Research Article

# Evaluation of the post- earthquake performance of insurance companies with DEA: 2021-2024 period

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**ABSTRACT**

This study aims to measure the effectiveness of the insurance sector after the 6 February 2023 Kahramanmaraş earthquakes. Considering the economic impacts of frequent earthquakes in Turkey, it is of great importance for the insurance sector to be prepared for disasters. In this context, the efficiency levels of six companies in the BIST Insurance Index for the period 2021-2024 were evaluated by the Data Envelopment Analysis (DEA) method. Total, technical, and scale efficiency scores were calculated using the output-oriented CCR and BCC models. The number of employees and total assets are used as input variables, while net profit and total premium production are used as output variables. According to the results, Ray, Türkiye, and AK Sigorta generally achieved the highest efficiency scores, while AGESA had the lowest. In addition, it was determined which efficient firms should serve as examples for inefficient companies. The findings reveal that insurance companies should increase their output by utilising their existing resources efficiently, thereby enhancing their competitiveness. The study contributes to the strategy development process by providing an analytical assessment of post-disaster sector performance

## 1. Introduction

Various natural disasters, especially earthquakes, occur in our country as well as in the world. Earthquakes differ from other types of disasters in terms of the effects they create and the dangers they carry. The main reason for this is that tremors directly affect residential areas and shelters (Yiyin, 2024).

Earthquakes, which are highly unpredictable, not only cause loss of life, but also leave deep negative effects on social life. In Turkey, which is one of the countries where such disasters are frequently observed due to its geological characteristics, earthquakes also cause serious economic losses (Say & Doğan, 2023). The disruption of daily life in earthquake-stricken regions causes many businesses to suspend their activities, which has negative consequences on employment and leads to an increase in unemployment. In addition, earthquakes can also have negative effects on macroeconomic indicators such as inflation, economic growth and public budget balance (Aksoy & Akyüzlü, 2024).

On 06 February 2023, at 04:17 and 13:24 Turkey time, two major earthquakes occurred with epicentres in Pazarcık and Elbistan (Kahramanmaraş), respectively. The first one had a magnitude of 7,7 and occurred at a depth of about 8,6 kilometres, while the second one had a magnitude of 7,6 and occurred at a depth of 7 kilometres. After the main shock, approximately 1300 aftershocks were recorded until 16:00 on 09 February 2023 (AFAD, 2023).

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According to the Turkish Statistical Institute's Address Based Population Registration System 2022 data, more than 14 million people were affected by the earthquakes affecting Adana, Adıyaman, Diyarbakır, Elâzığ, Gaziantep, Hatay, Kahramanmaraş, Kilis, Malatya, Osmaniye and Şanlıurfa provinces. Data on the destruction and damage caused by the earthquakes were evaluated based on the reports prepared by the Ministry of Environment, Urbanisation and Climate Change, General Directorate of Construction Works.

More than 48,000 people lost their lives in the earthquake-affected provinces. According to the damage assessment conducted in these provinces, the total number of residences categorized as urgently demolished, collapsed, or severely damaged is estimated at 518,009 (Türkiye Cumhuriyeti Cumhurbaşkanlığı Strateji ve Bütçe Başkanlığı, 2023).

According to the data of Turkish Statistical Institute, 51,14 per cent of the 3,478,575 houses in Adana, Adıyaman, Diyarbakır, Elazığ, Gaziantep, Hatay, Kahramanmaraş, Kilis, Malatya, Osmaniye and Şanlıurfa provinces affected by the earthquakes were built in 2001 and after, 27,56 per cent between 1981 and 2000 and 9,96 per cent in 1980 and before. In addition, there is no information on the date of construction of 11,33 per cent of these buildings.

After the earthquake, many areas, especially the insurance sector, were adversely affected. According to DASK's Kahramanmaraş Earthquake Report, 15,010 insured individuals requested advance payments (DASK, 2023). Over 39.7 billion TL in compensation payments were made for 630,000 damage reports (Özbuğutu, 2025). The importance of insurance for sustaining life after a possible earthquake and ensuring effective response has once again become clear. Insurance practices, which directly fulfil the concept of assurance, should not be limited to compulsory earthquake insurance, especially in earthquake-prone regions. In this respect, the insurance sector must develop damage minimisation strategies and follow the path of minimising risks by determining preventive steps against earthquakes, which is an inevitable reality of our country.

In this context, the first part of the study analyses the economic and social impacts of earthquakes and the strategic role of the insurance sector in the face of disasters. In the second section, the literature review on efficiency analysis in the insurance sector is included and the methodological approaches and findings of previous studies are evaluated. In the third section, the Data Envelopment Analysis (DEA) method used in the study and the input-output variables included in the model are detailed. In the fourth section, the efficiency scores and reference clusters obtained by using the data of six insurance companies in the BIST Insurance Index for the period 2021-2024 are analysed and the results are interpreted with graphs and tables. In the fifth and final section, a general evaluation is made in the light of the analysis findings and recommendations for the sector are given.

## 2. Literature Review

The insurance sector has strategic importance in terms of economic stability and protection of individuals against risks. Especially in countries with high earthquake risk such as Turkey, it is important to analyse the effects of disasters on the sector and to measure the performance of companies. In this context, evaluating the efficiency levels of insurance companies with quantitative methods such as Data Envelopment Analysis (DEA) contributes to increasing sectoral efficiency and more effective use of resources.

