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A comparative analysis of the affordability of healthy diets across Türkiye and BRICS countries using CoCoSo and MARCOS methods

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Abstract

Purpose: This study aims to provide a comparative evaluation of the affordability of healthy diets in Türkiye and BRICS countries (Brazil, Russia, India, China, South Africa, Egypt, Ethiopia, Indonesia, Iran and the United Arab Emirates) during the years 2017 and 2021. The study focuses on understanding the evolution of diet-related economic challenges and the structural disparities affecting food affordability in emerging economies.

Design/Methodology/Approach: A Multi-Criteria Decision-Making (MCDM) framework is used incorporating the Statistical Variance (SV) method for objective weighting of criteria and two decisionmaking techniques — CoCoSo and MARCOS—for ranking country performances. Data for the analysis are obtained from FAOSTAT and other international databases, covering key nutrition cost indicators such as Cost of a Healthy Diet (CoHD), Cost of Starchy Staples (CoSS), and Number of Unaffordable (NUA).

Findings: Results show that NUA was the most significant indicator in both years, reflecting its dominant role in healthy diet access. The importance of CoSS increased significantly in 2021, likely due to postpandemic market disruptions. Türkiye, Russian Federation, and UAE ranked highest in affordability across both years. On the other hand, countries such as India and Egypt experienced persistent challenges. MARCOS and CoCoSo methods provided consistent and complementary rankings, validating the robustness of the integrated MCDM approach.

Originality/Value: This research is among the first to apply a combined SV–CoCoSo–MARCOS approach to compare the affordability of healthy diets over time across Türkiye and BRICS countries. The integration of dynamic MCDM methods with updated cross-country nutrition data provides a valuable contribution to the literature on nutrition economics and food policy.

Keywords: CoCoSo method, healthy diet affordability, MARCOS method, Multi-Criteria Decision-Making, statistical variance.

CoCoSo ve MARCOS yöntemleri kullanılarak Türkiye ve BRICS ülkeleri arasında sağlıklı beslenmenin karşılanabilirliğinin karşılaştırmalı analizi

Özet

Amaç: Bu çalışma, Türkiye ve BRICS ülkelerinde (Brezilya, Rusya, Hindistan, Çin, Güney Afrika, Mısır, Etyopya, Endonezya, İran ve Birleşik Arap Emirliği) 2017 ve 2021 yıllarında sağlıklı diyetlerin karşılanabilirliğini karşılaştırmalı olarak değerlendirmeyi amaçlamaktadır. Araştırma, beslenmeyle ilişkili ekonomik sorunların gelişimini ve gelişmekte olan ekonomilerdeki yapısal eşitsizliklerin gıda karşılanabilirliğine etkisini ortaya koymayı hedeflemektedir.

Tasarım/Metodoloji/Yaklaşım: Çok Kriterli Karar Verme (ÇKKV) çerçevesinde oluşturulan analiz modelinde, kriterlerin objektif ağırlıklarının belirlenmesinde İstatistiksel Varyans (SV) yöntemi kullanılmış; ülke performanslarının sıralanmasında ise CoCoSo ve MARCOS yöntemlerinden yararlanılmıştır. Analiz için gerekli veriler FAOSTAT ve diğer uluslararası veri tabanlarından elde edilmiş olup; analizde Sağlıklı Diyet Maliyeti (CoHD), Nişasta Bazlı Temel Gıda Maliyeti (CoSS) ve Karşılayamayan Birey Sayısı (NUA) gibi temel göstergeler kullanılmıştır.

Bulgular: Her iki yılda da NUA en belirleyici gösterge olarak öne çıkmıştır ve sağlıklı diyete erişimdeki temel engelleri yansıtmaktadır. CoSS göstergesinin önemi ise 2021 yılında önemli ölçüde artmıştır, bu durum pandemi sonrası piyasa dalgalanmaları ile ilişkilendirilmektedir. Türkiye, Rusya ve BAE her iki yılda da en yüksek karşılanabilirliğe sahip ülkeler olmuştur. Öte yandan, Hindistan ve Mısır gibi ülkeler sürekli olarak düşük performans göstermiştir. CoCoSo ve MARCOS yöntemleri, tutarlı ve birbirini tamamlayıcı sıralama sonuçları sunmuş ve bu bütünleşik karar verme modelinin sağlamlığını doğrulamıştır.

Özgünlük/Değer: Bu araştırma, Türkiye ve BRICS ülkelerinde sağlıklı diyetlerin zaman içerisindeki karşılanabilirliğini karşılaştırmak için SV– CoCoSo–MARCOS yöntem kombinasyonunu uygulayan ilk çalışmalardan biridir. Güncel ülke verileriyle entegre edilen dinamik ÇKKV yöntemleri, beslenme ekonomisi ve gıda politikaları literatürüne anlamlı katkı sağlamaktadır.

Anahtar kelimeler: CoCoSo yöntemi, sağlıklı beslenmenin karşılanabilirliği, MARCOS yöntemi, Çok Kriterli Karar Verme, istatistiksel varyans.

INTRODUCTION

In recent years, food systems have been recognized as complex structures with far-reaching impacts on public health, environmental sustainability, and economic equity (Herforth et al., 2020; FAO et al., 2021). Ensuring access to affordable and nutritious diets remains a major global challenge, particularly in developing and emerging economies where structural disparities between income levels and the cost of healthy foods create significant barriers to food security (Rehm et al., 2008; Darmon & Drewnowski, 2015). Healthy nutrition, acknowledged as a basic human right, is still subject to inequalities shaped by national economic policies, trade dynamics, agricultural systems, and consumer behavior (Aljuraiban et al., 2020; FAO, 2021).

In this context, the BRICS nations—Brazil (Federative Republic of Brazil), Russia (Russian Federation), India (Republic of India), China (People's Republic of China), and South Africa (Republic of South Africa)—represent key players in the global food system. Together, these countries account for a substantial proportion of the world's population and food demand, and are increasingly shaping global trade and nutrition markets (Güneş, 2019). Similarly, Türkiye is a dynamic emerging economy with strategic geopolitical importance and expanding food markets. It is also exploring alternative economic alliances, such as deeper engagement with BRICS, in addition to its long-standing EU accession efforts (Güneş, 2019).

