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Financial Performance Evaluation of Food and Drink Index Using Fuzzy MCDM Approach*

Araştırma Makalesi /Research Article

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ABSTRACT: *Performance evaluation presents a very complex field involving different criteria and contradicted information. Though, there is an insisting need to a reliable and consistent approach where the application procedures are not complicated. In this study, a fuzzy Multi Criteria Decision Making (MCDM) approach is developed to evaluate the financial performance of companies listed in food and drink index of Istanbul Stock Exchange. Financial ratios were identified to create a base for financial performance evaluation in the areas of: profitability, efficiency, growth, liquidity, leverage and market ratios. Weight coefficients were obtained by the objective method of Fuzzy Shannon's Entropy (FSE). Evaluation and ranking were made on the base of the new method of Fuzzy Evaluation Based on Distance from Average Solution (FEDAS). In order to test the reliability of the approach a scenario analysis is conducted based on CRITIC weighting method. Comparison with other MCDM methods and spearman correlation are conducted to test validity of the proposed approach. The proposed approach is reliable and provides the most suitable result comparing with other MCDM methods.*

Keywords*: Fuzzy EDAS, Financial Performance Evaluation, Food and Drink Index*
JEL Codes*: G11, L66, Z23*

Gıda ve İçecek İndeksinin Finansal Performans Değerlendirmesinde Bulanık ÇKKV Yaklaşımı

ÖZ*: Performans değerlendirmesi, farklı kriterler ve çelişkili veriler içeren çok karmaşık bir uygulama alanıdır. Daha kaliteli bir sonuca ulaşmak için araştırmacılar var olan bütün verilere dayanarak en uygun yöntemi kullanmaya çalışmışlardır. Bu çalışmada, bulanık Çok Kriterli Karar Verme (ÇKKV) yöntemlerine dayanan bir finansal performans değerlendirme modeli önerilmekte, Gıda ve İçecek İndeksinde yer alan firmalara uygulanmıştır. Çalışmada, karlılık, verimlilik, büyüme, likidite, kaldıraç ve piyasa oranları kullanılmıştır. Kriterlerin ağırlıklar belirlemek amacıyla FSE, alternatifleri sıralamak amacıyla ise FEDAS yöntemleri kullanılmıştır. Çalışmada önerilen modelin güvenilirliğini test etmek için CRITIC yöntemine dayalı bir senaryo analizi yapılmıştır. Ayrıca, yaklaşımın geçerliliğini test etmek için farklı ÇKKV yöntemleriyle karşılaştırmalar yapılmıştır. Çalışma sonucunda önerilen modelin güvenilir olduğu tespit edilmiş olup diğer ÇKKV yöntemleriyle karşılaştırıldığında en uygun sonucu sağladığı görülmüştür.*

Anahtar Kelimeler*: Bulanık EDAS, Finansal Performans Değerlendirme, Gıda ve İçecek İndeksi*
JEL Kodu: *G11, L66, Z23*

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1. Introduction

The Food and Drink industry is one of the highest paid industries in the hospitality service sector. It includes all companies involved in processing raw food materials, packaging, and distributing them. The Food and Drink industry has become highly diversified, with businesses ranging from small labor intensive family run activities, to large, capital intensive and highly mechanized industrial processes (Malagie, 1998). Turkey's output of agriculture makes it the largest producer of fruits, nuts, and vegetables in the Middle East, and the 7^{th} largest producer in the world. On the other hand, production of foodstuffs covers about 20% of Turkey's Gross Domestic Product revealing an industry worth roughly $141 billion. Additionally, 62% out of Turkish retail sales are covered by the food retail. That is, Turkey’s production output of food around $140 billion. Also, up to 6% of the total food and drink commercial activities are made by the food service industry (worldfood-istanbul, 2018).

Financial Benchmarking and performance measurement of food companies and competitive ascertaining plays an essential role for the industry improvement. Financial ratios are the most common method used as a general measurement tool for understanding risk and profitability of a company and analyze financial situation. However, ratios are meaningless until they are benchmarked by some standards, industry norms and or certain competitor (Perçin and Aldalou, 2018). A number of studies have attempted to use different statistical methods such as: logit, probit, and discriminant analyses with financial ratios to produce early-warning signals to develop specific financial characteristics that distinguish between two or more groups (yeh 1996). Other studies used different MCDM methods such as: data envelopment analysis method is used to computes a firm's sufficiency by transforming inputs into outputs (Fenyves et al., 2015), or TOPSIS and VIKOR methods are used to measure the distance from ideal solution (Opricovic, 2011; Ghadikolaei et al., 2014). The notion of ideal solution is a theoretical norm which might not be possible to achieve, while, industry average have always been used as a general measure of assessment. Additionally, financial analysts often suggested that firms adjust their financial ratios according to industry-wide averages (Lev, 1969). For this purpose, a proposed approach based on Distance from Average Solution and financial ratios is used in this study.

Evaluation Based on Distance from Average Solution (EDAS) method is a new MCDM method was proposed by (Keshavarz Ghorabaee et al., 2015) for inventory selection. EDAS method is very useful especially in case of conflicting criteria. It has been considered as an efficient method and requires fewer computations in compare to other MCDM methods. EDAS method is a distance based ranking technique. To deal with ambiguous and uncertainty problems Keshavarz Ghorabaee et al. (2016) extended the EDAS method to fuzzy EDAS. Other studies have been proposed to extend the EDAS method and prove its applicability in different areas such as supplier selection, stairs shape assessment, hydrogen production pathways and others. Literature review of EDAS method related publications and application briefly presented in Table 1.

The purpose of this study is to create an inclusive financial performance evaluation model based on financial ratio analysis and an integrated fuzzy MCDM approach. To run a comprehensive financial performance analysis, all relative financial ratios are identified and used. Fuzzy Shannon's Entropy (FSE) method is used to assign criteria weights and Fuzzy EDAS (FEDAS) method is used to evaluate and rank alternatives. The proposed approach is used to evaluate the financial performance of Food and Drink Index of Turkey for the period 2015-2017. The rest of this paper is organized as follows. In section 2, research methodology and general framework is presented. In, section 3: the application of the proposed approach to Food and Drink index of Turkey is provided. In, section 4: the results and discussion of the proposed approach is provided.