Başkaya and Akar (2005) analysed the sales performance of insurance companies in Turkey by using Data Envelopment Analysis (DEA). Using 2003 data, the number of agencies, branches and employees were taken as inputs, while the number of policies and premium production were taken as outputs. In the analysis conducted with the output-oriented and fixed-return DEA model, many companies were found to be technically inefficient. The findings indicate that distribution channels should be diversified and human resource management should be improved. The study emphasises the suitability of DEA method for performance analysis in the insurance sector.

Sabet and Fadavi (2013), a two-stage DEA method was used to measure the performance of insurance companies in Iran between 2006 and 2010. The first stage considered five inputs and three outputs, while the second stage considered the outputs of the first stage as inputs for the second stage, and used three different outputs for this stage. The analysis results show that four of the insurance companies were efficient, while the others were significantly inefficient.

Koç, Şenol, and Çevik (2018) evaluated the financial performance of insurance companies in Turkey for the period 2006-2015 using ratio analysis method. Liquidity, financial structure, activity and profitability ratios were analysed

and it was determined that there were fluctuations in the profitability and financial structure of the companies and some of them moved away from sustainable financial structure. The study shows that ratio analysis is an effective tool for financial evaluation in the insurance sector.

Vintila et al. (2022) used the DEA model to analyze a sample of ten companies in the Romanian insurance sector for the period 2016–2020. The model used five predefined input sets: total expenses, provisions, average number of employees, total placements, and intangible assets; and one output: total revenue. The results show that Allianz and City were the most efficient firms, regardless of the model type (VRS or CRS). In contrast, Groupama and Omniasig did not operate at optimal levels in any of the analyzed periods.

Ihara and Laing (2023) used the DEA method to evaluate the performance and efficiency of 20 companies in the Japanese insurance sector. In the analysis using 2021 data, 10 of the 24 companies achieved technical efficiency. When the seven largest companies were analyzed separately, it was found that 4 of them achieved full technical efficiency.

Marangoz and İzci (2023) examined the economic, social and environmental effects of natural disasters on entrepreneurship in the context of the February 6, 2023 Kahramanmaraş centered earthquakes. The study, prepared using the literature review method, emphasizes that entrepreneurs make significant contributions by offering innovative solutions and new business opportunities in the post-disaster process. The authors state that supporting entrepreneurship in disaster areas can have positive effects on the recovery process.

Selçuk Şen (2023) analyses the effects of the Kahramanmaraş earthquake that occurred on 6 February 2023 on the Turkish economy. The study analyses the measures taken after the earthquakes, the estimated costs and the possible effects of these costs on the economy. The total cost of the earthquakes is estimated to be around USD 70 billion, and it is stated that a significant portion of this cost will be covered by the public sector. Moreover, it is concluded that earthquakes will have negative effects on macroeconomic indicators.

Using the event study approach, Akyüzlü and Aksoy (2024) examined the impact of the Kahramanmaraş earthquake on the returns of the Borsa Istanbul index on February 6, 2023. The BIST Insurance index showed negative abnormal returns on the day of the earthquake, while the BIST Stone and Soil index showed positive abnormal returns. In the following 5 and 10 days, negative (Antalya, Insurance, Tourism) and positive (Stone, Soil, Metal Main) cumulative abnormal returns were observed in some sectors. The study reveals that natural disasters lead to different sectoral responses in capital markets.

Tüfenk (2024) examined the effects of the 6 February 2023 Kahramanmaraş earthquakes on Turkey's foreign trade. Changes in exports and imports are analysed by comparing foreign trade data before and after the earthquake. In addition, the transformation in the sector-based trade structures of the affected regions and the reflections of this transformation on the local economy were evaluated. The study aims to contribute to the literature on the effects of earthquakes on foreign trade.

Özge Öztürk (2025) examined the effects of the February 6, 2023 Kahramanmaraş earthquake on entrepreneurial firms in Malatya Technopolis. In the study based on survey data, it was determined that the majority of firms experienced income loss, staff reduction and payment difficulties. In addition, it was determined that the loss of personnel negatively affected R&D activities. The study draws attention to the economic and operational effects of disasters on technopolis entrepreneurs and contributes to the literature on measures that can be taken against such crises.

Fahri Yiyin's study titled "Mitigation of Possible Damages in the Insurance Sector Following the 6 February 2023 Kahramanmaraş Earthquake" emphasises that the insurance sector should take more effective measures against disasters, given Turkey's high earthquake risk. In the study, damage preventive suggestions such as the involvement of insurance companies in building inspection processes, supporting building performance analyses and increasing insurance awareness are presented. It is stated that the insurance sector should assume an active role not only in post-damage but also in pre-damage processes.

The above-mentioned studies show that there is a significant accumulation in the literature on the economic and sectoral effects of natural disasters. However, studies on the insurance sector are generally limited to financial performance or loss mitigation strategies. Accordingly, it is noteworthy that the number of studies measuring the operational efficiency of insurance companies after disasters is insufficient. Based on this deficiency, this study aims

to make an original contribution to the literature by examining the efficiency of insurance companies after the 6 February 2023 Kahramanmaraş earthquakes by using Data Envelopment Analysis method.

