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Analysis of the Corporate Financial Performance Based on Grey PSI and Grey MARCOS Model in Turkish Insurance Sector

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ABSTRACT

The use of MCDM approaches in the insurance sector provides important information to the top management or decision maker's authorities of insurance companies on issues such as accurate performance measurement, identification of strengths and weaknesses, optimisation of operations and improvement of strategic decisions. This, in turn, helps senior management to balance profitability and risk and contributes to the establishment of a sustainable business model. The present study aims to measure and rank corporate financial performance in the non-life insurance sector by using the Grey PSI and Grey MARCOS integrated model. For the purpose of this study, the proposed decision-making approach is applied through a case study. The case study focuses on the corporate financial performance assessment process of nine companies operating in the Turkish non-life insurance sector and consistently ranked in the top ten in terms of premium production in the period 2021-2023.In the current study, twelve financial performance indicators were identified for corporate financial performance analysis, taking into account previous studies in the literature. The importance weights of these performance criteria are calculated using the Grey PSI procedure. The Grey MARCOS method was then employed to determine the ranking of the decision alternatives. The results obtained from the Grey PSI method indicate that the net profit-to-total equity, net premiums received-to-gross premiums received and total operating expenses-to-gross premiums received are the three most significant criteria affecting the corporate financial performance of the relevant non-life insurance companies. The application of the grey MARCOS ranking method shows that Türkiye Sigorta has superior corporate financial performance for the period 2021-2023 compared to other insurance companies analysed in the study. The assessment and evaluation of corporate financial performance in the insurance sector is of critical importance for sector managers, policyholders, regulatory authorities, policymakers and other stakeholders, due to the significant benefits insurance companies provide at both micro and macroeconomic levels.

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1. Introduction

The insurance sector, a key financial intermediary, helps individuals and businesses to manage the risks they face. The insurance sector is very important in establishing both financial stability and a sustainable economic growth in country economies [1]. This sector supports both microeconomic stability (individuals and firms) and macroeconomic growth (capital markets and national economies) [2-3]. The insurance sector provides significant contributions to national economies (long-term resources to the financial system, increasing the level of efficiency in the economy, reducing transaction costs, creating liquidity, etc.) thanks to the premiums collected from the decision units in the economy [4-5]. In addition, the insurance sector is an important financial intermediary institution that compensates for possible risks or damages that may occur in the economy and prevents losses in the national economy [6-7].

The macro-level competitive conditions brought about by globalization offer many opportunities to today's business world. These opportunities also expose companies to risks that are difficult, if not impossible, to predict [8]. Considering this situation, it is not possible to overcome the aforementioned risk factors and build a sustainable business world in an economic system without the insurance sector [9]. Thanks to the risk absorption role it plays, the insurance sector not only promotes financial stability but also pioneers the construction of a strong financial structure by eliminating vulnerabilities both in terms of financial assets and national economies [10]. Moreover, an adverse situation or failure in this sector can disrupt the structure of the entire financial sector, especially real sector companies, and cause serious damage to the economic system by increasing the systematic risk factor [11-12].

As in other developing countries, it is important to regularly analyses the performance of the insurance sector, which is critical to the financial system, and to objectively evaluate the results obtained, in order to ensure that the Turkish financial sector can effectively maintain its existence and continue to operate in a stable manner.

As in other developing countries, it is important to analyze the performance of the insurance sector, which is crucial for the financial system, on a regular basis and to objectively evaluate the results obtained in order to effectively maintain the existence of the Turkish financial sector and to continue its activities in a stable manner. Performance analysis and efficiency measurement carried out by researchers contribute to improving the quality of insurance activities on the one hand, and on the other hand, it contributes to the timely identification of existing or potential problems and taking measures [13]. As a result, the measurement and evaluation of corporate financial performance in the insurance sector is of critical importance to sector managers, policyholders, regulators, policymakers and other stakeholders due to the significant benefits of insurance companies at both micro and macroeconomic levels.

This research proposes a new integrated decision process for analyzing the corporate financial performance of companies in the insurance sector. The proposed decision process includes the Grey PSI and Grey MARCOS methods. In these procedures, Grey PSI is used to obtain objective criteria weights. The other component of the proposed model, the Grey MARCOS approach, is used to rank the alternatives. A case study has been designed in the research to implement and test the proposed corporate financial performance evaluation model. This case study focuses on the process of evaluating the financial performance of 9 companies operating in the non-life insurance sector in Turkey, which are consistently ranked among the top ten companies in terms of premium production for the period 2021-2023. The current research aims to answer the following research questions with the help of the presented integrated decision framework.

- RQ1. Why is it important to analyses the corporate financial performance of companies in the insurance industry?
- RQ2. Which evaluation criteria should be considered when analyzing corporate financial performance in the insurance sector?
- RQ3. What is the most important evaluating criteria of corporate financial performance in the insurance sector?
- RQ4. Which company in the insurance sector is more successful than its competitors in terms of corporate financial performance?

The novelty of this research and its contributions to the literature can be listed as follows:

- A new decision making approach has been developed for evaluating the financial performance of insurance company.
- A relatively new integrated weighting strategy is proposed to obtain importance weights for the criteria.
- The Grey PSI and Grey MARCOS methodologies are applied for the first time in the literature to solve a corporate financial performance evaluation problem.
- The developed decision procedure enables a comprehensive decision support system to provide assistance to insurance managers, policyholders, policymakers and other stakeholders in measuring, analyzing and evaluating corporate financial performance, thus facilitating more informed and robust decision making by all stakeholders involved in the insurance industry.
- The methodology introduced is applied to a case study of 9 companies in the insurance sector. Finally, no study has previously been conducted using a combination of Grey PSI and Grey MARCOS for the same case. The originality of the study lies in the fact that, for the first time, the financial performance of companies in the insurance sector is assessed on the basis of 12 financial criteria at the company level, rather than on the basis of a comparison between companies.

