of Business Administration, Horus University

dtalaat@horus.edu.eg

Scientific Journal for Financial and Commercial Studies and Research (SJFCSR)

Faculty of Commerce – Damietta University

Vol.6, No.1, Part 1., January 2025

APA Citation:

Neel, D. T. H. (2025). Evaluate operational performance and scale efficiency in non- life insurance companies in Egypt, *Scientific Journal for Financial and Commercial Studies and Research*, Faculty of Commerce, Damietta University, 6(1)1, 1351-1370.

Website: https://cfdj.journals.ekb.eg/

Evaluate operational performance and scale efficiency in non- life insurance companies in Egypt

Dr. Dina Talaat Hamdy Neel

Abstract

Efficiency is one of the company performance indicators, also is a relative indicator that reflects the results of a particular entity by comparing them with the results of other similar entities. Profitability is expressed through the values of indicators of the subject analysed. However, efficiency and profitability are important for insurance companies in terms of achieving their goals. The aim of this paper is to evaluate operational performance and scale efficiency in 12 Egyptian non-life insurance companies, for the period (2012-2022). This evaluation is done by non- parametric method Data Envelopment Analysis (DEA), with data of total expenditure and total assets as model inputs. Where both net profit after tax and total premiums are outputs. After applying DEA, performing Tobit regression analysis is to determine the factors which affect the efficiency of companies. The main finding of applying DEA is the varying in the operation systems in non- life insurance companies. For Tobit regression analysis shows that both BRANCHES and SIZE affect the scale efficiency, where the CAPITAL does not. In addition, the age of the company may not be an important determinant of efficiency.

Key words: Data Envelopment Analysis (DEA)- Tobit Regression analysis – Scale efficiency- Charnes, Cooper, and Rhode (CCR)- Banker, Charnes and Cooper (BCC).

1. Introduction

Insurance companies play an important role in financial services for the growth and development of every economy, also it is vital to ensure an efficient and competitive industry market. Efficiency is essential for insurance companies to stay profitable and maintain competitiveness in the market. The operations of insurance companies have an impact on the financial sector`s performance, while the government and banking sectors are crucial to the stability of the insurance sector.

Insurance companies need to develop plans and policies for underwriting and investment policies, to face their obligations to policyholders and stakeholders. The efficiency of insurance companies' performance depends on both underwriting and investments policies. also both surplus or deficit in insurance companies depends on these two activities.

Next table shows the development rates of (surplus or deficit) in non-life insurance companies in Egypt, for the period (2012-2022), for 12 insurance companies, CHUBB insurance is acquired ACE insurance since 2016.

Table1: Development rate of (surplus or deficit) in non-life insurance companies (2012-2012)

	years										
Company	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Misr Insurance	-	108.2	17.3	11.3	145.9	-95.7	1360.8	23.7	-14.1	129.3	0.5
Suez Canal Insurance	-	32.0	-9.5	12.4	4.9	50.0	45.5	-35.0	-51.2	-4.3	165.3
Mohandes Insurance co.	-	117.3	30.0	103.5	37.5	32.9	23.1	14.7	-15.0	17.0	16.2
Delta Insurance	-	60.1	-22.3	-7.3	172.5	-12.4	27.3	47.4	35.5	-6.0	35.5
AIG	-	202.6	-41.5	67.4	-101.9	2220.8	-456.0	-34.2	16.1	-21.7	-53.1
GIG	-	41.9	14.8	19.2	21.9	20.9	39.8	0.7	9.0	14.9	33.1
ACE Insurance - CHUBB since 2016	-	6.5	60.8	-3.2	75.9	-34.2	159.1	13.3	-32.0	19.3	10.2
Royal Insurance	-	76.5	42.9	31.1	17.2	-3.6	58.8	-2.9	7.5	57.8	6.1
Allianz Egypt	-	-30.4	115.5	15.9	23.7	97.6	-13.7	43.4	15.3	19.2	65.0
Egyptian Saudi Insurance House	-	-5.2	24.2	44.0	-4.3	68.0	-3.1	73.5	-26.1	-34.6	54.2
Boba Egypt	-	-322.1	184.5	24.6	162.8	-31.7	32.3	-7.7	-46.8	5.3	-183.2
Iskan Insurance Company	-	95.1	-38.7	182.9	21.5	1.2	80.8	32.0	-6.2	-39.1	54.0

Source: prepared by researcher based on insurance annual statistical book.

The table above shows variation in the annual results of companies, since all companies results show deficit, GIG company shows relative stability during the years of study. But from these results it requires studying the factors that affect the output of insurance activity, and the efficiency of insurance companies.

Actuarial models have a crucial role in measuring efficiency, the efficiency measurement focused on two approaches, the parametric (Stochastic Frontier Approach SFA, Distribution Free Approach DFA and the Thick Frontier Approach TFA. And non- parametric methods Free Disposable Hull FDH, and Data Envelopment Analysis DEA **(Sharew & Fentie, 2018),** since merging statistical and mathematical models offering comprehensive insights, the Data Envelopment Analysis (DEA) is one of these models. DEA model is a non-parametric method applied widely by previous researchers in measuring efficiency in insurance companies.

