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Evaluating the Performance of Iranian Insurance Companies Using Efficiency Measurement Method Based on Modified Slack-Based Measure in The Network Data Envelopment Analysis Approach

Elham Sadeghi
Ph.D. Student, Department of Management and Economics, Science and Research Branch, Islamic Azad University, Tehran, Iran.
elham_sadeghi1540@yahoo.com

Mohammadreza Miri Lavasani
Assistant Professor, Department of HSE Management, Science and Research Branch, Islamic Azad University, Tehran, Iran.
(corresponding author)
sm.lavasani@srbiau.ac.ir

Mohsen Rostai Malkhalife
Assistant Professor, Department of Mathematics, science and research branch, Islamic azad university, Tehran, Iran.
rostamy@srbiau.ac.ir

Mohamadhamed Khanmohamadi,
Assistant Professor, Department of Accounting, Damavand Branch, Islamic Azad University, Damavand, Iran.
dr.khanmohammadi@yahoo.com

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ABSTRACT

Since insurance is one of the most important and basic industries in the country, managerial evaluation and creating functional insight of companies in the country's insurance industry is of special importance. In this research, in order to achieve this insight, the dual effect of marketing and profit creation in insurance companies has been investigated using the network data envelopment analysis approach in the three periods of 1396 to 1398. In this approach, modified slack-based measure is selected due to the non-radial nature of the data and the existence of negative data Based on this, the marketing performance and profitability of ۲۰ insurance companies have been examined and the efficiency of the companies has been calculated. In order to be aware of the benefits of scale returns, the efficiency of the scale has been calculated as well. The results show that in the three periods studied, Asia, Parsian, Dey, Pasargad, Kowsar and Ta'avon insurance company were fully efficient and Novin Insurance Company had the lowest efficiency. In addition, the results indicate that Dey insurance company has a constant return to scale, Karafarin, Razi, Mellat, Novin, Mihan, Ma, Ta'avon, Sarmad and bime tejarat nou insurance company had increasing returns to scale And Asia, Kowsar and Moallem insurance company had decreasing returns to scale and in periods when companies had constant returns to scale, they acted efficiently.

Keywords: Efficiency, Scale efficiency, Iranian insurance companies, Network data envelopment analysis, Modified Slack-Based Measure

1. Introduction

Due to its long history and in comparison, with other economic sectors of the country and also in comparison with the world Insurance markets, the Iranian Insurance industry has not had a very good position and has lagged behind in terms of its growth. This is confirmed by the low penetration rate of Insurance and low acceptance of Insurance services in Iran. Conditions are prevailing in the Iranian Insurance market, which, given the nature and function of the Insurance industry, should provide confidence and calm in society and cover the risks of economic sectors; risks that can be a factor in reducing investment and economic activities and caution actors in what they are doing. Therefore, one of the measures that can boost the economy and facilitate the conditions for economic activities is the coverage of these risks by the Insurance industry in Iran; an industry that must have the capability and the desired conditions to be able to have a good and necessary impact in other areas, which requires a proper plan and strategy (Insurance Research Center, 2018).

One of the solutions to achieve the above goal is for organizations to determine and recognize their current position and continuously use methods and patterns to evaluate their performance compared to other companies, so that provide the ground for their continuous improvement by identifying weaknesses and strengths. Accordingly, they will draw a long-term horizon and plan in this regard by identifying the current situation. Efficiency is one of the basic criteria for measuring organizational performance and indicates the extent of an organization's productivity of its resources relative to the best performance over time (Pierce, 1997). Data envelopment analysis (DEA) is a set of mathematical models based on linear programming that measures the relative performance of organizations, classifies them and identifies the strengths and weaknesses of each and offers suggestions for improving the performance of each organization (Mehregan, 2016). In other words, efficient models based on which inefficient units are evaluated are introduced to inefficient units. Efficient patterns are units that have produced more outputs with the same inputs as the inefficient unit, or the same outputs using fewer inputs. It is this wide variety of results that has led to the rapid expanding use of this technique.

There are several studies on measuring the efficiency of Insurance companies in Iran and abroad. In Iran, Fallah (2007), Omrani et al. (2014), Daniali et al. (2013) and others measured the efficiency of some insurance companies, not all, and most of studies ignored the internal process of production systems (mediating stage) and considering the intermediate process is only seen in some research (Alirezaei et al. (2016)). Also in domestic research, the data were assumed to be radial and the calculation of return to scale and its relationship with efficiency is not seen. Moreover, both domestic and foreign research (Davutyan and Klumpes (2008), Boonyasai et al. (2002), Kessner (2001) and Elling and Jia (2019)) have used traditional methods to calculate the efficiency of Insurance companies. Therefore, in this research, the efficiency of 20 insurance companies is measured in three periods of 2017, 2018, and 2019 and the internal process of companies (intermediate stage) is considered. In other words, efficiencies are examined from two perspectives of marketing and profitability as series secret processes. Since we know that in Iranian insurance companies the relationship between inputs and outputs is not linear (radial), the data is considered non-radial. Also, due to the loss of some insurance activities in our country, which leads to negative data, so the model of Modified slack-based measure (MSBM) has been used, which is a newer method than other methods. Then, considering these two approaches, the returns to scale of companies and its relationship with efficiency have been calculated.

Thus, the structure of this article is organized as follows. Section 2 explains the theoretical foundations of the research. Section 3 describes the model used in the article and Section 4 discusses the data and sample selection. Section 5 describes the results of estimating efficiency and returns to scale, and finally, section 6 presents conclusions and future suggestions.

2. Theoretical foundations of research

2.1. Network DEA

Efficiency means the output value to input value (Shahabi Nejad, 2015); in other words, it means a firm can produce the most output from the least input or produce the most output with the same amount of input. DEA method is a non-parametric model that was first proposed by Charnes et al. (1978). In this method, based on linear programming (LP), the

relative efficiency for a group of decision-making units (DMU) is calculated using the weighted sum of inputs and outputs (Hou et al., 2014; Wanke, 2012; Kruger et al., 2002) and its significant advantage is that it does not need to specify parametric specifications (such as production function) to obtain performance scores (Siriopoulos and Tziogkidis, 2010). In a set consisting of n decision-making units, the j-deciding unit (DMU_j (j = 1,…, n)) uses m inputs (x_{ij} (i = 1,…, m)) to produce s outputs (y_{rj} (i = 1,…, s)). If DMU_o is one of the decision-making units under consideration, then x_{ij} and y_{rj} are the i^{th} input and r^{th} output of the DMU_o, respectively. Model 1 shows the modified input-oriented CCR envelopment model, which is one of the constant returns to scale models, in which ε is a very small non-Archimedean positive number and s_i^- and s_r^+ are the auxiliary variables of deficiency in the production for the specified output r, respectively. The surplus auxiliary variable expresses the amount of input i used by it (Zhu, 2003; Bazargan va Vasigh, 2003).