This study is organized in four sections. In the first section, the background of the research and previous literature are discussed in the introduction. The methodology of the research and the proposed decision framework are then presented in the second section. The third section reports the findings and the fourth and final section concludes the study with general evaluations.

1.1 Literature Review

In the insurance literature, many studies have been conducted on performance evaluation and ranking using different MCDM methods. For example, in a study using the AHP and TOPSIS methods, Hao and Chou [14] analyzed the performance of insurance companies operating in Taiwan for the years 1997-1999. Elitas *et al.,* [15] compared the performance of insurance companies in BIST for the years 2010-2011 using the GIA method. As a result of the study, Aksigorta was reported as the company with the highest performance. In addition, Khodamoradi *et al.,* [16] analyzed the performance of insurance companies in TSE for the period 2010-2012 using DEMATEL and PROMETHEE methods. Similarly, Sehhat *et al.,* [17] analyzed performance of seven insurance firms operating in Iran in 2015 using AHP and TOPSIS methodology. Having studied, Parsian firm was identified as the company with the highest performance. In addition, Venkateswarlu and Rao [3] analyzed the financial performance of 16 non-life insurance companies registered in the Indian insurance sector for the period 2008-2013 using equal weighting, GIA and TOPSIS procedure. Shri

Ram General was found to be a high performing company according to both approaches. Similarly, Ahmadi *et al.,* [18] evaluated the performance of 13 insurance companies operating in North Khorasan during 2012-2013 using AHP and TOPSIS methods. According to the empirical results of the study, Iran Insurance is the company with the highest performance. In addition, Aytekin and Karamasa [19] analyzed the performance of insurance companies whose shares are traded on BIST for the period 2011-2015 using the Fuzzy TOPSIS model. Having study, Anadolu Hayat Insurance was reported as the most successful company. On the other hand, the performance of private capital insurance companies operating in Iran was comparatively analyzed by Asadi and Moghri [4], the performance of insurance companies operating in Taiwan by Tsai *et al.,* [20] and the performance of insurance companies operating in Serbia by Mandić *et al.,* [21] within the framework of the TOPSIS method. Using similar decision-making methods, Isik [22] analyzed the performance of the Turkish non-life insurance sector for the years 2009-2017 using CRITIC, TOPSIS and MULTIMOORA algorithms.

In the studies made in recent years focusing on the insurance sector, *Pattnaik et al.,* [23] conducted the performance analysis of 12 Indian life insurance companies using the Fuzzy TOPSIS method. Similarly, Işık [5] evaluated the performance of Axa Insurance Company registered in the Turkish insurance sector for the period 2011-2020 using AHP, CRITIC and WEDBA methods. Mimovic *et al.,* [24] evaluated the performance of the Serbian insurance sector for the period 2008-2018 using the Fuzzy TOPSIS method, and having study they determined the most successful year of the sector as 2018. In addition, Cinaroglu [25] analyzed the performance of 15 private pension companies in Turkey using Entropy, EDAS and CODAS algorithms. Pala [26] analyzed the financial performance of six insurance companies in the BIST Insurance Index for 2019-2020, within the scope of the CRITIC and MULTIMOOSRAL approaches. The study concluded that Avivasa Life and Pension is the most successful company in terms of performance. In addition, using AHP, SV and MAIRCA algorithms Akbulut and Gumuskaya [27] compared the performance of the Turkish non-life insurance sector over the period 2010-2021. Further, Isik *et al.,* [8] proposed LOPCOW, SWARA II and MARCOS models for the performance of non-life insurance companies in Turkey for the period 2011-2019. Akbulut and Aydogan [28] analyzed the performance of the life/pension insurance sector operating in Turkey for the period 2010-2021 using SV, SAW and ARAS methods. Finally, Isik *et al.,* [29] proposed Pythagorean Fuzzy AHP and MAIRCA procedures in the performance measurement process of 5 non-life insurance companies whose shares are listed on BIST for the period 2015-2019. Different from these methods, Yao *et al.,* [30] used input-oriented CCR DEA analysis to evaluate the efficiency of 22 life and non-life insurance companies operating in China, while Kulekci and Saldanlı [31] used output-oriented CCR DEA analysis to evaluate the efficiency of non-life insurance companies in Turkey. Consequently, it can be clearly stated that most studies in previous literature on performance measurement in insurance sectors of different countries use traditional decision methods. Therefore, this study aims to fill the gap in the literature by proposing a new and original model based on the Grey System Theory to solve the problem of performance measurement in the insurance sector.

2. Methodology

In this study, the Grey PSI and Grey MARCOS methodologies are proposed as a decision-making procedure for corporate financial performance analysis in the insurance sector. Grey PSI is used to calculate objective weight scores for selected corporate financial performance indicators. Grey MARCOS method is used in the process of obtaining performance rankings of insurance companies. In this section discusses the theoretical framework of these decision-making procedures.

2.1 Grey PSI Procedure

Grey PSI procedure is an enhanced version of the PSI procedure introduced in the literature by Maniya and Bhatt [32]. Grey PSI procedure is an objective criteria weighting method. The main advantage of this method is that it does not use different weighting methods to compare criteria. By determining a weighting coefficient within itself, the PSI method eliminates the disagreements that lead to controversy over the weighting of evaluation criteria [32]. The application steps of the grey PSI method are as follows [33-34].