In the last decade, more studies have begun to address the issues of insurance companies' efficiency and the impact of various factors on this efficiency. according to**(Druva Kumar & J.P., 2024)** evaluated the performance of insurance companies by emerging trends incorporating advanced techniques like AI and ML, also addressing emerging trends in the insurance industry such as digital information, customer centricity and sustainability. Applied DEA model on 405 documents from 432 sources: web of science and Scopus academic databases for the period from 2010 to 2023. The study found significant geographical and sectoral differences in efficiency assessments, with higher efficiency levels found in developed markets such as North America and Europe compared to emerging markets in Asia and Africa. Also, a study found distinctive efficiency patterns between life and non - life insurance firms, influenced by factors such as product complexity and market competition.

Where **(Smętek et al., 2022)** demonstrated the use of Data Envelopment Analysis DEA to assess the financial effectiveness of insurance companies. Also explains the methodological assumptions and models (CCR & BCC) used in DEA. the paper also provides examples of using DEA in several countries and on dataset consists of financial data from many companies: Nigeria, Malaysia, Singapore, Indonesia, Serbia, Poland, and Slovakia.

Also, the study by **(Tuffour, J.K., Ofori-Boateng, K., Ohemeng, W., & Akuaku, J.K. 2021)** investigate the effectiveness of life insurance companies in Ghana, for the period from 2013 to 2017, applying panel regression and factors that affect cost and profit efficiency include price of labor, commission, gross premium, and net investment income. Using Efficiency Measurement System software to calculate efficiency scores, the main finding of this study was the significant of both cost and profit efficiency of life insurance are the price of labor, commission, gross premium, and net investment income. Improvements in both cost and profit efficiency have a statistically significant positive effect on the firm's Return on Assets (ROA).

Since **(Naushad et al., 2020)** determines the managerial effectiveness of 30 insurance businesses operating on the Saudi stock exchange using the (DEA) for the time period of 4 years from 2015 to 2018. Both traditional and Takaful insurance companies included within the businesses included in the study's sample.

The paper found that three companies are the most efficient in terms of managerial efficiency among 30 one analyzed, on other hand no company was found to have 0 or negative managerial efficiency.

(Jaloudi, M.M. 2019) evaluates the technical efficiency of 22 Jordanian insurance companies during the period 2000-2016 using DEA model. The results of this study found that there was a slight improvement in the technical efficiency between insurance companies each year. Also, the owners of insurance companies equity, size, and return on assets were important determinants of technical efficiency.

And **(Sharew et al., 2018)** uses DEA to evaluate the efficiency of insurance companies in Ethiopia. The aim of the study is to identify the factors that influence the effectiveness of insurance businesses. The paper dataset was panel data on the efficiency of insurance companies, a 10- year period from 2006-2015. The main result of the paper is that the size of the company at 95% confidence, the number of branches and efficiency score were significantly influencing each other.

In the light of determine the determinant of insurance companies **(Kozak, S. 2018)** examines Poland non -life insurance efficiency for the time period 2002-2016. In addition, identify the factors that affect their efficiency. The results of this study were the most companies had low efficiency, efficiency was positively impacted by higher gross written premiums, acquisition costs, profitability, average wages, and lower sector concentration.

(Derbali, A., & Jamel, L. 2018) investigates the effect of firm specific characteristics: size, leverage, tangibility, risk, growth, liquidity and age on the profitability of 8 Tunisian life insurance companies, the study period was from 2005 to 2015. Applying regression models on panel data shows that the variables: size, age and growth are the most important determinants of the insurance companies' performance. Since age and growth have a positive impact, the size has a negative impact. Where the other variables: leverage, Tangibility and liability risk are significant in relation to the performance of life insurance.

(Knežević et al., 2015) applies DEA to measure the efficiency of insurance companies in Serbia. The result of this paper summarized in evaluating the efficiency of insurance companies in their ability to cover the needs of potential and existing clients. Also, the efficiency of the insurance companies assessed in terms of their ability to adapt their strategies to the current market conditions and their own capabilities.

(Biener et al., 2011) illustrates the measurement of microinsurance programs performance and derive implications for viable provision of 20 microinsurance programs. The main result of this study is that DEA method can integrate the crucial social impact that micronsurers and deliver significant managerial perspectives. Also, this study illustrates Recent improvements in the efficiency literature incorporate the bootstrapping of efficiency scores and a reduced regression analysis of efficiency variables.

Based on all the above, insurance companies face challenges in operational efficiency and scale efficiency in the cases of constant changes in markets and technology. So that the problem of this paper is need for studying the efficiency of Egyptian non- life insurance companies and analyze and identify the factors which affecting it`s efficiency using advanced models.