Model 1

$$MinY_0 = \theta - \varepsilon\left(\sum_{r=1}^{s} S_r^+ + \sum_{i=1}^{m} S_i^-\right)$$

st :

$$\sum_{j=1}^{n} y_{rj}\lambda_j - S_r^+ = y_{ro} \qquad (r = 1, 2, \ldots, s)$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + S_i^- = \theta x_{io} \qquad (i = 1, 2, \ldots, m)$$

$$\lambda_j, S_r^+, S_i^- \geq 0 \qquad (j = 1, 2, \ldots, n)$$

θ : free

In the early DEA models introduced by Charans et al., the assumption that the input and output variables were positive was considered as the default. However, in relation to scientific issues, there are situations where the assumption of positivity of inputs and outputs is not true, so models were proposed that were able to evaluate units with negative inputs and outputs, and accordingly, different measurement scales for negative data handling have been proposed, one of which is slack-based measure (SBM) model. Sharp et al. (2006) rewrote the SBM model to calculate performance in the presence of negative variables, assuming that:

1. At least one of the inputs is positive.
2. At least one of the outputs is positive.
3. Some input variables and some output variables are negative.

Then, they proposed the MSBM model as follows:

Model 2

$$Min \quad \rho = \frac{1 - \sum_{i=1}^{m} w_i s_i^- / R_{io}}{1 + \sum_{r=1}^{s} v_r s_r^+ / R_{ro}}$$

st :

$$\sum_{j=1}^{n} y_{rj}\lambda_j - S_r^+ = y_{ro} \qquad (r = 1, 2, \ldots, s)$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + S_i^- = x_{io} \qquad (i = 1, 2, \ldots, m)$$

$$\sum_{j=1}^{n} \lambda_j = 1 \qquad (j = 1, 2, \ldots, n)$$

$$\sum_{i=1}^{m} w_i = 1 \qquad \sum_{r=1}^{s} v_r = 1$$

$$\lambda_j, S_r^+, S_i^-, v_r, w_j \geq 0$$

Where, R_{io} and R_{ro} are as follows:

$$R_{io} = x_{io} - \min_j \{x_{ij}\} \qquad (i = 1, 2, \ldots, m)$$

$$R_{ro} = \max_j \{y_{rj}\} - y_{ro} \qquad (r = 1, 2, \ldots, s)$$

Where R_{io} and R_{ro} are equal to zero, division by zero is avoided and zero is given as the coefficient of s_i^- and s_r^+.

The network structure, which connects the various stages of production with mediating inputs and outputs in a set of processes, was first introduced by Fair (1991) and was developed in later years. In network processes, intermediate sizes are the factors that play the role of input for the next stage and the role of output for the previous stage. The two-stage model is the simplest network structure shown in Figure 1. Suppose that every DMU_j (j = 1,…, n) has m inputs as x_{ij} (i = 1,…, m) and d outputs as z_{dj} (i = 1,…, d) for the mentioned step, where d outputs are considered as inputs for the second stage and outputs of the second stage are considered as y_{rj} (i = 1,…, s), which are referred to as intermediate sizes.

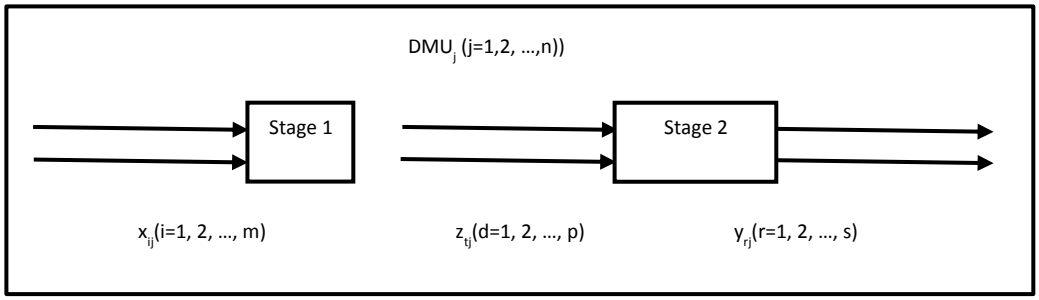

Figure 1: Two-stage process

2.2. Returns to scale

Scale efficiency is a development that an organization can derive from the benefits of returns to scale by changing its size to the optimal scale. If the size of the organization does not affect its performance, the return to scale is constant, and in firms where there are economies of scale, the assumption of constant return to scale is not true. In this type of firm, doubling the inputs may result in more than doubling the output (increasing returns to scale) and sometimes, as the organization grows and the inputs increase by a factor of two, they provide outputs of less than twice (decreasing returns to scale), which may be due to the inability to run a large organization and the resulting inconsistencies. If the size of the organization does not affect its performance, the returns to scale is constant (Coely, 1996). In order to evaluate and measure the efficiency of the scale, the following steps can be taken based on Farr and Groskov method.

Step 1: Solve the following three models for the units under review.

