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Performance Evaluation of Turkish Sustainability Funds Via FUZZY MCDM Approach

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Abstract

In this research, we attempt to analyze the performance of 30 sustainability – themed funds traded in Turkey via IVCIF AHP – ERUNS method. We also employ sensitivity and comparison analyses and the dataset spans August 16, 2022, to October 09, 2023. Our findings reveal that the funds which outperform the other funds invest predominantly in domestic stocks. In contrast to this, poor performing funds mainly hold foreign stocks or foreign ETFs in their portfolio compositions. Sensitivity analysis results state the high degree of stability related to proposed approach via the weights of criteria obtained. Besides, according to the comparison analysis, proposed IVCIF AHP – ERUNS method is valid and applicable. Following that, we provide managerial and practical implications along with future suggestions.

Key words: Sustainability Funds, Performance Evaluation, Circular Intuitionistic Fuzzy Sets, AHP, ERUNS

JEL Code: C63, C69, G11, G23

1. Introduction

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The concept of sustainability is a relatively recent phenomenon and emphasized by individuals, firms, international organizations and lawmakers. Especially following the Paris Agreement, which enters into force in 2016, many countries have started to create practices in line with the sustainable development goals. The main goal of these activities are reducing emissions, ensuring natural resources - energy efficiency and effectiveness in waste management and encouraging clean energy production. In recent years, with increasing awareness about environmental issues, sustainability and sustainable development have become trends. Sustainable finance is associated with investment tools that are used to raise money for environmentally friendly, also known as green, projects and the characteristics of these financial instruments. Sustainable finance practices generally refer to investments which are compatible with environmental, social and corporate governance principles. Firms can improve their reputation in the eyes of investors by paying special attention to ESG practices and concretely disclosing non-existent financial information about these standards in annual reports, as well as financial information.

Rising diversity of asset classes and the global spread of sustainability concept have led the launch of various mutual funds that invest in the securities of eco – friendly and sustainable companies. Mutual funds that contribute to a more sustainable world are generally gathered under one roof as "socially responsible investment funds" (Chung et al., 2012). Funds are divided into subcategories according to the field of activities of the firms whose securities included in portfolio. For example, funds that own stocks of companies investing in renewable energy projects are called by different names such as "green investment fund", "green energy fund" or "alternative energy fund". Herein, corporate social responsibility principles that the funds adopted gain importance. When we look at the current situation in Turkey, funds that hold a collection of sustainability – themed securities are classified as "sustainability funds". However, it is not known whether these funds appear attractive for institutional and retail investors. It therefore becomes crucial to analyze fund performance and to reveal differences in performance between funds and possible reasons for these differences.

Although numerous research in existing literature explores the performance of conventional funds, only a few studies attempt to examine sustainability funds. So, the main motivation of this paper is to guide investors who are interested in sustainability – themed assets. The current paper measures the performance of sustainability – themed funds operating in Turkey using IVCIF AHP-ERUNS method and various performance metrics. We also utilize sensitivity and comparison analyses to assess the impacts of changing criteria weights and to test the validity and reliability of models. Our dataset is based on the daily return data of 30 sustainability funds and covers the period from August 16, 2022, to October 09, 2023. Alpha and Beta coefficients were estimated by Capital Asset Pricing Model (CAPM) and covariance - variance approach. The findings indicated that the funds ranked in the top quartile or the bottom quartile remain mostly the same.

Our results contribute to the common literature in many ways: (1) Evaluating and comparing the performances of Turkish sustainability funds, (2) Discussing whether fund performances are compatible with sustainability goals by taking into account portfolio allocations and fund investment strategies, (3) Increasing investor interest in these type of financial assets by providing insights on the sustainability – themed funds.

The rest of the paper is arranged as follows. Section 2 reviews the related studies on sustainable and conventional funds. Section 3 describes the methodology. Section 4 presents the data and application. In sections 5 and 6, we give sensitivity and comparison analyses, respectively. Finally, section 7 concludes.

2. Literature Review

Pioneering research on the performance of mutual funds has been done at an early period of financial modelling. These studies aimed to provide a solution to the portfolio selection problem by considering risk – return criteria (Sharpe, 1966; Jensen, 1968; Arditti, 1971; McDonald, 1974; Kon & Jen, 1979). In the later period, studies which develop different methods regarding performance measurement have been conducted. Also, various research seeking answers to the question of whether fund performances vary in response to changing conditions have found place in literature (Henriksson, 1984; Lehmann & Modest, 1987; Grinblatt & Titman, 1989; Lee & Rahman, 1990; Carhart, 1997). Recent studies mainly gathered around themes such as fund performance rankings, fund comparison and factors influencing the performance of funds (Arslan & Arslan, 2010; Ferreira et al., 2013; Doshi et al., 2015; Gusni et al., 2018; Gül & Altınırmak, 2018; Grau – Carles et al., 2019; Cornell et al., 2020; Widyaningrum, 2023). In brief, it seems that the related literature on conventional funds performance evaluation is quite rich both from an empirical and a theoretical point of view. However, the number of sustainability – themed papers is limited since sustainability has become a very popular term in recent times. Many academic studies focus on the difference between performances of conventional funds and sustainability funds. Climent and Soriano (2011), for instance, examined the relative performances of U.S. green mutual funds compared to conventional mutual funds over the period 1987 - 2009. Authors also analyzed the social responsibility funds and discovered that green funds had lower performance than traditional funds with similar characteristics. During the period from 2001 to 2009, however, returns of the green funds did not show a statistically significant difference from both traditional and socially responsible funds. Likewise, Chang et al. (2012) argued that sustainability funds yield lower returns than conventional mutual funds, although they have similar levels of risk. Ibikunle and Steffen (2017) comparatively analyzed the performances of 175 European green funds, 259 fossil energy investment funds and 976 traditional funds for the period 1991 – 2014 and found out that green funds exhibited lower performance than other funds over the whole sample period. In a similar vein, Naqvi et al. (2021), using the data of 2339 funds from 27 emerging markets, revealed that conventional energy funds generate better performance than green energy funds. Another study was conducted using a crisis approach by Fernández et al. (2019). Authors evaluated the performances of green energy funds, conventional funds and socially responsible funds across different market environments in 2007 – 2018 to show that green energy funds had worse performance compared to other funds. Looking at crisis and non – crisis periods, on the other hand, green funds exhibit better performance during the 2007 – 2008 financial crisis while green funds returns are not significantly different from the conventional funds in the European debt crisis period.

In addition to studies claiming that conventional funds are superior to sustainability funds, some studies argue that sustainability funds exhibit better performance than traditional funds. In this sense, Ateş et al. (2022) focused on the performance of sustainability – themed funds and conventional funds traded in Turkey using daily data from 2019 to 2022. Authors present empirical evidence that sustainability – themed funds are more successful than their traditional peers. Another similar study conducted by Neves et al. (2023). They investigated whether green investment funds (GIF) and socially responsible funds (SRIF) outperform their traditional counterparts. Employing data envelopment analysis, authors stated that GIF and SRIF beat conventional funds. Moreover, traditional funds have not been able to exceed the performance of GIF in the last five years. Gonçalves et al. (2021) compared the performances of sustainable funds and traditional funds selected from EU members over the period 2005 – 2020 and reported that the abnormal returns of sustainable funds and traditional funds are negative when the world market is used as the benchmark index. For the European market benchmark, however, sustainable funds exhibit positive performance for both single – factor and multi – factor asset pricing models. Although Yue et al. (2020), unlike the abovementioned studies, could not affirm that sustainability funds earn higher returns than conventional funds, they emphasized that sustainable funds have lower risk.

Another group of research sheds some light on the relative performance of sustainability – themed assets and market indices. The pioneering study was carried out by Sabbaghi (2011). Researcher built an equally weighted portfolios of sustainability funds and investigated whether sustainability funds outperform the S&P – 500 indexes. Findings revealed that sustainability funds performed better than the S&P – 500 until the 2008 financial crisis but this situation was reversed in subsequent periods. It is also worth mentioning that sustainability funds exhibit high volatility. The study of Özman (2022) highlighted the rising interest in corporate social responsibility and growing investor appetite for sustainable funds. Using data from BIST 100 and BIST Sustainability Index over 2014 – 2022, author documented that the sustainability index had worse performance than BIST – 100 for the years 2015 and 2018. According to Silva and Cortez (2016), European green funds, in particular, had poorer performance compared to benchmark portfolios. More recently, Rohilla (2023) analyzed the performance of sustainability funds traded in India to claim that sustainability funds outperform market portfolio.

