**FINANCIAL PERFORMANCE EVALUATION USING FUZZY GRA AND FUZZY ENTROPY METHODS: WHOLESALE AND RETAIL INDUSTRY[[1]](#footnote-1)**

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**Abstract**

Financial evaluation is the starting point for making business plan and strategy, therefore, this study aimed mainly to present an effective approach to evaluate the financial performance of the BIST Wholesale and Retail Industry firms listed on Istanbul Stock Exchange over the period of 2015-2018. The Fuzzy Grey Rational Analysis (GRA) method is used to evaluate financial performance of different alternatives considering the distances between fuzzy sets based on the grey and fuzzy theory. While, Fuzzy Entropy method is used to determine the relative importance of 15 financial criteria (ratios). Based on a comprehensive financial evaluation framework the study ranks the financial performance of the 17 wholesale and retail trade index firms and shows that MIPAZ firm has the best relative financial performance. Moreover, net profit margin ratio has the highest relative importance indicator for evaluating financial performance. A sensitivity analysis is presented for confirming validity of the proposed model, in addition to a comparison between fuzzy GRA and GRA is demonstrated to test the reliability of the proposed model.

***Keywords:*** *Financial performance evaluation, Financial Ratios, Fuzzy GRA, Fuzzy Entropy.*

***JEL Classification:*** *L81, G11, O16*

**BULANIK GİA VE BULANIK ENTROPİ YÖNTEMLERİNE DAYALI FİNANSAL PERFORMANS DEĞERLENDİRME: TOPTAN VE PERAKENDE ENDÜSTRİ**

**Öz**

Finansal değerlendirme, işletme planı ve stratejisi için başlangıç noktasıdır. Bu nedenle, çalışmada BIST Toptan ve Perakende Ticaret indeksindeki şirketlerin 2015-2018 dönemindeki finansal performanslarını değerlendirmek için etkili bir model sunmak amaçlanmıştır. Finansal performans çok boyutlu bir kavram olduğundan, çalışmada çok kriterli karar verme yöntemlerinden Bulanık Gri İlişkisel Analiz (GİA) yöntemi ve Bulanık Entropi yöntemi kullanılmıştır. Bulanık GİA, Gri teoriye dayalı bulanık kümeler arasındaki mesafeleri göz önünde bulundurarak farklı alternatiflerin finansal performansını değerlendirmek için kullanılmıştır. Bulanık Entropi yöntemi ise, çalışmada kullanılan kârlılık, kaldıraç, büyüme, likidite, verimlilik ve piyasa oranlarının ağırlıklarını hesaplamak için kullanılmıştır. Önerilen modeli, toptan ve perakende ticaret endeksinde yar alan 17 şirkete uygulanmış olup ve MIPAZ şirketinin en iyi finansal performansa sahip olduğu sonucuna ulaşılmıştır. Önerilen modelin geçerliliğini doğrulamak için duyarlılık analizi ve GİA ile karşılaştırma analizi yapılmıştır. Bu doğrultusunda, çalışma sonuçları toptan ve perakende ticaret firmalarının değerlendirilmesinde önerilen modelin geçerli ve güvenilir olduğunu göstermiştir.

***Anahtar kelimeler:*** *Finansal Performans değerlendirme, Finansal oranları, Bulanık GİA, Bulanık Entropi.*

***JEL Sınıflandırılması:*** *L81, G11, O16*

**1. Introduction:**

The wholesale and retail industry is an engine of growth and employment, which plays a critical role in the future of Turkey’s economy and prosperity. Turkish wholesale industry includes all businesses that selling to an intermediary business, in other word it is a type of business-to-business (B2B). While, Turkish retail industry is an organized umbrella including clothing retailers, shopping centers, food retailers, chain stores, and restaurants. Meanwhile the wholesale and retail sales account shares of 12% in the gross domestic product, and is expected to continue growing in the upcoming periods, in spite of the expected future fluctuated circumstances. In the other hand, the economic and social contributions of the wholesale and retail industry are revealed in every aspect of daily life. Based on that, the necessity of evaluating the financial performance of the Turkish wholesale and retail industry has been driven. While, there is no previous study have been considered the financial performance of this industry, this study significantly adds to the literature

Financial performance significantly influences current and future decisions, as it may reveal critical information for managers concerning recent trends and potential occurrences that in turn influences firm strategic planning or implementation of ongoing operational policy. Meanwhile, financial performance evaluation is important for all stakeholders, as they can better understand their relative positions in a company’s capital mix.