Model 3

$$Min\rho = \frac{1 - \sum_{i=1}^{m} w_i \, s_i^- / R_{io}}{1 + \sum_{r=1}^{s} v_r s_r^+ / R_{ro}}$$

$$st:$$

$$\sum_{j=1}^{n} y_{rj} \, \lambda_j - S_r^+ = y_{ro} (r = 1,2, \dots, s)$$

$$\sum_{j=1}^{n} x_{ij} \, \lambda_j + S_i^- = x_{io} (i = 1,2, \dots, m)$$

$$\sum_{i=1}^{m} w_i = 1 \sum_{r=1}^{s} v_r = 1$$

$$\lambda_j, S_r^+, S_i^-, v_r, w_j \geq 0$$

Model 4

$$Min\rho = \frac{1 - \sum_{i=1}^{m} w_i \, s_i^- / R_{io}}{1 + \sum_{r=1}^{s} v_r s_r^+ / R_{ro}}$$

$$st:$$

$$\sum_{j=1}^{n} y_{rj} \, \lambda_j - S_r^+ = y_{ro} (r = 1,2, \dots, s)$$

$$\sum_{j=1}^{n} x_{ij} \, \lambda_j + S_i^- = x_{io} (i = 1,2, \dots, m)$$

$$\sum_{j=1}^{n} \lambda_j = 1 (j = 1,2, \dots, n)$$

$$\sum_{i=1}^{m} w_i = 1 \sum_{r=1}^{s} v_r = 1$$

$$\lambda_j, S_r^+, S_i^-, v_r, w_j \geq 0$$

Model 5

$$Min\rho = \frac{1 - \sum_{i=1}^{m} w_i \, s_i^- / R_{io}}{1 + \sum_{r=1}^{s} v_r s_r^+ / R_{ro}}$$

$$st:$$

$$\sum_{j=1}^{n} y_{rj} \, \lambda_j - S_r^+ = y_{ro} (r = 1,2, \dots, s)$$

$$\sum_{j=1}^{n} x_{ij} \, \lambda_j + S_i^- = x_{io} (i = 1,2, \dots, m)$$

$$\sum_{j=1}^{n} \lambda_j \leq 1 (j = 1,2, \dots, n)$$

$$\sum_{i=1}^{m} w_i = 1 \sum_{r=1}^{s} v_r = 1$$

$$\lambda_j, S_r^+, S_i^-, v_r, w_j \geq 0$$

Step 2: Compare the performance scores of the 3 and 4 models. If the two scores are equal, the return to scale is constant and otherwise variable.
Step 3: Compare the performance scores of models 4 and 5. If the two scores are equal, the returns to scale is decreasing and otherwise increasing.

2.3. Research background

Several studies have been conducted on the application of DEA in various fields, including the insurance industry, some of which are mentioned below.

In Iran, Fallah (2007) measured the efficiency of three Iran, Alborz and Asia Insurance companies. The results showed that out of 153 branches studied in Iran Insurance, only 20 branches and out of 43 branches of Alborz Insurance Company, only 6 units were efficient and comparisons between Asia Insurance branches were not possible due to their heterogeneity. Alirezaei et al. (2016) measured the efficiency of 5 selected Insurance companies in the years 2010 to 2013 using two-stage marketing and profitability models. In their research, they have considered the inputs of the first stage as administrative and general expenses and the Insurance costs, the output of the second stage as the accumulated profit during the period under review, and the intermediate sizes as the issued premium and the reinsurance premium. They considered the inefficiency of companies to be related to their profitability performance. Omrani et al. (2014) presented a hybrid model based on the methods of hierarchical analysis, principal component analysis, and DEA for ranking and evaluating the performance of Iranian Insurance companies using the experts' opinion. The input in their research included the number of agencies, number of branches, number of manpower, general or total operating costs, investment costs, total assets, and equity, and output included premiums issued, net profit, investment income, total debts, number of Insurance issued, and number of claims paid. Daniali et al. (2013) used DEA to examine and measure the efficiency of Iran Insurance branches in the southern provinces of Iran.

In order to calculate the efficiency according to the above models, it is necessary to determine the input, intermediate and output indices. In the following tables, some domestic studies and indicators considered for calculating the efficiency have been presented.

Table 1: Inputs and outputs of performance measurement models of Insurance companies in domestic studies

Authors	Input	Output
Kaviani et al. (2018)	Operating and administrative labor force, shareholders' equity, administrative and general expenses	Price of damages incurred, mediating price
Naderifar and Farifteh (2015)	Number of employees, number of branch representatives	Net premium, net loss
Najafi et al. (2014)	Labor force, general and administrative expenses, resources available for investment	Loss incurred, ROE
Zakeri et al. (2015)	Labor force, total equity and Insurance reserves, general and administrative expenses	Return on equity, loss paid
Sameri (2013)	Number of staff, staff costs, number of real and legal representatives, geographical location of branches	Number of Insurance issued, operating balance, earned Insurance premiums, loss ratio, Insurance premiums other than third party car Insurance policies (mandatory)
Ayoubi et al. (2012)	Assets of the Insurance company, number of employees, general and administrative expenses paid to the premium, fee paid to the issued premium	Loss paid, number of claims paid, net profit of Insurance companies, net profit after tax on premiums issued, production premiums by the Insurance company, number of Insurance issued, debts of the Insurance company
Hanifehzadeh (2010)	Assets, labor force, Insurance costs	Insurance income, investment income
Hemmati et al. (2007)	Labor force, fixed assets	Premiums received, investment income

In foreign research Davutyan and Klumpes (2008) examined the efficiency, net efficiency and returns to scale of the life and non-life Insurance of 7 European countries (France, Germany, Italy, the Netherlands, Spain, Switzerland and the United Kingdom) in the period 1996-2002. The highest life Insurance

efficiency was related to France and the lowest was related to the Netherlands, and in non-life Insurance, the highest efficiency was related to Switzerland and the lowest was related to Spain. Boonyasai et al. (2002) measured performance in the field of life Insurance in the period 1978-1997 in four Asian countries of Korea, Philippines, Taiwan and Thailand using the DEA technique and observed that the performance of all four countries has improved and the efficiency of Korea and the Philippines is higher than Taiwan and Thailand. Kessner (2001) also examined the technical efficiency of Germany and the United Kingdom and concluded that the efficiency of the United Kingdom is higher than that of Germany. Elling and Jia (2019) examined the profitability and efficiency of more than 5,000 Insurance companies worldwide and the results of the study confirmed the correlation between the two and stated that the correlation of efficiency in the field of life Insurance is higher than non-life Insurance.

Also, in research in the field of banking, performance and efficiency have been studied using data envelopment analysis technique. Vanke et al. in 2017 examined the performance of South African banks through a two-stage data envelopment analysis model with two approaches to profitability and marketing. Vanke et al. (2015) used the DEA model to analyze the performance of Angolan banks. Vanke et al. (A2016) first analyzed Mozambican banks with a DEA model. Barros et al. (2010) analyzed the performance of Angolan banks with a random Bayesian boundary. Poshakwale and Qian (2011) analyzed the competition and efficiency of Egyptian banks.

The following table shows the inputs, intermediates and outputs of some foreign sources that have examined the efficiency and performance of insurance companies using the data envelopment analysis method.