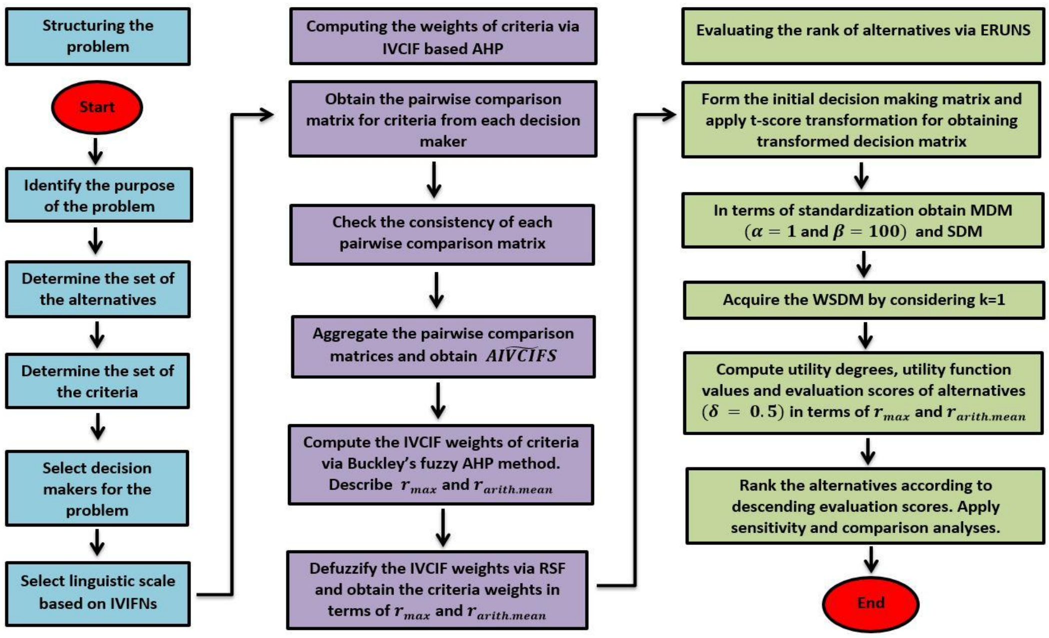
Several studies evaluate the performance of sustainability funds according to their ESG ratings, environmental factors or the sustainability approach (environmental, social, corporate governance) adopted. In particular, Abate et al. (2021) utilized data envelopment analysis (DEA) in a dataset of 634 European mutual funds to examine whether funds with high ESG scores outperform the funds with low scores. They indicated that high ESG rated funds perform better than low ESG ranked funds. Similarly, Pavlova and Boyrie (2022) concentrated on the performance of sustainability funds before and during the COVID – 19 pandemic and determined that low ESG funds showed better performance relative to high ESG funds. Put differently, they argue that high rated funds could not provide hedging benefits during crisis periods. In another research, authors compared the environmental performances of 378 Chinese open – ended mutual funds for the period 2010 – 2019 and stated that green investments of funds are accelerating and funds following these strategies may gain above-market returns (Chen et al., 2023). Reboredo et al. (2017) analyzed the financial performance of alternative energy funds using multifactor models. Results derived from the data of funds quoted in Euro and Dollar over 2010 – 2016 demonstrates that return performances of alternative energy funds are lower than corporate and socially responsible funds. These findings support the view that investors should pay additional premiums to achieve a greener world. Lastly, Ielasi et al. (2018) evaluated the risk profiles and performances of sustainability – themed mutual funds operating in Europe. Using data of 106 ethical funds and 51 sustainability funds, they found that sustainability funds did not differ significantly in terms of portfolio characteristics. Regarding performance metrics, sustainability funds underperform ethical funds according to Jensen's alpha.

Generally, studies on sustainability funds cover the last decade but the number worldwide is increasing rapidly. Based on the review of existing body of literature, only a limited number of prior studies examine the performance of Turkish sustainability – themed funds and hence we believe that the current study will have important implications for fund managers, investors and regulators. Also, this research can contribute to filling gaps in literature and to understanding sustainability funds.

3. Methodology

Methodology section consists of Circular Intuitionistic Fuzzy Sets, Interval-valued Circular Intuitionistic Fuzzy Sets, Interval-valued Circular Intuitionistic Fuzzy AHP and ERUNS respectively. A flowchart related to the steps of the study is presented in Figure 1.

Figure 1. Flowchart of the study



Preliminaries related to Circular Intuitionistic Fuzzy Sets

Circular intuitionistic fuzzy (CIF) sets proposed by Atanassov easily explain the magnitude of experts' hesitation and uncertainty (Otay et al., 2023).

A single-valued circular intuitionistic fuzzy (SVCIF) set $\tilde{G}$ that can be identified with a circle showing the ambiguity, vagueness and impreciseness in terms of membership $\left(\mu_{\tilde{G}}(x)\right)$ and non-membership $\left(v_{\tilde{G}}(x)\right)$ degrees, is stated as below (Atanassov, 2020; Otay et al., 2023):

A SVCIF set $\tilde{G}_r$ in D can be described as an object that has the form for a fixed universe D:

$$\tilde{G}_r = \{\langle x, \mu_{\tilde{G}}(x), v_{\tilde{G}}(x); r \rangle | x \in D\} \quad (1)$$

where $0 \leq \mu_{\tilde{G}}(x) + v_{\tilde{G}}(x) \leq 1, r \in [0,1], \mu_{\tilde{G}} : D \rightarrow [0,1]$ and $v_{\tilde{G}} : D \rightarrow [0,1]$

According to Eq.(1), a radius of the circle around each component $x, x \in D$ to the set $G \subseteq D$, is identified by "r ". Additionally, the degree of indeterminacy is calculated as below:

$$\pi_{\tilde{G}}(x) = 1 - \mu_{\tilde{G}}(x) - v_{\tilde{G}}(x) \quad (2)$$

Assume $\tilde{\beta}_i = \left(\mu_{\tilde{\beta}_i}, v_{\tilde{\beta}_i}\right)(i = 1,2, \cdots, n)$ as a set of intuitionistic fuzzy (IF) pairs. Besides, these IF pairs are aggregated via Intuitionistic Fuzzy Weighted Geometric (IFWG) operator as in Eq.(3), and the values of $\mu_{tpl} = \prod_{j=1}^{m} \mu_{\tilde{\beta}_j}{}^{w_j}$ and

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$v_{tpl} = \prod_{j=1}^{m} v_{\tilde{\beta}_j}{}^{w_j}$ related to the aggregated fuzzy numbers are obtained. Then, Euclidean distances between the views of each decision maker and the aggregated intuitionistic fuzzy sets are computed via Eq.(4), and the radius value related to each criterion can be found by handling maximum of these distances.

$$IFWG(\tilde{\beta}_1, \tilde{\beta}_2, \cdots, \tilde{\beta}_n) = \left(\prod_{j=1}^{m} \mu_{\tilde{\beta}_j}{}^{w_j}, \prod_{j=1}^{m} v_{\tilde{\beta}_j}{}^{w_j}\right) \quad (3)$$

where $w = (w_1, \cdots, w_n)^T$ can be considered as the weight vector for $\tilde{\beta}_i (i = 1,2, \cdots, n)$ with $w_j \in [0,1]$ and $\sum_{j=1}^{n} w_j = 1$.

$$r_i = \max_{1 \le j \le p_i} \sqrt{\left(\prod_{j=1}^{m} \mu_{\tilde{\beta}_j}{}^{w_j} - \mu_{\tilde{\beta}_i}\right)^2 + \left(\prod_{j=1}^{m} v_{\tilde{\beta}_j}{}^{w_j} - v_{\tilde{\beta}_i}\right)^2} \quad (4)$$

where experts are shown by p_i.

Assume $\widetilde{SVCIF}_1 = \langle \mu_1(x), v_1(x); r_1 \rangle$ and $\widetilde{SVCIF}_2 = \langle \mu_2(x), v_2(x); r_2 \rangle$ as two single-valued circular intuitionistic fuzzy numbers (SVCIFNs). Some arithmetic operations consisting of intersection, union, addition and multiplication related to these SVCIFNs are given in Eqs. (5) – (14) (Atanassov, 2020; Otay et al., 2023; Kahraman & Otay, 2022).

Intersection:

$$\widetilde{SVCIF}_1 \cap_{min} \widetilde{SVCIF}_2 = \{\langle x, min(\mu_1(x), \mu_2(x)), max(v_1(x), v_2(x)); min(r_1, r_2) \rangle | x \in X\} \quad (5)$$

$$\widetilde{SVCIF}_1 \cap_{max} \widetilde{SVCIF}_2 = \{\langle x, min(\mu_1(x), \mu_2(x)), max(v_1(x), v_2(x)); max(r_1, r_2) \rangle | x \in X\} \quad (6)$$

Union:

$$\widetilde{SVCIF}_1 \cup_{min} \widetilde{SVCIF}_2 = \{\langle x, max(\mu_1(x), \mu_2(x)), min(v_1(x), v_2(x)); min(r_1, r_2) \rangle | x \in X\} \quad (7)$$

$$\widetilde{SVCIF}_1 \cup_{max} \widetilde{SVCIF}_2 = \{\langle x, max(\mu_1(x), \mu_2(x)), min(v_1(x), v_2(x)); max(r_1, r_2) \rangle | x \in X\} \quad (8)$$

Addition:

$$\widetilde{SVCIF}_1 \oplus_{min} \widetilde{SVCIF}_2 = \{\langle x, \mu_1(x) + \mu_2(x) - \mu_1(x) * \mu_2(x), v_1(x) * v_2(x); min(r_1, r_2) \rangle | x \in X\} \quad (9)$$

$$\widetilde{SVCIF}_1 \oplus_{max} \widetilde{SVCIF}_2 = \{\langle x, \mu_1(x) + \mu_2(x) - \mu_1(x) * \mu_2(x), v_1(x) * v_2(x); max(r_1, r_2)\rangle | x \in X\} \quad (10)$$

Multiplication:

$$\widetilde{SVCIF}_1 \otimes_{min} \widetilde{SVCIF}_2 = \{\langle x, \mu_1(x) * \mu_2(x), v_1(x) + v_2(x) - v_1(x) * v_2(x); min(r_1, r_2)\rangle | x \in X\} \quad (11)$$

$$\widetilde{SVCIF}_1 \otimes_{max} \widetilde{SVCIF}_2 = \{\langle x, \mu_1(x) * \mu_2(x), v_1(x) + v_2(x) - v_1(x) * v_2(x); max(r_1, r_2)\rangle | x \in X\} \quad (12)$$

Multiplication by a scaler:

$$\lambda.\widetilde{SVCIF}_1 = \left\{\langle x, 1 - \left(1 - \mu_1(x)\right)^{\lambda}, \left(v_1(x)\right)^{\lambda}; r_1\rangle \,|x \in X\right\} \quad (13)$$

Power operation:

$$\widetilde{SVCIF}_1{}^{\lambda} = \left\{\langle x, \left(\mu_1(x)\right)^{\lambda}, 1 - \left(1 - v_1(x)\right)^{\lambda}; r_1\rangle \,|x \in X\right\} \quad (14)$$

Interval Valued Circular Intuitionistic Fuzzy Sets

Preliminaries related to interval valued circular intuitionistic fuzzy (*IVCIF*) sets are given as follows (Otay et al., 2023):

An $\widetilde{IVCIFS}$ can be described as below:

$$\widetilde{IVCIFS} = ([\mu_1, \mu_2], [v_1, v_2]; r) \quad (15)$$

where membership interval is represented by μ_1 *and* μ_2, non-membership interval is shown by v_1 *and* v_2 ($\mu_1, \mu_2, v_1, v_2 \in [0,1]$), and the uncertainty related to membership and non-membership intervals is identified by radius r. Larger uncertainty requires larger radius.

