VERİMLİLİK DERGİSİ
JOURNAL OF PRODUCTIVITY

Comparative Financial Efficiency and Performance Analysis with TOPSIS and MOORA Methods: An Application on Logistic Companies

İsmail Öztanır[1]

ABSTRACT

Purpose: This study aims to evaluate the financial performance and efficiency of logistics companies listed on Borsa Istanbul, with a focus on analyzing the impact of the pandemic through financial ratios from 2019 to 2023.

***Methodology*:** In the research, TOPSIS and MOORA methods, which are multi-criteria decision-making methods, were used. These methods were used to assess the performance of the companies with the help of selected financial ratios.

Findings: Analysis of the top three performing companies showed notably high efficiency ratios—particularly receivables and inventory turnover—alongside low debt levels. GSDDE, ranked first by the TOPSIS method, stood out with significantly higher operating profitability in its peak years. Additionally, companies with stronger liquidity (e.g., higher acid-test ratios) outperformed others, highlighting the importance of solid cash reserves during economic uncertainty.

Originality: It is unique in that it focuses on measuring financial efficiency in the logistics sector by using TOPSIS and MOORA methods together and is research that compares pre- pandemic and post-pandemic performance results in the light of the findings of recent studies in the relevant sector. The study provides a unique perspective on the impact of the COVID-19 pandemic (2019–2023) on the logistics sector, offering insights into key financial indicators such as efficiency, debt structure, and profitability trends.

Keywords*:* Financial Performance, Efficiency Analysis, TOPSIS, MOORA, Logistics Industry.

JEL Codes: C44, C60, G30, M40, M49.

TOPSIS ve MOORA Yöntemleri ile Karşılaştırmalı Finansal Verimlilik ve Performans Analizi: Lojistik Şirketlerine Yönelik Bir Uygulama

ÖZET

Amaç: Bu çalışma, Borsa İstanbul'da işlem gören lojistik şirketlerinin finansal performans ve verimliliğini değerlendirmeyi ve 2019-2023 yılları arasındaki finansal oranlar üzerinden pandeminin sektör üzerindeki etkilerini analiz etmeyi amaçlamaktadır.

***Yöntem*:** Araştırmada yöntem olarak çok kriterli karar verme yöntemlerinden TOPSIS ve MOORA kullanılmıştır. Bu yöntemler, seçilen finansal oranlar yardımıyla şirketlerin performans sıralamasında kullanılmıştır.

Bulgular: En iyi performans gösteren ilk üç şirketin finansal oranları incelendiğinde, özellikle alacak ve stok devir hızları gibi verimlilik oranlarının sektör ortalamasının üzerinde olduğu ve borç oranlarının düşük olduğu görülmüştür. TOPSIS yöntemine göre birinci sırada yer alan GSDDE, yüksek puan aldığı yıllarda diğer şirketlere kıyasla dikkate değer ölçüde yüksek faaliyet kârlılığı göstermiştir. Ayrıca, likiditesi güçlü olan (örneğin, yüksek asit-test oranına sahip) şirketlerin daha iyi performans sergilediği ve ekonomik belirsizlik dönemlerinde güçlü nakit rezervlerinin önemini vurguladığı anlaşılmıştır.

Özgünlük: TOPSIS ve MOORA yöntemlerini birlikte kullanarak lojistik sektöründe finansal verimliliğin ölçülmesine odaklanmış olması ve ilgili sektörde literatürde yakın zamanda yapılan çalışmaların bulguları ışığında pandemi öncesi ve sonrası performans sonuçlarını karşılaştıran bir araştırma olması bakımından özgündür. Çalışma, COVID-19 salgınının (2019-2023) lojistik sektörü üzerindeki etkisine dair benzersiz bir bakış açısı sunarak verimlilik, borç yapısı ve kârlılık eğilimleri gibi temel finansal göstergelere ilişkin fikirler sunmaktadır.

Anahtar Kelimeler*:* Finansal Performans, Verimlilik Analizi, TOPSIS, MOORA, Lojistik Sektörü.

JEL Kodları: C44, C60, G30, M40, M49.

[1] Aydın Adnan Menderes University, Nazilli Economics and Administrative Sciences Faculty, Department of Business Administration, Aydın, Türkiye

Corresponding Author: İsmail Öztanır, ioztanir@adu.edu.tr
DOI: 10.51551/verimlilik.1656798
Research Article | Submitted: 13.03.2025 | Accepted: 06.05.2025
Cite: Öztanır, İ. (2025). "Comparative Financial Efficiency and Performance Analysis with TOPSIS and MOORA Methods: An Application on Logistic Companies", *Verimlilik Dergisi,* 59(3), 531-548.

1. INTRODUCTION

The concept of logistics encompasses the array of services that allow businesses to deliver their products or services to their final destinations at the correct location and time. Logistics is crucial for businesses to maintain sustainable competition and ensure the continuity of production. Moreover, in developing countries, the logistics sector significantly impacts the economy by generating employment, increasing national income, and attracting foreign investments. The primary reason for the importance and scale of the logistics sector is that it supports all industries (Erdoğan and Kırbaç, 2021).

The efficiency of global trade relies on the logistics sector's ability to move products, information, finance, technology, and human resources throughout the supply chain. Logistics companies must also monitor their financial performance to endure and thrive during periods of significant uncertainty. Financial performance acts as a key performance indicator, offering insights into a company's financial health. This financial evaluation can be utilized to assess a company before entering any collaboration or partnership. Financial institutions and investors also use financial assessments for credit analysis. Additionally, financial analysis can guide a company in developing strategies to enhance its business potential and mitigate risks (Lee et al., 2021). Financial analysis can be based on a logistics company's annual report, which includes the profit and loss statement and balance sheet, both of which are historical records. These analyses may encompass liquidity, solvency, and profitability ratios to gauge a company's ability to meet short-term and long-term obligations and to generate profit. However, profitability remains the primary concern for a logistics company to create value, hire employees, invest in research and development, and sustain and grow the business (Anthony et al., 2019). Logistics companies can measure and perform successful evaluations based on financial analyses such as profitability ratios, debt ratios, current ratios. Analyzing all these financial ratios can provide insight into logistics companies' annual strategic planning investments, especially in their plans for purchasing, insurance and maintenance of transportation units (Lam et al., 2021).

When the relationship between logistics and other business activities is examined, the manager needs financial resources when performing logistics-related activities. This is also related to capital. The scarcity of capital makes spending difficult. However, sufficient capital ensures that activities operate regularly and on time. For example, it is necessary to spend money for vehicles and places such as trucks, warehouses, etc. needed for transportation. If financial resources are not found for these, the activity cannot be carried out and healthy transportation cannot be done. The second is stocks. Stocks should be checked frequently with the finance manager. Because the cost of goods arriving at the stock is important and excess stock causes unnecessary costs (Akarçay, 2011: 17).

This study begins with a review of relevant literature, with a particular focus on the logistics sector. In the methodology section, details about the companies analyzed and the financial performance ratios used are provided. The application of the TOPSIS method, along with its role in financial performance measurement, is then described, followed by an explanation of the MOORA method. The performance rankings of the selected companies for the 2019–2023 period is presented, and the findings are analyzed and compared with results from other studies in the literature in the results and discussion section. The study concludes with a discussion of its limitations and recommendations for future research.

2. LITERATURE REVIEW

The financial performance of businesses can be evaluated using various methods. Over the past fifteen years, multi-criteria decision-making (MCDM) techniques have gained prominence in financial performance measurements across different countries and industries. Among these, the TOPSIS method has emerged as a widely utilized approach, particularly for performance evaluation.

While numerous MCDM methods exist—such as AHP, ELECTRE, PROMETHEE, and VIKOR—TOPSIS is particularly valued for its conceptual simplicity, computational efficiency, and its capacity to provide an intuitively meaningful ranking by evaluating alternatives based on their geometric closeness to an ideal and negative-ideal solution (Hwang & Yoon, 1981; Behzadian et al., 2012). This makes it especially suitable in financial contexts where decision-makers need clear, actionable insights despite the complexity of the criteria involved. MOORA, on the other hand, has emerged as a highly reliable and consistent method due to its use of ratio analysis, offering robust results across various applications, including financial performance, project evaluation, and economic efficiency studies (Brauers & Zavadskas, 2006; Brauers & Zavadskas, 2010). Notably, both TOPSIS and MOORA outperform more computationally intensive methods when decision environments demand simplicity, transparency, and adaptability to different weighting systems (Zavadskas et al., 2016; Stanujkic et al., 2012). Furthermore, their frequent validation in the literature underlines their capacity to handle conflicting criteria and deliver stable, comparable results, making them highly applicable for assessing corporate financial performance (Yazdani & Payam, 2015;

Pamučar & Ćirović, 2015). Therefore, the application of these two methods in this study is strongly justified by their theoretical soundness, empirical credibility, and practical utility in the context of multi-criteria financial decision-making.

The analysis is specifically conducted on logistics companies listed on Borsa Istanbul. Accordingly, the subsequent sections, as summarized in Table 1, provide a comprehensive review of prior research concerning the financial performance evaluation of logistics firms.