Table 2: inputs, intermediates and outputs of performance measurement models of Insurance companies in foreign studies

Authors	Input	Mediation	Output
Elling and Jia (2019)	Labor force, equity, debts	Premiums, invested assets	Profit before tax deduction
Barros et al. (2014)	Operating costs, wages, capital, number of employees		Receivables paid, interest paid, premiums received, assigned reInsurance
Bai-qing et al. (2012)	Total assets, employees, expenses		Final reserves, investment income, Insurance profit, net premium
Kao and Hwang (2008)	Operating cost, fee paid to agents	Premiums received from customers, assigned reInsurance premiums	Insurance profit, profit from invested assets
Cummins and Xhi (2008)	Administrative and general expenses, expenses of branches and agencies, capital	Premiums, invested assets	Types of premiums received, assets invested
Barros and Barroso (2005)	Wages paid, amount of capital, income from investment, premiums issued		Net profit
Mahlberg & Url (2003)	Administrative and distribution costs and investment costs		Total assets, health, life and liability Insurance
Cummins et al. (1999)	Administrative and general expenses, expenses of branches and agencies, capital	Premiums received from customers, assigned reInsurance premiums	Types of premiums received
Fukuyama (1997)	Daily value of assets, number of employees and sales representatives	Premiums, invested assets	Production premiums, corporate debts

3. Research model

After reviewing the research foundations and other research and also using the opinion of experts, since the research of Cao and Huang (2008) has more comprehensively investigated efficiency from two perspectives of marketing and profitability, the criteria used in the present research are mainly similar to their research. The only difference is the addition of market value input according to numerous researches of Cummins in this field. In Cummins' research, efficiency measurement has been studied in one step and only with a marketing approach, who has considered daily capital (equivalent to the current value of assets) as one of the input parameters. Now, the proposed model in order to evaluate the performance and efficiency of Insurance companies is a two-stage DEA method that its first stage measures marketing and the second stage measures the profitability of Insurance companies. In other words, the output of the first stage (marketing) is considered as the input of the second stage (profitability). Therefore, input and output indicators are selected as follows:

The daily value of assets is considered as the input of the first stage, whose market value has been used due to the lack of further revaluation of Insurance companies. Also, operating expenses are considered as another input that can be extracted from the financial statements of Iranian Insurance companies under the heading of general and administrative expenses. Fees paid to agents are also available under the heading Commission costs and Interest Fees. As a result, the first stage inputs are selected as follows:

X_1: Commission costs and interest fees

X_2: General and administrative expenses

X_3: Market value

The outputs of the first stage and the inputs of the second stage are similar to the research of Cao and Huang as follows (according to the nature of the companies surveyed, premiums with life and non-life premiums are included in the calculations of both disciplines).

Z_1: Life Insurance premium

Z_2: Non-life Insurance premium

The outputs of the second stage are separately considered as the net profit of life and non-life Insurance and the ratio of profit from investment to the amount of short-term and long-term investment.

Y_1: Net profit of life insurance

Y_2: Net profit of non-life Insurance benefit

Y_3: Return on invested assets

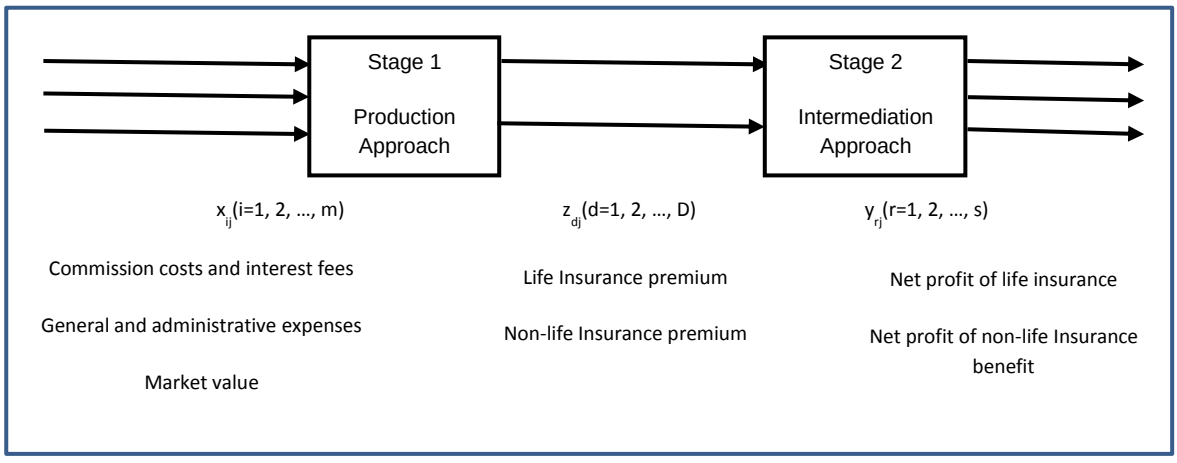

Figure 2: Two-step process for Iranian Insurance companies

As a result, the input and output indicators of the two-stage process of Insurance companies are used as follows:

Since some of the above inputs, intermediates and outputs are negative, the non-radial two-stage MSBM model is used to calculate performance and based on model 2, following model is used to calculate the two-step process.

Model 6

$$Min\rho = \frac{1-\frac{1}{P}\sum_{t=1}^{p} L_t^- / R_{to}}{1+\frac{1}{S}\sum_{r=1}^{s} L_r^+ / R_{ro}} \times \frac{1-\frac{1}{m}\sum_{i=1}^{m} s_i^- / R_{io}}{1+\frac{1}{P}\sum_{t=1}^{p} s_t^+ / R_{to}^{'}}$$

st:

$$\sum_{j=1}^{n} z_{tj}\,\lambda_j - S_t^+ = z_{to}(t = 1,2,\dots,p)$$

$$\sum_{j=1}^{n} x_{ij}\,\lambda_j + S_i^- = x_{io}(i = 1,2,\dots,m)$$

$$\sum_{j=1}^{n} y_{rj}\,\mu_j - L_r^+ = y_{ro}(r = 1,2,\dots,s)$$

$$\sum_{j=1}^{n} z_{tj}\,\mu_j + L_t^- = z_{to}(t = 1,2,\dots,p)$$

$$\sum_{j=1}^{n} \lambda_j = 1(j = 1,2,\dots,n)$$

$$\sum_{j=1}^{n} \mu_j = 1(j = 1,2,\dots,n)$$

$$\lambda_j, \mu_j, S_t^+, S_i^-, L_r^+, L_t^- \geq 0$$

Where, R_{io}, R_{to}, R'_{to} and R_{ro} are as follows:

$$R_{io} = x_{io} - min_j\{x_{ij}\}\,(i = 1,2,\dots,m)$$
$$R_{to} = z_{to} - min_j\{x_{ij}\}\,(t = 1,2,\dots,p)$$
$$R_{to}^{'} = max_j\{z_{tj}\} - z_{to}(t = 1,2,\dots,p)$$
$$R_{ro} = max_j\{y_{rj}\} - y_{ro}(r = 1,2,\dots,s)$$

After calculating the efficiency since the model under study is two-step models 7, 8 and 9 are used to determine types of returns on scale of Insurance companies.