The main difference that distinguishes this study from its counterparts in the literature is that it is one of the first applied studies to analyse the operational efficiency of companies operating in the Turkish insurance sector over a period of time (2021-2024) after the 6 February 2023 Kahramanmaraş earthquakes. In the existing literature, studies on the insurance sector are generally limited to financial ratios, loss mitigation strategies or general performance analyses. In this study, on the other hand, by using annual data directly covering the post-earthquake period, the relative efficiency levels of the companies are evaluated comparatively with the Data Envelopment Analysis method. Thus, not only financial but also structural and managerial efficiency differences are revealed. In addition, through reference clusters, structures that can be taken as examples for inefficient firms have been identified and concrete improvement suggestions have been presented. In this respect, the study makes a unique and up-to-date contribution to the literature both methodologically and periodically.

## 3. Method

Data Envelopment Analysis (DEA) is a linear programming-based analytical technique for determining the relative efficiency levels of decision-making units. This method aims to evaluate production units that are assumed to have similar characteristics in comparison with each other (Avcı & Çınaroğlu, 2017). It offers an effective alternative to measure the performance of production processes in multiple input and multiple output structures where traditional regression methods are not sufficient. In recent years, this method is widely preferred especially in the fields of operations research and business management (Ömürbek et al., 2013).

Data Envelopment Analysis (DEA) is a method developed by Rhodes, Cooper and Charnes in 1978 to evaluate the relative efficiency of similar economic decision units in terms of production of goods or services (Eken & Pehlivaan, 2009). In 1957, Farrell's single input and single output model was developed by Charnes, Cooper and Rhodes by adapting it to a multiple input and output structure, and this new approach was named CCR model after the initials of the developers in the literature and took its place among DEA methods (Avcı et al., 2018). Another DEA model is the Slack Based Measure. This model not only focuses on radial efficiency measures but also takes into account slack values (Sarıca, 2017).

The main models used in DEA are CCR and BCC models. The BCC model, which consists of the initials of the developers, was developed and included in the literature by Banker, Charnes and Cooper in 1984 and its main difference from the CCR model is the way it deals with returns to scale. While the CCR model is based on constant returns to scale, the BCC model is based on the assumption of variable returns to scale (Demirci & Tarhan, 2017).

In performance analyses, the rate of increase in inputs and the rate of increase in outputs may not always be the same. If the rate of change in inputs and the rate of change in outputs coincide exactly, this situation is defined as constant returns. However, if the rates of change between inputs and outputs are different, then we speak of variable returns to scale (VRS). However, DEA models are divided into two types according to their focal points: input-oriented and output-oriented approaches (Doğan & Tanç, 2010).

The models used in Data Envelopment Analysis are classified as input or output oriented. In the input-oriented approach, while a certain level of output is kept constant, the minimum amount of input required to obtain this output is tried to be determined. In the output-oriented model, on the other hand, the maximum output level that can be obtained with the available inputs is estimated based on a fixed input level. In this direction, input-oriented models show how much the inefficient unit should reduce the amount of input to produce the same output, while output-oriented models reveal to what extent it should increase its output in order to achieve efficiency with the same input (Korkmaz et al., 2016).

Input-oriented CCR, BCC model and output-oriented CCR, BCC model are shown in Table 1.

**Table 1.** Input Oriented and Output Oriented CCR and BCC Models

| **Input Orianted CCR** | **Output Orianted CCR** |
|---|---|
| $\min z_0 = \theta$ <br> Constraints <br> $$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_0$$ <br> $$\theta x_0 - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0 \qquad j = 1, \dots, n;$$ <br> $\lambda_0 \geq; \quad j = 1, \dots, n;$ <br> $r = 1, \dots, s; \quad i = 1, \dots, m;$ | $\max z_0 = \theta$ <br> Constraints <br> $$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_0$$ <br> $$\theta y_0 - \sum_{j=1}^{n} \lambda_j y_{rj} \leq 0 \qquad j = 1, \dots, n;$$ <br> $\lambda_0 \geq 0;$ <br> $r = 1, \dots, s; \quad i = 1, \dots, m;$ |
| **Input Orianted BCC** | **Output Orianted BCC** |
| $\min z_0 = \theta$ <br> Constraints <br> $$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_0$$ <br> $$\theta x_0 - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0$$ <br> $$\sum_{j=1}^{n} \lambda_j = 1$$ <br> $\lambda_0 \geq; 0; \quad j = 1, \dots, n;$ <br> $r = 1, \dots, s; \quad i = 1, \dots, m;$ | $\max z_0 = \theta$ <br> Constraints <br> $$\sum_{j=1}^{n} \lambda_j y_{rj} \leq x_0$$ <br> $$\theta y_0 - \sum_{j=1}^{n} \lambda_j y_{rj} \leq 0$$ <br> $$\sum_{j=1}^{n} \lambda_j = 1$$ <br> $\lambda_0 \geq; 0;$ <br> $r = 1, \dots, s; \quad i = 1, \dots, m;$ |

In the analysis, 2 input (number of employees and total assets) and 2 output (net profit and total premium production) variables, which were found to be the most preferred in the literature research and which are most compatible with the purpose and method of the application, were used. The data used in the analysis were compiled from the annual activity reports of insurance companies included in the BIST Insurance Index for the years 2021, 2022, 2023, and 2024. Each company's reports for the years included in the analysis are listed in the references. Data of 6 insurance companies were included in the analysis. Başkaya (2005), Koç et al. (2018), Girginer et al. (2007), Altan (2010), Aydın (2019), Şenel & Kalfa (2022) have similarly published studies focused on comparison among insurance companies. Table 2 shows the data used as input and output in the analysis.