Despite this significance, comparative analyses of the affordability of healthy diets across Türkiye and BRICS countries remain scarce in the academic literature (Yaşar & Bolat, 2023). To address this gap, this study conducts a systematic evaluation of daily healthy diet costs in Türkiye and BRICS countries for the years 2017 and 2021. The analysis employs advanced Multi-Criteria Decision-Making (MCDM) methods, specifically the Combined Compromise Solution (CoCoSo) and Measurement Alternatives and Ranking according to Compromise Solution (MARCOS) techniques. These methods have demonstrated superior capability in integrating diverse socio-economic and nutritional indicators, providing a balanced and robust assessment framework (Stević et al., 2020; Yazdani et al., 2019; Hami et al., 2019).

Additionally, the Statistical Variance (SV) method is used to determine criteria weights. The SV method is preferred for its objectivity, as it relies on the variability of indicators within the dataset, allowing for a data-driven prioritization of more informative variables (Çilek, 2022). The combination of SV, CoCoSo, and MARCOS methods ensures comprehensive and accurate comparative results, capturing the complexity of food affordability across different national contexts.

The focus on Türkiye and BRICS countries is particularly relevant, as these economies share similarities in their growth trajectories while differing in trade structures, agricultural systems, and public health challenges (Güneş, 2019; Yaşar & Bolat, 2023). The insights generated from this research aim to support policymakers in designing effective food security strategies and promoting equitable access to healthy diets in line with sustainable development goals (FAO et al., 2021; Herforth et al., 2020).

In this study, the affordability of healthy diets was analyzed comparatively for Türkiye and BRICS countries between 2017 and 2021 in the context of the pandemic impact and structural inequalities.

LITERATURE REVIEW

In recent years, healthy nutrition has evolved into a multidimensional issue, shaped by economic conditions, food policies, and price variability rather than individual choices alone (Aljuraiban et al., 2020; Herforth et al., 2020). Numerous studies have demonstrated that food affordability directly affects the quality of diets, especially in low- and middle-income countries (Rehm et al., 2008; Darmon & Drewnowski, 2015).

To address this complexity, researchers increasingly use MCDM methods, which allow for the integration of economic, social, and nutritional factors (Stević et al., 2020; Yazdani et al., 2019). The Table 1 below summarizes key studies that have applied different MCDM or economic methods in related fields.

Table 1. The related studies in the literatüre

Year	Authors	Method	Title	Main Findings
2004	Drewnowski & Specter	Economic-Nutrition Analysis	*Poverty and Obesity*	Energy-dense cheap foods are linked to obesity.
2008	Rehm et al.	HEI Score	*Diet Quality of Low-Income and Higher Income Americans*	Lower income leads to poorer diet quality.
2015	Darmon & Drewnowski	Economic Analysis	*Is Cost a Major Factor in Eating Healthy?*	Healthy foods are more expensive.
2018	Özdemir & Toksarı	AHP - TOPSIS	*Agricultural Sector Performance in Türkiye*	AHP & TOPSIS are effective in ranking productivity.
2019	Hami et al.	MARCOS	*Sustainable Supplier Selection*	MARCOS method is sensitive to sustainability criteria
2019	Yazdani et al.	CoCoSo	*Integrated CoCoSo Method for MCDM Problems*	Effective integration is obtained for multiple solutions.
2020	Aljuraiban et al.	Literature Review	*Defining a Healthy Diet*	Diet patterns reduce disease risk.
2020	Stević et al.	MARCOS	*MARCOS: A New MCDM Method*	Balanced ranking are obtained using ideal/anti-ideal references.
2021	FAO (UN)	Conceptual Analysis	*The True Cost of Food*	Food costs must include social & environmental factors.
2021	Peng et al.	CoCoSo and CRITIC	*A Novel İnterval-Valued Fuzzy Soft Decision-Making Method Based on CoCoSo and CRITIC for Intelligent Healthcare Management Evaluation*	In this study, interval-valued fuzzy soft decision-making algorithm-based CoCoSo is developed. The validity of algorithm is demonstrated with the experimental results of some MCDM methods on the healthcare management industry.
2021	Torkayesh et al.	CoCoSo	*An Integrated BWM-LBWA-CoCoSo Framework for Evaluation of Healthcare Sectors in Eastern Europe*	Method is used to evaluate healthcare performances of several countries. Seven Easthern Europe countries' health systems are compared to indicate the best one.
2021	Torkayesh et al.	CoCoSo	*Comparative Assessment of Social Sustainability Performance: Integrated Data-Driven Weighting System and CoCoSo Model*	Countries are comparatively evaluated and ranked using the CoCoSo. The result shows the best performance with respect to social sustainability indicators.
2022	Chen et al.	CoCoSo	*New Model for Occupational Health and Safety Risk Assessment based on Fermatean Fuzzy Linguistic Sets and CoCoSo Approach*	The CoCoSo approach is utilized to determine the risk priority of the identified occupational hazards.
2022	Çilek	SV - CoCoSo	*Activity Analysis with Integrated SV-CoCoSo Techniques*	Integrated SV-CoCoSo method have effectively evaluated and ranked the decision alternatives.
2023	Yaşar & Bolat	TOPSIS	*BRICS Ülkeleri ile Türkiye'nin Ekonomik Performansının Dış Ticaret Verileri Kapsamında TOPSIS Yöntemi ile İncelenmesi*	TOPSIS reveals the relative economic performance effectively. China and Russia had the highest economic performances while South Africa and India had the worst. Brazil's and Turkey's performances have changed with respect to time.
2024	Çukur & Işın	TOPSIS	*Bazı Avrupa Birliği Ülkelerinin Organik Tarım Performanslarının TOPSİS Yöntemiyle Değerlendirilmesi*	The analyisis reveals that France is the country with the highest organic agriculture performance in terms of the criteria considered for the period 2017-2021 .
2024	Wang et al.	MEREC and CoCoSo	*Underground Mine Safety and Health: A Hybrid MEREC–CoCoSo System for the Selection of Best Sensor*	A novel hybrid MEREC - CoCoSo system is proposed to address safety and health conditions in underground mines through the selection of optimal sensor technologies.
2025	Işın et al.	VIKOR	*Bazı Avrupa Birliği Ülkelerinin Gıda Güvencesi Göstergelerinin VIKOR Yöntemiyle Değerlendirilmesi*	According to the analysis, significant differences have been observed in terms of food security in the European Union countries. The countries such as Austria, Belgium and France are in the best situation when compared with other European countries.
2025	Arıkan Kargı, V.S.	MEREC based MARCOS	*Analysis of the Performance of Companies in the Individual Pension System Using the Merec-Based Marcos Method*	The MEREC method is utilised to calculate the criteria weights. The MARCOS method is applied to rank the performance of the individual pension companies, and the analysis showed that Turkey Life and Pension is the highest-performing company
2025	Lukić	SWARA and MARCOS	*Analysis of Occupational Frauds Based on SWARA and MARCOS Method.*	According to the research results, occupational fraud is most prevalent in the construction sector, while the information industry experiences the least occupational fraud. Retail also has a relatively low incidence of occupational fraud.
2025	Khalilzadeh et al.	DEMATEL and MARCOS	*Identification and Ranking of Human Resource-Related Risks Considering Secondary and Residual Risks in Water Transfer Projects Using the DEMATEL–MARCOS Method*	Main findings of the study are that "accidents during material transportation" (primary risk), "corrosion" (secondary risk), and "pipeline pressure" (residual risk) are the most critical factors influencing human capital in such projects.

