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EDITORIAL PREFACE

Dear readers of the International Journal of Insurance and Finance It gives us great pleasure to welcome you in the tenth issue of our new journal in the field of insurance and finance. As indicated in the earlier issues, the journal was aimed to contribute the fields of insurance and finance. This journal presents papers intended to advance scientific knowledge of the insurance industry and finance sector as well as to stimulate dialogue between scientists and practioners in both two sectors.

Using a double blind reviewing process, IJIF will continue to publish original scientific papers. Scientists and practitioners in the field of insurance and finance are encouraged to submit their papers to our new journal online via the link https://www.ijif.net

IJIF has started its publication life since 2021 as peer-reviewed journal to publish articles written in English with this concept, and still continues to maintain this feature for now. We strongly believe that all actors of these fields, such as researchers, professionals, students and politicians, will continue to benefit from IJIF articles published.

Starting from the second issues, IJIF are still being indexed or abstracted by Crossref, IZOR, ISI, DOAJ, Euro Pub, ASOS, Ideal Online and IP Indexing databases.

We would like to thank the leading companies of the finance and insurance sector operating in the national and international arena, for their trust in IJIF, after the first issue of our journal was published. In addition, we are pleased to have valuable number of submitting articles by scientists and practitioners to our journal as the recognition of our journal becomes more widespread.

Finally, we would like to thank to our authors, the advisory and referee boards who contributed to the sixth issue; Türk Reasürans, AXA Insurance Companie as well as Ziraat Bank, TARSİM, Insurance Thought Center and Sivas Soft for their support to publication of this issue.

As the journal editors we will be honored to welcome to all national and international valuable scientists and practitioners who will submit and publish the articles of in the eleventh.

Kind Regards,

Ahmet Şengönül
Ahmet Genç
Fuat Çamlıbel

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ORIGINAL ARTICLE

AN ANALYSIS OF COMPULSORY TRAFFIC VEHICLE INSURANCE SYSTEMS IN TURKEY AND EUROPEAN COUNTRIES AND A MODEL PROPOSAL *

Akbermet KUBATBEKOVA
Özgür AKPINAR

Abstract
This study examines the compulsory traffic vehicle insurance systems in Turkiye and selected European countries such as Germany, France, Italy, the Netherlands, and Poland. The research focuses on the history, legal framework, premium calculation methods, bonus-malus systems, supervision, and current structure of compulsory traffic insurance in these countries. Statistical data for each country were collected from official insurance institutions and guarantee fund reports, and the findings were analyzed through a comparative approach. First, the current situation of compulsory traffic insurance in Turkiye was examined. The high rate of uninsured vehicles, high loss ratio, unprofitable market, and problems in the pricing process were identified as the main issues. Later, the systems in European countries were studied, showing that wider insurance coverage, financial sustainability, risk-based pricing, and technological innovations (such as black boxes and usage-based insurance) are common practices. Based on these examples, a model proposal for Turkiye was developed to improve the structure and efficiency of the system. The aim of the study is to suggest ways to make Turkey's compulsory traffic insurance system more effective and to contribute to academic research in this field.

Keywords
Compulsory traffic Insurance, Bonus-malus System, Comparative Analysis, Uninsured Vehicles

JEL Classification
G20, G22, L10, L50.

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** This study was conducted at Marmara University Institute of Banking and Insurance, Department of Insurance under the supervision of Prof. Dr. Özgür Akpınar by Akbermet KUBATBEKOVA with the title "An Examination of Compulsory Traffic Insurance Systems in Turkey and European Countries and a Proposed Model," defended on June 25, 2025.*

1. INTRODUCTION

The number of traffic vehicles worldwide has increased significantly in recent years. The main reasons for this trend include economic growth, the development of transportation infrastructure, and increased demand for individual mobility. In Turkey, the number of cars, which was approximately 28 million in 2023, rose to 32 million in 2024, representing an increase of approximately 14% (Turkish Statistical Institute [TUIK], 2024). Similarly, vehicle ownership rates are increasing worldwide. This rapid increase in the number of vehicles has many problems. The increase in the number of traffic accidents is at the forefront of these problems. The rise in accidents causes damage to both vehicles and people.

In this context, the importance of compulsory traffic insurance is increasing day by day. Compulsory traffic insurance is a type of insurance mandated by the state that guarantees compensation for material and bodily harm that vehicle owners may cause to third parties while using their vehicles. This insurance protects individuals against potential financial losses while also contributing to the maintenance of traffic order, public safety, and public order (Goliadze, 2023, p.2).

It is a legal obligation for every traffic vehicle to be insured with this insurance, which is mandatory by the state. Compulsory traffic insurance covers compensation for bodily injury, permanent disability, and loss of support, as well as material damage suffered by third parties in the event of an accident (Temur, 2018, p.309).

This study examines the compulsory traffic insurance system by comparing its implementation in Turkey with that in European countries. Most studies conducted in the literature to date have addressed the compulsory traffic insurance systems of Turkey and certain European countries only within the framework of specific criteria. For example, the activities of Guarantee Funds in European countries and Turkey have been compared; according to these studies, Guarantee Funds in Europe carry out various preventive activities, such as projects analyzing the causes of traffic accidents, in addition to compensation payments. For example, while projects analyzing the causes of accidents are implemented in Spain, it has been stated that studies in this area are limited in Turkey (Eren, 2010). Furthermore, previous studies have highlighted structural problems in Turkey's compulsory traffic insurance system, such as the high rate of uninsured vehicles, fraudulent damage claims, and premiums not being determined based on damage costs (Öztürk, 2008, p.68).

This study, however, goes beyond specific criteria and examines the compulsory traffic insurance systems in Turkey, Germany, Italy, Poland, France, and the Netherlands in a multidimensional manner. The analysis comparatively evaluates various elements such as each country's legal regulations on compulsory traffic insurance, premium determination systems, rates of uninsured drivers, and methods of combating uninsured driving. The results of the research identified the strengths and weaknesses of each country's system, including the current problems in Turkey. Furthermore, a model proposal for Turkey was developed by drawing on successful practices in European countries.

This study consists of seven sections. First, a literature review is conducted, followed by an explanation of the research methodology and data sources. Subsequently, the compulsory traffic insurance system in Turkey is examined, followed by a review of the systems in European countries. After these reviews, a comparative analysis is performed, and the final section presents the conclusions, evaluations, and recommendations.

2. LITERATURE

Eren (2010) conducted a comparative analysis of Guarantee Funds in Turkey and European countries. According to this study, a large portion of the fund's expenditures in Turkey is allocated to covering damages caused by uninsured vehicles, indicating that the number of uninsured vehicles in the country is high. In contrast, guarantee funds in European countries combat uninsured driving and carry

out activities to prevent traffic accidents. The study concluded that similar practices should be implemented in Turkey.

Goliadze (2019) conducted a comparative analysis of compulsory traffic insurance systems in Turkey, Europe, and Asia. According to the study, European countries have long-established, robust legal frameworks for compulsory traffic insurance and employ a risk-based pricing method. It was concluded that this system serves as a model for underdeveloped or developing countries.

Browne, Chung, and Frees (2000) conducted a study on liability insurance, particularly mandatory insurance practices, among OECD countries. The researchers conducted a comparative analysis of insurance premiums and insurance penetration levels in these countries. The study found that the rates in Turkey were below those of other countries, particularly below the average for European countries.

Porrini, Fusco, and Magazzino (2020) examined Italy's compulsory traffic insurance system between 2014 and 2017. The study focused particularly on the use of black box technology in determining premiums. The researchers found that black box applications enabled insurance companies to obtain more detailed and accurate information about the risk profile of policyholders, which contributed to premiums being set in a more fair and realistic manner.

Öztürk (2008) examined the traffic vehicle insurance sector in European countries and Turkey. The research found that although traffic vehicle insurance accounts for more than half of total premium production in Turkey, it is a loss-making sector within the year. The study listed the reasons for this situation as including an increase in damage costs, ineffective use of no-claims discounts, and similar factors. It also determined that similar problems were seen in European countries, but that these countries had solved or minimized most of the problems in question.

Peleckienė (2018) addressed the problems experienced in the compulsory traffic insurance system in European Union member states. According to the researcher, some insurance companies avoid providing insurance by offering high premiums, which leads to an increase in the rate of uninsured drivers in certain countries. She also emphasized that some regulations and improvements are needed in European Union directives to resolve these issues.

Gönülal (2009) examined compulsory traffic insurance systems in developing countries. According to the researcher, the implementation of the TRAMER system in Turkey has partially resolved certain issues such as uninsured drivers and fake insurance policies. However, Gönülal noted that various problems still persist in the country and emphasized that a more effective pricing system and strengthened oversight mechanisms are needed to address these issues.

Scalera and Zazzaro (2004) examined traffic vehicle insurance systems in European countries, classifying them according to the periods in which liberalization occurred in the insurance market. According to the research findings, some countries experienced a rapid price liberalization process in insurance premiums. The researchers stated that liberalization should be implemented in a controlled manner; otherwise, liberalization policies carried out without the necessary oversight and control mechanisms could lead to premium increases.

Engin and Karakuş (2020) examined the insurance sectors of European countries and Turkey using a comparative analysis method. According to the researchers, the Turkish insurance market is an attractive market for foreign insurance companies due to its high potential, and there are a large number of companies operating in the sector. Furthermore, it was noted that the state's requirement for certain types of insurance has led to these branches occupying a significant place in the total market share. However, the researchers emphasized that insurance is essentially a sector that should develop based on individuals' preferences and on a voluntary basis.

Karaoğlu (2007) analyzed the insurance sector in Turkey and European countries using ANOVA and Kruskal-Wallis tests. According to the researcher, the insurance penetration rate in Turkey remains low compared to European countries. However, Karaoğlu stated that Turkey has high potential in terms of the insurance sector and emphasized that insurance awareness must be increased in order to effectively evaluate this potential.

Kwiecień and Poprawska (2011) evaluated Poland's compulsory traffic insurance system in com-

parison with developments in Europe. The study examined the effects of increasing compensation claims, road safety levels, frequency of damage, premium rates, and changes in legal regulations on the insurance sector. The findings revealed that following Poland's accession to the EU, it had largely aligned with European Union standards in terms of guarantee limits and compensation principles, but that premium rates remained below the Western European average.

Demirbilek (2007) examined liability insurance systems in European countries and Turkey. According to the researcher, the main reason why compulsory traffic insurance has the highest share among liability insurances in Turkey is that it is a legally compulsory type of insurance. In other words, individuals take out this insurance not by their own choice but because it is a legal requirement. It was also emphasized that insurance awareness in Turkey is not at the desired level.

3. METHOD

This research is based on the comparative analysis method. The study examines the legal framework, structural characteristics, premium determination mechanisms, operation of guarantee funds, and technical systems applied in compulsory traffic insurance systems in Turkey and some European countries. In this context, the study is descriptive in nature, analyzing the current status of the systems in the countries, revealing their similarities and differences, and aiming to develop a suitable model proposal for Turkey in light of the findings obtained from these examinations.

4. DATA SOURCES

The data used in this study has been compiled from primary and secondary sources. Primary sources include each country's national insurance legislation, legal regulations concerning guarantee funds, and official statistics and reports published by insurance supervisory authorities, such as UFG in Poland, FGAO in France, and BaFin in Germany. Secondary sources include reports and statistical data published by national and international organizations such as the OECD, the European Insurance and Occupational Pensions Authority (EIOPA), the European Commission, the Turkish Insurance Association (TSB), and the Insurance and Private Pension Regulation and Supervision Agency (SEDDK). Academic studies, master's theses, and sectoral publications related to the subject were also used to supplement the research data.

5. COMPULSORY TRAFFIC INSURANCE SYSTEM IN TURKEY

Compulsory traffic insurance in Turkey is regulated based on the Highway Traffic Law No. 2918. This law makes it a legal obligation for traffic vehicle operators to insure themselves and cover any damages they may cause to third parties (Petek, 2014, p.3287). The scope of this insurance is regulated in Article 2 of the General Conditions, which states that the insurance covers material damages and bodily injuries. Bodily injuries include disability, loss of support due to death, and medical expenses.

The coverage limits for damages falling under this scope are determined annually by the Insurance and Private Pension Regulation and Supervision Authority (SEDDK). The limits are updated taking into account the economic conditions and inflation rates of the relevant year and are binding for all insurance companies. The coverage amounts determined for 2024 are 300,000 TL per vehicle and 600,000 TL per accident for material damages. In terms of medical expenses, the coverage is 2.7 million TL per person and, depending on the type of vehicle, between 6 million TL and 31.5 million TL per accident. For compensation for loss of support due to disability or death, the limit is 2.7 million TL per person and between 6 million TL and 31.5 million TL per accident (Insurance and Private Pension Regulation and Supervision Authority [SEDDK], 2024).

In Turkey's compulsory traffic insurance, the premium determination system was changed in 2017 and maximum premiums were applied. Under this system, SEDDK determines the highest premium

amounts according to vehicle types, and insurance companies determine premiums on the condition that they do not exceed these amounts. This regulation is implemented to keep premium increases under control and ensure stability in the insurance system. In addition, an eight-tier bonus-malus system is used in Turkey, whereby discounts are applied to policyholders during accident-free periods, while premium increases (malus) are applied to vehicle owners who have frequent accidents (Baykal & Bülbül, 2016, p.21). The effective implementation of the bonus-malus system is made possible through TRAMER, which enables the central collection of insurance data. This system contains policy and claims history information for policyholders. In the premium determination process, insurance companies use this information to assess the policyholder's risk history. Additionally, a "High-Risk Insurance Pool" has been created for drivers in the high-risk group. This pool balances risk distribution by sharing high-risk policies among insurance companies (Umut, 2020, p.365).

Compulsory traffic insurance premiums in Turkey have followed a fluctuating trend. Looking at the change in premiums over the years, they have increased significantly in the last two periods. First, with the transition to a free tariff system in 2015, there was an excessive increase in premiums, which led to instability in the market. In 2017, the government imposed maximum premiums to curb price increases. In 2022, the country experienced a second major increase due to the deterioration of its macroeconomic situation, high inflation rates, and exchange rate fluctuations. One of the fundamental problems facing the compulsory traffic insurance system in Turkey is the high rate of uninsured vehicles. Although insurance is a legal requirement, the number of uninsured vehicles has been increasing every year. Indeed, while the rate of uninsured vehicles was approximately 20% in 2023, this rate rose to 22% in 2024 (Guarantee Account, 2024). This situation is considered one of the main structural problems negatively affecting the effectiveness of the system.

Table 1

Compulsory Traffic Insurance Data for Turkey Between 2020 and 2024

Years	Earned Premiums (Billion TL)	Claims Paid (Billion TL)	Claims Ratio (%)	Technical Profit/Loss (Billion TL)
2020	12.8	12	93.6	+0.8
2021	13	16.3	125.2	-2.8
2022	20	35.9	179.3	-11.7
2023	56.6	79.4	134.2	-13.8
2024	121.3	152.7	127	-17

Source: *Turkish Insurance Association (TSB), Financial Statements 2024, retrieved on December 18, 2024, from https://www.tsb.org.tr/tr.*

Table 1 shows Turkey's compulsory traffic insurance data for the years 2020–2024. According to these data, the compulsory traffic insurance branch only achieved a technical profit of approximately 0.8 billion TL in 2020. The main reason for this is the decrease in traffic density during the COVID-19 pandemic and, consequently, the decline in the frequency of accidents. In other years, the sector consistently incurred losses. The highest loss occurred in 2024, with the technical loss reaching 17 billion TL in that year. This amount represents an increase of approximately 23% compared to the previous year (Turkish Insurance Association [TSB], 2024).

6. COMPULSORY TRAFFIC INSURANCE SYSTEM IN EUROPEAN COUNTRIES

The compulsory traffic insurance system in European countries is regulated under the European Union's traffic Insurance Directives 72/166/EEC, 84/5/EEC, 2000/26/EC, and 2009/103/EC. These

directives aim to prevent uninsured vehicles, protect cross-border compensation rights, and ensure the free movement of vehicles. Each member state implements this framework by adapting it to its own national law, resulting in some structural differences in the operation of the system. The examples of Germany, France, Italy, the Netherlands, and Poland are examined below.

6.1. Compulsory traffic Insurance in Germany

Germany is one of the European countries with the longest history of compulsory traffic insurance. This system came into force in 1939 and is currently regulated by the German Compulsory traffic Insurance Act (Pflichtversicherungsgesetz – PflVG). Furthermore, the legal framework of the system is supported by the Road Traffic Act (Straßenverkehrsgesetz – StVG) and European Union traffic insurance directives. Compulsory traffic vehicle insurance in Germany covers compensation for material and bodily harm caused to third parties in the event of an accident (Fromm, 1961, p. 2).

In Germany, the mandatory traffic insurance system transitioned to a free pricing system in 1994. Since then, insurance companies have been granted the authority to independently determine premiums. When calculating premiums, various criteria based on risk assessment are taken into account. These include factors such as the driver's age, occupation, region of residence, vehicle type, traffic volume, and number of claim-free years (Gesamtverband der Deutschen Versicherungswirtschaft [GDV], 2025). In addition, insurance companies in Germany use the Bonus-Malus system when setting premiums. This system has a very detailed structure in the country and is applied through a multi-level classification called Schadenfreiheitsklasse (SF). The SF system consists of 54 levels, and drivers in the highest class can receive a premium discount of approximately 85% (Gyetvai, 2021). For new insurance policyholders, there are two different entry levels initially determined based on driving experience. This structure allows drivers to be assessed more fairly based on their risk history. The strongest aspect of the Bonus–Malus system in Germany is that the large number of levels allows risk groups to be separated more precisely.

Compulsory traffic insurance premiums in Germany generally follow a stable trend. While the average premium was €251 in 2023, it rose by approximately 9% to €273 in 2024 (GDV, 2024). Compared to Turkey and other European countries, this increase is quite limited. The rate of uninsured vehicles in Germany is quite low. The country's strong crackdown on uninsured vehicles is the main reason for this. Vehicles without insurance are automatically prevented from entering traffic because their insurance information is monitored online via the Zentralruf der Autoversicherer and Kraftfahrt-Bundesamt (KBA) databases. Thanks to this digital control system, the use of uninsured vehicles in Germany has fallen below 1%.

Table 2

German Compulsory Traffic Insurance Data for the Years 2019-2023

Years	Premium Income (Billion Euros)	Paid Claims (Billion Euros)	Loss Ratio %	Combined Ratio %
2020	16.9	13.3	79.4	91.8
2021	17	13.5	79.9	88.3
2022	16.9	14.9	88.4	96.5
2023	17.7	16.1	92.4	101.5
2024	19.5	17.2	88.2	100

Source: *German Insurance Association (GDV), Statistics on the German Insurance Industry 2024, retrieved on January 5, 2025, from https://www.gdv.de/gdv/statistik/statistiken-zur-deutschen-versicherungswirtschaft-uebersicht.*

Table 2 contains data on compulsory traffic insurance in Germany for the period 2020–2024. Premium income, which was €16.9 billion in 2020, rose to €19.5 billion in 2024. During the same period, loss ratios ranged between 79% and 92%, reaching their highest level in 2023. Nevertheless, the fact that combined ratios remained around 100% indicates that the German compulsory traffic insurance system generally exhibits a balanced financial structure.

6.2. Compulsory Traffic Insurance in France

The legal framework for compulsory traffic insurance in France is established by the second section of the French Insurance Code (Code des assurances) and the French Highway Code (Code de la route). Furthermore, the European Union's traffic insurance directives form the basis for these national regulations. In this context, compulsory traffic insurance in France also guarantees compensation for material and bodily damage caused to third parties in traffic accidents (Richaudeau, 1998, p. 433).

In France, compulsory traffic insurance premiums are determined by insurance companies based on individual risk factors such as the insured's age, occupation, and region of residence. In addition, a bonus-malus system is used in premium calculations in the country. A distinctive feature of the French system, unlike other European countries, is that it has a proportional structure rather than a tiered one. Accordingly, drivers receive a 5% discount for each accident-free year, while a 25% penalty is applied for each accident (Pitrebois, Denuit, & Lambert, 2006, p.248). France also has a Central Pricing Office (Bureau Central de Tarification [BTC]) that provides support to individuals who have difficulty obtaining insurance. The number of applications to this institution is increasing every year, with elderly and young drivers making up the majority of applicants. In 2024, the highest rate among the reasons for rejection by insurance companies was drivers with a history of frequent accidents, accounting for 35% (BTC, 2024).

Uninsured motorists are one of the main problems facing France's compulsory traffic insurance system. In 2023, the number of people killed in accidents involving uninsured vehicles was 160, an increase of approximately 1.9% compared to 2022. During the same period, the number of people injured or suffering material damage in accidents caused by uninsured vehicles was 7,687, a decrease of approximately 9.8% compared to 8,519 cases in 2022 (Fonds de Garantie des Assurances Obligatoires de dommages [FGAO], 2023). An analysis of data from the last five years shows that the number of accidents caused by uninsured vehicles has generally been on the rise. This indicates that the problem of uninsured vehicles remains a serious issue in France.

Looking at the combined ratios after reinsurance in France's compulsory traffic insurance sector, a generally stable trend has been observed over the past five years. The combined ratio, which was 94% in 2020, rose to 99.5% in 2021 and 100% in 2022, before falling back to 98% in 2023. These rates show that the sector generally exhibits a balanced financial structure and that, although profitability has declined to a limited extent in some years, the system has maintained its sustainability.

6.3. Compulsory Traffic Insurance in the Netherlands

The Netherlands was the last European country to implement compulsory traffic insurance, which came into effect in 1965. The compulsory traffic insurance system in the Netherlands is regulated by the Motor Vehicle Liability Insurance Act (Wet Aansprakelijkheidsverzekering traffic rijtuigen WAM) and the Road Traffic Act (Wegenverkeerswet), as well as by European Union directives (Watcher, 1962, p.15). Pursuant to Article 3 of the aforementioned law, compulsory traffic insurance in the Netherlands covers material and bodily damage caused to third parties.

In the Netherlands, insurance companies are free to set premiums based on the characteristics of the driver and the vehicle, as well as the type of insurance. One of the most important factors in determining premiums is the age of the insured. Previously, insurance companies used the bonus-malus system to determine the initial class based on the driver's age and annual mileage. Today, however,

insurance companies use a central digital database called Roy Data. This database contains information such as the number of accidents the insured has had in the past or the number of years without a claim (Verbond van Verzekeraars, 2022). Insurance companies apply the bonus-malus system based on the data in the Roy Data system, and the operation of the system may vary from company to company.

The Waarborgfonds, known as the Guarantee Fund operating in the Netherlands, compensates for damages caused by uninsured or unidentified vehicles. According to the fund's data, compensation payments amounted to €68 million in 2022 and €79 million in 2023. Based on these figures, fund payments increased by approximately 16% in 2023. In 2022, 11% of these payments were allocated to damages caused by uninsured vehicles, and this percentage remained the same in 2023. This stability in payment rates indicates that the problem of uninsured vehicles in the Netherlands has not been completely eliminated but continues at a certain level (Waarborgfonds traffic verkeer, 2023). Previously, higher rates of uninsured vehicles in the Netherlands posed a significant problem for the country's traffic insurance system. However, the Rijksdienst voor het Wegverkeer (RDW) system was established in 2011 and has made significant progress in this area. RDW is a system that digitally collates the registration, license, and insurance information of all vehicles on the road throughout the country. This system automatically detects vehicles without insurance policies, and administrative fines are imposed on vehicle owners. As a result, the detection of uninsured vehicles in the Netherlands has accelerated, and the uninsured rate has decreased.

An analysis of the combined ratios for compulsory traffic insurance in the Netherlands over recent years indicates a decline in the sector's profitability. Between 2019 and 2022, combined ratios ranged between 108% and 111%, indicating a continuing trend of technical losses. In 2023, during a period of significantly increased losses in the sector, the ratio rose to 120%. These figures show that the compulsory traffic insurance sector in the Netherlands is operating at a loss (De Nederlandsche Bank, 2024).

6.4. Compulsory Traffic Insurance in Italy

Like other European countries, the legal framework for compulsory traffic insurance in Italy is based on European Union directives and the national insurance law, the "Codice delle Assicurazioni Private" (Private Insurance Code) No. 209 (Martinelli, 2016, p. 6). Article 122 of this law defines the scope of compulsory traffic vehicle insurance and stipulates that this insurance covers material and bodily harm caused to third parties.

In Italy, which has transitioned to a free tariff system to comply with European Union directives, insurance premiums are determined by insurance companies based on the risk characteristics of the insured and the vehicle. Italian insurance companies use a wide variety of methods to calculate premiums, one of which is the bonus-malus system, which is also used in other European countries. However, they also use a deductible, known as franchigia, whereby the insured agrees to pay a certain amount of the damage, which reduces the premium payable.

Additionally, Article 133 of the Private Insurance Act stipulates that insurance companies are obligated to provide mandatory premium discounts under certain circumstances. For example, a premium discount is applied if the insured vehicle is equipped with a "scatola nera" (black box) electronic device or passes a technical inspection upon request. This device records the vehicle's speed, braking, direction changes, and the impact force at the moment of an accident, enabling insurance companies to accurately assess the vehicle's driving behavior. Furthermore, if the vehicle is equipped with a system that measures alcohol levels and prevents the engine from starting when legal limits are exceeded, a premium discount is also applied to the driver. Such technological equipment enables insurance companies to price risks more fairly and accurately.

The rate of uninsured drivers in Italy has been around 6% in recent years. Although this rate is relatively low compared to other European countries, it has shown an upward trend in recent years.