Model 7

$$Min\rho = \frac{1-\frac{1}{P}\sum_{t=1}^{p} L_t^- / R_{to}}{1+\frac{1}{S}\sum_{r=1}^{s} L_r^+ / R_{ro}} \times \frac{1-\frac{1}{m}\sum_{i=1}^{m} s_i^- / R_{io}}{1+\frac{1}{P}\sum_{t=1}^{p} s_t^+ / R_{to}^{'}}$$

st:

$$\sum_{j=1}^{n} z_{tj}\,\lambda_j - S_t^+ = z_{to}(t = 1,2,\dots,p)$$

$$\sum_{j=1}^{n} x_{ij}\,\lambda_j + S_i^- = x_{io}(i = 1,2,\dots,m)$$

$$\sum_{j=1}^{n} y_{rj}\,\mu_j - L_r^+ = y_{ro}(r = 1,2,\dots,s)$$

$$\sum_{j=1}^{n} z_{tj}\,\mu_j + L_t^- = z_{to}(t = 1,2,\dots,p)$$

$$\lambda_j, \mu_j, S_t^+, S_i^-, L_r^+, L_t^- \geq 0$$

Model 8

$$Min\rho = \frac{1-\frac{1}{P}\sum_{t=1}^{p} L_t^- / R_{to}}{1+\frac{1}{S}\sum_{r=1}^{s} L_r^+ / R_{ro}} \times \frac{1-\frac{1}{m}\sum_{i=1}^{m} s_i^- / R_{io}}{1+\frac{1}{P}\sum_{t=1}^{p} s_t^+ / R_{to}^{'}}$$

st:

$$\sum_{j=1}^{n} z_{tj}\,\lambda_j - S_t^+ = z_{to}(t = 1,2,\dots,p)$$

$$\sum_{j=1}^{n} x_{ij}\,\lambda_j + S_i^- = x_{io}(i = 1,2,\dots,m)$$

$$\sum_{j=1}^{n} y_{rj}\,\mu_j - L_r^+ = y_{ro}(r = 1,2,\dots,s)$$

$$\sum_{j=1}^{n} z_{tj}\,\mu_j + L_t^- = z_{to}(t = 1,2,\dots,p)$$

$$\sum_{j=1}^{n} \lambda_j = 1(j = 1,2,\dots,n)$$

$$\sum_{j=1}^{n} \mu_j = 1(j = 1,2,\dots,n)$$

$$\lambda_j, \mu_j, S_t^+, S_i^-, L_r^+, L_t^- \geq 0$$

Model 9

$$Min\rho = \frac{1-\frac{1}{P}\sum_{t=1}^{p} L_t^- / R_{to}}{1+\frac{1}{S}\sum_{r=1}^{s} L_r^+ / R_{ro}} \times \frac{1-\frac{1}{m}\sum_{i=1}^{m} s_i^- / R_{io}}{1+\frac{1}{P}\sum_{t=1}^{p} s_t^+ / R_{to}^{'}}$$

st:

$$\sum_{j=1}^{n} z_{tj}\,\lambda_j - S_t^+ = z_{to}(t = 1,2,\dots,p)$$

$$\sum_{j=1}^{n} x_{ij}\,\lambda_j + S_i^- = x_{io}(i = 1,2,\dots,m)$$

$$\sum_{j=1}^{n} y_{rj}\,\mu_j - L_r^+ = y_{ro}(r = 1,2,\dots,s)$$

$$\sum_{j=1}^{n} z_{tj}\,\mu_j + L_t^- = z_{to}(t = 1,2,\dots,p)$$

$$\sum_{j=1}^{n} \lambda_j \leq 1(j = 1,2,\dots,n)$$

$$\sum_{j=1}^{n} \mu_j \leq 1 (j = 1,2, \dots, n)$$
$$\lambda_j, \mu_j, S_t^+, S_i^-, L_r^+, L_t^- \geq 0$$

4. Data and statistical samples

At present, Iran State Insurance Company and 24 non-governmental Asia, Alborz, Dana, Moallem, Parsian, Tose'e, Razi, Karafarin, Sina, Mellat, Dey, Saman, Novin, Pasargad, Mihan, Kowsar, Ma, Arman, Ta'avon, Sarmad, Tejarat-e-No, Hekmat Saba, Khavar Mianeh, and Baran Insurance companies, 2 Amin and Iranian Reliance Insurance Company in the mainland, and 6 Insurance companies of Hafez, Omid, Iran Moin, Motaghabel Kish, Motaghabel Etemad Qeshm and Asmari in free and special economic zones are active. Two Khavar Mianeh and Baran Insurances are specialized companies in the field of life Insurance and two Amin and Iranian reinsurance companies are also active in reinsurance operations. Thus, at the beginning of 2020 (end of 2017), there were 33 Insurance companies operating in Iran. Due to the fact that Iran Insurance Company is a state-owned company and is subject to its own laws, it was excluded from the study. Out of 24 non-governmental Insurance companies, Tose'e Insurance Company has been excluded due to the fact that its license in car Insurance (third party, driver and car accident) and various types of life Insurance has been revoked in February 2014. Moreover, Khavar Mianeh and Baran Insurance companies are excluded as they are specifically active only in the field of life Insurance and on the other hand, like Hekmat Saba Company, they are considered as start-up companies. Another 6 companies have been excluded from the research due to special working conditions in free and special economic zones and 2 Amin and Iranian reinsurance companies are excluded due to the different nature of their activities. Therefore, the statistical samples of this research include 20 non-governmental Insurance companies of Asia, Alborz, Dana, Moallem, Parsian, Razi, Karafarin, Sina, Mellat, Dey, Saman, Novin, Pasargad, Mihan, Kowsar, Ma, Arman, C Ta'avon, Sarmad, Tejarat-e-No. For the three periods of 2017, 2018 and 2019, data related to input, mediating, and output criteria, except market value, have been extracted from the financial statements of the above companies. Their market value at the end of each year has been extracted from the Tehran Stock Exchange.