2. Paper objectives

The goal of this paper is:

1. evaluate the relative efficiency of 12 non- life insurance companies in Egypt for the period 2012-2022 using DEA model.
2. Determine the factors which affect the efficiency of companies using Tobit regression analysis.

3. Importance of paper

The importance of the paper stems from the role of insurance in the national economics, this importance may be summarized as follows:

1. Scientific importance in understanding of the relationship between operational efficiency and the factors influencing it in the Egyptian non-life insurance sector.
2. Help insurance companies determine strength and weakness points which affect operational system.
3. Providing recommendations based on scientific analysis to decision makers in the insurance sector.
4. Enhancing the efficiency of insurance companies has a vital role in increasing the financial stability of the insurance sector, which has a positive impact on the national economy.

4. Methodology

The aim of this paper is to study the effect of factors on scale efficiency using DEA, then perform a Tobit regression analysis by making the value of the efficiency level from the first stage as the dependent variable, while external factors as the independent variable. The purpose of this stage is to find out whether certain exogenous factors seem to be influencing company efficiency.

The scope of this paper is 12 Egyptian non -life insurance, for the period (2012-2022) using data from statistical annual insurance book. The methodology is organized as follows:

1. Data Envelopment Analysis DEA.
2. Tobit regression.
3. Applied study.

1. Data Envelopment Analysis DEA

Data Envelopment Analysis (DEA) is a method which is used to measure efficiencies of decision-making units (DMUs) with multiple inputs and outputs. It evaluates weights to the inputs and outputs by assigning the maximum efficiency score for a DMU under evaluation.

DEA methodology is a linear programming model. Widely applied in Operations Research (OR), and economics for the estimation of production frontier. What makes the DEA a good choice of methodology to use is the option to include and simultaneously analyze.

What follows are the fundamental DEA models for evaluating technical efficiency.

a. Overall Technical Efficiency.
b. Pure Technical Efficiency.
c. Scale Efficiency/Scale Efficiency (SE) Ratio.

a. Overall Technical Efficiency (CCR)

This approach illustrates the number of inputs that could be reduced with no impact on
the *output* levels of a decision-making unit (insurance company) in this paper. In this case the overall technical efficiency is done using the Charnes, Cooper, and Rhode (CCR) DEA model, taking into consideration the Constant Return to Scale (CRS) assumption. The type of model is **(Sharew et al., 2018)**

$$Max\ E_m = \sum_{j=1}^{J} V_{jm}\ Y_{jm} \qquad (1)$$

Subject to

$\sum_{j=1}^{J} V_{jm}\ Y_{jm} - \sum_{i=1}^{I} U_{im}\ X_{in} \leq 0,$ for all I (2)

Where:

- $\sum_{i=1}^{I} U_{im}\ X_{im} = 1$ to shift from ratio to linear programming.
- E_m: Technical efficiency of the m[th] decision-making unit (DMU).
- Y_{jm}: j[th] *output* of m[th] decision making unit (DMU).
- X_{im}: i^{th} *input* of m^{th} decision making unit (DMU).
- U_{im}: the weight of i^{th} input of m^{th} decision making unit (DMU).
- $V_{jm}, U_{im} \geq 0; i = 1,2,..,I\ ; j = 1,2,..,J$

b. Pure Technical Efficiency (BCC)

Shows the severity of overall inefficiency brought on by waste of resources or managerial mistakes that do not consider scale. This model measure efficiency by using the ***Banker, Charnes and Cooper (BCC)*** DEA model which supposes the ***Variable Return to Scale (VRS)*** Consider considering the variations in scale sizes of businesses. The model is:

$$Min\ \theta m$$

Such that $Y\lambda \geq Y_m\ ,\quad X\lambda \leq \theta X_m$

Where:

- $\lambda \geq 0;\ \theta m$ is free or unconstrained.
- $\sum_{n=1}^{N} \lambda_n = 1$; by adjusting CRS, this convexity limitation is added for VRS.
- $Y =$ vector of all DMUs and Microfinance institutions outputs.
- $Y_m =$ is the output of the m^{th} DMU, which is the standard DMU.
- $\theta =$ the dual variable that normalizes the weighted sum inputs and represents the equality condition.
- $\lambda =$ the dual that corresponds to additional primal inequality constraints (CCR method)

c. Scale Efficiency/Scale Efficiency (SE) Ratio.

The degree of all inefficiency resulted due to an incorrect choice of scale of an insurance company's operations is measured by scale efficiency (SE). The scale efficiency of the companies is estimated by dividing the efficiency scores of the institutions obtained using the CCR model in (a) the BCC scores in (b) dividing the TE of CRS by the TE of

VRS ($SE = TECRS \div TEVRS$). The equation is:

$$Scale\ Efficicncy = \frac{CCR\ efficiency}{BCC\ efficiency} \qquad (3)$$

2. Tobit regression

Variable y^* is assumed to follow a linear regression model of the form **(Frees, 2009):**

$$y_i^* = x_i'\beta + \varepsilon_i \qquad (4)$$

Where:

- β: the regression coefficients, which interpret as the marginal change of $E\ y^*$ per unit change in each explanatory variable.
- $Var\ \varepsilon_i = \sigma^2$: the variability term

The responses are censored or "limited" in the sense that we observe $y_i = \max(y_i^*, d_i)$, where:

d_i: limiting value and a known amount.