**Table 2.** Inputs and Outputs Included in the Analysis

| **Inputs** | **Description** |
|---|---|
| Number of Employees | Total number of personnel employed by the insurance company |
| Total Assets | Total economic assets owned by the company |
| **Outputs** | |
| Net Profit | Final profit amount remaining after deducting expenses from total revenues |
| Total Premium Production | Total premium income generated from life and non life insurance operations |

For the reliability of the DEA model results; if the number of inputs is m and the number of outputs is s, there must be at least m+s+1 decision-making units (Algın, 2014). Accordingly, the six insurance companies included in the analysis are presented in Table 3.

**Table 3.** List of Insurance Companies Included in the Analysis

| | |
|---|---|
| **1.** Anadolu Sigorta (ANSGR.E) | **4.** Anadolu Hayat Emeklilik (ANHYT.E) |
| **2.** Ray Sigorta (RAYSG.E) | **5.** AGESA (AGESA.E) |
| **3.** Türkiye Sigorta (TURSG.E) | **6.** AK Sigorta (AKGRT.E) |

## 4. Empirical Results

In this study, Data Envelopment Analysis (DEA) approach was used to measure the efficiency levels of six insurance companies in the BIST Insurance Index. Total efficiency values were calculated with the CCR model based on the assumption of constant returns to scale and technical efficiency values were calculated with the BCC model based on the assumption of variable returns to scale. These analyses were carried out through DEAP 2.1 software within the framework of the output-oriented model and the findings obtained are interpreted in detail.

The analysis process started with the determination of the efficiency scores of the firms. In this way, efficient and inefficient firms were identified. In order for inefficient decision units to reach an efficient position, which firms should be taken as reference firms and the weights of these reference firms were determined. In the last stage, the total factor productivity levels of the companies were calculated and included in the evaluation.

### 4.1. Efficiency Scores of Insurance Companies

When evaluating the efficiency or inefficiency of insurance companies, output-oriented BCC and CCR approaches were utilised. It aims to provide the maximum output ratio that can be obtained with the input ratio. The reason why output-side BCC and CCR models are preferred in this study is that firms have limited direct control over input factors. For example, it is often not possible or desirable to reduce inputs such as total assets, number of employees or number of agencies in the short run. Moreover, since these inputs reflect the organisational size and structural capacity of firms, their reduction is not recommended. Therefore, the main objective in the analysis is to achieve the highest level of output net profit with the available resources. Firms' ability to produce higher output with the same inputs will increase their competitiveness within the sector, strengthen their financial performance and improve their overall efficiency. In this context, the output-oriented approach offers a more realistic and strategic evaluation opportunity to increase the efficiency of enterprises.

While evaluating the efficiency results, in addition to the constant return assumption expressed by the CCR model and the variable return assumption represented by the BCC model, the 'scale efficiency' (CCR/BCC) values calculated as the ratio of these two values are also taken as basis in the analysis. Total efficiency level is measured by the CCR model, under the assumption of constant returns to scale, and this value reflects the extent to which the firm operates efficiently in terms of both technical and scale. Technical efficiency, on the other hand, is based on the logic of comparing similar firms with each other and is determined by the BCC model, under the assumption of variable returns to scale. The scale efficiency value, which is the ratio of the CCR and BCC scores, is used to determine whether insurance companies conduct their activities in accordance with their scale. This value is important in terms of showing how efficient companies are not only in terms of their internal processes, but also in terms of the scale in which they operate.