Table 1: Literature Review of EDAS Method

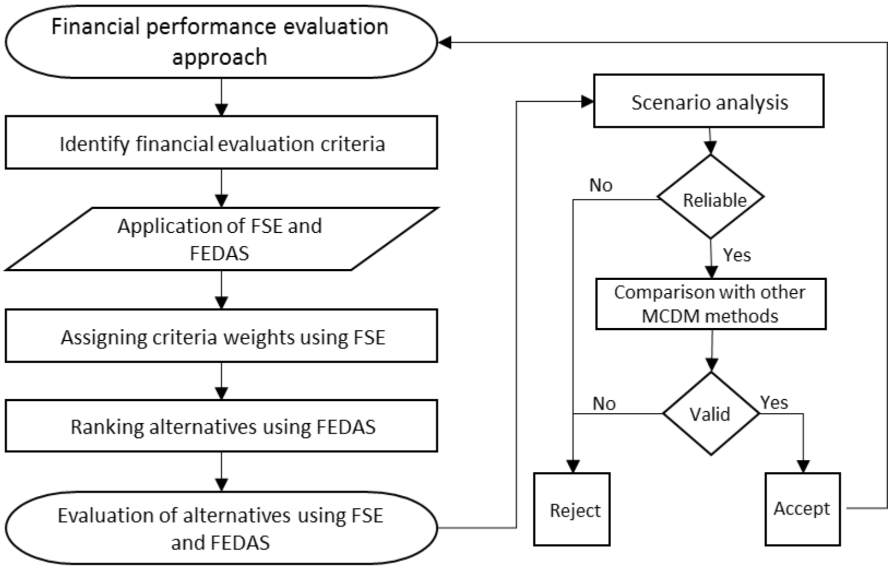
Papers	Method	Area of application
Keshavarz-Ghorabaee et al., 2015	EDAS	Inventory classification
Keshavarz-Ghorabaee et al., 2016	Extended EDAS Method (Fuzzy)	Supplier selection
Turskis and Juodagalvienė, 2016	Ten MCDM methods include EDAS	Stairs shape assessment
Peng and Liu, 2017	EDAS, new similarity measure and level soft set	Algorithms for neutrosophic soft decision making
Kahraman et al., 2017	Intuitionistic fuzzy EDAS	Solid waste disposal site
Keshavarz-Ghorabaee et al., 2017a	Interval type-2 fuzzy sets and EDAS	Supplier evaluation
Keshavarz-Ghorabaee et al., 2017b	extended EDAS method with interval type-2 fuzzy sets	Evaluation of subcontractors in the construction industry
Keshavarz-Ghorabaee et al., 2017c	Stochastic EDAS	Evaluation of bank branches
Keshavarz-Ghorabaee et al., 2017d	Fuzzy CODAS, fuzzy EDAS and fuzzy TOPSIS	Market segment evaluation and selection
Turskis et al., 2017	Integrated AHP and EDAS	Cultural heritage structures evaluation
Stević et al., 2017	Rough DEMATEL and novel Rough EDAS	Supplier selection
Keshavarz-Ghorabaee et al., 2017e	TOPSIS, COPRAS, WASPAS and EDAS	Evaluating airlines
Karaşan and Kahraman, 2017	Interval-valued neutrosophic EDAS	Supplier selection
Gündoğdu et al., 2018	A novel hesitant fuzzy EDAS method	Hospital selection
Erkayman et al., 2018	Modified fuzzy DEMATEL and EDAS	ERP deployment strategy
Stević et al., 2018	Fuzzy EDAS	Carpenter Manufacturer
Liang et al., 2018	Integrated EDAS-ELECTRE	Cleaner Production Evaluation
Keshavarz-Ghorabaee et al., 2018a	Dynamic Fuzzy Approach Based on the EDAS Method	Subcontractor evaluation
Ilieva et al., 2018	Classic and Fuzzy EDAS Modifications	Inventory analysis
Ren and Toniolo, 2018	Combining LCSA, improved DEMATEL and interval EDAS	Hydrogen production pathways
Keshavarz Ghorabaee et al., 2018b	fuzzy SWARA, fuzzy CRITIC and fuzzy EDAS	Evaluation of construction equipment
Kundakcı, 2019	MACBETH and EDAS	Evaluating steam boilers

2. Research Methodology

2.1. Comprehensive Framework

Figure 1 shows the comprehensive framework of the proposed approach. First; financial evaluation criteria are identified, then criteria weights are assigned using FSE method and alternatives are ranked using FEDAS method. Results of the proposed approach are tested for reliability by scenario analysis and tested for validity by comparing results with other MCDM methods. As the proposed approach is reliable and valid it can be used for solving financial performance evaluation problems.

Figure 1: Comprehensive Framework



2.2. Evaluation Criteria

In order to create an inclusive financial performance evaluation model, previous financial studies have been examined, as well as opinions from financial experts have been collected. The financial criteria proposed in this study and similarities with literature are shown in Table 2:

Profitability ratios examine the level of profit a company makes out of its activities at the gross, operational, and overall activity stages of an income statement. It can be measured relative to equity, total assets, and sales. It also serves as an indicator of how efficiently a company controls costs to generate profits (Katchova and Enlow, 2013).

Leverage ratios measure the company's liability burden in compared to mix of liability and equity. The larger the amount of debt held by a company, the larger the financial risk (Katchova and Enlow, 2013), thus leverage ratios are considered cost criteria.

Growth ratios are general indicators of how fast the company is growing. They are also an important measure of the company stability and help assessing the direction in which the company is going.

Liquidity ratios are indicators of a company's ability to pay its short term debts as those debts fall due. They also provide an insight into the efficiency of the company's control and management of working capital (Chadwick, 1984).

Table 2: Evaluation Criteria

Financial Ratio	Reference
Return On Assets (PRF1)	(Chadwick, 1984) (Tan et al., 1997) (Edirisinghe and Zhang, 2008) (Katchova, Enlow, 2013) (Khuan Chan, Abdul-Aziz, 2017) (Karimi and Barati, 2018)
Return On Equity (PRF2)	(Chadwick, 1984) (Tan et al., 1997) (Edirisinghe and Zhang, 2008) (Katchova, Enlow, 2013) (Khuan Chan, Abdul-Aziz, 2017) (Karimi and Barati, 2018)
Net Profit Margin (PRF3)	(Chadwick, 1984) (Tan et al., 1997) (Edirisinghe and Zhang, 2008) (Katchova, Enlow, 2013) (Khuan Chan, Abdul-Aziz, 2017) (Aras et al, 2018) (Karimi and Barati, 2018)
Debt To Assets Ratio (LEV1)	(Tan et al., 1997) (Edirisinghe and Zhang, 2008) (Katchova, Enlow, 2013) (Jitmaneeroj, 2017) (Khuan Chan, Abdul-Aziz, 2017) (Aras et al, 2018) (Karimi and Barati, 2018)
LTD To Assets Ratio (LEV2)	(Tan et al., 1997) (Katchova, Enlow, 2013)
Debt To Equity Ratio (LEV3)	(Chadwick, 1984) (Tan et al., 1997) (Edirisinghe and Zhang, 2008) (Katchova, Enlow, 2013) (Khuan Chan, Abdul-Aziz, 2017) (Aras et al, 2018) (Karimi and Barati, 2018)
Assets Growth (GR1)	(Edirisinghe and Zhang, 2008) (Aras et al, 2018)
Sales Growth (GR2)	(Edirisinghe and Zhang, 2008) (Aras et al, 2018) (Karimi and Barati, 2018)
Net Income Growth (GR3)	(Edirisinghe and Zhang, 2008) (Karimi and Barati, 2018)
Current Ratio (LIQ1)	(Chadwick, 1984) (Tan et al., 1997) (Edirisinghe and Zhang, 2008) (Katchova, Enlow, 2013) (Khuan Chan, Abdul-Aziz, 2017) (Aras et al, 2018) (Karimi and Barati, 2018)
Quick Ratio (LIQ2)	(Chadwick, 1984) (Tan et al., 1997) (Edirisinghe and Zhang, 2008) (Katchova, Enlow, 2013) (Khuan Chan, Abdul-Aziz, 2017) (Karimi and Barati, 2018)
NWC To Asset R (LIQ3)	(Tan et al., 1997) (Khuan Chan, Abdul-Aziz, 2017) (Aras et al, 2018)
Assets Turnover (EF1)	(Chadwick, 1984) (Tan et al., 1997) (Edirisinghe and Zhang, 2008) (Katchova, Enlow, 2013) (Khuan Chan, Abdul-Aziz, 2017) (Aras et al, 2018) (Karimi and Barati, 2018)
Accounts Receivable Turnover (EF2)	(Tan et al., 1997) (Edirisinghe and Zhang, 2008) (Karimi and Barati, 2018)
Inventory Turnover (EF3)	(Chadwick, 1984) (Tan et al., 1997) (Edirisinghe and Zhang, 2008) (Karimi and Barati, 2018)
Earnings Per Share (MAR1)	(Edirisinghe and Zhang, 2008) (Katchova, Enlow, 2013) (Jitmaneeroj, 2017) (Khuan Chan, Abdul-Aziz, 2017) (Karimi and Barati, 2018)
Price/Earnings Ratio (MAR2)	(Edirisinghe and Zhang, 2008) (Katchova, Enlow, 2013) (Jitmaneeroj, 2017) (Karimi and Barati, 2018)
Market To Book Value (MAR3)	(Edirisinghe and Zhang, 2008)