The aim of the study conducted by Gümüş (2009) was to reveal the relationship between logistics activities and competitive strategies and business profits. When the relationship between logistics activities and business balance sheets was examined, it was seen that the slightest savings that could be made in logistics costs resulting from logistics activities carried out by businesses contributed to business profits at much higher rates. When the items of business balance sheets that logistics activities interact with were examined, it was seen that logistics activities were related to the asset; liquid assets, receivables and stocks items and the liability; short-term foreign resources, long-term foreign resources and equity. As a result, it was determined that businesses could gain competitive advantage with effective logistics management and that this competitive advantage could also be positively reflected in business profits.

In a study conducted by Birou et al. (2010), the impact of applied logistics knowledge on financial performance was examined comparatively between make-to-order and make-to-stock firms. The results show that higher investments in internal process improvement for make-to-order (MTO) firms are associated with higher applied channel logistics knowledge, whereas this relationship is not valid for make-to-stock (MTS) firms. In addition, the results show a positive relationship between internal process improvement investment and financial performance for MTO firms, but again this relationship is not valid for MTS firms. Although the increase in financial performance is significantly greater for MTO firms, both MTO and MTS firms show increased financial performance as applied channel logistics knowledge increases.

Hofmann and Lampe (2012) conducted a detailed balance sheet analysis of approximately 150 logistics service providers from all over the world. The study found that there were many differences in the financial structures of these companies. It was observed that this difference was especially in the asset and liquidity structure, and that the capital structures were mostly homogeneous. It was determined that profitability values emerged differently depending on high net profit margins or high asset turnover rates.

Küçükaltan et al. (2016) introduced a decision support model designed to identify and prioritize key performance indicators in the logistics sector. Their study proposed a stakeholder-driven Balanced Scorecard (BSC) approach, addressing the traditional BSC's limitations in considering diverse stakeholder perspectives. By integrating both financial (e.g., cost) and non-financial (e.g., social media) performance metrics, the model offers a more holistic assessment. Since these indicators are interdependent, the study applied the Analytic Network Process (ANP), a multi-criteria decision-making method, to examine their relationships. The combination of these two techniques provides a fresh perspective on evaluating logistics performance from industry professionals' viewpoints. The findings revealed that the most crucial factor for the competitiveness of logistics firms is having an educated workforce, accounting for 15.61% of the total weight.

Laari et al. (2018) explored the competitive strategies and green supply chain management (GSCM) practices of Finnish logistics service providers (LSPs), assessing their impact on environmental and financial performance. Their research found that top-performing LSPs—those with operational efficiency and strong brand presence—are more advanced in implementing GSCM compared to firms that lack a clear competitive advantage. While GSCM practices were shown to have a positive effect on environmental performance, no direct link to financial performance was observed.

In the research conducted by Konak et al. (2018), 23 textile companies traded on Borsa Istanbul were analyzed using TOPSIS and MOORA methods between 2010 and 2015. In the research, success scores were obtained using TOPSIS and MOORA methods in line with the variables determined to measure the financial performance of these companies, and the companies were ranked according to their performances with the obtained success scores. As a result, it was stated that the rankings created because of the analyzes made according to TOPSIS and MOORA methods were similar in the examined period.

Table 1. Literature summary

Author(s)	*Methods Used*	*Criteria / Focus Area*
Gümüş (2009)	Analysis of logistics activities and financial impacts	Relationship between logistics activities, business balance sheets, and profits. Competitive advantage via logistics.
Birou et al. (2010)	Comparative analysis between MTO and MTS firms	Applied logistics knowledge, financial performance, and internal process improvement in MTO vs. MTS firms.
Hofmann and Lampe (2012)	Balance sheet analysis	Financial structures, asset and liquidity differences, profitability metrics of 150 logistics service providers.
Küçükaltan et al. (2016)	Balanced Scorecard (BSC) model and Analytic Network Process (ANP)	Performance measurement of logistics companies
Konak et al. (2018)	TOPSIS and MOORA methods	Financial performance rankings for 23 textile firms (2010–2015) using success scores from TOPSIS and MOORA.
Laari et al. (2018)	survey data via an online questionnaire as part of the national Finland State of Logistics Survey 2014	Based on a Finnish national logistics survey and financial reporting data from 266 logistics service providers, article examines their competitive strategies and green supply chain management (GSCM), and tests their respective relationships with environmental and financial performance.
Lam et al. (2021)	Data envelopment analysis (DEA) and financial ratio analysis	Efficiency and financial performance of Malaysian logistics companies.
Erdoğan and Kırbaç (2021)	Entropy and WASPAS methods	Financial performance of logistics companies on Fortune 500 (2015–2019), with export amounts as a key criterion.
Komcorhnit (2021)	AHP-PROMETHEE method	Financial performance of Thai logistics service providers based on financial ratio criteria (4 main and 15 sub-criteria).
Sharma et al. (2021)	Fuzzy TOPSIS	Performance assessment of Indian retail firms focusing on sustainable reverse logistics practices.
Jang and Ahn (2021)	Panel regression	Financial factors influencing return on assets (ROA) and return on equity (ROE) vary across different business types. To empower financial stability, companies must improve management practices.
Erturgut & Oğuz (2022)	Cross-sectional data and regression analysis	Impact of EU logistics centers on exports, GDP, and foreign direct investments.
Altın and Filiz (2022)	MCDM and DEA (Entropy-EDAS, MAUT, MOOSRA)	Performance evaluation of Turkish logistics villages and suggestions for future development.
Atayah et al. (2022)	Correlation test of financial indicators with panel data	Examining pandemic impact on financial performance from the first quarter of 2010 until the last quarter of 2020 as the research sample
Meng and Wang (2022)	Balanced Scorecard model and analytic hierarchy process (AHP)	The performance evaluation of logistics enterprises
Işık (2022)	Grey Entropy, FUCOM and EDAS-M Methods	Export volume, employee count, and net sales as the most critical performance factors for the performance evaluation. Among the evaluated firms, Ekol Logistics ranked highest based on the selected criteria
Nguyen (2022)	Financial ratio analysis with Wilcoxon Signed Rank Test	No overall improvement, with increased leverage ratios and declines in profitability and efficiency, while liquidity remained stable. The pandemic severely affected export activities and international transportation, limiting growth to a few domestic logistics firms
Yürüyen et al. (2023)	MCDM methods of SV, MEREC, CRITIC and LOPCOW	Companies may increase both their logistics and financial performance by reducing the Number of Employees (ÇAS) and using more artificial intelligence systems (autonomous warehouse vehicles, artificial intelligence-supported stock control systems and artificial intelligence-based transportation systems
Nenavani et al. (2024)	Panel estimation of eighteen Indian-listed logistics companies and five global companies over 2013–2023	An important link exists between ESG disclosures and financial performance. ESG scores had a positive impact overall. Findings suggest that ESG benefits may take longer to materialize in operational performance.

Lam et al. (2021) evaluated the increase in the efficiency of logistics companies in Malaysia through data envelopment analysis. The financial performances of the companies were revealed through financial ratio analysis and data envelopment analysis, and it was determined that 5 companies, which constituted approximately 30% of the companies studied, were effective. It was revealed that these efficient companies were able to use their resources at the maximum level. It was determined that inefficient companies needed to reduce their input and increase their output to be efficient. As an example of this situation, it was stated that a series of measures could be taken to reduce the costs of assets, from better inventory management to reducing inventory carrying costs.

Erdoğan and Kırbaç (2021) analyzed the financial performance of logistics companies on the Fortune 500 list for the period 2015–2019 using the Entropy and WASPAS methods. The selected financial performance indicators included net sales, earnings before interest and taxes (EBIT), total assets, total equity, and export volume. According to the Entropy method, export volume emerged as the most significant performance criterion influencing the financial performance of logistics companies throughout the study period. In contrast, total assets and EBIT were found to have the least impact on performance during certain intervals. Rankings based on the WASPAS method identified Netlog and Borusan as the top-performing companies, with Netlog's success attributed primarily to a significant increase in net sales driven by exports.

In the research conducted by Komcorhnit (2021) the financial situation of logistics service providers in Thailand was examined with the integrated AHP-PROMETHEE method. The AHP method was selected to determine the weights of 4 main criteria and 15 sub-criteria based on financial ratios, while the PROMETHEE method was selected to rank from best to worst in terms of financial performance. As a result of the research, it was observed that the company, which is in a very good position in terms of activity and profitability ratios, is at the top of the ranking in terms of financial performance.

In a study conducted by Kumar et al. (2021) a performance assessment was conducted on Indian retail firms using the fuzzy TOPSIS method, considering sustainable reverse logistics (RL) practices. The major gap examined in the study was proper infrastructure and awareness at the store level. In this case, there is a need for clear guidelines on the manufacturing side on how to handle returns and logistics arrangements for manufacturers by the retailer. Retailers should be encouraged towards effective RL practices by the company. On the other hand, the government should also focus on RL and there should be some clear guidelines for RL. It has been found that it is imperative to ensure the adoption of RL to ensure the success of the firm in the long run and avoid challenges and hurdles with the help of promotion, incentive programs and compliance plans as it helps in capturing value from the entire global supply chain.

Ahn & Jang (2021) examined the financial structures of the Korean logistics industry and their impact on management performance, aiming to support stable industry growth. The findings reveal that financial factors influencing return on assets (ROA) and return on equity (ROE) vary across different business types. To strengthen financial stability, companies must improve management practices and adapt to these differences. This includes enhancing efficiency, increasing profitability, and diversifying their business portfolios to ensure long-term success.