Several authors have highlighted financial ratio analysis as a reliable indicator for evaluating and comparing the firm performance over the years and against other rivals in the same industry. Early, Chadwick (1984) showed that ratios may be used to illustrate the broad aspects of financial and managerial performance, although it could help assess the effects of internal and external environmental factors upon the company; managerial decisions, governmental legislation, economic factors and so on. More recently, Borhan, et al. (2014) showed that financial ratios have an impact on the company's financial performance as; higher liquidity shows that the company is in good condition, while higher leverage is a warning sign that the company is at risk. However, the rule of thumb is that the higher the risk, the higher the expected return. In addition, a higher profitability means that the company is highly efficient.

Multi Criteria Decision Making (MCDM) methods are used to identify the ideal choice and evaluate performance for various industries despite of the confliction, uncertainty and imprecision among the alternatives. However, financial ratios have significant advantages, a significant shortness and imperfection existed in case of using ratios in isolation. Therefore, the study employs MCDM to conduct a comprehensive financial evaluation framework. Furthermore, the study considers fuzzy model to overcome the uncertainty among a wide boundary of alternatives, Li and Zahoa (2016) showed that fuzzy model could efficiently grasp the ambiguity in available information as well as the fuzziness in human judgment and preferences.

Grey Relational Analysis (GRA) method was proposed by Deng in 1982, based on the greyness concept which is the incomplete or unknown information. GRA method is used to measure the relationships among elements when the trends of their development have either homogeneity or heterogeneity (Deng 1989). In addition, Wu (2002) found that GRA method has advantages over other MCDM methods as its calculations easy, straightforward and based upon original data, although it is one of the best methods to make decisions under business environment.

In this regard, GRA is supposed to evaluate financial performance of different alternatives reliably, while fuzzy GRA is more reliable in case of studying the distance between fuzzy sets as it is proposed based on the grey and fuzzy theory, assessment of alternatives with respect to criteria and the importance weights of criteria.

Therefore, for evaluating and ranking the financial performance of the “BIST” wholesale and retail industry listed on Istanbul Stock Exchange, the study uses fuzzy GRA method and fuzzy Entropy method for determining the relative importance and weighting performance indicators.

The reminder of the study is organized as follow: The next section contains the literature review and defines the performance indicators. The research method and the proposed methodology section describes GRA, Fuzzy GRA and Fuzzy Entropy. The application section illustrates how the propped methodology applied on the target industry. While results and discussion section contains the financial performance evaluation results of the fuzzy GRA and sensitivity analysis of the evaluation results and comparison with other method. The last section sets out the conclusions and suggestions for further studies.

**2. Literature Review:**

The financial performance improvement of any firm does not only promote the market value of individual firms but although the whole industry, in parallel with its contributions toward the overall growth of the economy. As the financial evaluation is the starting point for making business plan and strategy, before using any sophistical forecasting and planning procedures, there is a necessity to study the financial performance evaluation. In addition, Yalcin et al. (2012) asserted on the necessity of improving the tools of measuring the financial performance as the increasing changes in market competition, liberalization and internationalization of financial market, the mobility of capital, and the continuing attempts to increase the company value and develop financial performance.

However, there are variety of ways to deﬁne and measure firm ﬁnancial performance but primarily financial characteristics of liquidity, solvency, proﬁtability, repayment capacity, and ﬁnancial efﬁciency need to be considered. In the same regard Horrigan (1968) described how financial ratios were used in the late nineteenth century for credit analysis, as well as for managerial analysis that emphasized profitability measures. More recently, (Feng and Wang, 2000; Bertoneche and Knight, 2001) showed that ratio analysis is a primary analytical technique of financial statements provides the basis for valuing a business and appraising its financial health.

Using financial ratios in performance evaluation process can be suitable for both the individual firm and the related sector. TEKER el at. (2016) supposed that to evaluate financial performance of a firm, there are various indicators to include in modelling; leverage, liquidity, operational efficiency, profitability, growth and other factors are the main tools to certainly examine.Throughout the years, the literature of financial performance evaluation has been developed, as more comprehensive evaluation models have been established based on financial ratios, Table 1 shows some of the related previous studies.

Five main financial performance criteria were used in the study, they are; liquidity, leverage, efficiency, profitability and growth ratios. Each financial performance criterion was chosen based on the related previous literature, as collectively, they represent commonly used financial performance indicators.

