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Multidimensional Performance Evaluation Using the Hybrid MCDM Method: A Case Study in the Turkish Non-Life Insurance Sector

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Abstract

The aim of this study is to assess and rank the financial and service network performance of seven Turkish non-life insurance companies from 2018 to 2022 using the ENTROPY- MEREC - MACONT decision model. The study evaluates multidimensional firm performance based on selected performance indicators. The weights of these indicators were determined using ENTROPY and MEREC (method based on the removal effects of criteria) procedures. The MACONT (mixed aggregation by comprehensive normalization technique) procedure is used to obtain the multidimensional performance ranking of non-life insurance companies over time. The results of the MEREC and ENTROPY procedures indicate that the number of agencies, asset size, technical profit, and return on assets are generally effective criteria for the multidimensional performance of non-life insurance companies. The MACONT ranking results show that company IC2 had the best multidimensional performance during the analysis period. The validity and consistency of the results of the proposed decision model were tested using various sensitivity analyses.

Keywords: Insurance, Multidimensional Performance, ENTROPY, MEREC, MACONT.

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1. INTRODUCTION

In societies, individuals and companies within the economic system may face various risks and uncertainties. Realized risks can result in significant costs for these entities (Işık et al., 2023: 1391). Insurance organizations play a crucial role in protecting these entities and minimizing the costs associated with potential risks. Insurance functions to establish stability in financial markets and provide a peaceful environment in societies (Camino-Mogro & Bermúdez-Barrezueta, 2019; Akotey et al., 2013; Deniz and Aydın, 2022).

The insurance sector plays a crucial role in the economy of every country, whether developed or developing. In addition to providing financial security, insurance companies offer long-term financing to economic systems through significant investments funded by their premium income. Furthermore, they contribute to the development of other sectors within the economic system, thereby benefiting the entire country's economy. This is achieved through functions such as employment creation and tax revenue generation for the government (Işık, 2021b; Zhang et al., 2023a; Msomi & Nzama, 2023).

Insurance companies are organizations that provide coverage for individuals and organizations against uncertainty in exchange for a mutually agreed upon financial price, known as a premium. They are crucial in compensating both individuals and businesses for any losses they may incur due to various risks and returning them to their previous positions before the damage occurred. Currently, insurance companies hold a central position alongside banks in the country's financial sector. Efficient and successful performance is crucial for insurance companies (Işık et al., 2023; Mazviona et al. 2017). Good performance not only enhances the company's market value but also promotes the long-term development of the insurance industry. The insurance industry's growth has a positive impact on other sectors of the economy, including infrastructure, banking, automotive, and health. Therefore, it plays a crucial role in ensuring stability and prosperity in the national economy (Banarjee & Majumdar, 2018).

The objective of this study is to propose a hybrid decision model comprising of ENTROPY, MEREC, and MACONT procedures. A study will be conducted on the Turkish insurance sector to test the consistency and validity of the proposed model. As of the end of 2022, 45 out of the 70 companies operating in the Turkish insurance sector provide services in the non-life branch. In 2022, the Turkish insurance sector achieved a premium production of 235 billion TL. Non-life insurance companies produced 204 billion TL, accounting for 83% of the total premium production (TSB Sector Report, 2022). The study evaluated the performance of non-life insurance companies in Turkey using financial and service network indicators. The top 20 non-life insurance companies in terms of premium production were selected as case study examples for multidimensional performance evaluation. According to year-end data from 2022, the analysis covers 35% of the total non-life premium production, including the COVID-19 pandemic period, and involves 7 non-life insurance companies.

The contributions of the study to the previous literature on performance in the insurance sector are presented below:

i. Previous studies in literature have primarily focused on evaluating insurance companies' financial performance through financial ratios. However, this study takes a multidimensional approach to evaluate insurance companies, considering both financial performance and service network performance criteria.

ii. The ENTROPY and MEREC weighting methods were used to identify the financial and service network indicators that affect the performance of insurance companies, and the results obtained were combined with the common weighting method to calculate more optimal objective weights.

iii. The MACONT ranking methodology used in the study is a state-of-the-art approach used for the first time in multi-dimensional performance assessment in the insurance sector.

iv. The study tested the validity of the proposed hybrid multidimensional performance evaluation model through a comprehensive sensitivity analysis.

The other parts of the study are organized as follows: in the second part, a comprehensive literature review on the subject is explained. The third section explains the methodology of the study. The fourth section presents the application results. This section also includes the results of the sensitivity analysis. Finally, the fifth section presents the conclusions of the study and suggestions for future research.

2. LITERATURE REVIEW

This section is divided into two parts. The first part of our paper examines previous literature in detail, while its second part identifies critical research gaps in previous literature associated with insurance industry.

2.1. Literature Summary on The Methods That Make Up The Proposed Model

MCDM methods are commonly used for performance measurement in various fields. For instance, Varmazyar et al. (2016) used MCDM methods to measure the performance of research and technology organizations, Belke (2020) evaluated the macroeconomic performance of G7 countries, Özcan and Ömürbek (2020) evaluated the performance of an iron and steel enterprise, and Bassed et al. (2020) evaluated the performance of manufacturing industries. evaluated its financial performance. Mešić et al.'s work is another example of the use of MCDM methods in performance measurement. (2022), Ersoy and Taslak (2023), Althaqafi (2023), Altıntaş (2024), and Baihaqi et al. (2024) conducted evaluations on logistics performance index of the Western Balkan countries, corporate sustainability performance in the energy sector, green supply chain management performance, press freedom performances of G7 countries, and shipyard performance respectively, using various MCDM methods.

Upon examining the previous literature on the subject, it is evident that numerous studies have been conducted on performance in the insurance sector in recent years using MCDM techniques. However, these studies have primarily focused on financial performance. This study differs from previous literature by conducting a multidimensional performance evaluation that considers both the service network performance and financial performance of insurance companies.

This section examines national and international studies that use MCDM methods for performance analysis in the insurance sector. It then summarizes studies that used the ENTROPY, MEREC, and MACONT procedures in the proposed multidimensional performance evaluation model. Işık et al. (2023) investigated the causal relationship between premium production and financial performance of non-life insurance companies in Turkey using LOPCOW, SWARA II and MARCOS methods. Bektaş (2023) evaluated the performance of companies in the BIST insurance index in his study in which he used a hybrid MCDM model consisting of MEREC, MABAC and COCOSO methods. Mohanta and Sharanappa (2023) evaluated the performance of the Indian insurance industry with neutrosophic two-stage network data envelopment analysis. Hamzeh et al. (2022) used ENTROPY and TOPSIS methods in their study where they focused on the performance of Iranian insurance companies. Beiragh et al. (2020) examined the sustainability performance of insurance companies with AHP and DEA methods. Pala (2022) analyzed the financial performances of insurance companies operating in BIST using the CRITIC and MULTIMOOSRAL methods, focusing on the 2019-2020 period. In their study where they evaluated the COVID-19 pandemic performance of insurance companies in terms of health services, Ecer and Pamucar (2021) used the MARCOS method. Işık (2021a) evaluated the financial performance of an insurance company operating in Turkey using an integrated MCDM model consisting of AHP, CRITIC and WEDBA methods. Mandic et al. (2017) analyzed the performance evaluation of insurance companies operating in Serbia based on Fuzzy AHP and TOPSIS methods. Alenjagh (2015) analyzed the performance of insurance companies in the Tehran Stock Exchange using a combined ANP and PROMETHEE model. Tsai et al. (2008) analyzed Taiwan property and liability insurance companies using a performance evaluation model consisting of GIA and AHP techniques.

Table 1 summarizes the literature on ENTROPY, MEREC, and MACONT procedures, which constitute the multidimensional performance evaluation model proposed in the study.