To interpret marginal changes, assume that latent variable y_i^* is normal or equivalent for the disturbance ε_i, so the standard calculations show that:

$$E\ y_i = d_i + \Phi\left(\frac{x_i'\beta - d_i}{\sigma}\right)(x_i'\beta - d_i + \sigma\lambda_i) \qquad (5)$$

Where:

$$\lambda_i = \frac{\phi((x_i'\beta - d_i)/\sigma)}{\Phi((x_i'\beta - d_i)/\sigma)} \qquad (6)$$

Both $\phi(\cdot) and\ \Phi(\cdot)$ are the distribution function and the standard normal density, respectively. An *inverse Mills ratio* is the ratio of a probability density function to a cumulative distribution function. For large values of $((x_i'\beta - d_i)/\sigma)$, λ_i is close to 0 and $\Phi((x_i'\beta - d_i)/\sigma)$ is close to 1, this interpret as for large values of the systematic component $x_i'\beta$ the regression function $E\ y_i$ has a capacity to be linear, and conventional interpretations are applicable. Equation (4) demonstrates how a regression function differs considerably from the standard linear regression function if the analyst ignores the effect of censoring.

In this paper, Tobit applied model employed and estimated following **(Sharew et al., 2018)**

$$CEFF_{it} = \beta_1 + \beta_2(SIZE_{it}) + \beta_3(BRANCH_{it}) + \beta_4(AGE_{it}) + \beta_5(CAPITAL) + U_{it} \qquad (7)$$

Where:

- t: year.
- i: Insurance company.
- CEEF: The efficiency rankings recorded during the study's initial phase. is the dependent variable measure varies between (0 to 1).
- β_1: Intercept terms are constant.
- $\beta_2 - \beta_5$: coefficients.
- U_{it}: error term.

In the model the explanatory (independent variables). This was integrated in the Tobit regression analysis.

are:

1. (SIZE)- Economies of scale: total assets used as proxy for company size.
2. (CAPITAL) capital structure/ Financial leverage, leverage Ratio= Total Liabilities÷Total Assets. Financial ratio expressed as proportion of a company's debt-financed assets.
3. (BRANCHES) Branches, number of branches.
4. (AGE). Measured as the number of years from establishment date.

3. Applied study

Applied study of this paper is carried out in two steps first, Data Envelopment Analysis, and second is Analysis of efficiency determinants as follows:

3.1. Data Envelopment Analysis (DEA)

This section about apply the total technical efficiency of the insurance companies is calculated using (CCR), (BCC) and (scale efficiency) as follows:

3.1.1. Definition of inputs and outputs

The first step to measure the efficiency of decision-making units is identify appropriate input and output variables. The data for this study are from the annual insurance statistical book for years (2012-2023), on 12 non- life insurance companies. next table summarize the input and output for applying DEA:

Table 2: Input and output of DEA model

Input	Output
Total expenditure (X_1)	Net profit after tax (Y_1)
Total assets (X_2)	Total premiums (Y_2)

As mentioned before, in this paper 12 insurance companies operated in Egypt, were selected as DMU to assess their respective input and output performance. Next table shows the DMU`s.

Table 3: Decision Making Units DMU`s

Decision Making Units DMU`s	Company Name
DMU1	Misr Insurance
DMU2	Suez Canal Insurance
DMU3	Mohandes Insurance co.
DMU4	Delta Insurance
DMU5	AIG
DMU6	GIG
DMU7	ACE Insurance - CHUBB since 2016

Decision Making Units DMU`s	Company Name
DMU8	Royal Insurance
DMU9	Allianz Egypt
DMU10	Egyptian Saudi Insurance House
DMU11	Boba Egypt
DMU12	Iskan Insurance Company

The following table shows results of efficiency scores based on constant returns to scale.

Table 4: CCR Efficiency Scores (2012-2022) output oriented.