The boundaries (bound) related to $\widetilde{IVCIFS}$ are presented as in Eq.(16).

$$bound(\widetilde{IVCIFS}) = \begin{cases} y = v_1 - r; x \in [\mu_1, \mu_2] \\ y = v_2 + r; x \in [\mu_1, \mu_2] \\ x = \mu_1 - r; y \in [v_1, v_2] \\ x = \mu_2 + r; y \in [v_1, v_2] \\ (x - \mu_1)^2 + (y - v_1)^2 = r^2; x \in [(\mu_1 - r), \mu_1], y \in [(v_1 - r), v_1] \\ (x - \mu_1)^2 + (y - v_2)^2 = r^2; x \in [(\mu_1 - r), \mu_1], y \in [v_2, (v_2 + r)] \\ (x - \mu_2)^2 + (y - v_1)^2 = r^2; x \in [\mu_2, (\mu_2 + r)], y \in [(v_1 - r), v_1] \\ (x - \mu_2)^2 + (y - v_2)^2 = r^2; x \in [\mu_2, (\mu_2 + r)], y \in [v_2, (v_2 + r)] \end{cases} \quad (16)$$

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All the points in the area of $\widetilde{IVCIFS}$ are stated as below:

$$area\left(\widetilde{IVCIFS}\right) = (\mu_2 - \mu_1)(v_2 - v_1) + 2r(\mu_2 - \mu_1 + v_2 - v_1) + \pi r^2 \quad (17)$$

Interior (IRP) and exterior reference points (ERP) denoting an $\widetilde{IVCIFS}$ are given in Eq.(18) and Eq.(19), respectively.

$$IRP_1 = (\mu_1, v_1), IRP_2 = (\mu_1, v_2), IRP_3 = (\mu_2, v_1), IRP_4 = (\mu_2, v_2) \quad (18)$$

$$ERP_1 = \left(\mu_1 - \frac{r}{\sqrt{2}}, v_1 - \frac{r}{\sqrt{2}}\right), ERP_2 = \left(\mu_1 - \frac{r}{\sqrt{2}}, v_2 + \frac{r}{\sqrt{2}}\right), \\ ERP_3 = \left(\mu_2 + \frac{r}{\sqrt{2}}, v_1 - \frac{r}{\sqrt{2}}\right), ERP_4 = \left(\mu_2 + \frac{r}{\sqrt{2}}, v_2 + \frac{r}{\sqrt{2}}\right) \quad (19)$$

Assume $A\widetilde{IVCIFS}$ as an aggregation of n $\widetilde{IVCIFS}s$ shown as $\widetilde{IVCIFS}_1, \widetilde{IVCIFS}_2, \cdots, \widetilde{IVCIFS}_n$. $A\widetilde{IVCIFS}$ can be described as in Eq.(20).

$$A\widetilde{IVCIFS} = ([\mu_{1A}, \mu_{2A}], [v_{1A}, v_{2A}]; r_A) \quad (20)$$

where $\mu_{1A} = \sum_{p=1}^{P} \mu_{1p} w_p$, $\mu_{2A} = \sum_{p=1}^{P} \mu_{2p} w_p$ $v_{1A} = \sum_{p=1}^{P} v_{1p} w_p$, $v_{2A} = \sum_{p=1}^{P} v_{2p} w_p$

According to Eq.(20) the weight of an expert is shown by w_p and number of experts is indicated via P, $p = 1,2, \dots, P$.

ERP related to $A\widetilde{IVCIFS}$ are stated as below:

$$ERP_{1A} = \left(\mu_{1A} - \frac{r_p}{\sqrt{2}}, v_{1A} - \frac{r_p}{\sqrt{2}}\right), ERP_{2A} = \left(\mu_{1A} - \frac{r_p}{\sqrt{2}}, v_{2A} + \frac{r_p}{\sqrt{2}}\right), \\ ERP_{3A} = \left(\mu_{2A} + \frac{r_p}{\sqrt{2}}, v_{1A} - \frac{r_p}{\sqrt{2}}\right), ERP_{4A} = \left(\mu_{2A} + \frac{r_p}{\sqrt{2}}, v_{2A} + \frac{r_p}{\sqrt{2}}\right) \quad (21)$$

The radius values (r) are calculated via Eq.(22).

$$r = max\begin{pmatrix} uz_{\forall p=1,\dots,P}\left(IRP_1, ERP_{1Ap}\right), \left(IRP_2, ERP_{2Ap}\right), \\ \left(IRP_3, ERP_{3Ap}\right), \left(IRP_4, ERP_{4Ap}\right) \end{pmatrix} \quad (22)$$

where

$$uz\left(IRP_1, ERP_{1Ap}\right)_{p=1,\dots,P} = \sqrt{\left(\mu_{1p} - \frac{r_p}{\sqrt{2}} - \mu_{1A}\right)^2 + \left(v_{1p} - \frac{r_p}{\sqrt{2}} - v_{1A}\right)^2}$$

$$uz\left(IRP_2, ERP_{2Ap}\right)_{p=1,\dots,P} = \sqrt{\left(\mu_{1p} - \frac{r_p}{\sqrt{2}} - \mu_{1A}\right)^2 + \left(v_{2p} + \frac{r_p}{\sqrt{2}} - v_{2A}\right)^2}$$

$$uz\left(IRP_3, ERP_{3Ap}\right)_{p=1,\dots,P} = \sqrt{\left(\mu_{2p} + \frac{r_p}{\sqrt{2}} - \mu_{2A}\right)^2 + \left(v_{1p} - \frac{r_p}{\sqrt{2}} - v_{1A}\right)^2}$$

$$uz\left(IRP_4, ERP_{4Ap}\right)_{p=1,\dots,P} = \sqrt{\left(\mu_{2p} + \frac{r_p}{\sqrt{2}} - \mu_{2A}\right)^2 + \left(v_{2p} + \frac{r_p}{\sqrt{2}} - v_{2A}\right)^2}$$

Assume $I\widetilde{VCIF}S_1 = ([\mu_{11}(x), \mu_{21}(x)], [v_{11}(x), v_{21}(x)]; r_1)$ and $I\widetilde{VCIF}S_2 = ([\mu_{12}(x), \mu_{22}(x)], [v_{12}(x), v_{22}(x)]; r_2)$ as two $IVCIF$ numbers. Multiplication and power operation related to these numbers are given in Eqs. (23) – (26) (Otay et al., 2023).

Multiplication:

$$I\widetilde{VCIF}S_1 \otimes_{min} I\widetilde{VCIF}S_2 = \left\{ \left\langle \begin{matrix} x, [\mu_{11}(x) * \mu_{12}(x), \mu_{21}(x) * \mu_{22}(x)], \\ \begin{bmatrix} v_{11}(x) + v_{12}(x) - v_{11}(x) * v_{12}(x), \\ v_{21}(x) + v_{22}(x) - v_{21}(x) * v_{22}(x) \end{bmatrix}; min(r_1, r_2) \end{matrix} \right\rangle | x \in X \right\} \quad (23)$$

$$I\widetilde{VCIF}S_1 \otimes_{max} I\widetilde{VCIF}S_2 = \left\{ \left\langle \begin{matrix} x, [\mu_{11}(x) * \mu_{12}(x), \mu_{21}(x) * \mu_{22}(x)], \\ \begin{bmatrix} v_{11}(x) + v_{12}(x) - v_{11}(x) * v_{12}(x), v_{21}(x) \\ +v_{22}(x) - v_{21}(x) * v_{22}(x) \end{bmatrix}; max(r_1, r_2) \end{matrix} \right\rangle | x \in X \right\} \quad (24)$$

$$I\widetilde{VCIF}S_1 \otimes_{arith.mean} I\widetilde{VCIF}S_2 = \left\{ \left\langle \begin{matrix} x, [\mu_{11}(x) * \mu_{12}(x), \mu_{21}(x) * \mu_{22}(x)], \\ \begin{bmatrix} v_{11}(x) + v_{12}(x) - v_{11}(x) * v_{12}(x), \\ v_{21}(x) + v_{22}(x) - v_{21}(x) * v_{22}(x) \end{bmatrix}; (r_1 + r_2)/2 \end{matrix} \right\rangle | x \in X \right\} \quad (25)$$

Power operation:

$$I\widetilde{VCIF}S_1^{\ \lambda} = \left\{ \langle x, \left[\left(\mu_{11}(x)\right)^\lambda, \left(\mu_{21}(x)\right)^\lambda \right], \left[1 - \left(1 - v_{11}(x)\right)^\lambda, 1 - \left(1 - v_{21}(x)\right)^\lambda \right]; r_1 \rangle \, | x \in X \right\} \quad (26)$$

Interval Valued Circular Intuitionistic Fuzzy AHP

Steps of *IVCIF* AHP can be summarized as follows (Otay et al., 2023):

Step 1. Hierarchical structure related to the problem is formed by taking experts' judgments and extensive literature review into account. Finite set of criteria $\left(C_j, j = 1,2, \dots, n\right)$ and alternatives $(A_i, i = 1,2, \dots, m)$ comprise this structure.