Step 1. Firstly, a grey initial decision matrix is created consisting of m decision alternatives and n evaluation criteria according to Eq. (1).

$$\otimes X = [\otimes x_{ij}]_{m\times n} = \begin{bmatrix} [x_{11}^l, x_{11}^u] & [x_{12}^l, f_{12}^u] & \cdots & [x_{1n}^l, x_{1n}^u] \\ [x_{21}^l, x_{21}^u] & [x_{22}^l, f_{22}^u] & \cdots & [x_{2n}^l, x_{2n}^u] \\ \vdots & \vdots & \ddots & \vdots \\ [x_{m1}^l, x_{m1}^u] & [x_{m2}^l, x_{m2}^u] & \cdots & [x_{mn}^l, x_{mn}^u] \end{bmatrix} \tag{1}$$

Where $\otimes x_{ij} = [x_{ij}^l, x_{ij}^u]$ represents the grey value of the i-th alternative according to the j-th criterion. In addition, the values x_{ij}^l and x_{ij}^u represent the lower and upper values of the criteria in the grey decision matrix.

Step 2. Each value in the grey decision matrix is normalized according to the cost-benefit properties of the criteria. Eq. (2) is used for the beneficial criteria and Eq. (3) for the non-beneficial criteria.

$$\otimes y_{ij} = \frac{min(\otimes x_{ij})}{\otimes x_{ij}} = \left[\frac{min\ (x_{ij}^l)}{x_{ij}^u}, \frac{min\ (x_{ij}^l)}{x_{ij}^l}\right] \tag{2}$$

$$\otimes y_{ij} = \frac{\otimes x_{ij}}{max(\otimes x_{ij})} = \left[\frac{x_{ij}^l}{min\ (x_{ij}^u)}, \frac{x_{ij}^u}{max\ (x_{ij}^u)}\right] \tag{3}$$

Step 3. The grey average performance value of each evaluation criterion in the grey normalized matrix is determined using Eq. (4).

$$\otimes \bar{z}_{ij} = \frac{\sum_{i=1}^{m} y_{ij}}{m} = \left[\frac{\sum_{i=1}^{m} y_{ij}^l}{m}, \frac{\sum_{i=1}^{m} y_{ij}^u}{m}\right] \tag{4}$$

Step 4. Eq. (5) is used to determine the grey preference variability value $(\otimes t_j = [t_j^l, t_j^u])$ for each evaluation criterion.

$$\otimes t_j = \sum_{i=1}^{m}(\otimes y_{ij} - \otimes \bar{z}_{ij})^2 = \left[min\left(\sum_{i=1}^{m}(y_{ij}^l - \bar{z}_{ij}^l)^2, \sum_{i=1}^{m}(y_{ij}^u - \bar{z}_{ij}^u)^2\right), max\left(\sum_{i=1}^{m}(y_{ij}^l - \bar{z}_{ij}^l)^2, \sum_{i=1}^{m}(y_{ij}^u - \bar{z}_{ij}^u)^2\right)\right] \tag{5}$$

Step 5. The grey deviation values of the criteria are calculated using Eq. (6).

$$\otimes d_j = [d_j^l, d_j^u] = |1 - \otimes t_j| = [|1 - t_j^u|, |1 - t_j^l|] \tag{6}$$

Step 6. In the last stage of the method, the grey objective importance weights for each criterion are determined using Eq. (7).

$$\otimes w_{jPI} = \left[w_{jPI}^{l}, w_{jPI}^{u}\right] = \frac{\otimes d_j}{\sum_{j=1}^{n} \otimes d_j} = \left[\frac{d_j^l}{\sum_{j=1}^{n} d_j^u}, \frac{d_j^u}{\sum_{j=1}^{n} d_j^l}\right] \tag{7}$$

The most important (unimportant) performance indicator is the criterion with the highest (lowest) $\otimes w_{jPI}$ value.

2.2 Grey MARCOS Procedure

Grey MARCOS procedure is an improved version of MARCOS introduced in the literature by Stevic *et al.,* [35]. This procedure makes it possible to reveal both the relationship between alternatives and reference values and the functionality of the options. According to this method, the best decision alternative is the one that is closest to the ideal and the one that is most distant from the anti-ideal. The application of the method consists of the following steps [35-36].

Step 1. Grey initial decision matrix is designed according to Eq. (1).

Step 2. Using Eq. (9) and Eq. (10), the grey ideal (AI) and grey anti-ideal (AAI) solution points for the grey decision matrix are determined. Then, the extended grey decision matrix shown in Eq. (8) is generated.

$$\otimes X = \left[\otimes x_{ij}\right]_{m\times n} = \begin{matrix} \\ AAI \\ A_1 \\ A_2 \\ \cdots \\ A_m \\ AI \end{matrix} \begin{matrix} C_1 & C_2 & \cdots & C_n \\ \left[\begin{matrix} \otimes x_{aa1} \\ \otimes x_{a11} \\ \otimes x_{a21} \\ \cdots \\ \otimes x_{m1} \\ \otimes x_{ai1} \end{matrix}\right. & \begin{matrix} \otimes x_{aa2} \\ \otimes x_{a12} \\ \otimes x_{a22} \\ \cdots \\ \otimes x_{m2} \\ \otimes x_{ai2} \end{matrix} & \begin{matrix} \cdots \\ \cdots \\ \cdots \\ \cdots \\ \cdots \\ \cdots \end{matrix} & \left.\begin{matrix} \otimes x_{aan} \\ \otimes x_{a1n} \\ \otimes x_{a2n} \\ \cdots \\ \otimes x_{mn} \\ \otimes x_{ain} \end{matrix}\right] \end{matrix} \tag{8}$$

$$AAI = min\ x_{ij}^{l}\ \ if\ j\ \in B\ and\ max\ x_{ij}^{u}\ if\ j\ \in C \tag{9}$$

$$AI = max\ x_{ij}^{u}\ \ if\ j\ \in B\ and\ min\ x_{ij}^{l}\ if\ j\ \in C \tag{10}$$

In Eqs. (9-10), B represents beneficial criteria, and C represents non-beneficial criteria.