### 4.1.1. Efficiency of Insurance Companies in 2021

Chart 1 shows the CCR efficiency values calculated under the fixed return assumption, the BCC efficiency values obtained under the variable return assumption and the scale efficiency (CCR/BCC) values expressed as the ratio between these two models for 2021. The efficiency values of the companies vary between 0 and 1, and companies that reach a value of 1 are considered fully efficient. This indicates that the current performance of the company in question coincides with the highest performance that it can theoretically achieve. On the other hand, an efficiency score below 1 indicates that the company is relatively inefficient and its current performance level has the potential for improvement
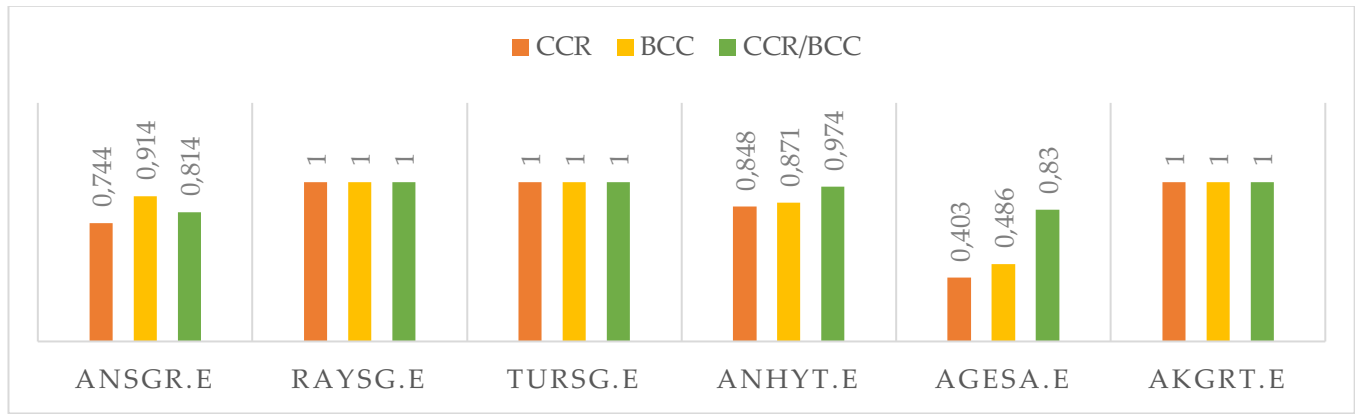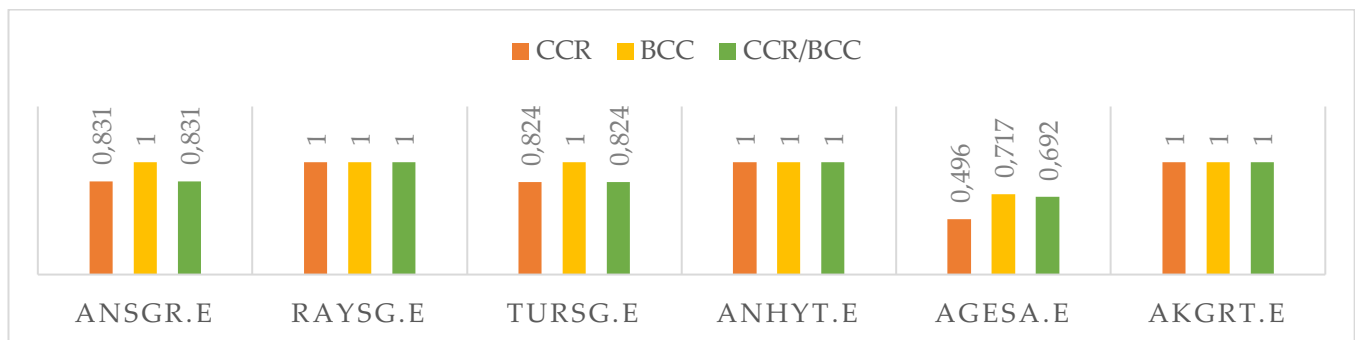
**Chart 1.** Efficiency Scores for the Year 2021

When the fixed return efficiency results are evaluated, it is concluded that these units are efficient in terms of the total efficiency level of 3 companies (Ray Sigorta, Türkiye Sigorta, AK Sigorta) in 2021. According to the efficiency analysis based on the fixed return model; it can be said that AGESA has the lowest total efficiency value with a score of 0,403.

When the variable return efficiency scores are evaluated, it is seen that 3 companies (Ray Sigorta, Türkiye Sigorta, AK Sigorta) are effective in terms of technical efficiency in 2021. According to the variable return efficiency scores, it is understood that AGESA has the lowest technical efficiency value with a score of 0,486.

 When the scale efficiency values are analysed, it is concluded that 3 companies (Ray Sigorta, Türkiye Sigorta, AK Sigorta) operated under appropriate scale conditions in 2021. According to the scale efficiency scores, it can be said that Anadolu Sigorta has the lowest technical efficiency value with a score of 0,814.

### 4.1.2. Efficiency of Insurance Companies in 2022

Chart 2 shows the CCR efficiency values calculated under the fixed return assumption, BCC efficiency values obtained under the variable return assumption and scale efficiency (CCR/BCC) values expressed as the ratio between these two models for the year 2022.