Step 2. Pairwise comparison matrices in terms of criteria that can be seen as Eq.(27), are obtained according to the experts' views via linguistic scale given in Table 1.

$$\tilde{X} = \begin{bmatrix} 1 & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & 1 & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{n1} & \tilde{x}_{n2} & \cdots & 1 \end{bmatrix} \quad (27)$$

Table 1. Linguistic scale and related IVIFNs

Linguistic terms	IVIFNs
Absolutely Low (AL)	([0,0], [0.8,1])
Very Low (VL)	([0,0.1], [0.7,0.9])
Low (L)	([0,0.2], [0.6,0.8])
Medium Low (ML)	([0.1,0.3], [0.5,0.7])
Exactly Equal (EE)	([0.5,0.5], [0.5,0.5])
Medium High (MH)	([0.5,0.7], [0.1,0.3])
High (H)	([0.6,0.8], [0,0.2])
Very High (VH)	([0.7,0.9], [0,0.1])
Absolutely High (AH)	([0.8,1], [0,0])

Source: (Otay et al., 2023)

Step 3. Consistency ratios (CR) related to each pairwise comparison matrix is calculated for satisfying CR≤ 0.10. A new score index (SCI) is proposed by utilizing Eq.(28). Then Saaty's (1980) Classical Consistency Ratio is calculated via obtained SI values related to linguistic evaluations.

$$SI = 0.9905 + 3.174\left(\left(\frac{\mu_1+\mu_2}{2}\right) - \left(\frac{v_1+v_2}{2}\right)\right) + 4.458\left(\left(\frac{\mu_1+\mu_2}{2}\right) - \left(\frac{v_1+v_2}{2}\right)\right)^2 + 2.251\left(\left(\frac{\mu_1+\mu_2}{2}\right) - \left(\frac{v_1+v_2}{2}\right)\right)^3 \quad (28)$$

Step 4. If the satisfied CR are obtained, IVIF pairwise comparison matrices are aggregated and $AI\widetilde{VCIF}S$ is obtained via Eqs. (20-22). Besides, r values are computed in terms of Eq.(22) by taking the maximum distance between $AI\widetilde{VCIF}S$ (Eq.(20)) and ERP (Eq.(21)) into account.

Step 5. Criteria weights are computed in terms of *IVCIF* numbers via Buckley's (1985) fuzzy AHP method (Eqs. (29 – 30)). Firstly, related multiplication formula in Eqs. (23 – 25) is employed and following to that power operator in Eq.(26) is applied. Radius values are described according to maximum value (r_{max}) and arithmetic mean ($r_{arith.mean}$).

$$\tilde{k}_j = \left[\left(AI\widetilde{VCIF}S_1 \otimes \cdots \otimes AI\widetilde{VCIF}S_n\right)^{\frac{1}{n}}\right], j = 1,2,\dots,n \quad (29)$$

$$\tilde{w}_{Cj} = \tilde{k}_j \otimes \left[\tilde{k}_1 \oplus \cdots \oplus \tilde{k}_n\right]^{-1}, j = 1,2,\dots,n \quad (30)$$

Step 6. Similar procedure is applied for obtaining the weights of sub-criteria in terms of $IVCIF$ numbers $\left(\widetilde{w}_{subCj}, j = 1,2, \ldots, n\right)$ if any.

Step 7. Weights in terms of $IVCIF$ numbers are defuzzified via Relative Score Function (RSF) described as in Eq. (31).

$$RSF_i = \frac{\mu_1+\mu_2+(1-v_1)+(1-v_2)+\mu_1\mu_2-\sqrt{(1-v_1)(1-v_2)}}{4} x \left(\frac{1/r_i}{\sqrt{\sum_{i=1}^{m}(1/r_i^2)}}\right)^{\tau} \quad (31)$$

where τ showing the parameter related to the distinction among $IVCIFS$ can be considered as a small number such as 0.1 or 0.01. Additionally the coefficient $\left(\frac{1/r_i}{\sqrt{\sum_{i=1}^{m}(1/r_i^2)}}\right)^{\tau}$ $(i = 1,2,\cdots,m)$ states the relative magnitude degree related to an $\widetilde{IVCIFS}$ in terms of the other $\widetilde{IVCIFS}s$.

Step 8. Final weights are obtained in terms of corresponding RSF_i values based on the r_{max} and $r_{arith.mean}$.

Evaluation based on relative utility and nonlinear standardization (ERUNS)

This new hybrid technique, proposed to the literature by the research conducted by Biswas et al. (2024), uses a newly developed non-linear standardization system that improves benefit categorization and provides decision makers with greater flexibility in choosing the most suitable option. This method is primarily designed to analyze objective data, but analysts have the option to select the desired normative domain based on the problem at hand. The calculation steps of the method are given below (Biswas et al., 2024):
Step 1. Creating the decision matrix

$$X = \left[x_{ij}\right]_{mxn} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (32)$$

Step 2. Standardization

The method's second stage involves standardizing the X matrix's elements using a function that matches criterion ranges with any range $[\alpha, \beta]$ that can be arbitrarily selected. In this case, α denotes the range's left limit while β denotes its right limit. The first-choice matrix $X = \left[x_{ij}\right]_{mxn}$ elements are standardized in two stages, as indicated below:

a) Equation (33) is used to map the choice matrix's elements to the range $[\alpha, \beta]$:

$$\varphi_{ij} = \left(\frac{x_j^{min}}{x_{ij}}\right)^3 \beta + \frac{\alpha}{x_j^{min}} \tag{33}$$

where the left and right boundaries of the standardized interval are denoted by α and β respectively, and $x_j^{min} = \min_{1 \le i \le m}(x_{ij})$ stands for the absolute minimum values from the matrix $X = [x_{ij}]_{mxn}$. The determination of the left and right bounds of the interval $[\alpha, \beta]$ is contingent upon the attributes of the decision-making problem and is established in accordance with the decision maker's preferences. For instance, when we aim to assign values from the matrix $[x_{ij}]_{mxn}$ to the interval [1,9], we select the values $\alpha = 1$ and $\beta = 9$. Consequently, equation (33) is transformed into equation (34) in the following manner:

$$\varphi_{ij} = \left(\frac{x_j^{min}}{x_{ij}}\right)^3 \cdot 9 + \frac{1}{x_j^{min}} \tag{34}$$

When dealing with decision problems involving numerous alternatives, it is advisable to choose an interval with a wider range. By utilizing equation (33), we derive a modified decision matrix (MDM) $X^N = [\varphi_{ij}]_{mxn}$.

b) In the second step, $X^N = [\varphi_{ij}]_{mxn}$ values are modified using equation (35) if the criterion is pointing in the direction of maximization.

$$\xi_{ij} = -\varphi_{ij} + \max_{1 \le i \le m}(\varphi_{ij}) + \min_{1 \le i \le m}(\varphi_{ij}) \tag{35}$$

where the values of "X" are acquired using equation (33).

Therefore, if the criteria is pointing in the direction of decrease, $\xi_{ij} = \varphi_{ij}$ is taken for granted. As a result, $\mathbb{Q} = [\xi_{ij}]_{mxn}$ represents the final standardized decision matrix (SDM).

Step 3. Constructing the weighted standardized decision matrix (WSDM)

$V = [v_{ij}]_{mxn}$ is the weighted standardized decision matrix. In this case, the soft-max function is used to show the weighted relationships between criteria:

$$v_{ij} = \frac{exp\left(\frac{f(\xi_{ij})}{k}\right)w_j}{\sum_{j=1}^{n} exp\left(\frac{f(\xi_{ij})}{k}\right)w_j} \tag{36}$$

For $f(\xi_{ij}) = \frac{\xi_{ij}}{\sum_{j=1}^{n} \xi_{ij}}, j \in \{1,2,3 \dots, n\}$ w_j in this instance, j. denotes the criterion's weight and $k > 0$ denotes the modulation parameter. It is advised to use $k = 1$ for a more straightforward computation. This parameter has the ability to simulate several situations in sensitivity analysis.

Step 4. Determine the degrees of utility about the ideal and anti-ideal solutions

The utility levels of the ith alternative according to ideal and anti-ideal solutions are calculated as in Eqs. (37) and (38).

$$U^{+} = \prod_{j=1}^{n} (\xi_{ij})^{v_{ij}} / \sum_{j=1}^{n} v_j^{+} \tag{37}$$

$$U^{-} = -\frac{\sum_{j=1}^{n} v_j^{-}}{\prod_{j=1}^{n} (\xi_{ij})^{v_{ij}}} + \max_{1 \le i \le m} \left(\frac{\sum_{j=1}^{n} v_j^{-}}{\prod_{j=1}^{n} (\xi_{ij})^{v_{ij}}} \right) + \min_{1 \le i \le m} \left(\frac{\sum_{j=1}^{n} v_j^{-}}{\prod_{j=1}^{n} (\xi_{ij})^{v_{ij}}} \right) \tag{38}$$

where $v_j^{+} = \max_{1 \le i \le m} (\xi_{ij} \cdot w_j)$ and $v_j^{-} = \min_{1 \le i \le m} (\xi_{ij} \cdot w_j)$ $(i = 1,2 \dots m; j = 1,2 \dots n)$.