Liquidity ratios, are an indication of a company's ability to pay its debts as those debts fall due (Chadwick,1984). Liquidity ratios are calculated using the following equations:

 (1)

Table 1: **Financial Performance Indicators Employed in the Literature.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Author**  | **Liquidity Ratio** | **Leverage Ratio** | **Efficiency Ratio** | **Profitability Ratio** | **Growth Ratio** |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Ho and Wu (2006) |  |  |  | ✓ | ✓ | ✓ |  |  | ✓ | ✓ |  |  | ✓ | ✓ | ✓ |
| Edirisinghe and Zhang (2008) | ✓ | ✓ |   | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |   |   |   |
| Ahrendsen and Katchova (2012) | ✓ |   | ✓ | ✓ | ✓ | ✓ |   |   | ✓ | ✓ |   |   | ✓ |   |   |
| Katchova and Enlow (2013) | ✓ | ✓ |   | ✓ |   | ✓ |   |   | ✓ | ✓ | ✓ | ✓ |   |   |   |
| Reddy et al. (2013) | ✓ | ✓ |   |   | ✓ | ✓ |   | ✓ | ✓ | ✓ | ✓ |   | ✓ |   |   |
| Shaverdi et al. (2014) | ✓ | ✓ |  |  | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |  |  | ✓ | ✓ |
| Kazan and Özdemir (2014) | ✓ | ✓ |   | ✓ |   | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |   |   |   |
| Önder and Altintaş (2017) | ✓ | ✓ |   |   |   | ✓ |   |   | ✓ | ✓ | ✓ |   |   |   | ✓ |
| Chan and Abdul-Aziz (2017) | ✓ | ✓ |   | ✓ | ✓ | ✓ |   |   | ✓ | ✓ | ✓ |   |   |   |   |
| Karimi and Barati (2018) | ✓ | ✓ | ✓ |   |   | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |   |   | ✓ |   |
| Aras et al. (2018) | ✓ |   | ✓ | ✓ | ✓ | ✓ |   |   | ✓ | ✓ | ✓ |   | ✓ |   | ✓ |
| Perçin and Aldalou (2018) | ✓ | ✓ | ✓ | ✓ |  | ✓ | ✓ | ✓ | ✓ |  |  |  |  |  |  |

 (2)

 (3)

The leverage (solvency) ratio is the farm’s ability to pay all its debt if the farm were to be sold and all assets used to cover debt. (Ahrendsen and Katchova, 2012)

 (4)

 (5)

Financial efﬁciency shows how effectively the farm business uses assets to generate income. (Ahrendsen and Katchova, 2012)

 (6)

 (7)

 (8)

Proﬁtability is the difference between the value of goods produced and the cost of the resources used in their production (Ahrendsen and Katchova, 2012). The most common used indicators of profitability are the Return on Investment (ROI), the Return on Equity (ROCE) and the evolution of profit margins.

 (9)

 (10)𝑞𝑢𝑖𝑡𝑦𝑜𝑛 profit margins,cretria were used in the study , they are; (11)

 (12)

 (13)

Growth ratios, which are simply expressed as the difference between two values in time in terms of a percentage of the first value.

 (14)

 (15)

Previous studies show how the MCDM methods are utilized to formulate effective solutions for real problems in practice. MCDM methods are categorized based on the concept of selecting the alternative into hierarchical, compromise and outranking ranking methods (Aldalou and Perçin, 2020). Early in 1970s MCDM methods have been used in operation and decision-making theory, later on appeared in various disciplines such as financial evaluation (Roy and Das, 2018). Because financial performance evaluation problems take into consideration various and contradicting criteria, they are considered MCDM problems. In the same regard authors use different MCDM methods for evaluating financial performance (Saini and Khanduja, 2019; Kumar, 2016; Roy and Das, 2018; Perçin and Aldalou, 2018; Eyüboglu and Çelik, 2016; Visalakshmi et al., 2015; Onder and Altintas, 2017; Lee et al., 2018).

While, hierarchical MCDM methods work based on priority-based theory as the relative value of alternatives are used rather than the actual values, in other word, consider problem as unidirectional situation (Panjwani et al., 2019 and Girubha et al., 2016). Compromise and outranking MCDM methods select the most preferable alternative, as constructing comparison among all alternatives and finding out the best performing alternative in relation with others (Aldalou and Perçin, 2020). However, in the real-world business environment the problem situation is not unidirectional neither comparison among alternatives is precise. Therefore, GRA method has advantages over other MCDM as it is developed based on grey theory which considers the vagueness and uncertainty of real problem while handling original data in straightforward way (wu, 2002).