Efficiency ratios show how effectively the company uses its assets and available resources to generate income.

Market ratios evaluate the value at which stocks are traded as well as market return achieved by these stocks. They are very important and used by investors to make investment decisions.

2.3. Fuzzy Shannon's Entropy

There are different methods to identify weights of criteria in a MCDM problems. These methods can be categorized as subjective and objective weighting methods. Avoiding the subjectivity problems and preferences of decision makers, objective methods are more suitable to be used especially when the data of the decision matrix is known. Entropy method helps generating faster and accurate criteria weights where credible subjective weights cannot be obtained. The idea of information entropy, up to Wu et al., (2011), reveals that the quality of information –or number- acquired through the decision-making setting is one of the main indicators of accuracy and reliability. In this study, FSE method proposed by Lotfi & Fallahnejad (2010) has been applied to assign weights of criteria. FSE application steps are as follows;

Step 1: Construct the fuzzy decision matrix.

The fuzzy decision matrix is as follow:

$$D = \begin{bmatrix} \breve{x}_{11} & \cdots \breve{x}_{1j} & \cdots \breve{x}_{1n} \\ \vdots & \vdots & \vdots \\ \breve{x}_{i1} & \cdots \breve{x}_{ij} & \cdots \breve{x}_{in} \\ \vdots & \vdots & \vdots \\ \breve{x}_{m1} & \cdots \breve{x}_{mj} & \cdots \breve{x}_{mn} \end{bmatrix} \quad where\ \breve{x}_{ij} = (x_{ij}^{l}, x_{ij}^{m}, x_{ij}^{u}) \qquad (1)$$

$$i = 1; 2; \ldots; m \quad , j = 1; 2; \ldots; n$$

$\breve{x}_{ij}$: The performance values of alternative i ∈ m, alternatives$(A1, A2, \ldots, Am)$, from the view point of criterion j ∈ n, criteria$(C1, C2, \ldots, Cn)$.

Step 2: Construct the fuzzy interval data decision matrix using the α-level sets:

The α-level set of a fuzzy variable $\breve{x}_{ij}$ is defined by a set of elements that belong to the fuzzy variable $\breve{x}_{ij}$ with membership of at least α

$$\text{That is; } (\tilde{x}_{ij})_{\alpha} = \left\{ x \in R \ \middle|\ \mu_{\tilde{x}_{ij}}(x) \geq \alpha \right\} \qquad (2)$$

Where $(0 < \alpha \leq 1)$. Fuzzy data, triangular fuzzy numbers (TFN) can be transformed into Fuzzy interval data using levels of confidence 1-α, explained as follow;

$$\breve{x}_{ij} = (x'_{ij}, x''_{ij}), \tilde{x}_{ij} = \left[\alpha x_{ij}^{m} + (1-\alpha) x_{ij}^{l}, \alpha x_{ij}^{m} + (1-\alpha) x_{ij}^{u}\right] \qquad (3)$$

Step3: Calculate the normalized fuzzy interval decision matrix

The normalized interval decision matrix can be calculated using the following equations:

$$p_{ij}^{l} = \frac{x'_{ij}}{\sum_{j=1}^{m} x_{ij}^{u}} \;,\; p_{ij}^{u} = \frac{x''_{ij}}{\sum_{j=1}^{m} x_{ij}^{u}} \tag{4}$$

Step4: Calculate the interval entropy's lower bound e_j^l and upper bound e_j^u

$$e_j^l = min\{-k \sum_{j=1}^{m} p_{ij}^{l}. ln\, p_{ij}^{l}, -k \sum_{j=1}^{m} p_{ij}^{u}. ln\, p_{ij}^{u}\},$$

$$e_j^u = max\{-k \sum_{j=1}^{m} p_{ij}^{l}. ln\, p_{ij}^{l}, -k \sum_{j=1}^{m} p_{ij}^{u}. ln\, p_{ij}^{u}\} \tag{5}$$

Where the entropy constant $k = (\ln m)^{-1}$. If $p_{ij} = 0$, and/or $\ln p_{ij} = 0$ then $p_{ij}. ln\, p_{ij}$ is equal to 0.

Step 5: Calculate the lower and upper pounds of the interval of diversification; d_j^l, d_j^u

$$d_j^l = 1 - e_j^u,\; d_j^u = 1 - e_j^l \tag{6}$$

Step 6: Calculate the interval weights of criteria $\tilde{w}_j = [w_j^l, w_j^u]$:

$$w_j^l = \frac{d_j^l}{\sum_{j=1}^{n} d_j^u},\; w_j^u = \frac{d_j^u}{\sum_{j=1}^{n} d_j^l} \tag{7}$$

Theorem; the inequality $w_j^l \leq w_j^u,\; j = 1, \dots, n$ is held.

Step 7. Defuzzify the interval fuzzy numbers into a crisp value

$$w_j = (w_j^l + w_j^u)/2 \tag{8}$$

Then criteria weights should be normalized as $\sum_j^n w_j = 1$

2.4. Fuzzy Evaluation Based on Distance from Average Solution

In EDAS method, the best alternative is calculated based on the positive distance from average solution (PDA) and the negative distance from average solution (NDA). The evaluation of the alternatives is made in accordance with PDA and NDA values. Higher values of PDA and/or lower values of NDA represent that the alternative is better than average solution. In this study, FEDAS method is used for financial performance evaluation problem. Steps of the FEDAS method are as follows (Keshavarz-Ghorabaee et al., 2016):

The weights of criteria are calculated by FSE as shown earlier.