5. Research findings

5.1. Descriptive statistics of variables

After determining the criteria for evaluating Insurance companies' efficiency and considering them as input, mediating and output variables, descriptive statistics of variables was reviewed using information collected from the surveyed companies in three years of 2017, 2018, and 2019. The results are presented in tables 3, 4, and5. In 2017 and 2018, Dey Insurance and Tejarat-e-No Insurance, unlike other Insurance companies, had succeeded in identifying profits from commission costs and profit commissions, so in these two years, the coefficient of variation1 was above 1, while it has reached below 1 in 2019, after eliminating the profit in these two companies. The coefficient of variation of general and administrative expenses in these three years is almost constant and the coefficient of variation of market value in 2018 and 2019 is constant but has increased compared to 2017 and the coefficient of variation of life and non-life Insurance premiums in these 3 years is about 1. The highest coefficient of variation is related to life Insurance net profit. In 2018, the average net profit of life Insurance in the industry was negative and in 2019, the average net profit was positive again, but the standard deviation of its net profit in the industry was high this year. Meanwhile, the average net profit of non-life Insurance in the industry in 3 years has been positive and its coefficient of variation has been between 1 and 2. The lowest coefficient of variation in 2017 and 2018 is related to the return on invested assets and is equal to 0.4, which has increased to 0.9 in 2019.

In the inputs of the first stage, the highest commission cost and profit commission and general and administrative expenses in 3 years are related to Asia Insurance and the highest market value in 3 years belongs to Pasargad Insurance, so that at the end of 2019, the market value of this company has reached about 67 thousand billion rials. In 2017 and 2018, Dey Insurance and Tejarat-e-No Insurance identified income benefits from commission costs and commission profits, and in 2019, Mihan Insurance had the lowest expenses on this. The lowest general and administrative expenses in 2017 belonged to Tejarat-e-No Insurance, in 2018 to Tejarat-e-No Insurance and Ta'avon Insurance, and in 2019 to Mihan and Ta'avon

1 Coefficient of Variation $= CV = \frac{\sigma}{\mu}$

Insurance companies. Also, the lowest market value in 2017 belonged to Ta'avon Insurance, in 2018 to Arman and Ta'avon Insurance, and in 2019 to Arman Insurance.

In the outputs of the first stage, the highest net life Insurance premium (maintenance share) received in 3 years was related to Pasargad Insurance, in which the company succeeded in obtaining the highest net profit (output of the second stage). Also, the highest net non-life Insurance premium (maintenance share) received in 3 years was related to Asia Insurance, which also succeeded in obtaining the highest net profit in this field in these 3 years (second stage output). In 2017, the activity of Karafarin Insurance Company led to the identification of negative non-net non-life Insurance premiums, subsequently leading to net losses, which was the lowest figure among companies in that year. Similarly, the activity of Parsian Insurance Company in 2019 led to the identification of negative net life Insurance premiums, subsequently leading to net losses, which in 2019 was the lowest figure among companies. In 2018, the lowest net life and non-life Insurance premiums were related to Ta'avon and Tejarat-e-No Insurance companies, respectively. In 2018, the activities of Karafarin Insurance and Dey Insurance led to net losses in the field of life and non-life insurance, respectively, which were the lowest in this year.

In the outputs of the last stage, the highest return on assets invested in 2017 belongs to Ta'avon insurance and then Kosar insurance, in 2018 to Kosar insurance, and in 2019 to Razi insurance and on the other hand the lowest return in 2017 and 2018 belonged to Arman insurance and in 2019 to Asia insurance.

Table 3: Summary of descriptive statistics for the input, mediating, and output variables of 20 insurance companies in 2017 (amounts in million Rials)

	Variables	Min	Max	Mean	SD	CV
X						
	Commission costs and interest fees	(1,321,903)	2,285,973	445,111	730,195	1.6
	General and administrative expenses	172,291	2,695,668	830,560	665,261	0.8
	Market value	392,000	6,238,418	2,765,532	1,594,946	0.6
Z						
	Life Insurance premium	(33,602)	1,425,044	436,890	429,144	0.98
	Non-life Insurance premium	381,107	24,557,517	6,156,339	6,473,599	1.1
Y						
	Net profit of life insurance	(768,031)	917,217	40,591	341,061	8.4
	Net profit of non-life Insurance benefit	(5,468,238)	6,716,262	1,461,751	2,658,059	1.8

Table 4: Summary of descriptive statistics for the input, mediating, and output variables of 20 insurance companies in 2018 (amounts in million Rials)

	Variables	Min	Max	Mean	SD	CV
X						
	Commission costs and interest fees	(2,955,196)	3,356,268	603,900	1,227,969	2.0
	General and administrative expenses	266,973	3,110,173	1,020,536	758,436	0.7
	Market value	1,116,000	18,088,434	4,109,319	3,777,502	0.9
Z						
	Life Insurance premium	54,223	2,060,916	634,664	556,786	0.88
	Non-life Insurance premium	1,080,539	31,959,122	7,817,604	7,918,390	1.0
Y						
	Net profit of life insurance	(1,740,550)	1,022,290	(36,944)	558,278	(15.1)
	Net profit of non-life Insurance benefit	(6,034,241)	7,314,157	1,214,967	2,859,214	2.4
	Return on invested assets	٪٥	٪٤٥	٪٢٠	٪٧	0.4

Table 5: Summary of descriptive statistics for the input, mediating, and output variables of 20 insurance companies in 2019 (amounts in million Rials)

Variables	Min	Max	Mean	SD	CV
X					
Commission costs and interest fees	143,948	5,110,735	1,497,666	1,412,042	0.9
General and administrative expenses	408,502	4,361,981	1,491,623	1,078,224	0.7
Market value	3,475,500	67,339,188	18,080,051	17,166,181	0.9
Z					
Life Insurance premium	(309,373)	3,259,761	745,954	785,271	1.05
Non-life Insurance premium	1,946,971	41,398,294	10,877,396	10,629,578	1.0
Y					
Net profit of life insurance	(935,647)	1,615,055	10,147	584,871	57.6
Net profit of non-life Insurance benefit	26,251	8,157,532	2,318,261	2,365,726	1.0
Return on invested assets	٪١٦	٪٢١٠	٪٤٤	٪٤١	0.9