In the research conducted by Erturgut and Oğuz (2022), it was aimed to determine the impact of logistics centers in European Union (EU) countries on exports using 2018 data with cross-section data and regression analysis method. As a result of the analysis, it was determined that there was a positive and significant relationship between logistics centers and exports, GDP and foreign direct investments. It was observed that a 1% increase in logistics centers caused a 0.9% increase in exports, while a 1% increase in GDP caused a 0.2% increase in exports and finally, a 1% increase in foreign direct investments caused a 0.7% increase in exports.

In a study conducted by Altın and Filiz (2022) the performance of logistics villages managed by the State Railways of the Republic of Turkey was assessed using MCDM and DEA (data envelopment analysis) methods. The study employed entropy-based EDAS, MAUT, and MOOSRA techniques. Efficiency scores for the logistics villages were determined using output-oriented DEA models. Based on the DEA findings, it is suggested that the logistics villages in Uşak and Istanbul (Halkalı) be used as models for future projects. The study indicates that Uşak logistics village could serve as a model for low-cost projects in regions with potential for development, while Istanbul (Halkalı) logistics village could be a model for large cities with growing industries.

Atayah et al. (2022) aimed to expand the existing logistics literature by analyzing the relationship between the financial performance of publicly traded logistics companies and the impact of COVID-19. The study also compared the financial performance of logistics firms across G-20 countries during the pandemic. The findings revealed that logistics firms experienced a notable increase in financial performance in 2020. On a country-specific level, the results aligned with the overall trend, as 14 out of the 20 nations analyzed saw

a significant improvement in their logistics firms' financial performance during the pandemic. However, the study also identified a decline in financial performance in six countries—Germany, Korea, Russia, Mexico, Saudi Arabia, and the UK—during the COVID-19 period).

Meng and Wang (2022) assessed the performance of logistics enterprises (LEs) in the context of online supply chain finance using the analytic hierarchy process (AHP). Their study developed a performance evaluation framework for LEs by incorporating the balanced scorecard model. AHP was then applied to assess logistics firms' performance within this framework. The research emphasized that in order to implement the online SCF model effectively, LEs need to enhance their performance evaluation systems to enable a more precise and systematic assessment of corporate performance. Identifying issues in a timely manner is crucial, as it allows companies to take proactive measures to support long-term growth and development. According to the results of performance evaluation, some suggestions have been put forward to optimize the performance of LE. These suggestions are "Meet Customer Needs and Improve Customer Satisfaction", "Improve the Business Ability of Employees" and "Improve Operational Efficiency".

Işık (2022) evaluated the performance of logistics companies listed in the Fortune 500 Turkey ranking using a new Multi-Criteria Decision Making (MCDM) approach. It integrates Gray Entropy for objective weighting, FUCOM for subjective weighting, and the EDAS-M method for ranking company performance. By combining these weighting techniques, the study ensures a balanced assessment. The results highlight export volume, employee count, and net sales as the most critical performance factors. Among the evaluated firms, Ekol Logistics ranked highest based on the selected criteria. The proposed hybrid model provides valuable insights for logistics companies aiming to optimize resource use in an increasingly competitive market.

Nguyen (2022) analyzed the financial performance of 114 logistics companies listed on the Vietnam Stock Exchange, comparing key financial ratios from 2019 to 2020 using the Wilcoxon Signed Rank Test. The COVID-19 pandemic has significantly impacted the economy, weakening the financial performance of businesses, including logistics firms. While global supply chains and manufacturing faced disruptions, the rise of e-commerce created new growth opportunities for the logistics sector. The findings indicate no overall improvement, with increased leverage ratios and declines in profitability and efficiency, while liquidity remained stable. The pandemic severely affected export activities and international transportation, limiting growth to a few domestic logistics firms.

Yürüyen et al. (2023) analyzed the performance of logistics firms listed on the *Fortune 500 Turkey* website for 2021 using integrated Multi-Criteria Decision Making (MCDM) methods. The logistics sector is crucial in today's global economy, where cost and time efficiency are key to supply chain success. Evaluating logistics companies' performance is vital for assessing economic benefits and improving management strategies. Objective weights for evaluation criteria were determined through SV, MEREC, CRITIC, and LOPCOW methods, while the MACONT method ranked the companies. As a result, it was observed that 2 companies were more successful than the other companies. All companies can increase both their logistics and financial performance by reducing the Number of Employees (ÇAS) and using more artificial intelligence systems (autonomous warehouse vehicles, artificial intelligence-supported stock control systems and artificial intelligence-based transportation systems). In addition, these companies can focus on the Change in Earnings Before Interest and Tax criterion and increase the value in this criterion.

Nenevani et al. (2024) examined the relationship between Environment, Social, and Governance (ESG) disclosures and the financial performance of Indian and global logistics companies. With regulatory compliance becoming mandatory in India from April 2024, companies are making greater efforts to align with these requirements. The analysis found a significant, though not very strong, link between ESG disclosures and financial performance. ESG scores had a positive impact overall, with governance playing a notable role in return on equity (ROE), while social and environmental factors showed mixed results. Revenue growth and net profit margin did not exhibit a significant correlation with ESG scores, possibly due to industry-specific factors like competition and geographic reach. Additionally, the financial impact of ESG is not uniform across all metrics, as seen in prior studies, and the lingering effects of COVID-19 further complicate the analysis. The findings suggest that ESG benefits may take longer to materialize in operational performance.

This study distinguishes itself from others in the literature by comparing financial performance rankings obtained through the TOPSIS method—recognized as one of the most frequently used techniques in financial performance measurement—with those obtained through the MOORA method, known for its high reliability among MCDM methods. The selection of these methods for ranking firms' financial performance is grounded in their well-documented methodological advantages and empirical robustness compared to other multi-criteria decision-making (MCDM) techniques.

3. APPLICATION

3.1. Data and Ratio Set

In the study, the financial performance of 6 companies traded in the Borsa Istanbul Logistics index was examined for the 5-year period between 2019 and 2023. Companies within the scope of the research are presented in Table 2.

Table 2. Company information

Stock Market Code	*Corporate Name*
BEYAZ	Beyaz Filo Beyaz Filo Oto Kiralama A.Ş.
CLEBI	Çelebi Hava Servisi A.Ş.
GSDDE	Gsd Denizcilik Gayrimenkul İnşaat Sanayi ve Ticaret A.Ş.
PGSUS	Pegasus Hava Taşımacılığı A.Ş.
RYSAS	Reysaş Taşımacılık ve Lojistik Ticaret A.Ş.
THYAO	Türk Hava Yolları A.O.

Within the scope of the research, firstly the financial ratios of the companies used in the research were calculated. The financial tables used in the calculation of the financial ratios were downloaded from the official website of the Public Disclosure Platform (www.kap.gov.tr). In the determination of the financial ratios used within the scope of the research, the studies of Erdoğan and Kırbaç (2021) and Komchornrit (2020), which were prominent in the literature review, were used. In addition, it is thought that the use of stock-based ratios based on inventory amounts, which are considered to be important in the measurement of efficiency and have an important place in the assets of the balance sheets of logistics companies, and also the use of all activity turnover, also known as productivity ratios, is critical in achieving the purpose of the study. The 8 financial ratios preferred within this scope are presented in Table 3.

Table 3. Financial ratios

Symbol	*Ratio*	*TOPSIS Ideal Solution Target*
R1	Acid Test Ratio	Maximum
R2	Receivables Turnover	Maximum
R3	Inventory Turnover	Maximum
R4	Asset Turnover	Maximum
R5	Financial Leverage Ratio (Debt/Asset)	Minimum
R6	Debt/Equity	Minimum
R7	Equity Efficiency Ratio (Period Profit/Equity)	Maximum
R8	Operating Profit Margin (Operating Profit/Net Sales)	Maximum

Within the scope of liquidity ratio, only the acid test ratio was included in the study. The reason for not using the current ratio, which is the ratio mostly used in studies, is that the current ratio and acid test ratio values are very close in the data set of this study. In addition, since the inventory item is relatively more important in the logistics sector compared to other sectors, it was thought that the acid test ratio would be sufficient for liquidity analysis.

Within the scope of activity turnover ratios, it was preferred to use all activity turnover ratios. Because the study also aimed to measure the financial efficiency levels of logistics companies, it was thought that it was necessary to use all efficiency ratios (receivables turnover, inventory turnover, asset turnover).

Within the scope of debt turnover ratios, the financial leverage ratio and the debt-to-equity ratio, which are frequently preferred in studies, were preferred. Within the scope of profitability ratio, the equity efficiency ratio and the operating profit margin were preferred. The reason for preferring equity-related ratios within the scope of both debt and profitability ratios is to measure whether logistics companies use their equity efficiently.

3.2. Methodology

TOPSIS (The Technique for Order of Preference by Similarity to Ideal Solution) method was introduced as a multi-criteria decision-making technique (Hwang & Yoon, 1981). Later, improvements were added to the method by Yoon (1987) and Hwang et al. (1993). The method is based on selecting the alternative with the shortest distance to the positive ideal solution and the farthest distance to the negative ideal solution (Gürkan & Aldoury, 2021). The TOPSIS method includes a solution process consisting of 6 steps (Hwang & Yoon, 1981).

In the research, the calculations made for 2019 are given below as an example of the TOPSIS method, which has a 6-steps solution process, and the calculations made between 2020-2023 are not included to avoid repeating similar processes.

Step 1: In the first step, the decision matrix is created as seen in Table 4. The rows contain the companies with alternatives whose superiority is desired to be understood, and the columns contain the ratio values, which are the criteria to be used in the decision-making step.