Step 1: prepare the average solution matrix,

$$AV = [\widetilde{av}_j]_{1*m} \text{, as } \widetilde{av}_j = \frac{1}{n} \sum_{i=1}^{n} \tilde{x}_{ij} \tag{9}$$

Step 2: In this step the matrices of PDA and NDA are calculated according to the type of criteria; benefit (b), and cost (c):

$$PDA = \left[\widetilde{pda}_{ij}\right]_{n*m}, \; NDA = \left[\widetilde{nda}_{ij}\right]_{n*m}, \text{ as}$$

$$\widetilde{pda}_{ij} = \begin{cases} \frac{\max(\tilde{x}_{ij} - \widetilde{av}_j, 0)}{k(\widetilde{av}_j)} & , j \in b \\ \frac{\max(\widetilde{av}_j - \tilde{x}_{ij}, 0)}{k(\widetilde{av}_j)} & , j \in c \end{cases},$$

$$\widetilde{nda}_{ij} = \begin{cases} \frac{\max(\widetilde{av}_j - \tilde{x}_{ij}, 0)}{k(\widetilde{av}_j)} & , j \in b \\ \frac{\max(\tilde{x}_{ij} - \widetilde{av}_j, 0)}{k(\widetilde{av}_j)} & , j \in c \end{cases} \tag{10}$$

$$k\left(\widetilde{av}_j\right) = \frac{1}{3}\left(\tilde{x}^l + \tilde{x}^m + \tilde{x}^u - \frac{\tilde{x}^m \tilde{x}^u - \tilde{x}^l \tilde{x}^m}{(\tilde{x}^m + \tilde{x}^u) - (\tilde{x}^l + \tilde{x}^m)}\right) \tag{11}$$

Step 3: Calculate the weighted sum of positive ($\widetilde{sp}_i$) and negative ($\widetilde{sn}_i$) distances for all alternatives,

$$\widetilde{sp}_i = \sum_{j=1}^{m} (\tilde{w}_j * \widetilde{pda}_{ij}), \; \widetilde{sn}_i = \sum_{j=1}^{m} (\tilde{w}_j * \widetilde{nda}_{ij}) \tag{12}$$

Where: $\tilde{w}_j$ is the weight coefficient assigned using fuzzy Shannon's Entropy method.

Step 4: Calculate the normalized values of $\widetilde{sp}_i$ and $\widetilde{sn}_i$ for all alternatives,

$$\widetilde{nsp}_i = \frac{\widetilde{sp}_i}{\max(k(\widetilde{sp}_i))},$$

$$\widetilde{nsn}_i = 1 - \frac{\widetilde{sn}_i}{\max(k(\widetilde{sn}_i))} \tag{13}$$

The values of $k(\widetilde{sp}_i)$ and $k(\widetilde{sn}_i)$ are calculated as to $k\left(\widetilde{av}_j\right)$

Step 5: Calculate the appraisal score ($\widetilde{as}_i$) for all alternatives,

$$\widetilde{as}_i = \frac{1}{2}(\widetilde{nsp}_i + \widetilde{nsn}_i) \tag{14}$$

Step 6: Rank the alternatives according to the decreasing values of the appraisal scores ($\widetilde{as}_i$).

3. Case Study

In this section, the proposed fuzzy Shannon Entropy and fuzzy EDAS approach is applied to evaluate the financial performance of companies listed in Food and drink Index of Turkey for the period of 2015-2017. In which no previous study was applied to this sector using the proposed methods._The application of the proposed approach is as follows:

3.1. Identifying Criteria Weights

Data is collected from companies' annual financial reports and ratios are calculated for 2015 to 2017. After, the fuzzy decision matrix is constructed from the calculated ratios. Fuzzy decision matrix is shown in Table 3.

Table 3: Fuzzy Decision Matrix

	PRF1			..	LEV1			..	LIQ1			..	MAR3		
A1	0.99	1.00	1.01		0.53	0.56	0.58		1.58	1.90	2.24		1.68	1.82	1.90
A2	1.00	1.01	1.02		0.54	0.57	0.63		1.13	1.27	1.37		11.05	9.04	16.45
A3	1.01	1.02	1.03		0.46	0.47	0.48		1.14	1.31	1.43		1.39	2.36	3.74
A4	1.00	1.01	1.02		0.41	0.45	0.48		1.38	1.74	2.09		2.57	2.85	3.35
A5	0.98	1.00	1.02		0.74	0.79	0.84		2.06	3.12	4.41		1.67	1.82	2.05
A6	0.97	1.04	1.09		0.58	0.64	0.68		1.07	1.38	1.70		6.02	7.56	8.95
A7	0.96	0.98	1.02		0.09	0.11	0.22		0.40	0.81	1.10		0.85	1.00	1.13
A8	1.10	1.12	1.14		0.76	0.81	0.88		2.53	5.12	8.65		2.11	2.26	2.48
…			…								…				…
A19	1.02	1.02	1.03		0.23	0.29	0.34		1.29	1.31	1.32		1.84	2.02	2.24
A20	1.05	1.05	1.06		0.23	0.28	0.31		1.08	1.74	2.18		3.56	4.24	4.59
A21	0.82	0.94	1.03		0.64	0.73	0.86		0.42	3.07	6.41		1.70	2.51	2.96

AEFES (A1), AVOD (A2), BANVT (A3), CCOLA (A4), ERSU (A5), KENT (A6), KERVT (A7), KNFRT (A8), KRSTL (A9), MERKO (A10), OYLUM (A11), PENGD (A12), PETUN (A13), PINSU (A14), PNSUT (A15), TATGD (A16), TUKAS (A17), TBORG (A18), ULUUN (A19), ULKER (A20), and VANGD (A21).

Then fuzzy Shannon Entropy method is applied to assign weights of criteria. The assigned criteria weights are shown in Table 4.

Table 4: Weights of the Criteria

Criteria	**PRF1**	**PRF2**	**PRF3**	**LEV1**	**LEV2**	**LEV3**	**GR1**	**GR2**	**GR3**
Weight	0.050	0.033	0.118	0.013	0.035	0.039	0.081	0.084	0.105
Criteria	**LIQ1**	**LIQ2**	**LIQ3**	**EF1**	**EF2**	**EF3**	**MAR1**	**MAR2**	**MAR3**
Weight	0.028	0.028	0.040	0.020	0.053	0.026	0.076	0.081	0.090

3.2. Evaluating and Ranking of Alternatives Using FEDAS:

Using the fuzzy decision matrix shown in Table 3 and Eq. 9 the calculated average solution matrix is shown in Table 5.