Before starting to assess alternatives, the importance level of the assessment criteria needs to be identified. There are many methods that can be used for assigning criteria weights which can be classified into subjective methods such as (AHP, SWARA and DAMATEL) and objective methods such as (Entropy and CRITIC). Relaying on the idea of information entropy and avoiding the subjectivity of decision makers (Wu et al., 2011) Fuzzy entropy is highly preferred by many researchers. Zhang and Liu (2011) used fuzzy entropy to define the weight for personnel selection criteria, Erol et al., (2014) used Fuzzy entropy to select the best potential alternative for nuclear power plants in Turkey, Ji et al., (2015) assed the risk of hydropower stations in the Xiangxi River based on Fuzzy entropy and, Aldalou and Perçin (2020) used Fuzzy entropy to evaluate the financial performance of Turkish Information and communications technology sector. On the other hand, for selecting the most appropriate alternatives many researchers used Fuzzy GRA method; Li and Zhao (2016) used Fuzzy GRA to evaluate the performance of developing eco-industrial plants in China, Ayağ and Samanlioglu (2019) evaluated the energy sources in Turkey using Fuzzy GRA, Lee and Kang (2019) evaluated the service quality of Korean airlines using Fuzzy GRA.

Meanwhile, the wholesale and retail sales account shares of 12% in the gross domestic product of Turkey, and is expected to continue growing in the upcoming periods, there is no previous study that have been considered the financial performance of this industry. Therefore, this study significantly adds to the literature as the first study to consider the financial performance of wholesale and retail industry in Turkey.

**3. The Proposed Methodology and Research Method:**

**3.1. The Proposed Methodology:**

The study aims to identify the appropriate ﬁnancial criteria for performance evaluation, ranking and selection of the most efﬁcient companies listed on BIST Retail industry index.

The proposed methodology is divided into two phases as shown in Figure 1.

In the first phase: the data was obtained from the annual financial reports of the BIST wholesale and Retail Industry of 2015-2018, then the financial ratios; Liquidity Ratios; (current ratio, quick ratio, working capital turnover ratio), Leverage Ratios; (debt to total assets, debt to equity), Efficiency Ratios; (assets turnover, account receivable turnover, stock turnover), Profitability Ratios; (ROA, ROE, net profit margin, gross profit, operating profit) and Growth Ratios; (sales growth, assets growth) were calculated.

In the second phase: Fuzzy Grey Relational Analysis method was used for evaluating and ranking the alternatives. While, in order to identify the relative importance of criteria and determine the subjective weights, Fuzzy entropy method was used based on the information of the decision matrix. Fuzzy theory was used to handle the uncertainty and vagueness of data.

Figure1: **Research Framework.**

Obtaining financial reports (2015-2018) of BIST wholesale and retail industry and determining financial indicators

Construct the fuzzy decision matrix of the BIST wholesale and retail industry

Calculate the normalized decision matrix

Determine the reference series

Establish the distance matrix

Calculate the fuzzy grey relational coefficient

Estimate the fuzzy grey relational grade by using the weights

Apply defuzzification with respect to:

* Normalize the decision matrix
* Calculate the interval entropy's lower and upper bounds
* Calculate the lower and upper pounds of the interval of diversification
* Calculate the interval weights of criteria
* Defuzzify the interval fuzzy numbers into a crisp value (Weights)

Center of Area (COA)

-cut method

Compare fuzzy GRA with GRA method

Fuzzy Grey Relational Method

Fuzzy Entropy Method

Conduct sensitivity analysis

**3.2. Research Method:**

**3.2.1 Fuzzy Entropy Method:**

Entropy method was proposed by Shannon in 1948, it has been widely used in variety of fields such as engineering, management, health, etc. Shannon’s entropy is a well-known method in obtaining the weights for MCDM problems especially for obtaining a suitable weight when the preferences and decision makers experiments are not available. Generally, entropy is used for evaluating the decision making units and employing them for weighting decision criteria. The fuzzy entropy concept has been introduced by Ishikawa and Mieno in 1979 and has been used to evaluate the subjective value of information under uncertainty conditions in the pattern recognition problem (Narayanamoorthy et al.,2019). Shannon’s entropy main steps are shown in Figure 2 and all the steps are explained in the next section in step 6 (6.1-6.6 steps).

Figure 2: **Shannon’s Entropy Steps**

**3.2.2. Fuzzy Grey Relational Method:**

GRA has been developed by Deng (1982), is one of the widely applied MCDM methods, is also a quantitative analysis tool of grey system theory, which can address imprecise and incomplete information (Deng, 1988; Ishikawa and Mieno, 1979). The principle of GRA is to analyze the similarity relationship between the reference series and alternative series (Wu, 2017). The main procedure of GRA is shown in Figure 3.