**Chart 2.** Efficiency Scores for the Year 2022

When the fixed return efficiency values are analysed, it is determined that 3 companies (Ray Sigorta, Anadolu Hayat Emeklilik, AK Sigorta) are efficient in terms of total efficiency in 2022. According to the results obtained under the fixed return assumption; considering AGESA's score of 0,496, it can be stated that it has the lowest performance in terms of total efficiency.
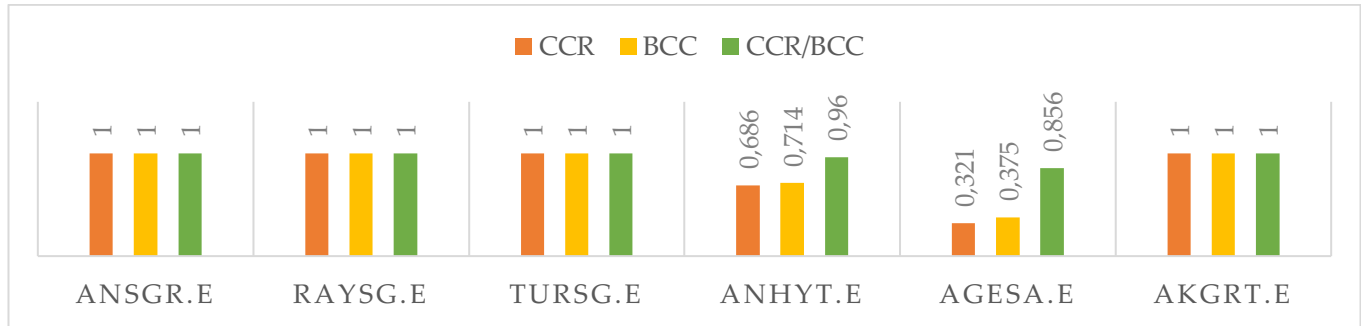
When the variable return efficiency values are analysed in terms of technical efficiency of 5 companies (Anadolu Sigorta, Ray Sigorta, Türkiye Sigorta, Anadolu Hayat Emeklilik, AK Sigorta) in 2022, it is concluded that these units are efficient. According to the findings of the analysis based on the variable return model, it is understood that AGESA is not efficient with a score of 0,717.

 When the scale efficiency values are analysed, it is concluded that 3 companies (Ray Sigorta, Anadolu Hayat Emeklilik, Türkiye Sigorta, Anadolu Hayat Emeklilik, AK Sigorta) are efficient in terms of working with appropriate

scale in 2022. According to the scale efficiency results, it can be said that AGESA has the lowest performance with a score of 0,692.

### 4.1.3. Efficiency of Insurance Companies in 2023

Chart 3 shows the CCR efficiency values of the analysed insurance companies calculated under the fixed return assumption, BCC efficiency values obtained under the variable return assumption and scale efficiency (CCR/BCC) values expressed as the ratio between these two models for 2023.
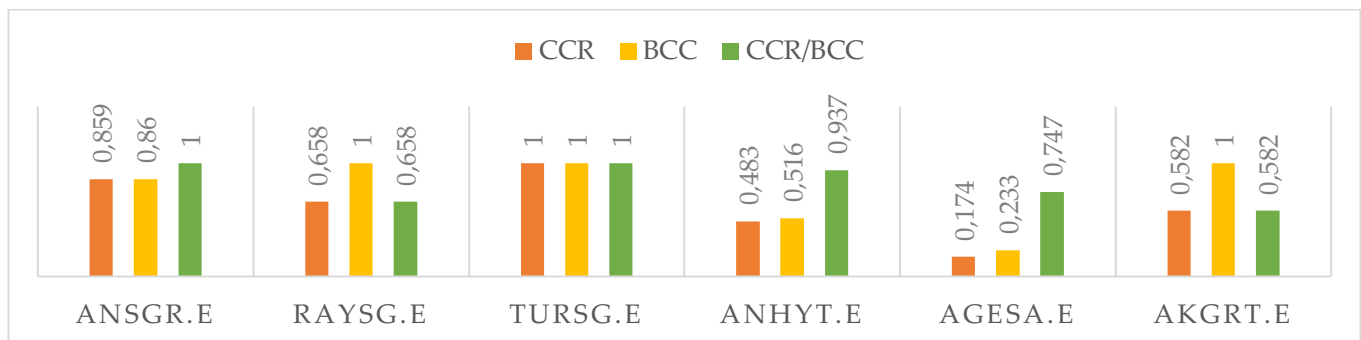


**Chart 3**. Efficiency Scores for the Year 2023

When the fixed return efficiency values are analysed, it is determined that 4 companies (Anadolu Sigorta, Ray Sigorta, Türkiye Sigorta, AK Sigorta) are efficient in terms of total efficiency in 2023. According to the results obtained under the fixed return assumption, it can be stated that AGESA has the lowest performance in terms of total efficiency, considering its score of 0,321.

When the variable return efficiency values are analysed, it is concluded that 4 companies (Anadolu Sigorta, Ray Sigorta, Türkiye Sigorta, AK Sigorta) are efficient in terms of technical efficiency in 2023. In terms of variable return efficiency values; it is understood that AGESA is not efficient with a score of 0,375.

When the scale efficiency values are analysed, it is concluded that 4 companies (Anadolu Sigorta, Ray Sigorta, Türkiye Sigorta, AK Sigorta) operate under appropriate scale conditions in 2023. According to the scale efficiency scores, it can be stated that AGESA has the lowest technical efficiency performance with a score of 0,856.

### 4.1.4. Efficiency of Insurance Companies in 2024

Chart 4 shows the CCR efficiency values of the analysed insurance companies for the year 2024 calculated under the fixed return assumption, the BCC efficiency values obtained under the variable return assumption and the scale efficiency (CCR/BCC) values expressed by the ratio between these two models.



**Chart 4.** Efficiency Scores for the Year 2024

When the fixed return efficiency values are analysed, it is determined that this unit is efficient in terms of total efficiency of 1 company (Türkiye Sigorta) in 2024. According to the results obtained under the fixed return assumption; it can be stated that AGESA has the lowest total efficiency score with a score of 0,174.