Step 3. Expanded grey decision matrix is normalized by considering the benefit-cost characteristics of the criteria. In this context, Eq. (11) is used for beneficial criteria and Eq. (12) for non-beneficial criteria.

$$\otimes n_{ij} = \frac{\otimes x_{ij}}{max\left(x_{ij}^{u}\right)} = \left(\frac{x_{ij}^{l}}{max\left(x_{ij}^{u}\right)}, \frac{x_{ij}^{u}}{max\left(x_{ij}^{u}\right)}\right) if\ j \in\ B \tag{11}$$

$$\otimes n_{ij} = \frac{min\left(x_{ij}^{l}\right)}{\otimes x_{ij}} = \left(\frac{min\left(x_{ij}^{l}\right)}{x_{ij}^{u}}, \frac{min\left(x_{ij}^{l}\right)}{x_{ij}^{l}}\right) if\ j \in\ C \tag{12}$$

Step 4. The weighted normalized grey matrix is obtained by multiplying the importance weights of the criteria by the normalized grey matrix according to Eq. (13).

$$\otimes v_{ij} = \left[v_{ij}^{l}, v_{ij}^{u}\right] = \otimes w_j \times \otimes n_{ij} = \left[w_j^l \times n_{ij}^{l}, w_j^u \times n_{ij}^{u}\right] \tag{13}$$

Step 5. In this step, the degrees of grey utility of the decision alternatives are determined using the grey ideal and grey anti-ideal solution points. The degree of grey utility for each decision alternative is calculated using Eq. (14) and Eq. (15).

$$\otimes K_i^- = \frac{\otimes S_i}{\otimes S_{AAI}} = \left(\frac{S_i^l}{S_{AAI}^u}, \frac{S_i^u}{S_{AAI}^l}\right) \quad (14)$$

$$\otimes K_i^+ = \frac{\otimes S_i}{\otimes S_{AI}} = \left(\frac{S_i^l}{S_{AI}^u}, \frac{S_i^u}{S_{AI}^l}\right) \quad (15)$$

Where, $\otimes S_i$ represents the sum of the weighted grey matrix values for each alternative, as expressed in Eq. (16).

Step 6. The grey utility functions for the alternatives are calculated using Eq. (17).

$$f(K_i) = \frac{K_i^+ + K_i^-}{1 + \frac{1-f(K_i^+)}{f(K_i^+)} + \frac{1-f(K_i^-)}{f(K_i^-)}} \quad (17)$$

Where $f(K_i^-)$ and $f(K_i^+)$ values represent the utility functions according to the grey anti-ideal and grey ideal solutions respectively. These values are obtained by Eq. (18) and Eq. (19) respectively.

$$\otimes f(K_i^-) = \frac{\otimes K_i^+}{max(\otimes K_i^+ + \otimes K_i^-)} \quad (18)$$

$$\otimes f(K_i^+) = \frac{\otimes K_i^-}{max(\otimes K_i^+ + \otimes K_i^-)} \quad (19)$$

Step 7. In the final step of grey MARCOS procedure, the decision alternatives are ranked in terms of the final values of the grey utility function. Here, the alternative with the highest grey utility function is accepted as the most successful.

3. Results

This study proposes a new hybrid decision framework for analyzing corporate financial performance in the Turkish insurance sector. Within the framework of the study, a case study was conducted to implement and test the proposed corporate financial performance evaluation model. This case study focuses on the corporate financial performance assessment process of 9 non-life insurance companies in Turkey during the period 2021-2023. The 9 insurance companies analyzed are Türkiye Sigorta (IC1), Allianz (IC2), Anadolu Anonim Türk (IC3), Axa (IC4), Aksigorta (IC5), HDI (IC6), Quick (IC7), Sompo (IC8) and Ray (IC9). In order to analyse the corporate financial performance of the selected insurance companies, 12 performance indicators were determined using previous literature Alenjagh [13]; Akbulut and Gumuskaya [27]; Asadi and Moghri [4]; Isik [22]; Mandić *et al.,* [21]; Mimovic *et al.,* [24]; Pattnaik *et al.,* [23]; Venkateswarlu and Rao [3]. These indicators and qualifications for decision-makers are respectively, total equity-to-total assets (EC1-max), current assets-to-current liabilities (EC2-max), net profit-to-total equity (EC3-max), net profit-to-total assets (EC4-max), net premiums received-to-gross premiums received (EC5-max), gross premiums received-to-total assets (EC6-max), cash and cash equivalents assets-to-total assets (EC7-max), total liabilities-to-total equity (EC8-min), gross premiums received-to-total equity (EC9-min), total current liabilities-to-total assets (EC10-min), gross claims paid-to-gross premiums received (EC11-min) and total operating expenses-to-gross premiums received (EC12-min). The data for the performance indicators were obtained from the regularly published financial and annual reports of the companies concerned.

3.1 The Results of Grey PSI Procedure

Analysis process was started with the calculation of objective importance weights for the evaluation criteria. The first step was to create the grey decision matrix according to Eq. (1), as shown in Table 1.