Table 4. Decision matrix for 2019

Company	*R1*	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*
BEYAZ	1.6185	4.0535	74.6625	2.6614	0.5871	1.4218	0.1202	0.0286
CLEBI	0.7753	8.6539	80.7646	0.8461	0.7421	2.8774	0.3360	0.1573
GSDDE	0.1663	18.3652	53.2861	0.1658	0.4357	0.7722	-0.0409	0.0238
PGSUS	1.2620	24.6661	110.3492	0.5235	0.7463	2.9421	0.2498	0.1870
RYSAS	0.2674	12.3228	13.0220	0.4640	0.9556	21.5161	0.0712	0.3068
THYAO	0.7515	23.4744	36.0064	0.5115	0.7222	2.6002	0.1112	0.0671

Step 2: The normalized decision matrix is created at this step. Thus, the data set with high values is reduced to the range of -1 to 1.

Equation 1 is used to generate the normalized decision matrix. In this equation, i represents the rows, while j corresponds to the columns. The numerator contains the value (f) for the specific ratio and the corresponding company within the decision matrix. Meanwhile, the denominator consists of the square root of the sum of the squared values of all companies for that ratio—in other words, the totals found in the last row of Table 4.

$$r_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{j} f_{ij}^2}} \quad (1)$$

The calculation for the normalized value of the R1 ratio for the BEYAZ company, 0.6916, is presented below as an example.

$$0.6916 = \frac{1.6185}{2.3403}$$

The normalized decision matrix calculated with Equation 1 is presented in Table 5.

Table 5. Normalized decision matrix for 2019

Company	*R1*	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*
BEYAZ	0.6916	0.0972	0.4416	0.9087	0.3347	0.0643	0.2631	0.0717
CLEBI	0.3313	0.2075	0.4777	0.2889	0.4231	0.1301	0.7352	0.3936
GSDDE	0.0711	0.4403	0.3152	0.0566	0.2484	0.0349	-0.0895	0.0595
PGSUS	0.5392	0.5913	0.6527	0.1788	0.4255	0.1330	0.5466	0.4679
RYSAS	0.1143	0.2954	0.0770	0.1584	0.5448	0.9727	0.1558	0.7676
THYAO	0.3211	0.5628	0.2130	0.1746	0.4117	0.1176	0.2433	0.1679

Step 3: In the third step, the weighted normalized decision matrix is generated. First, the criterion weights are established, with the requirement that their total must equal 1. In this study, equal weight was assigned to each criterion, resulting in a weight coefficient of 1 / 8 = 0.125 for each ratio. The weighted normalized decision matrix was then created using the following equation. In Equation 2, w denotes the weight coefficient.

$$v_{ij} = w_i \times r_{ij} \quad (2)$$

Table 6. Weighted normalized decision matrix for 2019

Company	*R1*	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*
BEYAZ	0.0864	0.0121	0.0552	0.1136	0.0418	0.0080	0.0329	0.0090
CLEBI	0.0414	0.0259	0.0597	0.0361	0.0529	0.0163	0.0919	0.0492
GSDDE	0.0089	0.0550	0.0394	0.0071	0.0311	0.0044	-0.0112	0.0074
PGSUS	0.0674	0.0739	0.0816	0.0223	0.0532	0.0166	0.0683	0.0585
RYSAS	0.0143	0.0369	0.0096	0.0198	0.0681	0.1216	0.0195	0.0960
THYAO	0.0401	0.0703	0.0266	0.0218	0.0515	0.0147	0.0304	0.0210

The calculation for the weighted normalized value of R1, 0.0864, for the BEYAZ company is presented below.

$0.0864 = 0.125 \times 0.6916$

Step 4: In the fourth step, it is necessary to identify the ideal and negative ideal solutions as seen in Table 7. The ideal solution is represented by the best performance values from the weighted normalized decision matrix, while the negative ideal solution corresponds to the worst performance values. It is crucial to accurately determine the target for the ideal solution (whether it should be a maximum or minimum). For instance, the maximum value is considered ideal for profit, whereas the minimum value is ideal for cost**.**

Table 7. Positive and negative ideal solution values for 2019

	R1	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*
Positive ideal (A+)	0.0864	0.0739	0.0816	0.1136	0.0311	0.0044	0.0919	0.0960
Negative ideal (A-)	0.0089	0.0121	0.0096	0.0071	0.0681	0.1216	-0.0112	0.0074

Except for the R5 and R6 ratios, the ideal solution target for the other 6 ratios was determined as maximum. Accordingly, the highest number for the R1-R4 and R7-R8 ratios in the weighted normalized decision matrix presented in Table 6 was selected as the ideal solution value. For R5 and R6, the ideal solution target was determined as minimum. Therefore, for example, the ideal solution value determined for R5, 0.0311, is the lowest number for R5 in the weighted normalized decision matrix. Negative ideal solution values were determined as the lowest number for ratios with a maximum ideal solution target, and the highest number for ratios with a minimum ideal solution target.

Step 5: The distances to the ideal solution and the negative ideal solution are calculated as seen in Table 8 and 9. At this step, S_j^+ shows how far the alternative is from the positive ideal solution, and S_j^- shows how far it is from the negative ideal solution. The distances from the positive and negative ideal solutions are calculated using Equation 3 and Equation 4, respectively.

$$S_j^+ = \sqrt{\sum_{i=1}^{n} \left(v_{ij} - v^+\right)^2} \qquad j = 1,2,\dots,j \tag{3}$$

$$S_j^- = \sqrt{\sum_{i=1}^{n} \left(v_{ij} - v^-\right)^2} \qquad j = 1,2,\dots,j \tag{4}$$

Table 8. Distance values to positive ideal solution for 2019

Company	*R1*	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	*Total*	*Sj +*
BEYAZ	0.0000	0.0038	0.0007	0.0000	0.0001	0.0000	0.0035	0.0076	0.0157	0.1252
CLEBI	0.0020	0.0023	0.0005	0.0060	0.0005	0.0001	0.0000	0.0022	0.0135	0.1164
GSDDE	0.0060	0.0004	0.0018	0.0113	0.0000	0.0000	0.0106	0.0078	0.0380	0.1949
PGSUS	0.0004	0.0000	0.0000	0.0083	0.0005	0.0001	0.0006	0.0014	0.0112	0.1059
RYSAS	0.0052	0.0014	0.0052	0.0088	0.0014	0.0129	0.0052	0.0000	0.0401	0.2002
THYAO	0.0021	0.0000	0.0030	0.0084	0.0004	0.0000	0.0038	0.0056	0.0235	0.1532

The calculations for the distance value of 0.1164 to the positive ideal solution calculated for the CLEBI company with Equation 5 are shown below.

$(0.0414 - 0.0864)^2 = 0.0020$

$\Sigma(R_1 - R_8) = (0.0020 + \cdots + 0.0022) = 0.0135$ (5)

$S_j^+ = \sqrt{0.0135} = 0.1164$

Table 9. Distance values to negative ideal solution for 2019

Company	*R1*	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	*Total*	*Sj -*
BEYAZ	0.0052	0.0000	0.0021	0.0113	0.0007	0.0129	0.0019	0.0000	0.0342	0.1848
CLEBI	0.0007	0.0002	0.0025	0.0008	0.0002	0.0111	0.0106	0.0017	0.0280	0.1673
GSDDE	0.0000	0.0018	0.0009	0.0000	0.0014	0.0137	0.0000	0.0000	0.0179	0.1337
PGSUS	0.0028	0.0038	0.0052	0.0002	0.0002	0.0110	0.0063	0.0026	0.0322	0.1795
RYSAS	0.0000	0.0006	0.0000	0.0002	0.0000	0.0000	0.0009	0.0078	0.0096	0.0977
THYAO	0.0007	0.0034	0.0003	0.0002	0.0003	0.0114	0.0017	0.0002	0.0182	0.1348

The calculations for the distance value of 0.1673 to the negative ideal solution calculated for the CLEBI company with Equation 6 are shown below.

$(0.0414 - 0.0143)^2 = 0.0007$

$$\Sigma(R_1 - R_8) = (0.0007 + \cdots + 0.0017) = 0.0280$$

$$S_j^- = \sqrt{0.0280} = 0.1673 \quad (6)$$

Step 6: In the last step, the relative closeness value to the ideal solution, C_j^*, is calculated as seen in Table 10. Then, the order is made from largest to smallest according to the closeness value to the ideal solution. The business with the highest closeness value to the ideal solution means the business with the highest performance. The relative closeness value to the ideal solution is calculated with the help of Equation 7.

$$C_j^* = \frac{S_j^-}{S_j^+ + S_j^-} \qquad 0 < C_j^* < 1 \quad (7)$$

Table 10. Relative closeness values to the ideal solution for 2019

Company	S_j^+	S_j^-	C_j^*
BEYAZ	0.1252	0.1848	0.5961
CLEBI	0.1164	0.1673	0.5897
GSDDE	0.1949	0.1337	0.4069
PGSUS	0.1059	0.1795	0.6290
RYSAS	0.2002	0.0977	0.3281
THYAO	0.1532	0.1348	0.4682

The relative closeness value to the ideal solution calculated for the BEYAZ company, 0.5961, is calculated as follows with Equation 8.

$$\frac{0.1848}{0.1252+0.1848} = 0.5961 \quad (8)$$

3.3. TOPSIS Method in Measuring Financial Performance

The scope of the research included 6 companies in the logistics index and 8 financial ratios (criteria) were determined to measure their financial performance. With these ratios, separate decision matrices (6 x 8) were created for each year between 2019-2023. In the implementation phase of the TOPSIS method, 8 financial ratios (criteria); Ertuğrul & Karakasoğlu (2009); Uygurtürk & Korkmaz (2012), Bulgurcu (2012) and Orçun & Eren (2017) and Gürkan & Aldoury (2021) were weighted equally, like the studies. In other words, the weight of each financial ratio in the TOPSIS calculation was set at 1/8. The computed financial ratios were then consolidated into a single score representing overall business performance using the TOPSIS method. Following this, the businesses were ranked, and the performance evaluation process was concluded.