The combined ratios for compulsory traffic insurance in 2022 and 2023 were 107.8% and 105.5%, respectively, indicating that insurance companies are technically operating at a loss. However, the revision of reserves set aside in previous years contributed to these ratios falling to 102.3% and 99.3%, respectively. This situation shows that, as of 2023, the reserves created in previous periods are sufficient to protect the financial balance of insurance companies (Associazione Nazionale fra le Imprese Assicuratrici [ANIA], 2024).

6.5. Compulsory Traffic Insurance in Poland

Poland is one of the most recent and developing countries to join the European Union. For this reason, it has adopted compulsory traffic insurance later than other European countries. The compulsory traffic insurance system in the country is regulated by European Union directives and the "Act on Compulsory Insurance, the Insurance Guarantee Fund, and the Polish Motor Insurers' Bureau" (Ustawa o obowiązkowych ubezpieczeniach, Ubezpieczeniowym Funduszu Gwarancyjnym i Polskim Biurze Ubezpieczycieli Komunikacyjnych). The insurance coverage includes material and bodily harm caused to third parties.

In Poland, the premium determination system for compulsory traffic insurance is free. Insurance companies determine premiums in a two-stage process. In the first stage, criteria such as the driver's age, occupation, region of residence, driving experience, and vehicle model are evaluated, taking into account the characteristics of the insured and the vehicle, and a priori tariffs are established accordingly. In the second stage, a posteriori pricing is applied based on the insured's past claims history, i.e., the bonus-malus system comes into play (Szymańska, 2007, p.929). The number of classes and transition rules in the bonus-malus system vary depending on the insurance company. However, in general, the number of classes in the system ranges from 11 to 13. For example, the bonus-malus system applied by PZU, one of the largest insurance companies in Poland, consists of 11 classes, with a maximum premium discount of 60% and a premium increase of up to 200% applied in this system.

The percentage of uninsured vehicles in Poland is higher than in other European countries. According to data from the Polish Guarantee Fund, also known as the Ubezpieczeniowy Fundusz Gwarancyjny, 348,795 uninsured vehicle owners were identified in 2023, and a total of PLN 358.5 million was recovered from uninsured drivers through recourse in the same year (UFG, 2024). In terms of average premium amounts, Poland is one of the countries with the lowest premium levels among European countries. In 2023, the average premium amount for compulsory traffic insurance was approximately 117 euros.

Looking at the technical results for the period 2019–2023, it is evident that the compulsory traffic insurance sector in Poland has generally incurred losses. During the period under review, a profit of 13.6 million euros was achieved only in 2021. In all other years, the sector reported losses. In particular, the loss amounted to €76.8 million in 2019, and the highest loss for the period was recorded in 2022 at €86.8 million. In 2023, a loss of €78.6 million was also recorded. These findings show that technical profitability cannot be consistently achieved in the compulsory traffic insurance system in Poland. It shows that the pricing system fails to balance risks and that premium revenues are insufficient to cover claims costs.

7. Comparison of Compulsory Traffic Insurance Systems in Turkey and European Countries

After briefly explaining each country's compulsory traffic insurance system, a comparative analysis of these systems was conducted. Table 3 presents a comparative overview of the compulsory traffic insurance systems in the countries examined, based on key criteria such as scope, coverage limits, uninsured rate, penalty amount for uninsured drivers, premium determination method, bonus-malus system, and the system's financial balance.

Table 3

Data on Compulsory Traffic Insurance in European Countries and Turkey

	Turkey	Germany	France	Italy	Netherlands	Poland
Scope	Material Personal Damage	Material Personal Damage	Material Personal Damage	Material Personal Damage	Material Personal Damage	Material Personal Damage
Collateral Limits	300.000,00 TL 2.7 million TL	1.3 million € 7.5 million €	1.3 million € Unlimited	1.3 million € 6.4 million €	1,3 million € 6,4 million €	1.4 million € 6.4 million €
Uninsured Rate	%20	%1 under	%2,4	%6	%1.5	%18
Penalty for Lack of Insurance	992 TL Traffic Ban	Income-Based Traffic Offense Imprisonment	3750 € Public Work Traffic Ban	886-3464 € Traffic Ban	460-500 € Traffic Ban	2190 € Traffic Ban
Premium Determination	Maximum Premium	Free	Free	Free Discounts Exemption	Free	Free
Bonus-Malus	8 steps	SF system 54+step	Proportional system	18 step	Company-based 20-22 steps	Company-based 11-13 steps
System Balance	Loss	Balanced	Balanced	Loss	Loss	Loss

Source: *The author's own work. Prepared based on data obtained from institutional reports, official statistics, and academic publications pertaining to the insurance sectors of the relevant countries.*

According to the data in the table, the scope of compulsory traffic insurance is similar in all countries examined. The insurance covers material and bodily damage caused to third parties. In accordance with the EU Traffic Insurance Directives, the 2024 coverage limits have been set at quite high levels in European Union countries. Despite recent increases, Turkey's coverage limits remain relatively low compared to European countries.

The percentage of uninsured vehicles exists to some extent in every country, but in Europe, thanks to effective monitoring and digital tracking systems, these rates have been reduced to very low levels. For example, as of 2024, this rate is 6% in Italy, 1% in Germany, and higher in Poland due to its developing insurance market and new applications. In Turkey, the uninsured vehicle rate is around 20%, which remains a significant problem for the sector.

There are also significant differences between countries in the administrative penalties imposed on uninsured vehicles. In Turkey, individuals who drive uninsured vehicles are subject to an administrative fine of 992 TL and the vehicle is impounded. However, enforcement is generally limited to the fine. This violation faces much harsher penalties in European countries. For example, in France, driving an uninsured vehicle can result in a fine of up to €3,750 and community service, while in Poland the fine is approximately €2,190. In Germany, driving without insurance is considered a more serious offense and can sometimes result in penalties such as imprisonment.

In terms of premium determination systems, a free tariff system is applied in European Union countries, and insurance companies determine premiums based on the risk characteristics of the vehicle and the insured. In contrast, the maximum premium system continues to be applied in Turkey, and maximum premium rates are regulated by the state. The bonus-malus system is used in all countries,

but there are differences in how the system operates. While a step-by-step system is applied in most European countries, a proportional system is used in France.

Finally, when examining the system's financial balance, it is evident that the compulsory traffic insurance sector in Turkey exhibits a loss-making structure. Among European countries, Italy, the Netherlands, and Poland are technically prone to losses, but the German and French systems perform better financially. More advanced risk assessment models, higher premium levels, and stronger control systems in Europe increase the system's sustainability.

8. Conclusion and Evaluation

Research shows that compulsory traffic insurance systems in both Turkey and some European countries are financially unbalanced and prone to losses. However, these losses are managed in a more controlled manner in European countries, while in some countries the system is balanced or profitable. In Turkey, the system has been generating technical losses for many years, indicating that structural problems persist.

Various recommendations have been developed based on the findings obtained for Turkey. First, the rate of uninsured vehicles in Turkey is quite high (around 20%), and the current administrative fines are low and not deterrent. In European countries, however, penalties for uninsured vehicle use are applied in the form of both high fines and administrative sanctions, which helps reduce uninsured rates. Therefore, in Turkey too, penalties need to be increased, digital tracking mechanisms need to be strengthened, and sanctions need to be effectively enforced.

In terms of premium determination systems, European countries have a risk-based and multi-variable structure. Insurance companies determine premiums based on factors such as the driver's risk profile, the vehicle's technical specifications, age, occupation, place of residence, and claims history. In Turkey, however, there is no pricing freedom due to the maximum premium application, and risk differentiation is limited because the bonus-malus system consists of only eight levels. Creating a more multi-level and fair classification system, similar to that in Germany, would contribute to premiums reflecting the actual risk.

The "black box" (scatola nera) system implemented in Italy provides insurance companies with objective data by recording vehicles' speed, braking, steering, and driving behavior. The widespread adoption of similar digital applications in Turkey will both increase the accuracy of risk analysis and enable fair pricing. As in examples from European countries, it is also important to establish a new institutional structure or assign an existing institution (such as the Guarantee Account) to carry out projects in the areas of combating uninsured driving, public awareness, and traffic safety.

In conclusion, to enhance the effectiveness of Turkey's compulsory traffic insurance system and make it sustainable, risk-based pricing, the development of digital monitoring tools, the implementation of deterrent sanctions, and the widespread promotion of activities that strengthen insurance awareness are necessary. Steps taken in this direction will significantly increase both the financial sustainability and social effectiveness of the system.

AUTHOR STATEMENT

Research and Publication Ethics Statement
This study has been prepared in accordance with scientific research and publication ethics rules.
Ethics Committee Approval
This study did not use data collection techniques requiring ethics committee approval.
Author Contributions
The authors contributed equally to the work.
Conflict of Interest
There is no conflict of interest arising from the work from the perspective of the authors or third

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ORIGINAL ARTICLE

THE ROLE OF PRIVATE PENSION SYSTEM IN FINANCIAL DEEPENING: AN EMPIRICAL APPLICATION ON TURKEY*

Gaye UGUN
Gürçem ÖZAYTÜRK

Abstract
The inadequacy of the social security system during retirement has led to a search for a new social security system. Thus, the private pension system emerged. In this respect, the private pension system complements the social security system. This system offers individuals the opportunity to supplement their retirement income by transferring savings earned during their working years into private pension funds. With this income, individuals can increase their standards and focus on investing. Thus, financial deepening, which refers to the diversification and proliferation of financial intermediaries and financial instruments, increases, and funds can be transferred between entrepreneurs seeking to invest and the private pension system.
This study investigates the role of the private pension system in financial deepening in Turkey using quarterly data from 2006Q4 to 2024Q1. The study used M2 money supply as an indicator of financial deepening and the fund amount of private pension participants as an indicator of private pensions as variables. The analysis was conducted using the ARDL bounds test and the Granger causality test. The results indicate that an increase in the amount of Private Pension System funds increases financial deepening. The Granger causality test results also support this conclusion, indicating that the Private Pension System is a Granger causal factor for financial deepening. Therefore, increasing participation in the Private Pension System through government support and incentives will lead to increased funds, increased resources for the financial system, and financial deepening.

Keywords
Financial Deepening, Individual Retirement System, Türkiye.

JEL Classification
G22 - G41.

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1. INTRODUCTION

The private pension system is a system that creates a sustainable standard of living and provides supplemental income during retirement by investing savings earned during working periods into regular funds. The private pension system is a sub-branch of the social security system and complements and expands the social security system. The essence of this system is to provide individuals with additional income during retirement and to transfer savings earned during active employment into income-generating funds (Ippolito, 1986: 13).

In other words, a private pension system is an organized retirement system where participants transfer contributions to their accounts at regular intervals and manage their funds until retirement under a predetermined contract. The private pension system is generally a complement to the state social security system. The system is based on the principle that participants contribute a portion of their savings during their working years to maintain their standard of living during retirement and provide another income-generating fund (EGM, 2001). The basis of the individual retirement system is to eliminate the concerns of its participants about the future, to guarantee their future while they are able to work, and to use a portion of their income effectively by saving (Önder, 2017: 8).

While there are significant differences in the retirement systems of countries, it has been observed that social security systems and pension funds are structured around a three-part structure. The first part is the traditional state pension system, which is based on a distributional principle and is a mandatory retirement system. This system, which allows for the redistribution of income provided by the state to various age groups within the social security system, is based on the principle that collections made to retired individuals are covered by funds collected from actively employed individuals. The second part, while based on occupational pension funds, is suitable for a group based on employment relationships or the practice of a profession. The third part is private pension funds. The purpose of private pension systems, which also include individual pensions, is to utilize personal contributions and pay the available funds as retirement income to individuals (Kara & Yıldız, 2016).

Financial deepening is defined as the channeling of funds from the financial sector to the real sector. Financial deepening is an indicator of the diversification of financial instruments and the development of the financial system (Şahin, 2022: 13). In other words, financial deepening refers to the channels through which savings are transferred to investment through financial innovations in the economy. It can also be defined as financial assets per capita, the increase in financial institutions, and financial services (Öztürk et al., 2011: 55). As the financial intermediaries and instruments that transfer funds between entrepreneurs seeking to invest and the private pension system become more widespread, the relationship between financial deepening and the private pension system gains importance.

The aim of this study is to investigate whether the private pension system affects financial deepening and, if so, to what extent, to present empirical findings. For this purpose, this study, conducted for Turkey between 2006Q4-2024Q1, aims to investigate the role of the private pension system in financial deepening. A review of the relevant literature reveals that most studies have a theoretical structure. This study, however, conducts an empirical analysis and presents evidence. Therefore, it is believed to contribute to the literature. In addition to the introduction and conclusion sections, the study includes two theoretical and one empirical section. The second section examines the relationship between the private pension system and financial deepening, and the third section provides a literature review. The fourth section presents the empirical component of the study, presenting the dataset, methodology, and empirical results.

2. THE IMPACT OF THE PRIVATE PENSION SYSTEM ON FINANCIAL DEEPENING

In the second half of the 20th century, social security systems faced numerous problems, impacted by developing technology and demographics. Rising welfare levels, a declining youth population, and a rising life expectancy led to the ineffective management of income. This, in turn, necessitated the government's increased support for the social security system. The burden placed on the state by the social security system and the desire to raise people's living standards led to the development of new criteria over time, leading to the idea that private pension systems could provide a solution to all these problems. The private pension system, which generates resources for the financial sector by channeling individuals' long-term and periodic savings into capital markets, thus deepening the financial sector, has been steadily increasing in funding since its inception (Önder, 2017: 129-132).

One of the key factors determining the effectiveness of a private pension system is the portfolio allocation of funds. Portfolio allocation is both a key factor in determining the returns generated by a private pension system and one of the indicators determining which sectors of the economy the resources accumulated within the system will be allocated to. As private pension fund portfolios expand, investors demand newly developed financial instruments, thereby fostering the development of financial markets. The increase in funds in a private pension system will increase the total stock of financial assets and positively impact financial deepening. (Oktayer & Oktayer, 2007: 77). Directing savings accumulated within the system into various investment instruments through the capital market contributes to the increase in national income, and individuals whose incomes increase and who benefit from the increase in national income have the opportunity to increase their savings. Furthermore, individuals' recording of their savings, made as a precaution against future uncertainty, by including them in the private pension system, eliminates short-term speculative funds and provides longer-term fund growth, thus enabling the deepening of the financial system (Asiltürk, 2018: 51). Furthermore, the private pension system, which eliminates the informal nature of savings and records all savings, can lead to the development of capital markets and the financial system by extending the maturities of collected funds (Çetiner & Gündoğdu, 2018: 33).

By facilitating the sharing of private pension funds, increasing real sector investments, and facilitating savings, the private pension system contributes to financial deepening by contributing to the liquidity and capitalization of financial markets. As financial markets deepen and become more efficient, private sector financing conditions further improve, enabling risk diversification. Thus, by providing financing for investments that yield high returns in the long term, the depth of financial markets increases again (İşseveroğlu & Hatunoğlu, 2012: 162).

The development of private pension funds contributes to the development of bond and stock markets and the increased diversity of funds. Consequently, the depth of financial markets increases. As savings increase and are channeled into effective investments, individuals' living standards also rise. Effectively managed private pension funds increase the depth of the capital market, increase the diversity and applications of financial instruments, and increase long-term savings, which are then invested both efficiently and effectively. Similarly, by transferring the savings that individuals keep under their pillows to the system, individuals can both gain profits and financial markets can be deepened (Günay & Güneş, 2015: 256).

As can be seen, the private pension system contributes not only to the development of the social security system but also to the economy and the financial sector. Savings in Turkey are low, financial markets and assets are still in their infancy, and demand for financial instruments is limited. Furthermore, savings are not channeled into financial instruments but are kept under the mattress, preventing the total funds available for investment from reaching a sufficient level. In this case, small savings can be accumulated, contributing to the growth of funds and increasing the depth of financial markets (Can, 2010: 141).

3. LITERATURE REVIEW

Impavido & Musalem (2000) investigated the relationship between individual pension systems and capital market instruments in a study conducted for 21 OECD countries and 5 developing countries between 1982-1996. The study found a positive relationship between individual pension funds and the development of capital market instruments. Gürbüz & Ekinci (2003) investigated the relationship between individual pension funds and government bonds, private sector bonds, certificates of deposit, and GNP in a study conducted for Chile, Peru, Colombia, Argentina, Mexico, Hungary, and Poland between 1981-1999. The study found that government bonds, private sector bonds, certificates of deposit, and GNP positively affected individual pension funds and that there was a bidirectional relationship between the variables. Aras & Müslümov (2005) investigated the relationship between institutional investors, stock markets, financial assets, stock market capitalization, and GDP in a study conducted for 23 OECD countries between 1982-2000. They concluded that there is a bidirectional Granger causality relationship between institutional investors and the independent variables used in the study.

Oktayer & Oktayer (2007) investigated the relationship between individual pension funds, total financial asset stock, and capital market instruments in a study conducted for Turkey between 2001-2006. They concluded that an increase in individual pension funds positively affects financial deepening. Kim (2008) investigated the relationship between individual pension funds and stocks, inflation rates, real interest rates, and the ratio of banks' private loans to the stock market in a study conducted for 21 OECD countries between 1992-2003. The study found no significant relationship between the variables, but indicated that individual pension funds positively affect GDP. Raddatz & Schmukler (2008) investigated the relationship between individual pension funds, bank deposits, and government bonds in a study conducted for Chile between 1995-2005. They concluded that bank deposits and government bonds have a statistically positive and significant effect on individual pension funds. Alptekin & Şıklar (2009) investigated the relationship between individual retirement system funds and stock retirement investment funds in their study for Turkey between 2007-2008. The study found that individual retirement system funds and stock retirement investment funds affect each other.

Asekunowo (2010) investigated the relationship between individual retirement system funds and GDP, private sector loans, bank deposits, M2 money supply, total domestic savings, and inflation rates in a study conducted for Nigeria between 2001-2007. The study concluded that individual retirement system funds positively and significantly affected the independent variables used. Meng & Pfau (2010) investigated how capital market instruments, stock markets, and bond markets affected individual retirement system funds in a study conducted for 16 developed and 16 underdeveloped countries between 2003-2007. The study found that capital market instruments, stock markets, and bond markets had a positive effect on individual retirement system funds. Niggemann & Rocholl (2010) investigated the relationship between individual retirement system funds, stock markets, and bond markets in a study conducted for 57 countries between 1976-2007. The study found that stock and bond markets positively affect individual retirement system funds. Raisa (2012), in a study conducted for European Union member states between 1994-2011, investigated the relationship between individual retirement system funds, the market capitalization of publicly traded companies, inflation rates, interest rates, and GDP per capita. The study concluded that individual retirement system funds positively affected financial development and negatively affected the inflation rate. Uyar (2012), in a study conducted for Turkey between 2004-2009, investigated the relationship between the number of individual retirement system participants, investment amount and number of policies, deposit interest, inflation, Istanbul Stock Exchange index, growth rate, exchange rate, and foreign trade. The study found a significant relationship only between deposit interest and the number of policies. Hu (2012), in a study conducted for Australia, China, Pakistan, Korea, India, New Zealand, Thailand, Singapore, and Malaysia between 2002-2010, investigated the relationship between individual retirement system funds, bond markets, stock markets, and GDP. As a result of the study, evidence was

obtained that the growth of private pension system funds has a statistically significant and positive effect on the development of the capital market.

Ayaydın (2013) investigated the relationship between individual retirement system funds, the stock market, treasury bonds, and interest rates in a study conducted for Turkey between 2010-2013. The study found that the relationship between the variables was positive. Özel & Yalçın (2013) investigated the relationship between the domestic savings rate, GDP, broad money supply, credit to the markets, urbanization rate, real interest rate, and deflator rate in a study conducted for 16 countries between 1970-2010. They concluded that the independent variables positively and significantly affected the domestic savings rate. Sibindi (2014) investigated the relationship between life insurance funds, M2 money supply, GDP, and long-term insurance density in a study conducted for South Africa between 1990-2012. The study found a causal relationship running from economic growth to the life insurance sector in the short run. Kılıç (2014) conducted a study for Turkey between 2005-2013, investigating the relationship between the number of private pension system participants, consumer price index (CPI), deposit interest rate, industrial production index, savings, expenditures, and income. The study found a statistically positive relationship between the number of private pension system participants and other variables. Enache et al. (2015) conducted a study for Bulgaria, Hungary, the Czech Republic, Estonia, Slovenia, Romania, Lithuania, Poland, Slovakia, and Latvia between 2001-2010, investigating the relationship between pension funds and the market capitalization of publicly traded companies. The study concluded that private pension funds positively influenced the development of capital markets in both the long and short term.

Akgiray et al. (2016) investigated how credit default risk, GDP, and portfolio investments affect private pension system funds in a study conducted for Chile and Turkey between 2004-2014. The study found that credit default risk, GDP, and portfolio investments positively affected private pension funds. İşi et al. (2016) investigated the relationship between private pension system funds and private pension contribution amounts in a study conducted for Turkey between 2004-2015. A break was identified in 2012, and they found evidence that the amount of contributions included in the private pension system has increased statistically significantly since then. Özmen (2016) investigated the relationship between private pension system funds, the number of private pension system participants, the amount of private pension system contributions, deposit interest rates, exchange rates, stock market indexes, and inflation in a study conducted for Turkey between 2010-2015. The study identified a bidirectional causal relationship between macroeconomic indicators and the private pension system. Başar et al. (2016), in their study conducted for 14 OECD countries between 2005-2014, investigated the relationship between private pension system funds, current account deficit, and savings amount. The study concluded that developments in the private pension system led to balance and improvement in the current account deficit. Bayar (2016), in their study conducted for Turkey between 2005-2015, investigated the relationship between private pension system funds, Borsa Istanbul national stock value, and debt instruments market transaction value. The study identified a causal relationship between private pension system funds and the private pension system market. Zubair (2016), in their study conducted for Nigeria between 2009-2016, investigated the relationship between private pension system funds, inflation, interest rates, and GDP per capita. The study identified a significant and positive relationship between the performance of private pension system funds and the investments of pension funds.

Moleko & Ikhide (2017) investigated the relationship between individual pension funds, the bond market, government debt instruments, and GDP in a study conducted for South Africa between 1975-2012. The study found no statistically significant long-term relationship between individual pension funds and other variables. Önder & Karabulut (2017) investigated the relationship between the amount of funds invested in the individual pension system and the BIST price index, industrial production index, and consumer price index in a study conducted for Turkey between 2005-2015. They concluded that funds directed to investment from the individual pension system have a positive effect on financial deepening. Bayar (2017) investigated the relationship between the asset value of individual

pension funds, GDP per capita, growth rate, and financial development index in a study conducted for 16 countries between 2002-2016. The study identified a bidirectional causal relationship between private pension funds and economic growth, and a unidirectional causal relationship running from financial development to private pension funds. Musawa & Mwaanga (2017) investigated the relationship between private pension funds and the stock market in their study for Zambia between 2009-2015. The study identified a long-term relationship between private pension funds and the stock market.

Şahin et al. (2018) investigated the relationship between the fund size of private pension system participants, the total value of the equity market, and the total value of the debt market in Turkey between 2006-2017. The study concluded that private pension system fund size affects the size of the equity market in the long run, but has no effect in the short run. Growth in the debt market affects pension funds in the long run, while pension funds have a positive impact on the equity market in the short run. Çelik & Erer (2018) investigated the relationship between private pension system funds and the current account deficit in their study for Turkey between 2004-2016. The study found a negative and unidirectional relationship between private pension system funds and the current account deficit in the long run. No statistically significant relationship was found between the variables in the short run. Çetiner & Gündoğdu (2018), in their study conducted for Turkey between 2011-2017, investigated the relationship between private pension system fund size and the number of private pension system participants, exchange rate, interest rate, and BIST 100 index. The study found a statistically positive and significant relationship between private pension system fund size and other variables. Yeşilyurt (2019), in their study conducted for Turkey between 2004-2016, investigated the relationship between the number of private pension system contracts, total investment amount, current account deficit, unemployment, deposit interest, exchange rate, growth, and investment. The study found a positive relationship between deposit interest and the number of private pension system contracts, and a unidirectional causality relationship from investment to unemployment, from investment to current account deficit, from growth to unemployment, and from growth to current account deficit. Udeh & Igwebuike (2019), in their study conducted for Nigeria between 1981-2016, investigated the relationship between private pension system funds, GDP, stock market, and savings. As a result of the study, it was proven that the relationship between stock capitalization and GDP is positive but not significant, and private pension system funds affect GDP positively and significantly.

Kahramanoğlu (2020) investigated the relationship between individual pension system funds and capital market instruments in a study conducted for Chile, OECD countries, Asian and Latin American countries between 2014-2019. The study concluded that individual pension system funds will contribute to the deepening and development of the capital market. Karabacak & Küçükçaylı (2020) investigated the relationship between the individual pension system, GDP, current account deficit, and capital market in a study conducted for Turkey between 2009-2018. While a long-term relationship was found between the individual pension system, GDP, and the capital market, no significant relationship was found between the current account deficit and the individual pension system. Furthermore, no causal relationship was found between the individual pension system and other variables. İslamoğlu et al. (2020), in a study conducted for Turkey and the G7 countries between 2004-2017, investigated the relationship between individual pension system funds and the ages and years of participation in the individual pension system. The study found that private pension system fund size and the number of participants positively affect the private pension system. Budak (2021) investigated the relationship between private pension system funds allocated for investment and the BIST full index in Turkey between 2010-2019. The study identified a causal relationship running from private pension system funds allocated for investment to the BIST full index. The causal relationship running from the BIST full index to the private pension system funds allocated for investment is long-term. Bregnard & Salva (2022) investigated the relationship between private pension system funds, market stock prices, and foreign assets in their study for Switzerland between 2010-2012. The study concluded that private pension system funds positively affect market stock prices and foreign asset variables.