Table 1 Grey Decision Matrix

	IC1	IC2	IC3	IC4	IC5	IC6	IC7	IC8	IC9
EC1	[0.20,0.29]	[0.11,0.12]	[0.19,0.24]	[0.24,0.27]	[0.14,0.16]	[0.14,0.18]	[0.20,0.27]	[0.20,0.28]	[0.16,0.19]
EC2	[1.26,12.8]	[1.45,1.60]	[1.16,1.23]	[1.30,1.38]	[1.14,1.16]	[1.15,1.21]	[0.99,1.14]	[1.21,12.8]	[1.14,1.21]
EC3	[0.09,0.40]	[0.24,0.47]	[0.16,0.42]	[0.30,0.49]	[0.06,0.36]	[0.14,0.57]	[0.14,0.46]	[0.16,0.51]	[0.16,0.45]
EC4	[0.02,0.08]	[0.03,0.05]	[0.03,0.10]	[0.08,0.12]	[0.01,0.06]	[0.02,0.10]	[0.03,0.12]	[0.04,0.12]	[0.03,0.08]
EC5	[0.04,0.32]	[0.46,0.58]	[0.43,0.64]	[0.36,0.53]	[0.49,0.55]	[0.36,0.47]	[0.29,0.69]	[0.38,0.65]	[0.30,0.45]
EC6	[0.77,0.89]	[0.18,0.26]	[0.64,0.77]	[0.49,0.69]	[0.95,1.29]	[0.75,0.99]	[0.53,0.72]	[0.47,0.85]	[0.97,1.18]
EC7	[0.32,0.43]	[0.11,0.13]	[0.19,0.30]	[0.11,0.22]	[0.25,0.40]	[0.37,0.51]	[0.30,0.39]	[0.17,0.24]	[0.33,0.39]
EC8	[0.35,2.40]	[7.54,8.01]	[3.11,4.24]	[2.71,3.12]	[5.45,6.04]	[4.62,5.97]	[2.65,4.12]	[2.55,3.92]	[4.19,5.11]
EC9	[2.78,3.92]	[1.56,2.26]	[3.11,3.93]	[1.97,2.84]	[6.66,8.33]	[4.30,6.57]	[2.05,2.70]	[1.67,4.16]	[5.05,6.90]
EC10	[0.07,0.69]	[0.22,0.26]	[0.74,0.78]	[0.70,0.74]	[0.83,0.84]	[0.77,0.82]	[0.72,0.80]	[0.71,0.79]	[0.77,0.80]
EC11	[0.04,0.32]	[0.46,0.58]	[0.43,0.64]	[0.36,0.53]	[0.49,0.55]	[0.36,0.47]	[0.29,0.69]	[0.38,0.65]	[0.30,0.45]
EC12	[0.07,0.09]	[0.13,0.17]	[0.12,0.14]	[0.13,0.17]	[0.07,0.10]	[0.11,0.22]	[0.07,0.17]	[0.09,0.14]	[0.06,0.11]

Grey normalized matrix calculated using Eq. (2) for the beneficial criteria and Eq. (3) for the non-beneficial criteria is shown in Table 2.

Table 2 Grey Normalized Matrix

	IC1	IC2	IC3	IC4	IC5	IC6	IC7	IC8	IC9
EC1	[0.68,1.00]	[0.38,0.40]	[0.65,0.83]	[0.82,0.92]	[0.48,0.53]	[0.49,0.61]	[0.66,0.93]	[0.69,0.96]	[0.56,0.66]
EC2	[0.10,1.00]	[0.11,0.12]	[0.09,0.10]	[0.10,0.11]	[0.09,0.09]	[0.09,0.09]	[0.08,0.09]	[0.09,1.00]	[0.09,0.09]
EC3	[0.16,0.70]	[0.42,0.83]	[0.29,0.73]	[0.52,0.85]	[0.11,0.63]	[0.25,1.00]	[0.24,0.80]	[0.27,0.89]	[0.27,0.78]
EC4	[0.17,0.64]	[0.21,0.44]	[0.25,0.81]	[0.64,0.98]	[0.08,0.45]	[0.16,0.82]	[0.22,1.00]	[0.31,0.97]	[0.24,0.67]
EC5	[0.06,0.47]	[0.66,0.84]	[0.62,0.92]	[0.53,0.77]	[0.71,0.80]	[0.52,0.69]	[0.42,1.00]	[0.55,0.94]	[0.43,0.65]
EC6	[0.60,0.69]	[0.14,0.20]	[0.50,0.60]	[0.38,0.53]	[0.73,1.00]	[0.58,0.77]	[0.41,0.55]	[0.36,0.65]	[0.75,0.91]
EC7	[0.62,0.83]	[0.21,0.25]	[0.37,0.59]	[0.22,0.43]	[0.48,0.78]	[0.72,1.00]	[0.59,0.75]	[0.33,0.46]	[0.63,0.76]
EC8	[0.15,1.00]	[0.04,0.05]	[0.08,0.11]	[0.11,0.13]	[0.06,0.06]	[0.06,0.08]	[0.09,0.13]	[0.09,0.14]	[0.07,0.08]
EC9	[0.40,0.56]	[0.69,1.00]	[0.40,0.50]	[0.55,0.79]	[0.19,0.23]	[0.24,0.36]	[0.58,0.76]	[0.37,0.93]	[0.23,0.31]
EC10	[0.10,1.00]	[0.26,0.30]	[0.09,0.09]	[0.09,0.09]	[0.08,0.08]	[0.08,0.09]	[0.08,0.09]	[0.08,0.09]	[0.08,0.09]
EC11	[0.13,1.00]	[0.07,0.09]	[0.06,0.09]	[0.08,0.11]	[0.07,0.08]	[0.09,0.11]	[0.06,0.14]	[0.06,0.11]	[0.09,0.13]
EC12	[0.73,0.86]	[0.37,0.50]	[0.46,0.51]	[0.37,0.49]	[0.66,0.90]	[0.29,0.58]	[0.38,0.94]	[0.46,0.74]	[0.60,1.00]

In the final stage of the procedure, the grey mean performance values ($\otimes\bar{z}_{ij}$) of the criteria were first calculated using Eq. (4) and the grey preference variability values ($\otimes t_j$) were calculated using Eq. (5). In the second step, the grey deviation ($\otimes d_j$) of each criterion was calculated from Eq. (6) and the grey objective importance weight ($\otimes w_{jPI}$) of each criterion was calculated from Eq. (7). The aggregated results of the calculations are shown in Table 3.