While these studies have contributed valuable insights, certain limitations remain:

1. Limited comparative focus: Most previous works either focused on *single countries* (Rehm et al., 2008; Darmon & Drewnowski, 2015) or broad conceptual analyses (FAO, 2021), rather than *systematic cross-country comparisons*, particularly among Türkiye and BRICS nations.

2. Lack of dynamic time analysis: The majority of studies used *static data* from a single year or period. Few examined changes over time (e.g., 2017 vs. 2021), which is critical given the rapid evolution of food prices and policy impacts (Bai et al., 2021).

3. Insufficient integration of MCDM techniques: Although MCDM methods such as TOPSIS and AHP have been used (Özdemir & Toksarı, 2018), more recent techniques like CoCoSo and MARCOS, which offer greater flexibility and sensitivity (Stević et al., 2020; Yazdani et al., 2019), remain underutilized in nutrition affordability research.

4. Weighting bias: Many earlier studies used subjective weighting systems. The SV (Statistical Variance) method provides an objective alternative by identifying the most informative criteria based on variability (Çilek, 2022).

Therefore, this study aims to fill these gaps by systematically comparing the cost of healthy nutrition in Türkiye and BRICS countries across two time points (2017 and 2021), using an integrated MCDM framework combining SV, CoCoSo, and MARCOS. This approach enables a more accurate and dynamic analysis, capturing both economic diversity and evolving food system trends across these emerging economies.

MATERIAL and METHOD

In this study, a comparative analysis of the daily costs of healthy eating for Türkiye and BRICS was conducted for the years 2017 and 2021. The dataset includes agricultural and food statistics, foreign trade data, and population indicators for the selected countries. The criteria used in the study are summarized in Table 2 below:

Table 2. The criteria and their descriptions

Criteria	Descriptions	Unit
CoHD	Cost of a healthy diet	PPP dollar per person per day
CoSS	Cost of starchy staples	PPP dollar per person per day
CoASF	Cost of animal source foods	PPP dollar per person per day
CoLNS	Cost of legumes, nuts and seeds	PPP dollar per person per day
CoV	Cost of vegetables	PPP dollar per person per day
CoF	Cost of fruits	PPP dollar per person per day
CoOF	Cost of oils and fats	PPP dollar per person per day
PUA	Prevalence of unaffordability	Percent
NUA	Number of people unable to afford a healthy diet	Million

In this study, SV method was used to determine the weights of the criteria. SV prioritizes criteria with higher variance, allowing data-driven emphasis on the most informative indicators (Çilek, 2022).

For the ranking of the countries, CoCoSo and MARCOS methods were used. These methods were chosen because they provide objective, balanced, and accurate results in multi-criteria analyses (Stević et al., 2020; Yazdani et al., 2019). MARCOS evaluates alternatives according to both ideal and anti-ideal solutions, offering greater sensitivity (Hami et al., 2019).

The datasets for 2017 and 2021 were compiled and analyzed in Excel. The data represent various socio-economic and agricultural indicators affecting the cost of healthy eating. These indicators reflect multiple structural factors that influence diet affordability (Bai et al., 2021; Herforth et al., 2020).

The criterion values for each country and each year are presented in the following tables Tables 3 and 4.

Table 3. Country based data for the Year 2017

Country	CoHD	CoSS	CoASF	CoLNS	CoV	CoF	CoOF	PUA	NUA
Brazil	3.22	0.44	0.64	0.74	0.47	0.46	0.07	27.40	57.20
China	2.68	0.43	0.67	0.28	0.48	0.62	0.09	28.20	398.10
Egypt	3.83	0.58	1.21	0.38	0.49	0.53	0.26	53.00	53.90
Ethiopia	2.83	0.44	0.88	0.27	0.55	0.78	0.19	59.30	64.20
India	2.86	0.41	0.89	0.29	0.59	0.50	0.14	69.50	941.10
Indonesia	3.69	0.69	0.93	0.43	1.16	0.79	0.13	51.40	135.90
Iran	3.01	0.44	0.70	0.68	0.49	0.63	0.17	7.70	6.50
Russian Federation	2.25	0.36	0.98	0.19	0.74	0.74	0.13	3.10	4.50
South Africa	3.05	0.63	1.06	0.85	0.70	0.73	0.13	61.00	34.60
Türkiye	3.44	0.36	0.82	0.27	0.45	0.85	0.13	11.70	9.60
United Arab Emirates	2.42	0.39	0.86	0.27	0.53	0.56	0.15	1.00	0.10

Table 4. Country based data for the Year 2021

Country	CoHD	CoSS	CoASF	CoLNS	CoV	CoF	CoOF	PUA	NUA
Brazil	3.84	0.62	0.83	0.94	0.67	0.65	0.13	30.20	64.70
China	3.08	0.45	0.90	0.29	0.59	0.73	0.13	17.60	251.30
Egypt	3.88	3.66	1.59	0.47	0.50	0.47	0.24	42.30	46.20
Ethiopia	3.37	0.57	1.28	0.29	0.34	0.72	0.16	55.20	66.30
India	3.11	0.42	0.91	0.37	0.64	0.53	0.24	59.00	830.90
Indonesia	4.22	0.69	1.25	0.46	0.78	0.91	0.13	46.60	127.60
Iran	4.17	—	—	—	—	—	—	15.00	13.20
Russian Federation	2.63	0.41	0.64	0.29	0.52	0.62	0.15	1.90	2.70
South Africa	3.39	0.56	1.08	0.31	0.68	0.66	0.01	61.20	36.40
Türkiye	3.82	0.51	1.14	0.42	0.60	0.97	0.19	8.70	7.40
United Arab Emirates	2.86	0.45	0.99	0.35	0.32	0.48	0.26	<0.1	<0.1

These tables were then analyzed using SV**,** CoCoSo**,** and MARCOS methods to perform a comparative evaluation across countries and over time.