4. DATASET, MODEL, AND EMPIRICAL FINDINGS

In this study, the model established to investigate the relationship between financial deepening and private pension system in Turkey using quarterly data between 2006Q4-2024Q1 is given in Equation 1.

$$FIN = \beta 1 + \beta 2\, LNBES_t + \beta 3\, ENF_t + \varepsilon_t \quad (1)$$

The dependent variable 'FIN' used in the model is an indicator of financial deepening, and the M2/GDP ratio is used. The independent variable 'LNBES' is included in the model as the fund amount of private pension system participants (TL). The control variable 'ENF' in the model is the inflation rate, and the Consumer Price Index (CPI) rate is used. Because the data for the dependent variable 'FIN' is obtained in TL and is proportional, and the control variable is proportional, ln is not used. However, the independent variable 'LNBES' in the model is in TL, so ln is used and included in the model. Quarterly data for the dependent variable 'FIN' and the control variable 'ENF' used in the model were obtained from the Central Bank of the Republic of Turkey (CBRT) database. Quarterly data for the independent variable 'LNBES' were obtained from the EGM database. Before proceeding with this analysis, descriptive statistics of the variables used are presented in Table 1.

Table 1
Descriptive Statistics of Variables

Variables Std.	Observation Number	Mean	Deviation	Minimum	Maximum
FIN	*70*	*1,908078*	*0,2740381*	*1,353324*	*2,9036*
LNBES	*70*	*24,36298*	*1,412155*	*21,75821*	*27,33678*
ENF	*70*	*1,356952*	*1,590907*	*-0,1066667*	*7,776667*

The model has 70 observations for each variable, and the average value of the dependent variable "FIN" for the quarterly periods between 2006Q4-2024Q1 is 1.908. The average value for the independent variable "LNBES" is 24.362, while the average value for the control variable "ENF" is 1.356. The maximum value for the "FIN" variable is 2.903, while the maximum values for the "LNBES" and "ENF" variables are 27.336 and 7.776, respectively.

Pearson Correlation Analysis, a pretest performed on variables, is used to measure the relationship between two variables and the strength of this relationship. Pearson Correlation Analysis is also used to calculate the effect of a change in one variable on other variables (Keskin & Özsoy, 2004: 67). Table 2 shows the results of Pearson Correlation Analysis for the variables.

Table 2
Pearson Correlation Matrix

Variable	FIN	LNBES	ENF
FIN	*1.0000*		
LNBES	*0,4554*	*1,0000*	
ENF	*0,0653*	*0,6176*	*1,0000*

According to Table 2, a relationship is understood between the variables, and it can be interpreted that as one variable increases, the other associated variable also increases. A positive correlation is observed between the dependent variable 'FIN' and the independent variable 'LNBES', with a correlation coefficient of 0.4554. Similarly, a positive correlation is observed between the variables 'FIN' and 'ENF', with a correlation coefficient of 0,0653. However, this coefficient is negligible, being almost zero. Furthermore, a positive correlation is observed between the variables 'LNBES' and 'ENF', with a correlation coefficient of 0.6176.

This study, which investigates the impact of the private pension system on financial deepening, uses time series analysis methods. Before starting the time series analysis, to ensure the accuracy and consistency of the model results and to eliminate spurious regression problems, it is necessary to test the stationarity of the variables using unit root tests. The Extended Dickey-Fuller (ADF) unit root test, frequently used in empirical applications, was used to test the stationarity of the series, and the results are presented in Table 3.

Table 3

Extended Dickey-Fuller (ADF) Unit Root Test Results

	Level		One difference	
Variable	**Constant**	**Constant and Trend**	**Constant**	**Constant and Trend**
FIN	*-2,2909*	*-2,7332*	*-3,2892*	*-3,5739*
	0,1779	*0,2276*	*0,0199***	*0,0411***
LNBES	*1,6790*	*1,2495*	*-3,6419*	*-3,9442*
	0,9995	*0,9999*	*0,0073****	*0,0154***
ENF	*-3,6030*	*-5,0360*		
	*0,0081****	*0,0006****		

Not: *The values given in ( ) represent MacKinnon (1996) one-sided p (probability) values. *, **, *** signs indicate 10%, 5%, 1% significance levels, respectively.*

According to the results in Table 3, the null hypothesis "Ho: There is a unit root (the series is not stationary)" could not be rejected for the FIN and LNBES variables in both the constant and constant-trend models. In this case, when the first difference is taken, it is observed that the variables become stationary in both the constant and constant-trend models. For the ENF variable, however, the null hypothesis "H0: There is a unit root (the series is not stationary)" was rejected in both the constant and constant-trend models, and the alternative hypothesis "Ha: There is no unit root (the series is stationary)" was accepted. Therefore, it can be said that the ENF variable is stationary at the level.

Autoregressive Distributed Lag (ARDL) bounds test, developed by Pesaran & Shin (1999), tests the existence of a cointegration relationship between series that are stationary at different degrees. Furthermore, this test provides statistically more reliable results than classical cointegration tests because it uses an unrestricted error correction model. The main feature of this error correction model is that it provides information about the long- and short-term relationships of the variables used. Another feature of this test is that it can be applied even in cases with small sample sizes and provides consistent results (Mülayim, 2022: 83). The dependent variable FIN and the independent variable LNBES used in the study were found to be I(1), while the control variable ENF was found to be I(0). Given that the variables were stationary at different levels, it was decided to apply the ARDL bounds test. Before the ARDL bounds test, the existence of cointegration between the variables was investigated using the F bounds test, and the results are presented in Tables 4 and 5.

Table 4
F Bound Test Results – Pesaran, Shin, and Smith (2001) (1,0,0)

Test Statistic	Significance Level	Limit Critical Values	
		I(0)	I(1)
F Statistics 5,575	*0,1*	*3,17*	*4,14*
	0,05	*3,79*	*4,85*
	0,025	*4,41*	*5,52*
	0,01	*5,15*	*6,36*

Table 5
F Bound Test Results – Kripfganz and Schneider (2018) (1,0,0)

Test Statistic	Significance Level	Limit Critical Values	
		I(0)	I(1)
F Statistics 5,575	*0,1*	*3,25*	*4,22*
	0,05	*3,94*	*5,00*
	0,01	*5,50*	*6,74*

The F-bounds test shows long-term coexistence between variables. If the obtained F-statistic values are compared with the critical values given in Pesaran et al. (2001), and the calculated F-statistic values are less than I(0), the hypothesis "Ho: There is no cointegration relationship between the variables" is accepted and can be interpreted as meaning that there is no cointegration relationship between the variables. However, if the F-statistic value is greater than I(1), Ho is rejected and a cointegration relationship between the two variables is accepted. Accordingly, based on the results of the bound tests given in Tables 4 and 5, the F test was found to be greater than the upper critical values at the 5% significance level, indicating a cointegration relationship between the variables. The long-run coefficient results obtained with the ARDL bound test are presented in Table 6.

Table 6
ARDL Bounds Test Results (Long-Term Coefficients)

Variables	Coefficient	p-value
LNBES	*0,0954*	*0,081**
ENF	*-0,0511*	*0,265*
Diagnostic Test Results		
ADJ (FIN)	*-0,4191 0,000****	
Autocorrelation (Durbin-Watson)	*1,855*	
Heteroscedasticity (white test)	*0,072*	
Normality Test (jaqaue- bera)	*0,065*	

***Note:** *, **, *** signs indicate 10%, 5%, 1% significance levels, respectively.*

Table 6 presents the long-term effects of variables on financial deepening. Accordingly, Turkey's LNBES coefficient is statistically significant at the 10% level, but the ENF coefficient is statistically insignificant. It can be concluded that there is a positive relationship between Turkey's financial deepening rate and the fund amount of private pension system participants. A one-unit increase in the fund amount of private pension system participants increases Turkey's financial deepening rate by 0.095 units. Therefore, an increase in the fund amount of Turkey's private pension system participants increases Turkey's financial deepening.

The regression assumes that there is no relationship between the error terms, that is, no autocorrelation problem, no heteroscedasticity problem, and finally, the series is normally distributed. For this purpose, the Durbin-Watson Autocorrelation Test, the White Test, and the Jarque-Bera Normal Distribution Test were also conducted, and the results are presented in Table 6. According to the results obtained, it was determined that there was no autocorrelation problem or heteroscedasticity problem in the series and the series was normally distributed.

Granger (1969), basing his theory on endogenousness and exogenousness, argued that causality occurs if two variables cause each other in a time series. Therefore, feedback occurs between them. The Granger causality test examines whether a change in one variable creates a change in the other variable in a bidirectional manner. The hypotheses of Granger causality analysis are as follows:

H_0: "X does not Granger cause Y (there is no Granger causality from X to Y)"

H_a: "X is the Granger cause of Y. (There is a Granger causality relationship from X to Y)"

As the final analysis of the study, the causality relationship between the variables was investigated and the results are given in Table 7.

Table 7
Granger Causality Test Results

Null Hypothesis	F-Statistic	Probability Value	Decision
LNBES is not Granger causal to FIN.	*3,09778*	*0,0521**	Reject
FIN is not Granger causal to LNBES.	*2,19182*	*0,1202*	Accept
ENF is not a Granger causal factor of FIN.	*2,70247*	*0,0748**	Reject
FIN is not a Granger causal factor of ENF.	*0,70154*	*0,4997*	Accept
ENF is not a Granger causal factor of LNBES.	*3,01002*	*0,0564**	Reject
LNBES is not a Granger causal factor of ENF.	*14,0369*	*0,0000****	Reject

***Note:** *, **, *** signs indicate 10%, 5%, 1% significance levels, respectively.*

The null hypothesis of the Granger causality test is "X is not Granger causal for Y." As can be seen in Table 7, at the 1% significance level, there is a causal relationship running from the "LNBES" variable to the "ENF" variable. Therefore, the main hypothesis is rejected. Similarly, at the 10% significance level, there is a causal relationship running from the "LNBES" variable to the "FIN" variable, from the "ENF" variable to the "FIN" variable, and back to the "LNBES" variable, and the main hypothesis is again rejected. According to these results, the causality between the "ENF" and "LNBES" variables is bidirectional. Furthermore, the fact that the fund amount of private pension system participants is Granger causal for the financial depth ratio is consistent with the obtained results.

5. CONCLUSION

The private pension system is a system, with pre-determined terms and conditions, that allows individuals to deposit their savings into private pension funds during their active working years and generate a second income during their retirement period. The basis of the relationship between financial deepening and the private pension system is that as funds are transferred between entrepreneurs seeking to invest and the private pension system, it fosters the proliferation and development of financial intermediaries and instruments, thereby increasing financial deepening. Savings accumulated in the private pension system are effectively invested in private pension system investment funds on behalf of the individuals participating in the system. These savings are transferred into various financial instruments such as real estate, gold, bonds, and stocks, contributing to the development and deepening of the financial sector through capital markets. The increase in private pension system funds is expected to increase the resources transferred to the real sector, which in turn will increase financial deepening.

This study examines the relationship between the private pension system and financial deepening using quarterly data from Turkey between 2006Q4-2024Q1 using ARDL bounds tests and Granger causality tests. The ARDL bounds test concludes that an increase in private pension system funds increases financial deepening. Government support and incentives will increase participation in the private pension system, leading to increased funds. This will provide significant resources to the financial system and contribute to its development. Consequently, financial deepening will increase. In summary, the increase in the private pension system positively impacts financial deepening. The Granger causality test results also support these findings, indicating that the private pension system Granger causally influences financial deepening. However, no causality running from financial deepening to the private pension system was found. In other words, a unidirectional causal relationship can be inferred, running from the private pension system to financial deepening.

In light of these results, it is believed that measures and incentives to increase the number of private pension system participants will contribute to financial deepening. To achieve this, it is necessary to promote and explain the participation of private pension system participants to individuals from all walks of life. While the automatic enrollment system offered by the private pension system to government employees has increased the number of private pension participants, ensuring that not only government employees but everyone benefits from this automatic enrollment system and is automatically enrolled in the system could help increase the number of participants. Furthermore, studies should be conducted to ensure that the private pension system offers higher income generation opportunities compared to other financial investment instruments. Considering these recommendations, it is anticipated that participation in the private pension system will increase significantly and the amount of funds will increase. This will provide significant resources to the financial sector and contribute to increased financial deepening.

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ORIGINAL ARTICLE

A HYBRID FRAMEWORK FOR ASSESSING MULTI-DIMENSIONAL BANK SUSTAINABILITY WITH MULTI-CRITERIA DECISION MAKING

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Abstract
This paper proposes a hybrid multi-criteria decision-making (MCDM) framework to comprehensively assess the multi-dimensional sustainability performance in the banking industry. The suggested framework integrates the Logarithmic Percentage Change-driven Objective Weighting (LOPCOW) and the Alternative Ranking Order Method Accounting for Two-Step Normalization (AROMAN) to ensure objective, consistent, and robust evaluation. The proposed hybrid framework is empirically applied to a real-world case study of Bank of America-recognized as the most valuable banking brand in the United States-to assess its performance across Environmental, Social, Governance, and Profitability (ESG-P) dimensions over the 2008–2021 period. Fourteen performance indicators were selected to reflect the bank's multi-dimensional sustainability profile. Indicator weights were determined objectively employig the LOPCOW technique, while the bank's annual performance rankings were obtained via the AROMAN method. The weighting analysis revealed that innovation, community, and corporate social responsibility (CSR) strategies had the most substantial influence on the bank's performance. In contrast, indicators related to human rights and certain profitability metrics exhibited relatively lower weight. Ranking outputs indicated notable fluctuations in Bank of America's ESG-P performance over the years, with 2019 emerging as the most successful year and 2008 as the least. Furthermore, sensitivity analyses validated the stability and reliability of the proposed hybrid decision-making framework.

Keywords
Banking sector, Sustainability performance, MCDM, LOPCOW, AROMAN

JEL Classification
C54, G17, G21, G32, G53.

1. INTRODUCTION

Financial intermediaries play a central role in modern economies by facilitating the flow of funds between savers and borrowers and supporting the efficient functioning of financial systems. Among these intermediaries, banks remain the most influential actors due to their dominant position in credit creation, deposit mobilization, and payment services (Işık et al., 2025a). In recent years, however, the evaluation of banking performance has expanded beyond traditional financial indicators, as banks are increasingly expected to balance profitability with environmental responsibility, social accountability, and sound governance practices. This shift has driven the need for multidimensional performance assessment frameworks that can capture the sustainability-oriented transformation of banking activities.

The banking industry continues to play a crucial role in promoting economic growth, efficient capital allocation, and financial stability (Shabir et al., 2021). Through its core functions-such as fund allocation, credit intermediation, payment system management, and risk mitigation-banking directly affects both the real economy and the public sector (Işık et al., 2025b). However, globalization, digital transformation, and sustainability-oriented regulatory and policy frameworks have significantly reshaped the operational priorities of modern banks. Beyond their traditional intermediation role, banks are now expected to contribute to social development, environmental accountability, and effective corporate governance structures (Ayyagari et al., 2007; Işık, 2023). Consequently, assessing bank performance through a multidimensional sustainability perspective provides deeper insights not only into institutional success but also into the broader economic and societal impact of banking activities (McDonald and Lai, 2011). This growing complexity exposes the limitations of one-dimensional or purely financial evaluation approaches.

Within this evolving context, large and systemically important banks constitute an appropriate setting for examining multidimensional sustainability performance, as they simultaneously face intense market competition, regulatory scrutiny, and increasing stakeholder expectations. Institutions operating at this scale are required to align environmental, social, governance, and profitability objectives in a consistent and measurable manner. Moreover, sustainability-oriented strategic decisions-such as innovation investments, responsible financing, and governance reforms-play a critical role in enhancing long-term resilience and financial stability (Kim and Li, 2021; Cohen, 2023). Therefore, the longitudinal assessment of ESG-based performance in a major banking institution can offer valuable insights into how sustainability and profitability dimensions interact over time, particularly in response to economic shocks and structural transformations (Shen, 2024; Juthi et al., 2024).

Therefore, this study aims to propose a hybrid multi-criteria decision-making (MCDM) framework for investigating environmental, social, governance, and profitability (ESG-P) performance in the banking sector. The proposed framework integrates the Logarithmic Percentage Change-driven Objective Weighting (LOPCOW) method and the Alternative Ranking Order Method Accounting for Two-Step Normalization (AROMAN) to ensure an objective, consistent, and robust evaluation. To demonstrate the applicability and validity of the proposed framework, an empirical case study is conducted using the ESG-P indicators of Bank of America over the 2008–2021 period. Within this framework, LOPCOW is employed to derive the objective importance of ESG-P criteria, while AROMAN is utilized to obtain a time-sensitive ranking of performance across years. Based on this integrated approach, the study seeks to address the following research questions:

What is the analytical value of evaluating banks' environmental, social, governance, and profitability (ESG-P) performance within an integrated and multidimensional decision-making framework?

Which ESG-P dimensions and indicators exert the greatest and least influence on overall sustainability performance when objectively weighted using the LOPCOW method?

How does the ESG-P performance of a large banking institution evolve over time when assessed through the integrated LOPCOW–AROMAN framework?

How robust and stable are the resulting ESG-P performance rankings when subjected to alternative multi-criteria decision-making approaches and sensitivity scenarios?

The remainder of this paper is organized as follows: Section 2 presents a comprehensive review of the national and international literature on performance measurement in the banking sector. Section 3 presents the methodological framework of the study, while Section 4 presents the dataset and sampling procedure used in the analysis. Section 5 reports the empirical results obtained by implementing the proposed model. Section 6 presents a series of sensitivity analyses to demonstrate the robustness of the integrated decision model. Section 7 presents the discussion of the results obtained by applying the proposed model to a real-time case study. Finally, Section 8 offers overall conclusions, outlines the limitations of the study, and provides recommendations for future research.

2. LITERATURE REVIEW

This section reviews national and international empirical research that has assessed environmental, social, governance, and profitability (ESG-P) performance in the banking sector. The methodologies applied, sample characteristics, and key findings of the reviewed literature are presented comparatively in Table 1.

Table 1
Literature Review

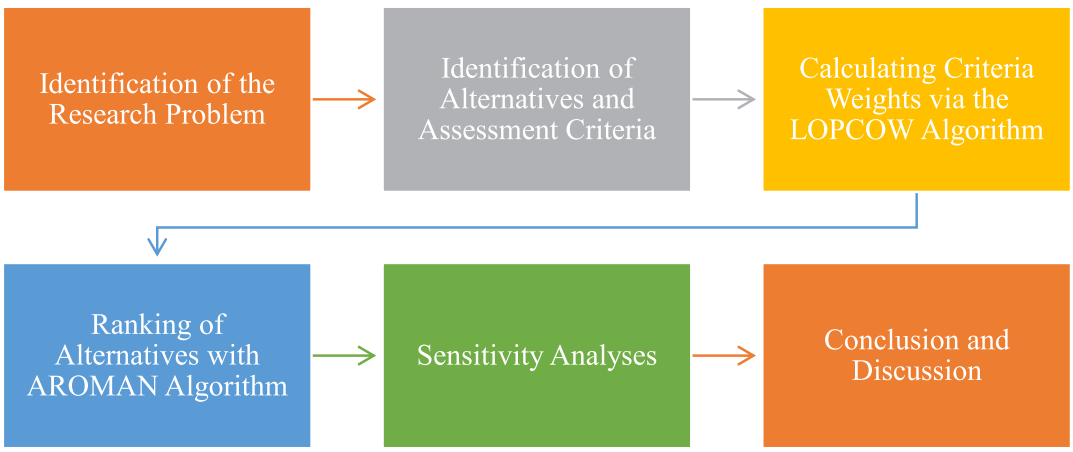
Author(s)	Method(s)	Country	Sample
Ozcelik and Ozturk (2014)	GIA	Turkey	The sustainability performance of three banks was assessed.
Raut et al., (2017)	Fuzzy AHP and Fuzzy TOPSIS	India	A comparative analysis was carried out on the sustainability performance of six large commercial banks
Omurbek et al., (2017)	Entropy, ARAS, MOOSRA and COPRAS	Turkey	The sustainability performance of the seven largest Turkish deposit-taking banks in terms of total assets was analysed.
Siew et al., (2017)	Equal Weight and TOPSIS	Malaysia	The performance of eight shares traded on the stock exchange was comparatively investigated.
Korzeb and Samaniego-Medina (2019)	TOPSIS	Poland	The performance of eight shares traded on the stock exchange was comparatively investigated.
Laha and Biswas (2019)	Entropy and CODAS	India	An assessment of the financial performance of ten banks was performed.
Yesmine et al., (2022)	VZA	Bangladesh	The performance and effectiveness of 20 banks with different ownership patterns were analysed.
Chaudhuri et al., (2023)	VZA	India	The contribution of ten private banks to environmental sustainability was examined.
Quynh (2023)	AHP and TOPSIS	Vietnam	The performance of four state-owned banks in terms of multidimensional sustainability has been assessed.
Sharma and Kumar (2024)	Entropy, TOPSIS and VIKOR	India	The banking industry has been subjected to a comprehensive multidimensional performance evaluation.
Akbulut (2024)	Grey LOPCOW and Grey PIV	Turkey	The environmental sustainability performance of six deposit-taking banks traded on the BIST was analysed.
Ali et al. (2024)	CRITIC ve RAFSI	Iraq	The financial sustainability performance of 19 banks was examined for the period 2007-2020.
Mastilo et al., (2024)	MEREC and MARCOS	Bosnia and Herzegovina	A study was carried out to comparatively analyze the financial performance of 21 banks.
Goel et al., (2024)	Equal Weight and GIA	India	The study used data from 10 banks to compare their performance.
Işık et al. (2025b)	F-LBWA, F-LMAW and MARCOS	Pakistan	An overall performance evaluation was conducted for 13 commercial banks.
Peci et al. (2025)	F-AHP and F-TOPSIS	Albania	A sample covering 8 financial indicators for 11 banks in 2020, 2021 and 2022 was employed.

Although the existing literature demonstrates a growing reliance on MCDM approaches for evaluating banking performance, important methodological shortcomings remain unresolved. In particular, many prior studies predominantly employ subjective or semi-subjective weighting techniques (e.g., AHP, fuzzy AHP, expert-based methods), which may introduce evaluator bias into sustainability assessments. Even when objective weighting schemes are adopted, they are frequently combined with conventional ranking methods based on single-stage normalization, potentially limiting the stability and robustness of the resulting rankings. Moreover, the majority of existing frameworks rely on static, cross-sectional analyses and thus fail to capture the dynamic evolution of bank performance over time. Notably, fully integrated environmental, social, governance, and profitability (ESG-P) performance assessments that simultaneously employ objective weighting schemes and time-sensitive ranking structures remain scarce in the existing banking literature. To address these gaps, the present study integrates LOPCOW method with the AROMAN. LOPCOW enables the objective determination of criterion importance based on information dispersion and logarithmic variation, while AROMAN provides a robust and time-sensitive ranking mechanism through its two-step normalization structure. By combining these complementary methods within a longitudinal ESG-P performance evaluation framework, this study offers a more objective, stable, and comprehensive decision-support model compared to existing approaches in the banking sustainability literature.

3. METHODOLOGICAL FRAMEWORK

This work assesses the ESG-P-based performance of Bank of America, one of the leading banks in the United States, by employing a hybrid multi-criteria decision-making framework. The proposed assessment process integrates LOPCOW and AROMAN. The selection of LOPCOW and AROMAN is motivated not only by their technical properties but also by their practical relevance for sustainability assessment in the banking sector. LOPCOW enables the derivation of fully objective criterion weights by capturing logarithmic percentage changes and information dispersion, thereby minimizing subjective bias in the evaluation of ESG-P indicators. AROMAN, on the other hand, incorporates a two-step normalization structure that ensures stable and time-sensitive rankings, making it particularly suitable for longitudinal performance analysis. Compared to commonly used MCDM techniques, the integrated LOPCOW-AROMAN framework offers a more robust, transparent, and analytically consistent decision-support tool for practitioners and policymakers seeking to assess bank sustainability performance under dynamic conditions. The overall structure of the proposed decision framework is illustrated in Figure 1, and the subsequent sections present the implementation steps of the adopted decision algorithms in detail.

Figure 1
Research Framework of the Proposed ESG-P Performance Model



3.1. LOPCOW Objective Criteria Weighting Algorithm

The LOPCOW algorithm was introduced to the literature by Ecer and Pamucar (2022). This innovative decision algorithm is often used by decision makers to objectively weight assessment criteria. The LOPCOW methodology calculates the criterion weights based on the standard deviation values of the assessment criteria, thereby taking into account the discriminative power of each criterion (Demir, 2025). The key contribution of this algorithm lies in its ability to integrate the information richness and significance of each criterion from a statistical perspective. In doing so, it allows for a systematic assessment of both the variability between criteria and the divergence between alternatives, resulting in more objective weight values (Biswas et al., 2022; Işık et al., 2024). The computational procedure of the LOPCOW approach consists of the following four steps (Ecer and Pamucar, 2022; Işık et al., 2023).

Step 1. The decision matrix is constructed in accordance with Eq. (1).

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

Step 2. The values in the decision matrix are normalised by taking into account the beneficial and non-beneficial characteristics of the criteria. Accordingly, Eq. (2) is applied for the beneficial criteria, while Eq. (3) is employed for the non-beneficial criteria.