Step 5. Determine the values of the utility function

We may characterize the final utility functions obtained as follows based on the total levels of utility. There is an additional component to the utility functions.

$$f(U_i^{+}) = U_i^{+} / U_i^{+} + U_i^{-} \tag{39}$$

$$f(U_i^{-}) = U_i^{-} / U_i^{+} + U_i^{-} \tag{40}$$

Step 6. Determine the evaluation score

In the last stage, the alternatives are ranked using the values of the utility functions. Evaluation scores of the alternatives are found using Equation (41).

$$AS_i = (U_i^{+} + U_i^{-}) \frac{\left(1+f(U_i^{+})\right)^{\delta} \left(1+f(U_i^{-})\right)^{1-\delta} - \left(1-f(U_i^{+})\right)^{\delta} \left(1-f(U_i^{-})\right)^{1-\delta}}{\left(1+f(U_i^{+})\right)^{\delta} \left(1+f(U_i^{-})\right)^{1-\delta} + \left(1-f(U_i^{+})\right)^{\delta} \left(1-f(U_i^{-})\right)^{1-\delta}} \tag{41}$$

The evaluation score has a parameter δ. This δ parameter is defined in the range $[0,1]$. The δ parameter is used to define the effect of the utility function values (equations (39 and (40)) on the final decision. It is recommended to use $\delta = 0.5$ in calculating the final evaluation score. The equal impact of utility function values on the final decision is simulated in this way. The final ranking of the alternatives is defined based on the final evaluation score, which is desired to have the highest possible value.

4. Data and Application

As of October 2023, 37 Turkish funds continue in operation with the fund type titles "sustainability fund". 29 of these funds are securities mutual funds, 7 are pension funds and 1 is an exchange traded fund. Daily data were collected from Turkey Electronic Fund Trading Platform (TEFAS) for the period from August 16, 2022, to October 09, 2023. Availability of fund data played an important role in determining the study period. There were 6 sustainability – themed funds in Turkey before 2021 and 16 before 2022. Our sample period starts in August 2022 in order to include more funds. The final sample consisted of 30 funds that invest in sustainability theme.

We calculate and use the daily returns (R_i) of funds by the following equation:

$$R_{it} = ln\left(\frac{P_{it}}{P_{it-1}}\right) \quad (42)$$

where R_i is the daily return of asset i, P_{it} is the closing price of asset i on day t, P_{it-1} is the closing price of asset i on day $t-1$. BIST All Shares Index (XUTUM) was adopted as the benchmark and market returns (R_i) were computed with the help of Eq. (42). Turkey's benchmark 2 – year bond rate is taken as the risk – free rate of return, expressed as R_f.

There are many different methods for measuring portfolio performance. Some of these are based on the portfolios' overall risk while others consider only the systematic risk. Additionally, more advanced methods aim to reveal the market timing abilities of fund managers and performance metrics that utilizes "downside risk" such as the Sortino ratio also exist in literature. In the current study, traditional performance measurement methods (Sharpe, Treynor, Jensen, M^2, Fama, Sortino and T^2) were applied and formulas and interpretations are presented in Table 2.

Table 2. Calculation and interpretation of portfolio performance metrics

Criteria	Criteria code (optimization side)	Formula	Interpretation
Sharpe (1966)	C1 (max)	$\frac{(R_p - R_f)}{\sigma_p}$	Indicates the excess return provided per unit of total risk. A higher ratio is better when comparing similar portfolios.
Treynor (1965)	C2 (max)	$\frac{(R_p - R_f)}{\beta_p}$	Indicates the excess return provided per unit of systematic

			risk. A higher ratio is better when comparing similar portfolios.
Jensen (1968)	C3 (max)	$\alpha = R_p - [R_f + \beta_p(R_m - R_f)]$	Determines the abnormal return over the expected return according to risk profile of the portfolio and market conditions. A higher Jensen ratio denote better performance.
M^2 (1997)	C4 (max)	$(\sigma_m/\sigma_p) * (R_p - R_f) + R_f$	An improved version of the Sharpe ratio and easier to interpret. A higher ratio is better when comparing similar portfolios.
Fama (1972)	C5 (max)	$(R_p - R_f) - (\sigma_p/\sigma_m) * (R_m - R_f)$	Compares the portfolio's actual return and expected return. A positive results denote better performance.
Sortino	C6 (max)	$\frac{(R_p - MAR)}{TDD}$	Indicates the excess return provided per unit of downside risk. A higher ratio is better when comparing similar portfolios.
T^2	C7 (max)	$\left[\frac{(R_p - R_f)}{\beta_p}\right] - (R_m - R_f)$	An improved version of the Treynor ratio and easier to interpret. A higher ratio is better when comparing similar portfolios.

Note: R_p denotes the fund return, R_f denotes the risk – free rate of return, R_m denotes the market return, σ_p denotes the standard deviation of the fund return, σ_m denotes the standard deviation of the market return, β_p denotes the beta coefficient of the fund, MAR denotes the minimum acceptable return and TDD denotes the target downside deviation.

The standard deviation (σ_p) used for calculation of Sharpe, M^2 and Fama ratios is shown in Eq. (43).

$$\sigma_i = \sqrt{\frac{\sum_{t=1}^{n}(R_{it}-\bar{R}_i)^2}{n-1}} \quad (43)$$

where, σ_i represents the standard deviation of asset i, R_{it} represents the return of asset i in period t and $\bar{R}_i$ represents the average return of asset i.

The beta coefficient (β_i) used for calculation of Treynor, Jensen and T^2 ratios is shown in Eq. (44).

$$\beta_i = \frac{COV\ (R_i, R_m)}{VAR\ (R_m)} = \frac{\frac{\sum_{t=1}^{n}(R_{it}-\bar{R}_i)*(R_{mt}-\bar{R}_m)}{n-1}}{\sum_{t=1}^{n}\frac{(R_{mt}-\bar{R}_m)^2}{n-1}} \quad (44)$$

where β_i is the beta coefficient of asset i, R_{it} is the return of asset i in period t, R_{mt} is the market return in period t, $\bar{R}_i$ is the average return of asset i and $\bar{R}_m$ is the average market return.

Jensen's Alpha coefficient is derived from the Capital Asset Pricing Model, and its calculation method is expressed as follows:

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$$R_i = \alpha_i + R_f + \beta_i(R_m - R_f) \quad (45)$$

where α_i is the Jensen's Alpha coefficient of asset i.

The target downside deviation (TDD) which is required to compute the Sortino ratio is found by taking into account the standard deviations of the negative excess returns of the relevant asset in a certain period. Minimum acceptable return (MAR), on the other side, is presumed to be zero or risk – free rate of return in practice. Funds analyzed are shown in Table 3.

Table 3. Turkish sustainability funds sample

Fund Code	Fund Title	Fund Code	Fund Title
AOY	Ak Asset Management Alternative Energy Foreign Share Fund	HMS	HSBC Asset Management Sustainability Equity (TRY) Fund (Equity Intensive Fund)
APG	Allianz Yaşam ve Emeklilik A.Ş. Sustainability Fund Basket Mutual Fund	IFN	ICBC Turkey Asset Management Sustainability Equity Fund
BHS	Anadolu Hayat Emeklilik A.Ş. Sustainability Equity Pension Mutual Fund	IKP	İş Asset Management Renewable Energy Mixed Fund
CVF	Ak Asset Management Sustainability Hedge (TRY) Private Fund	IPJ	İş Asset Management Electric Vehicles Mixed Fund
DHM	Deniz Asset Management ESG Sustainability Fund Basket Fund	IUT	Inveo Portfolio ESG Sustainability Fund Basket Fund
DLD	Deniz Asset Management Sustainability Equity Mutual Fund	KSR	KT Portfolio Sustainability Participation Fund
DYN	Deniz Asset Management Electric and Autonomous Vehicle Technologies Variable Fund	OLD	QNB Finans Portfolio Clean Energy and Water Fund Basket Fund
ESG	Aktif Asset Management ESG Sustainability Hedge Fund	RPC	Rota Portfolio Climate Change Solutions Variable Fund
FVI	HDI FİBA Emeklilik ve Hayat A.Ş ESG Sustainability Fund Basket Pension Investment Fund	TJF	TEB Asset Management Sustainability Fund Basket Fund
GFH	Agesa Hayat ve Emeklilik A.Ş. Sustainability Stock Pension Mutual Fund	VCY	Ak Asset Management Electric and Autonomous Technologies Variable Fund
GHH	Garanti Emeklilik ve Hayat A.Ş. Sustainability Stock Pension Mutual Fund	YJH	Yapı Kredi Asset Management Clean Energy Variable Fund
GVA	Garanti Asset Management Electric and Autonomous Vehicles Variable Fund	YLE	Yapı Kredi Asset Management Sustainability Index Equity Fund (Equity Intensive Fund)
GZH	Garanti Asset Management Clean Energy Variable Fund	YLO	Yapı Kredi Asset Management Electric Vehicles Variable Fund

GZR	Garanti Asset Management Sustainability Equity (TRY) Fund	YPC	Yapı Kredi Asset Management Climate Change Solutions Variable Fund
GZV	Garanti Asset Management ESG Sustainability Fund Basket Fund	ZHB	Türkiye Hayat ve Emeklilik A.Ş. Sustainability Equity Pension Mutual Fund

Source: TEFAS Historical Data, https://fundturkey.com.tr/TarihselVeriler.aspx, (October 9, 2023)

Table 4 provides information about the number of shares outstanding, the number of investors and the total market value of funds. The top three funds, in terms of total market capitalization, are ZHB, GHH and IPJ, respectively.