Table 1. Previous Literature Studies Utilizing ENTROPY, MEREC and MACONT Procedures

ENTROPY MCDM Procedure		
Author	**Method**	**Problem**
Senir (2023)	ENTROPY-CRITC	Ranking the importance of logistics performance indicators
Mansyur and Saban (2023)	ENTROPY-TOPSIS	Financial performance analysis of the transport and storage sector
Topal (2021)	ENTROPY-COCOSO	Financial performance analysis of electricity generation companies
Siew et al. (2021)	ENTROPY-EDAS	Performance assessment of construction companies
Özgüner and Özgüner (2020)	ENTROPY-TOPSIS	Supplier selection and evaluation problem
Ulutaş (2019)	ENTROPY-MABAC	Staff selection problem
Rani et al. (2019)	ENTROPY-VIKOR	Evaluation of renewable energy sources
Ömürbek et al. (2017)	ENTROPY-ARAS-MOOSRA	Evaluation of countries' quality of life performance
Akçakanat et al. (2017)	ENTROPY-WASPAS	Performance evaluation in the banking sector
Çakır and Perçin (2013)	ENTROPY-TOPSIS	Evaluation of research and development (r&d) performance of countries
MEREC MCDM Procedure		
Author	**Method**	**Problem**
Kara et al. (2024)	MEREC-AROMAN	Determining the level of sustainable competitiveness
İnce et al. (2024)	MEREC-CODAS	Comparison of pre-COVID-19 and COVID-19 period logistics performances of G20 countries
Oğuz and Satır (2024)	MEREC-COBRA	Analyzing profitability performance
Zhang et al. (2023b)	SF-PT-EDAS-MEREC	Stock investment selection
Lukic (2023)	MEREC-WASPAS	Performance analysis of the Serbian economy
Puska et al. (2023)	MEREC-CRADIS	Electric car selection issue
Mastilo et al. (2023)	MEREC-MARCOS	Banking sector evaluation in Bosnia and Herzegovina
Ecer and Zolfani (2022)	MEREC-DNMA	Assessment of economic freedom ın OPEC countrıes
Mishra et al. (2022)	MEREC-MULTIMOORA	Evaluation of the low carbon tourism strategy
Ayçin and Arsu (2021)	MEREC-MARCOS	Evaluation of a country's social development index
Keshavarz-Ghorabaee (2021)	SWARA-MEREC-WASPAS	Location-based selection of distribution centres
Rani et al. (2021)	MEREC-ARAS	Selection of technology for treating food waste

Table 1 (Continued)

MACONT MCDM Procedure		
Author	**Method**	**Problem**
Liang (2024)	EXPTODIM-MACONT	Evaluation of smart classroom teaching in basic english
Ecer and Torkayesh (2024)	MACONT	Sustainable circular supplier selection
Ulutaş et al. (2024)	MACONT	Evaluation of third-party logistics service providers
Wen and Liao (2024)	PL-MACONT-I	Demonstrate the feasibility of the proposed method
Gamal et al. (2024)	SF-MACONT	Sustainability assessment of energy storage systems
Shuangliu and Huazai (2023)	PL-MACONT	Quality assessment of ındustry-education integration for rural vocational education
Truong and Li (2023)	DS-MACONT-e-STEP	Determining the most appropriate investment decision in transportation budget allocation.
Simic et al. (2023)	CEBOM-MACONT	Decision process for sustainable management of end-of-life tyres
Yürüyen et al. (2023)	MEREC-CRITIC-LOPCOW-MACONT	Performance evaluation of logistics enterprises
Chakraborty et al. (2023)	G- MACONT	Selection of health service suppliers
Wen and Liao (2021)	MACONT	Selection of a pension service provider
Wen et al. (2020)	MACONT	Logistics provider selection

2.2 Research Gaps

In the literature review, it is seen that the majority of studies on performance measurement in the insurance sector focus on financial performance. No study has been found in the literature that concentrate on service network performance as well as financial performance in the insurance sector. In order to address this critical gap, the present paper introduces a new set of criteria to analyse insurers' performance in a multidimensional framework by incorporating both financial and service network performance into the decision-making process.

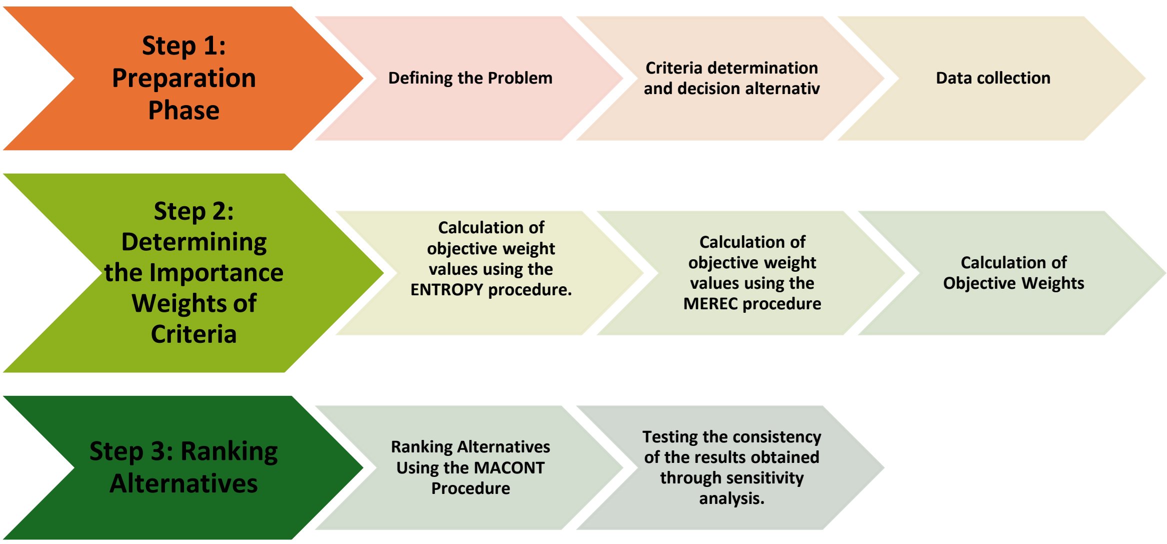
Furthermore, when literature is reviewed in detail, the lack of a generally accepted or applied mathematical tool or decision support system that measures and evaluates multidimensional performance in the insurance industry is the second major research gap in the literature. In order to fill the second crucial gap, the present paper introduces a novel hybrid decision making model consisting of ENTROPY, MEREC and MACONT algorithms to rank the overall performance of insurers. In conclusion, the originality of the present study stems from the fact that it uses a new set of criteria and a new mathematical tool in measuring and evaluating the overall performance in the non-life insurance sector.

3. RESEARCH METHODOLOGY

This section explains the proposed ENTROPY-MEREC-MACONT hybrid MCDM decision model for assessing the multidimensional performance of Turkish non-life insurance companies. Some critical advantages of the MCDM approaches included in the recommended decision framework for performance analysis in the present research can be summarized as follows: in the ENTROPY method, there is no need for expert evaluation when computing the criteria weights. Hence, this procedure is an objective data-based technique and does not involve inconsistencies related to expert opinions (Bakır and Atalık, 2018). Most methods for determining criterion weights use variations in criteria to calculate the weights. Besides, the MEREC model provides a novel approach to the identification of objective criterion weights, as it measures the elimination influence of criteria on the performance of alternatives (Keshavarz-Ghorabaee et al., 2021). In addition, the MEREC method is preferred because it is up-to-date, easy to calculate and understand, and has a solid mathematical infrastructure (Ecer & Ayçin, 2023). As for the MACONT method responsible for the ranking of alternatives, it combines three linear normalization procedures depending on the criterion type, thus reducing the biases caused by techniques using a single normalization tool. Furthermore, by measuring the performance of one alternative compared to other alternatives with only one reference alternative, the method facilitates its use and produces convincing results. (Wen et al., 2020).

The flow chart of the multidimensional performance evaluation model proposed in the study is presented in Figure 1.

Figure 1. Flow Chart of the Study



Source: Figure 1 was constructed by the author.

3.1. ENTROPY

The ENTROPY method is an objective method that allows determining criterion weights using decision matrix elements. The application procedures of the ENTROPY method consist of 4 steps. These steps are as follows (Wang and Lee, 2009; Ulutaş, 2019; Işık, 2019):

Step 1: Create a decision matrix that includes all alternatives and criteria.

$$X = \left[x_{ij}\right]_{m*n} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Step 2: The decision matrix is normalized to convert the criteria into units of the same type. Here, Equation (2) is used for the criteria targeting benefit, and Equation (3) is used for the criteria targeting cost.

$$r_{ij} = \frac{x_{ij}}{mak_{ij}} \quad (2)$$

$$r_{ij} = \frac{min_{ij}}{x_{ij}} \quad min_{ij} \neq 0 \quad (3)$$

Step 3: Calculation of ENTROPY values for each criterion.

$$e_{j} = -k \sum_{j=1}^{n} r_{ij} * \ln(r_{ij}), \quad i=1,2,3 \ldots\ldots m \quad j=1,2,3 \ldots\ldots n \quad (4)$$

$e_j = entropy\ coefficient$

k = $1/ln_m$

$r_{ij} = normalized\ values$

Step 4: In the last step of the ENTROPY method, the weights of the criteria are calculated using Equation (5).

$$w_j = \frac{1-e_j}{\sum_{i=1}^{n}(1-e_j)} \quad (5)$$

3.2. MEREC

Keshavarz-Ghorabaee et al. (2021) is based on the approach that the change in the total weights of the evaluation criteria determines the weight coefficient of a criterion. The MEREC procedure calculation steps are as follows (Keshavarz-Ghorabaee et al., 2021a: 8; Işık, 2022: 366):