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

$$r_{ij} = \frac{mak_{ij} - x_{ij}}{mak_{ij} - \min_{ij}} \quad (3)$$

Step 3. The percentage values and standard deviation values of the assessment criteria are calculated by means of Eq. (4) and Eq. (5), respectively.

$$PV_{ij} = \left| \ln \left[\frac{\sqrt{\frac{\sum_{i=1}^{n} r_{ij}^2}{n}}}{\sigma} \right] \right| \times 100 \quad (4)$$

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{m} (r_{ij} - \bar{r}_j)^2}{m}} \quad (5)$$

Step 4. In the final phase of the LOPCOW algorithm, the objective weight values for each criterion are calculated based on Eq. (6).

$$w_j = \frac{PV_{ij}}{\sum_{j=1}^{m} PV_{ij}}; \sum_{j=1}^{n} w_j = 1 \quad (6)$$

Where, the highest weighted criterion is taken into account, it is considered to have the greatest impact on performance.

3.2. AROMAN Ranking Algorithm

AROMAN procedure, developed and introduced to the literature by Bošković et al., (2023), is applied to the ranking of decision alternatives. The main difference of the AROMAN procedure from other existing methodologies in the literature is that the normalization process is performed in two steps. In this way, it provides the decision maker with an average matrix for solving the decision problem. The application of the AROMAN procedure consists of the following 5 steps (Bošković et al., 2023; Bošković et al., 2024).

Step 1. The initial matrix introduced in Eq. (1) is prepared.

Step 2. The values in the decision matrix are normalized regardless of their characteristics. Eq. (7) is applied for the linear normalization of the decision matrix. Meanwhile, Eq. (8) is applied for the vectorial normalization of the decision matrix.

Step 2.1. Linear Normalization

$$t_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \tag{7}$$

Step 2.2. Vectorial Normalization

$$t_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m}(x_{ij})^2}} \tag{8}$$

Step 2.3. After the two-stage normalization process, the total average normalized matrix values are obtained from Eq. (9).

$$t_{ij}^{norm} = \frac{\beta t_{ij} + (1-\beta) t_{ij}^{*}}{2} \tag{9}$$

The coefficient β in the equation is a weighting coefficient that can take values between 0-1. This coefficient is generally accepted in the literature as 0.5.

Step 3. Weighted normalized matrix is created through Eq. (10).

$$\hat{t_{ij}} = w_{ij} \times t_{ij}^{norm} \tag{10}$$

Step 4. The sums of the weighted values are obtained according to the type of criteria (beneficial-non-beneficial). Accordingly, Eq. (11) is employed for the beneficial criteria and Eq. (12) for the non-beneficial criteria.

$$A_i = \sum_{j=1}^{n} \hat{t_{ij}}^{(max)} \tag{11}$$

$$L_i = \sum_{j=1}^{n} \hat{t_{ij}}^{(min)} \tag{12}$$

Step 5. At the end of the AROMAN procedure, Eq. (13) is used to derive the success scores of the alternatives and the success rankings based on these scores.

$$R_i = L_i^{\lambda} + A_i^{(1-\lambda)} \tag{13}$$

The parameter λ in the equation expresses the coefficient degree of the criterion type. As there are two types of criteria in the study, this parameter is taken as 0.5 in the calculations. In addition, the alternative with the highest success score is taken as the most successful.

4. DATA AND SAMPLE

The objective of this paper is to develop and apply a novel hybrid decision-making framework integrating LOPCOW and AROMAN to assess the ESG-P performance of Bank of America, which holds the highest brand value among banking institutions in the United States. The empirical analysis covers the period from 2008 to 2021 and is based on an annual data set comprising 14 consecutive years, allowing for a longitudinal evaluation of multidimensional sustainability performance. Bank of America represents a large, systemically important financial institution operating at the core of the U.S. and global financial system. Founded in 1904, the bank has evolved into the second-largest banking institution in the United States in terms of asset size, customer base, and market capitalization, while also maintaining a strong presence in sustainable finance initiatives. As a leading financial intermediary, the bank faces the dual challenge of sustaining financial performance while complying with increasingly stringent environmental, social, and governance requirements. In response, Bank of America has embedded ESG considerations into its corporate strategy, with particular emphasis on environmental accountability, community engagement, diversity, inclusive governance, and innovation-driven sustainability practices. Its proactive involvement in digital transformation, carbon emission reduction, and sustainable investment financing further supports its suitability as a representative case for ESG-P performance assessment. To capture the bank's multidimensional sustainability profile, a total of 14 performance indicators were selected based on their relevance in the sustainability performance literature and data availability. Annual data for all indicators were obtained from the Refinitiv Eikon database, ensuring consistency and reliability of the empirical inputs. Detailed definitions and descriptive information regarding the selected indicators are provided in Table 2.

Table 2
ESG-P Measures

Rank	Type	Indicators	Code	Optimization
1	Environmental Indicators	Resource Use	E1	Max.
2		Emissions	E2	Max.
3		Innovation	E3	Max.
4	Social Indicators	Workforce	S1	Max.
5		Human Rights	S2	Max.
6		Community	S3	Max.
7		Product Responsibility	S4	Max.
8	Governance Indicators	Management	G1	Max.
9		Shareholders	G2	Max.
10		Corporate Social Responsibility	G3	Max.
11	Profitability Indicators	NIM (Net Interest Margin)	P1	Max.
12		ROA (Return on Assets)	P2	Max.
13		ROE (Return on Equity)	P3	Max.
14		ROIC (Return on Invested Capital)	P4	Max.

5. FINDINGS OF THE RESEARCH

This section presents the results of the integrated decision model that combines the LOPCOW and AROMAN algorithms. First, the LOPCOW algorithm was utilized to obtain the relative importance of the assessment criteria, and the objective weight coefficients for each indicator were computed. The AROMAN approach was then employed to rank Bank of America's ESG-P performance for the period 2008-2021, based on the calculated weight coefficients.

5.1. Findings of the LOPCOW Algorithm

To identify the importance weights of the ESG-P performance indicators, the LOPCOW methodology was first used in the analysis process. In this context, the decision matrix was first constructed based on Eq. (1) and is displayed in Table 3.

Table 3
Decision Matrix

	E1	E2	E3	S1	S2	S3	S4	G1	G2	G3	P1	P2	P3	P4
2008	75.00	55.76	42.50	70.05	20.46	77.48	87.13	87.80	49.65	58.94	2.98	0.59	1.82	1.34
2009	74.35	60.76	94.57	65.70	14.69	97.87	88.40	75.77	65.32	68.97	2.65	0.81	-1.33	1.80
2010	78.68	62.13	90.63	69.73	18.55	98.15	60.31	88.09	73.23	82.31	2.78	0.30	-1.77	0.67
2011	93.75	71.93	87.17	82.63	17.24	97.88	55.83	70.01	29.28	87.90	2.48	0.42	0.04	0.99
2012	94.55	73.62	85.93	80.81	15.83	96.60	57.44	71.07	25.15	85.14	2.35	0.48	1.29	1.22
2013	94.34	75.00	87.21	70.38	20.42	97.62	58.93	72.31	57.47	84.75	2.46	0.84	4.61	2.27
2014	94.49	82.68	89.20	68.64	31.15	99.54	63.57	16.33	57.16	85.92	2.25	0.49	1.71	1.41
2015	94.11	82.13	89.01	71.11	34.47	98.94	71.13	48.56	67.19	84.85	2.20	1.02	6.29	3.01
2016	96.44	81.84	87.56	84.81	29.93	99.02	76.76	42.13	65.81	95.61	2.25	0.81	6.82	3.36
2017	99.83	83.17	85.81	92.27	91.80	97.62	78.14	29.05	70.44	84.49	2.37	1.11	6.84	3.56
2018	99.86	84.69	83.84	84.43	87.40	97.66	77.74	39.97	78.87	95.30	2.42	1.68	10.94	5.52
2019	99.65	84.74	83.44	90.65	87.14	98.11	76.18	59.23	75.86	95.43	2.43	1.61	10.73	5.50
2020	96.26	85.42	79.40	97.87	87.37	98.45	74.27	57.58	77.34	97.29	1.90	0.84	6.73	3.11
2021	99.09	91.14	81.76	95.08	89.56	82.16	75.00	35.09	76.39	97.67	1.66	1.15	12.38	4.61

The chosen performance measures were normalized on the basis of their beneficial and non-beneficial characteristics, respectively, using Eq. (2). The results of the normalisation process are presented in Table 4.

Table 4
Normalized Decision Matrix

	E1	E2	E3	S1	S2	S3	S4	G1	G2	G3	P1	P2	P3	P4
2008	0.03	0.00	0.00	0.14	0.07	0.00	0.96	1.00	0.46	0.00	1.00	0.21	0.25	0.14
2009	0.00	0.14	1.00	0.00	0.00	0.92	1.00	0.83	0.75	0.26	0.75	0.37	0.03	0.23
2010	0.17	0.18	0.92	0.13	0.05	0.94	0.14	1.00	0.90	0.60	0.85	0.00	0.00	0.00
2011	0.76	0.46	0.86	0.53	0.03	0.92	0.00	0.75	0.08	0.75	0.62	0.09	0.13	0.07
2012	0.79	0.50	0.83	0.47	0.01	0.87	0.05	0.76	0.00	0.68	0.52	0.13	0.22	0.11
2013	0.78	0.54	0.86	0.15	0.07	0.91	0.10	0.78	0.60	0.67	0.61	0.39	0.45	0.33
2014	0.79	0.76	0.90	0.09	0.21	1.00	0.24	0.00	0.60	0.70	0.45	0.14	0.25	0.15
2015	0.77	0.75	0.89	0.17	0.26	0.97	0.47	0.45	0.78	0.67	0.41	0.52	0.57	0.48
2016	0.87	0.74	0.87	0.59	0.20	0.98	0.64	0.36	0.76	0.95	0.45	0.37	0.61	0.55
2017	1.00	0.77	0.83	0.83	1.00	0.91	0.68	0.18	0.84	0.66	0.54	0.59	0.61	0.60
2018	1.00	0.82	0.79	0.58	0.94	0.91	0.67	0.33	1.00	0.94	0.58	1.00	0.90	1.00
2019	0.99	0.82	0.79	0.78	0.94	0.94	0.62	0.60	0.94	0.94	0.58	0.95	0.88	1.00
2020	0.86	0.84	0.71	1.00	0.94	0.95	0.57	0.57	0.97	0.99	0.18	0.39	0.60	0.50
2021	0.97	1.00	0.75	0.91	0.97	0.21	0.59	0.26	0.95	1.00	0.00	0.62	1.00	0.81

The percentages for each assessment criterion were calculated with the help of Eq. (4) and Eq. (5). The results of these calculations are given in Table 5.

Table 5
Matrix of Percentage Values

	E1	E2	E3	S1	S2	S3	S4	G1	G2	G3	P1	P2	P3	P4
2008	0.00	0.00	0.00	0.02	0.01	0.00	0.92	0.99	0.21	0.00	1.00	0.04	0.06	0.02
2009	0.00	0.02	1.00	0.00	0.00	0.85	1.00	0.69	0.56	0.07	0.56	0.14	0.00	0.05
2010	0.03	0.03	0.85	0.02	0.00	0.88	0.02	1.00	0.80	0.36	0.72	0.00	0.00	0.00
2011	0.58	0.21	0.74	0.28	0.00	0.86	0.00	0.56	0.01	0.56	0.39	0.01	0.02	0.00
2012	0.63	0.25	0.70	0.22	0.00	0.75	0.00	0.58	0.00	0.46	0.27	0.02	0.05	0.01
2013	0.61	0.30	0.74	0.02	0.01	0.83	0.01	0.61	0.36	0.44	0.37	0.15	0.20	0.11
2014	0.62	0.58	0.80	0.01	0.05	1.00	0.06	0.00	0.36	0.49	0.20	0.02	0.06	0.02
2015	0.60	0.56	0.80	0.03	0.07	0.95	0.22	0.20	0.61	0.45	0.17	0.27	0.32	0.23
2016	0.75	0.54	0.75	0.35	0.04	0.95	0.41	0.13	0.57	0.90	0.20	0.14	0.37	0.31
2017	1.00	0.60	0.69	0.68	1.00	0.83	0.47	0.03	0.71	0.44	0.29	0.34	0.37	0.36
2018	1.00	0.67	0.63	0.34	0.89	0.84	0.45	0.11	1.00	0.88	0.33	1.00	0.81	1.00
2019	0.98	0.67	0.62	0.60	0.88	0.87	0.39	0.36	0.89	0.89	0.34	0.90	0.78	0.99
2020	0.74	0.70	0.50	1.00	0.89	0.90	0.32	0.33	0.94	0.98	0.03	0.15	0.36	0.25
2021	0.94	1.00	0.57	0.83	0.94	0.05	0.35	0.07	0.91	1.00	0.00	0.38	1.00	0.66

In the final step of the LOPCOW methodology, the importance weights for each ESG-P indicator were determined applying Eq. (6). The weighting scores for the performance criteria are reported in Table 6.

Table 6
LOPCOW Results

	E1	E2	E3	S1	S2	S3	S4	G1	G2	G3	P1	P2	P3	P4
$\sum$	8.48	6.13	9.39	4.40	4.77	10.57	4.62	5.66	7.93	7.91	4.87	3.56	4.40	4.02
$\sum$/m	0.61	0.44	0.67	0.31	0.34	0.75	0.33	0.40	0.57	0.56	0.35	0.25	0.31	0.29
σ_j	0.36	0.30	0.24	0.34	0.43	0.31	0.33	0.31	0.32	0.28	0.25	0.30	0.33	0.34
PV_{ij}	78.19	78.38	123.66	49.54	29.82	104.38	56.47	72.29	86.16	97.18	85.40	50.99	53.88	46.60
w_j	0.08	0.08	0.12	0.05	0.03	0.10	0.06	0.07	0.09	0.10	0.08	0.05	0.05	0.05
Sıra	7	6	1	12	14	2	9	8	4	3	5	11	10	13

According to the weighting results obtained using the LOPCOW methodology, E3 (innovation) emerged as the most critical indicator in determining Bank of America's ESG-P performance over the 2008-2021 period. This outcome indicates that innovation-related activities constitute the most influential component within the bank's multidimensional sustainability structure. The innovation indicator was followed by S3 (community) and G3 (corporate social responsibility strategy), which ranked second and third, respectively. The relative prominence of these indicators suggests that dimensions associated with strategic adaptation, social embeddedness, and sustainability-oriented governance exert a stronger influence on ESG-P performance differentiation across years. In contrast, indicators such as S2 (human rights), P4 (return on invested capital), and S1 (workforce) received comparatively lower weights. This finding implies that, within the examined period, these criteria contributed less to distinguishing annual ESG-P performance outcomes under the objective weighting structure. Overall, the LOPCOW results reveal a weighting pattern in which innovation-led and community-oriented dimensions dominate the ESG-P evaluation framework, while certain social compliance and profitability-related indicators exhibit more limited discriminative importance.

5.2. Findings of the AROMAN Algorithm

In this stage of the present research, the weights obtained from the LOPCOW model were incorpo-

rated into the AROMAN model in order to compare the multidimensional performance of Bank of America across years. In the first step of the AROMAN procedure, the decision matrix was created based on Eq. (1) and is displayed in Table 1. The values in the decision matrix were then normalised without distinguishing between beneficial and npn-beneficial criteria. In this context, the criteria were linearly normalised by means of Eq. (7). The findings of the linear normalization are reported in Table 7.

Table 7
Linear Normalization

	E1	E2	E3	S1	S2	S3	S4	G1	G2	G3	P1	P2	P3	P4
2008	0.03	0.00	0.00	0.14	0.07	0.00	0.96	1.00	0.46	0.00	1.00	0.21	0.14	0.14
2009	0.00	0.14	1.00	0.00	0.00	0.92	1.00	0.83	0.75	0.26	0.75	0.37	0.10	0.23
2010	0.17	0.18	0.92	0.13	0.05	0.94	0.14	1.00	0.90	0.60	0.85	0.00	0.14	0.00
2011	0.76	0.46	0.86	0.53	0.03	0.92	0.00	0.75	0.08	0.75	0.62	0.09	0.00	0.07
2012	0.79	0.50	0.83	0.47	0.01	0.87	0.05	0.76	0.00	0.68	0.52	0.13	0.10	0.11
2013	0.78	0.54	0.86	0.15	0.07	0.91	0.10	0.78	0.60	0.67	0.61	0.39	0.37	0.33
2014	0.79	0.76	0.90	0.09	0.21	1.00	0.24	0.00	0.60	0.70	0.45	0.14	0.14	0.15
2015	0.77	0.75	0.89	0.17	0.26	0.97	0.47	0.45	0.78	0.67	0.41	0.52	0.51	0.48
2016	0.87	0.74	0.87	0.59	0.20	0.98	0.64	0.36	0.76	0.95	0.45	0.37	0.55	0.55
2017	1.00	0.77	0.83	0.83	1.00	0.91	0.68	0.18	0.84	0.66	0.54	0.59	0.55	0.60
2018	1.00	0.82	0.79	0.58	0.94	0.91	0.67	0.33	1.00	0.94	0.58	1.00	0.88	1.00
2019	0.99	0.82	0.79	0.78	0.94	0.94	0.62	0.60	0.94	0.94	0.58	0.95	0.87	1.00
2020	0.86	0.84	0.71	1.00	0.94	0.95	0.57	0.57	0.97	0.99	0.18	0.39	0.54	0.50
2021	0.97	1.00	0.75	0.91	0.97	0.21	0.59	0.26	0.95	1.00	0.00	0.62	1.00	0.81

In the second stage, vector normalization was carried out by means of Eq. (8). The results of the vector normalisation calculations are presented in Table 8.

Table 8
Vector Normalization

	E1	E2	E3	S1	S2	S3	S4	G1	G2	G3	P1	P2	P3	P4
2008	0.22	0.19	0.13	0.23	0.10	0.22	0.32	0.39	0.21	0.18	0.33	0.16	0.07	0.11
2009	0.21	0.21	0.30	0.22	0.07	0.27	0.33	0.33	0.27	0.21	0.30	0.23	0.05	0.15
2010	0.23	0.21	0.29	0.23	0.09	0.27	0.22	0.39	0.30	0.25	0.31	0.08	0.07	0.06
2011	0.27	0.25	0.28	0.27	0.08	0.27	0.21	0.31	0.12	0.27	0.28	0.12	0.00	0.08
2012	0.27	0.25	0.27	0.27	0.08	0.27	0.21	0.31	0.10	0.26	0.26	0.13	0.05	0.10
2013	0.27	0.26	0.28	0.23	0.10	0.27	0.22	0.32	0.24	0.26	0.27	0.23	0.19	0.19
2014	0.27	0.29	0.28	0.23	0.15	0.28	0.24	0.07	0.24	0.26	0.25	0.14	0.07	0.12
2015	0.27	0.28	0.28	0.23	0.16	0.28	0.26	0.21	0.28	0.26	0.25	0.28	0.26	0.25
2016	0.28	0.28	0.28	0.28	0.14	0.28	0.28	0.19	0.27	0.29	0.25	0.23	0.28	0.28
2017	0.29	0.29	0.27	0.30	0.44	0.27	0.29	0.13	0.29	0.26	0.26	0.31	0.28	0.30
2018	0.29	0.29	0.27	0.28	0.42	0.27	0.29	0.18	0.33	0.29	0.27	0.47	0.45	0.47
2019	0.29	0.29	0.26	0.30	0.41	0.27	0.28	0.26	0.32	0.29	0.27	0.45	0.44	0.47
2020	0.28	0.29	0.25	0.32	0.42	0.27	0.27	0.25	0.32	0.30	0.21	0.23	0.27	0.26
2021	0.29	0.31	0.26	0.31	0.43	0.23	0.28	0.15	0.32	0.30	0.19	0.32	0.51	0.39

Following the two-step normalisation process, the aggregated mean normalized matrix values were obtained via Eq. (9). As emphasised earlier, the β coefficient in Eq. (9) is a weighting factor that ranges between 0 and 1. A review of previous empirical research in the literature reveals that researchers generally take a value of 0.5 for this coefficient in their calculations. Accordingly, in line with the literature, β was also set at 0.5 in this paper. The findings of these calculations are presented in Table 9.

Table 9
Total Mean Normalized Matrix

	E1	E2	E3	S1	S2	S3	S4	G1	G2	G3	P1	P2	P3	P4
2008	0.12	0.10	0.07	0.18	0.09	0.11	0.64	0.69	0.33	0.09	0.67	0.19	0.11	0.13
2009	0.11	0.18	0.65	0.11	0.03	0.60	0.66	0.58	0.51	0.24	0.52	0.30	0.08	0.19
2010	0.20	0.20	0.61	0.18	0.07	0.61	0.18	0.69	0.60	0.43	0.58	0.04	0.11	0.03
2011	0.52	0.35	0.57	0.40	0.06	0.60	0.10	0.53	0.10	0.51	0.45	0.10	0.00	0.07
2012	0.53	0.38	0.55	0.37	0.04	0.57	0.13	0.54	0.05	0.47	0.39	0.13	0.08	0.11
2013	0.53	0.40	0.57	0.19	0.09	0.59	0.16	0.55	0.42	0.46	0.44	0.31	0.28	0.26
2014	0.53	0.52	0.59	0.16	0.18	0.64	0.24	0.04	0.42	0.48	0.35	0.14	0.10	0.14
2015	0.52	0.51	0.59	0.20	0.21	0.62	0.37	0.33	0.53	0.47	0.33	0.40	0.38	0.37
2016	0.57	0.51	0.57	0.44	0.17	0.63	0.46	0.27	0.52	0.62	0.35	0.30	0.41	0.42
2017	0.64	0.53	0.55	0.57	0.72	0.59	0.49	0.15	0.57	0.46	0.40	0.45	0.42	0.45
2018	0.64	0.55	0.53	0.43	0.68	0.59	0.48	0.25	0.66	0.62	0.42	0.73	0.66	0.73
2019	0.64	0.56	0.53	0.54	0.68	0.60	0.45	0.43	0.63	0.62	0.43	0.70	0.65	0.73
2020	0.57	0.57	0.48	0.66	0.68	0.61	0.42	0.41	0.65	0.65	0.20	0.31	0.41	0.38
2021	0.63	0.66	0.51	0.61	0.70	0.22	0.43	0.21	0.64	0.65	0.09	0.47	0.75	0.60

Based on Eq. (10), the weighted normalized matrix was established and is shown in Table 10.

Table 10
Weighted Normalized Matrix

	E1	E2	E3	S1	S2	S3	S4	G1	G2	G3	P1	P2	P3	P4
2008	0.01	0.01	0.01	0.01	0.00	0.01	0.04	0.05	0.03	0.01	0.06	0.01	0.01	0.01
2009	0.01	0.01	0.08	0.01	0.00	0.06	0.04	0.04	0.04	0.02	0.04	0.01	0.00	0.01
2010	0.02	0.02	0.07	0.01	0.00	0.06	0.01	0.05	0.05	0.04	0.05	0.00	0.01	0.00
2011	0.04	0.03	0.07	0.02	0.00	0.06	0.01	0.04	0.01	0.05	0.04	0.01	0.00	0.00
2012	0.04	0.03	0.07	0.02	0.00	0.06	0.01	0.04	0.00	0.05	0.03	0.01	0.00	0.00
2013	0.04	0.03	0.07	0.01	0.00	0.06	0.01	0.04	0.04	0.04	0.04	0.02	0.01	0.01
2014	0.04	0.04	0.07	0.01	0.01	0.07	0.01	0.00	0.04	0.05	0.03	0.01	0.01	0.01
2015	0.04	0.04	0.07	0.01	0.01	0.06	0.02	0.02	0.05	0.04	0.03	0.02	0.02	0.02
2016	0.04	0.04	0.07	0.02	0.01	0.06	0.03	0.02	0.04	0.06	0.03	0.01	0.02	0.02
2017	0.05	0.04	0.07	0.03	0.02	0.06	0.03	0.01	0.05	0.04	0.03	0.02	0.02	0.02
2018	0.05	0.04	0.06	0.02	0.02	0.06	0.03	0.02	0.06	0.06	0.04	0.04	0.04	0.03
2019	0.05	0.04	0.06	0.03	0.02	0.06	0.03	0.03	0.05	0.06	0.04	0.04	0.03	0.03
2020	0.04	0.04	0.06	0.03	0.02	0.06	0.02	0.03	0.06	0.06	0.02	0.02	0.02	0.02
2021	0.05	0.05	0.06	0.03	0.02	0.02	0.02	0.01	0.05	0.06	0.01	0.02	0.04	0.03

In the final step of the AROMAN algorithm, the sums of the values in the weighted normalized matrix were computed by taking into account the beneficial and non-beneficial features of the assessment criteria. Accordingly, Eq. (11) was applied to calculate the L_i values for the beneficial type indicators, while Eq. (12) was employed to obtain the A_i values for the non-beneficial type indicators. Finally, the performance score (R_i) for each alternative was calculated based on Eq. (13). The outputs of all these calculations are reported in Table 11.

Table 11
AROMAN Results

	L_i	A_i	R_i	Rank
2008	0.0000	0.2469	0.4969	14
2009	0.0000	0.3859	0.6212	10
2010	0.0000	0.3873	0.6224	9
2011	0.0000	0.3666	0.6055	12
2012	0.0000	0.3599	0.5999	13
2013	0.0000	0.4219	0.6495	8
2014	0.0000	0.3778	0.6147	11
2015	0.0000	0.4514	0.6719	7
2016	0.0000	0.4787	0.6919	6
2017	0.0000	0.4976	0.7054	4
2018	0.0000	0.5618	0.7495	2
2019	0.0000	0.5734	0.7572	1
2020	0.0000	0.5034	0.7095	3
2021	0.0000	0.4891	0.6993	5

According to the ranking scores obtained using the AROMAN methodology, Bank of America's ESG-P performance exhibits notable fluctuations over the 2008–2021 period, reflecting the dynamic nature of multidimensional sustainability performance across time. The highest performance score is observed in 2019, followed by 2018, 2020, and 2017, indicating that the bank achieved a more balanced and effective alignment of environmental, social, governance, and profitability dimensions during these years. In contrast, the relatively lower rankings recorded in 2008 and the subsequent early years correspond to the peak of the global financial crisis, a period characterized by heightened financial instability and limited integration of sustainability-oriented strategies within banking operations. These results suggest that during crisis conditions, multidimensional ESG-P performance may deteriorate as financial pressures constrain strategic flexibility and sustainability investments.