SV method

The SV method is an objective technique used in weighting criteria. By calculating the variance of each criterion within the data set, criteria with higher variance are considered to have higher information density and are assigned higher weights. Thus, a weighting based on statistical distribution is made instead of subjective judgments on the data. This approach contributes to the determination of weights by taking into account the homogeneous or heterogeneous structures of the criteria (Çilek, 2022).

Step 1. In the first step of the technique, the initial decision string X, consisting of decisionoptions and evaluation criteria, is prepared by taking into account Equation (1).

$$X = \begin{bmatrix} x_{12} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \quad i = 1,2, \quad \dots m \quad j = 1,2, \quad \dots n \qquad (1)$$

In the matrix prepared in Equation (1), xij represents the value of the i. option in terms of the j. criterion.

Step 2. Using different units in the measurement of the evaluation criteria in the decision matrix makes it difficult to compare these criteria. In the second step of the technique, a normalization calculation is performed to bring these criteria values of X in different units to a uniform form with the help of Equation (2).

$$x_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \dots \dots \dots \; i = 1,2, \dots m \quad j = 1,2, \quad \dots n \qquad (2)$$

Step 3. In this step, the variance value of each criterion is obtained with the help of Equation (3).

$$V_j = \left(\frac{1}{n}\right)\sum_{i=1}^{n}(x_{ij}^{*} - (\,x_{ij}^{*})_{ort})^{x} \quad (3)$$

Step 4. In the last step of the technique, the importance weights of each criterion are found using Equation (4).

$$V_j = \left(\frac{V_j}{\sum_{i=1}^{n} V_j}\right) \quad (4)$$

When interpreting the importance levels of the criteria, the criterion with the highest value is interpreted as the most important effectiveness criterion.

MARCOS method

MARCOS method is a method developed by Stevic et al. in 2019. This method is based on defining the relationship between alternatives and reference values; ideal and non-ideal alternatives. Based on the defined relationships, the utility functions of the alternatives are determined, and a consensus ranking is made according to ideal and non-ideal solutions. Decision preferences are defined on the basis of utility functions. Utility functions represent the position of the alternative regarding an ideal and non-ideal solution. The best alternative is the closest point to the ideal solution and at the same time the farthest point from the non-ideal reference (Stevic et al., 2019).

The steps of the MARCOS method are as follows (Stevic et al., 2019).

Step 1. Creating a Decision Matrix

The decision matrix is obtained as in Equation (1), with the criteria in the columns and the alternatives in the rows.

Step 2. Creating an Extended Decision Matrix

The ideal solution (AI) and the non-ideal solution (AAI) are added to the decision matrix to obtain the extended decision matrix (X^0).

$$X^0 = \begin{array}{c} AAI \\ A_1 \\ A_2 \\ \dots \\ A_m \\ AI \end{array} \begin{vmatrix} x_{aa1} & x_{aa2} & \dots & x_{aan} \\ x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{22} & \dots & x_{mn} \\ x_{ai1} & x_{ai2} & \dots & x_{ain} \end{vmatrix} \quad (5)$$

In order to calculate the ideal solution and non-ideal solution values, the criteria must be classified as benefit and cost. After the relevant classification, the AI and AAI lines are calculated with the help of Equation (6) and Equation (7).

$$AAI = \min x_{ij} \text{ if } j \in B \text{ and } \max x_{ij} \text{ if } j \in C \quad (6)$$

$$AI = \max x_{ij} \text{ if } j \in B \text{ and } \min x_{ij} \text{ if } j \in C \quad (7)$$

Step 3. Creating the Normalized Extended Decision Matrix

While creating the normalized extended decision matrix (N), Equation (8) is used for cost-oriented criteria and Equation (9) is used for benefit-oriented criteria.

$$n_{ij} = \frac{x_{ai}}{x_{ij}} \; if \; j \in C \quad (8)$$

$$n_{ij} = \frac{x_{ij}}{x_{ai}} \; if \; j \in B \quad (9)$$

Step 4. Creating the Weighted Normalized Extended Decision Matrix

In this step, the weighted normalized extended decision matrix (V) is created and the calculation of the elements of the matrix is given in Equation (10). The weighted normalized extended decision matrix is obtained by multiplying the criterion weights vector (w) with the normalized extended decision matrix (N).

$$V_{ij} = N_{ij} \times w_j \quad (10)$$

Step 5. Calculation of Benefit Degrees for Alternatives

In this step, benefit degrees for ideal and non-ideal solutions are calculated for each criterion by means of Equation (11) and Equation (12). S_i represents the sum of the weighted matrix elements and is calculated by means of Equation (13).

$$K_i^+ = \frac{S_i}{S_{ai}} \quad (11)$$

$$K_i^- = \frac{S_i}{S_{aai}} \quad (12)$$

$$S_i = \sum_{i=1}^{n} V_{ij} \quad (13)$$

Step 6. Utility Function Calculation of Alternatives

In this step, the compromise solution values of the observed alternatives according to the ideal and non-ideal solutions are obtained. The utility function values of the alternatives are obtained with the help of Equation (14). While $f(K_i^+)$ expresses the utility function according to the ideal solution, $f(K_i^-)$ expresses the utility function according to the non-ideal solution.

$$K_i = \frac{K_i^+ + K_i^-}{\frac{1 - f(K_i^+)}{f(K_i^+)} + \frac{1 - f(K_i^-)}{f(K_i^-)}} \quad (14)$$

$$f(K_i^-) = \frac{K_i^+}{K_i^+ + K_i^i} \quad (15)$$

$$f(K_i^+) = \frac{K_i^-}{K_i^+ + K_i^i} \quad (16)$$

Step 7. Ranking of Alternatives

In this step, the ranking of the alternatives is obtained by ranking the utility function values of the alternatives calculated according to K_i value obtained using Equation (14), with the order from largest to smallest.