Figure 3: **Grey Relational Analysis Procedure**

Due to the globalizations, increasing competition and the complicity of financial markets, the uncertainty and vagueness of the financial data has increased, which creates the need for a complicated process. Fuzzy theory is often used to handle such imprecision of data (Li & Zhao, 2016). Thus; Fuzzy GRA method is used in this study to evaluate the financial performance of wholesale and retail industry of turkey. In which, fuzzy GRA method is a generalization of GRA on fuzzy and vague environment. The steps of the Fuzzy-GRA method can be defined as follows (Karimi et al., 2018; Gumus et al., 2013):

Step 1. Construct the fuzzy decision matrix of BIST Wholesale and Retail Trade firms (alternatives) and the financial ratios; assuming the situation under consideration has m alternatives, and n decision criteria

 The decision matrix is as follow:

 (16)

: is the performance value of alternative i from the view point of criterion j

: expresses the lowest ratio over 2015 to 2018 for alternative with respect to criterion

: expresses the average ratio over 2015 to 2018 for alternative with respect to criterion

: expresses the highest ratio over 2015 to 2018 for alternative with respect to criterion

Step 2: Calculate the normalized decision matrix R. Given the normalized performance rating can be calculated as:

 (17)

 (18)

Step 3: Determine the reference series. The reference series can be defined as:

 (19)

Step 4: Establish the distance matrix. The distance between the reference value and each comparison value is given as:

 (20)

Step 5: Calculate the fuzzy grey relational coefficient. The fuzzy grey relational coefficient is defined as:

 (21)

Step 6: Estimate the fuzzy grey relational grade by the relation:

 (22)

As is the weight of the jth criterion and where is calculated by the procedure of fuzzy Shannon’s entropy that can be expressed in a series of steps (Yin et al., 2017; Lotfi & Fallahnejad, 2010)

Step 6.1: Construct the fuzzy interval data decision matrix, from fuzzy decision matrix shown in equation 16, by using the α-level sets.

Triangular fuzzy number (TFN) can be transformed into Fuzzy interval data using levels of confidence 1-α, explained as follow;

 (23)

The fuzzy interval decision matrix would be as in the following equation:

 (24)

Step 6.2: Normalize the decision matrix as in the following equation:

 (25)

The raw data are normalized to eliminate anomalies with different measurement units and scales. This process transforms different scales and units among various criteria into common measurable units to allow for comparisons of different criteria.

Step 6.3: Calculate the interval entropy's lower bound and upper bound

,

 (26)

Where k is the entropy constant and. If, and/or then is equal to zero.

Step 6.4: Calculate the lower and upper pounds of the interval of diversification;

, (27)

Step 6.5: Calculate the interval weights of criteria:

 (28)

Theorem; the inequality is held.

Step 6.6: Defuzzify the interval fuzzy numbers into a crisp value using the following equation

 (29)

Then criteria weights should be normalized as

Step 7: Apply defuzzification with respect to center of area and α-cut methods.

Center-of-Area (CoA) Defuzzification the center-of-area defuzzification method is a way of transforming fuzzy triangular numbers into crisp numbers. This method can determine actual priorities and overall scores. For a convex fuzzy number , a real number corresponding to its center of area of can be estimated as:

 (30)

α-Cut Method The α-cut method is used to validate the proposed methodology results and. The α-cut method compares two fuzzy numbers A and B in terms of their α-cuts and

The α-cuts can be applied to transform the total weighted performance matrices into interval performance matrices, which provide left α and right α for each alternative as follows:

 (31)

Then the interval matrices are converted into crisp values. It is done by applying the λ function and λ values are ranged between 0 and 1:

 (32)

Step 8: Rank the alternatives in accordance with the value of grey relational grade; the bigger the value is, the better is among the alternatives.

**3.3. Applications of the Proposed Methodology:**

The precision of evaluation model depends in one way or another on the characteristics of data, which has considerable margin of uncertainty. The implicit uncertainty in financial performance evaluation process especially in data or in determining financial indicators has significant impact on evaluation accuracy. To overcome challenge of inaccuracy this study integrates the grey relational analysis with fuzzy theory in the evaluation process.

Assume that A= {A1, A2,... A17} is a set of alternative retail firms shown in Table 2, while C= {C1, C2, ..., C15} is a criterion set of 15 financial ratios indicators, in which the set of performance indicators shown in Table 3. The 15 financial ratios are classified into five categories: liquidity, leverage, efficiency, profitability, and growth.