Table 5: The Average Solution Matrix

	$\widetilde{av}_j$				$\widetilde{av}_j$		
av1	0.999	1.03	1.05	av10	1.30	1.81	2.39
av2	0.94	1.03	1.10	av11	0.85	1.16	1.55
av3	0.97	1.06	1.22	av12	1.05	1.15	1.22
av4	0.47	0.51	0.56	av13	0.71	0.84	1.02
av5	0.09	0.12	0.16	av14	4.92	7.57	11.38
av6	1.08	1.37	1.75	av15	4.26	5.58	6.90
av7	1.01	1.29	1.52	av16	1.02	1.30	1.60
av8	0.92	1.18	1.50	av17	3.11	5.37	6.22
av9	0.84	1.19	1.61	av18	2.77	3.12	3.92

Following, the matrices of PDA and NDA are calculated using Eq. 10 and 11 and are shown in Tables 6, 7.

Table 6: PDA Matrix

	PRF1			..	**LEV1**			..	**LIQ1**			..	**MAR3**		
A1	0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00
A2	-0.05	-0.02	0.02		0.00	0.00	0.00		0.00	0.00	0.00		2.57	1.89	3.49
A3	0.00	0.00	0.00		-0.03	0.08	0.18		0.00	0.00	0.00		-0.91	-0.25	0.25
A4	-0.05	-0.01	0.02		-0.03	0.12	0.27		0.00	0.00	0.00		0.00	0.00	0.00
A5	-0.07	-0.02	0.02		0.00	0.00	0.00		-0.25	0.73	1.30		0.00	0.00	0.00
A6	0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.76	1.42	1.58
A7	0.00	0.00	0.00		0.52	0.79	0.85		0.00	0.00	0.00		0.00	0.00	0.00
A8	0.05	0.09	0.13		0.00	0.00	0.00		0.11	1.83	3.08		0.00	0.00	0.00
…				..				..				..			…
A19	0.00	0.00	0.00		0.27	0.42	0.59		0.00	0.00	0.00		0.00	0.00	0.00
A20	-0.01	0.03	0.06		0.34	0.45	0.58		0.00	0.00	0.00		-0.13	0.36	0.46
A21	0.00	0.00	0.00		0.00	0.00	0.00		-1.52	0.70	2.14		0.00	0.00	0.00

Table 7: NDA Matrix

	PRF1			..	**LEV1**			...	**LIQ1**			..	**MAR3**		
A1	-0.01	0.02	0.05		-0.05	0.10	0.20		0.00	0.00	0.00		0.32	0.42	0.57
A2	-0.02	0.02	0.05		-0.05	0.12	0.29		-0.06	0.29	0.53		0.00	0.00	0.00
A3	-0.04	0.00	0.04		0.00	0.00	0.00		-0.10	0.27	0.52		-0.35	0.25	0.65
A4	-0.02	0.01	0.05		0.00	0.00	0.00		-0.61	0.04	0.42		-0.21	0.09	0.34
A5	-0.03	0.02	0.06		0.39	0.55	0.68		0.00	0.00	0.00		0.26	0.42	0.57
A6	0.00	0.00	0.00		0.05	0.25	0.39		-0.31	0.24	0.55		0.00	0.00	0.00
A7	-0.02	0.04	0.09		0.00	0.00	0.00		0.15	0.55	0.83		0.59	0.68	0.78
A8	0.00	0.00	0.00		0.43	0.59	0.75		0.00	0.00	0.00		0.11	0.28	0.46
…				..				..				..			…
A19	-0.03	0.00	0.03		0.00	0.00	0.00		-0.01	0.28	0.46		0.19	0.35	0.53
A20	0.00	0.00	0.00		0.00	0.00	0.00		-0.68	0.04	0.55		0.00	0.00	0.00
A21	-0.03	0.08	0.22		0.17	0.43	0.71		0.00	0.00	0.00		-0.07	0.20	0.57

Then the weighted sum of positive ($\widetilde{sp}_i$) and negative ($\widetilde{sn}_i$) distances for all alternatives are calculated using equation 12, the normalized values of $\widetilde{sp}_i$ and $\widetilde{sn}_i$ are also calculated using equation 13. The weighted sums and normalized values are shown in Table 8. Finally, using Eq. 14 the appraisal scores ($\widetilde{as}_i$) are calculated and the alternatives are ranked as shown in Table 9.

Table 8: The Weighted Sums and Normalized Values

	sp_i			sn_i			nsp_i			nsn_i		
A1	0.07	0.10	0.18	-0.05	0.15	0.28	0.31	0.50	0.86	-0.56	0.16	1.28
A2	0.18	0.17	0.33	-0.04	0.15	0.27	0.85	0.83	1.59	-0.52	0.17	1.21
A3	-0.23	0.17	0.25	-0.09	0.07	0.19	-1.09	0.81	1.21	-0.07	0.59	1.50
A4	0.12	0.15	0.22	-0.12	0.11	0.24	0.59	0.72	1.06	-0.38	0.37	1.66
A5	-0.07	0.15	0.28	-0.02	0.23	0.40	-0.36	0.70	1.37	-1.24	-0.29	1.14
A6	0.13	0.32	0.37	-0.14	0.07	0.21	0.60	1.55	1.79	-0.19	0.63	1.78
A7	-0.36	0.52	0.98	0.06	0.25	0.38	-1.73	2.50	4.73	-1.13	-0.43	0.64
A8	0.08	0.23	0.33	-0.11	0.07	0.19	0.40	1.11	1.59	-0.05	0.62	1.62
A9	0.02	0.12	0.16	0.00	0.15	0.25	0.09	0.58	0.79	-0.42	0.17	0.98
A10	-0.06	0.01	0.05	-0.02	0.31	0.56	-0.28	0.03	0.23	-2.14	-0.77	1.14
A11	-0.17	0.04	0.19	0.04	0.22	0.35	-0.84	0.20	0.90	-0.96	-0.23	0.79
A12	-0.02	0.02	0.05	-0.02	0.27	0.44	-0.08	0.10	0.22	-1.49	-0.50	1.08
A13	0.02	0.12	0.18	-0.11	0.11	0.24	0.08	0.58	0.88	-0.35	0.36	1.60
A14	-0.10	-0.02	0.04	-0.08	0.26	0.47	-0.49	-0.07	0.19	-1.65	-0.49	1.43
A15	-0.06	0.10	0.19	-0.10	0.09	0.22	-0.29	0.46	0.92	-0.25	0.49	1.59
A16	0.01	0.12	0.19	-0.07	0.12	0.24	0.07	0.59	0.90	-0.33	0.34	1.38
A17	-0.04	0.06	0.12	-0.07	0.14	0.26	-0.21	0.30	0.57	-0.49	0.21	1.40
A18	0.03	0.16	0.23	-0.11	0.06	0.10	0.15	0.76	1.10	0.41	0.69	1.62
A19	0.01	0.09	0.13	-0.08	0.18	0.34	0.03	0.42	0.63	-0.91	0.00	1.44
A20	0.02	0.13	0.23	-0.11	0.12	0.24	0.10	0.65	1.10	-0.34	0.35	1.61
A21	-0.26	0.25	0.72	-0.17	0.25	0.48	-1.23	1.19	3.46	-1.71	-0.39	1.94