	years												
DMU`s	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	AVG	Rank
DMU1	0.466262	1	0.612058	0.614141	0.63331	0.59319	0.639385	0.590861	0.633227	0.63445	0.594703	0.637417	9
DMU2	0.549268	0.615978	1	0.74741	0.704147	0.742417	0.721896	0.633848	0.713578	0.630739	0.591197	0.695498	7
DMU3	0.555189	0.540115	0.583123	0.65907	0.665664	0.626839	0.601151	0.621897	0.614799	0.642297	0.663999	0.615831	10
DMU4	0.672077	0.110181	0.675491	0.710693	0.735297	0.812847	0.873053	0.904401	0.978992	0.923005	0.981849	0.761626	4
DMU5	0.739399	0.710205	0.377749	0.41223	0.515596	0.234043	0.50063	0.46228	0.650517	0.743945	0.775868	0.556587	11
DMU6	0.650036	0.860244	0.753028	0.743088	0.703053	0.679855	0.667673	0.667781	0.727515	0.708767	0.697182	0.714384	5
DMU7	0.622709	0.461647	1	0.441258	0.74711	0.206223	0.302265	0.375686	0.311528	0.369968	0.280615	0.465364	12
DMU8	0.767721	0.795765	0.79047	0.780756	0.78245	0.774284	0.725738	0.725681	0.846424	0.900319	0.982838	0.806586	2
DMU9	0.649667	0.68346	0.730573	0.699475	0.885352	0.904737	0.962314	0.881881	0.840497	1	1	0.839814	1
DMU10	0.737364	0.727535	0.774483	0.769343	0.720299	0.571977	0.863011	0.831567	0.814279	0.770158	0.87263	0.768422	3
DMU11	0.627318	0.700092	0.709897	0.609949	0.628241	1	0.750901	0.727346	0.668325	0.694282	0.720845	0.712472	6
DMU12	0.758063	0.825271	0.580417	0.40383	0.463255	0.62977	0.574281	0.495146	0.527374	0.85899	0.899624	0.63782	8

Source: prepare by researcher based on R program output.

As shown in the table above, DMU1 was CCR efficient only in (2013). DMU2 was CCR efficient only in (2014). DMU3, DMU4, DMU5, and DMU6 were insufficient in all years. DMU7 was CCR sufficient only in (2014). DMU8 was insufficient in all the years. DMU9 was sufficient in both 2021 and 2022. DMU 10 was insufficient in all years. DMU11 was sufficient only in 2017. DMU12 was insufficient in all years.

In terms of *average efficiency score***,** none of the decision-making units was perfectly efficient for the period of study. But the decision-making units could increase their output on average by (36.3%, 30.5%, 38.4%, 23.8%, 44.3%, 28.6% 53.5%, 19.3%, 16% 23.2%, 28.8% and 36.2%) respectively.

Now, the decision-making units' efficiency ratings on the variable returns scale are shown in the following table. When ideal scenarios (constant returns scale) aren't achievable, a variable returns scale may be used.

Table 5: BCC Efficiency Scores (2012-2022)

	years												
DMU`s	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	AVG	Rank
DMU1	0.504817	1	0.785442	0.830704	0.926135	0.90956	1	1	0.970999	1	1	0.902514	1
DMU2	0.602258	0.662472	1	0.773406	0.725255	0.754072	0.733961	0.646535	0.724983	0.641396	0.603743	0.71528	10
DMU3	0.646833	0.627931	0.660687	0.72529	0.705866	0.651253	0.61583	0.623995	0.635573	0.663068	0.672562	0.657172	11
DMU4	0.763518	0.359745	0.768607	0.796017	0.780948	0.85636	0.908579	0.925636	0.985032	0.926383	0.984688	0.823229	5
DMU5	0.818945	0.784962	0.461176	0.447516	0.57284	0.294486	0.565276	0.517134	0.679889	0.902561	0.895688	0.630952	12
DMU6	0.712484	0.925373	0.805718	0.768775	0.712739	0.687196	0.672481	0.672541	0.730919	0.710549	0.707744	0.736956	9
DMU7	1	0.968151	1	0.955825	1	0.732768	0.9903	0.894307	0.850707	0.740708	0.545202	0.879815	2
DMU8	0.841353	0.869072	0.843883	0.826919	0.817634	0.799872	0.753281	0.744172	0.857441	0.905919	1	0.841777	4
DMU9	0.734299	0.75154	0.791779	0.756064	0.924426	0.924048	0.96809	0.889775	0.843181	1	1	0.8712	3
DMU10	0.848655	0.820177	0.865023	0.842074	0.729502	0.609894	0.905158	0.867602	0.838793	0.792192	0.892573	0.81924	6
DMU11	0.688193	0.752305	0.756674	0.652544	0.649929	1	0.767809	0.743754	0.680219	0.705738	0.724586	0.738341	8
DMU12	1	1	0.695917	0.609259	0.621296	0.727513	0.659052	0.569009	0.601335	0.976569	0.984594	0.767686	7

Source: prepare by researcher based on R program output.

From the above table, could consider that DMU1 (Misr Insurance which is governmental sector) was best insurance in terms of gross written premium and net profit after tax. DMU2 was efficient only in 2014. DMU3, DMU4, DMU5, and DMU6 were not efficient for all years. DMU7 was efficient in (2012, 2014, and 2016) DMU8 efficient in 2022 only. DMU9 efficient in both (2021 & 2022). DMU10 is not efficient in all years. DMU11 was efficient only in 2017. DMU12 was efficient in both (2012 &2013). On average also, could consider that only DMU1 almost efficient.