When variable return efficiency scores are analysed, it is seen that 3 companies (Ray Sigorta, Türkiye Sigorta, AK Sigorta) are effective in terms of technical efficiency in 2024. According to the variable return efficiency values, AGESA is inefficient with a value of 0,233.

When the scale efficiency values are analysed, it is concluded that 2 companies (Anadolu Sigorta, Türkiye Sigorta) operate under appropriate scale conditions in 2024. According to the scale efficiency results, it can be said that AK Sigorta has the lowest technical efficiency value with a score of 0,582.

## 4.2. Reference Set and Weight Values

Within the scope of Data Envelopment Analysis, a separate reference set is created for each inefficient decision unit. This reference set consists of decision units that are considered relatively efficient as a result of the analysis. Inefficient units need to utilise these reference units in order to reach the efficiency frontier. These reference units constitute an example of inefficient decision units with certain weight coefficients (Avcı et al., 2018).

Following the identification of inefficient insurance companies, it was analysed which companies on the border should be taken as reference in order for these companies to reach the efficiency frontier.

### 4.2.1. 2021 Reference Set and Weight Values

Table 4 below shows the reference set and weight values for 2021.

**Table 4.** Reference Sets and Weight Values of Companies for the Year 2021

| Companies | Reference Sets and Weight Values |
|---|---|
| Anadolu Sigorta (ANSGR.E) | Türkiye Sigorta (TURSG.E) **(1.000)** |
| Anadolu Hayat Emeklilik (ANHYT.E) | Türkiye Sigorta (TURSG.E) **(0.744)** <br> Ray Sigorta (RAYSG.E) **(0.256)** |
| AGESA (AGESA.E) | Türkiye Sigorta (TURSG.E) **(1.000)** |

When Table 4 is analysed, it is concluded that in order to be effective, Anadolu Sigorta should take Turkey Sigorta as an example in 2021 compared to the others. In that year, an improvement can be made for this company by taking Turkey Insurance as an example at a rate of 100%. Anadolu Hayat Emeklilik should also take Türkiye Sigorta and Ray Sigorta as a reference in order to be effective. In the relevant year, 74,4% of the improvements can be made for this company by taking Türkiye Sigorta as an example and 25,6% by taking Ray Sigorta as an example. AGESA, on the other hand, can make progress by taking Turkey Sigorta as an example 100% of the time in order to be effective.

### 4.2.2. 2022 Reference Set and Weight Values

Table 5 below shows the reference set and weight values for 2022.

**Table 5.** Reference Sets and Weight Values of Companies for the Year 2022

| Company | Reference Sets and Weight Values |
|---|---|
| AGESA (AGESA.E) | Anadolu Sigorta (ANSGR.E) **(0.394)** <br> Anadolu Hayat Emeklilik (ANHYT.E) **(0.606)** |

When Table 5 is analysed, it is concluded that in order to be effective, AGESA should take Anadolu Hayat Emeklilik and Anadolu Sigorta as examples compared to others in 2022. In that year, improvements can be made by taking Anadolu Sigorta with 39,4% and Anadolu Hayat Emeklilik with 60,6% as an example for this company.

### 4.2.3. 2023 Reference Set and Weight Values

Table 6 below shows the reference set and weight values for 2023.

**Table 6.** Reference Sets and Weight Values of Companies for the Year 2023

| Companies | Reference Sets and Weight Values |
|---|---|
| Anadolu Hayat Emeklilik (ANHYT.E) | Türkiye Sigorta (TURSG.E) **(0.578)**<br>Ray Sigorta (RAYSG.E)      **(0.422)** |
| AGESA (AGESA.E) | Türkiye Sigorta (TURSG.E) **(1.000)** |

When Table 6 is analysed, it is seen that Anadolu Hayat Emeklilik can make improvements by taking Türkiye Sigorta as an example for 57,8% and Ray Sigorta as an example for 42,2% in 2023 in order to be effective. It is concluded that AGESA should take Türkiye Sigorta as a reference at a rate of 100% in order to be effective.

### 4.2.4. 2024 Reference Set and Weight Values

Table 7 below shows the reference set and weight values for 2024.

**Table 7.** Reference Sets and Weight Values of Companies for the Year 2024

| Companies | Reference Sets and Weight Values |
|---|---|
| Anadolu Sigorta (ANSGR.E) | Türkiye Sigorta (TURSG.E)   **(0.995)**<br>Ray Sigorta (RAYSG.E)        **(0.005)** |
| Anadolu Hayat Emeklilik (ANHYT.E) | Türkiye Sigorta (TURSG.E)   **(0.552)**<br>Ray Sigorta (RAYSG.E)        **(0.448)** |
| AGESA (AGESA.E) | Türkiye Sigorta (TURSG.E)   **(1.000)** |
| AK Sigorta (AKGRT.E) | Ray Sigorta (RAYSG.E)        **(1.000)** |

When Table 7 is analysed, it is seen that in order for Anadolu Sigorta to become effective in 2024, 99,5% of the companies should take Türkiye Sigorta and 0,05% of the companies should take Ray Sigorta as a reference. In order to become efficient, Anadolu Hayat Emeklilik can make improvements by taking Turkey Sigorta as an example 55,2% of the time and Ray Sigorta as an example 44,8% of the time. It is concluded that AGESA should take Türkiye Sigorta as a reference at a rate of 100% in order to be effective. In order to be effective, AK Sigorta should take Ray Sigorta as an example at a rate of 100%.