Table 3 Grey PSI Results

	$\otimes\bar{z}_{ij}$	$\otimes d_j$	$\otimes w_{jPI}$	Crisp w_j	Rank
EC1	[0.6015, 0.7578]	[0.6247, 0.8509]	[0.0828, 0.1029]	0.0928	4
EC2	[0.0936, 0.2992]	[0.2578, 0.9992]	[0.0425, 0.0972]	0.0698	10
EC3	[0.2809, 0.8025]	[0.8769, 0.9039]	[0.0880, 0.1444]	0.1162	1
EC4	[0.2532, 0.7520]	[0.6247, 0.7954]	[0.0774, 0.1029]	0.0901	5
EC5	[0.5006, 0.7852]	[0.7032, 0.7777]	[0.0757, 0.1158]	0.0957	2
EC6	[0.4943, 0.6571]	[0.5673, 0.6966]	[0.0678, 0.0934]	0.0806	6
EC7	[0.4632, 0.6490]	[0.5550, 0.7140]	[0.0695, 0.0914]	0.0804	7
EC8	[0.0835, 0.1988]	[0.2693, 0.9920]	[0.0443, 0.0965]	0.0704	9
EC9	[0.4039, 0.6057]	[0.3809, 0.7603]	[0.0627, 0.0740]	0.0683	12
EC10	[0.1048, 0.2139]	[0.2658, 0.9732]	[0.0438, 0.0947]	0.0692	11
EC11	[0.0780, 0.2073]	[0.2900, 0.9966]	[0.0478, 0.0970]	0.0724	8
EC12	[0.4807, 0.7244]	[0.6578, 0.8177]	[0.0796, 0.1083]	0.0939	3

According to the empirical results displayed in Table 3, the three criteria with the most impact on the corporate financial performance of the analyzed insurance companies for the period 2021-2023 are EC3 (net profit-to-total equity), EC5 (net premiums received-to-gross premiums received) and EC12 (total operating expenses-to-gross premiums received). On the other hand, three criteria with the lowest impact on companies' corporate financial performance are EC9 (gross premiums received-to-total equity), EC10 (total current liabilities-to-total assets) and EC8 (total liabilities-to-total equity).

3.2 The Results of Grey MARCOS Procedure

In this part of the study, the importance weights determined by the Grey PSI procedure for corporate financial performance criteria are integrated into the Grey MARCOS method to determine the success rankings of insurance companies. In the first step of the Grey MARCOS method, grey decision matrix is created according to Eq. (1), as shown in Table 1. Then, in the second step, the extended grey decision matrix containing the grey ideal (AI) and grey anti-ideal (AAI) solution points of the criteria was obtained using Eqs. (8-10). The extended grey decision matrix created as a result of the calculations is shown in Table 4.

Table 4 Grey Extended Decision Matrix

	AAI	IC1	IC2	IC3	IC4	IC5	IC6	IC7	IC8	IC9	AI
EC1	[0.11,0.12]	[0.20,0.29]	[0.11,0.12]	[0.19,0.24]	[0.24,0.27]	[0.14,0.16]	[0.14,0.18]	[0.20,0.27]	[0.20,0.28]	[0.16,0.19]	[0.24,0.29]
EC2	[0.99,1.14]	[1.26,12.8]	[1.45,1.60]	[1.16,1.23]	[1.30,1.38]	[1.14,1.16]	[1.15,1.21]	[0.99,1.14]	[1.21,12.8]	[1.14,1.21]	[1.45,12.8]
EC3	[0.06,0.36]	[0.09,0.40]	[0.24,0.47]	[0.16,0.42]	[0.30,0.49]	[0.06,0.36]	[0.14,0.57]	[0.14,0.46]	[0.16,0.51]	[0.16,0.45]	[0.30,0.57]
EC4	[0.01,0.05]	[0.02,0.08]	[0.03,0.05]	[0.03,0.10]	[0.08,0.12]	[0.01,0.06]	[0.02,0.10]	[0.03,0.12]	[0.04,0.12]	[0.03,0.08]	[0.08,0.12]
EC5	[0.04,0.32]	[0.04,0.32]	[0.46,0.58]	[0.43,0.64]	[0.36,0.53]	[0.49,0.55]	[0.36,0.47]	[0.29,0.69]	[0.38,0.65]	[0.30,0.45]	[0.49,0.69]
EC6	[0.18,0.26]	[0.77,0.89]	[0.18,0.26]	[0.64,0.77]	[0.49,0.69]	[0.95,1.29]	[0.75,0.99]	[0.53,0.72]	[0.47,0.85]	[0.97,1.18]	[0.97,1.29]
EC7	[0.11,0.13]	[0.32,0.43]	[0.11,0.13]	[0.19,0.30]	[0.11,0.22]	[0.25,0.40]	[0.37,0.51]	[0.30,0.39]	[0.17,0.24]	[0.33,0.39]	[0.37,0.51]
EC8	[7.54,8.01]	[0.35,2.40]	[7.54,8.01]	[3.11,4.24]	[2.71,3.12]	[5.45,6.04]	[4.62,5.97]	[2.65,4.12]	[2.55,3.92]	[4.19,5.11]	[0.35,2.40]
EC9	[6.66,8.33]	[2.78,3.92]	[1.56,2.26]	[3.11,3.93]	[1.97,2.84]	[6.66,8.33]	[4.30,6.57]	[2.05,2.70]	[1.67,4.16]	[5.05,6.90]	[1.56,2.26]
EC10	[0.83,0.84]	[0.07,0.69]	[0.22,0.26]	[0.74,0.78]	[0.70,0.74]	[0.83,0.84]	[0.77,0.82]	[0.72,0.80]	[0.71,0.79]	[0.77,0.80]	[0.07,0.26]
EC11	[0.49,0.69]	[0.04,0.32]	[0.46,0.58]	[0.43,0.64]	[0.36,0.53]	[0.49,0.55]	[0.36,0.47]	[0.29,0.69]	[0.38,0.65]	[0.30,0.45]	[0.04,0.32]
EC12	[0.13,0.22]	[0.07,0.09]	[0.13,0.17]	[0.12,0.14]	[0.13,0.17]	[0.07,0.10]	[0.11,0.22]	[0.07,0.17]	[0.09,0.14]	[0.06,0.11]	[0.06,0.09]

Eq. (11) is used for the beneficial criteria and Eq. (12) for the non-beneficial criteria, and the values of the expanded grey decision matrix are normalized. The results for the normalized grey values are given in Table 5.