6. SENSİTİVİTY AND COMPARATİVE ANALYSES

In MCDM-based analyses, sensitivity and comparative analyses are essential tools for ensuring methodological rigor and decision reliability. Sensitivity analysis involves systematically varying criteria weights or model parameters to assess the robustness and stability of the initial outcomes. On the other hand, comparative analysis involves evaluating the consistency of the initial results by comparing the suggested MCDM approach with other MCDM techniques. This not only validates the performance and reliability of the adopted methodology but also highlights its relative advantages or limitations. Together, these analyses contribute significantly to verifying the credibility, robustness, and practical applicability of the decision-making model, particularly in complex sustainability assessments (Işık and Adalar, 2025)

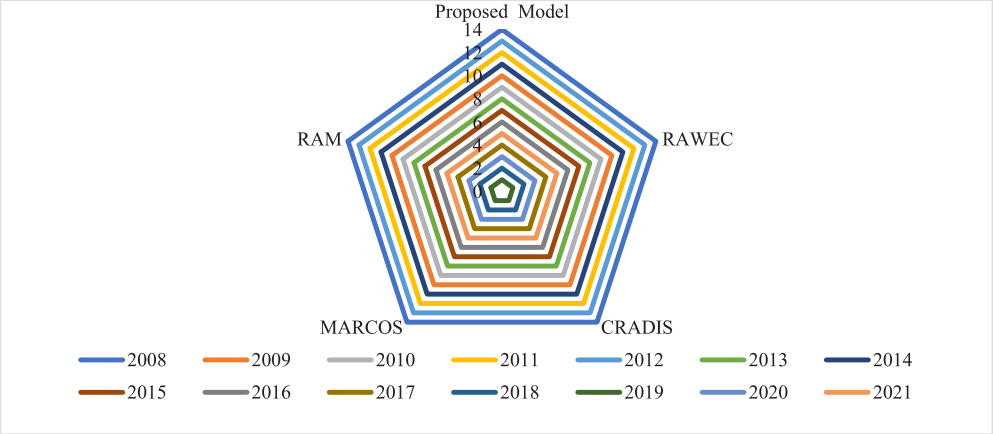
Assessing the robustness and reliability of the developed decision algorithm is crucial for the evaluation of ESG-P performance. In this case study, a comprehensive set of sensitivity analyses was performed to validate the conceptual framework proposed in this work. First, in order to show the consistency of the proposed integrated model, the ranking results obtained by the AROMAN procedure were compared with those obtained by other established decision-making methods. Secondly, the impact of changes in the λ parameter embedded in the AROMAN procedure on the ranking performance of decision alternatives was investigated.

6.1. Comparison of the Developed Model with Alternative Decision Frameworks

In this case study, the ranking results obtained by the proposed decision algorithm were compared with those generated by alternative multi-criteria decision methods commonly used by researchers in the literature, including RAWEC (Puška et al., 2024), CRADIS (Puška et al., 2022), MARCOS (Stević et al., 2020) and RAM (Sotoudeh-Anvari, 2023). The results of the comparative ranking are shown in Figure 2. Accordingly, the proposed conceptual model provides highly robust and reliable results, demonstrating its validity across different methodological frameworks.

Figure 2

Rankings Based on Different MCDM Approaches

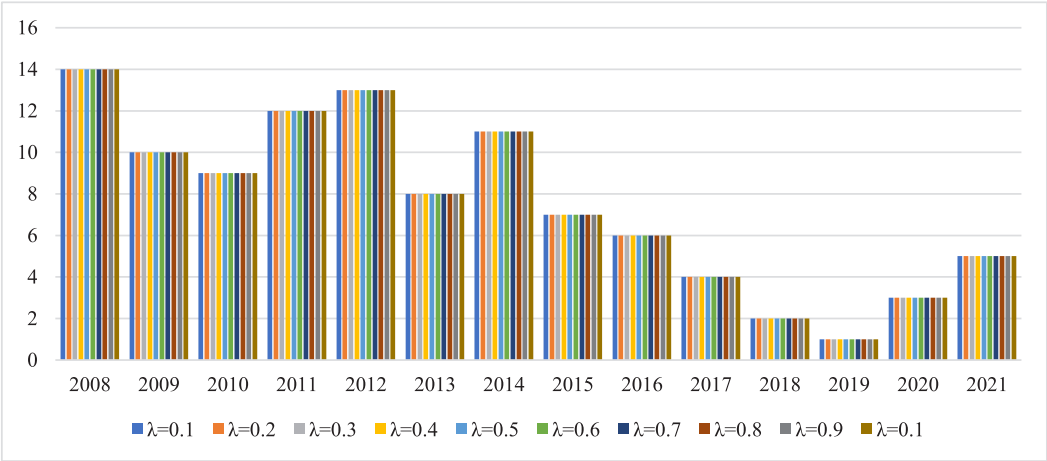


6.2. Analysis of the Effects of Variation of the λ Parameter on the Rankings in the AROMAN Approach

In the final part of the AROMAN procedure, the λ parameter was included in the ranking calculations with a value of 0.5, based on previous literature. However, this parameter can take different values in the range from 0 to 1. Therefore, in the final stage of the sensitivity analysis, the effect of variations in the λ parameter on the ranking of the decision alternatives was assessed. The results of this analysis are displayed in Figure 3. As indicated in Figure 3, variations in the λ parameter did not result in any change in the ranking of the alternative years. This result indicates that the proposed decision algorithm is consistent and reliable.

Figure 3

Re-Ranking of Alternatives Based on the λ Parameter



7. DISCUSSION

This study employed a hybrid multi-criteria decision-making (MCDM) framework, integrating the LOPCOW and AROMAN methods, to objectively evaluate the sustainability and profitability performance of Bank of America (BoA) over the 2008–2021 period. A total of 14 performance indicators were selected to assess Bank of America's sustainability and financial performance across four primary dimensions: Environmental, Social, Governance, and Profitability. Each indicator is treated as a maximization criterion, meaning higher values represent better performance. The findings from the weighting and ranking analyses offer critical insights into the evolving priorities in corporate sustainability and performance assessment.

The LOPCOW-based weightings reveal the relative importance of the 14 selected indicators under the ESG-P framework. Among all criteria, Environmental Innovation (E3) received the highest weight (0.12), signaling its pivotal role in shaping the bank's long-term sustainability profile. This reflects growing investor and regulatory pressure on financial institutions to foster environmentally innovative practices, such as green finance, carbon-conscious lending, and eco-friendly operational strategies. Other high-weight indicators include Community (S3) and CSR (G3), with weights of 0.10 each. These results emphasize the increasing relevance of social outreach and governance transparency, both of which contribute significantly to stakeholder trust and reputational capital. Conversely, traditional financial indicators like ROIC (P4) and Employee Welfare (S2) had comparatively lower weights (0.05 and 0.03 respectively), suggesting that their variability and impact across the years were less pronounced, or that they played a more stable, background role in overall performance.

The application of the AROMAN method to rank annual ESG-P performance produced nuanced results, reflecting BoA's varying success in integrating sustainability and profitability goals over time. The best-performing year was 2019, followed closely by 2018 and 2020. These years coincide with the bank's increased disclosure practices, robust CSR initiatives, and enhanced environmental funding commitments, aligning with its public sustainability pledges and improvements in stakeholder engagement. On the other hand, 2008, the year of the global financial crisis, recorded the lowest performance score, underscoring the vulnerability of ESG-P performance in periods of systemic financial distress. The years 2012 and 2011 also ranked among the lowest, suggesting that the bank's post-crisis restructuring period was marked by inconsistencies in sustainability efforts and profitability recovery. Notably, the middle-ranking years (2013–2017) represent a transitional phase, with steady yet moderate performance improvements as BoA worked to rebuild its ESG profile and align its operations with evolving sustainability standards.

The integration of the LOPCOW and AROMAN methods not only ensured objectivity and robustness in the analysis but also highlighted critical strategic areas for improvement. The results suggest that enhancing governance practices, fostering environmental innovation, and deepening community relations should remain central to BoA's long-term sustainability agenda. Additionally, the sharp contrast between the highest and lowest performing years demonstrates the importance of resilience and consistency in ESG-P efforts. The findings validate the usefulness of MCDM techniques in tracking longitudinal performance and identifying weak points in a firm's sustainability strategy.

8. CONCLUSION AND RECOMMENDATIONS

In today's context, the integrated assessment of environmental, social and governance (ESG) factors alongside financial performance is of strategic significance not only for corporate sustainability, but also for long-term value creation and stakeholder trust. For large institutions in the financial sector in particular, ESG performance has a direct impact on both market perception and corporate reputation. In this context, assessing ESG performance in conjunction with profitability indicators has become a paramount necessity, enabling companies to more effectively manage the relationship between their environmental and social impacts and financial success. This paper aims to assess the environmental,

social, governance and profitability (ESG-P) performance of Bank of America, one of the largest financial institutions in the United States, over the period 2008-2021. In this regard, the multidimensional performance of the bank was measured on an annual basis using 14 performance indicators chosen from the relevant literature. The LOPCOW procedure was applied to identify the weights of the criteria, while the AROMAN procedure was utilized to rank the alternative years. Both ESG-based corporate sustainability performance and financial performance indicators were analyzed in an integrated manner, and a decision support model sensitive to temporal changes was proposed.

The LOPCOW weighting process reveals pronounced differences in the relative importance of the ESG-P indicators considered in the analysis, underscoring the heterogeneous contribution of sustainability dimensions to overall bank performance. The results indicate that innovation emerges as the most influential indicator shaping the multidimensional sustainability performance of Bank of America over the 2008-2021 period. This finding suggests that innovation-oriented practices-particularly those related to environmental sustainability and strategic transformation-play a central role in enhancing the bank's ESG-P profile. Following innovation, community engagement and corporate social responsibility strategy also receive relatively high weights, implying that social embeddedness and strategically aligned CSR initiatives constitute key drivers of performance differentiation across years. In contrast, indicators such as human rights, return on invested capital, and workforce exhibit comparatively lower weights within the LOPCOW framework. This outcome indicates that these criteria contribute less to distinguishing ESG-P performance over time, reflecting lower informational content and discriminative power under an objective weighting structure. Overall, the weighting results demonstrate that ESG-P components do not contribute uniformly to sustainability assessment, with innovation-led and socially oriented indicators exerting a more decisive influence on multidimensional performance outcomes.

From a broader sectoral perspective, the prominence of innovation- and CSR-related indicators is consistent with prevailing trends in sustainable finance and contemporary banking practice. In recent years, banks have increasingly relied on innovation capacity, community-oriented initiatives, and strategically embedded CSR policies to strengthen reputational capital, address stakeholder expectations, and respond to evolving regulatory and societal pressures. Conversely, the relatively lower importance assigned to human rights and certain profitability indicators can be attributed to a high degree of regulatory standardization and compliance-driven convergence among large, well-regulated banking institutions, which constrains cross-temporal variability. Likewise, profitability measures such as return on invested capital may convey diminished informational value during periods characterized by macroeconomic volatility or heightened regulatory intervention. Taken together, these findings indicate that ESG-P performance differentiation in major banks is increasingly driven by innovation-centered and socially embedded strategies rather than by traditionally standardized financial or compliance-oriented indicators.

The ranking, based on the AROMAN approach, revealed that Bank of America's ESG-P performance showed significant fluctuations during the time period from 2008 to 2021. The year 2019 stood out with the highest performance score, followed by 2018, 2020 and 2017, implying that the bank demonstrated a more balanced and impactful performance across environmental, social, governance and profitability dimensions during these years. In comparison, the years after 2008, which coincided with the aftermath of the global financial crisis, were characterized by relatively low performance scores. In this regard, the AROMAN methodology not only provided a ranking of alternatives, but also allowed for a time-sensitive analysis of the bank's performance, allowing for the identification of both improvements and deteriorations over time. Building upon these temporal ranking outcomes, the observed performance patterns provide broader insights into the evolving role of sustainability-oriented strategies in large banking institutions. The superior ESG-P performance achieved in later years reflects the gradual institutionalization of environmental, social, and governance considerations within corporate decision-making, as well as the increasing alignment between sustainability initiatives and financial objectives. From a managerial perspective, these findings suggest that sustained

investments in innovation, community engagement, and strategically embedded CSR practices can enhance a bank's ability to achieve balanced performance across ESG and profitability dimensions. Moreover, from a methodological standpoint, the ability of the AROMAN approach to capture such temporal dynamics reinforces its suitability as a decision-support tool for evaluating sustainability performance under changing economic and regulatory conditions. Consequently, the proposed hybrid LOPCOW-AROMAN framework offers not only a robust ranking mechanism but also a valuable analytical lens for understanding the long-term evolution of bank sustainability performance.

The sensitivity analyses carried out in the final phase of the research provided important insights into the robustness of the proposed decision-making framework. Firstly, the ranking scores obtained by the AROMAN algorithm were compared with those created by other decision-making methodologies widely available in the literature, and a high degree of consistency was identified. This finding reinforces the methodological reliability of the model. Secondly, the effect of changes in the λ parameter embedded in the AROMAN procedure was investigated in relation to the ranking results. It was observed that changes in the value of λ, within the range of 0 to 1, did not cause any changes in the ranking of the alternative years. This result indicates that the proposed decision strategy is highly stable with respect to parameter sensitivity, and provides reliable results for decision makers.

Despite the methodological robustness of the proposed hybrid LOPCOW-AROMAN framework, several limitations of this study should be acknowledged. First, the empirical analysis is confined to a single large banking institution, Bank of America, which may limit the generalizability of the findings to other banks with different ownership structures, regulatory environments, or business models. While the selected case represents a systemically important and highly visible financial institution, extending the analysis to a multi-bank or cross-country sample would allow for more comprehensive benchmarking and comparative assessment across heterogeneous banking systems. Second, the selection of ESG and profitability indicators was guided by data availability and established practices in the sustainability performance literature. Although this approach ensures consistency and replicability, alternative indicator sets or the inclusion of additional qualitative ESG dimensions could potentially lead to different weighting structures and ranking outcomes. Future studies may therefore explore the sensitivity of ESG-P performance assessments to alternative indicator specifications and data sources. Third, from a methodological perspective, this study employs the LOPCOW method for objective weighting and the AROMAN approach for performance ranking. While this combination offers notable advantages in terms of objectivity, robustness, and temporal sensitivity, the integration of alternative weighting and ranking techniques-such as entropy-based, distance-based, or outranking methods-could further enrich comparative methodological insights. Conducting large-scale robustness and consensus analyses across multiple MCDM frameworks would provide deeper evidence regarding the stability of sustainability performance rankings. Finally, future research could benefit from integrating advanced analytical tools, including modern time-series techniques and artificial intelligence-driven decision support systems, to capture non-linear dynamics and long-term structural changes in ESG performance. Such extensions would not only enhance the predictive and explanatory power of sustainability assessments but also contribute to the development of more adaptive and forward-looking decision-support models in the banking and finance literature.

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ORIGINAL ARTICLE

AN INTEGRATED MULTI-CRITERIA DECISION MAKING MODEL (MCDM) FOR FINANCIAL PERFORMANCE MONITORING IN THE EUROPEAN INSURANCE SECTOR

Mehmet Zafer TAŞÇI
Esengül SALİHOĞLU

Abstract
The insurance sector ranks as one of the largest institutional investors in financial markets and significantly influences these markets. In Europe, particularly in industrialized countries, the insurance industry accounts for a sizable portion of the financial system. The purpose of this study is to assess and evaluate the performance of the insurance industry in the European Union. In today's world, the use of multi-criteria decision-making models (MCDM) is a common method for analyzing the performance of insurance companies. In this article, PSI, LOPCOW, and AROMAN methodologies are used to evaluate the performance of European insurance businesses. This study is based on data from the European insurance sector. Also the study utilizes a temporal framework covering the years from 2004 to 2020. The statistics were compiled from papers available on the European Insurance Association's website. The study demonstrates that, while the insurance sector is critical to financial markets, it is also influenced by changes in the economy and financial markets.

Keywords
Financial markets, Insurance sector, MCDM, PSI, LOPCOW, AROMAN.

JEL Classification
B23, G22.

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1. INTRODUCTION

Finance-growth nexus hypothesis states that technical innovation, saving rate, efficiency in directing savings toward investments, and marginal productivity of capital are the ways which financial development drives economic growth (Levine, 1997). Financial intermediation functions of insurance companies affect economic growth through various channels. Insurance companies are also important financial sustainability. For the stability of the financial system insurers are crucial for three primary reasons. First, insurers are important investors in financial markets. Insurers have a strong relationship with banks and other financial organizations, so any issues companies face can also affect the banking industry. Insurers contribute to the stability of household and firm balance sheets by insuring risks (ECB FSR, December 2009: 161).

Insurance companies, in addition to mutual and pension funds, are among the largest institutional investors in financial markets. Insurance companies directly contribute to the growth and development of capital markets and national economies by transferring risks to more than one party while carrying out insurance and reinsurance activities, thereby increasing the efficiency and financial stability of the financial system and providing resources to the financial system. (Akotey et al., 2013: 286; Akyüz and Kaya, 2013: 355; Caporale et al., 2017: 108; ECB FSR, December 2009:161). In addition, companies in the insurance sector assume the risks that individuals, firms and countries may face in return for the premiums collected. In addition, insurance companies provide important services in financing long-term investments in the economy, minimizing transaction costs and maximizing the level of liquidity in the economy (Alenjagh, 2013: 3479; Akotey vd., 2013: 286-287). In addition to commodity and accident insurance, health and life insurance also have a significant share in the European insurance sector (Statista, 2024). Especially in industrialized European countries such as Germany, the UK and France, the insurance sector has a significant impact on the financial system. Europe's largest institutional investor is the insurance sector with more than half of GDP (Insurance Europe, 2024). In this context, it is important to monitor, measure and objectively evaluate the performance of the insurance sector in order to ensure the continuity of the activities of the financial sector in Europe and the development of the regional economy. Performance and efficiency analyses for the insurance sector increase the quality of activities in the sector. In addition, the insurance sector can provide important information to decision-making mechanisms to identify problems in a timely manner and develop strategies to solve these problems (Alenjagh, 2013: 3478; Ünal, 2019: 556). This study aims to measure and evaluate the performance of the insurance sector operating in the European Union Insurance sector. The application of multi-criteria decision-making models (MCDM) has become a prevalent approach in evaluating the performance of insurance organisations in the present era. In this article, PSI, LOPCOW and AROMAN techniques are used to analyze the performance of insurance companies in Europe.

After the introduction, the first part of the study includes a literature review. The second section presents the research methodology, and the third section presents the case study. The book chapter is completed with the fourth and conclusion section.

2. THE REVIEW OF LITERATURE

A substantial corpus of literature exists which analyses the performance of companies from all sectors, including the insurance sector, based on various multi-criteria decision-making methods (Güçlü, 2024; Gürler et al, 2024; Joshi, 2024; Kaya et al., 2024; Khabbazi and Fashkache (2024); Işık et al., 2024; Taşçı, 2024; Lukic, 2023; Wang et al., 2021; Akhisar and Tunay, 2016). The past studies that assess performance and efficiency by applying MCDM methods in the insurance industry are overviewed in this section. In the literature, there are a large number of studies that examine the performance of companies operating in the insurance sector with various MCDM techniques. A similar situation has recently emerged with regard to literature in the insurance sector in European countries (Puska et al., 2023; Mourmouris and Poufinas, 2023; Ardielli, 2020). The below summarizes key studies in the insurance sector in European countries.

Puska et al. (2023) used Fuzzy LMAW Fuzzy CRADIS techniques in their study. The researchers concluded that Fuzzy methods can be used in the selection of insurance companies. Mourmouris and Poufinas (2023), in their study, compared the Promethee methods with the CRM methods. The researchers concluded that CRM techniques facilitate, support and help to improve the risk selection process. Ardielli (2020) used TOPSIS, WSA and MAPPAC techniques in his study. The researcher concluded that in the evaluation of e-health diffusion in the European Union member countries, Scandinavian countries are among the countries with the highest score in terms of ranking, while Eastern Europe has the lowest score.

As can be seen in the literature summary presented above, there are few studies analyzing the evaluation of insurance companies in European countries using multi-criteria decision-making (MCDM) methods. Since the literature review reveals that few studies have been conducted, this study aims to contribute to filling the gap in the field. For this purpose, the performance of the European insurance sector was evaluated and measured with new evaluation models consisting of MCDM PSI-LOPCOW-AROMAN methods were used.

3. RESEARCH METHODOLOGY

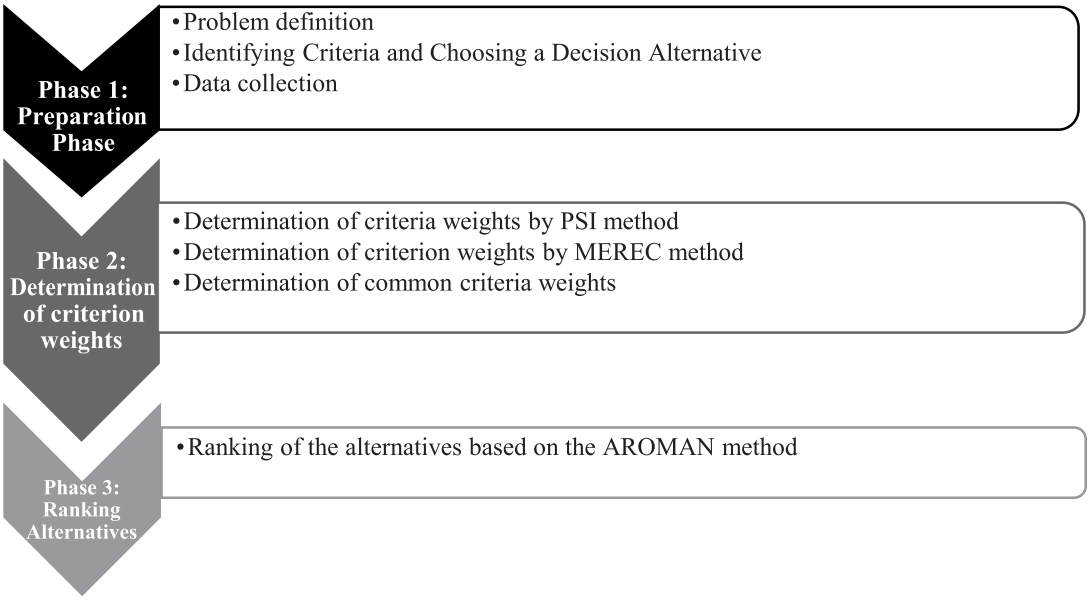
This section elucidates the rationale behind the PSI-LOPCOW-AROMAN hybrid MCDM decision model, which has been proposed for evaluation of the performance of the European insurance ındustry. The study posits that the PSI and LOPCOW objective weighting methods can be employed to circumvent the potential for subjective evaluations when determining the importance weights of the evaluation criteria. Furthermore, in contrast to numerous other MCDM methods, the PSI method has been selected due to its computational simplicity and the clarity of its mathematical infrastructure (Maniya and Bahat, 2010: 1786). The rationale for employing the LOPCOW approach in this investigation is threefold. Firstly, it represents a contemporary methodology, free from the limitations imposed by negative data. Secondly, it bridges the gap resulting from the disparate sizes of the data sets by expressing them As a percentual value relative to the standard deviations of the mean square values of the series. Thirdly, it is not susceptible to the issues associated with the use of traditional statistical techniques in the presence of outliers (Bektaş, 2022: 254). The AROMAN method, which combines the normalized data obtained as a result of the two-step normalization process and creates an average matrix from the normalized data, represents a current approach to multi-criteria decision-making method (Kahreman, 2024: 77; Macit, 2023: 37).

3.1. Studies Using PSI, LOPCOW and AROMAN Methods

The study used the AROMAN method to rank the alternatives. Figure 1 shows the model proposed in the study.

Figure 1

Scheme of Progress of The Study



3.1.1 PSI Procedure

The PSI method, which is employed to ascertain the objective weights of the criteria and to rank the alternatives, was first introduced to the literature by Maniya and Bhaat (2010). The steps for applying the PSI method are as follows (Maniya and Bhaat, 2010: 1786; Işık, 2022: 367):

Step 1: In the first step, the initial decision matrix containing m alternatives and n criteria is created.