Table 9: The Appraisal Scores and Final Ranking

		as_i		$K(as_i)$	Rank
A1	-0.12	0.33	1.07	0.32	12
A2	0.16	0.50	1.40	0.52	4
A3	-0.58	0.70	1.35	0.26	13
A4	0.11	0.54	1.36	0.49	5
A5	-0.80	0.21	1.25	0.15	17
A6	0.21	1.09	1.79	0.67	1
A7	-1.43	1.04	2.69	0.42	6
A8	0.17	0.86	1.60	0.59	2
A9	-0.16	0.37	0.89	0.24	14
A10	-1.21	-0.37	0.69	-0.17	21
A11	-0.90	-0.01	0.84	-0.02	18
A12	-0.79	-0.20	0.65	-0.04	19
A13	-0.13	0.47	1.24	0.37	9
A14	-1.07	-0.28	0.81	-0.09	20
A15	-0.27	0.48	1.25	0.33	11
A16	-0.13	0.46	1.14	0.33	10
A17	-0.35	0.25	0.99	0.21	15
A18	0.28	0.72	1.36	0.55	3
A19	-0.44	0.21	1.03	0.20	16
A20	-0.12	0.50	1.36	0.41	7
A21	-1.47	0.40	2.70	0.41	8

4. Results and Discussion

In this study, a fuzzy Shannon's entropy and fuzzy EDAS approach is proposed to deal with financial evaluation problems. The proposed approach is applied to a real case; Food and drink index of Turkey. The results of analysis showed that net profit margin and growth in net income are the most important indicators for financial evaluation, and, that other ratios have close importance levels. The result of fuzzy EDAS shows that KENT (A6) is the best alternative by the proposed approach, followed by KNFRT (A8), TBORG (A18), and AVOD (A2). In order to test the applicability of the proposed method scenario analysis and comparison with other MCDM methods, in addition to Spearman correlation are calculated and shown in the following sections.

4.1. Scenario Analysis

To test the stability of results, the proplem is solved with a different set of criteria weights using CRITIC method. CRITIC method was proposed by Diakoulaki et al. (1995) for determining objective weights in financial performance evaluation problems. Table 10 shows the simulated weights calculated based on CRITIC method. Table 11 shows the new ranking of alternatives.

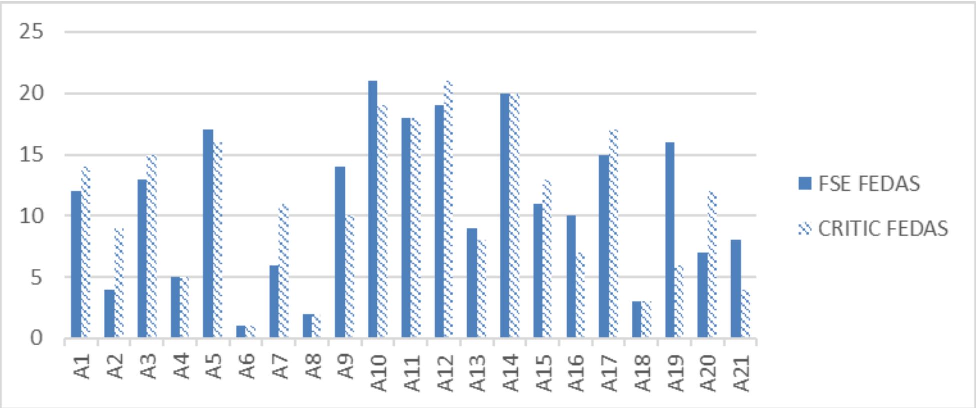
Table 10: FSE and CRITIC Weights of Criteria

Criteria	PRF1	PRF2	PRF3	LEV1	LEV2	LEV3	GR1	GR2	GR3
FSE	0.050	0.033	0.118	0.013	0.035	0.039	0.081	0.084	0.105
CRITIC	0.047	0.039	0.045	0.083	0.068	0.069	0.046	0.040	0.047
Criteria	**LIQ1**	**LIQ2**	**LIQ3**	**EF1**	**EF2**	**EF3**	**MAR1**	**MAR2**	**MAR3**
FSE	0.028	0.028	0.040	0.020	0.053	0.026	0.076	0.081	0.090
CRITIC	0.049	0.051	0.048	0.049	0.063	0.070	0.055	0.079	0.053

Table 11: Ranking of Alternatives

Firm	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
FSE FEDAS	12	4	13	5	17	1	6	2	14	21	18
CRITIC FEDAS	14	9	15	5	16	1	11	2	10	19	18
Firm		**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**	**A19**	**A20**	**A21**
FSE FEDAS		19	9	20	11	10	15	3	16	7	8
CRITIC FEDAS		21	8	20	13	7	17	3	6	12	4

Figure 2: Scenario Analysis Results



As can be seen in Table 11, the ranking of all alternatives are relatively stable in different weights of criteria. The best alternative is A6 followed by A8 then A18 using FSE and FCRITIC methods. To show the changes clearly, the result of scenario analysis is embodied in Figure 2. The slight changes show the stability of the anticipated model when the criteria weights are varied.

4.2. Comparison with Other MCDM Methods

To test the result of EDAS method Keshavarz-Ghorabaee et al. (2015) compared results with VIKOR, TOPSIS, SAW and COPRAS. Keshavarz-Ghorabaee et al. (2017d) compared fuzzy CODAS with fuzzy EDAS and fuzzy TOPSIS methods. Stević et al. (2017) compared Rough EDAS method with different methods includes an extension of the COPRAS and MULTIMOORA methods. Keshavarz Ghorabaee et al. (2017e) used the four methods of TOPSIS, COPRAS, WASPAS, EDAS and the aggregate of these methods, and Ilieva et al. (2018) compared EDAS with the new varieties of the method, as well as with VIKOR, TOPSIS, and SAW. In this section, to test validity of the proposed approach, result of fuzzy EDAS method is compared with FCOPRAS (Zarbakhshnia et al., 2018), FMOORA (Siddiqui and Tyagi, 2016), FVIKOR (Opricovic, 2011), FTOPSIS (Perçin and Aldalou, 2018), and FSAW (Roszkowska and Kacprzak, 2016) methods.

As EDAS method selects the best alternative based on the distance from average solution, TOPSIS method selects the closest to positive ideal solution and farthest (longest) from negative ideal solution. Also VIKOR method selects the closest alternative to the ideal solution. COPRAS method selects the best alternative based on the comparison between the direct and proportional ratio of the best solution. The ratio of the ideal-worst solution, MOORA method selects the best alternative were each response of an alternative on an objective is compared to a denominator which is a representative for all alternatives concerning that objective. However, SAW method selects the best alternative based on the weighted sum of performance ratings on each alternative on all attributes.