Step 1: A decision matrix containing n alternatives and m criteria is created. The elements of the decision matrix must be greater than zero. In case of a negative value, it should be converted to positive values with an appropriate technique.

$$X = \begin{bmatrix} X_{11} & \ldots & X_{1j} & \cdots & X_{1n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ X_{m1} & \ldots & X_{mj} & \ldots & X_{mn} \end{bmatrix} \quad (6)$$

Step 2: Equation (7) is used to normalise the decision matrix.

$$n_{ij}^{x} = \begin{cases} \frac{min_{xij}}{xij} & if\ j \in benefit\ criterion \\ \frac{x_{ij}}{maks_{xij}} & if\ j \in cost\ criterion \end{cases} \quad (7)$$

Step 3: The alternatives overall performance value (S_i) is determined using Equation (8).

$$S_i = \ln\left(1 + \left(\frac{1}{m}\sum_j \left|\ln\left(n_{ij}^{x}\right)\right|\right)\right) \quad (8)$$

Step 4: Equation (9) is used to calculate the performance of the alternatives (S'_{ij}) by removing each criterion from the set separately.

$$S'_{ij} = \ln\left(1 + \left(\frac{1}{m}\sum_{k,k\neq j}|\ln(n_{ik}^{x})|\right)\right) \tag{9}$$

Step 5: Sum of absolute deviations (E_j) the criterion's removal effect is measured by calculating it using Equation (10), based on the values obtained from step 3 and step 4.

$$E_j = \sum_i \left|S'_{ij} - S_i\right| \tag{10}$$

Step 6: The weights for the criteria E_j değeri are calculated in accordance with Equation 11.

$$W_j = \frac{E_j}{\sum_k E_k} \tag{11}$$

3.3. Common Weighting

Equation (12) combines the criteria weights obtained from ENTROPY and MEREC methods (Işık, 2022; Zavadskas & Podvezko, 2016).

$$W_{j,combined} = \frac{w_{j,ENTROPY} w_{j,MEREC}}{\sum_{j=1}^{m} w_{j,ENTROPY} w_{j,MEREC}} \tag{12}$$

3.4. MACONT

The MACONT method was developed in 2020 by Wen, Liao, and Zavadskas (Wen et al., 2020). The method steps are listed below according to Wen et al. (2020) and Aksakal et al. (2022).

Step 1: A decision matrix has been created.

$$X = [x_{ij}]_{mxn} \tag{13}$$

Step 2: The decision matrix undergoes normalization using three techniques. The first technique is linear summation-based normalization, as shown in Equation 14, and the normalized value is denoted by $\hat{x}_{ij}^{1}$.

$$\hat{x}_{ij}^{1} = \begin{cases} x_{ij}/\sum_{i=1}^{m} x_{ij} & (criteria\ for\ use\ benefit) \\ \frac{1}{x_{ij}}/\sum_{i=1}^{m}\frac{1}{x_{ij}} & (for\ cost\ criteria) \end{cases} \tag{14}$$

The second normalisation technique is based on the linear ratio, as shown in Equation 15. The normalised value is denoted by $\hat{x}_{ij}^{2}$.

$$\hat{x}_{ij}^{2} = \begin{cases} x_{ij}/max_i x_{ij} & criteria\ for\ use\ benefit \\ min_i x_{ij}/x_{ij} & for\ cost\ criteria \end{cases} \tag{15}$$

The linear maximum-minimum normalisation technique, as shown in Equation 16, is the third normalisation technique. The normalised value is denoted by $\hat{x}_{ij}^{3}$.

$$\hat{x}_{ij}^{3} = \begin{cases} (x_{ij} - min_i x_{ij})/(max_i x_{ij} - min_i x_{ij}) & for\ benefit\ criteria \\ (x_{ij} - max_i x_{ij})/(min_i x_{ij} - max_i x_{ij}) & for\ cost\ criteria \end{cases} \tag{16}$$

The three decision matrices are normalised using Equation 17. The values of θ and µ as shown in Equation 17, are taken as 0.330 (Yürüyen et al., 2023: 739).

$$\hat{x}_{ij}=\theta\hat{x}_{ij}^{1}+\mu\hat{x}_{ij}^{2}+(1-\theta-\mu)\,\hat{x}_{ij}^{3} \quad (17)$$

Step 3: Equations 18 and 19 are used to find the two mixed adders U_{1i} and U_{2i}

$$U_{1i}=\delta\frac{\pi_i}{\sqrt{\sum_{i=1}^{m}(\pi_i)^2}}+(1-\delta)\frac{Q_i}{\sqrt{\sum_{i=1}^{m}(Q_i)^2}} \quad (18)$$

$$U_{2i}=\beta max_j(w_{jBR}(\hat{x}_{ij}-\bar{x}_j))+(1-\beta)min_j\left(w_{jBR}(\hat{x}_{ij}-\bar{x}_j)\right) \quad (19)$$

$\pi_i=\sum_{j=1}^{n}w_{jBR}(\hat{x}_{ij}-\bar{x}_j)$ and $Q_i=\prod_{\gamma=1}^{n}\left(\bar{x}_j-\hat{x}_{ij}\right)^{w_{jBR}}/\prod_{\omega=1}^{n}\left(\hat{x}_{ij}-\bar{x}_j\right)^{w_{jBR}}$ and γ, criterion $\hat{x}_{ij}<\bar{x}_j$ represents the part that satisfies the condition ω, criterion $\hat{x}_{ij}\geq\bar{x}_j$ The condition is met. However, the sum of the weights of the criteria should equal 1. The study will use δ and β values 0,5 (Yürüyen vd., 2023: 739).

Step 4: For each alternative, calculate U_i(final comprehensive score) using the following formula.

$$U_i=\frac{1}{2}\left(U_{1i}+\frac{U_{2i}}{\sqrt{\sum_{i=1}^{m}(U_{2i})^2}}\right) \quad (20)$$

3.5. Borda Count (BC) Procedure

The BC rank aggregation algorithm, suggested by Jean-Charles de Borda (1781), is a commonly utilised technique for acquiring optimum alternative priority ranks with minimum deviation from the initial ranking results of the alternatives. The process steps of BC are given below (Biswas et al., 2022; Işık et al., 2024).

Step 1. Determining the final ranks of the alternatives for different years in a decision problem with m alternatives.

Step 2. Giving points to each alternative depending on the BC approach. Taking into account the Borda rule, the alternatives are given scores (m-1), (m-2), (m-3), etc. from best to worst. This procedure is carried out separately for each year.

Step 3. Getting BC scores for each alternative. Here, the sum of the BC scores for each alternative across all years gives the total BC score.

Step 4. Ranking of alternatives based on their total BC points. Alternatives are ranked from highest to lowest considering their total Borda points. As a result, the alternative with the largest BC point is identified as the best alternative.

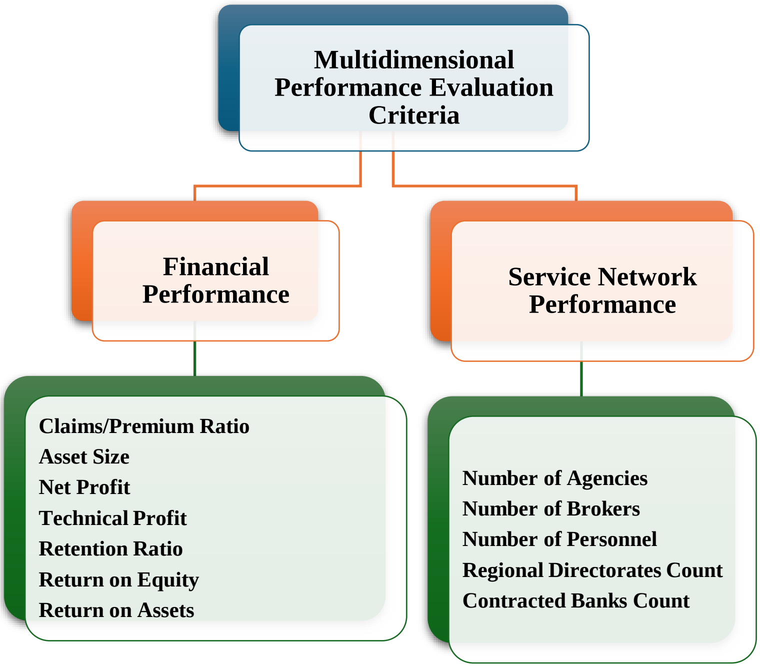
4. CASE STUDY

The study proposes a hybrid model combining ENTROPY, MEREC and MACONT methods to assess multidimensional performance of Turkish non-life insurance companies. ENTROPY and MEREC methods are used to determine the importance weights of the criteria in line with the proposed hybrid model, while MACONT method is used to evaluate the multidimensional performance of insurance companies. After calculating the multidimensional performance scores of the companies, we conducted a sensitivity analysis to test the consistency of the results. This section presents the results of the analyses used to evaluate the multidimensional.