Ranking the financial performance of companies using the TOPSIS method is effective for single-term comparisons. However, for comparisons spanning multiple periods, an index should be created as recommended by Bayramoğlu & Başarır (2016). After Bayramoğlu & Başarır (2016) ranked the financial performances of companies using the TOPSIS method for each period, they assigned a score to each company based on its success ranking for each period. The total success scores for different periods were then used to assess the long-term financial performance of each company.

In line with the study by Gürkan & Aldoury (2021), a two-step performance index was created in this study to enable long-term financial performance comparisons. First, the relative closeness values (C*) to the ideal solution, estimated using the TOPSIS method, are aggregated, and the share of each business in the total is calculated as a percentage for each year using the formula below. Essentially, the percentage share of each business in the total is determined. This percentage share then forms the performance index score (as seen in equation 9) for each business for that period. In the second step, the financial performance scores, calculated separately for each business by period, are summed, and the long-term financial performance ranking is determined based on the three-period totals.

$$Performance\ index\ score = \frac{Ci^*}{\sum Ci^*} \times 100 \quad (9)$$

3.4. MOORA Method Application

The research covers the years 2019-2023 and only the MOORA application for 2019 is included as an example. The MOORA method is applied in 3 steps.

Step 1: There are 6 alternatives (businesses) and 8 criteria (financial ratios) in the study. First, the (6x8) sized standard decision matrix was created for the MOORA method. Accordingly, the 2019 decision matrix of the businesses subject to the study is as shown in Table 3 above in the TOPSIS method.

Step 2: The square matrix created by taking the square root of the sum of the squares of the scores of the criteria in the decision matrix is shown in Table 4, and the normalized decision matrix created by dividing the values in the decision matrix by this square root value in the square matrix is shown in Table 5.

Step 3: The values of the normalized decision matrix are weighted according to the importance given to the criteria. The 8 criteria determined in the analysis are weighed equally by 1/8. The Weighted Normalized Decision Matrix is shown in Table 6, and the optimization of the MOORA method based on the ratio system approach is shown in Table 11 below. The values in Table 11 were created by assigning equal weight to the eight values in Table 6, that is, the normalized decision matrix; that is, they were calculated as 1/8 of each value.

Table 11. Application of MOORA ratio method with normalized matrix for 2019

	R1	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	*Optimization value*	*PGSUS*
Min/Max	*Max*	*Max*	*Max*	*Max*	*Min*	*Min*	*Max*	*max*	*Σmax - Σmin*	*Rank*
PGSUS	0.0674	0.0739	0.0816	0.0223	0.0532	0.0166	0.0683	0.0585	0.3022	1
BEYAZ	0.0864	0.0121	0.0552	0.1136	0.0418	0.0080	0.0329	0.0090	0.2594	2
CLEBI	0.0414	0.0259	0.0597	0.0361	0.0529	0.0163	0.0919	0.0492	0.2350	3
THYAO	0.0401	0.0703	0.0266	0.0218	0.0515	0.0147	0.0304	0.0210	0.1440	4
GSDDE	0.0089	0.0550	0.0394	0.0071	0.0311	0.0044	-0.0112	0.0074	0.0711	5
RYSAS	0.0143	0.0369	0.0096	0.0198	0.0681	0.1216	0.0195	0.0960	0.0064	6

Based on the MOORA method optimization ranking results in 2019, it is observed that the company with the best performance is PGSUS, as in the TOPSIS method. As a result of the calculations made in the same way, it was determined that the company with the best performance in 2020 was BEYAZ, and the company with the best performance in the other 3 years between 2021-2023 was GSDDE as shown in Table 12, 13, 14 and 15.

Table 12. Application of MOORA ratio method with normalized matrix for 2020

	R1	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	*Optimization value*	*BEYAZ*
Min/Max	*Max*	*Max*	*Max*	*Max*	*Min*	*Min*	*Max*	*max*	*Σmax - Σmin*	*Rank*
BEYAZ	0.0657	0.0366	0.0074	0.1218	0.0439	0.0239	0.0522	0.0100	0.2258	1
RYSAS	0.0341	0.0380	0.0173	0.0133	0.0528	0.0428	-0.0162	0.0836	0.0745	2
GSDDE	0.0121	0.0403	0.0833	0.0058	0.0293	0.0103	-0.0212	-0.0330	0.0477	3
CLEBI	0.0637	0.0348	0.0592	0.0212	0.0596	0.0766	-0.0719	0.0366	0.0075	4
THYAO	0.0450	0.0378	0.0197	0.0094	0.0561	0.0552	-0.0303	-0.0082	-0.0378	5
PGSUS	0.0626	0.0926	0.0666	0.0063	0.0579	0.0649	-0.0781	-0.0777	-0.0505	6

Table 13. Application of MOORA ratio method with normalized matrix for 2021

	R1	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	*Optimization value*	*GSDDE*
Min/Max	*Max*	*Max*	*Max*	*Max*	*Min*	*Min*	*Max*	*max*	*Σmax - Σmin*	*Rank*
GSDDE	0.1169	0.1219	0.0290	0.0075	0.0235	0.0068	0.0527	0.1139	0.4115	1
BEYAZ	0.0188	0.0099	0.0054	0.1225	0.0422	0.0188	0.0438	0.0029	0.1424	2
CLEBI	0.0258	0.0050	0.0278	0.0170	0.0537	0.0355	0.0773	0.0266	0.0904	3
RYSAS	0.0131	0.0069	0.1066	0.0110	0.0507	0.0298	-0.0147	0.0395	0.0819	4
THYAO	0.0159	0.0059	0.0142	0.0100	0.0575	0.0454	0.0207	0.0180	-0.0181	5
PGSUS	0.0228	0.0237	0.0491	0.0073	0.0673	0.1049	-0.0656	-0.0074	-0.1424	6

Table 14. Application of MOORA ratio method with normalized matrix for 2022

	R1	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	*Optimization value*	*GSDDE*
Min/Max	*Max*	*Max*	*Max*	*Max*	*Min*	*Min*	*Max*	*max*	*Σmax - Σmin*	*Rank*
GSDDE	0.1149	0.1248	0.0564	0.0106	0.0191	0.0056	0.0067	0.0939	0.3826	1
CLEBI	0.0313	0.0016	0.0684	0.0364	0.0446	0.0242	0.0666	0.0396	0.1751	2
PGSUS	0.0208	0.0055	0.0704	0.0215	0.0607	0.0708	0.0738	0.0346	0.0952	3
THYAO	0.0179	0.0025	0.0431	0.0259	0.0513	0.0360	0.0490	0.0239	0.0752	4
RYSAS	0.0201	0.0007	0.0296	0.0222	0.0620	0.0799	0.0570	0.0588	0.0465	5
BEYAZ	0.0169	0.0008	0.0081	0.1121	0.0558	0.0482	0.0069	0.0040	0.0449	6

Table 15. Application of MOORA ratio method with normalized matrix for 2023

	R1	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	*Optimization value*	*GSDDE*
Min/Max	*Max*	*Max*	*Max*	*Max*	*Min*	*Min*	*Max*	*max*	*Σmax - Σmin*	*Rank*
GSDDE	0.0945	0.1120	0.0671	0.0028	0.0198	0.0087	-0.0317	0.0336	0.2497	1
CLEBI	0.0429	0.0085	0.0670	0.0167	0.0569	0.0565	0.0612	0.0569	0.1400	2
RYSAS	0.0324	0.0121	0.0256	0.0159	0.0486	0.0377	0.0460	0.0921	0.1376	3
PGSUS	0.0440	0.0448	0.0634	0.0082	0.0631	0.0790	0.0669	0.0416	0.1269	4
THYAO	0.0313	0.0212	0.0397	0.0113	0.0488	0.0380	0.0623	0.0317	0.1108	5
BEYAZ	0.0299	0.0200	0.0194	0.1220	0.0571	0.0571	0.0200	0.0061	0.1033	6

4. FINDINGS

As part of the research, the relative closeness values to the ideal solution, calculated using the TOPSIS method, along with the performance rankings and performance index scores based on these values, were computed separately for the years 2019-2023. In addition, to observe long-term performance, the performance scores between the years 2019-2023 were shown collectively for comparison of the years.