CoCoSo method

The CoCoSo technique, which is based on both the consensus of preferred decision options and the identification of the best alternative, was developed by Yazdani, Zarate, Zavadskas, and Turskis (2019). The application of this technique consists of five steps and is as follows (Yazdani et al., 2019: 2507-2508; Ulutaş, Karakuş and Topal, 2020: 9-12; Özdağoğlu, Ulutaş and Keleş, 2020: 376-377; Ecer and Pacamur, 2020: 7-8; Deveci, Pamucar and Gokasar, 2021: 7-9; Akbulut and Hepşen, 2021: 687-689; Akgül, 2021: 78-79);

Step 1. The initial decision string indicated by "X" is prepared with the help of Equation (17).

$$X = \begin{bmatrix} x_{12} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad i = 1,2,\ldots m \quad j = 1,2,\ldots n \quad (17)$$

Step 2. In this step, the benefit-oriented evaluation criteria are normalized with the help of Equation (18) and the cost-oriented criteria are normalized with the help of Equation (19).

$$r_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} \text{ for benefit criteria} \quad (18)$$

$$r_{ij} = \frac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} \text{ for cost criteria} \quad (19)$$

Step 3. In this step, the total weighted comparability matrices of each decision option, shown as S_i, and the total exponentially weighted comparability matrices, shown as P_i, are obtained with the help of Equation (20) and Equation (21).

$$S_i = \sum_{j=1}^{n} (w_j r_{ij}) \quad 20$$

$$P_i = \sum_{j=1}^{n} (r_{ij})^{w_j} \quad 21$$

Step 4. In this step, the triple evaluation scores of each decision option are obtained by using Equation (22), Equation (23) and Equation (24).

The arithmetic mean of the sum of the weighted multiplication technique and the weighted sum technique is calculated using Equation (22).

$$\mathrm{K_{i}}_{a} = \frac{P_i + S_i}{\sum_{i=1}^{m}(P_i + S_i)}, \quad i = 1,2, \ldots . m \quad 22$$

The sum of the weighted total and weighted product scores compared to the best decision option is calculated using Equation (23).

$$\mathrm{K_{i}}_{b} = \frac{S_i}{\min\limits_{i} S_i} + \frac{P_i}{\min\limits_{i} P_i}, \quad i = 1,2, \ldots . m \quad 23$$

The balanced scores of the weighted sum technique and the weighted product technique are calculated using Equation (24).

$$\mathrm{K_{i}}_{c} = \frac{\lambda(S_i) + (1-\lambda)(P_i)}{\lambda \max\limits_{i} S_i + (1-\lambda) \max\limits_{i} P_i}, \qquad i = 1,2, \ldots m \; ve \; 0 \leq \lambda \leq 1 \quad 24$$

The parameter in Equation (24) indicated by λ is generally accepted as 0.50 and can also be determined by decision makers.

Step 5. The efficiency scores shown in the last step of the technique are determined using Equation (25).

$$\mathrm{K_i} = (\mathrm{k_{i}}_{a}, \mathrm{k_{i}}_{b,} \mathrm{k_{i}}_{c})^{\frac{1}{3}} + \frac{1}{3}(\mathrm{k_{i}}_{a} + \mathrm{k_{i}}_{b} + \mathrm{k_{i}}_{c}) \quad 25$$

The decision option with the highest efficiency score is considered the most ideal option.

FINDINGS

Table 5 presents the SV based weights for each criterion across 2017 and 2021. The results reveal that NUA (Number of People Unable to Afford a Healthy Diet) consistently holds the highest weight in both years (72.74% in 2017 and 54.40% in 2021), indicating it is the most dominant factor influencing the comparative analysis. This reflects the direct impact of unaffordability on healthy diet access.

In 2021, CoSS (Cost of Starchy Staples) gains significantly more importance, moving from rank 6 (2017) to rank 2 (2021), most likely due to rising prices in global staple markets post-pandemic (Bai et al., 2021). PUA and CoLNS also remain among the more influential criteria in both years, underlining the critical role of logistics, affordability, and food insecurity on dietary outcomes.

Table 5. Weighting of criteria based on the SV method for the years 2017-2021

Criteria	W_i (2017)	Rank of SV for (2017)	W_i(2021)	Rank of SV for (2021)
CoHD	0.005787	9	0.003881	9
CoSS	0.012184	6	0.249505	2
CoASF	0.008209	8	0.011275	7
CoLNS	0.062063	3	0.038076	4
CoV	0.025325	5	0.011879	6
CoF	0.008760	7	0.010768	8
CoOF	0.026336	4	0.035216	5
PUA	0.123849	2	0.095385	3

NUA	0.727488	1	0.544015	1

In Table 6, the MARCOS method results for 2017 show that United Arab Emirates achieved the highest ranking (Rank 1), followed by Russian Federation and Türkiye. This indicates that these countries had relatively better performance in terms of affordability and access to a healthy diet in 2017, as per the MARCOS utility values. On the contrary, South Africa**,** Indonesia, and Egypt ranked lower, suggesting greater challenges in food affordability and distribution.

Table 6. SV based MARCOS for 2017

Countries	S_i	K_i^+	K_i^-	$f(K_i^+)$	$f(K_i^-)$	K_i	**Rank of MARCOS$_{2017}$**
Breazil	0.103291	0.103291	2.006198	0.951035	0.048965	0.103031	7
China	0.120313	0.120313	2.336823	0.951035	0.048965	0.120011	4
Egypt	0.087973	0.087973	1.708672	0.951035	0.048965	0.087751	9
Ethiopia	0.103024	0.103024	2.001018	0.951035	0.048965	0.102765	8
India	0.104217	0.104217	2.024193	0.951035	0.048965	0.103955	6
Indonesia	0.075008	0.075008	1.456869	0.951035	0.048965	0.074820	10
Iran	0.106915	0.106915	2.076587	0.951035	0.048965	0.106646	5
Russian Federation	0.176539	0.176539	3.428874	0.951035	0.048965	0.176095	2
South Africa	0.070174	0.070174	1.362982	0.951035	0.048965	0.069998	11
Türkiye	0.128459	0.128459	2.495040	0.951035	0.048965	0.128136	3
United Arab Emirates	0.958735	0.958735	18.621310	0.951035	0.048965	0.956324	1

The 2021 MARCOS results (Table 7) reveal noticeable shifts. United Arab Emirates again leads the ranking, followed by Russian Federation, India, and South Africa. Notably, Iran was excluded from this analysis in 2021 due to the unavailability of key data points, a limitation acknowledged in this study. The absence of Iran's data affects cross-year comparability and reflects the data collection challenges in certain economies (FAO, 2021).