Table 2**: Fuzzy GRA Alternatives (Wholesale and Retail Industry Firms)**

|  |  |  |
| --- | --- | --- |
| Code | BIST Code | Firm |
| A1 | ADESE | ADESE ALIŞVERİŞ MERKEZLERİ TİCARET A.Ş. |
| A2 | BIMAS | BİM BİRLEŞİK MAĞAZALAR A.Ş. |
| A3 | BIZIM | BİZİM TOPTAN SATIŞ MAĞAZALARI A.Ş. |
| A4 | CRFSA | CARREFOURSA CARREFOUR SABANCI TİCARET MERKEZİ A.Ş. |
| A5 | DOAS | DOĞUŞ OTOMOTİV SERVİS VE TİCARET A.Ş. |
| A6 | INTEM | İNTEMA İNŞAAT VE TESİSAT MALZEMELERİ YATIRIM VE PAZARLAMA A.Ş. |
| A7 | MAVI | MAVİ GİYİM SANAYİ VE TİCARET A.Ş. |
| A8 | MEPET | MEPET METRO PETROL VE TESİSLERİ SANAYİ TİCARET A.Ş. |
| A9 | MGROS | MİGROS TİCARET A.Ş. |
| A10 | MIPAZ | MİLPA TİCARİ VE SINAİ ÜRÜNLER PAZARLAMA SANAYİ VE TİCARET A.Ş. |
| A11 | PSDTC | PERGAMON STATUS DIŞ TİCARET A.Ş. |
| A12 | SANKO | SANKO PAZARLAMA İTHALAT İHRACAT A.Ş. |
| A13 | SELEC | SELÇUK ECZA DEPOSU TİCARET VE SANAYİ A.Ş. |
| A14 | SOKM | ŞOK MARKETLER TİCARET A.Ş. |
| A15 | TKNSA | TEKNOSA İÇ VE DIŞ TİCARET A.Ş. |
| A16 | TGSAS | TGS DIŞ TİCARET A.Ş. |
| A17 | VAKKO | VAKKO TEKSTİL VE HAZIR GİYİM SANAYİ İŞLETMELERİ A.Ş. |

Table 3: **Financial Performance Indicators**

|  |  |  |
| --- | --- | --- |
| Code | Sub-Financial Indicator | Main Financial Indicator |
| C1 | Current Ratio | Liquidity Ratio |
| C2 | Quick Ratio |
| C3 | Working Capital Turnover Ratio |
| C4 | Debt to Total Assets Ratio | Leverage Ratio |
| C5 | Debt to Equity Ratio |
| C6 | Assets Turnover Ratio | Efficiency Ratio |
| C7 | Account Receivable Turnover Ratio |
| C8 | Stock Turnover Ratio |
| C9 | ROA Ratio | Profitability Ratio |
| C10 | ROE Ratio |
| C11 | Net Profit Margin  |
| C12 | Gross Profit Margin |
| C13 | Operating Profit Margin  |
| C14 | Sales Growth Ratio | Growth Ratio |
| C15 | Assets Growth Ratio |

**3.3.1. The Value of Evaluation Indicator of Each Firm:**

In this study, the criteria values of alternative firms are considered as grey triangular fuzzy number; as each alternative firm has triangle value for each financial indicator, which expresses; the lowest value, the average and the highest value over the period of 2015-2018. The original value of each financial ratio for each firm is calculated and shown in Table 4, which represents the decision matrix.