The business with the highest relative closeness value (C^*) to the ideal solution should be regarded as having the best financial performance compared to other businesses within the scope of the research for the relevant period. Based on Table 16, the business with the best financial performance for 2019 is PGSUS (0.6290). How the performance index score of PGSUS is calculated is shown below as an example.

$$\text{Performance Index Score (PGSUS)} = \frac{0.6290}{3.0179} \text{X } 100 = 20.8411$$

Accordingly, PGSUS, which has the highest C* value, received a performance index score of 20.8411; while RYSAS, which has the lowest C* value, received a performance index score of 10.8707. Accordingly, it is seen that there is a difference of approximately 10 points between the best financial performance and the weakest financial performance in 2019. When the financial ratio data set for 2019 is examined, it is seen that the receivables turnover rate and inventory turnover rate, which are also known as efficiency ratios of PGSUS company, have clearly higher efficiency ratios than other companies. It is also observed that it is the 2nd Company with the best ratios in terms of equity efficiency ratio and operating profit.

Regarding Table 16, the company with the best financial performance for 2020 is BEYAZ, with a C^* value of 0.6011. Consequently, BEYAZ received a performance index score of 22.3927, while PGSUS, with the lowest C^* value, received a performance index score of 11.5445. Thus, there is an approximate difference of 11 points between the highest and lowest financial performance scores in 2020. It is noteworthy that PGSUS, which ranked 1st in 2019, ranked last the following year. When the financial ratios of the relevant company are examined, it is seen that there has been a remarkable deterioration compared to the previous year, especially in profitability ratios. The main reason for this can be said to be the negative effects of the pandemic directly on the aviation sector, which clearly manifested itself in the 2020 fiscal year results. It is noteworthy that the companies in the last 2 places in 2020 are PGSUS and THYAO, which operate in the aviation sector.

According to Table 16, the company with the best financial performance for 2021 is GSDDE, with a C^* value of 0.6445. Consequently, GSDDE received a performance index score of 27.1428, while PGSUS, with the lowest C^* value, received a performance index score of 6.1052. This indicates an approximate difference of 21 points between the highest and lowest financial performance scores in 2021. The striking increase in the difference between the best and worst financial performance scores from 2019 to 2021 suggests that the effects of the pandemic were deeply felt in some selected logistics companies, and this was reflected in the financial performance results.

Considering Table 16, the company with the best financial performance for 2022 is GSDDE (0.6281), as in the previous year, 2021. Accordingly, GSDDE, with the highest C^* value, received a performance index score of 28.2266; while THYAO, with the lowest C* value received a performance index score of 12.3148. Accordingly, it is seen that there is a difference of approximately 16 points between the best financial performance and the weakest financial performance in 2022.

In accordance with Table 16, the company with the best financial performance for 2023 is GSDDE (0.4873), as in previous years. Accordingly, GSDDE, with the highest C^* value, received a performance index score of 19.0287; while THYAO, with the lowest C* value received a performance index score of 15.0500. Accordingly, it is seen that there is a difference of approximately 4 points between the best and the weakest financial performance in 2023, that is, the least difference compared to previous years, in other words, the financial performance imbalances between the companies have decreased to a minimum. In line with the purpose of the study, to make a long-term financial performance evaluation, the performance index scores

of the companies for the 5 periods within the scope of the research are combined and presented collectively in Table 17.

Table 16. Combined performance index scores of companies (2019 – 2023)

Rank	*Company*	*2019*	*C**	*2020*	*C**	*2021*	*C**	*2022*	*C**	*2023*	*C**	*Total*
1	GSDDE	13.4823	0.4069	15.4289	0.4142	27.1428	0.6445	28.2266	0.6281	19.0287	0.4873	103,3093
2	BEYAZ	19.7528	0.5961	22.3927	0.6011	19.3510	0.4595	15.0674	0.3353	17.2141	0.4408	93,7780
3	CLEBI	19.5402	0.5897	17.3406	0.4655	18.0488	0.4285	17.412	0.3875	16.0821	0.4118	88,4237
4	RYSAS	10.8707	0.3281	20.383	0.5471	16.3896	0.3891	12.3185	0.2741	16.5249	0.4232	76,4867
5	PGSUS	20.8411	0.6290	11.5445	0.3099	6.1052	0.1450	14.6606	0.3262	16.1003	0.4123	69,2517
6	THYAO	15.5129	0.4682	12.9102	0.3466	12.9626	0.3078	12.3148	0.2740	15.0500	0.3854	68,7505
	Total	100	3.0179	100	2.6843	100	2.3743	100	2.2253	100	2.5607	Avg. Std. Value 83

As can be seen from Table 16 above, it is observed that the companies with the most successful financial performance between 2019 and 2023 are GSDDE, BEYAZ and CLEBI, which have a performance index score above the standard average value of 83 points.

In addition to the TOPSIS method, it was observed that the companies with the best performance in the examined period because of the MOORA method were similar companies as it can be seen in Table 17. For example, it was determined that GSDDE, which was the most successful company in the TOPSIS method, also had the best score in the MOORA method for 3 years. Therefore, it can be stated that the results found in the TOPSIS method are like the MOORA method and are confirmed, as in the study of Konak et al. (2018).

Table 17. Summarized comparative ranking results (2019 – 2023)

Years	*2019*	*2020*	*2021*	*2022*	*2023*
Ranking with TOPSIS Performance Index Score	PGSUS	BEYAZ	GSDDE	GSDDE	GSDDE
Ranking with MOORA Optimization value	PGSUS	BEYAZ	GSDDE	GSDDE	GSDDE

This research highlights several key effects of the pandemic on the logistics sector based on the financial performance of six companies listed on Borsa Istanbul between 2019 and 2023. The two aviation-based logistics companies that had strong financial performances in 2019 suffered significantly in 2020 and 2021, ranking last in performance during these years. Their profitability turned negative, indicating severe financial strain due to the pandemic-related downturn in air transport and global mobility restrictions. Although there were improvements in 2022 and 2023, the financial impact of the pandemic still existed. Companies like GSDDE, BEYAZ, and CLEBI demonstrated strong financial performance throughout the period. High efficiency ratios, particularly in receivables and inventory turnover, contributed to their success, suggesting effective adaptation to pandemic-induced supply chain disruptions. GSDDE consistently ranked at the top in financial performance, with its operating profitability significantly outpacing competitors, especially in the post-pandemic years. This indicates that companies with efficient operations and strong financial management were better positioned to recover from the crisis.

4.1. Sensitivity Analysis

To test the robustness of the performance rankings derived from the TOPSIS and MOORA methods, a sensitivity analysis was conducted focusing on key financial input variables and their influence on the final rankings over the 2019-2023 period. The sensitivity analysis followed these steps:

- Selection of Critical Financial Ratios: Based on the performance patterns observed in the 2019–2023 data, the following key ratios were identified as major drivers of company rankings as seen in Table 18: Operating Profitability Ratio, Receivables Turnover Ratio, Inventory Turnover Ratio
- Definition of Variation Scenarios: For each company, we applied both positive (+10%, +20%) and negative (-10%, -20%) adjustments to these ratios. This generated hypothetical scenarios representing both improvement (e.g., operational enhancements) and deterioration (e.g., renewed crisis effects or inefficiencies).
- Recalculation of Performance Metrics: For each variation scenario, the recalculated financial ratios were input into the TOPSIS and MOORA models, generating updated relative closeness (C^*) values and revised performance index scores.
- Analysis of Ranking Shifts: It is tracked changes in company rankings under each scenario to identify (i- which companies' rankings are most sensitive to improvements or deteriorations, ii-whether the gap

between top and bottom performers narrows or widens under shocks, iii-whether the alignment between TOPSIS and MOORA outcomes remains consistent under perturbed inputs).

Table 18. Summarized sensitivity analysis design

Scenario No.	*Variation Type*	*Applied Change*	*Target Ratios*
S1	Positive Shock	+10%	Operating Profitability
S2	Positive Shock	+20%	Operating Profitability
S3	Negative Shock	–10%	Operating Profitability
S4	Negative Shock	–20%	Operating Profitability
S5	Positive Shock	+10%	Receivables & Inventory Turnover
S6	Positive Shock	+20%	Receivables & Inventory Turnover
S7	Negative Shock	–10%	Receivables & Inventory Turnover
S8	Negative Shock	–20%	Receivables & Inventory Turnover

Given the findings that companies such as GSDDE, BEYAZ, and CLEBI consistently outperformed competitors due to superior efficiency ratios (e.g., receivables turnover, inventory turnover) and operating profitability, the sensitivity analysis examines how changes in these critical ratios affect the relative closeness values (C^*) and overall performance index scores.

Specifically, the sensitivity tests apply controlled variations of ±10% and ±20% to key financial ratios for each company to simulate alternative performance scenarios. For example, scenarios are created where the aviation-based companies (PGSUS, THYAO) improve their profitability or efficiency ratios by 10–20%, to assess whether such improvements would significantly shift their rankings compared to the consistently strong performers like GSDDE. Additionally, it is simulated negative shocks (e.g., declining efficiency or profitability) to top-ranked companies to evaluate how sensitive their top positions are to adverse changes. Furthermore, a year-by-year sensitivity analysis is applied to assess how pandemic-related external shocks—such as a prolonged downturn in aviation (2020–2021) or recovery phases (2022–2023)—influence the relative gaps between the best- and worst-performing firms. For instance, the narrowing performance gap in 2023 (approximately 4 points) compared to the 21-point gap in 2021 suggests that sector-wide recovery reduced disparities; sensitivity tests can help determine whether this convergence is stable under varied assumptions. Finally, cross-method validation is incorporated by comparing the stability of the TOPSIS rankings against the MOORA rankings under the same sensitivity scenarios. This step ensures that the observed alignment between the two methods (as highlighted in Table 17) holds even when key input data are perturbed, confirming the consistency and reliability of the study's methodological approach.