4.1. Data

As of the end of 2022, there are 45 non-life insurance companies operating in the Turkish insurance sector. The study focuses on eight of the top 20 companies in terms of premium production, namely Ak Sigorta (IC1), Anadolu Sigorta (IC2), HDI Sigorta (IC3), Ray Sigorta (IC4), Zurich Sigorta (IC5), Ankara Sigorta (IC6), and Doğa Sigorta (IC7), which have complete data on multidimensional performance evaluation criteria. The analysis includes the data of these companies from 2018 to 2022, compiled from their annual reports and insurance statistics published by TSB. As some companies' annual reports for 2023 were not completed, the data was limited to 2022. Figure 2 presents the criteria used in the multidimensional performance assessment.

Figure 2. Multidimensional Performance Evaluation Criteria



Source: Figure 2 was constructed by the author.

Number of Agencies (C1), Number of Brokers (C2), Number of Personnel (3), Number of Regional Offices (C4), Number of Contracted Banks (C5), Claims/Premium Ratio(C6) Asset Size (C7), Net Profit (C8), Technical Profit (C9), Retention Ratio (C10), Return on Equity (C11), and Return on Assets (C12). The evaluation criteria for performance are multidimensional and include the following: Criteria C3 and C6 are cost-side criteria, while all other criteria are benefit-side criteria.

Table 2 below explains the criteria for evaluating performance in multiple dimensions.

Table 2. Multidimensional Performance Evaluation Criteria

Criteria	Description
Number of Agencies	An individual or entity with the authority to negotiate or conclude insurance contracts on behalf of insurance companies.
Number of Brokers	An insurance broker is a person, either individual or legal entity, whose profession is to represent those who wish to conclude an insurance contract and to assist them in selecting the companies with which to conclude the contract.
Number of Personnel	Number of employees in insurance companies.
Number of Regional Offices	Directorates of insurance companies located in different regions of Turkey (including the Northern Cyprus branch for some companies).
Number of Contracted Banks	Number of banks working as distribution channels of insurance companies.
Claims/Premium Ratio	The ratio of incurred losses to earned premiums.
Asset Size	Total value of insurance companies' assets.
Net Profit	It represents the financial profit of insurance companies.
Technical Profit	Insurance companies' profits from insurance activities.
Retention Ratio	The conservation ratio is the ratio of the net premiums received by insurance companies, which are not transferred to reinsurance companies but kept by the company, to the gross premiums received.
Return on Equity	It is the ratio that shows how effectively the investments made by the insurance company shareholders are used in the company.
Return on Assets	This ratio indicates the total profit made by insurance companies per asset they own.

4.2. Results of The ENTROPY Algorithm

The study conducted an analysis of a 5-year period from 2018 to 2022. This section presents the implementation steps of the ENTROPY algorithm for the 2018 data.

Table 3 displays the initial decision matrix created using the study's data set.

Table 3. Initial Decision Matrix (2018)

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
IC1	3000	69	650	10	1	0.74	3515000000	228000000	368000000	0.59	0.34	0.06
IC2	2319	105	1260	10	6	0.90	7904032000	307574000	502067448	0.67	0.19	0.04
IC3	1915	93	328	9	7	0.90	2058235962	58152135	58516585	0.58	0.12	0.03
IC4	1138	80	261	8	2	0.79	926672507	28391530	23319435	0.46	0.13	0.03
IC5	164	67	276	9	4	0.53	1220373467	80147161	142058634	0.68	0.26	0.07
IC6	761	21	113	5	2	0.85	677605905	32577735	26809463	0.79	0.17	0.05
IC7	1655	66	256	8	2	0.85	13731303377	64064838	-9669602	0.45	0.41	0.00

To convert the negative values in the decision matrix into positive values, we applied the Z-score standardization transformation (Arslan, 2023; Zhang et al., 2014) to the column containing the C9 criterion in the decision matrix. The transformed matrix is presented in Table 4. The formula used for this transformation is $z_{ij} = \frac{x_{ij} - \bar{X}_j}{\sigma_j}$

Table 4. Initial Decision Matrix after Transformation

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
IC1	1.000	0.657	0.174	1.000	0.143	0.715	0.256	0.741	0.739	0.749	0.829	0.988
IC2	0.773	1.000	0.090	1.000	0.857	0.588	0.576	1.000	1.000	0.850	0.456	0.593
IC3	0.638	0.886	0.345	0.900	1.000	0.590	0.150	0.189	0.137	0.731	0.291	0.430
IC4	0.379	0.762	0.433	0.800	0.286	0.668	0.067	0.092	0.068	0.588	0.326	0.467
IC5	0.055	0.638	0.409	0.900	0.571	1.000	0.089	0.261	0.300	0.867	0.628	1.000
IC6	0.254	0.200	1.000	0.500	0.286	0.624	0.049	0.106	0.075	1.000	0.425	0.732
IC7	0.552	0.629	0.441	0.800	0.286	0.620	1.000	0.208	0.004	0.566	1.000	0.071

Table 5 shows the standardized matrix obtained by applying Equation (2) and Equation (3) to standardize the elements of the decision matrix.

Table 5. Standardized Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
IC1	1.000	0.863	0.235	1.000	0.077	0.633	0.418	0.127	0.004	0.675	0.176	0.156
IC2	0.812	0.820	0.101	1.000	0.538	0.645	1.000	1.000	1.000	0.892	0.723	0.800
IC3	0.959	1.000	0.204	0.900	1.000	0.705	0.478	0.004	0.112	0.858	0.003	0.005
IC4	0.489	0.655	0.511	0.800	0.077	1.000	0.177	0.336	0.222	0.536	0.755	0.746
IC5	0.146	0.705	0.546	0.800	0.308	0.661	0.132	0.356	0.155	0.811	0.703	1.000
IC6	0.432	0.403	1.000	0.900	0.077	0.797	0.108	0.281	0.171	1.000	1.000	0.708
IC7	0.542	0.647	0.541	0.900	0.385	0.618	0.150	0.206	0.005	0.684	0.279	0.264

Table 6 presents the normalized decision matrix, which is obtained by dividing each element in the standardized decision matrix by the sum of all standardized decision matrix elements in the column where it is located.

Table 6. Normalized Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
IC1	0.274	0.138	0.060	0.169	0.143	0.149	0.117	0.285	0.318	0.140	0.210	0.231
IC2	0.212	0.210	0.031	0.169	0.857	0.122	0.263	0.385	0.430	0.159	0.115	0.138
IC3	0.175	0.186	0.119	0.153	1.000	0.123	0.069	0.073	0.059	0.137	0.074	0.101
IC4	0.104	0.160	0.150	0.136	0.286	0.139	0.031	0.036	0.029	0.110	0.083	0.109
IC5	0.015	0.134	0.142	0.153	0.571	0.208	0.041	0.100	0.129	0.162	0.159	0.234
IC6	0.069	0.042	0.346	0.085	0.286	0.130	0.023	0.041	0.032	0.187	0.107	0.171
IC7	0.151	0.132	0.153	0.136	0.286	0.129	0.457	0.080	0.002	0.106	0.253	0.017

Equation (4) was used to obtain the ENTROPY values for each criterion. Then, Equation (5) was used to calculate the importance weights of the criteria. For instance, the weight coefficient for the first criterion was calculated as follows using Equation (4) and Equation (5):

$$E_{ij} = \frac{-(-1{,}757)}{\ln(7)} = 0{,}903,\ 1\text{-}0{,}903 = 0{,}097,\ W_1 = \frac{0{,}097}{1{,}176} = 0{,}082$$

Table 7 presents the ENTROPY values and criteria weights for all criteria in 2018.

Table 7. 2018 ENTROPY Criteria Importance Weights and Values for Data

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
E_{ij}	0.903	0.964	0.897	0.990	0.927	0.991	0.754	0.821	0.712	0.991	0.953	0.922
1-E_{ij}	0.097	0.036	0.103	0.010	0.073	0.009	0.246	0.179	0.288	0.009	0.047	0.078
W_{ij}	0.082	0.031	0.088	0.009	0.062	0.008	0.209	0.152	0.245	0.008	0.040	0.066

Table 7 shows the impact levels of the criteria used to determine the multidimensional performance of insurance companies in 2018. The criteria were ranked in the following order: C9, C7, C8, C3, C1, C12, C5, C11, C2, C4, C10, and C6.