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

Step 2: Obtaining the normalized decision matrix. The normalization process of the values in the initial decision matrix is done using Equality (2) (beneficial criterion) and Equality (3) (cost criterion).

$$n_{ij} = \frac{x_{ij}}{maksx_{ij}} \quad (2)$$

$$n_{ij} = \frac{minx_{ij}}{x_{ij}} \quad (3)$$

Step 3: In this step, the preference variance value (PV_j) is calculated for each criterion.

$$PV_j = \sum_{i=1}^{N}(n_{ij}^x - \overline{n_j^x})^2 \quad (4)$$

$\overline{n_j^x}$= Average of normalized value of jth criterion. $\overline{n_j^x} = \frac{1}{N}\sum_{i=1}^{N} n_{ij}^x$

Step 4: The deviation in the preference value for each criterion (Θ_j) is calculated using Equality (5). Then, the overall preference value, i.e. the criterion weights W_j is calculated using Equality (6).

$$\Theta_j = 1 - PV_j \quad (5)$$

$$Wj = \frac{\Theta_j}{\sum_{j=1}^{m}\Theta_j} \quad (6)$$

3.1.2. LOPCOW Procedure

The LOPCOW method represents a novel objective criterion weighting method that was first introduced to the literature by Ecer and Pamucar in 2022. Once the standard deviation and percentage values for each criterion have been calculated, the weights of the criteria can be determined in an objectively valid manner. The method is applied in the following stages (Ecer and Pamucar, 2022: 4-5):

Step 1: For a decision-making problem with m number of alternatives and n number of criteria, the initial decision matrix is created in the first stage.

$$X=\begin{bmatrix} X_{11} & \dots & X_{1j} & \cdots & X_{1n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ X_{m1} & \dots & X_{mj} & \dots & X_{mn} \end{bmatrix} \quad (7)$$

Step 2: At this stage of the method, the initial decision matrix elements are normalized with the help of Equality (8) (cost-oriented) and Equality (9) (benefit-oriented).

$$r_{ij}=\frac{X_{max}-X_{ij}}{X_{max}-X_{min}} \quad (8)$$

$$r_{ij}=\frac{X_{ij}-X_{min}}{X_{max}-X_{min}} \quad (9)$$

Step 3: At this stage of the method, percentage values (PV) of each criterion are calculated. In this step, The mean square value as a percent of the standard deviations of all criteria is calculated with the help of Equality (10) in order to eliminate the discrepancy caused by the size of the data set.

$$PV_{ij}=\left|\ln\left(\frac{\sqrt{\frac{\sum_{i}^{m}=r_{ij}^{2}}{m}}}{\sigma}\right).100\right| \quad (10)$$

Step 4: In the final stage of the process, the objective weightings for the criteria are determined through the application of Equation (11).

$$w_{ji}=\frac{PV_{ij}}{\sum_{i=1}^{n} PV_{ij}} \quad (11)$$

Combined Weighting

The criteria weights obtained from the PSI and LOPCOW methods are combined in equation (12) (Işık, 2022: 367; Zavadskas & Podvezko, 2016: 8).

$$W_{j,combined}=\frac{W_{j,PSI}W_{j,LOPCOW}}{\sum_{J=1}^{m} W_{j,PSI}W_{j,LOPCOW}} \quad (12)$$

3.1.3. AROMAN Procedure

The AROMAN method, which was introduced to the MCDM literature in 2023 by Bošković et al. are as follows (Bošković et al., 2023: 39500; Kahreman; 2024: 77) :

Step 1: Creating the Initial Decision Matrix

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & & x_{2m} \\ \vdots & & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \quad (13)$$

Step 2: Creating the Normalized Decision Matrix

$$Y_{ij} = \frac{x_{ij} - minx_{ij}}{maksx_{ij} - minx_{ij}}, \quad \text{For linear normalization} \quad (14)$$

$$Y_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}}, \quad \text{For vector normalization} \quad (15)$$

$$Y_{ij}^{norm} = \frac{\beta Y_{ij} + (1-\beta) Y_{ij}^{*}}{2}, \quad \text{For batch normalization} \quad (16)$$

Step 3: Creation of Weighted Aggregate Normalized Decision Matrix

$$\widehat{Y_{ıJ}} = w_j * Y_{ij}^{norm} \quad (17)$$

Step 4: Calculation of Ranking Score (Z_i)

$$K_i = \sum_{j=1}^{n} \widehat{Y_{ıJ}}^{(cost)}, \quad \text{For cost-oriented criteria} \quad (18)$$

$$N_i = \sum_{j=1}^{n} \widehat{Y_{ıJ}}^{(benefit)}, \quad \text{For benefit-oriented criteria} \quad (19)$$

$$Z_i = K_i^{\lambda} + N_i^{(1-\lambda)} \quad (20)$$

The λ parameter represents the criterion diversity coefficient and can be used at different rates between 0 and 1. However, in the MCDM problem where only benefit and cost criteria are included, the λ value is accepted as 0.5 in order not to obtain undefined results. In this study, the λ parameter is also taken as 0.5. In addition, the λ value varies according to the cost and benefit status of the criteria considered. For example, if 1 cost criteria consist of 5 benefit criteria, the λ value can be taken as 1/6. The β parameter represents the weight parameter that takes different values between 0 and 1. In this study, the β parameter is taken as 0.5.

4. CASE STUDY

The study suggests a new model for evaluating the European insurance sector, using PSI, LOPCOW, and AROMAN methods. While the PSI and LOPCOW methods are employed to ascertain the relative importance of the criteria in accordance with the proposed hybrid model, the AROMAN method is utilised for assessing the European insurance sector's performance over time. This section presents the results of an analysis conducted to evaluate the performance of the European insurance sector. It begins by introducing the data set and alternatives used in the analysis, and then proceeds to present the results.

4.1. Data

The study is based on data from the European insurance sector for the period between 2004 and

2020. The study employs a temporal framework encompassing the annual periods between 2004 and 2020. The data employed in the study are collated from the reports published on the website of the European Insurance Association. The criteria employed to assess the performance of the European insurance sector, along with the associated criterion codes and the desired qualities of these criteria, are presented in Table 1 below.

Table 1
Performance evaluation criteria

Criteria	Code	Qualification
Number of companies on total market	C1	Maximum
Number of direct employees	C2	Maximum
Premiums written on total market	C3	Maximum
Gross claims expenditure	C4	Minimum
Density (total premiums per inhabitant)	C5	Maximum
Penetration (total premiums to GDP)	C6	Maximum

4.2. Results from the PSI procedure

The initial decision matrix, comprising data from the European insurance sector for the period 2004-2020, was constructed and presented in Table 2.

Table 2
Initial Decision Matrix

Year	C1	C2	C3	C4	C5	C6
2004	10.193	1.134.178	899.914	575.763	3.759	0,06
2005	10.490	1.103.338	1.029.588	627.295	5.407	0,06
2006	10.675	1.098.405	1.094.754	784.431	7.629	0,06
2007	11.093	1.097.221	1.186.379	812.151	7.799	0,07
2008	12.183	1.093.501	1.062.777	785.046	7.057	0,06
2009	12.451	1.105.305	1.125.869	769.938	9.754	0,07
2010	13.607	1.021.995	1.180.037	814.118	10.309	0,07
2011	12.529	1.018.783	1.142.186	874.909	3.265	0,06
2012	12.627	1.015.287	1.125.208	896.171	3.248	0,06
2013	12.085	1.013.154	1.179.338	654.660	2.655	0,06
2014	7.284	999.051	1.259.110	856.216	2.855	0,06
2015	8.999	951.073	1.284.611	967.917	3.254	0,07
2016	10.083	952.204	1.300.057	1.013.060	5.707	0,08
2017	9.992	942.512	1.317.315	1.085.803	7.314	0,09
2018	10.130	835.344	1.385.825	1.088.026	7.604	0,09
2019	9.913	947.665	1.361.829	1.045.472	8.024	0,10
2020	9.101	924.060	1.264.236	1.010.379	3.679	0,07

The values in the initial decision matrix were normalized using Equality (2) and Equality (3). The matrix consisting of normalized values is presented in Table 3.

Table 3
Normalized Matrix

Year	C1	C2	C3	C4	C5	C6
2004	0,749	1,000	0,649	1,000	0,365	0,617
2005	0,771	0,973	0,743	0,918	0,524	0,665
2006	0,785	0,968	0,790	0,734	0,740	0,681
2007	0,815	0,967	0,856	0,709	0,757	0,688
2008	0,895	0,964	0,767	0,733	0,685	0,659
2009	0,915	0,975	0,812	0,748	0,946	0,749
2010	1,000	0,901	0,852	0,707	1,000	0,764
2011	0,921	0,898	0,824	0,658	0,317	0,659
2012	0,928	0,895	0,812	0,642	0,315	0,672
2013	0,888	0,893	0,851	0,879	0,257	0,618
2014	0,535	0,881	0,909	0,672	0,277	0,649
2015	0,661	0,839	0,927	0,595	0,316	0,683
2016	0,741	0,840	0,938	0,568	0,554	0,861
2017	0,734	0,831	0,951	0,530	0,709	0,967
2018	0,744	0,737	1,000	0,529	0,738	0,979
2019	0,729	0,836	0,983	0,551	0,778	1,000
2020	0,669	0,815	0,912	0,570	0,357	0,714

After obtaining the normalized decision matrix, the PV_j value of each criterion was calculated using Equality (4), the Θ_j value of each criterion was calculated using Equality (5) and finally the criterion weights W_j were calculated using Equality 6 and the relevant values are given in

Table 4
PV_j, Θ_j, W_j *Values*

	C1	C2	C3	C4	C5	C6
PV_j	0,793	0,895	0,857	0,691	0,567	0,743
Θ_j	0,227	0,085	0,136	0,304	0,961	0,263
W_j	0,192	0,228	0,215	0,173	0,010	0,183

As illustrated in Table 4, the impact levels of the criteria employed in evaluating the performance of the European insurance sector are ordered as C2>C3>C1>C6>C4>C5.

4.3. Results from the LOPCOW procedure

The initial decision matrix elements presented in Table 2 are normalised using Equality (8) and (9), and the resulting normalised decision matrix is shown in Table 5.

Table 5
Normalized Matrix

Year	C1	C2	C3	C4	C5	C6
2004	0,460	1,000	0,000	1,000	0,144	0,000
2005	0,507	0,897	0,267	0,899	0,360	0,127
2006	0,536	0,880	0,401	0,593	0,650	0,168
2007	0,602	0,876	0,590	0,539	0,672	0,185
2008	0,775	0,864	0,335	0,591	0,575	0,111
2009	0,817	0,903	0,465	0,621	0,927	0,346
2010	1,000	0,625	0,576	0,535	1,000	0,384
2011	0,830	0,614	0,499	0,416	0,080	0,110
2012	0,845	0,602	0,464	0,375	0,078	0,144
2013	0,759	0,595	0,575	0,846	0,000	0,003
2014	0,000	0,548	0,739	0,453	0,026	0,085
2015	0,271	0,387	0,792	0,234	0,078	0,173
2016	0,443	0,391	0,823	0,146	0,399	0,638
2017	0,428	0,359	0,859	0,004	0,609	0,914
2018	0,450	0,000	1,000	0,000	0,647	0,946
2019	0,416	0,376	0,951	0,083	0,701	1,000
2020	0,287	0,297	0,750	0,152	0,134	0,253

Percentage values (PV) for each criterion were calculated using Equation (10). The importance weight W_j for each criterion was determined using Equation (11). The relevant values are shown in Table 6.

Table 6
Percentile Values (PV) and Criteria Weights (W_j)

Year	C1	C2	C3	C4	C5	C6
2004	0,460	1,000	0,000	1,000	0,144	0,000
2005	0,507	0,897	0,267	0,899	0,360	0,127
2006	0,536	0,880	0,401	0,593	0,650	0,168
2007	0,602	0,876	0,590	0,539	0,672	0,185
2008	0,775	0,864	0,335	0,591	0,575	0,111
2009	0,817	0,903	0,465	0,621	0,927	0,346
2010	1,000	0,625	0,576	0,535	1,000	0,384
2011	0,830	0,614	0,499	0,416	0,080	0,110
2012	0,845	0,602	0,464	0,375	0,078	0,144
2013	0,759	0,595	0,575	0,846	0,000	0,003
2014	0,000	0,548	0,739	0,453	0,026	0,085
2015	0,271	0,387	0,792	0,234	0,078	0,173
2016	0,443	0,391	0,823	0,146	0,399	0,638
2017	0,428	0,359	0,859	0,004	0,609	0,914
2018	0,450	0,000	1,000	0,000	0,647	0,946
2019	0,416	0,376	0,951	0,083	0,701	1,000
2020	0,287	0,297	0,750	0,152	0,134	0,253
Sum	6,277	7,354	7,090	4,812	4,692	3,629
M	17,000	17,000	17,000	17,000	17,000	17,000
sum/m	0,369	0,433	0,417	0,283	0,276	0,213
Sq	0,608	0,658	0,646	0,532	0,525	0,462
Std	0,256	0,276	0,263	0,308	0,330	0,335
Pv	86,402	86,891	89,826	54,762	46,459	32,196
W_j	0,218	0,219	0,227	0,138	0,117	0,081

Upon examination of the LOPCOW procedure results presented in Table 6, it becomes evident that the impact level of the criteria in determining the performance of the European insurance sector is C3>C2>C1>C4>C5>C6.

4.4. Results from the Hybrid Weighting Procedure

To get more consistent and better objective weights for the criteria, we combined the weights from the PSI and LOPCOW procedures with an operator based on a weighted average (Equation 12). Thus, the combination of the two methods yielded more optimal results by capitalising on the advantages inherent to both. Table 7 shows the final weight values for the criteria.

Table 7
Common Criteria Weights

	C1	C2	C3	C4	C5	C6
W_j	0,232	0,277	0,270	0,132	0,006	0,082

Table 7 presents the final importance weights of the criteria used in the assessment of the performance of the European insurance sector. Upon examination of the results, it becomes evident that the criterion with the highest level of impact on the performance of the European insurance sector is C2 (Number of direct employees), while the criterion with the lowest level of impact is C5 (Density).

4.5. Results from the AROMAN Procedure

In the second stage of the study, the application procedures of the AROMAN method were used to calculate and rank the performance of the insurance sector. Using the initial decision matrix given in

Table 2, the linear normalisation matrix, the vector normalisation matrix and the batch normalisation matrix were calculated using equations 14-16 and are presented in Tables 8, 9 and 10 respectively.

Table 8

Linear Normalization Matrix

Year	C1	C2	C3	C4	C5	C6
2004	0,460	1,000	0,000	0,000	0,144	0,000
2005	0,507	0,897	0,267	0,101	0,360	0,127
2006	0,536	0,880	0,401	0,407	0,650	0,168
2007	0,602	0,876	0,590	0,461	0,672	0,185
2008	0,775	0,864	0,335	0,409	0,575	0,111
2009	0,817	0,903	0,465	0,379	0,927	0,346
2010	1,000	0,625	0,576	0,465	1,000	0,384
2011	0,830	0,614	0,499	0,584	0,080	0,110
2012	0,845	0,602	0,464	0,625	0,078	0,144
2013	0,759	0,595	0,575	0,154	0,000	0,003
2014	0,000	0,548	0,739	0,547	0,026	0,085
2015	0,271	0,387	0,792	0,766	0,078	0,173
2016	0,443	0,391	0,823	0,854	0,399	0,638
2017	0,428	0,359	0,859	0,996	0,609	0,914
2018	0,450	0,000	1,000	1,000	0,647	0,946
2019	0,416	0,376	0,951	0,917	0,701	1,000
2020	0,287	0,297	0,750	0,848	0,134	0,253

Table 9

Vector Normalization Matrix

Year	C1	C2	C3	C4	C5	C6
2004	0,227	0,270	0,183	0,159	0,144	0,199
2005	0,233	0,263	0,209	0,174	0,207	0,214
2006	0,237	0,262	0,222	0,217	0,292	0,219
2007	0,247	0,261	0,241	0,225	0,299	0,221
2008	0,271	0,261	0,216	0,217	0,270	0,212
2009	0,277	0,263	0,229	0,213	0,373	0,241
2010	0,303	0,243	0,240	0,225	0,395	0,246
2011	0,279	0,243	0,232	0,242	0,125	0,212
2012	0,281	0,242	0,228	0,248	0,124	0,216
2013	0,269	0,241	0,239	0,181	0,102	0,199
2014	0,162	0,238	0,256	0,237	0,109	0,209
2015	0,200	0,227	0,261	0,268	0,125	0,220
2016	0,224	0,227	0,264	0,281	0,218	0,277
2017	0,222	0,225	0,267	0,301	0,280	0,311
2018	0,225	0,199	0,281	0,301	0,291	0,315
2019	0,220	0,226	0,276	0,289	0,307	0,322
2020	0,202	0,220	0,257	0,280	0,141	0,230

Table 10

Batch Normalization Matrix

Year	C1	C2	C3	C4	C5	C6
2004	0,172	0,318	0,046	0,040	0,072	0,050
2005	0,185	0,290	0,119	0,069	0,142	0,085
2006	0,193	0,285	0,156	0,156	0,235	0,097
2007	0,212	0,284	0,208	0,172	0,243	0,102
2008	0,261	0,281	0,138	0,156	0,211	0,081
2009	0,274	0,292	0,173	0,148	0,325	0,147
2010	0,326	0,217	0,204	0,173	0,349	0,157
2011	0,277	0,214	0,183	0,207	0,051	0,081
2012	0,281	0,211	0,173	0,218	0,050	0,090
2013	0,257	0,209	0,204	0,084	0,025	0,050
2014	0,041	0,196	0,249	0,196	0,034	0,073
2015	0,118	0,153	0,263	0,258	0,051	0,098
2016	0,167	0,154	0,272	0,284	0,154	0,229
2017	0,163	0,146	0,282	0,324	0,222	0,306
2018	0,169	0,050	0,320	0,325	0,234	0,315
2019	0,159	0,150	0,307	0,302	0,252	0,331
2020	0,122	0,129	0,252	0,282	0,069	0,121

The batch normalization matrix was weighted with the help of Equation 17 and the findings are presented in Table 11.

Table 11
Weighted Normalization Matrix

Year	C1	C2	C3	C4	C5	C6
2004	0,037	0,070	0,010	0,006	0,008	0,004
2005	0,040	0,064	0,027	0,009	0,017	0,007
2006	0,042	0,063	0,035	0,022	0,028	0,008
2007	0,046	0,062	0,047	0,024	0,028	0,008
2008	0,057	0,062	0,031	0,022	0,025	0,007
2009	0,060	0,064	0,039	0,020	0,038	0,012
2010	0,071	0,048	0,046	0,024	0,041	0,013
2011	0,060	0,047	0,041	0,029	0,006	0,007
2012	0,061	0,046	0,039	0,030	0,006	0,007
2013	0,056	0,046	0,046	0,012	0,003	0,004
2014	0,009	0,043	0,056	0,027	0,004	0,006
2015	0,026	0,034	0,060	0,036	0,006	0,008
2016	0,036	0,034	0,062	0,039	0,018	0,019
2017	0,035	0,032	0,064	0,045	0,026	0,025
2018	0,037	0,011	0,073	0,045	0,027	0,026
2019	0,035	0,033	0,069	0,042	0,030	0,027
2020	0,027	0,028	0,057	0,039	0,008	0,010

For cost-oriented criteria (C4), Equation 18, for benefit-oriented criteria (C1, C2, C3, C5 and C6), Equation 19 was used, and the ranking score was calculated with the help of Equation 20. The findings are presented in Table 12.

Table 12
AROMAN Procedure Ranking Results

Year	K	N	Z	Rank
2004	0,006	0,130	0,434	17
2005	0,009	0,154	0,490	16
2006	0,022	0,175	0,566	11
2007	0,024	0,192	0,592	7
2008	0,022	0,181	0,573	9
2009	0,020	0,213	0,604	6
2010	0,024	0,218	0,622	4
2011	0,029	0,161	0,570	10
2012	0,030	0,160	0,574	8
2013	0,012	0,155	0,501	15
2014	0,027	0,118	0,508	14
2015	0,036	0,133	0,553	13
2016	0,039	0,168	0,608	5
2017	0,045	0,182	0,638	2
2018	0,045	0,173	0,628	3
2019	0,042	0,193	0,644	1
2020	0,039	0,130	0,558	12

Table 12 presents the ranking results of the European insurance sector's performance in the period 2004-2020 according to the AROMAN procedure. When the results are examined, it is determined that the European insurance sector showed the best performance in 2019 and the worst performance in 2004.

5. CONCLUSION

The insurance sector is among the largest institutional investors in financial markets and plays an important role in financial markets. In Europe, especially in industrialized countries, the insurance sector has a large share in the financial system (Insurance Europe, 2024). The goal of this study is

to evaluate the performance of the European insurance sector using sectoral indicators. To this end, we propose a new integrated MCDM model comprising PSI, LOPCOW, and AROMAN methods for assessing the performance of the European insurance ındustry.

The determination of the objective importance weights of the assessment criteria employed in the evaluation of the performance of the European insurance sector was conducted through the utilisation of the PSI and LOPCOW methodologies, as proposed within the model. Subsequently, the results of the aforementioned two methods were integrated to derive the final importance weights of the criteria. Upon examination of the results produced by the common weighting method, it is seen that the two most effective criteria on the performance of the European insurance sector are C2 (Number of direct employees) and C3 (Premiums written on total market), respectively, while the two least effective criteria are C5 (Density) and C6 (Penetration) respectively. These results can be interpreted as indicating that the European insurance sector has the potential to enhance its performance by developing a robust personnel infrastructure and increasing premium production. The annual premium production is an essential indicator that is utilised as a measure of success for both individual companies and the insurance sector as a whole. This evidence lends support to the assertion that the premiums written on a total market basis represent a significant and influential criterion. Furthermore, the identification of personnel and premium production as the two most significant criteria suggests that an increase in the former may lead to an increase in the latter, thus strengthening the sector's personnel capabilities and boosting sales and premium production.

When the results of the AROMAN ranking procedure are examined, it is seen that the performance of the European insurance sector has fluctuated between 2004-2020. The best performance of the European insurance sector was determined as 2019, and the worst performance was determined as 2004. While the European insurance sector showed its best performance in 2019, it is seen that there was an eleven-place drop in the performance ranking in 2020. It can be thought that this situation was caused by the Covid-19 pandemic, which started in 2019 and spread throughout the world and started to show its negative effects in Europe in 2020. Increasing health claims, uncertainty in life insurance, and operational difficulties may be contributing factors. Upon examination of the AROMAN method results, it becomes evident that there was a fluctuating decline in the performance of the European insurance sector after 2010 until 2016. This situation can be interpreted as the negative impact of the European debt crisis, which first manifested in Greece in 2009 and subsequently spread to a considerable extent by affecting neighbouring countries, on the European insurance sector. It can be stated that the decline in insurance companies' investment income following the 2008 crisis and tighter regulations also had a negative impact on performance.

The study shows that while the insurance sector is important for financial markets, the insurance sector itself is also affected by changes in the economy and financial markets. In order to ensure the stability of the financial performance of the insurance sector, future research should focus on methods (e.g. balance sheet management) that may minimize the extent to which the insurance sector is affected by macroeconomic indicators. The study's findings suggest that insurance companies should enhance their financial resilience by strengthening their personnel infrastructure and increasing premium production through digital sales channels. Furthermore, policymakers should consider implementing macroprudential measures to protect the sector's liquidity during times of crisis.

The findings of this study may inform the decision-making processes of those involved in the insurance industry, including policymakers, regulatory and supervisory institutions, insurance company managers, investors, and customers. Additionally, the insights gained may contribute to the development of future strategies. Moreover, the decision model proposed in the study can be applied to a range of research areas, including the assessment of firm-level performance, the comparison of performance across countries, and the analysis of sector-specific performance.

Objective weighting methods such as PSI and LOPCOW were used to determine the criteria weights in the study. While this minimizes errors that may arise from the subjective judgments of decision-makers, the lack of use of Fuzzy Logic based approaches that reflect the views of industry experts

can be seen as a limitation. In future studies, the latest weighting methods such as SITDE, CRISUS, and LOGSTA can be used to validate and enrich the results of the model proposed in this article.

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ORIGINAL ARTICLE

EVALUATION OF ESG RISKS IN THE BANKING INDUSTRY THROUGH AN INTEGRATED DECISION-MAKING FRAMEWORK

Erdal DEMİR

Abstract
This manuscript develops and applies a hybrid multi-criteria decision-making (MCDM) framework for the systematic assessment of Environmental, Social, and Governance (ESG) risks within the Turkish banking industry. The recommended framework combines the CRISUS objective weighting technique, which quantifies the relative importance of ESG risk criteria, with the Proximity Indexed Value (PIV) ranking algorithm, which enables stable and rank-reversal-free prioritization of bank alternatives. The empirical analysis is conducted on major commercial banks included in the Borsa İstanbul Sustainability Index. The outcomes derived from the CRISUS procedure indicate that environmental and governance-related risks dominate the ESG risk structure of Turkish banks, reflecting heightened regulatory requirements and systemic exposure, whereas social risk criteria display relatively weaker discriminatory capacity. The application of the PIV algorithm yields a clear and interpretable ranking of bank alternatives, with Yapı Kredi identified as the most resilient institution, followed by Halkbank and İş Bank, all of which exhibit close proximity to the ideal ESG risk profile. Additional sensitivity and comparative analyses confirm the robustness and reliability of the proposed hybrid framework. Overall, this research contributes to the existing literature by introducing one of the limited number of integrated ESG risk assessment models tailored to an emerging market setting. Beyond its methodological contribution, the framework offers practical decision-support insights for regulators, investors, and bank managers seeking to benchmark ESG risk exposure and enhance resilience within the banking industry.

Keywords
ESG risk assessment, Turkish banking industry, Risk management, Sustainable finance, MCDM.

JEL Classification
C54, G17, G22, G32, G41.

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1. INTRODUCTION

In recent years, Environmental, Social, and Governance (ESG) considerations have come to be recognized as fundamental determinants of strategic orientation, competitive positioning, and long-term value creation in the global banking industry. As sustainability principles have been progressively integrated into financial systems, banks have been expected not only to maintain sound credit and liquidity structures but also to ensure that their activities are conducted in a responsible, transparent, and socially accountable manner (Işık et al., 2025a). Consequently, ESG-related performance has increasingly been treated as a key differentiating factor influencing banks' reputational standing, regulatory alignment, investor confidence, access to international funding, and consistency with sustainable finance standards. Under these conditions, the incorporation of ESG considerations into banking operations has evolved from a voluntary strategic preference into a structural requirement for institutional resilience within a rapidly transforming financial ecosystem (Tekgün, 2025).