Table 5 Grey Normalized Matrix

	AAI	IC1	IC2	IC3	IC4	IC5	IC6	IC7	IC8	IC9	AI
EC1	[0.38,0.40]	[0.68,1.00]	[0.38,0.40]	[0.65,0.83]	[0.82,0.92]	[0.48,0.53]	[0.49,0.61]	[0.66,0.93]	[0.69,0.96]	[0.56,0.66]	[0.82,1.00]
EC2	[0.08,0.09]	[0.10,1.00]	[0.11,0.12]	[0.09,0.10]	[0.10,0.11]	[0.09,0.09]	[0.09,0.09]	[0.08,0.09]	[0.09,1.00]	[0.09,0.09]	[0.11,1.00]
EC3	[0.11,0.63]	[0.16,0.70]	[0.42,0.83]	[0.29,0.73]	[0.52,0.85]	[0.11,0.63]	[0.25,1.00]	[0.24,0.80]	[0.27,0.89]	[0.27,0.78]	[0.52,1.00]
EC4	[0.08,0.44]	[0.17,0.64]	[0.21,0.44]	[0.25,0.81]	[0.64,0.98]	[0.08,0.45]	[0.16,0.82]	[0.22,1.00]	[0.31,0.97]	[0.24,0.67]	[0.64,1.00]
EC5	[0.06,0.47]	[0.06,0.47]	[0.66,0.84]	[0.62,0.92]	[0.53,0.77]	[0.71,0.80]	[0.52,0.69]	[0.42,1.00]	[0.55,0.94]	[0.43,0.65]	[0.71,1.00]
EC6	[0.14,0.20]	[0.60,0.69]	[0.14,0.20]	[0.50,0.60]	[0.38,0.53]	[0.73,1.00]	[0.58,0.77]	[0.41,0.55]	[0.36,0.65]	[0.75,0.91]	[0.75,1.00]
EC7	[0.21,0.25]	[0.62,0.83]	[0.21,0.25]	[0.37,0.59]	[0.22,0.43]	[0.48,0.78]	[0.72,1.00]	[0.59,0.75]	[0.33,0.46]	[0.63,0.76]	[0.72,1.00]
EC8	[0.04,0.05]	[0.15,1.00]	[0.04,0.05]	[0.08,0.11]	[0.11,0.13]	[0.06,0.06]	[0.06,0.08]	[0.09,0.13]	[0.09,0.14]	[0.07,0.08]	[0.15,1.00]
EC9	[0.19,0.23]	[0.40,0.56]	[0.69,1.00]	[0.40,0.50]	[0.55,0.79]	[0.19,0.23]	[0.24,0.36]	[0.58,0.76]	[0.37,0.93]	[0.23,0.31]	[0.69,1.00]
EC10	[0.08,0.08]	[0.10,1.00]	[0.26,0.30]	[0.09,0.09]	[0.09,0.09]	[0.08,0.08]	[0.08,0.09]	[0.08,0.09]	[0.08,0.09]	[0.08,0.09]	[0.26,1.00]
EC11	[0.06,0.08]	[0.13,1.00]	[0.07,0.09]	[0.06,0.09]	[0.08,0.11]	[0.07,0.08]	[0.09,0.11]	[0.06,0.14]	[0.06,0.11]	[0.09,0.13]	[0.13,1.00]
EC12	[0.29,0.49]	[0.73,0.86]	[0.37,0.50]	[0.46,0.51]	[0.37,0.49]	[0.66,0.90]	[0.29,0.58]	[0.38,0.94]	[0.46,0.74]	[0.60,1.00]	[0.73,1.00]

The weighted normalized grey matrix is constructed according to Eq. (13) and reported in Table 6.

Table 6 Grey Weighted Normalized Matrix

	AAI	IC1	IC2	IC3	IC4	IC5	IC6	IC7	IC8	IC9	AI
EC1	[0.03,0.04]	[0.06,0.10]	[0.03,0.04]	[0.05,0.09]	[0.07,0.09]	[0.04,0.05]	[0.04,0.06]	[0.06,0.10]	[0.06,0.10]	[0.05,0.07]	[0.07,0.10]
EC2	[0.00,0.01]	[0.00,0.10]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.10]	[0.00,0.01]	[0.01,0.10]
EC3	[0.01,0.09]	[0.01,0.10]	[0.04,0.12]	[0.03,0.11]	[0.05,0.12]	[0.01,0.09]	[0.02,0.14]	[0.02,0.12]	[0.02,0.13]	[0.02,0.11]	[0.05,0.14]
EC4	[0.01,0.05]	[0.01,0.07]	[0.02,0.05]	[0.02,0.08]	[0.05,0.10]	[0.01,0.05]	[0.01,0.08]	[0.02,0.10]	[0.02,0.10]	[0.02,0.07]	[0.05,0.10]
EC5	[0.00,0.05]	[0.00,0.05]	[0.05,0.10]	[0.05,0.11]	[0.04,0.09]	[0.05,0.09]	[0.04,0.08]	[0.03,0.12]	[0.04,0.11]	[0.03,0.08]	[0.05,0.12]
EC6	[0.01,0.02]	[0.04,0.06]	[0.01,0.02]	[0.03,0.06]	[0.03,0.05]	[0.05,0.09]	[0.04,0.07]	[0.03,0.05]	[0.03,0.06]	[0.05,0.09]	[0.05,0.09]
EC7	[0.01,0.02]	[0.04,0.08]	[0.01,0.02]	[0.03,0.05]	[0.01,0.04]	[0.03,0.07]	[0.05,0.09]	[0.04,0.07]	[0.02,0.04]	[0.04,0.07]	[0.05,0.09]
EC8	[0.00,0.00]	[0.01,0.10]	[0.00,0.00]	[0.00,0.01]	[0.01,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.01,0.10]
EC9	[0.01,0.02]	[0.02,0.04]	[0.04,0.07]	[0.02,0.04]	[0.03,0.06]	[0.01,0.02]	[0.01,0.03]	[0.04,0.06]	[0.02,0.07]	[0.01,0.02]	[0.04,0.07]
EC10	[0.00,0.01]	[0.00,0.09]	[0.01,0.03]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.01,0.09]
EC11	[0.00,0.01]	[0.01,0.10]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.00,0.01]	[0.01,0.10]
EC12	[0.02,0.05]	[0.06,0.09]	[0.03,0.05]	[0.04,0.06]	[0.03,0.05]	[0.05,0.10]	[0.02,0.06]	[0.03,0.10]	[0.04,0.08]	[0.05,0.11]	[0.06,0.11]