The ENTROPY procedure was used to calculate criteria importance weights for all years. The results are presented in Table 8.

Table 8. ENTROPY Procedure Criteria Weights and Importance Rankings for All Years

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
2018	0.082	0.031	0.088	0.009	0.062	0.008	0.209	0.152	0.245	0.008	0.040	0.066
Ranks	5	9	4	10	7	12	2	3	1	11	8	6
2019	0.094	0.039	0.114	0.010	0.018	0.004	0.156	0.186	0.262	0.008	0.076	0.034
Ranks	5	7	4	10	9	12	3	2	1	11	6	8
2020	0.099	0.033	0.123	0.002	0.050	0.007	0.187	0.197	0.216	0.008	0.051	0.026
Ranks	5	8	4	12	7	11	3	2	1	10	6	9
2021	0.043	0.010	0.063	0.001	0.104	0.003	0.143	0.129	0.125	0.004	0.068	0.306
Ranks	8	9	7	12	5	11	2	3	4	10	6	1
2022	0.045	0.012	0.075	0.001	0.111	0.005	0.117	0.142	0.269	0.007	0.106	0.110
Ranks	8	9	7	12	4	11	3	2	1	10	6	5

4.3. Results of the MEREC Algorithm

The normalized decision matrix in Table 9 is presented, consisting of normalized values obtained with the help of Equation (7) to transform the decision matrix in Table 4.

Table 9. Normalised Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
IC1	0.055	0.304	0.516	0.500	1.000	0.822	0.193	0.125	0.006	0.756	0.351	0.072
IC2	0.071	0.200	1.000	0.500	0.167	1.000	0.086	0.092	0.004	0.666	0.638	0.120
IC3	0.086	0.226	0.260	0.556	0.143	0.998	0.329	0.488	0.031	0.774	1.000	0.165
IC4	0.144	0.263	0.207	0.625	0.500	0.881	0.731	1.000	0.062	0.963	0.891	0.152
IC5	1.000	0.313	0.219	0.556	0.250	0.588	0.555	0.354	0.014	0.653	0.463	0.071
IC6	0.216	1.000	0.090	1.000	0.500	0.943	1.000	0.872	0.057	0.566	0.684	0.097
IC7	0.099	0.318	0.203	0.625	0.500	0.949	0.049	0.443	1.000	1.000	0.291	1.000

Equation (8) was used to calculate the S_i values for each alternative. For the first alternative, the value was calculated as follows.

$$S_1 = \ln\left(1 + \left(\frac{1}{12}(|\ln(0{,}055)| + |\ln(0{,}0304)| + |\ln(0{,}516)| + |\ln(0{,}500)| + |\ln(1{,}000)| + |\ln(0{,}822)| + |\ln(0{,}193)| + |\ln(0{,}125)| + |\ln(0{,}006)| + |\ln(0{,}756)| + |\ln(0{,}351)| + |\ln(0{,}072)|)\right)\right) = 0.137$$

The values for all other S_i were calculated using Equation (8) 0.117, 0.084, 0.139, 0.017, 0.023, and 0.109.

Once the S_i values had been determined, the S'_{ij} values were calculated for each alternative by removing each criterion from the criteria set separately. The first alternative was calculated using Equation (9) as follows.

$$S'_{11} = \ln\left(1 + \left(\frac{1}{12}(|\ln(0.0304)| + |\ln(0.516)| + |\ln(0.500)| + |\ln(1.000)| + |\ln(0.822)| + |\ln(0.193)| + |\ln(0.125)| + |\ln(0.006)| + |\ln(0.756)| + |\ln(0.351)| + |\ln(0.072)|)\right)\right) = 0.091$$

Table 10 shows the matrix of S'_{ij} values for all alternatives.

Table 10. S'_{ij} Values

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
IC1	0.091	0.214	0.178	0.176	0.137	0.140	0.149	0.180	0.179	0.134	0.174	0.035
IC2	0.092	0.168	0.117	0.167	0.086	0.117	0.134	0.131	0.101	0.086	0.199	0.043
IC3	0.111	0.181	0.171	0.116	0.141	0.084	0.166	0.137	0.098	0.089	0.181	0.105
IC4	0.012	0.060	0.079	0.139	0.142	0.136	0.149	0.139	0.142	0.142	0.051	0.039
IC5	0.017	0.108	0.081	0.031	0.025	0.002	0.006	0.006	0.007	0.018	0.068	0.102
IC6	0.141	0.023	0.075	0.023	0.034	0.018	0.023	0.012	0.031	0.069	0.054	0.051
IC7	0.074	0.161	0.160	0.111	0.128	0.106	0.155	0.168	0.109	0.109	0.132	0.018

Equation (10) is used to calculate the effect of removing each criterion on the overall performance of the alternatives E_j Eşitlik (10) For instance, to calculate the effect of removing the first criterion, follow these steps.

$$E_1 = |0.091 - 0.137| + |0.092 - 0.117| + |0.111 - 0.084| + |0.012 - 0.139| + |0.017 - 0.017| + |0.141 - 0.023| + |0.074 - 0.109| = 0.378$$

The values for E_j are calculated as follows: 0.446, 0.355, 0.138, 0.138, 0.128, 0.031, 0.176, 0.192, 0.093, 0.088, 0.409, and 0.501, respectively, using Equation (10).

The objective weights of the criteria were calculated using Equation (11). For instance, the objective weight coefficient for the first criterion is calculated as follows.

$$W_1 = \frac{0.378}{2.934} = 0.129$$

Table 11 presents the weights of all criteria calculated using the 2018 data.

Table 11. Importance Weights for MEREC Procedure Criteria Related to Year 2018 Data

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
W_{ij}	0.129	0.152	0.121	0.047	0.044	0.011	0.060	0.065	0.032	0.030	0.139	0.171

Upon analysing Table 11 using the MEREC procedure for 2018, the criteria's impact levels in determining the multidimensional performance of insurance companies were determined as follows: C12, C2, C11, C1, C3, C8, C7, C4, C5, C9, C10, and C6.

The MEREC procedure's calculation steps were applied to the data for all years, and Table 12 shows the calculated criteria importance weights.

Table 12. MEREC Procedure Criteria Weights and Importance Rankings for All Years

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
2018	0.129	0.152	0.121	0.047	0.044	0.011	0.060	0.065	0.032	0.030	0.139	0.171
Ranks	4	2	5	8	9	12	7	6	10	11	3	1
2019	0.173	0.150	0.091	0.074	0.055	0.013	0.040	0.031	0.046	0.018	0.139	0.170
Ranks	1	3	5	6	7	12	9	10	8	11	4	2
2020	0.193	0.094	0.071	0.019	0.055	0.031	0.059	0.063	0.067	0.038	0.108	0.202
Ranks	2	4	5	12	9	11	8	7	6	10	3	1
2021	0.125	0.102	0.088	0.028	0.069	0.017	0.099	0.073	0.049	0.061	0.116	0.173
Ranks	2	4	6	11	8	12	5	7	10	9	3	1
2022	0.198	0.064	0.090	0.021	0.068	0.033	0.078	0.075	0.071	0.052	0.078	0.172
Ranks	1	9	3	12	8	11	4	6	7	10	5	2

4.4. Results of the Combined Weighting Algorithm

In order to identify more consistent and optimal weights for the criteria, the criteria weights from the ENTROPY and MEREC methodologies were computed as indicated in Equation (12). This allowed us to obtain more optimal results by combining the advantageous aspects of both methods. As seen in Figure 3, the final weight values of the criteria are provided in Table 13.