Table 4. Fund summaries

Fund Code	Number of Outstanding Shares (Unit)	Number of Investors	Fund Total Value (TRY)
AOY	2.263.759.020,00	32.769	391.021.837,93
APG	2.597.334.177,44	25.372	319.346.552,35
BHS	9.956.336.539,71	28.958	563.188.227,25
CVF	125.264.970,00	1	180.757.039,96
DHM	6.105.199,00	521	13.841.121,61
DLD	14.923.282,00	602	59.643.086,50
DYN	32.965.101,00	3.440	66.180.323,71
ESG	37.237.563,00	97	82.751.696,43
FVI	1.881.417.566,84	1.101	26.359.870,87
GFH	31.337.468.218,10	66.462	1.142.255.534,06
GHH	12.130.150.535,56	49.895	1.910.178.630,74
GVA	83.085.950,00	6.219	152.812.708,50
GZH	80.174.140,00	6.055	190.152.168,93
GZR	62.703.656,00	2.527	385.159.325,49
GZV	26.354.401,00	2.232	91.400.640,91
HMS	6.846.767.458,00	2.564	355.990.356,36
IFN	5.521.394,00	985	29.477.478,09
IKP	159.955.295,00	11.523	444.869.909,45
IPJ	184.943.462,00	29.835	1.356.289.246,91
IUT	1.692.709,00	508	3.554.722,68
KSR	87.015.396,00	2.638	181.519.710,53
OLD	85.280.335,00	3.189	146.847.312,74
RPC	9.776.257,00	584	18.520.048,74
TJF	43.892.773,00	891	101.588.295,68
VCY	74.438.032,00	14.335	123.990.356,27
YJH	56.653.796,00	5.150	103.644.256,04
YLE	77.473.143,00	3.857	339.132.328,44
YLO	70.732.077,00	6.775	135.618.285,04
YPC	18.016.964,00	2.828	36.885.609,18
ZHB	15.584.115.898,99	259.211	2.676.406.403,23

Source: TEFAS Historical Data, https://fundturkey.com.tr/TarihselVeriler.aspx, (October 9, 2023)

Table 5 reports the descriptive statistics regarding the daily return series of Turkish sustainability funds. Returns are calculated over a 291 – day sample period. The ICBC Turkey Asset Management Sustainability Equity Fund (IFN) provided the highest average return while Ak Asset Management Alternative Energy Foreign Share Fund (AOY) achieved the lowest return. Concurrently, aforesaid fund was the only fund that experienced losses during the study period. Apart from this,

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"YLE" had the highest degree of risk and "ESG" had the lowest degree of risk. Also, the difference between the maximum and minimum average daily returns of "ESG" is -2.56% and "YLE" is -18.91%. Even though it carries the lowest levels of risk, "ESG" yielded higher returns than 10 of the 29 funds.

Table 5. Descriptive statistics

Fund Code	N	Min.	Max.	Mean	Std. Dev.	Beta	Skewness	Kurtosis
AOY	291	-5,05%	8,54%	-0,03%	1,86%	0,025	0,501	1,602
APG	291	-2,96%	4,09%	0,22%	1,12%	-0,003	0,519	0,882
BHS	291	-5,22%	5,92%	0,36%	1,61%	0,033	0,149	1,863
CVF	291	-4,39%	6,53%	0,13%	0,83%	-0,014	2,224	19,376
DHM	291	-8,06%	7,67%	0,21%	1,36%	0,033	0,358	8,786
DLD	291	-7,81%	8,58%	0,38%	2,15%	0,022	-0,095	2,271
DYN	291	-3,25%	7,99%	0,24%	1,53%	0,055	0,657	2,098
ESG	291	-0,96%	1,59%	0,13%	0,33%	0,013	0,669	2,579
FVI	291	-7,23%	5,34%	0,12%	1,08%	0,061	-0,996	13,201
GFH	291	-5,97%	7,10%	0,35%	1,80%	0,025	0,004	1,962
GHH	291	-4,50%	5,06%	0,32%	1,32%	0,029	0,218	2,080
GVA	291	-3,39%	6,08%	0,19%	1,28%	0,018	0,613	1,480
GZH	291	-3,88%	6,98%	0,09%	1,56%	0,011	0,630	1,811
GZR	291	-7,77%	8,88%	0,42%	2,13%	0,023	-0,036	2,147
GZV	291	-2,86%	7,15%	0,16%	1,06%	0,027	1,354	7,729
HMS	291	-8,45%	9,70%	0,45%	2,32%	0,010	0,018	2,504
IFN	291	-8,27%	9,21%	0,48%	2,21%	0,026	-0,075	2,390
IKP	291	-3,04%	6,79%	0,09%	1,08%	0,034	1,159	5,502
IPJ	291	-3,26%	8,43%	0,12%	1,40%	0,040	0,973	4,078
IUT	291	-5,59%	6,97%	0,21%	1,25%	0,017	0,730	5,921
KSR	291	-2,15%	6,39%	0,21%	0,91%	0,030	1,523	9,373
OLD	291	-3,47%	8,43%	0,11%	1,50%	0,038	0,869	3,462
RPC	291	-5,06%	8,29%	0,19%	1,40%	0,006	0,736	4,433
TJF	291	-3,28%	7,55%	0,11%	1,24%	0,024	1,233	5,738
VCY	291	-3,67%	6,09%	0,12%	1,58%	0,036	0,550	0,944
YJH	291	-3,95%	7,02%	0,05%	1,48%	0,004	0,494	1,670
YLE	291	-8,70%	10,21%	0,42%	2,27%	0,023	0,076	2,737
YLO	291	-3,33%	5,80%	0,17%	1,27%	0,029	0,559	1,406
YPC	291	-4,60%	5,56%	0,25%	1,31%	0,021	0,462	2,376
ZHB	291	-8,52%	9,64%	0,42%	2,17%	0,014	-0,064	2,688

Source: Authors' calculations

According to Table 5, very small beta coefficients were estimated, and these coefficients appear to be different from the "normal" values. In studies computing the beta coefficients of stocks, estimated coefficients ranged from 30% - 120% (Er & Kaya, 2012; Karakoç, 2016; Intrisano et al., 2017). However, for mutual funds, a similar relationship may not be observed when high – frequency data is used. This situation which contradicts the Efficient Market Hypothesis proposed by Fama (1970) is known as the "low volatility" or "low beta" anomaly in the literature.

One can claim that the coefficient beta computed according to the CAPM explains the fund's systematic risk to a limited extent and ignores other factors affecting the overall risk of fund. Higher values of beta coefficients are estimated if they are calculated from monthly data. On the other hand, the impact of funds' volatility on beta becomes clear when the analysis is based on daily frequency data. For example, using the daily returns of stocks, the beta coefficients which are estimated both by the covariance – variance method (linear regression) and by the CAPM under the assumption that the other factors have no impact (when market risk is considered only) are very close to each other. But fund's beta coefficients computed with the same methods using the high – frequency data differ significantly. When the number of securities in the fund portfolio increases, the fund moves further away from the market, and the information characteristics of funds weaken the relationship among market and fund. This can be explained by the fact that since the funds include many securities in portfolio composition, they may have lower volatility than benchmark indices, in other words, diversification benefits.

After determining criteria and alternatives via depth literature review and experts' views, a questionnaire is designed for obtaining criteria weights via *IVCIF* AHP based on the r_{max} and $r_{arith.mean}$. Seven decision makers are selected from academicians and equity research professionals. Pairwise comparison of criteria for all DMs with their CR values are given in Tables 6-12.

Table 6. Pairwise comparison of criteria for DM1

DM1	C1	C2	C3	C4	C5	C6	C7
C1	EE	ML	VL	EE	ML	ML	EE
C2	MH	EE	EE	VH	VH	VH	VH
C3	VH	EE	EE	VH	VH	VH	VH
C4	EE	VL	VL	EE	L	EE	EE
C5	MH	VL	VL	H	EE	EE	EE
C6	MH	VL	VL	EE	EE	EE	EE
C7	EE	VL	VL	EE	EE	EE	EE

Note: CR=0.085

Table 7. Pairwise comparison of criteria for DM2

DM2	C1	C2	C3	C4	C5	C6	C7
C1	EE	ML	EE	VL	ML	EE	EE
C2	MH	EE	EE	MH	ML	EE	MH
C3	EE	EE	EE	EE	VL	EE	MH
C4	VH	ML	EE	EE	VL	EE	MH
C5	MH	MH	VH	VH	EE	VH	VH
C6	EE	EE	EE	EE	VL	EE	MH
C7	EE	ML	ML	ML	VL	ML	EE

Note: CR=0.098

Table 8. Pairwise comparison of criteria for DM3

DM3	C1	C2	C3	C4	C5	C6	C7
C1	EE	EE	EE	EE	EE	EE	EE
C2	EE	EE	MH	L	EE	EE	ML
C3	EE	ML	EE	ML	EE	EE	L
C4	EE	H	MH	EE	EE	EE	MH
C5	EE	EE	EE	EE	EE	EE	EE
C6	EE	EE	EE	EE	EE	EE	EE
C7	EE	MH	H	ML	EE	EE	EE

Note: CR=0.092

Table 9. Pairwise comparison of criteria for DM4

DM4	C1	C2	C3	C4	C5	C6	C7
C1	EE	ML	ML	L	ML	MH	L
C2	MH	EE	ML	EE	ML	H	L
C3	MH	MH	EE	MH	EE	H	ML
C4	H	EE	ML	EE	EE	H	ML
C5	MH	MH	EE	EE	EE	H	EE
C6	ML	L	L	L	L	EE	L
C7	H	H	MH	MH	EE	H	EE

Note: CR=0.067

Table 10. Pairwise comparison of criteria for DM5

DM5	C1	C2	C3	C4	C5	C6	C7
C1	EE	EE	EE	MH	ML	EE	MH
C2	EE	EE	EE	H	ML	EE	MH
C3	EE	EE	EE	MH	ML	EE	MH
C4	ML	L	ML	EE	L	ML	EE
C5	MH	MH	MH	H	EE	MH	H
C6	EE	EE	EE	MH	ML	EE	MH
C7	ML	ML	ML	EE	L	ML	EE

Note: CR=0.005

Table 11. Pairwise comparison of criteria for DM6

DM6	C1	C2	C3	C4	C5	C6	C7
C1	EE	ML	VH	EE	VL	ML	ML
C2	MH	EE	VH	EE	VL	ML	EE
C3	VL	VL	EE	VL	AL	AL	VL
C4	EE	EE	VH	EE	VL	ML	ML
C5	VH	VH	AH	VH	EE	H	VH
C6	MH	MH	AH	MH	L	EE	MH
C7	MH	EE	VH	MH	VL	ML	EE

Note: CR=0.095

Table 12. Pairwise comparison of criteria for DM7

DM7	C1	C2	C3	C4	C5	C6	C7
C1	EE	EE	ML	MH	H	MH	MH
C2	EE	EE	ML	MH	MH	EE	H
C3	MH	MH	EE	H	H	MH	H
C4	ML	ML	L	EE	EE	L	EE
C5	L	ML	L	EE	EE	L	EE
C6	ML	EE	ML	H	H	EE	H
C7	ML	L	L	EE	EE	L	EE

Note: CR=0.039

All CR values are smaller than the threshold value so pairwise comparisons related to criteria are found as consistent. Following that *IVIF* pairwise evaluation matrices are formed for all DMs according to the linguistic terms given in Table 1. The priority weight of each DM is set to 0.143. Then *IVIFNs* based judgements of seven DMs are aggregated via Eqs. (20-22) and obtained $A\widetilde{IVCIFS}$ is presented in Table 13.