The change in rankings between 2017 and 2021 reflects the dynamic impact of the COVID-19 pandemic on food prices, logistics, and economic access to nutrition.

Table 7. SV based MARCOS 2021

Countries	S_i	K_i^+	K_i^-	$f(K_i^+)$	$f(K_i^-)$	K_i	**Rank of MARCOS$_{2021}$**
Breazil	0.204275	0.204275	3.515799	0.945089	0.054911	0.203625	8
China	0.292827	0.292827	5.039888	0.945089	0.054911	0.291896	4
Egypt	0.078465	0.078465	1.350476	0.945089	0.054911	0.078216	10
Ethiopia	0.246631	0.246631	4.244808	0.945089	0.054911	0.245847	7
India	0.301578	0.301578	5.190500	0.945089	0.054911	0.300619	3
Indonesia	0.193603	0.193603	3.332129	0.945089	0.054911	0.192987	9
Federation	0.320810	0.320810	5.521504	0.945089	0.054911	0.319789	2
South Africa	0.276476	0.276476	4.758476	0.945089	0.054911	0.275597	5
Türkiye	0.249366	0.249366	4.291873	0.945089	0.054911	0.248573	6
United Arab Emirates	0.932910	0.932910	16.056460	0.945089	0.054911	0.929943	1

Table 8 summarizes the 2017 CoCoSo method results. Again, United Arab Emirates ranks highest, consistent with MARCOS findings. Russian Federation and Iran also appear near the top, demonstrating strong affordability and food system resilience at that time. Countries such as India**,** Indonesia, and Egypt are positioned lower in the CoCoSo ranking, highlighting structural barriers in those markets. The alignment between CoCoSo and MARCOS results in 2017 validates the robustness of the chosen methods (Stević et al., 2020; Yazdani et al., 2019).

Table 8. SV based CoCoSo for 2017

Countries	k_{ia}	k_{ib}	k_{ic}	k_i	**Rank**
Breazil	0.09982917	8.951729	0.970704	4.294466	5
China	0.09825485	7.017162	0.955396	3.560365	8
Egypt	0.06439183	7.854951	0.626124	3.530113	9
Ethiopia	0.09813110	8.520562	0.954193	4.118440	6
India	0.08144080	2.450062	0.791902	1.648428	11
Indonesia	0.07471273	7.398664	0.726481	3.471061	10
Iran (Islamic Republic of)	0.10107038	9.495569	0.982773	4.507163	3
Russian Federation	0.10260986	9.959268	0.997742	4.693035	2
South Africa	0.08590928	7.953919	0.835352	3.787920	7
Türkiye	0.09080796	9.567304	0.882985	4.429123	4
United Arab Emirates	0.10284203	10.03444	1.000000	4.722969	1

Table 9 displays the CoCoSo results for 2021. The Russian Federation moves into first place, followed closely by United Arab Emirates and Türkiye. Iran is again missing from this year's results due to unavailable data, limiting comparative insights for this country in the post-pandemic period.

The general upward movement of countries like Türkiye suggests improvements in food affordability and supply chain management between 2017 and 2021, whereas other countries like India and Egypt remained challenged.

Table 9. SV based CoCoSo 2021

Countries	k_{ia}	k_{ib}	k_{ic}	k_i	Rank
Breazil	0.099549	3.799254	0.457979	2.009695	7
China	0.109520	3.775834	0.503854	2.055910	6
Egypt	0.084583	2.906074	0.389128	1.583922	9
Ethiopia	0.109512	3.930019	0.503813	2.115217	4
India	0.091289	2.137683	0.419980	1.317358	10
Indonesia	0.085866	3.443578	0.395031	1.796984	8
Russian Federation	0.114250	4.435177	0.525614	2.335077	1
South Africa	0.101065	3.899171	0.518559	2.095275	5
Türkiye	0.101431	4.106906	0.520439	2.176996	3
United Arab Emirates	0.102935	4.245974	0.528157	2.239123	2

In summary, across both MARCOS and CoCoSo analyses, the rankings of Russian Federation, Türkiye, and United Arab Emirates suggest positive positioning in terms of healthy diet affordability. The results also demonstrate that the pandemic significantly impacted food systems, reflected in the increased weights of criteria such as CoSS and NUA.

Moreover, the absence of Iran's data for 2021 presents a known limitation. Future studies should address this gap through expanded data collection or imputation methods to ensure full comparative analysis across all countries (Herforth et al., 2020).

CONCLUSION and DISCUSSION

Table 10 presents the comparative analysis of SV based criteria rankings between the years 2017 and 2021. The criterion NUA (Number of People Unable to Afford a Healthy Diet) consistently held the first position across both years, reinforcing its dominant influence in the assessment of healthy diet affordability. This result indicates that, despite economic shifts and external shocks, the absolute number of people facing diet unaffordability remains the most critical factor in determining food system performance (Herforth et al., 2020).

A notable change is observed in CoSS (Cost of Starchy Staples), which rose from 6th place in 2017 to 2nd place in 2021. This shift likely reflects the pandemic-induced price volatility in staple food markets (Bai et al., 2021). Additionally, CoLNS (Cost of Legumes, Nuts, and Seeds) remained an influential factor (3rd in 2017, 4th in 2021), highlighting the continued importance of nutrient-dense food costs.

On the other hand, CoHD (Cost of a Healthy Diet) remained relatively low in weight (9th in both years), suggesting that broader structural factors (PUA, NUA) play a more critical role than headline diet cost indicators alone.

This evolution in SV rankings demonstrates that while some criteria (such as NUA) show stability, others (such as CoSS) can fluctuate significantly depending on external global and regional economic conditions. These dynamics underscore the importance of ongoing, flexible monitoring of food affordability indicators.