The results of comparisons are shown in Table 12. Additionally, Spearman's correlation is also used to analyze the correlation between these methods, and results are shown in Table 13. The ranking results of the proposed approach is highly consistent with FMOORA, FVIKOR and FSAW methods, meanwhile it has showed less consistency with FCOPRAS and FTOPSIS. Additionally, an overall ranking of alternatives has been calculated (average ranking). FEDAS method is highly consistent with average ranking than other methods. For more comprehensive assessment Spearman correlation test have been used. Spearman's test showed that FEDAS is highly correlated to average results by %92.3, and there is a strong positive correlation with FMOORA and FSAW, and a significant positive relation with FVIKOR.

Table 12: Comparisons with Other MCDM Methods

Firm	FEDAS	FCOPRAS	FMOORA	FVIKOR	FTOPSIS	FSAW	Average
A1	12	7	14	13	13	8	13
A2	4	3	6	16	21	11	9
A3	13	8	5	15	11	6	8
A4	5	18	10	7	18	3	9
A5	17	17	15	8	6	20	16
A6	1	5	2	6	10	4	2
A7	6	2	1	17	20	1	5
A8	2	6	4	2	2	5	1
A9	14	10	12	10	7	13	12
A10	21	21	21	20	19	21	21
A11	18	4	18	21	17	19	18
A12	19	12	19	18	15	18	19
A13	9	11	9	5	4	9	5
A14	20	20	20	19	16	17	20
A15	11	14	11	12	12	10	14
A16	10	16	13	9	5	12	11
A17	15	13	16	3	9	16	15
A18	3	9	7	1	1	7	2
A19	16	19	17	14	8	14	17
A20	7	15	8	4	3	2	4
A21	8	1	3	11	14	15	7

Table 13: Spearman Correlation

Spearman	FEDAS	FCOPRAS	FMOORA	FVIKOR	FTOPSIS	FSAW	Average
FEDAS	1	0.519*	0.878**	0.613**	0.251	0.817**	0.923**
FCOPRAS		1	0.682**	0.01	-0.136	0.335	0.541*
FMOORA			1	0.43	0.156	0.777**	0.915**
FVIKOR				1	0.783**	0.460*	0.673**
FTOPSIS					1	0.2	0.455*
FSAW						1	0.826**

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

On the other hand, FCOPRAS and FTOPSIS neither have a significant correlation with FEDAS nor with the average results. These methods of FTOPSIS and FCOPRAS are ideal solution distance based MCDM method. The ideal solution is identified by the highest values of all alternatives. A company with very high liquidity ratio and current loss my look bitter than a company with an average liquidity and normal profit ratio. Furthermore, financial analysts often suggested that firms adjust their financial ratios according to industry-wide averages. For these reasons, FEDAS method is significantly more reliable than other methods proposed, and can be used in the area of financial evaluation.

5. Conclusion

Because of complicity of financial evaluation process and the inclusion of different criteria in the evaluation process, there is an insisting need for more efficient and reliable financial performance evaluation approach. Not only the used financial ratio should cover all the relevant aspects, but also a reliable method needs to be used. From the first hand, the assignment a relative weight to each criterion, based on the importance of the criterion to the decision to be made. To avoid subjectivity of the decision makers, Fuzzy Shannon's entropy method is used for determining objective weights and the analysis is supported by the CRITIC method. On the second hand, FEDAS method is used to rank alternatives. The proposed approach is used to evaluate the financial performance of companies listed in Food Index of Turkey and the results are compared to other MCDM methods.

Results of application shows that net profit margin and keeping a suitable growth in that income are the most important criteria for evaluation. It also reveals that KENT (A6) is the best alternative by the proposed approach, followed by KNFRT (A8), TBORG (A18), and AVOD (A2). The scenario analysis proves the stability and applicability of the proposed approach. Additionally, results show that FEDAS method is correlated with FMOORA, FVIKOR, FSAW, and highly correlated with average results. Ideal solution distance based MCDM methods such as FTOPSIS method failed to prove consistency with average results as extremely cases distort the assessment process.

As industry average have always been used as a general measure of performance assessment, the distance from average solution based FEDAS method is significantly more reliable than other methods proposed, and can be used in the area of financial evaluation.

Future studies may consider the application of the proposed approach to different Indexes and using objective weighting methods.

References

Aras, G., Tezcan, N., and Kutlu Furtuna, Ö. (2018). Comprehensive evaluation of the financial performance for intermediary institutions based on multi-criteria decision making method. *Journal of Capital Markets Studies*, 2(1), 37-49.

Chadwick, L. (1984). Comparing financial performance: Ratio analysis and retail management. *Retail and Distribution Management*, 12(2), 35-37.

Diakoulaki, D., Mavrotas, G., and Papayannakis, L. (1995). Determining objective weights in multiple criteria problems: the critic method. *Comput Oper Res*, 22(7), 763–70.

Edirisinghe, N.C.P. and Zhang, X. (2008). Portfolio selection under DEA-based relative financial strength indicators: case of US industries. *Journal of the Operational Research Society*, 59(6), 842-856.

Erkayman, B., Khorshidi, M., and Usanmaz, B. (2018). An integrated fuzzy approach for ERP deployment strategy selection under conflicting criteria. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi*, 32(3), 807-823.

Fenyves, V., Tarnoczi, T. and Zsido, K. (2015). Financial performance evaluation of agricultural enterprises with DEA method. *Procedia Economics and Finance*, 32, 423–431.

Ghadikolaei, A.S., Esbouei, S.K. and Antucheviciene, J. (2014). Applying fuzzy MCDM for financial performance evaluation of Iranian companies. *Technological and Economic Development of Economy*, 20(2), 274–291.

Gündoğdu, F.K., Kahraman, C., and Civan, H.N. (2018). A novel hesitant fuzzy EDAS method and its application to hospital selection. *Journal of Intelligent and Fuzzy Systems*, 35, 6353-6365.

Ilieva, G., Yankova, T. and Klisarova-Belcheva, S. (2018). Decision Analysis with Classic and Fuzzy EDAS Modifications. *Computational & Applied Mathematics*. 37.

Jitmaneeroj, B. (2017). Does investor sentiment affect price-earnings ratios?. *Studies in Economics and Finance*, 34(2), 183-193.

Kahraman, C., Keshavarz-Ghorabaee, M., Zavadskas, E., Çevik, S., Yazdani, M. and Öztayşi, B. (2017). Intuitionistic fuzzy EDAS method: an application to solid waste disposal site selection. *Journal of Environmental Engineering and Landscape Management*. 25, 1-12.

Karaşan, A., and Kahraman, C. (2017). Interval-Valued Neutrosophic Extension of EDAS Method. *Advances in Intelligent Systems and Computing*, 343–357.

Karimi, A. and Barati, M. (2018). Financial performance evaluation of companies listed on Tehran Stock Exchange: A negative data envelopment analysis approach. *International Journal of Law and Management*, 60(3), 885-900.

Katchova, A.L., and Enlow, S.J. (2013). Financial performance of publicly-traded agribusinesses. *Agricultural Finance Review*, 73(1), 58-73.