Table 4**: The Decision Matrix**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **ADESE** | **BIMAS** | **…** | **VAKKO** |
| **C/Year** | **2018** | **2017** | **2016** | **2015** | **2018** | **2017** | **2016** | **2015** |  | **2018** | **2017** | **2016** | **2015** |
| **C1** | 0.61 | 0.84 | 0.94 | 1.18 | 0.94 | 0.94 | 0.89 | 0.90 | 1.19 | 1.26 | 1.36 | 1.47 |
| **C2** | 0.50 | 0.53 | 0.61 | 0.74 | 0.53 | 0.56 | 0.52 | 0.49 | 0.41 | 0.57 | 0.71 | 0.71 |
| **C3** | -2.91 | -11.14 | -34.97 | 13.48 | -111.85 | -108.52 | -64.08 | -73.05 | 10.63 | 8.59 | 7.24 | 6.42 |
| **C4** | 0.54 | 0.50 | 0.51 | 0.49 | 0.61 | 0.58 | 0.62 | 0.60 | 0.66 | 0.61 | 0.58 | 0.57 |
| **C5** | 1.19 | 1.01 | 1.05 | 0.94 | 1.55 | 1.38 | 1.62 | 1.50 | 1.93 | 1.57 | 1.37 | 1.30 |
| **C6** | 0.45 | 0.61 | 0.67 | 0.75 | 3.61 | 3.53 | 4.02 | 4.18 | 1.16 | 1.13 | 1.18 | 1.19 |
| **C7** | 14.08 | 25.42 | 20.60 | 18.63 | 27.87 | 28.24 | 31.09 | 33.15 | 10.08 | 7.18 | 7.08 | 7.32 |
| **C8** | 7.98 | 4.40 | 4.46 | 4.30 | 12.69 | 14.11 | 14.93 | 14.98 | 1.22 | 1.49 | 1.93 | 1.99 |
| **C9** | -0.01 | 0.04 | 0.03 | 0.06 | 0.14 | 0.12 | 0.13 | 0.14 | 0.08 | 0.07 | 0.03 | 0.01 |
| **C10** | -0.03 | 0.08 | 0.07 | 0.12 | 0.36 | 0.29 | 0.35 | 0.35 | 0.22 | 0.18 | 0.08 | 0.02 |
| **C11** | -0.03 | 0.06 | 0.05 | 0.08 | 0.04 | 0.03 | 0.03 | 0.03 | 0.07 | 0.06 | 0.03 | 0.01 |
| **C12** | 0.21 | 0.23 | 0.23 | 0.23 | 0.18 | 0.17 | 0.17 | 0.16 | 0.54 | 0.53 | 0.52 | 0.50 |
| **C13** | -0.08 | 0.02 | 0.03 | 0.02 | 0.05 | 0.04 | 0.04 | 0.04 | 0.11 | 0.09 | 0.06 | 0.04 |
| **C14** | -0.21 | 0.07 | 0.01 | 0.06 | 0.30 | 0.23 | 0.15 | 0.21 | 0.39 | 0.25 | 0.15 | 0.18 |
| **C15** | 0.08 | 0.16 | 0.13 | 0.11 | 0.27 | 0.41 | 0.20 | 0.29 | 0.35 | 0.31 | 0.17 | -0.03 |

**3.3.2. The Weight of the Financial Indicators (Criteria):**

Five main financial ratios that cover five financial dimensions have been considered in order to rank out the firms; these financial indicators (ratios) have been weighted according to their relative importance. Fuzzy Entropy method is used to weight financial indicators (the steps of the method are shown in previous section) by using the same decision matrix (Table 4). Interval fuzzy weights and final weights of criteria are shown in Table 5. Figure 4 shows the weight of each financial indicator. Based on the proposed method stock turnover ratio and net profit margin has the highest weight or the most relative importance.

Table 5: **Interval Fuzzy Weights and Final Weights of Criteria**

|  |  |  |  |
| --- | --- | --- | --- |
| **Criteria** |  |  | **W** |
| **C1** | 0.03 | 0.09 | 0.048 |
| **C2** | 0.03 | 0.09 | 0.048 |
| **C3** | 0.05 | 0.16 | 0.086 |
| **C4** | 0.00 | 0.02 | 0.011 |
| **C5** | 0.04 | 0.13 | 0.069 |
| **C6** | 0.04 | 0.11 | 0.061 |
| **C7** | 0.03 | 0.09 | 0.048 |
| **C8** | 0.08 | 0.17 | 0.106 |
| **C9** | 0.02 | 0.21 | 0.093 |
| **C10** | 0.03 | 0.17 | 0.082 |
| **C11** | 0.09 | 0.18 | 0.109 |
| **C12** | 0.02 | 0.05 | 0.027 |
| **C13** | 0.05 | 0.15 | 0.081 |
| **C14** | 0.02 | 0.16 | 0.070 |
| **C15** | 0.01 | 0.14 | 0.063 |

Figure 4: **The Relative Importance of Financial Performance Indicators Based on Fuzzy Entropy**

**3.3.3. The evaluation results of fuzzy GRA and fuzzy Entropy:**

Based on the results of fuzzy GRA and fuzzy Entropy methods (A10) firm has the best financial performance among the wholesale and retail-trading index firms, while the rest of the firms are ranked out as shown in Table 6.