5.2. Efficiency of insurance companies

After collecting the required information, the efficiency of insurance companies has been calculated using the two-stage non-radial MSBM method. First, to evaluate the profitability and marketing performance of each insurance company, their efficiency is calculated according to Model 2 and the results are presented in Tables 6 and 7. Then, the total efficiency of these companies is calculated as Model 6 and the efficiency results of 20 insurance companies are extracted according to Table 8. As shown in Table 6, in the first stage, which indicates marketing activities, Asia, Alborz, Dana, Moallem, Parsian, Dey, Pasargad, Kowsar, Arman and Ta'avon insurance companies are efficient for three consecutive years which means they had the best outputs according to their inputs, and five Karafarin, Sina, Mellat, Mihan and Sarmad insurance companies, after inefficiency in 2017, have succeeded in improving their performance in 2018 and 2019. After reviewing the input and output data of these 5 companies, it is observed that net premium (maintenance share) in the field of life insurance of Karafarin insurance was negative in 2017, which was positive in the following years. Four other companies had improved their performance in the field of life and non-life insurance premium (maintenance share) compared to expenses in 2018 and 2019 compared to 2017 which have led to such a result. Despite efficiency in the two years of 2017 and 2018, Tejarat-e-No insurance has faced a decline in performance in 2019 that is due to the conversion of commission income and profit commission into expenses. Four Razi, Saman, Novin and Ma insurance companies have not performed well in three consecutive years, so that the lowest efficiency in the two years 2017 and 2018 is related to Novin insurance, and in 2019 was related to Razi insurance.Investigations show the costs of Novin company, especially its assets, have been higher than the company's revenues and Razi insurance has experienced an increase of costs of more than 100%, while premium income has not had a significant growth which efficiency results also confirm these inefficiencies.

Also, in the second stage (Table 7), which shows profitable activities, Asia, Parsian, Dey, Pasargad, Mihan, Kowsar, Ma, Ta'avon, and Tejarat-e-No and to some extent Saman insurance companies are efficient, this means that these companies have been able to make the best profit from their premiums. The two insurance companies of Dana and Arman, despite the poor profitability performance in 2017 compared to other companies that were among the lowest efficient companies in that period, succeeded in this activity in the next two years. Karafarin and Mellat insurance companies were the most inefficient companies in 2018. In that period the data tables show, Karafarin insurance had a poor performance in making profit from life insurance and Mellat insurance had a poor performance in making profit from non-life insurance.

Table 6: Results of the first stage of insurance companies' efficiency with non-radial MSBM method

No.	Name of Company	2017	2018	2019
1	Asia Insurance company	1	1	1
2	Alborz Insurance company	1	1	1
3	Dana Insurance company	1	1	1
4	Moallem Insurance c company	1	1	1
5	Parsian Insurance company	1	1	1
6	Karafarin Insurance company	0.55	1	1
7	Razi Insurance company	0.68	0.58	0.48
8	Sina Insurance company	0.96	1	1
9	Mellat Insurance company	0.54	1	1
10	Dey Insurance company	1	1	1
11	Saman Insurance company	0.62	0.95	0.56
12	Novin Insurance company	0.48	0.63	0.56
13	Pasargad Insurance company	1	1	1
14	Mihan Insurance company	0.82	1	1
15	Kowsar Insurance company	1	1	1
16	Ma Insurance company	0.43	0.44	0.71
17	Arman Insurance company	1	1	1
18	Ta'avon Insurance company	1	1	1
19	Sarmad Insurance company	0.81	1	1
20	Tejarat-e- No Insurance company	1	1	0.75

Table 7: Results of the Scond stage of insurance companies' efficiency with non-radial MSBM method

No.	Name of Company	2017	2018	2019
1	Asia Insurance company	1	1	1
2	Alborz Insurance company	0.35	0.81	0.73
3	Dana Insurance company	0.25	1	1
4	Moallem Insurance company	0.36	0.42	0.87
5	Parsian Insurance company	1	1	1
6	Karafarin Insurance c company	1	0.04	0.12
7	Razi Insurance company	0.4	0.52	1
8	Sina Insurance company	0.55	0.57	0.84
9	Mellat Insurance company	0.52	0.07	0.78
10	Dey Insurance company	1	1	1
11	Saman Insurance company	1	1	0.98
12	Novin Insurance company	0.58	0.56	0.7
13	Pasargad Insurance company	1	1	1
14	Mihan Insurance company	1	1	1
15	Kowsar Insurance company	1	1	1
16	Ma Insurance company	1	1	1
17	Arman Insurance company	0.39	1	1
18	Ta'avon Insurance company	1	1	1
19	Sarmad Insurance company	1	0.92	0.88
20	Tejarat-e- No Insurance company	1	1	1

After reviewing each stepو in the last stage, the efficiency of the whole system is calculated by considering both activities. This means that a company may have good performance in the first stage but have inadequate performance in the second stage, or vice versa. In this part, the efficiency of the whole company is measured by considering both stages and its impact on each other. The result shows in general (Table 8), Asia, Parsian, Dey, Pasargad, Kowsar and Ta'avon insurance companies operated efficiently, and three Dana, Mihan and Arman insurance companies were able to operate efficiently in 2018 and 2019 (In 2017,

the effect of inefficiency of the first stage of Mihan Insurance and the effect of inefficiency of the second stage of Dana and Arman Insurance has led to total inefficiency in these three companies). Tejarat-e-No insurance company, after being efficient in two consecutive years in 2017 and 2018, has witnessed a decrease in performance in 2019 (inefficiency of first stage has led to this result).

A noteworthy point in comparing the efficiency of the two approaches of marketing and profitability shows that Ma insurance company has been fully efficient in the field of profitability and weak in the field of marketing in three periods. The two companies of Tejarat-e-No and Razi insurance in 2019, Saman insurance company in 2017 and 2019, and Karafarin, Mihan and Sarmad insurance companies in 2017 have performed poorly in the field of marketing in comparison to profitability. Saman insurance has performed almost equally in two areas, and other companies have been stronger in terms of profitability than marketing in the three periods under review.