The section following this one concern insurance firms' SE. Hence TE measures calculated under the assumptions of constant returns to scale (CRS) and variable returns to scale (VRS) can be evaluated to obtain (SE). Overall technical efficiency (OTE), which evaluates inefficiencies brought on by the input/output system, is represented by the TE measure in relation to the CRS assumption also the size of operations. Next table presents the scale efficiency in numbers range between 0 and 1.

Table 6: Scale Efficiency (2012-2022)

	years												
DMU`s	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	AVG	Rank
DMU1	0.923626	1	0.779253	0.739302	0.683821	0.652172	0.6393846	0.590861	0.6521397	0.63445	0.594703	0.717247	11
DMU2	0.912014	0.9298175	1	0.966387	0.683821	0.984545	0.9835622	0.980377	0.9842682	0.983384	0.979221	0.944309	1
DMU3	0.85832	0.8601504	0.882602	0.908699	0.683821	0.962512	0.9761643	0.996637	0.9673144	0.968675	0.987269	0.913833	6
DMU4	0.880238	0.3062744	0.878851	0.892812	0.683821	0.949188	0.9608995	0.977059	0.9938683	0.996354	0.997117	0.865135	8
DMU5	0.902867	0.9047634	0.8191	0.921151	0.683821	0.794752	0.8856395	0.893926	0.9567992	0.82426	0.866225	0.859391	9
DMU6	0.912351	0.9296185	0.934604	0.966586	0.683821	0.989317	0.992851	0.992922	0.9953434	0.997492	0.985077	0.943635	2
DMU7	0.622709	0.4768333	1	0.461651	0.683821	0.281431	0.3052258	0.420086	0.3661992	0.499478	0.514699	0.512012	12
DMU8	0.912484	0.9156499	0.936706	0.944175	0.683821	0.968009	0.9634359	0.975152	0.9871511	0.993818	0.982838	0.933022	5
DMU9	0.884744	0.9094131	0.922698	0.925153	0.683821	0.979101	0.9940337	0.991129	0.9968177	1	1	0.935174	4
DMU10	0.868862	0.8870473	0.895332	0.913629	0.683821	0.93783	0.9534364	0.958466	0.9707747	0.972186	0.977656	0.910822	7
DMU11	0.911544	0.9305957	0.938181	0.934725	0.683821	1	0.9779784	0.977938	0.9825146	0.983768	0.994838	0.937809	3
DMU12	0.758063	0.8252707	0.834031	0.662822	0.683821	0.865647	0.8713741	0.87019	0.877006	0.8796	0.913701	0.821957	10

Source: prepare by researcher based on R program output.

So, the table shows that DMU1 was efficient at 2013, where for all years the DMU1 need to be insufficient. DMU2 was efficient in 2014, and all years were insufficient. For DMU3, DMU4, DMU5, DMU6, DMU8, and DMU10, all years the DMU`S insufficient. DMU7 was sufficient at 2014, but not all years. DMU9 both 2021 and 2022 are sufficient, where all years the DMU`s not. DMU11 sufficient only in 2017, all years not. DMU12, insufficient all years.

But the important point in Scale efficiency is the interpretation the relation between BCC and CCR, since this relation classify DMU`s according to its size. The following table presented scale efficiency interpretation for all DMU` s by years.

Table 7: Scale Efficiency interpretation

	DMU`s	DMU1	DMU2	DMU3	DMU4	DMU5	DMU6	DMU7	DMU8	DMU9	DMU10	DMU11	DMU12
years	2012	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	DRS
	2013	Optimal Scale	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	DRS
	2014	IRS	Optimal Scale	IRS	IRS	IRS	IRS	Optimal Scale	IRS	IRS	IRS	IRS	IRS
	2015	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS
	2016	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS
	2017	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	Optimal Scale	IRS
	2018	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS
	2019	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS
	2020	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS
	2021	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	Optimal Scale	IRS	IRS	DRS
	2022	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	Optimal Scale	IRS	IRS	DRS

Source: prepare by researcher based on R program output.

The table presents three cases summarize as follows:

- $BCC = CCR$: presents optimal Scale, it means the DMU operates at the most productive scale size.
- $BCC > CCR$: presents Increasing Returns to Scale (IRS). Which means the DMU needs to increase it is size would improve efficiency, and the DMU operates less than its optimal scale.
- $BCC < CCR$: presents Decreasing Returns to scale (DRS). Which means that DMU should reduce its size to improve efficiency, also its operates above its optimal scale.

So, the table shows that for DMU1 the optimal scale was at 2013, where for all years the DMU1 need to increase it s size to improve efficiency. DMU2 was optimal at 2014, were all years need to increase it is size to improve efficiency. For DMU3, DMU4, DMU5, DMU6, DMU8, and DMU10, all years the DMU`S need to increase it is size to improve efficiency. DMU7 was optimal at 2014, but all years IRS. DMU9 both 2021 and 2022 are operates at the most productive scale size, where all years the DMU`s has IRS. DMU11 is optimal only in 2017, all years IRS. DMU12, 2012,2013, 2021,2022 shows that DMU needs to reduce its size to improve efficiency.