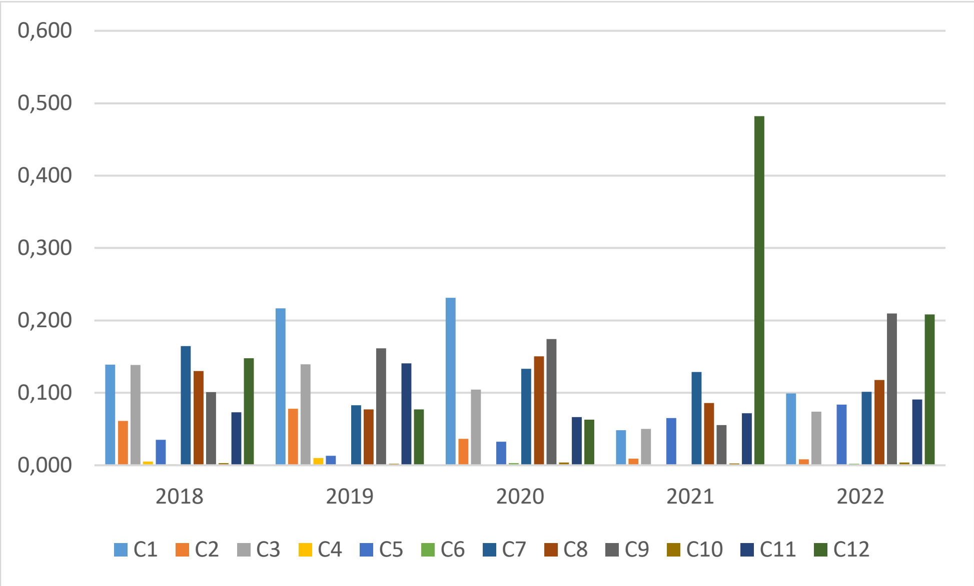
Table 13. Combined Criteria Weights

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
2018	0.139	0.061	0.139	0.005	0.035	0.001	0.164	0.130	0.101	0.003	0.073	0.148
Rank	3	8	4	10	9	12	1	5	6	11	7	2
2019	0.217	0.078	0.139	0.010	0.013	0.001	0.083	0.077	0.161	0.002	0.141	0.077
Rank	1	6	4	10	9	12	5	8	2	11	3	7
2020	0.231	0.037	0.105	0.000	0.033	0.003	0.133	0.150	0.174	0.004	0.067	0.063
Rank	1	8	5	12	9	11	4	3	2	10	6	7
2021	0.049	0.009	0.050	0.000	0.065	0.000	0.129	0.086	0.055	0.002	0.072	0.482
Rank	8	10	7	12	5	11	2	3	6	9	4	1
2022	0.099	0.008	0.074	0.000	0.084	0.002	0.102	0.118	0.210	0.004	0.091	0.208
Rank	5	9	8	12	7	11	4	3	1	10	6	2

Upon examining the importance weights of the multidimensional performance indicators presented in Table 13, it is evident that the importance weights of the performance evaluation criteria have changed over the years in the 2018-2022 period when determining the multidimensional performance of the insurance companies included in the analysis. The COVID-19 pandemic, inflationary environment, and exchange rate fluctuations in Turkey have caused changes in the criteria that determine the performance of insurance companies over time.

Table 13 shows that the criteria C1 (number of agencies), C7 (asset size), C9 (technical profit) and C12 (return on assets) are generally effective in determining the multidimensional performance of insurance companies in the 2018-2022 period. However, the criteria C4 (number of regional offices), C6 (claims/premium ratio) and C10 (retention ratio) have a low impact on the multidimensional performance of insurance companies.

Figure 3. Combined Criteria Weights



Source: Figure 3 was constructed by the author.

4.5. Results of the MACONT Algorithm

This section presents the ranking of non-life insurers employing the MACONT approach, based on multidimensional financial and service network performance indicators. The decision matrix elements presented in Table 4 were utilized to obtain the normalised decision matrix, according to the first normalisation technique, by applying the process given in Equation (14). The related data are presented in Table 14.

Tablo 14. First Normalised Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
IC1	0.274	0.138	0.060	0.169	0.042	0.149	0.117	0.285	0.318	0.140	0.210	0.231
IC2	0.212	0.210	0.031	0.169	0.250	0.122	0.263	0.385	0.430	0.159	0.115	0.138
IC3	0.175	0.186	0.119	0.153	0.292	0.123	0.069	0.073	0.059	0.137	0.074	0.101
IC4	0.104	0.160	0.150	0.136	0.083	0.139	0.031	0.036	0.029	0.110	0.083	0.109
IC5	0.015	0.134	0.142	0.153	0.167	0.208	0.041	0.100	0.129	0.162	0.159	0.234
IC6	0.069	0.042	0.346	0.085	0.083	0.130	0.023	0.041	0.032	0.187	0.107	0.171
IC7	0.151	0.132	0.153	0.136	0.083	0.129	0.457	0.080	0.002	0.106	0.253	0.017

Table 15 shows the decision matrix normalised using Equation (15) with the second normalisation technique.

Table 15. Second Normalised Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
IC1	1.000	0.657	0.174	1.000	0.143	0.715	0.256	0.741	0.739	0.749	0.829	0.988
IC2	0.773	1.000	0.090	1.000	0.857	0.588	0.576	1.000	1.000	0.850	0.456	0.593
IC3	0.638	0.886	0.345	0.900	1.000	0.590	0.150	0.189	0.137	0.731	0.291	0.430
IC4	0.379	0.762	0.433	0.800	0.286	0.668	0.067	0.092	0.068	0.588	0.326	0.467
IC5	0.055	0.638	0.409	0.900	0.571	1.000	0.089	0.261	0.300	0.867	0.628	1.000
IC6	0.254	0.200	1.000	0.500	0.286	0.624	0.049	0.106	0.075	1.000	0.425	0.732
IC7	0.552	0.629	0.441	0.800	0.286	0.620	1.000	0.208	0.004	0.566	1.000	0.071

Table 16 displays the third normalized matrix, which was created by normalizing the elements of the decision matrix using Equation (16) and the third normalization technique.

Table 16. Third Normalised Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
IC1	1.000	0.571	0.532	1.000	0.000	0.432	0.217	0.715	0.738	0.421	0.759	0.987
IC2	0.760	1.000	0.000	1.000	0.833	0.000	0.554	1.000	1.000	0.655	0.232	0.561
IC3	0.617	0.857	0.813	0.800	1.000	0.006	0.106	0.107	0.133	0.381	0.000	0.387
IC4	0.343	0.702	0.871	0.600	0.167	0.290	0.019	0.000	0.064	0.050	0.050	0.426
IC5	0.000	0.548	0.858	0.800	0.500	1.000	0.042	0.185	0.296	0.694	0.476	1.000
IC6	0.211	0.000	1.000	0.000	0.167	0.139	0.000	0.015	0.071	1.000	0.189	0.712
IC7	0.526	0.536	0.875	0.600	0.167	0.124	1.000	0.128	0.000	0.000	1.000	0.000

After calculating the matrices generated by the three normalization techniques, they were combined using Equation (17). Table 17 presents the resulting combined normalized matrix.

Table 17. Combined Normalised Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
IC1	0.760	0.457	0.258	0.726	0.061	0.432	0.197	0.582	0.600	0.436	0.601	0.738
IC2	0.583	0.739	0.040	0.726	0.649	0.234	0.465	0.797	0.812	0.556	0.267	0.432
IC3	0.478	0.645	0.429	0.619	0.766	0.237	0.108	0.123	0.110	0.416	0.120	0.307
IC4	0.276	0.543	0.488	0.513	0.178	0.365	0.039	0.042	0.054	0.247	0.152	0.335
IC5	0.023	0.441	0.474	0.619	0.414	0.739	0.057	0.182	0.242	0.575	0.422	0.747
IC6	0.178	0.080	0.784	0.193	0.178	0.296	0.024	0.054	0.060	0.732	0.240	0.540
IC7	0.411	0.433	0.494	0.513	0.178	0.289	0.821	0.139	0.002	0.222	0.753	0.029

After obtaining the combined normalized matrix, Equation 18-20 is used to calculate the final comprehensive score (U_i) for each alternative using the two mixed aggregators (U_{1i}) ve (U_{2i}) Table 18 presents the multidimensional performance ranking of π_i, Q_i, U_{1i}, U_{2i}, U_i and insurance companies for each alternative.

Table 18. 2018 Results of the MACONT Procedure on Data

	π_i	Q_i	U_{1i}	U_{2i}	U_i	**Ranking**
IC1	0.144	0.708	0.426	0.014	0.474	1
IC2	0.152	0.846	0.471	0.007	0.369	3
IC3	-0.058	1.046	0.129	-0.004	-0.004	5
IC4	-0.127	0.410	-0.141	-0.012	-0.296	7
IC5	-0.039	0.686	0.083	-0.003	-0.015	6
IC6	-0.092	0.546	-0.046	0.007	0.100	4
IC7	0.020	1.281	0.327	0.017	0.464	2

Upon analysing the results of the multidimensional performance evaluation for 2018, presented in Table 18, it is evident that IC1 (Ak Insurance) performed the best, while IC4 (Ray Insurance) performed the worst.

The MACONT procedure was applied separately for the period 2018-2022, and Table 19 presents the results of the multidimensional performance ranking of insurance companies for all years.