Table 8: Results of insurance companies' efficiency with non-radial MSBM method

No.	Name of Company	2017	2018	2019
1	Asia Insurance company	1	1	1
2	Alborz Insurance company	0.35	0.81	0.73
3	Dana Insurance company	0.25	1	1
4	Moallem Insurance company	0.36	0.78	0.87
5	Parsian Insurance company	1	1	1
6	Karafarin Insurance company	0.55	0.04	0.12
7	Razi Insurance company	0.27	0.3	0.7
8	Sina Insurance company	0.53	0.57	0.84
9	Mellat Insurance company	0.28	0.07	0.78
10	Dey Insurance company	1	1	1
11	Saman Insurance company	0.62	0.95	0.67
12	Novin Insurance company	0.28	0.35	0.39
13	Pasargad Insurance company	1	1	1
14	Mihan Insurance company	0.82	1	1
15	Kowsar Insurance company	1	1	1
16	Ma Insurance company	0.43	0.44	0.71
17	Arman Insurance company	0.39	1	1
18	Ta'avon Insurance company	1	1	1
19	Sarmad Insurance company	0.81	0.92	0.88
20	Tejarat-e- No Insurance company	1	1	0.75

5.3. Returns on scale of insurance companies

In order to evaluate the returns on scale of insurance companies, the efficiency of the above companies in the three years has been calculated using models 4-1, 4-2 and 4-3, and then, the calculated efficiency is used to extract return to scale, the results of which are presented below.

As can be seen in the table above, Dey insurance company during three periods, Parsian insurance in two years 2017 and 2019, Pasargad insurance in two years 2017 and 2018, and Arman insurance only in 2019 have had constant returns to scale (CRS). Karafarin, Razi, Mellat, Novin, Mihan, Ma, Ta'avon, Sarmad, and Tejarat-e-No have had increasing returns to scale (IRS) during all three periods, and Asia, Kowsar, and Moallem insurance companies have also experienced decreasing returns to scale (DRS) in all three periods. Dey, Parsian, Pasargad and Arman have been efficient in periods with constant returns, but companies such as Asia and Kowsar, which have been efficient in these three periods, have also had decreasing returns to scale. Finally, Ta'avon insurance, which has been efficient in three periods, has experienced increasing returns to scale. In other words, in periods when companies had constant returns to scale, they acted efficiently, but companies that were efficient did not necessarily have constant returns to scale and had increasing or decreasing returns to scale.

Table 9: Results of returns to scale of companies

No.	Name of Company	2017	2018	2019
1	Asia Insurance company	DRS	DRS	DRS
2	Alborz Insurance company	DRS	IRS	DRS
3	Dana Insurance company	DRS	CRS	DRS
4	Moallem Insurance company	DRS	DRS	DRS
5	Parsian Insurance company	CRS	IRS	IRS
6	Karafarin Insurance company	IRS	IRS	IRS
7	Razi Insurance company	IRS	IRS	IRS
8	Sina Insurance company	IRS	IRS	IRS
9	Mellat Insurance company	IRS	IRS	IRS
10	Dey Insurance company	CRS	CRS	CRS
11	Saman Insurance company	IRS	IRS	DRS
12	Novin Insurance company	IRS	IRS	IRS
13	Pasargad Insurance company	CRS	CRS	DRS
14	Mihan Insurance company	IRS	IRS	IRS
15	Kowsar Insurance company	DRS	DRS	DRS
16	Ma Insurance company	IRS	IRS	IRS
17	Arman Insurance company	IRS	IRS	CRS
18	Ta'avon Insurance company	IRS	IRS	IRS
19	Sarmad Insurance company	IRS	IRS	IRS
20	Tejarat-e- No Insurance company	IRS	IRS	IRS

6. Discussions and Conclusion

This study sought to identify indicators and provide a model for evaluating the efficiency of insurance companies in the fields of life and non-life insurance. After reviewing the research foundations and some researches (Wanke et al., 2017; Cummins et al., etc.) as well as using the experts' opinion to evaluate the performance and efficiency of insurance companies, the network DEA method was proposed. Since the selection of correct inputs and outputs for effective and acceptable interpretation of the model analysis results is very important, so in this study, the two main indicators of marketing and profitability were examined to provide a comprehensive and complete analysis of insurance companies. In the marketing index, the inputs of the model are the commission cost and profit commission, general and administrative expenses, and the market value and its outputs included life and non-life premiums. Profitability inputs were life and non-life premiums and outputs were the net profit of life insurance, net profit of non-life insurance, and the return on invested assets. Since some of the above variables were negative, the efficiency measurement method based on MSBM was used in DEA method. After extracting the above data from the financial statements and the Tehran Stock Exchange site, the efficiency of 20 insurance companies was calculated using the MSBM model in the three years 2017, 2018, and 2019. Out of 20 insurance companies active in the Iranian market in the three years under review, 6 insurance companies of Asia, Parsian, Dey, Pasargad, Kowsar and Ta'avon were efficient, Novin insurance company has experienced the weakest efficiency, and Sarmad insurance has had the same performance without fluctuations. Ma insurance has had a poor performance in marketing for three years, but has been efficient in the field of profitability. In contrast, Mellat and Karafarin insurance companies have had a reverse performance compared to Ma insurance in 2018. This means that by comparing the two indicators of marketing and profitability in this industry, it is observed that the performance weakness in companies is sometimes in the field of marketing and sometimes in the field of profitability. In other words, each company has its own situation, which contradicts the research of Alirezaei et al.

Then, using the MSBM model with constant returns, the variable of returns to scale of companies was calculated, and among the companies in all three periods, Dey insurance company had constant returns on scale, Karafarin, Razi, Mellat, Novin, Mihan, Ma, Ta'avon, Sarmad, and Tejarat-e-No companies had

incremental returns to scale, Asia, Kowsar and Moallem had a decreasing return to scale, and the other 7 insurance companies had different returns to scale in three periods. It was also observed that in periods when companies had constant returns to scale, they acted efficiently.

In order to further improve research in this field, the following suggestions are provided:

- Perform efficiency calculations using other methods of network DEA (Chen et al., 2010).
- Measure efficiency through a random boundary function and compare results with the results of DEA.
- Investigate the relationship between efficiency and wealth of insurance companies.
- Use 2 solvency parameters, which are more complete and comprehensive than 1 solvency, to measure efficiency.

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