From this perspective, ESG risk has emerged as a complementary but distinct concept, referring to the potential vulnerabilities that may undermine banks' financial soundness when sustainability-related challenges are not effectively managed. Such risks originate from environmental stressors such as climate change, social pressures associated with labor practices and stakeholder relations, and governance deficiencies related to weak transparency and oversight mechanisms. These vulnerabilities may materialize in the form of tangible financial losses, most notably through the deterioration of asset quality and the escalation of non-performing loans, thereby weakening balance-sheet resilience. Accordingly, the establishment of robust ESG risk management frameworks has been widely acknowledged as essential for safeguarding financial stability and mitigating credit risk exposure (Yudaruddin & Yudaruddin, 2025).

The banking industry is inherently characterized by high risk intensity, stemming from exposure to credit market volatility, macroeconomic shocks, regulatory pressure, operational fragilities, and reputational sensitivities. Within this already complex risk environment, ESG-related dimensions introduce an additional and increasingly material layer of uncertainty (Ahmed et al., 2018; Pyka & Nocoń, 2024). Although ESG factors were initially perceived as largely qualitative and peripheral considerations, they are now recognized as financially material risk drivers capable of influencing banks' asset quality, operational continuity, compliance capacity, and long-term financial stability. Climate-induced physical disruptions, cybersecurity threats associated with digitalization, governance failures, and weaknesses in disclosure practices collectively constitute what is now widely defined as ESG risk (Yudaruddin et al., 2025; Erhemjamts et al., 2024).

The growing salience of ESG risks has reinforced the need for banks to systematically assess their exposure to sustainability-related vulnerabilities. However, ESG risk assessment remains methodologically challenging, as it involves multiple interrelated dimensions, heterogeneous indicators, and expert-dependent judgments that cannot be adequately captured through a single financial metric. Consequently, ESG risk evaluation is best conceptualized as a multi-criteria and multidimensional decision-making problem, requiring the adoption of structured, transparent, and analytically rigorous assessment frameworks capable of integrating diverse sources of information into a coherent analytical structure. Within this analytical landscape, Multi-Criteria Decision-Making (MCDM) methods offer powerful tools for addressing the complexity of ESG risk evaluation. MCDM techniques allow for the integration of heterogeneous qualitative and quantitative criteria, facilitate expert-based assessment, and provide systematic weighting mechanisms that enhance objectivity and comparability

across decision alternatives. They are particularly well-suited for ESG analyses because sustainability dimensions are intrinsically multi-attribute, interdependent, and difficult to evaluate using conventional statistical models alone.

In the current paper, the criterion weight coefficients are derived via the CRISUS (CRiterion Importance Based on SUm of Squares) objective weighting technique, whereas the prioritization of bank alternatives is performed using the Proximity Indexed Value (PIV) method. The CRISUS is employed owing to its transparent computational structure, its independence from inter-criterion correlation effects, and its capacity to capture the discriminative contribution of each criterion through variance-based calculations. The PIV technique, in turn, is adopted as it produces a linear, easily interpretable, and stable ranking structure, while effectively eliminating rank-reversal problems and enhancing robustness in comparative evaluations. The joint implementation of CRISUS and PIV therefore facilitates the development of a consistent, replicable, and decision-oriented framework for ESG risk assessment.

Within this methodological setting, the study seeks to address three central research questions. First, it examines which ESG risk dimensions exert the strongest influence on the overall risk exposure of Turkish commercial banks. Second, it investigates how banks included in the Borsa İstanbul Sustainability Index differ with respect to their ESG risk profiles. Third, it evaluates whether an integrated CRISUS–PIV framework can deliver a stable and rank-reversal-free prioritization of banks under ESG risk considerations.

By responding to these questions, our paper contributes to the existing literature in several important ways. It introduces one of the relatively limited number of integrated ESG risk assessment frameworks applied specifically to the Turkish banking sector using a hybrid MCDM structure. In addition, ESG risks are systematically operationalized through a structured set of environmental, social, and governance criteria that explicitly reflect the risk characteristics of commercial banks. From an empirical perspective, the focus on major banks listed in the Borsa İstanbul Sustainability Index provides a context-specific and policy-relevant comparison of ESG risk exposure. From a methodological standpoint, the combined use of CRISUS and PIV represents a novel and effective approach for addressing the multidimensional and complex nature of ESG risk evaluation. Accordingly, the study aims to make both methodological and empirical contributions to the growing body of research on ESG risk-oriented decision-making in the banking industry.

The remainder of the manuscript is organized as follows. Section 2 reviews the relevant literature and establishes the theoretical and empirical background of the study. Section 3 describes the proposed research methodology and the integrated MCDM framework. Section 4 presents the case study on ESG risk assessment for commercial banks, while Section 5 reports the empirical application and results. Section 6 discusses the validation and robustness analyses, and Section 7 concludes with policy implications, study limitations, and directions for future research.

2. RELATED LITERATURE

In recent years, a growing body of research has applied multi-criteria decision-making (MCDM) approaches to assess corporate sustainability and ESG performance across different industries. Scholars have introduced hybrid models that combine classical techniques such as AHP, TOPSIS, VIKOR, and MAUT with advanced extensions including fuzzy sets, intuitionistic fuzzy sets, spherical fuzzy sets, neutrosophic sets, and grey systems theory. These methodological innovations have been employed to assess sustainability in diverse contexts such as banking, insurance, manufacturing, energy, and electronics industries, offering structured tools to capture uncertainty, subjectivity, and data limitations. Case studies from Spain, Turkey, India, China, and global industries demonstrate how integrated MCDM frameworks can benchmark firms, prioritize ESG criteria, and provide robust rankings of corporate performance. The following section presents a concise overview of these recent contributions, highlighting the methodological configurations and sectoral applications that inform the design

of our study.

Aktaş and Demirel (2021) introduced a hybrid MCDM tool to estimate corporate sustainability performance across the economic, environmental, and social dimensions of the triple bottom line. The methodology integrates the Entropy method for objective criteria weighting with three ranking techniques—VIKOR, TOPSIS, and MAUT—to assess sustainability reports. To consolidate results and avoid inconsistencies across methods, the Borda count data fusion technique was applied to generate a final robust ranking. A case study was conducted on a leading Turkish furniture company, where sustainability performance was evaluated over multiple years.

Reig-Mullor and Brotons-Martinez (2021) developed a novel performance assessment model for Spanish commercial banks by integrating financial and non-financial indicators within an expanded CAMELS-ESG rating system. To address uncertainty and subjectivity in decision-making, the study employed intuitionistic fuzzy sets (IFS) combined with the Analytic Hierarchy Process (IFAHP) for weighting criteria and intuitionistic fuzzy TOPSIS (IFTOPSIS) for ranking alternatives.

Reig-Mullor et al. (2022) proposed a novel hybrid methodology to evaluate corporate ESG performance by integrating the AHP and the TOPSIS within a neutrosophic environment. The approach employs single-valued triangular neutrosophic numbers to capture uncertainty, indeterminacy, and subjectivity in sustainability reporting. Leveraging single-valued triangular neutrosophic numbers, the model effectively addressed uncertainty, indeterminacy, and subjectivity inherent in sustainability reporting. Its applicability was demonstrated through a case study assessing the ESG performance of leading global oil and gas firms.

Li et al. (2023) examined the role of ESG factors and policy options in shaping green finance investment decisions for sustainable development in China. To address the complexity and uncertainty inherent in ESG evaluation, the study applied two fuzzy MCDM techniques: the fuzzy AHP to identify and prioritize ESG factors and sub-factors, and the fuzzy DEMATEL to analyze causal relationships and rank policy options.

Sharma and Kumar (2024) investigated the sustainable performance of banking institutions using a multidimensional framework that incorporates ESG, and financial dimensions, supported by 52 sustainability indicators. The authors used data for the period 2021–2022 to examine banks' responsiveness to sustainability dimensions. A hybrid MCDM approach was then employed, integrating Entropy, TOPSIS, and VIKOR to assign relative weights to indicators and prioritize banks based on their sustainable performance.

Akbulut and Aydın (2024) recommended a hybrid multidimensional performance measurement model for Turkish banks by integrating the MSD, MPSI, and RAWEC approaches. Their framework evaluated banks' sustainability performance across financial, environmental, social, and corporate governance dimensions, employing 21 indicators derived from the CAMELS rating system and ESG practices to ensure a holistic assessment. Within this model, MSD and MPSI were utilized to generate objective and reliable weights for the criteria, while RAWEC was implemented to provide a robust ranking of banks according to their overall sustainability performance. To validate the applicability of the recommended methodology, a comprehensive case study was conducted on six major Turkish commercial banks representing significant market shares in the sector.

Yu et al. (2024) developed an integrated MCDM framework to assess the ESG sustainable performance of companies by combining the interval type-2 (IT2) fuzzy set, AHP, and CoCoSo. In this approach, IT2 fuzzy sets were employed to transform qualitative linguistic judgments into quantitative values, IT2FAHP was applied to derive the weights of ESG criteria, and IT2F-CoCoSo was employed to rank the alternatives. The framework was tested through a case study of five listed medical companies, evaluated across 14 ESG sub-criteria under environmental, social, and governance dimensions.

Hoang et al. (2024) introduced a combined MCDM methodology to assess the ESG performance of the global electronics industry under uncertainty. The study combined the AHP and WASPAS within a spherical fuzzy environment, resulting in the SF-AHP–SF-WASPAS approach. In this framework, SF-AHP was utilized to determine the relative importance of ESG criteria, while SF-WASPAS

provided the final rankings of companies. The methodology was applied to leading electronics firms' ESG sustainability indicators.

Akbulut (2024) developed an integrated grey MCDM tool to evaluate the environmental sustainability performance of Turkish banks. The proposed model combines the Grey LOPCOW method for objective weighting of criteria with the Grey PIV ranking procedure, enabling robust analysis under conditions of uncertainty and limited data. A case study was conducted with six commercial banks, thirteen environmental performance indicators, and assessments from seven experts.

Demir (2025) developed a new decision-making framework for evaluating the sustainability performance of banks traded on the BIST by integrating the MPSI and RAWEC methods. In the 2022 case study, the MPSI objectively determined the weights of the indicators, and RAWEC provided the multi-criteria ranking of the banks. The findings revealed that ROE was the most decisive indicator, and according to RAWEC results, Akbank demonstrated the highest sustainability performance.

Işık and Adalar (2025) evaluated the sustainability performance of 10 Turkish non-life insurance companies through ESG criteria derived from the Refinitiv Eikon database, reflecting the triple bottom line of sustainability. The authors extended the classical CRADIS technique with intuitionistic fuzzy sets, resulting in the IF-CRADIS approach, which more effectively captured uncertainty, hesitation, and subjectivity in expert evaluations.

Adalar and Işık (2025) proposed a novel hybrid multi-criteria decision-making framework by introducing CRISUS, an objective weighting method, and integrating it with the RAM to rank decision alternatives for assessing corporate sustainability performance. The proposed methodology was applied to seven BIST-listed food and beverage firms, utilizing seven performance criteria that encompassed both ESG and financial indicators.

Işık et al. (2025b) introduced a grey-based hybrid decision support framework to evaluate the sustainability performance of Turkish banks. The study developed an integrated model that incorporated extended versions of the MSD, SPC, and PIV methods within the grey system theory. A case study was conducted on seven banks using ten ESG indicators, with assessments provided by five experts.

Tekgün (2025) developed a novel MCDM framework to assess the ESG sustainability performance of banks listed on Borsa İstanbul. The proposed hybrid model combined two objective weighting techniques—Grey LOPCOW and Grey MSD—with the Grey PIV ranking procedure to effectively manage epistemic uncertainty in sustainability data, incorporating ten ESG indicators from the Refinitiv Eikon database for the 2021–2023 period.

Karki et al. (2025) conducted an ESG performance assessment of Indian deposit banks using a hybrid multi-criteria decision-making framework. The study applied the R-SWARA technique to determine the weights of ESG criteria and then employed the CoCoSo approach to rank the banks according to their sustainability performance.

In spite of the fact that recent studies have significantly advanced the application of hybrid MCDM approaches for evaluating corporate sustainability and ESG performance across a wide range of sectors—including banking, insurance, manufacturing, and energy—important conceptual and methodological limitations remain. First, the prevailing focus of the existing literature is largely oriented toward ex post ESG performance measurement and corporate sustainability ranking, rather than the structured assessment of ESG-related risks, which represent forward-looking vulnerabilities with direct implications for financial stability and risk management. This limitation is particularly pronounced in the banking sector, where ESG risks are closely intertwined with credit risk, regulatory exposure, and systemic resilience, yet remain insufficiently operationalized within dedicated risk assessment frameworks. Second, although several studies rely on standardized ESG databases or broad indicator sets, these approaches often fail to translate ESG dimensions into risk-sensitive criteria that reflect the specific operational, regulatory, and portfolio-related characteristics of commercial banks. As a result, existing models may overlook the channels through which ESG risks materialize and propagate within banking systems. Third, from an empirical perspective, while MCDM-based ESG assessments have been widely applied to banks operating in developed markets or global samples,

empirically grounded ESG risk comparisons for major Turkish banks listed in the Borsa İstanbul Sustainability Index remain scarce, limiting the relevance of prior findings for regulators, investors, and policymakers in emerging market contexts.

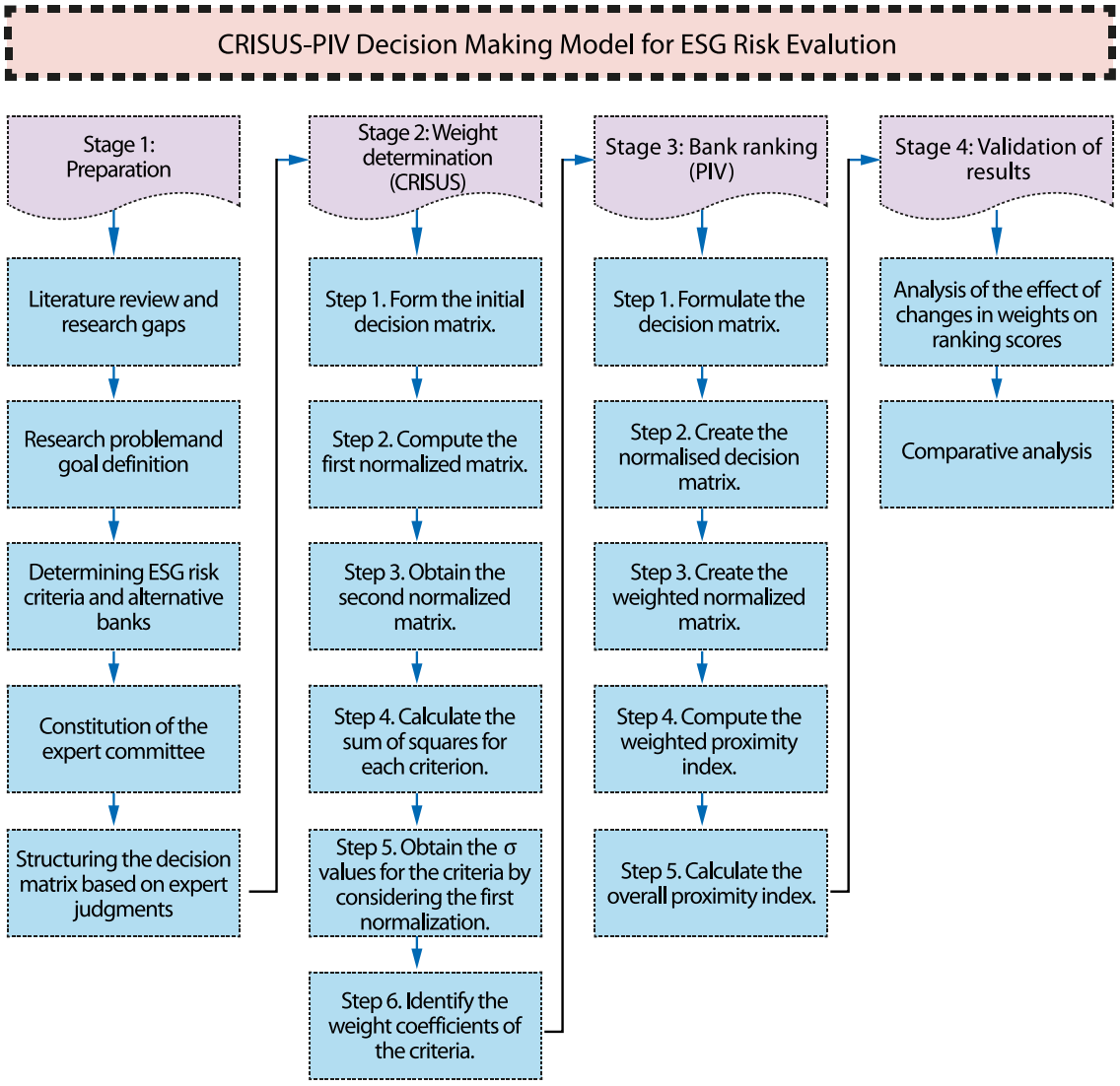
From a methodological standpoint, previous research has introduced a variety of hybrid MCDM configurations combining Entropy, TOPSIS, VIKOR, fuzzy AHP, DEMATEL, and grey-based approaches. However, these models often suffer from either instability in ranking outcomes, sensitivity to normalization procedures, or limited transparency in weight derivation. Notably, the joint application of the CRISUS objective weighting method and the PIV ranking algorithm has not yet been explored in the context of ESG risk evaluation, despite their complementary strengths in capturing criterion discriminative power and ensuring rank-reversal-free prioritization.

By addressing these gaps, the present work makes several contributions. It shifts the analytical focus from ESG performance to ESG risk assessment, offering a decision-oriented framework that is directly applicable to banking risk management. It operationalizes ESG risks through a bank-specific and risk-sensitive criterion structure, enhancing the interpretability and practical relevance of the evaluation. Empirically, it provides one of the first comprehensive ESG risk comparisons for Turkish banks listed in the BIST Sustainability Index. Methodologically, the integrated CRISUS–PIV framework delivers transparent weighting, stable rankings, and high robustness, thereby offering decision makers, regulators, and practitioners a reliable tool for benchmarking ESG risk exposure, supporting supervisory oversight, strategic planning, and ESG-informed investment decisions.

3. RESEARCH METHODOLOGY

This section elaborates on the core algorithmic structure of the proposed integrated MCDM framework. The ESG risk performance of Turkish commercial banks was systematically assessed through a sequence of methodological stages, as depicted in Figure 1. In the initial stage, a comprehensive decision matrix was constructed to capture the environmental, social, and governance risk dimensions across the selected bank alternatives. Subsequently, the objective weights of the criteria were derived employing the CRISUS weighting procedure, which ensures methodological rigor by minimizing subjectivity and enhancing the robustness of the weighting process. Once the criterion weights were established, the prioritization of bank alternatives was performed through the SPR ranking algorithm.

Figure 1
The methodological framework



3.1. The CRISUS-PIV Methodology

3.1.1. Stage 1: CRISUS algorithm for criterion weighting

The CRISUS approach was introduced into the decision-making literature by Adalar and Işık (2025) with the aim of calculating the objective weight coefficients of evaluation criteria in the process of solving decision problems. This method constitutes an analytical weighting technique developed by drawing upon the fundamental principles of the Statistical Variance (SV) approach proposed by Rao and Patel (2010) and the Entropy approach introduced by Shannon (1948). The CRISUS methodology estimates objective weights through a two-stage normalization procedure, employing the sum-of-squares operator. The rationale underlying the preference for this weighting algorithm, together with its methodological advantages, can be summarized as follows: (i) the computational steps of the CRISUS approach are straightforward, offering decision-makers an easy-to-use algorithm that does not require specialized software or advanced user expertise; (ii) the method is not affected by the number of alternatives considered in the decision problem; (iii) the normalization procedure is implemented in two stages, explicitly accounting for the benefit–cost characteristics of the evaluation criteria; (iv) the approach is immune to inconsistencies inherent in expert judgments that typically

affect subjective weighting models; and (v) compared with alternative weighting methodologies, the sum-of-squares operation specific to the CRISUS method provides a simpler mechanism for weight estimation. The application procedure of the CRISUS methodology consists of the six steps outlined below (Adalar and Işık, 2025).

Step 1. To address the decision problem, the decision matrix—consisting of the set of bank alternatives and ESG risk-based criteria—is formulated in accordance with Equation (1).

$$\tilde{X} = \left(\begin{bmatrix} \tilde{x}_{11} & \cdots & \tilde{x}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \cdots & \tilde{x}_{mn} \end{bmatrix} \right) \quad (1)$$

Step 2. The first normalization procedure is carried out through vector normalization based on the sum of Euclidean distances, as developed by Van Delft and Nijkamp (1977). Accordingly, Equation (2) is applied to beneficial criteria, whereas Equation (3) is employed for non-beneficial criteria.

$$x_{ij} = \frac{\tilde{x}_{ij}}{\sqrt{\sum_{i=1}^{m} \tilde{x}_{ij}^2}} \quad (2)$$

$$x_{ij} = 1 - \frac{\tilde{x}_{ij}}{\sqrt{\sum_{i=1}^{m} \tilde{x}_{ij}^2}} \quad (3)$$

Step 3. In the second normalization procedure, all elements of the matrix normalized in the previous step are transformed into the interval [0,1] with the help of Equation (4). In other words, all values are adjusted to conform to a standard distribution.

$$s_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (4)$$

Step 4. For each assessment criterion, the sum of squares is computed by means of Equation (5).

$$\rho_j = \sum_{i=1}^{m} s_{ij}^2 \quad (5)$$

Step 5. Following the first normalization procedure, the standard deviation value corresponding to each criterion $(\sigma_j,\ j = 1,2,\dots,n)$ is computed.

Step 6. The objective importance weights of the assessment criteria are derived in the final stage of the CRISUS approach via Equation (6).

$$w_j = \frac{\sigma_j \rho_j}{\sum_{j=1}^{n} \sigma_j \rho_j} \quad (6)$$

Here, the criterion associated with the highest importance weight is identified as exerting the most significant impact on performance.

3.1.2. Stage 2: Proximity Indexed Value (PIV) procedure for bank ranking

The Proximity Indexed Value (PIV) method is a relatively recent addition to the family of MCDM techniques, designed to provide decision makers with a simple yet reliable tool for ranking alternatives (Mufazzal and Muzakkir, 2018). Unlike more complex approaches, PIV relies on straightforward normalization and aggregation procedures, which makes it easy to implement and interpret. One of

its key advantages is robustness against the rank reversal problem, ensuring that the inclusion or exclusion of irrelevant alternatives does not distort the final ordering. Moreover, the method is flexible enough to handle both benefit and cost criteria, as well as datasets containing negative values, by transforming them into a comparable scale. The PIV approach proceeds through the following steps:

Step 1. The initial decision matrix, as presented in Equation (1), is constructed

Step 2. The decision matrix constructed in the previous step is normalized using Equation (7).

$$R_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{7}$$

Step 3. The weighted normalized matrix is constructed. This matrix shown below is obtained through the application of Equation (8).

$$z_{ij} = R_{ij}.w_j \tag{8}$$

Step 4. The Weighted Proximity Index, denoted as k_i, is evaluated via Equation (9).

$$k_i = \begin{cases} z_{max} - z_{ij}; \text{for beneficial criteria} \\ z_{ij} - z_{min}; \text{for cost criteria} \end{cases} \tag{9}$$

Step 5. The Overall Proximity Value (μ_i) is obtained by applying Equation (10)

$$\mu_i = \sum_{j=1}^{n} k_i \tag{10}$$

Alternatives are ranked according to their μ_i values. The alternative with the smallest μ_i indicates the minimum deviation from the ideal solution and is therefore placed first, followed by alternatives with progressively larger μ_i values.

4. CASE STUDY FOR COMMERCIAL BANKS' ESG RISK ASSESSMENT

In order to demonstrate the applicability of the proposed methodology, a case study was conducted on commercial banks operating in Turkey. The objective of this case study is to evaluate the Environmental, Social, and Governance (ESG) risk exposure of banks listed in the BIST Sustainability Index, thereby providing a comparative framework for assessing their resilience and sustainability performance. The study follows a structured MCDM approach, beginning with the construction of an expert panel, the definition of ESG risk criteria, and the identification of bank alternatives.

4.1. Construction of a team of experts

To ensure methodological rigor and sectoral relevance, an expert panel was established to guide the ESG risk assessment process. The panel consisted of three senior professionals with extensive experience in sustainability and corporate governance within the banking industry. The first expert was a member of a bank's sustainability committee with 5 years of ESG experience, the second expert served as an independent board member with 7 years of ESG expertise, and the third expert was a member of a corporate governance committee with 6 years of ESG experience.

4.2. Definition of criteria

The evaluation framework was structured around a comprehensive set of ESG risk criteria, categorized into environmental, social, and governance dimensions. The set of criteria defined in the study was established through expert opinions and constructed within a consensus-based framework.

Carbon Emission Risk (E1): This criterion reflects the bank's direct (Scope 1) and indirect (Scope 2 and 3) carbon emissions generated through its branches, data centers, ATM networks, and financed activities. Higher carbon intensity elevates regulatory exposure to carbon pricing mechanisms, increases transition-related financial losses, and weakens sustainability performance in global ESG benchmarking frameworks.

Carbon-Intensive Portfolio Risk (E2): This criterion evaluates the proportion of loans and investments allocated to carbon-intensive industries such as fossil fuels, heavy manufacturing, cement, mining, and transportation. A higher share of carbon-intensive assets increases transition risk, elevates default probabilities for high-emission borrowers, and creates stranded asset exposure that threatens long-term portfolio stability.

Climate-Related Physical Damage Risk (E3): This criterion captures the vulnerability of the bank's physical infrastructure and loan collateral to climate-induced hazards such as floods, heatwaves, storms, wildfires, and rising sea levels. Physical climate stressors directly threaten operational continuity and reduce the recoverable value of collateral.