Table 7 shows the aggregated results of the Grey MARCOS method calculated using Eqs. (14-19) and the success rankings of the insurance companies.

Table 7 Grey MARCOS Results

	$\otimes \mathbf{S_i}$	$\otimes \mathbf{K_i^-}$	$\otimes \mathbf{K_i^+}$	$\mathbf{f(K_i^-)}$	$\mathbf{f(K_i^+)}$	$\mathbf{f(K_i)}$	**Rank**
AAI	[0.122,0.372]	[0.327,3.059]	[0.100,0.830]				
IC1	[0.275,0.983]	[0.739,8.083]	[0.226,2.194]	[0.072,0.787]	[0.022,0.213]	0.572	1
IC2	[0.253,0.526]	[0.681,4.325]	[0.208,1.174]	[0.066,0.421]	[0.020,0.114]	0.178	9
IC3	[0.280,0.620]	[0.754,5.099]	[0.230,1.384]	[0.073,0.496]	[0.022,0.135]	0.245	7
IC4	[0.325,0.650]	[0.873,5.343]	[0.267,1.450]	[0.085,0.520]	[0.026,0.141]	0.278	4
IC5	[0.270,0.595]	[0.726,4.891]	[0.222,1.327]	[0.071,0.476]	[0.022,0.129]	0.225	8
IC6	[0.255,0.659]	[0.685,5.416]	[0.209,1.470]	[0.067,0.527]	[0.020,0.143]	0.266	6
IC7	[0.273,0.753]	[0.735,6.190]	[0.224,1.680]	[0.071,0.602]	[0.022,0.163]	0.346	3
IC8	[0.269,0.817]	[0.724,6.718]	[0.221,1.823]	[0.070,0.654]	[0.022,0.177]	0.401	2
IC9	[0.293,0.649]	[0.788,5.335]	[0.241,1.448]	[0.077,0.519]	[0.023,0.141]	0.269	5
AI	[0.448,1.218]	[1.204,10.017]	[0.368,2.719]				

According to the empirical findings shown in Table 7, the most successful insurance company in terms of corporate financial performance for the period 2021-2023 is IC1 (Türkiye Sigorta). This company is followed by IC8 (Sompo), IC7 (Quick), IC4 (Axa), IC9 (Ray), IC6 (HDI), IC3 (Anadolu Anonim Türk), IC5 (Aksigorta) and IC2 (Allianz).

4. Conclusions

Insurance sector, one of the most important actors in the money and capital markets, provides many important services to economies at both macro and micro levels. Macroeconomically, insurance sector promote economic growth by increasing savings and microeconomically by providing opportunities for business owners to obtain credit more easily. Due to the role of insurance companies, which are key financial intermediaries in the financial system, in minimizing risks in the economy, it is very important to analyze the performance of these companies on a regular basis. For this reason, this study focuses on insurance companies operating in the Turkish non-life insurance sector. In this context, a new MCDM procedure is proposed to analyze the corporate financial performance of insurance companies. The proposed decision algorithm consists of Grey PSI and Grey MARCOS procedures.

Grey PSI method is used to calculate the objective weights of the selected criteria. The Grey MARCOS method is used to rank the decision alternatives. According to the weighting results obtained on the basis of the Grey PSI method, the three most important criteria affecting the corporate financial performance of the relevant non-life insurance company are net profit-to-total equity, net premiums received-to-gross premiums received and total operating expenses-to-gross premiums received. On the other hand, the results based on the Grey MARCOS procedure used to determine the success ranking of the selected insurance companies show that the most successful insurance company in terms of corporate financial performance for the period 2021-2023 is Türkiye Sigorta.

Considering the products and services insurance companies provide to economic actors, it is very important for a wide range of stakeholders to regularly analyze the corporate financial performance of companies operating in the insurance sector. Increasing the number of empirical studies focusing on corporate financial performance can make a decisive contribution both to raising awareness of insurance in the country and to improving the competitive environment and service quality among companies.

Finally, present study has some limitations. This study is limited to assessing the corporate financial performance of non-life insurers operating in the Turkish insurance sector. Therefore, the findings cannot be generalized to other firms in the sector. In future empirical studies to be conducted by future researchers, the research topic can be re-examined using different financial measures. In addition to financial indicators, the inclusion of sustainability indicators in the studies can add depth to the literature. In addition, corporate financial performance of insurance companies can be evaluated according to decision-making approaches based on fuzzy set theory by taking expert opinions.

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"The dataset used in the study was derived from the annual reports of the relevant insurance companies".

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"The author/s declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper".

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