Table 10. Comparison of criteria importance

Criteria	Rank of SV Weights for 2017	Rank of SV Weights for 2021
CoHD	9	9
CoSS	6	2
CoASF	8	7
CoLNS	3	4
CoV	5	6
CoF	7	8
CoOF	4	5
PUA	2	3
NUA	1	1

Table 11 synthesizes the 2017 CoCoSo and MARCOS scores into a combined average and overall rank for each country. The results indicate that United Arab Emirates ranked 1st overall, followed by Russian Federation (2nd) and Iran (3rd). Türkiye achieved a strong 4th place, demonstrating relatively favorable affordability of healthy diets during this period.

Countries such as South Africa, India, and Indonesia ranked lower, indicating challenges related to affordability and food system performance in these contexts.

Importantly, this 2017 snapshot reflects a period prior to the global pandemic, characterized by relatively stable supply chains and pricing. The alignment of rankings across CoCoSo and MARCOS also supports the reliability of the integrated MCDM approach (Stević et al., 2020; Yazdani et al., 2019).

Table11. Summary table for 2017

Countries	k_i - CoCOSo Value	K_i - MARCOS Value	Avareage Value	Rank
Breazil	4.294465511	0.103031151	2.198748331	5
China	3.560365275	0.120010884	1.840188079	8
Egypt	3.530112766	0.087751316	1.808932041	9
Ethiopia	4.118440033	0.102765144	2.110602589	6
India	1.648427548	0.103955319	0.876191434	11
Indonesia	3.471060627	0.074819613	1.772940120	10
Iran (Islamic Republic of)	4.507162906	0.106646108	2.306904507	3
Russian Federation	4.693035183	0.176094730	2.434564957	2
South Africa	3.787919769	0.069997884	1.928958826	7
Türkiye	4.429122719	0.128136305	2.278629534	4
United Arab Emirates	4.722969305	0.956323954	2.839646630	1

Table 12 summarizes the post-pandemic results for 2021. Once again, United Arab Emirates retained the 1st position, followed by Russian Federation (2nd) and Türkiye, which improved to 3rd place — suggesting increased resilience and adaptability in Türkiye's food systems during the pandemic recovery phase.

Conversely, India and Egypt were positioned at the lower end of the rankings, likely due to lingering structural issues and pandemic-related disruptions. Iran could not be included in this analysis due to missing data for 2021 — a recognized limitation that affects longitudinal comparability (Herforth et al., 2020).

Between 2017 and 2021, clear changes emerged in national performance levels. Countries such as Türkiye improved in relative terms, while others (notably India) struggled to maintain affordability gains. The shift in ranks confirms that the pandemic period had profound impacts on food systems, underlining the importance of responsive public policies and effective supply chain management (FAO, 2021).

Table 12. Summary table for 2021

Countries	k_i - CoCOSo Value	K_i - MARCOS Value	Avareage Value	Rank
Breazil	2.009695095	0.203624844	1.106659969	7
China	2.055909881	0.291895667	1.173902774	6
Egypt	1.583922376	0.078215665	0.831069021	9
Ethiopia	2.115217367	0.245846921	1.180532144	5
India	1.317358032	0.300618640	0.808988336	10
Indonesia	1.796983848	0.192987205	0.994985526	8
Russian Federation	2.335076827	0.319789460	1.327433144	2
South Africa	2.095275480	0.275597066	1.185436273	4
Türkiye	2.176996202	0.248572791	1.212784496	3
United Arab Emirates	2.239122977	0.929943216	1.584533097	1

The comparative analysis across Table 10, Table 11, and Table 12 reveals three key insights:

1.Persistent structural challenges: Despite global efforts, NUA remains the dominant factor affecting affordability across all countries.

2.Dynamic sensitivity to external shocks: Criteria such as CoSS and CoLNS showed notable shifts, indicating vulnerability to global price volatility.

3.Differentiated national responses: Countries like Türkiye and Russian Federation demonstrated relative resilience, while others faced growing affordability gaps.

These findings offer valuable guidance for policymakers aiming to design adaptive food security strategies in the face of ongoing economic and environmental disruptions. In summary, this comparative analysis highlights both the persistent challenges and the dynamic nature of healthy diet affordability across Türkiye and BRICS countries. The observed shifts between 2017 and 2021 underscore the significant influence of external shocks — such as the COVID-19 pandemic — on food system performance. These findings emphasize the urgent need for adaptive, data-driven food security policies that can effectively respond to changing economic and social conditions. The insights gained from this study provide a valuable foundation for further research and offer practical guidance for policymakers seeking to promote equitable and sustainable access to healthy diets in emerging markets.

This study has provided a comprehensive comparative analysis of the affordability of healthy diets in Türkiye and BRICS countries for the years 2017 and 2021. By applying advanced Multi-Criteria Decision-Making (MCDM) methods — namely CoCoSo and MARCOS — combined with objective SV based weighting, the research offers a robust evaluation of food system performance across time and national contexts.

The findings indicate that structural challenges in food affordability remain widespread, with NUA consistently emerging as the most influential criterion. The pandemic period introduced notable shifts, particularly in the importance of CoSS (starchy staples), reflecting global market volatility. Countries such as Türkiye and Russian Federation demonstrated relative resilience and improvement in affordability rankings between 2017 and 2021, while others — notably India and Egypt — faced increasing difficulties.

Similarly, some researchers studying on this topic have compared EU member states in terms of food security (Işın et al., 2025) and organic agriculture performance (Çukur and Işın, 2024). The researchers found that EU countries do not exhibit homogeneous performance and have the significant differences between them. These findings have supported the results of current study and suggested that multifaceted efforts to access and purchase healthy and safe food should be among the priority goals of countries in the world.

The absence of complete data for Iran in 2021 represents a known limitation and suggests the need for more comprehensive and harmonized data collection at the international level. Additionally, the results underscore the value of applying dynamic, time-sensitive analytical frameworks, such as the integrated SV-CoCoSo-MARCOS approach used in this study. The overall findings confirm that affordability remains a critical barrier to healthy diets in emerging economies, particularly influenced by income disparities and staple food inflation.