Table 6: **The Rank of the Wholesale and Retail Trading Index Firms by Using Fuzzy GRA Method**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rank/Firm  | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 | A15 | A16 | A17 |
| α-Cut | 15 | 2 | 11 | 16 | 13 | 8 | 10 | 5 | 7 | 1 | 6 | 3 | 9 | 14 | 17 | 4 | 12 |
| CoA Rank | 15 | 2 | 11 | 16 | 13 | 7 | 10 | 5 | 8 | 1 | 6 | 3 | 9 | 14 | 17 | 4 | 12 |

**4. Results and Discussion:**

The financial performances of the wholesale and retail industry firms listed on Istanbul Stock Exchange (BIST) are evaluated and ranked out by using combined methods of fuzzy Grey Relational Analysis and fuzzy Entropy, while determining financial indicators’ weights by employing objective or subjective methods does not significantly affect the results, fuzzy entropy method is preferred to use due to its objectivity. Based on that value of the proposed model the ranking of all firms in descending order are A10, A2, A12, A16, A8, A11, A9, A6, A13, A7, A3, A17, A5, A14, A1, A4, and A15.

**4.1. Sensitivity Analysis of the Evaluation Results:**

Sensitivity analysis is used to verify the stability and rationality of the proposed method and analyze the reliability as applying different α-cut values; α-cut=0.1, α-cut=0.3 and α-cut=0.5 in the defuzzification method do not affect the results.

Figure 5 illustrates how the outputs of applying different α-cut values are satisfactory, as the ranking orders of the three cases are closed. Though, the study can confirm that the results of the ranking orders of wholesale and retail trade firms by using the proposed methodology are reliable and these results can help decision-makers to improve the financial performance.

Figure 5: **Sensitivity Analysis with Different α-cut Values**

**4.2. Comparison between Fuzzy GRA and GRA:**

In order to examine the validity of the proposed model, the study compares the ranking results of fuzzy GRA and GRA methods, while maintaining the weight of the indicators, which calculated by fuzzy Entropy in order to conduct a reliable comparison. Figure 6 summarizes how the comparison between the two methods give a slightly different ranking. However, A10 has the highest rank in fuzzy GRA, in GRA has the third rank, at the same time the fourth rank in fuzzy GRA has the highest rank in GRA. The reasons behind the slightly difference is mostly a result of using different ranking principles besides the existence of uncertainty and vagueness of the decision information. In this regard, the results of the proposed and comparable methods illustrate the advantages that the proposed method have over the other methods, in which the proposed method can effectively deal with the constraints and easily evaluate, find and select the best alternative. Based on the comparison results this study can confirm that the results of the ranking orders of all alternatives by using the proposed method are valid.

Figure 6: **Comparison the Result of Fuzzy GRA and Crisp GRA**

**5. Conclusion:**

In this study, a comprehensive financial evaluation framework is developed by using triangular fuzzy sets and grey relational analysis in order to increase preciseness and decrease vagueness. The proposed evaluation framework is used to evaluate and rank the financial performance of the 17 wholesale and retail industry firms listed on Istanbul Stock Exchange. A total 15 of financial indicators dividing into the five categories are selected to reflect the financial performance of the firms.

A fuzzy GRA along with fuzzy Entropy methods are suggested for the study purposes. It is worth to mention that, fuzzy GRA is used to measure the distances of alternatives from fuzzy ideal points under uncertainty conditions and ambiguity of the available information, which enables researcher to asses and rank efficiently the 17 alternatives in the following descending order; MIPAZ, BIMAS, SANKO, TGSAS, MEPET, PSDTC, MGROS, INTEM, SELEC, MAVI, BIZIM, VAKKO, DOAS, SOKM, ADESE, CRFSA, TKNSA. Moreover, Fuzzy Entropy is used for obtaining objective weighting of financial indicators under uncertainty conditions and finds that net profit margin has the highest weight of 10.9%, which means the achieved net profit by firm is the most important indicator of evaluating financial performance.

A sensitivity analysis of α-cut was presented to test the validity and stability of the ranking order of alternatives, in which, the ranks of all alternatives are relatively stable in different α-cut values. In addition to a comparative study between fuzzy GRA and GRA was demonstrated to test the reliability of the proposed methodology which shows closed ranking order with slightly differences due to the favorable characteristic of fuzzy GRA in considering of ambiguousness and uncertainty. Based on that the study confirms that the results of the ranking orders of wholesale and retail trade firms by using the proposed methodology is valid and stable and reliable.

Whereas, the study provides a methodology of relatively reasonable and rational analysis methods for financial evaluation of wholesale and retail trade firms, the study confirms that using fuzzy GRA and fuzzy Entropy for financial evaluation is an effective method. Additionally, the study contributes to; firstly, the literature by proposing reasonable financial evaluation approach which could be applicable to adopt and apply on other sectors, secondly, suggests decision makers, investors and managers efficient and effective model to actively participate in decision making process and ultimately improve business performance.

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