After applying Scale Efficiency, and since the aim of this paper is to determine the factors which affect scale efficiency. The next step is analysis of efficiency score and selected independent variables.

3.2. Analysis of efficiency score by Tobit regression

This section for applying Tobit regression analysis (censored regression model) to determine factors related to the relative efficiency score of insurance companies. As mentioned before, the dependent variables are the scale efficiency scores of the insurance companies. The independent variables are:

1. (SIZE)
2. (CAPITAL)
3. (BRANCHES)
4. (AGE)

The data extracted and modified from the annual statistical insurance book from (2012-2022). The following table shows the Tobit regression.

Table 8: Tobit regression output

Observations:	Log-likelihood: 11.46 on 6 Df
Total: 12	Wald-statistic: 8.697 on 4 Df (p-value: 0.069149)
Left-censored: 0	Scale: 0.09313
Uncensored: 12	Gaussian distribution
Right-censored: 0	Number of Newton-Raphson Iterations: 5

Variable	*Estimate*	*Std. Error*	*z value*	*Pr(>|z|)*
Intercept	-0.634342	0.822618	-0.771	0.44063
BRANCHES	-0.008062	0.003497	-2.305	0.02116
CAPITAL	-0.747077	0.745556	-1.002	0.31632
SIZE	0.388346	0.143265	2.711	0.00671
AGE	0.001019	0.003446	0.296	0.76737
Log(scale)	-2.373733	0.204124	-11.629	< 2e-16

Source: prepare by researcher based on R program output.

From the table above the analysis is:

1. Branches have a negative effect on Scale score efficiency, significant ($p = 0.02116$)
2. Capital has no significant impact on Scale score efficiency, ($p = 0.31632$)
3. Size significant, and has positive effect on scale score efficiency ($p = 0.00671$)
4. Age with ($p = 0.31632$) has no significant impact on scale score efficiency.

From the above all 12 data points are uncensored, with none at the lower or upper limit. And significant predictors both Branches (negative) and Size (positive) have significant effects on Scale score efficiency. Since age not significant, and its inclusion adds unnecessary complexity.

According to previous analysis, detect that age has no significant impact on scale score efficiency, next step is repeat analysis without Age predictor.

Table 9: Tobit regression output without Age predictor

Observations:
- Total: 12
- Left-censored: 0
- Uncensored: 12
- Right-censored: 0

Log-likelihood: 11.41 on 5 Df
Wald-statistic: 8.547 on 3 Df (p-value: 0.035966)
Scale: 0.09347
Gaussian distribution
Number of Newton-Raphson Iterations: 5

Variable	*Estimate*	*Std. Error*	*z value*	*Pr(>|z|)*
Intercept	-0.665897	0.818641	-0.813	0.41598
BRANCHES	-0.007341	0.002518	-2.915	0.00356
CAPITAL	-0.683441	0.716445	-0.954	0.34012
SIZE	0.386163	0.143596	2.689	0.00716
Log(scale)	-2.3701	0.204124	-11.611	< 2e-16

Source: prepare by researcher based on R program output.

The table shows that Tobit analysis is:

1. Branches still have significant negative effect $(p = 0.0356)$
2. Size still has significant positive effect $(p = 0.00716)$
3. Capital with $(p = 0.34012)$ still not significant.

5. Conclusion:

In this paper three models of DEA analysis applied on 12 non- life insurance companies, the time duration (2012-2021). The results show for the first model CCR, that DMU9 (Allianz Egypt) is the best efficiency company, since DMU7 (ACE Insurance) is the last one. For BCC, DMU1 (Misr Insurance) is the best efficiency company with higher average, while DMU5 (AIG) is the last order which means that this company insufficient. For SE ratio the last method the first sufficient company order is for DMU7 (Suez Canal Insurance), and the last order DMU7 (ACE Insurance). These results clarify the varying in the operation systems in non- life insurance companies.

Tobit regression analysis shows that for both models (with age predictor& without age predictor), Branches are consistently negative and significant, which may explain that an increase in the number of branches might reduce scale efficiency score. Since size is consistently positive and significant, this indicates that larger companies may have higher scale efficiency score

according to better resources allocation. For capital non-significant in both models, which means that capital investment alone does not directly influence efficiency. But age predictors have no significant and do not improve model fit and have no effect on Scale Score efficiency, which indicate that age of company may not be important determinant of efficiency.

In addition, model 2 is better because it provides better fit with Wald-statistics ($p = 0.035966$). fewer predictors after excluding age. Stability of significant effects for branches and size.

6. Recommendation

- Do more research with different output and input to study the effect of it is on performance of companies which change the efficiency of companies.
- Incorporate dynamic models to examine how efficiency changes over time and evaluate temporal consequences.
- Smaller insurance companies should rely on sustainable growth strategies like expanding product lines, study the effect of merging.
- Leverage economics of scale by risk management systems.
- Study releases new types of insurance policies which encouraging use technologies to reduce operational costs.