Table 13. Aggregated pairwise comparison matrix related to criteria $\left(A\widetilde{IVCIFS}\right)$

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	([0.5,0.5], [0.5,0.5]; 0)	([0.27,0.38], [0.5,0.61]; 0.25)	([0.34,0.44], [0.45,0.55]; 0.64)	([0.35,0.45], [0.42,0.54]; 0.5)	([0.21,0.37], [0.45,0.62]; 0.62)	([0.38,0.5], [0.38,0.5]; 0.34)	([0.37,0.48], [0.4,0.51]; 0.46)
C2	([0.5,0.61], [0.27,0.38]; 0.25)	([0.5,0.5], [0.5,0.5]; 0)	([0.41,0.52], [0.37,0.47]; 0.52)	([0.47,0.61], [0.25,0.38]; 0.62)	([0.28,0.44], [0.4,0.55]; 0.64)	([0.48,0.57], [0.35,0.42]; 0.48)	([0.41,0.58], [0.25,0.41]; 0.56)
C3	([0.45,0.55], [0.34,0.44]; 0.64)	([0.37,0.47], [0.41,0.52]; 0.52)	([0.5,0.5], [0.5,0.5]; 0)	([0.41,0.57], [0.27,0.42]; 0.66)	([0.34,0.44], [0.42,0.55]; 0.64)	([0.47,0.55], [0.34,0.44]; 0.78)	([0.34,0.52], [0.28,0.47]; 0.6)
C4	([0.42,0.54], [0.35,0.45]; 0.5)	([0.25,0.38], [0.47,0.61]; 0.62)	([0.27,0.42], [0.41,0.57]; 0.66)	([0.5,0.5], [0.5,0.5]; 0)	([0.21,0.3], [0.58,0.7]; 0.34)	([0.32,0.44], [0.44,0.55]; 0.56)	([0.38,0.5], [0.38,0.5]; 0.34)
C5	([0.45,0.62], [0.21,0.37]; 0.62)	([0.4,0.55], [0.28,0.44]; 0.64)	([0.42,0.55], [0.34,0.44]; 0.64)	([0.58,0.7], [0.21,0.3]; 0.34)	([0.5,0.5], [0.5,0.5]; 0)	([0.48,0.62], [0.24,0.37]; 0.64)	([0.57,0.65], [0.28,0.34]; 0.37)
C6	([0.38,0.5], [0.38,0.5]; 0.34)	([0.35,0.42], [0.48,0.57]; 0.48)	([0.34,0.44], [0.47,0.55]; 0.78)	([0.44,0.55], [0.32,0.44]; 0.56)	([0.24,0.37], [0.48,0.62]; 0.64)	([0.5,0.5], [0.5,0.5]; 0)	([0.44,0.58], [0.27,0.41]; 0.58)
C7	([0.4,0.51], [0.37,0.48]; 0.46)	([0.25,0.41], [0.41,0.58]; 0.56)	([0.28,0.47], [0.34,0.52]; 0.6)	([0.38,0.5], [0.38,0.5]; 0.34)	([0.28,0.34], [0.57,0.65]; 0.37)	([0.27,0.41], [0.44,0.58]; 0.58)	([0.5,0.5], [0.5,0.5]; 0)

Criteria weights are computed in terms of *IVCIF* numbers by using Eqs. (29 – 30) for both r_{max} and $r_{arith.mean}$. *IVCIF* numbers-based weights are defuzzified via RSF as in Eq.(31) by taking $\tau = 0.1$ into the account. Obtained *IVCIF* criteria weights and final weights are given in Table 14.

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Table 14. IVCIF criteria weights and final weights

Criteria	$\widetilde{IVCIF}$ weights $(\tilde{w}_{Cj})$	r_{max}	$RSF_{i,m}$	Final weight (max)	Rank (max)	$r_{arith.mea}$	$RSF_{i,a}$	Final weight (arith mean)	Rank (arith mean)
C1	([0.34,0.44], [0.44,0.55];	0.78)	0.33	0.126	5	0.40)	0.32	0.125	6
C2	([0.44,0.55], [0.34,0.44];	0.78)	0.41	0.159	2	0.44)	0.41	0.157	2
C3	([0.42,0.52], [0.37,0.47];	0.78)	0.39	0.150	3	0.49)	0.38	0.147	3
C4	([0.33,0.43], [0.45,0.56];	0.78)	0.32	0.122	7	0.37)	0.32	0.123	7
C5	([0.50,0.60], [0.30,0.39];	0.78)	0.46	0.178	1	0.38)	0.46	0.178	1
C6	([0.39,0.48], [0.42,0.51];	0.78)	0.36	0.137	4	0.39)	0.36	0.137	4
C7	([0.34,0.45], [0.43,0.54];	0.78)	0.33	0.125	6	0.29)	0.33	0.129	5

According to Table 14 while Fama ratio (C5) was found as the most important criterion with the value of 0.178 for both r_{max} and $r_{arith.mean}$, M^2 ratio (C4) was obtained as the least essential one with the values of 0.122 and 0.123 for r_{max} and $r_{arith.mean}$ respectively. Besides while the ranking of criteria in terms of r_{max} is stated as C5>C2>C3>C6>C1>C7>C4, criteria ranking for $r_{arith.mean}$ is C5>C2>C3>C6>C7>C1>C4. As it can be seen from the ranking results of r_{max} and $r_{arith.mean}$, only the order of C1 and C7 changes.

After obtaining criteria weights for both r_{max} and $r_{arith.mean}$, sustainability funds as alternatives are ranked via *ERUNS* method. For that purpose firstly initial decision-making matrix for r_{max} is formed as Eq.(32) and presented in Table 15.

Table 15. Initial decision-making matrix

Fund Code	C1	C2	C3	C4	C5	C6	C7
AOY	-0.0366	-0.0275	-0.08	-0.0004	-0.0039	-0.0528	-0.0312
APG	0.1606	-0.5985	0.18	0.0038	-0.0001	0.2850	-0.6022
BHS	0.1996	0.0959	0.31	0.0046	0.0004	0.3471	0.0922
CVF	0.1134	-0.0688	0.10	0.0028	-0.0005	0.2180	-0.0725
DHM	0.1259	0.0510	0.16	0.0030	-0.0006	0.2047	0.0473
DLD	0.1590	0.1527	0.33	0.0037	-0.0003	0.2513	0.1490
DYN	0.1351	0.0378	0.19	0.0032	-0.0006	0.2281	0.0341
ESG	0.2947	0.0741	0.09	0.0066	0.0004	0.5910	0.0704
FVI	0.0800	0.0140	0.06	0.0021	-0.0010	0.1170	0.0104
GFH	0.1756	0.1246	0.31	0.0041	0.0000	0.2913	0.1210
GHH	0.2133	0.0960	0.27	0.0049	0.0005	0.3711	0.0923
GVA	0.1179	0.0855	0.14	0.0029	-0.0007	0.1992	0.0818
GZH	0.0379	0.0544	0.05	0.0012	-0.0021	0.0593	0.0508
GZR	0.1789	0.1643	0.37	0.0042	0.0001	0.2901	0.1606
GZV	0.1139	0.0443	0.11	0.0028	-0.0006	0.1995	0.0406
HMS	0.1795	0.4306	0.41	0.0042	0.0002	0.2922	0.4269
IFN	0.2011	0.1736	0.43	0.0046	0.0006	0.3280	0.1699
IKP	0.0478	0.0150	0.04	0.0014	-0.0013	0.0813	0.0113
IPJ	0.0604	0.0210	0.07	0.0016	-0.0016	0.0989	0.0174
IUT	0.1378	0.0995	0.17	0.0033	-0.0004	0.2371	0.0958
KSR	0.1953	0.0588	0.17	0.0045	0.0002	0.3689	0.0551
OLD	0.0517	0.0202	0.06	0.0015	-0.0018	0.0825	0.0166
RPC	0.1104	0.2554	0.15	0.0027	-0.0009	0.1829	0.2517
TJF	0.0578	0.0305	0.06	0.0016	-0.0014	0.0963	0.0268

VCY	0.0554	0.0239	0.07	0.0015	-0.0018	0.0881	0.0202
YJH	0.0088	0.0344	0.01	0.0005	-0.0024	0.0134	0.0307
YLE	0.1718	0.1714	0.38	0.0040	0.0000	0.2818	0.1677
YLO	0.1076	0.0469	0.13	0.0026	-0.0008	0.1784	0.0432
YPC	0.1620	0.1031	0.20	0.0038	-0.0001	0.2801	0.0995
ZHB	0.1796	0.2762	0.38	0.0042	0.0001	0.2886	0.2726

In order to apply the ERUNS method, the elements of initial decision-matrix for *ERUNS* method (X_{mxn}) need to be greater than zero $(x_{ij} > 0)$. Therefore, T-score transformation as specified in Eq. (46) will be used in this study.

$$e_{ij} = \frac{10(x_{ij}-\mu_j)}{\sigma_j} + 50 \tag{46}$$

According to Eq. (46) while μ_j denotes the arithmetic mean of the criterion j, and σ_j represents the standard deviation of criterion j (Aytekin, 2022). Obtained transformed decision matrix for r_{max} is given in Table 16.