### 4.3 Total Factor Productivity Values of Insurance Companies by Year (Malmquist)

As a result of the analysis, the productivity values of insurance companies for the years 2022, 2023 and 2024 are presented in Chart 5.
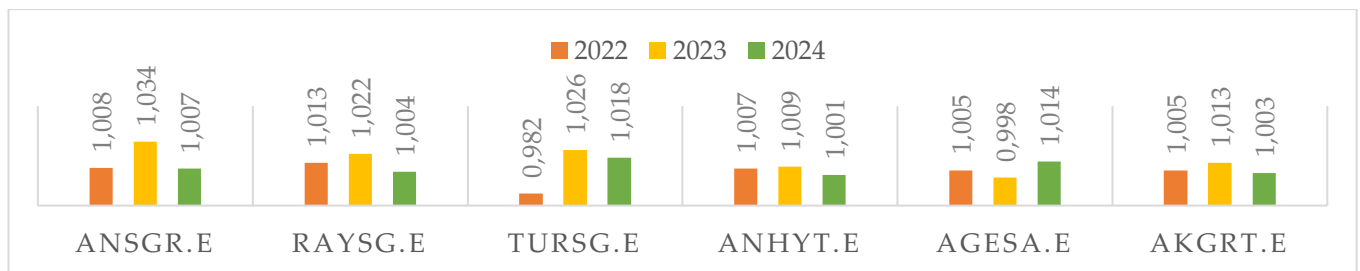


**Chart 5.** Companies' Productivity Values Over the Years

Türkiye Sigorta increased its productivity the most in the next two years compared to 2022. Ray Sigorta and Anadolu Sigorta peaked in productivity in 2023 but could not sustain this momentum in 2024. AGESA experienced a decline in 2023, but regained productivity in 2024. Anadolu Hayat Emeklilik and AK Sigorta, on the other hand, exhibited relatively stable but limited productivity growth throughout the period. These findings reveal that companies show different trends in productivity levels in the post disaster period.

## 5. Conclusion

In this study, the relative efficiency levels of the companies operating in the Turkish insurance sector following the 6 February 2023 Kahramanmaraş earthquakes were evaluated by Data Envelopment Analysis method. Ray, Türkiye, and AK Sigorta were efficient in 2021; Ray, Anadolu Hayat Emeklilik, and AK Sigorta were efficient in 2022; Anadolu, Ray, Türkiye, and AK Sigorta were efficient in 2023; and only Türkiye Sigorta was efficient in 2024. Furthermore, when total factor productivity was examined by year, Anadolu, Ray, Anadolu Hayat Emeklilik, AGESA, and AK Sigorta were efficient in 2022; Anadolu, Ray, Türkiye, Anadolu Hayat Emeklilik, AK Sigorta were efficient in 2023; and all insurance companies were efficient in 2024.The results of the analyses revealed that Ray, Türkiye and AK Sigorta achieved higher efficiency scores in general, while AGESA had the lowest efficiency levels in all years. This finding suggests that although resources are utilised in a similar manner across the sector, there are significant differences in the capacity to produce output. In addition, in order for inefficient firms to improve their performance, the efficient firms that they can take as reference and the weight values of these firms are determined. In line with the findings, it is understood that insurance companies should develop strategies to maximise output by using their existing resources more efficiently. In this context, it is suggested that especially companies with low efficiency scores should restructure their operational structures, make use of digital solutions to increase efficiency and take the practices of the leading companies of the sector as a model. The study provides an analytical perspective on the performance of the insurance sector in the post-disaster period and contributes to strategic decision-making processes for policymakers and sector representatives.

The low productivity observed in insurance companies after the earthquake stems largely from the sector's structural weaknesses. Firstly, inadequacies in technological infrastructure and differences in digitalization across companies cause processes to slow down during periods of high damage intensity. Furthermore, limited human resource capacity relative to the scale of the disaster and the inability of the number of experts and damage specialists to meet rapidly increasing demand exacerbate the loss of productivity. Limitations in the reinsurance structure and inadequate capital buffers cause companies to slow down their operations under liquidity pressure. Furthermore, the inflexibility of the regulatory framework during disaster periods can lead to bureaucratic prolongation of processes. All these structural factors combined make it inevitable for insurance companies to lose productivity in the face of high post-earthquake demand.

This study analyzed the performance of insurance companies after the earthquake using DEA, providing important findings regarding the sector's productivity dynamics. It is recommended that future research expand the scope of the DEA model and enrich it with different analysis techniques to support these findings more comprehensively. Firstly, diversifying both input and output variables in future studies, particularly incorporating operational indicators such as the level of digitalization, claim resolution time, reinsurance capacity, and customer satisfaction into the model, will contribute to a multidimensional assessment of post-earthquake performance.

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## ETHICAL AND SCIENTIFIC PRINCIPLES STATEMENT OF RESPONSIBILITY

The authors declare that ethical rules and scientific citation principles were complied with throughout the preparation process of this study.

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