References

- Anandarao, S., Durai, S. R. S., & Goyari, P. (2019). Efficiency decomposition in two-stage data envelopment analysis: an application to life insurance companies in India. *Journal of Quantitative Economics*, *17*, 271-285.
- Biener, C., & Eling, M. (2011). The Performance of Microinsurance Programs: A Data Envelopment Analysis. *Microeconomics: Decision-Making under Risk & Uncertainty eJournal*.
- Derbali, A., & Jamel, L. (2018). Determinants of performance of Tunisia insurance companies: case of life insurance. *International Journal of Productivity and Quality Management, 24*, 531-542.
- Frees, E. W. (2009). *Regression modeling with actuarial and financial applications*. Cambridge University Press.
- Fotova Cikovi´c, Katerina, ˇ Violeta Cvetkoska, and Mila Mitreva. (2024). Investigating the Efficiency of Insurance Companies in a Developing Country: A Data Envelopment Analysis Perspective. *Economies* 12: 128. https://doi.org/10.3390/ economies12060128

- Jaloudi, M.M. (2019). The efficiency of Jordan insurance companies and its determinants using DEA, slacks, and logit models. *Journal of Asian Business and Economic Studies*.
- 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*, 307-344.
- Kozak, S. (2018). Efficiency of Non-life Insurance Companies and its Determinants. *Acta Scientiarum Polonorum. Oeconomia*.
- K. S. Druva Kumar and Senthil Kumar J. P. (2024). Efficiency assessment and trends in the insurance industry: a bibliometric analysis of DEA application. *insurance Markets and Companies,* 15(1), 83-98. Doi: **10.21511/ins.15(1).2024.07.**
- Knežević, S., Marković, M., & Brown, A. (2015). Measuring the efficiency of Serbian insurance companies. *Acta Oeconomica, 65*, 91-105.
- Smętek, K., Zawadzka, D., & Strzelecka, A. (2022). Examples of the use of Data Envelopment Analysis (DEA) to assess the financial effectiveness of insurance companies. *International Conference on Knowledge-Based Intelligent Information & Engineering Systems*.
- Sharew, A., & Fentie, G. (2018). Data Envelopment Analysis on Efficiency of Insurance Companies in Ethiopia. *American Scientific Research Journal for Engineering, Technology, and Sciences, 48*, 138-170.
- Tuffour, J.K., Ofori-Boateng, K., Ohemeng, W., & Akuaku, J.K. (2021). Life Insurance Companies: Determinants of Cost Efficiency and Profitability. *Journal of Accounting, Business and Management (JABM)*. Naushad, M., Faridi, M.R., & Faisal, S. (2020). Measuring the Managerial Efficiency of Insurance Companies in Saudi Arabia: A Data Envelopment Analysis Approach. *Journal of Asian Finance, Economics and Business, 7*, 297-304.

Dr. Dina Talaat Hamdy Neel

تقييم الكفاءة التشغيلية وكفاءة الحجم في شركات التأمينات العامة في سوق التأمين المصري

ملخص:

تعد الكفاءة أحد أهم المؤشرات لأداء الشركة، حيث إنها تعتبر مؤشر نسبي يعكس كفاءة نتائج أداء شركة معينة مقارنة بنفس هذه النتائج في شركة أخرى. ويتم التعبير عن الربحية من خلال قيم مؤشرات الشركة موضوع التقييم. يمثل كل من الكفاءة والربحية حجر الزاوية لشركات التأمين لتحقيق خططهم. وبناء عليه يتمثل الهدف من هذه الدراسة في تقييم كل من الكفاءة التشغيلية وكفاءة الحجم في اثني عشر شركة من شركات التأمينات العامة في سوق التأمين المصري، وذلك للفترة الزمنية (٢٠١٢-٢٠٢٢). يتم تطبيق نموذج تحليل مغلف البيانات Data Envelopment Analysis (DEA) على المدخلات المتمثلة في: اجمالي المصروفات واجمالي الأصول، بينما تتمثل المخرجات في: اجمالي الربح بعد الضريبة، واجمالي الأقساط. بينما يتم تطبيق انحدار Tobitلتحديد العوامل التي من شأنها التأثير على كفاءة الشركات. كانت أهم النتائج التي توصلت لها الدراسة هي التباين في الأنظمة التشغيلية في الشركات موضع التقييم. بينما أظهرت نتائج انحدار Tobit تأثير كل من: عدد فروع الشركة وحجم الشركة على كفاءة الحجم، بينما لم يكن هناك تأثير يذكر لرأس المال. في حين لا يمكن اعتبار عمر الشركة عامل ذو تأثير على الكفاءة التشغيلية.

كلمات مفتاحية: تحليل مغلف البيانات Data Envelopment analysis DEA- انحدار Tobit- كفاءة الحجم- -Charnes, Cooper, and Rhode (CCR)- Banker, Charnes and Cooper (BCC).