Table 19. MACONT Procedure Ranking Results for Alternatives, 2018-2022

	2018	**2019**	**2020**	**2021**	**2022**
IC1	1	2	2	4	6
IC2	3	1	1	2	1
IC3	5	3	3	3	7
IC4	7	5	5	6	3
IC5	6	4	4	7	2
IC6	4	6	6	5	4
IC7	2	7	7	1	5

Table 19 presents the results of the MACONT procedure for ranking non-life insurance companies based on their performance from 2018-2022. Upon examination of the results of the Macont procedure, it was determined that Anadolu Insurance Company (IC2) maintained the top three ranks by demonstrating stable performance in all years considered, as indicated by financial and service network indicators. Although Ray Insurance (IC4) and Ankara Insurance (IC6) companies have shown improvements in their performance in some years, their overall performance based on financial and service network indicators is generally poor.

4.6. Results of the Borda Count Algorithm

As mentioned before, our study covers a period of 5 years. Therefore, the rankings of the companies on a yearly basis are determined within the framework of the proposed methodology. However, it reveals that the final decision regarding the evaluation of companies is not clear. In such cases, the literature suggests various integration methods in order to aggregate the year-wise ranking results and reduce the problem to a single result (Biswas et al., 2022; Işık et al., 2024). One of them is the Borda Count (BC) approach. BC scores calculated for each alternative also provide a consensus ranking between the performance rankings obtained by utilizing five diferent data. The rankings obtained based on the performance indicators of five diferent years covering the 2018–2022 period are merged with the Borda rule and the findings are given in Table 20.

Table 20. Final Rankings of Insurers Based on BC Method

	Rank Based Number					Total	Aggrated Rank
	2018	2019	2020	2021	2022		
IC1	6	5	5	3	1	20	2
IC2	4	6	6	5	6	27	1
IC3	2	4	4	4	0	14	3
IC4	0	2	2	1	4	9	7
IC5	1	3	3	0	5	12	5
IC6	3	1	1	2	3	10	6
IC7	5	0	0	6	2	13	4

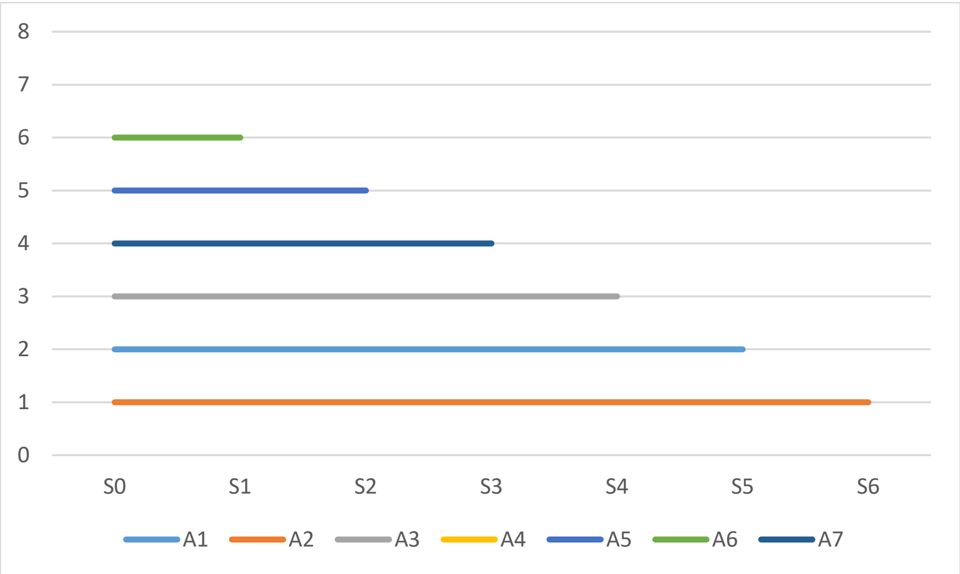
The MACONT ranking results based on the BORDA procedure demonstrate that Anadolu Sigorta (IC2) performed the best, while Ray Sigorta (IC4) performed the worst.

4.7. Rank Reversal Feature-Based Sensitivity Analysis

This section applies sensitivity analysis to test the reliability and validity of the results obtained from the proposed MCDM model for evaluating the multidimensional performance of insurance companies. A sensitivity analysis was chosen to test the resistance of the proposed model to the order reversal problem. According to Demir (2022), changing the decision matrix by alternative addition or removal may affect the ranking results. The proposed model, including ENTROPY, MEREC and MACONT methods, will be tested for validity using six different scenarios in which the decision matrix elements are changed. The aim is to examine the variability that may occur in ranking results. The scenarios are arranged so that each evaluation excludes the worst alternative in the previous scenario. In each new scenario, the remaining alternatives are ranked according to the updated initial decision matrix (Stevic et al., 2020).

Figure 4 shows the new ranking results according to six different scenarios.

Figure 4. Re-ranking of Alternatives Based on Different Scenarios



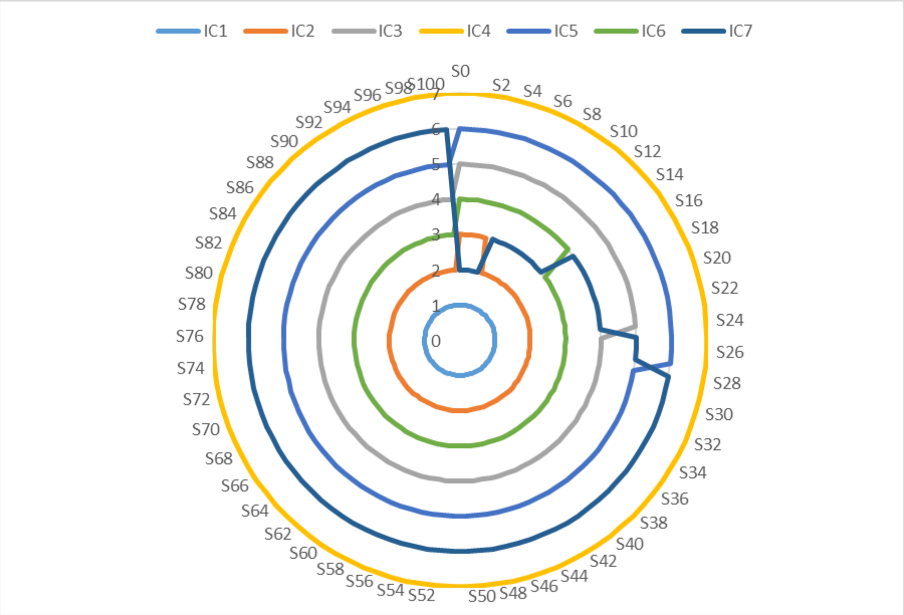
Source: Figure 4 was constructed by the author.

Based on the sensitivity analysis results presented in Figure 4, it is evident that alternative IC1 is the optimal choice in all scenarios. These findings confirm the consistency, robustness, and feasibility of the proposed MCDM performance evaluation model.

4.8. Sensitivity Analysis Based on Various Criteria Weights

To examine the impact of changes in importance weights of criteria on decision alternative rankings, we created 100 different scenarios. In each scenario, we reduced the importance weight of one evaluation criterion by 10% and added this amount proportionally to the other criteria, ensuring the sum of weight values remained at 1. Figure 5 shows the ranking results for the alternatives in the new scenarios. The sensitivity analysis was applied for all years of the study, and the results were approximately consistent. An example of the application of the sensitivity analysis based on sensitivity analysis based on various criteria weights for 2018 is shown below.

Figure 5. Ranking Results of Decision Alternatives Across 100 Scenarios (2018)



When the results given in Figure 5 are analysed, it is seen that the best alternative IC1 is not affected by different criteria weighting scenarios and the ranking of the alternative does not change for all scenarios. According to the results reported in Figure 5, it is seen that there are no major and significant changes in the performance rankings of other decision alternatives in different scenarios. In conclusion, the ranking results obtained with the sensitivity analysis applied confirm that the hybrid performance evaluation model proposed in the study is consistent, robust and applicable.

4.9. Comparison with Alternative Decision Algorithms

The results obtained with the hybrid model consisting of the ENTROPY-MEREC and MACONT methods proposed in the study were compared with the ranking results obtained with different MCDM methods. The relevant results are shown in Table 21.

Table 21. Results Ranking from Various MCDM Techniques

	MACONT	ROV	CRADIS
IC1	2	2	2
IC2	1	1	1
IC3	3	4	4
IC4	7	5	6
IC5	5	5	5
IC6	6	6	5
IC7	4	3	3

After the data for the 2018-2022 period, which constitutes the study period, was analyzed with ROV (Range of Value) and CRADIS (Compromise Ranking of Alternatives from Distance to Ideal Solution) procedures, the ranking results obtained for all years were combined with the BORDA method and a general result was obtained. Table 21 shows that the sequencing results obtained with the ROV and CRADIS procedures are largely similar to those obtained with the MACONT procedure. Comparative analysis results with different decision algorithms confirm that the model proposed in the study provides consistent results.