Keshavarz-Ghorabaee, M., Zavadskas, E., Olfat, L., and Turskis, Z. (2015). Multi-Criteria Inventory Classification Using a New Method of Evaluation Based on Distance from Average Solution (EDAS). *Informatica*. 26, 435–451.

Keshavarz-Ghorabaee, M., Zavadskas, E., Amiri, M. and Turskis, Z. (2016). Extended EDAS Method for Fuzzy Multi-criteria Decision-making: An Application to Supplier Selection. *International Journal of Computers Communications & Control*, 11(3), 358-371.

Keshavarz-Ghorabaee, M., Amiri, M., Zavadskas, E.K., Turskis, Z. and Antucheviciene, J., (2017a). A new multi-criteria model based on interval type-2 fuzzy sets and EDAS method for supplier evaluation and order allocation with environmental considerations. *Computers & Industrial Engineering*, 112, 156-174.

Keshavarz-Ghorabaee, M., Amiri, M., Zavadskas, E., and Turskis, Z. (2017b). Multi-criteria group decision-making using an extended EDAS method with interval type-2 fuzzy sets. *E+M Ekonomie a Management*. 20, 48-68.

Keshavarz-Ghorabaee, M., Amiri, M., Zavadskas, E.K., Turskis, Z., and Antucheviciene, J. (2017c). Stochastic EDAS method for multi-criteria decision-making with normally distributed data. *Journal of Intelligent and Fuzzy Systems*, 33, 1627-1638.

Keshavarz-Ghorabaee, M., Amiri, M., Zavadskas, E., Hooshmand, R., and Antuchevičienė, J. (2017d). Fuzzy extension of the CODAS method for multi-criteria market segment evaluation. *Journal of Business Economics and Management*, 18(1), 1-19.

Keshavarz-Ghorabaee, M., Amiri, M., Zavadskas, E.K., Turskis, Z. and Antucheviciene, J. (2017e). A new hybrid simulation-based assignment approach for evaluating airlines with multiple service quality criteria. J. *Air Transport Manage*. 63, 45–60.

Keshavarz-Ghorabaee, M., Amiri, M., Zavadskas, E., Turskis, Z. and Antucheviciene, J. (2018a). A Dynamic Fuzzy Approach Based on the EDAS Method for Multi-Criteria Subcontractor Evaluation. *Information (Switzerland)*. 9.

Keshavarz-Ghorabaee, M., Amiri, M., Zavadskas, E. K., and Antucheviciene, J. (2018b). A new hybrid fuzzy MCDM approach for evaluation of construction equipment with sustainability considerations. *Archives of Civil and Mechanical Engineering*, 18(1), 32–49.

Khuan Chan, T., and Abdul-Aziz, A.R. (2017). Financial performance and operating strategies of Malaysian property development companies during the global financial crisis. *Journal of Financial Management of Property and Construction*, 22(2), 174-191.

Kundakcı, N. (2019). An integrated method using MACBETH and EDAS methods for evaluating steam boiler alternatives. *J Multi-Crit Decis Anal*. 26, 27-34.

Lev, B. (1969). Industry Averages as Targets for Financial Ratios. *Journal of Accounting Research*, 7(2), 290-299.

Liang, W., Zhao, G., and Luo, S. (2018). An Integrated EDAS-ELECTRE Method with Picture Fuzzy Information for Cleaner Production Evaluation in Gold Mines. *IEEE Access*, 6, 65747-65759.

Lotfi, F.H. and Fallahnejad, R., (2010). Imprecise Shannon's Entropy and Multi Attribute Decision Making. *Entropy*, 12, 53-62.

Malagie, M., Jensen, G., Graham, J. C., and Smith, D. L. (1998). *Food industry processes*. In ‘‘Encyclopedia of Occupational Health and Safety’’, (J. M. Stellman, Ed.), 4th edn, 67, 2–7. International Labor Office, Geneva.

Opricovic, S. (2011). Fuzzy VIKOR with an application to water resources planning. *Expert Systems with Applications*. 38, 12983–12990.

Peng, X. and Liu, C. (2017). Algorithms for neutrosophic soft decision making based on EDAS, new similarity measure and level soft set. *Journal of Intelligent & Fuzzy Systems*. 32(1), 955-968.

Perçin S. and Aldalou E., (2018). Financial Performance Evaluation of Turkish Airline Companies Using Integrated Fuzzy AHP Fuzzy Topsis Model, *Uluslararası İktisadi ve İdari İncelemeler Dergisi*, 583-598.

Ren, J. and Toniolo, S. (2018). Life cycle sustainability decision-support framework for ranking of hydrogen production pathways under uncertainties: An interval multi-criteria decision making approach. *Journal of Cleaner Production*. 175. 222-236.

Roszkowska, E. and Kacprzak, D. (2016). The fuzzy saw and fuzzy TOPSIS procedures based on ordered fuzzy numbers. *Information Sciences*, 369, 564-584.

Siddiqui, Z.A. and Tyagi, K. (2016). Application of fuzzy-MOORA method: Ranking of components for reliability estimation of component-based software systems. *Decision Science Letters*, 5, 169–188.

Stević, Ž., Pamučar, D., Vasiljević, M., Stojić, G. and Korica, S. (2017). Novel Integrated Multi-Criteria Model for Supplier Selection: Case Study Construction Company. *Symmetry*, 9, 279.

Stević, Ž., Vasiljević, M., Zavadskas, E., Sremac, S. and Turskis, Z. (2018). Selection of carpenter manufacturer using fuzzy EDAS method. *Engineering Economics*, 29. 281-290.

Tan, P.M., Koh, H.C. and Low, L.C. (1997). Stability of Financial Ratios: A Study of Listed Companies in Singapore. *Asian Review of Accounting*, 5(1), 19-39.

Turskis, Z. and Juodagalvienė, B. (2016). A novel hybrid multi-criteria decision-making model to assess a stairs shape for dwelling houses. *Journal of Civil Engineering and Management*, 22(8), 1078-1087.

Turskis, Z., Morkunaite, Z. and Kutut, V. (2017). A hybrid multiple criteria evaluation method of ranking of cultural heritage structures for renovation projects. *International Journal of Strategic Property Management*, 21(3), 318-329.

Worldfood Istanbul (2018). How well do you know Turkey's food & drink industry?. https://www.worldfood-istanbul.com/Articles/taking-a-look-at-the-turkish-food-drink-indus (Access: 07.06.2019)

Wu, J., Sun, J., Liang, L. and Zha, Y. (2011). Determination of weights for ultimate cross efficiency using Shannon entropy, *Expert Systems with Applications*, 38, 5162-5165.

Yeh Q-J (1996). Application of Data Envelopment Analysis in Conjunction with Financial Ratios for Bank Performance Evaluation. *JORS*, 47(8), 980-988.

Zarbakhshnia, N., Soleimani, H. and Ghaderi, H. (2018). Sustainable third-party reverse logistics provider evaluation and selection using fuzzy SWARA and developed fuzzy COPRAS in the presence of risk criteria. *Applied Soft Computing*, 65, 307-319.