Environmental Compliance Risk (E4): This risk reflects the bank's level of alignment with environmental regulations, green taxonomy requirements, sustainability reporting standards, and environmental due-diligence obligations. Non-compliance increases the likelihood of regulatory penalties, legal action, financial sanctions, and reputational losses.

Customer Protection Risk (S1): This criterion measures the bank's exposure to customer complaints, misselling behavior, product suitability issues, and consumer protection breaches. Poor customer protection weakens social credibility, lowers stakeholder trust, and increases supervisory scrutiny.

Financial Inclusion Risk (S2): This risk assesses the bank's performance in providing accessible financial services to underserved groups, low-income individuals, SMEs, and disadvantaged regions. Low inclusion levels indicate social vulnerability and limit the bank's alignment with sustainable development goals and inclusive finance principles.

Cybersecurity Risk (S3): Cybersecurity risk refers to the vulnerability of the bank's information systems to data breaches, ransomware attacks, system outages, and unauthorized access. As digitalization expands, cyber risks have become a critical operational and reputational threat, directly affecting customer trust and regulatory compliance.

Human Capital Risk (S4): This risk captures challenges related to employee turnover, insufficient training, low engagement, weak workplace well-being, and inadequate skill development. Strong human capital is essential for sustainable transformation, effective ESG governance, and long-term operational resilience.

Board Independence Risk (G1): This criterion measures the independence, diversity, and objectivity of the board of directors, as well as the existence of potential conflicts of interest. Low independence undermines governance quality, weakens oversight, and increases the likelihood of biased strategic decisions.

Corruption and Ethical Misconduct Risk (G2): This risk captures exposure to bribery, fraud, money laundering, and ethical misconduct. Weaknesses in ethical systems threaten the bank's regulatory standing, public trust, and long-term legitimacy.

Regulatory Compliance Risk (G3): Regulatory compliance risk reflects the bank's adherence to BDDK, MASAK, Basel III–IV, AML/KYC obligations, and international sustainability frameworks. Higher non-compliance increases operational losses, penalties, and supervisory intervention.

Transparency and ESG Disclosure Risk (G4): This criterion evaluates the quality, depth, and accuracy of ESG reporting practices aligned with TCFD, GRI, SASB, and other disclosure frameworks.

Insufficient transparency undermines investor confidence, weakens ESG scoring, and restricts access to sustainable finance instruments.

4.3. Definition of bank alternatives

The case study focused on commercial banks listed in the BIST Sustainability Index, representing key players in the Turkish financial system. These institutions were chosen due to their significant market presence and active participation in sustainability initiatives. By evaluating these banks against the defined ESG risk criteria, the study aimed to provide a comparative analysis of their risk exposure and resilience, thereby offering valuable insights for both academic research and managerial decision-making.The selected alternatives are Akbank (A1), Garanti BBVA (A2), Halkbank (A3), İş Bank (A4), Şekerbank (A5), Vakıfbank (A6), and Yapı Kredi (A7).

5. APPLICATION AND RESULTS

In the final stage of the evaluation process, each decision-maker was requested to assign an importance score ranging from 1 (least important) to 9 (most important) for every criterion under consideration. These individual judgments were then aggregated by computing the arithmetic mean of the assigned values, thereby yielding a consolidated initial decision matrix.

The evaluations of the alternatives with respect to each criterion, provided by the experts selected from the banking sector, are presented in Tables 1, 2, and 3, respectively. Subsequently, by averaging these matrices, the initial decision matrix shown in Table 4 was constructed.

Table 1

The first expert's evaluation of the alternatives with respect to the criteria

	E1	E2	E3	E4	S1	S2	S3	S4	G1	G2	G3	G4
A1	8	8	8	9	8	8	9	8	8	7	6	9
A2	9	9	8	9	8	8	9	8	9	9	9	9
A3	6	5	6	7	6	5	7	7	6	6	7	7
A4	5	6	6	7	6	7	5	7	6	6	7	7
A5	9	9	8	7	8	7	9	8	8	8	9	9
A6	8	8	7	8	7	7	8	8	7	8	9	8
A7	5	6	4	6	6	4	4	6	6	6	4	6

Table 2

The second expert's assessment of the banks with respect to the criteria

	E1	E2	E3	E4	S1	S2	S3	S4	G1	G2	G3	G4
A1	8	8	8	8	8	8	8	8	9	8	9	9
A2	9	9	8	9	8	9	9	8	9	8	9	9
A3	6	4	6	4	6	4	7	7	6	6	6	6
A4	4	6	4	6	6	6	7	7	6	5	6	6
A5	9	8	8	9	8	9	9	8	9	9	8	9
A6	8	8	7	8	7	8	8	8	8	9	8	9
A7	5	4	5	5	4	5	6	6	6	4	5	5

Table 3

The third expert's evaluation of the bank alternatives based on the criteria

	E1	E2	E3	E4	S1	S2	S3	S4	G1	G2	G3	G4
A1	8	8	8	8	8	8	9	8	8	8	8	9
A2	9	9	8	9	8	9	9	8	9	9	9	9
A3	4	3	3	3	6	6	7	7	6	6	6	6
A4	6	4	3	3	6	6	7	7	6	6	6	6
A5	9	9	8	9	8	8	9	8	9	8	9	9
A6	8	8	7	8	7	8	8	8	9	8	8	9
A7	5	4	5	4	5	5	6	6	5	4	4	5

Table 4
The initial decision matrix

	E1	E2	E3	E4	S1	S2	S3	S4	G1	G2	G3	G4
A1	8.00	8.00	8.00	8.33	8.00	8.00	8.67	8.00	8.33	7.67	7.67	9.00
A2	9.00	9.00	8.00	9.00	8.00	8.67	9.00	8.00	9.00	8.67	9.00	9.00
A3	5.33	4.00	5.00	4.67	6.00	5.00	7.00	7.00	6.00	6.00	6.33	6.33
A4	5.00	5.33	4.33	5.33	6.00	6.33	6.33	7.00	6.00	5.67	6.33	6.33
A5	9.00	8.67	8.00	8.33	8.00	8.00	9.00	8.00	8.67	8.33	8.67	9.00
A6	8.00	8.00	7.00	8.00	7.00	7.67	8.00	8.00	8.00	8.33	8.33	8.67
A7	5.00	4.67	4.67	5.00	5.00	4.67	5.33	6.00	5.67	4.67	4.33	5.33

5.1. The results obtained from the CRISUS methodology

By applying Equations (2) and (3), the decision matrix presented in Table 4 was normalized, and the resulting initial normalized decision matrix is reported in Table 5. Next, by means of Equation (4), the second normalized decision matrix was determined, as illustrated in Table 6. Finally, Table 7 displays the outcomes produced employing the CRISUS objective weighting approach.

Table 5
The first normalised matrix

	E1	E2	E3	E4	S1	S2	S3	S4	G1	G2	G3	G4
A1	0.583	0.573	0.543	0.560	0.565	0.572	0.576	0.595	0.580	0.597	0.608	0.564
A2	0.531	0.519	0.543	0.525	0.565	0.536	0.560	0.595	0.546	0.545	0.540	0.564
A3	0.722	0.786	0.714	0.754	0.674	0.732	0.658	0.646	0.698	0.685	0.677	0.693
A4	0.740	0.715	0.753	0.719	0.674	0.661	0.690	0.646	0.698	0.702	0.677	0.693
A5	0.531	0.537	0.543	0.560	0.565	0.572	0.560	0.595	0.563	0.562	0.557	0.564
A6	0.583	0.573	0.600	0.578	0.619	0.589	0.609	0.595	0.597	0.562	0.574	0.580
A7	0.740	0.751	0.733	0.736	0.728	0.750	0.739	0.696	0.714	0.755	0.779	0.742

Table 6
The second normalised matrix

	E1	E2	E3	E4	S1	S2	S3	S4	G1	G2	G3	G4
A1	0.132	0.129	0.123	0.126	0.129	0.130	0.131	0.136	0.132	0.135	0.138	0.128
A2	0.120	0.117	0.123	0.118	0.129	0.121	0.127	0.136	0.124	0.124	0.122	0.128
A3	0.163	0.177	0.161	0.170	0.153	0.166	0.150	0.148	0.159	0.155	0.153	0.158
A4	0.167	0.161	0.170	0.162	0.153	0.150	0.157	0.148	0.159	0.159	0.153	0.158
A5	0.120	0.121	0.123	0.126	0.129	0.130	0.127	0.136	0.128	0.128	0.126	0.128
A6	0.132	0.129	0.135	0.130	0.141	0.134	0.139	0.136	0.136	0.128	0.130	0.132
A7	0.167	0.169	0.166	0.166	0.166	0.170	0.168	0.159	0.163	0.171	0.176	0.169

Table 7
The results of CRISUS approach

	E1	E2	E3	E4	S1	S2	S3	S4	G1	G2	G3	G4
ρ_j	0.146	0.147	0.146	0.146	0.144	0.145	0.144	0.143	0.144	0.145	0.145	0.145
σ_j	0.097	0.111	0.097	0.098	0.066	0.085	0.070	0.040	0.072	0.083	0.085	0.077
$\sigma_j \rho_j$	0.014	0.016	0.014	0.014	0.01	0.012	0.01	0.006	0.01	0.012	0.012	0.011
w	0.099	0.114	0.099	0.100	0.067	0.086	0.071	0.040	0.073	0.084	0.087	0.079
rank	3	1	4	2	11	6	10	12	9	7	5	8

The CRISUS analysis indicates that E2 (Carbon-Intensive Portfolio Risk), E4 (Environmental Compliance Risk), and E1 (Carbon Emission Risk) are the most critical determinants of banks' ESG risk performance, while S4 (Human Capital Risk), S1 (Customer Protection Risk), and S3 (Cybersecurity Risk) emerge as the least influential factors. The overall importance ranking of the criteria is as follows: E2 > E4 > E1 > E3 > G3 > S2 > G2 > G4 > G1 > S3 > S1 > S4.

5.2. The results obtained from the PIV methodology

The normalized decision matrix was calculated using Equation (7) and presented in Table 8. Subsequently, the weighted ranking matrix was obtained with the help of Equation (8) and reported in Table 9. The Weighted Proximity Index was derived through Equation (9), while the Overall Proximity Value was determined using Equation (10). Finally, the Weighted Proximity Index, the Overall Proximity Value, and the corresponding ranking results are summarized in Table 10.

Table 8
The normalized decision matrix

	E1	E2	E3	E4	S1	S2	S3	S4	G1	G2	G3	G4
A1	0.417	0.427	0.457	0.440	0.435	0.428	0.424	0.405	0.420	0.403	0.392	0.436
A2	0.469	0.481	0.457	0.475	0.435	0.464	0.440	0.405	0.454	0.455	0.460	0.436
A3	0.278	0.214	0.286	0.246	0.326	0.268	0.342	0.354	0.302	0.315	0.323	0.307
A4	0.260	0.285	0.247	0.281	0.326	0.339	0.310	0.354	0.302	0.298	0.323	0.307
A5	0.469	0.463	0.457	0.440	0.435	0.428	0.440	0.405	0.437	0.438	0.443	0.436
A6	0.417	0.427	0.400	0.422	0.381	0.411	0.391	0.405	0.403	0.438	0.426	0.420
A7	0.260	0.249	0.267	0.264	0.272	0.250	0.261	0.304	0.286	0.245	0.221	0.258

Table 9
The weighted ranking matrix

	E1	E2	E3	E4	S1	S2	S3	S4	G1	G2	G3	G4
A1	0.041	0.049	0.045	0.044	0.029	0.037	0.030	0.016	0.031	0.034	0.034	0.034
A2	0.046	0.055	0.045	0.048	0.029	0.040	0.031	0.016	0.033	0.038	0.040	0.034
A3	0.028	0.024	0.028	0.025	0.022	0.023	0.024	0.014	0.022	0.027	0.028	0.024
A4	0.026	0.032	0.025	0.028	0.022	0.029	0.022	0.014	0.022	0.025	0.028	0.024
A5	0.046	0.053	0.045	0.044	0.029	0.037	0.031	0.016	0.032	0.037	0.038	0.034
A6	0.041	0.049	0.040	0.042	0.025	0.035	0.028	0.016	0.030	0.037	0.037	0.033
A7	0.026	0.028	0.026	0.027	0.018	0.022	0.019	0.012	0.021	0.021	0.019	0.020

Table 10
Weighted proximity index, overall proximity index and ranking results

	E1	E2	E3	E4	S1	S2	S3	S4	G1	G2	G3	G4	μ_i	Rank
A1	0.015	0.024	0.021	0.019	0.011	0.015	0.012	0.004	0.010	0.013	0.015	0.014	0.174	5
A2	0.021	0.030	0.021	0.023	0.011	0.019	0.013	0.004	0.012	0.018	0.021	0.014	0.206	7
A3	0.002	0.000	0.004	0.000	0.004	0.002	0.006	0.002	0.001	0.006	0.009	0.004	0.038	2
A4	0.000	0.008	0.000	0.004	0.004	0.008	0.003	0.002	0.001	0.004	0.009	0.004	0.047	3
A5	0.021	0.028	0.021	0.019	0.011	0.015	0.013	0.004	0.011	0.016	0.019	0.014	0.193	6
A6	0.015	0.024	0.015	0.018	0.007	0.014	0.009	0.004	0.009	0.016	0.018	0.013	0.162	4
A7	0.000	0.004	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	1

Based on the calculated μ_i values, the overall ranking of the banks was obtained. The results indicate that A7 (Yapı Kredi) is ranked first with the lowest proximity value, reflecting the minimum deviation from the ideal solution. This is followed by A3 (Halkbank) and A4 (İş Bankası), which also demonstrate relatively strong performance. A6 (Vakıfbank) occupies the fourth position, while A1 (Akbank) and A5 (Şekerbank) are placed in the fifth and sixth ranks, respectively. Finally, A2 (Garanti BBVA) is ranked last, as it exhibits the highest deviation from the best option.

6. VALIDATION TESTS

The validation procedures employed in this study serve a dual purpose: first, to examine the sensitivity of the proposed model to variations in criterion weights, and second, to benchmark its performance against established multi-criteria decision-making techniques. The scenario analyses, encompassing 120 distinct weighting schemes, provide strong evidence that the model's outcomes are not unduly

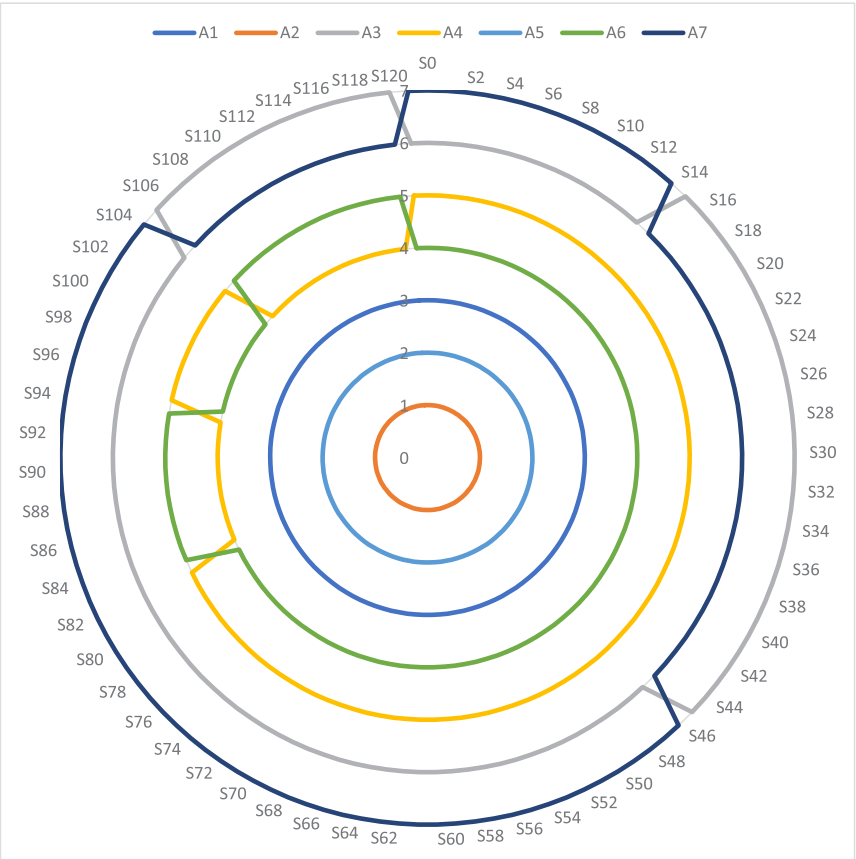
influenced by marginal changes in input parameters. This stability is particularly important in practical applications, where decision environments are often characterized by uncertainty and fluctuating stakeholder priorities. The comparative evaluation with MAUT and SAW further reinforces the credibility of the proposed hybrid framework. By demonstrating convergence in rankings across different methodological paradigms, the study confirms that the model is not only internally consistent but also externally validated against widely recognized approaches. Such methodological triangulation enhances confidence in the reliability of the results and underscores the model's potential applicability in diverse decision-making contexts.

6.1. Assessing the impacts of various weight values on rankings results

The robustness of the model was evaluated through 120 scenario analyses in which the weight values of all criteria were systematically varied (Görçün et al., 2022; Görçün et al., 2025). Specifically, in the first ten scenarios, the weight of the first criterion was gradually reduced from 10% to 100%, reaching 0%, while the weights of the remaining criteria were proportionally adjusted so that the sum of all fourteen criteria weights equaled one. The same procedure was subsequently applied to each of the other criteria, thereby generating ten scenarios per criterion and yielding a total of 120 distinct weighting schemes. As illustrated in Figure 2, alternative A7—identified as the optimal option under the proposed model—consistently retained its top ranking across all 120 scenarios. Likewise, alternatives A3 and A4 maintained their respective positions throughout the entire set of scenario analyses, confirming the stability of the ranking outcomes. While slight variations in the ranking occurred, these did not substantially affect the overall ordering of alternatives.

Figure 2

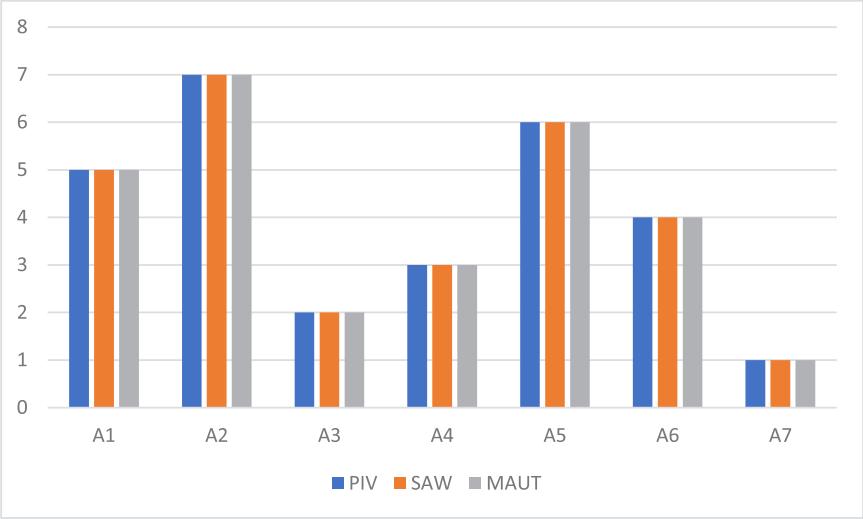
Impact of criteria weight changes on the ranking of bank alternatives



6.2. Comparison with other MCDM approaches

In the second phase of validating the proposed framework, a comparative analysis was undertaken using two established MCDM techniques, namely MAUT (Keeney and Raiffa, 1979) and SAW (MacCrimmon, 1968). The comparative results are presented in Figure 3. A review of the outcomes obtained from all three methods revealed that the ranking of alternatives remained unchanged. This consistency demonstrates the robustness of the suggested hybrid model and confirms its ability to deliver effective and reliable results, thereby reinforcing its suitability for application in diverse multi-criteria decision-making contexts.

Figure 3
Comparative ranking of alternatives obtained through alternative approaches



7. CONCLUSION

The growing importance of Environmental, Social, and Governance (ESG) risk management in the banking sector underscores the necessity of adopting rigorous analytical frameworks that can capture the multidimensional nature of sustainability challenges. By integrating the CRISUS weighting method with the PIV ranking procedure, this study provides a transparent and replicable approach to evaluating ESG risks among Turkish commercial banks listed in the BIST Sustainability Index. The primary objective was to identify the most critical ESG risk dimensions and to establish a comparative hierarchy of banks' resilience, thereby offering insights relevant to both academic research and practical policymaking.

The CRISUS analysis demonstrates that Carbon-Intensive Portfolio Risk (E2) holds the highest weight (w=0.114, rank=1), followed closely by Environmental Compliance Risk (E4) (w=0.100, rank=2), Carbon Emission Risk (E1) (w=0.099, rank=3), and Climate-Related Physical Damage Risk (E3) (w=0.099, rank=4). This outcome clearly indicates that environmental dimensions dominate the ESG risk landscape for Turkish banks. The predominance of E2 reflects the systemic vulnerability of banks' loan portfolios to transition risks associated with carbon-intensive industries. In parallel, the strong weight of E4 underscores the critical importance of regulatory alignment with environmental standards, suggesting that compliance failures could generate substantial financial and reputational costs. Within the governance dimension, Regulatory Compliance Risk (G3) (w=0.087, rank=5) and Corruption and Ethical Misconduct Risk (G2) (w=0.084, rank=7) emerge as highly influential. These findings highlight that governance failures, particularly in regulatory adherence and ethical conduct, remain material threats to institutional resilience. Transparency and ESG disclosure (G4) also occu-

pies a mid-level position (w=0.079, rank=8), reflecting the growing importance of accurate reporting in sustaining investor confidence and access to sustainable finance. Social risks, by contrast, exhibit relatively lower weights. Financial Inclusion Risk (S2) (w=0.086, rank=6) is the only social criterion with moderate influence, suggesting that inclusive finance remains a relevant but secondary differentiator among Turkish banks. Customer Protection Risk (S1) (w=0.067, rank=11), Cybersecurity Risk (S3) (w=0.071, rank=10), and Human Capital Risk (S4) (w=0.040, rank=12) occupy the lowest ranks. This pattern implies that, while social risks are acknowledged, they do not significantly differentiate banks' ESG performance in the current dataset. Overall, the CRISUS results reveal a hierarchy in which environmental and governance risks dominate, while social risks play a comparatively limited role. This distribution reflects both the regulatory pressures shaping environmental compliance and the structural importance of governance integrity in the Turkish banking sector.

The comparative evaluation of the banks based on the given criteria reveals a distinct ranking pattern. Yapı Kredi emerges as the best-performing alternative with the lowest score (0.008), indicating the minimum deviation from the ideal solution. It is followed by Halkbank (0.038) and İş Bankası (0.047), both of which demonstrate strong proximity to the optimal outcome. Vakıfbank occupies the fourth position (0.162), while Akbank (0.174) and Şekerbank (0.193) are placed in the middle range, reflecting moderate performance. Garanti BBVA, with the highest score (0.206), ranks last, signifying the greatest deviation from the ideal solution.

Building on the empirical evidence, the study translates its results into concrete policy implications for strengthening ESG risk management across stakeholder groups. For bank management, the outcomes highlight the importance of giving precedence to criteria with higher relative weights in strategic decision-making. Institutions exposed to elevated carbon portfolio risks should accelerate the adoption of green lending practices, while those with shortcomings in ESG reporting need to strengthen disclosure mechanisms to comply with international standards. Enhancing cybersecurity and governance structures is equally essential to reduce operational vulnerabilities and reputational exposure. For regulators, the evidence indicates that policy measures should concentrate on domains where banks display notable divergence, particularly in environmental compliance and governance transparency. Stricter disclosure obligations, incentives for green financial instruments, and sanctions for non-compliance would mitigate systemic ESG risks and promote greater consistency across the sector. In areas of relative uniformity, such as financial inclusion, regulators may set more ambitious objectives to encourage progress beyond baseline compliance. For investors, the PIV-based rankings serve as a valuable instrument for embedding ESG risk considerations into portfolio allocation strategies. Banks demonstrating stronger ESG risk management are likely to benefit from lower risk premiums and improved access to sustainable finance, whereas weaker performers may encounter higher funding costs. This mechanism of market discipline can accelerate the convergence of Turkish banks with global sustainability benchmarks.

Despite its methodological rigor, this manuscript is subject to certain limitations. The findings are confined to the context of Turkish banks and therefore cannot be generalized to other banking sectors. Moreover, the evaluation relies on expert-based judgments; although the panel comprises professionals with substantial expertise in ESG and banking practices, the number of experts remains relatively limited. Future research could strengthen the proposed framework by engaging a larger and more diverse pool of experts or by triangulating expert opinions with large-scale ESG databases. Expanding the empirical scope to include banks across multiple jurisdictions would enhance the comparative validity of ESG risk assessments. From a methodological standpoint, integrating CRISUS–PIV with advanced fuzzy, grey-based, or hybrid multi-criteria decision-making extensions may better capture uncertainty, dynamic interactions, and interdependencies among criteria. Comparative analyses between emerging and developed economies could further illuminate how institutional maturity, regulatory environments, and market structures shape ESG risk prioritization. Additionally, incorporating qualitative dimensions—such as stakeholder perceptions, corporate culture, and strategic orientation—into quantitative models would enrich the explanatory power of ESG evaluations. Finally, co-

upling CRISUS–PIV with machine learning and explainable AI techniques offers promising avenues for predictive modeling, scenario analysis, and benchmarking, thereby equipping both academics and practitioners with a more comprehensive toolkit for advancing sustainable finance research.

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