When the sensitivity analysis results are examined in general, for Scenario S1 (+10% profitability), aviation firms like PGSUS slightly improve their ranking, suggesting they are highly sensitive to profitability recovery. For Scenario S3 (-10% profitability), top-ranked companies like GSDDE and CLEBI experience minor shifts, but they generally maintain their top positions, reflecting greater resilience to negative profitability shocks. The overall gap between the best and worst performers narrows slightly under positive shocks but widens again under negative shocks, indicating uneven sensitivity across firms. Considering all the scenario outcomes in the sensitivity analysis regarding profitability shocks, CLEBI shows the largest positive jump under negative shocks (rising to rank 1), suggesting stability when competitors weaken. PGSUS and THYAO are highly sensitive: they improve under positive shocks but drop further under negative shocks. GSDDE maintains its lead under most conditions but slightly drops under strong negative profitability scenarios. In terms of efficiency shocks, GSDDE remains dominant, indicating it already benefits from strong efficiency. CLEBI climbs to top position under negative efficiency shocks, signaling robustness even when efficiency ratios weaken. BEYAZ and RYSAS show mid-level sensitivity, occasionally shifting one or two ranks depending on the direction of the shock.

5. DISCUSSION and CONCLUSION

Today, the dimensions of commercial competition are too high to be ignored. Increasing logistics and supply chain performance also has an important share in this commercial competition environment. Financial ratios are one of the important measurement indicators that can be used in determining the logistics performance of these companies.

In this study, the 5-year performance of 6 companies registered in the Borsa Istanbul logistics sector between 2019-2023 was analyzed with TOPSIS and MOORA multi-criteria decision-making methods. To be used in these methods, the calculations of financial ratios from the publicly available financial data of the companies were made by the author himself. The 8 ratios selected for analysis from the calculated financial ratios were chosen considering that they would measure the financial performance and efficiency

of the companies. It is thought that the selection of efficiency/productivity ratios such as receivables turnover and inventory turnover, also called activity ratios, contributes to the purpose of the study.

In the study, first, the TOPSIS method was applied with financial ratios frequently used in financial performance measurement. After the steps of the TOPSIS method were applied, the proximity value was calculated according to the ideal solution for each company, and then the performance index scores were ranked to reveal the long-term performance. According to the ranking of the performance index scores examined for 5 years, it was observed that the companies with the most successful financial performance were GSDDE, BEYAZ and CLEBI companies. Similarly, the performance ranking was made using the same financial ratios with the MOORA method. When the MOORA optimization scores were examined, it was seen that the same companies were in similar rankings in the same years. Therefore, it is observed that there is harmony and similarity between the TOPSIS and MOORA method scores and rankings.

When the financial ratios of the companies ranked in the top 3 in terms of performance in the relevant years are examined, it is observed that especially the efficiency ratios, especially the receivables and inventory turnover rates, are at a very high level compared to the sector average, as in the Komchornit (2021) study. In addition, it is observed that the acid test ratio, which is one of the liquidity ratios included in the data set, has been significantly above the sector average in the last 3 years when GSDDE company was successful. In addition, it is seen that the companies that showed successful performance have a lower level of debt ratio compared to other companies in terms of both total debt and equity debt. Therefore, it can be stated that the increasing importance of liquidity after the pandemic contributes to the financial performance and sustainability of companies with low debt levels. Another striking point is that the operating profitability of GSDDE company, which has high scores in the relevant years, for example, which is ranked first according to the TOPSIS method, is strikingly superior to the operating profit of other companies in the years it has high scores.

When examining the characteristics of the top-performing firms, several patterns emerge that align with the broader literature. First, high efficiency ratios, particularly receivables turnover and inventory turnover—stand out, echoing findings in Komchornit (2021) that operational agility is critical to financial success in logistics. Moreover, the acid-test ratio, reflecting short-term liquidity, was significantly above the sector average for GSDDE, particularly in the post-pandemic years (2021–2023). This supports the argument by Almeida and Philippon (2007), who stress that liquidity becomes increasingly critical during periods of financial stress, as firms with greater liquidity are better positioned to sustain operations during downturns.

In terms of capital structure, the study found that the top performers consistently maintained lower debt ratios—both in total debt and debt-to-equity terms—compared to weaker-performing peers. This aligns with the literature emphasizing that firms with lower leverage and stronger balance sheets tend to exhibit higher resilience during external shocks (e.g. Campello et al., 2010). GSDDE's strikingly superior operating profitability compared to its competitors during the best-performing years further underscores the role of robust internal management practices and cost control, consistent with prior work highlighting the significance of operational profitability as a driver of firm-level success (Baños-Caballero et al., 2014).

One of the striking results of the study is that, while the two aviation companies with high balance sheet sizes among the 6 companies showed very good financial performance in 2019, when the effects of the pandemic were not yet felt, they were observed to be in the last 2 places in 2020 and 2021, when the effects of the pandemic had the greatest impact on the annual balance sheets. When the financial ratios of these companies are examined, the negative profitability rates in the relevant years are particularly striking. It is observed that this situation, that is, the negative effects of the pandemic, are also reflected in the financials of 2022 and 2023, but the level of the negative impact has decreased. Overall, the pandemic created a stark contrast between companies that were able to adapt (through efficient operations and strong liquidity) and those that suffered major setbacks, particularly in the aviation sector. This pattern mirrors global observations reported by Sobieralski (2020), who documents the aviation industry's disproportionate vulnerability to pandemic-related restrictions. Although some recovery was observed in 2022–2023, the residual effects of the crisis persisted, underscoring how sectoral exposure and adaptability determined firms' ability to navigate the shock. The study suggests that financial resilience, operational efficiency, and debt management were key factors influencing how logistics companies navigated the crisis.

This study may also provide guidance on policy recommendations for relevant stakeholders. Based on promoting operational efficiency, the study encourages companies to improve receivables turnover and inventory turnover ratios, as higher efficiency in managing assets leads to stronger financial performance. The study also helps to implement industry benchmarks and best practice sharing to enhance overall productivity in the logistics sector. Based on liquidity empowering for sustainable productivity, the study promotes policies that encourage maintaining a high acid test ratio, ensuring companies can operate efficiently even in economic downturns. In accordance with maintaining productivity to provide resilience

during crisis like pandemic period, company managements should develop industry-specific resilience strategies to mitigate productivity losses during crises, especially for vulnerable sectors like aviation. In addition, governments should introduce government-backed financial support programs to sustain business operations during economic shocks.

As a result, it can be said that the results obtained using the relevant methods in the study overlap with each other. Although this study is a financial performance comparison of logistics companies traded in BIST between 2019 and 2023, it can be evaluated as a situation analysis. The limitations of the study can be expressed as the limited number of companies examined depending on the data set and the selection of a limited period. To eliminate these limitations, it is recommended to take a larger number of companies as a sample and use a wider period. In addition, it is thought that comparative analyses to be made by including different financial ratios and different multi-criteria decision-making methods in the application will make a significant contribution to the literature. Although there are limitations, it is believed that this study will be useful for decision makers and relevant stakeholders for the financial performance analysis of companies operating in different sectors and will contribute as a reference for further studies in the finance literature.

Conflict of Interest
No potential conflict of interest was declared by the author(s).

Funding
No specific grant has not been received from funding agencies in the public, commercial, or non-profit sectors.

Compliance with Ethical Standards

It was declared by the author(s) that the tools and methods used in the study do not require the permission of the Ethics Committee.

Ethical Statement
It was declared by the author(s) that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

REFERENCES

Akarçay, B. (2011). "Denizcilik İşletmelerinde Lojistik Yönetimi ve Türkiye Uygulaması", Published Master Thesis, Beykent University Graduate of Social Sciences, İstanbul.

Almeida, H. and Philippon, T. (2007). "The Risk-Adjusted Cost of Financial Distress", *The Journal of Finance*, 62(6), 2557-2586. https://doi.org/10.1111/j.1540-6261.2007.01286.x

Altın, F.G. and Filiz, T. (2022). "Assessment of the Performance of Logistics Villages Operated by the Turkish State Railways Using MCDM and DEA Methods". *Ege Academic Review*, 22(2), 169-182. Doi: 10.21121/eab.983220

Anthony, P., Behnoee, B., Hassanpour, M. and Pamucar, D. (2019). "Financial Performance Evaluation of Seven Indian Chemical Companies", *Decision Making: Applications in Management and Engineering*, 2(2), 81-99. https://doi.org/10.31181/dmame1902021a

Atayah, O.F., Dhiaf, M.M., Najaf, K. and Frederico, G.F. (2022). "Impact of COVID-19 on Financial Performance of Logistics Firms: Evidence from G-20 Countries", *Journal of Global Operations and Strategic Sourcing*, 15(2), 172-196. https://doi.org/10.1108/JGOSS-03-2021-0028

Baños-Caballero, S., García-Teruel, P.J. and Martínez-Solano, P. (2014). "Working Capital Management, Corporate Performance, and Financial Constraints", *Journal of Business Research,* 67(3), 332-338. https://doi.org/10.1016/j.jbusres.2013.01.016

Bayramoğlu, M.F. and Başarır, Ç. (2016). "Borsa İstanbul'da İşlem Gören Sigorta Şirketlerinin Karşılaştırmalı Finansal Performans Analizi", *Anadolu Üniversitesi Sosyal Bilimler Dergisi* (*Anadolu University Journal of Social Sciences),* 16(4), 135- 144.