In conclusion, the results underline the dominant influence of structural affordability constraints — especially reflected by NUA and CoSS — in shaping healthy diet access. The consistent rankings provided by SV–CoCoSo–MARCOS methods validate their suitability for cross-country policy assessments. Going forward, food policy in emerging economies should prioritize affordability through targeted interventions, especially for vulnerable populations. This research contributes valuable analytical tools for identifying and addressing food inequality challenges in the post-pandemic global context.

Researchers' Contribution Statement Summary

The authors declare that they have contributed equally to the article and have not plagiarised.

Conflict of Interest Statement

The authors declare that there is no conflict of interest between them.

REFERENCES

Aljuraiban, G. S., Griep, L. M., Chan, Q., Daviglus, M. L., Stamler, J., Van Horn, L. and Elliott, P. (2020), "Defining a Healthy Diet: Evidence for the Role of Dietary Patterns in Health Outcomes", *Advances in Nutrition,* 11(5), 998–1009.

Arıkan Kargı, V. S. (2025). "Analysis of the Performance of Companies in the Individual Pension System Using the Merec-Based Marcos Method", F*irat Üniversitesi Sosyal Bilimler Dergisi,* 35(2), 685-702.

Bai, Y., Costlow, L., Ebel, A., Laves, S., Ueda, Y., Volin, N., Zamek, M., Herforth, A. and Masters, W. A. (2021), "Retail Consumer Price Data Reveal Gaps and Opportunities to Monitor Food Systems for Nutrition", *Food Policy*, 104, 102148.

Chen, Q., Liu, H. Wang, J. and Shi, H.(2022). "New Model for Occupational Health and Safety Risk Assessment Based on Fermatean Fuzzy Linguistic Sets and CoCoSo Approach ", *Applied Soft Computing,* 126, 109262.

Çilek, A. (2022). "Bütünleşik SV-CoCoSo Teknikleriyle Etkinlik Analizi: Mevduat Bankaları Gruplarında Bir Uygulama", *Karadeniz Sosyal Bilimler Dergisi, 14(26),* 52-69.

Çukur, T., and Işın, F. (2024), "Bazı Avrupa Birliği Ülkelerinin Organik Tarım Performanslarının TOPSIS Yöntemiyle Değerlendirilmesi", *Tarım Ekonomisi Dergisi*, 30(2), 99-109.

Darmon, N. and Drewnowski, A. (2015), "Is Cost a Major Barrier to Eating Healthy? Evidence on the Relation Between Diet Quality and Cost", *Current Obesity Reports*, 4(1), 20–26.

Drewnowski, A. and Specter, S. E. (2004), "Poverty and Obesity: The Role of Energy-Dense Foods in Low-Income Populations", *American Journal of Clinical Nutrition*, 79(1), 6–16.

FAO, IFAD, UNICEF, WFP and WHO (2021), *The State of Food Security and Nutrition in the World 2021: Transforming Food Systems for Food Security, Improved Nutrition and Affordable Healthy Diets for All*, Roma: FAO Yayınları.

Güneş, İ. (2019), "Türkiye'nin BRICS Ülkeleri ile Dış Ticaret Analizi", *Journal of Institute of Economic Development and Social Researches*, 5(20), 301–308.

Hami, N., Rezaei, M., Fattahi, Y. and Hatami-Marbini, A. (2019), "Sustainable Supplier Selection Using the MARCOS Method with Interval Type-2 Fuzzy Sets", *Computers & Industrial Engineering*, 139, 106231.

Herforth, A., Bai, Y., Venkat, A. and Masters, W. A. (2020), *Cost and Affordability of Healthy Diets Across and Within Countries: Background Paper for The State of Food Security and Nutrition in the World 2020*, Roma: FAO.

Işın, F., Çukur, T., and Çukur, F. (2025), "Bazı Avrupa Birliği Ülkelerinin Gıda Güvencesi Göstergelerinin VIKOR Yöntemiyle Değerlendirilmesi", *ÇOMÜ Ziraat Fakültesi Dergisi*, 13(1), 70-78.

Lukić, R. (2025). Analysis of Occupational Frauds Based on SWARA and MARCOS Method. *Revizor,* 28((1(109)):37-52.

Özdemir, İ. and Toksarı, M. D. (2018), "Türkiye'de Tarım Sektörünün Performans Değerlendirmesi: AHP-TOPSIS Yöntemi Uygulaması", *Sosyoekonomi*, *26(38),* 73–91.

Peng, X., Krishankumar, R., and Ravichandran, K. S. (2021), " A Novel Interval-Valued Fuzzy Soft Decision-Making Method Based on CoCoSo and CRITIC For Intelligent Healthcare Management Evaluation", *Soft Computing*, 25:4213–4241.

Rehm, C. D., Monsivais, P. and Drewnowski, A. (2008), "Diet Quality of Low-Income and Higher-Income Americans in 2003–2004 as Measured by the Healthy Eating Index", *American Journal of Clinical Nutrition*, 88(2), 480–487.

Stević, Ž., Pamučar, D., Stojić, G. ve Chatterjee, P. (2020), "MARCOS: A New Decision-Making Method", *Applied Soft Computing*, 87, 106019.

Torkayesh, A.E., Pamucar, D., Ecer, F. and Chatterjee, P. (2021), "An integrated BWM-LBWA-CoCoSo framework for evaluation of healthcare sectors in Eastern Europe", *Socio-Economic Planning Sciences,* 78, 101052.

Torkayesh, A.E., Ecer, F., Pamucar, D. and Karamaşa, Ç. (2021), "Comparative Assessment of Social Sustainability Performance: Integrated Data-Driven Weighting System and CoCoSo Model", *Sustainable Cities and Society,* 71, 102975.

Wang, Q. Cheng, T., Lu, Y. Liu, H. Zhang, R. and Huang, J. (2024), "Underground Mine Safety and Health: A Hybrid MEREC–CoCoSo System for the Selection of Best Sensor", Sensors, 24, 1285.

Yazdani, M., Chatterjee, P., Zavadskas, E. K. ve Zolfani, S. H. (2019), "Integrated CoCoSo Method for MCDM Problems: Application to Engineering Projects", *Management Decision*, 57(9), 2501–2515.

Yaşar, F. ve Bolat, İ. (2023). "BRICS Ülkeleri ile Türkiye'nin Ekonomik Performansının Diş Ticaret Verileri Kapsamında TOPSIS Yöntemi ile İncelemesi". Erzincan Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 16(2), 181-194.