5. DISCUSSION, PRACTICAL AND MANAGERIAL IMPLICATIONS

Performance assessment of insurers, which provide protection to their customers from various risks in almost all economies, is of great critical significance for the successful management of risks, improvement of insurance service quality, and sustainability of the financial system and the economy (Aydın, 2019; Aydın, 2021).

When the prior performance measurement studies in the Turkish non-life insurance sector are analysed in detail, it is observed that researchers and practitioners have used different MCDM methods, criteria, alternatives, and periods. According to the results of current study, the top three most successful companies in terms of multidimensional performance in the Turkish non-life insurance sector are Anadolu Sigorta (IC2), Ak Sigorta (IC1), and HDI Sigorta (IC3). However, Isik et al. (2024) found Halk Sigorta and Anadolu Anonim Türk to be the most successful and unsuccessful insurance companies, respectively. Akpınar and Pehlivan (2023) reported that the non-life insurance company with the best performance is BNP Paribas and the non-life insurance company with the worst performance is Unico. Koca and Bingöl (2022) identified Allianz Sigorta as the most successful company and Generali Sigorta as the most unsuccessful company in their study. Demir and Arslan (2022) found that the most successful and least successful non-life insurance companies are Allianz Sigorta and Halk Sigorta, respectively. Aydın (2021) determined Anadolu Sigorta and Ak Sigorta as the firms with the highest and lowest performance scores, respectively. Akyüz et al. (2020) reported that Allianz Sigorta and Anadolu Anonim Türk Sigorta are the two most successful companies, whereas Unico and Ergo Sigorta are the two least successful companies. The comparison of the findings of the studies that measure and rank the performance of non-life insurers in the past literature with the results of the present study indicates that there are differences between the findings. The main reason for this may be attributed to the inclusion of different alternatives, criteria sets, and period periods in the decision-making process in each study.

The existing manuscript has practical implications as follows.

i. The first practical contribution of the work is to provide a novel, comprehensive, and integrated framework for measuring the financial and non-financial performance of insurers.
ii. The proposed MCDM tool has a basic and straightforward mathematical procedure that can be easily applied by DMs without advanced mathematical knowledge.
iii. The combined weighting procedure integrating the Entropy and MEREC procedures allows DMs to obtain more acceptable weighting coefficients. Moreover, DMs can obtain more robust and reliable results by applying the MACONT procedure based on joint weighting because the proposed decision framework is resistant to the order inversion problem.
iv. Validation tests provide evidence that the proposed decision-making framework produces consistent results.

The managerial implications from existing manuscript can be summarized as follows;

i. The findings of the current article are of great importance, firstly, in terms of supervisory mechanisms that monitor the performance of insurers. Supervisory authorities can easily monitor insurers' performance thanks to the proposed model.
ii. Analysis of insurers' performance, both financial and non-financial, provides sector managers and employees with various vital information, especially on gaining competitive advantage. It also provides critical information about whether the policies implemented by insurers are successful or not, based on the findings of the performance analysis of other industry stakeholders.
iii. Regular performance analyzes are also very important for insurance customers. because this makes it easier for insurance customers (i.e., policyholders) to choose an insurer.
iv. The empirical results obtained can provide an important road map for senior management in improving insurers' financial performance and service network.

6. CONCLUSION

Recently, there has been an increased interest in the insurance sector due to the frequent occurrence of financial crises, epidemics, and natural disasters. The insurance sector serves the purpose of minimizing the negative consequences of these events and ensuring that the insured are least affected by these situations (Işık et al., 2023). The COVID-19 pandemic in Turkey, the earthquake on 6 February 2023 that affected 11 provinces, the inflationary environment, and the fluctuations in the exchange rate all highlight the social and economic significance of the insurance sector. Therefore, it is necessary to measure and evaluate the performance of insurance companies.

The aim of this study is to examine the multidimensional performance of non-life insurance companies operating in Turkey based on criteria based on financial and service network performance. For this purpose, a new integrated MCDM model consisting of ENTROPY, MEREC and MACONT methods has been proposed to evaluate the multidimensional performance of insurance companies. With the proposed model, unlike many studies in the literature, not only the financial performances of insurance companies but also their service network performances were evaluated. In addition, the results of the proposed model were tested with different sensitivity analyzes and it was determined that it gave valid results.

The objective importance weights of the evaluation criteria used in the multidimensional performance evaluation of insurance companies were determined using the ENTROPY and MEREC methods recommended in the model. Then, the results of these two methods were combined to obtain the final importance weights of the criteria. When the results of the common weighting method were examined, the three most effective criteria on the financial and service network performance of insurance companies in 2018 were determined to be C7 (asset size), C8 (asset profitability) and C1 (number of agencies), respectively. According to the study results, it can be said that their asset structures are decisive on the performance of the insurance companies included in the analysis in 2018. Table 12 results for 2019 indicate the first three criteria that determine the performance of insurance companies as C1 (number of agencies), C9 (technical profit) and C11 (return on equity capital), respectively. It can be stated that both the technical profit obtained from insurance activities and the return on equity, which is the measure of the profit earned by company partners in return for the capital they invested, were effective on the performance of insurance companies in the year in question. In addition, it is seen that the number of agencies criterion has a high impact weight in determining performance in the first two years included in the analysis. The fact that agencies are the distribution channel with the highest share in the premium production of non-life insurance companies can be shown as supporting this situation. In 2020, the three most effective criteria in determining the multidimensional performance of insurance companies were determined as C1 (number of agencies), C9 (technical profit) and C8 (net profit), respectively. It can be said that the determinants of multidimensional performance in the year in question were the profitability of the companies and the effective use of the agency distribution channel. The results for 2021-2022 obtained from the common weighting procedure can be interpreted as the multidimensional performance of insurance companies with a solid asset structure, efficient use of their assets and high asset profitability. When the results are examined, it can be said that insurance companies that want to increase their multi-dimensional performance in terms of financial and service network should give importance to their profitability and agency distribution channel.

The 2018-2022 ranking results of all companies obtained from the MACONT procedure were combined using the BORDA method and an overall ranking result was obtained. According to these results, Anadolu Sigorta ranked first in the multidimensional performance ranking evaluated according to financial and service network indicators. The company's multidimensional performance was driven by its nearly 100 years of experience in the sector, its history and deep-rooted traditions that have earned the trust of its customers, as well as its strong market position with a high share of premium production. By the end of 2022, the Company will rank second in premium production in the non-life insurance sector with a market share of 11.64%. In addition, the strong bancassurance distribution channel of Anadolu Sigorta, a subsidiary of İşbank, together with the synergy of İşbank, can be considered to be effective in the company's multidimensional successful performance. The results obtained from the MACONT procedure based on BORDA showed that Ak Sigorta ranked second in the multidimensional performance ranking. This success can be attributed to Ak Sigorta high market share in the non-life insurance sector. In addition, the company has a very strong bancassurance network with 710 Akbank branches. It can be said that these conditions are supportive of the company's success. The analysis results indicate that the multidimensional performances of Ray, Zurich, and Ankara sigorta companies were generally low during the period covered. This may be due to the fact that these companies are ranked lower in terms of premium production and market share. To test the consistency and robustness of the hybrid decision model proposed in the study, sensitivity analysis was conducted based on different criterion weights and rank reversal features. Additionally, a comparison analysis was performed using different MCDM algorithms. The results of the model were found to be consistent and reliable.

In contrast to previous studies, this research evaluates firm performance from multiple dimensions by considering both financial and service network performance of insurance companies. This approach contributes to the existing literature. Furthermore, the decision model suggested in the study can be applied to various research areas, including assessing firm-level performance, comparing performance across countries, and analyzing sector-specific performance.

The first limitation of this study relates to the data period and the companies included in the analysis. The second limitation is that the results obtained are valid only for non-life sector companies. Additionally, in future studies, researchers or practitioners can integrate subjective weighting methods such as BWM, LMAW, LBWA, AHP, DEMATEL, etc., and obtain more detailed results using different decision criteria. Besides, in future studies, more comprehensive decision support systems can be produced using methods based on fuzzy numbers or gray numbers. In this context, decision support models based on gray numbers such as grey MABAC, grey MAIRCA, grey MARCOS, grey LOPCOW, grey SWARA or intuitionistic fuzzy, neutrosophic fuzzy, pythagorean fuzzy, picture fuzzy, q rung orthoair fuzzy, and spherical fuzzy sets can be used.

The study does not necessitate Ethics Committee permission.

The study has been crafted in adherence to the principles of research and publication ethics.

The author declares that there exists no financial conflict of interest involving any institution, organization, or individual(s) associated with the article.

The entire work was carried out by its only, stated author.

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