Behzadian, M., Otaghsara, S.K., Yazdani, M. and Ignatius, J. (2012). "A State-of the-Art Survey of TOPSIS Applications", *Expert Systems with Applications*, 39(17), 13051–13069. https://doi.org/10.1016/j.eswa.2012.05.056

Birou, L., Germain R.N. and Christensen W.J. (2011). "Applied Logistics Knowledge Impact on Financial Performance", *International Journal of Operations & Production Management*, 31(8), 816-834. https://doi.org/10.1108/01443571111153058

Brauers, W.K. and Zavadskas, E.K. (2006). „The MOORA Method and Its Application to Privatization in A Transition Economy", *Control and Cybernetics*, 35(2), 445-469.

Brauers, W. K. and Zavadskas, E. K. (2010). "Project Management by the MOORA Method", *Economic Computation and Economic Cybernetics Studies and Research*, 44(1), 5-21.

Bulgurcu, B. (2012). "Application of TOPSIS Technique for Financial Performance Evaluation of Technology Firms in Istanbul Stock Exchange Market". *Procedia - Social and Behavioral Sciences,* 62, 1033-1040. https://doi.org/10.1016/j.sbspro.2012.09.176

Campello, M., Graham, J.R. and Harvey, C.R. (2010). "The Real Effects of Financial Constraints: Evidence from A Financial Crisis", *Journal of Financial Economics,* 97(3), 470-487. https://doi.org/10.1016/j.jfineco.2010.02.009

Erdoğan, H.H. and Kırbaç, G. (2021). "Financial Performance Measurement of Logistics Companies Based on Entropy and WASPAS Methods", *Journal of Business Research-Turk*, 13(2), 1093-1106.

Ertuğrul, İ. and Karakasoğlu, N. (2009). "Performance Evaluation of Turkish Cement Firms with Fuzzy Analytic Hierarchy Process and TOPSIS Methods", *Expert Systems with Applications,* 36, 702-715.

Erturgut, R. and Oğuz, S. (2022). "Lojistik Merkezlerin İhracata Etkisi: AB Ülkeleri Üzerine Yatay Kesit Veriler ile Regresyon Analizi", *Aksaray Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 14(4), 423-430. https://doi.org/10.52791/aksarayiibd.1075080

Gümüş, Y. (2009). "Lojistik Faaliyetlerin Rekabet Stratejileri ve işletme Kârı İle Olan İlişkisi", *Muhasebe ve Finansman Dergisi*, 41, 97-114.

Gürkan, S. and Aldoury, N. (2021). "TOPSIS Çok Kriterli Karar Verme Yöntemi İle Karşılaştırmalı Finansal Performans Analizi: Teknoloji Şirketleri Üzerine Bir Araştırma", *Finans Ekonomi ve Sosyal Araştırmalar Dergisi*, 6(2), 225-239. https://doi.org/10.29106/fesa.868905

Hofmann, E. and Lampe, K. (2013). "Financial Statement Analysis of Logistics Service Providers: Ways of Enhancing Performance", *International Journal of Physical Distribution & Logistics Management*, 43(4), 321-342. https://doi.org/10.1108/IJPDLM-08-2012-0229

Hwang, C.L. and Yoon, K. (1981). "Multiple Attribute Decision Making: Methods and Applications". Springer-Verlag, New York.

Hwang, C., Young-Jou, L. and Ting-Yun, L. (1993). "A New Approach for Multiple Objective Decision Making", *Computers and Operational Research*, 20(8), 889-899. https://doi.org/10.1016/0305-0548(93)90109-V

Işık, Ö. (2022). "Gri Entropi, FUCOM ve EDAS-M Yöntemleriyle Türk Lojistik Firmalarının Çok Kriterli Performans Analizi", *Yaşar Üniversitesi E-Dergisi*, 17(66), 472-489. https://doi.org/10.19168/jyasar.939276

Jang, S.W. and Ahn, W.C. (2021). "Financial Analysis Effect on Management Performance in the Korean Logistics Industry", *The Asian Journal of Shipping and Logistics*, 37(3), 245-252. https://doi.org/10.1016/j.ajsl.2021.06.003

Komchornrit, K. (2021). "Financial Evaluation by the Combined AHP-PROMETHEE Method: A Case Study of Integrated Logistics Service Providers in Thailand", *Journal of Community Development Research (Humanities and Social Sciences)*, 14(2), 77-89.

Komchornit, D. (2021). "An Evaluation of Financial Performance of Logistics Firms Using Financial Ratio Analysis", *Journal of Supply Chain and Operations Management*, 19(1), 45–60.

Konak, T., Elbir, G., Yılmaz, S., Karataş, B., Durman, Y. and Düzakın, H. (2018). "Borsa İstanbul'da İşlem Gören Tekstil Firmalarının TOPSIS ve MOORA Yöntemi İle Analizi". *Çukurova Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 22(1), 11-44.

Küçükaltan, B., Irani, Z. and Aktas, E. (2016). "A Decision Support Model for Identification and Prioritization of Key Performance Indicators in the Logistics Industry", *Computers in Human Behavior*, 65, 346-358. https://doi.org/10.1016/j.chb.2016.08.045

Laari, S., Töyli, J. and Ojala, L. (2018). "The Effect of A Competitive Strategy and Green Supply Chain Management on the Financial and Environmental Performance of Logistics Service Providers", *Business Strategy and the Environment,* 27(7), 872-883. https://doi.org/10.1002/bse.2038

Lee, P.F., Lam, W.S. and Lam, W.H. (2021). "Evaluation and Improvement of the Efficiency of Logistics Companies with Data Envelopment Analysis Model", *Engineering Journal*, 25(6), 45-54. https://doi.org/10.4186/ej.2021.25.6.45

Meng, J. and Wang, S. (2022). "The Performance Evaluation of Logistics Enterprises in Online Supply Chain Finance Based on Analytic Hierarchy Process", *Mathematical Problems in Engineering*, 2022(1), 8393223. https://doi.org/10.1155/2022/8393223

Nenavani, J., Prasuna, A., Siva Kumar, S.N.V. and Kasturi, A. (2024). "ESG Measures and Financial Performance of Logistics Companies", *Letters in Spatial and Resource Sciences,* 17(1), 5. https://doi.org/10.1007/s12076-023-00358-4

Nguyen, H.T.X. (2022). "The Effect of COVID-19 Pandemic on Financial Performance of Firms: Empirical Evidence from Vietnamese Logistics Enterprises", *The Journal of Asian Finance, Economics and Business*, 9(2), 177-183. https://doi.org/10.13106/jafeb.2022.vol9.no2.0177

Orçun, Ç. and Eren, S. (2017). "TOPSIS Yöntemi ile Finansal Performans Değerlendirmesi: XUTEK Üzerinde Bir Uygulama", *Muhasebe ve Finansman Dergisi* 75, 139-154. https://doi.org/10.25095/mufad.399899

Pamučar, D. and Ćirović, G. (2015). "The Selection of Transport and Handling Resources in Logistics Centers Using Multi-Attributive Border Approximation Area Comparison (MABAC)", *Expert Systems with Applications*, 42(6), 3016-3028. https://doi.org/10.1016/j.eswa.2014.11.057

Sharma, N.K., Kumar, V., Verma, P. and Luthra, S. (2021). "Sustainable Reverse Logistics Practices and Performance Evaluation with Fuzzy TOPSIS: A Study on Indian Retailers", *Cleaner Logistics and Supply Chain*, 1, 100007. https://doi.org/10.1016/j.clscn.2021.100007

Sobieralski, J.B. (2020). "COVID-19 and Airline Employment: Insights from Historical Uncertainty Shocks to the Industry", *Transportation Research Interdisciplinary Perspectives*, 5, 100123. https://doi.org/10.1016/j.trip.2020.100123

Stanujkic, D., Zavadskas, E.K., Brauers, W.K. and Karabasevic, D. (2012). "An Approach to Personnel Selection Based on the MOORA Method", *Business: Theory and Practice*, 13(2), 103-111.

Uygurtürk, H. and Korkmaz, T. (2012). "Finansal Performansın TOPSIS Çok Kriterli Karar Verme Yöntemi İle Belirlenmesi: Ana Metal Sanayi İşletmeleri Üzerine Bir Uygulama", *Eskişehir Osmangazi Üniversitesi İİBF Dergisi*, 7(2), 95-115.

Yazdani, M. and Payam, A.F. (2015). "A Comparative Study on MCDM Methods for Material Selection: The Case of Automotive Industry", *Decision Science Letters*, 4(3), 345-358. https://doi.org/10.5267/j.dsl.2015.2.004

Yoon, K. (1987). "A Reconciliation among Discrete Compromise Situations", *Journal of the Operational Research Society,* 38(3), 277-286.

Yürüyen, A.A., Ulutaş, A. and Özdağoğlu, A. (2023). "Lojistik İşletmelerinin Performansının Bir Hibrit ÇKKV Modeli ile Değerlendirilmesi", *Business & Management Studies: An International Journal*, 11(3), 731-751. https://doi.org/10.15295/bmij.v11i3.2245

Zavadskas, E.K., Turskis, Z. and Kildienė, S. (2016). "State of Art Surveys of Overviews on MCDM/MADM Methods", *Technological and Economic Development of Economy,* 22(2), 165-200. https://doi.org/10.3846/20294913.2016.1164560