Table 16. Transformed decision matrix

Fund Code	C1	C2	C3	C4	C5	C6	C7
AOY	26.9608	43.9986	30.8119	27.0395	18.2180	29.1944	43.9972
APG	54.8100	8.3683	50.1988	54.9914	55.7246	55.2811	8.3676
BHS	60.3177	51.6987	59.8923	60.3155	60.6597	60.0768	51.6972
CVF	48.1443	41.4215	44.2336	48.3362	51.7766	50.1070	41.4201
DHM	49.9096	48.8969	48.7075	49.6672	50.7896	49.0799	48.8955
DLD	54.5841	55.2430	61.3836	54.3258	53.7506	52.6786	55.2414
DYN	51.2088	48.0733	50.9444	50.9982	50.7896	50.8870	48.0718
ESG	73.7481	50.3384	43.4879	73.6259	60.6597	78.9121	50.3369
FVI	43.4274	46.5881	41.2510	43.6775	46.8415	42.3073	46.5930
GFH	56.9284	53.4896	59.8923	56.9879	56.7117	55.7677	53.4943
GHH	62.2525	51.7049	56.9097	62.3121	61.6467	61.9302	51.7034
GVA	48.7798	51.0497	47.2162	49.0017	49.8026	48.6552	51.0483
GZH	37.4819	49.1091	40.5053	37.6878	35.9843	37.8514	49.1139
GZR	57.3944	55.9668	64.3662	57.6534	57.6987	55.6750	55.9653
GZV	48.2149	48.4789	44.9792	48.3362	50.7896	48.6784	48.4774
HMS	57.4791	72.5839	67.3488	57.6534	58.6857	55.8372	72.5820
IFN	60.5296	56.5471	68.8401	60.3155	62.6338	58.6018	56.5456
IKP	38.8800	46.6505	39.7597	39.0189	43.8805	39.5503	46.6492
IPJ	40.6594	47.0249	41.9966	40.3499	40.9194	40.9095	47.0298
IUT	51.5901	51.9233	49.4531	51.6638	52.7636	51.5820	51.9218
KSR	59.7105	49.3837	49.4531	59.6500	58.6857	61.7603	49.3822
OLD	39.4308	46.9750	41.2510	39.6844	38.9454	39.6430	46.9799
RPC	47.7206	61.6514	47.9618	47.6706	47.8285	47.3964	61.6498
TJF	40.2923	47.6177	41.2510	40.3499	42.8934	40.7087	47.6163
VCY	39.9533	47.2059	41.9966	39.6844	38.9454	40.0755	47.2045
YJH	33.3723	47.8611	37.5227	33.0292	33.0233	34.3067	47.8597
YLE	56.3917	56.4099	65.1118	56.3224	56.7117	55.0340	56.4083
YLO	47.3252	48.6411	46.4705	47.0051	48.8155	47.0489	48.6397
YPC	55.0077	52.1480	51.6901	54.9914	55.7246	54.9027	52.1527
ZHB	57.4933	62.9493	65.1118	57.6534	57.6987	55.5591	62.9539

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In terms of standardizing the initial decision matrix X the interval is selected as $[1,100]$, i.e. $\alpha = 1$ and $\beta = 100$, according to the DMs' preferences. Following to that by applying the Eq.(33) the elements of MDM $X^N = [\varphi_{ij}]_{mxn}$ are derived. After that the elements of SDM Q=[ξ_ij]_mxn are obtained via Eq.(35). Then by considering k=1 and applying Eq.(36) WSDM is acquired.

Utility degrees of the alternatives in terms of the ideal and anti-ideal solutions are found via Eqs.(37 – 38). Then by utilizing the Eqs. (39 – 41) the utility function values and evaluation scores related to each alternative are computed respectively. Final calculations and ranking of alternatives by assuming $\delta = 0.5$ for r_{max} is exhibited in Table 17.

Table 17. Utility degrees, utility function values, evaluation scores and ranking of alternatives according to max

Alternative	U+	U-	f(U+)	f(U-)	Evaluation Score	Rank
AOY	0.1504	0.0389	0.7945	0.2054	0.1077	30
APG	0.2199	0.1188	0.6492	0.3507	0.1746	29
BHS	0.9727	0.2529	0.7936	0.2063	0.6967	3
CVF	0.9027	0.2498	0.7832	0.2167	0.6487	19
DHM	0.9194	0.2506	0.7858	0.2141	0.6601	15
DLD	0.9562	0.2522	0.7912	0.2087	0.6853	9
DYN	0.9307	0.2511	0.7575	0.2124	0.6678	14
ESG	0.9548	0.2521	0.7910	0.2089	0.6844	11
FVI	0.8515	0.2473	0.7749	0.2250	0.6138	21
GFH	0.9634	0.2525	0.7923	0.2076	0.6903	8
GHH	0.9729	0.2529	0.7936	0.2063	0.6969	2
GVA	0.9120	0.2503	0.7846	0.2153	0.6550	16
GZH	0.7801	0.2432	0.7623	0.2376	0.5654	27
GZR	0.9685	0.2527	0.7930	0.2069	0.6938	6
GZV	0.9034	0.2499	0.7833	0.2166	0.6492	18
HMS	0.9715	0.2528	0.7934	0.2065	0.6959	4
IFN	0.9792	0.2531	0.7945	0.2054	0.7012	1
IKP	0.8042	0.2447	0.7667	0.2332	0.5817	26
IPJ	0.8300	0.2461	0.7712	0.2287	0.5992	22
IUT	0.9307	0.2511	0.7875	0.2124	0.6679	13
KSR	0.9558	0.2522	0.7912	0.2087	0.6851	10
OLD	0.8124	0.2451	0.7681	0.2318	0.5873	25
RPC	0.9076	0.2500	0.7839	0.2160	0.6520	17
TJF	0.8263	0.2459	0.7706	0.2293	0.5966	23
VCY	0.8199	0.2456	0.7695	0.2304	0.5923	24
YJH	0.6781	0.2358	0.7419	0.2580	0.4969	28
YLE	0.9664	0.2526	0.7927	0.2072	0.6924	7
YLO	0.9008	0.2497	0.7829	0.2170	0.6474	20
YPC	0.9473	0.2518	0.7899	0.2100	0.6793	12
ZHB	0.9692	0.2527	0.7931	0.2068	0.6943	5

Table 17 shows that "IFN" is the best performer according to the ranking of alternatives in terms of r_{max}. This fund is followed by "GHH". "BHS" is the third highest ranked fund. On the contrary, AOY appears to be the worst performing fund. Similar calculations are made for $r_{arith.mean}$ and utility degrees, utility function values, evaluation scores and ranking of alternatives are shown in Table 18.

Table 18. Utility degrees, utility function values, evaluation scores and ranking of alternatives according to arith mean

Alternative	U+	U-	f(U+)	f(U-)	Evaluation Score	Rank
AOY	0.1511	0.0386	0.7962	0.2037	0.1081	30
APG	0.2179	0.1155	0.6535	0.3464	0.1722	29
BHS	0.9728	0.2503	0.7953	0.2046	0.6965	3
CVF	0.9034	0.2473	0.7850	0.2149	0.6488	19
DHM	0.9199	0.2481	0.7875	0.2124	0.6601	15
DLD	0.9562	0.2496	0.7929	0.2070	0.6850	10
DYN	0.9310	0.2485	0.7892	0.2107	0.6677	14
ESG	0.9557	0.2496	0.7928	0.2071	0.6847	11
FVI	0.8525	0.2448	0.7768	0.2231	0.6140	21
GFH	0.9635	0.2499	0.7940	0.2059	0.6901	8
GHH	0.9731	0.2503	0.7953	0.2046	0.6967	2
GVA	0.9125	0.2477	0.7864	0.2135	0.6550	16
GZH	0.7809	0.2407	0.7643	0.2356	0.5655	27
GZR	0.9685	0.2501	0.7947	0.2052	0.6935	6
GZV	0.9041	0.2473	0.7851	0.2148	0.6493	18
HMS	0.9715	0.2502	0.7951	0.2048	0.6956	4
IFN	0.9792	0.2505	0.7962	0.2037	0.7009	1
IKP	0.8052	0.2422	0.7687	0.2312	0.5819	26
IPJ	0.8308	0.2436	0.7732	0.2267	0.5993	22
IUT	0.9312	0.2486	0.7892	0.2107	0.6678	13
KSR	0.9563	0.2496	0.7929	0.2070	0.6851	9
OLD	0.8132	0.2427	0.7701	0.2298	0.5873	25
RPC	0.9081	0.2475	0.7857	0.2142	0.6520	17
TJF	0.8271	0.2434	0.7725	0.2274	0.5968	23
VCY	0.8206	0.2431	0.7714	0.2285	0.5924	24
YJH	0.6791	0.2335	0.7441	0.2558	0.4970	28
YLE	0.9664	0.2500	0.7944	0.2055	0.6920	7
YLO	0.9014	0.2472	0.7847	0.2152	0.6474	20
YPC	0.9477	0.2493	0.7917	0.2082	0.6792	12
ZHB	0.9692	0.2501	0.7948	0.2051	0.6940	5

r_{max} and $r_{arith.mean}$ showed similar ranking results. Fund with the best performance is "IFN". The second highest performer is "GHH" and the third best performance is displayed by "BHS". "AOY", again, found itself in the last place according to the ranking of alternatives in terms of $r_{arith.mean}$ and also the average fund return is less than the risk – free rate during the period under consideration.

In general, "IFN", "GHH" and "BHS" are among the top three in both r_{max} and $r_{arith.mean}$. Along with this, "HMS" and "ZHB" also perform well. On the other hand, "AOY" is by far the worst performer while "APG" and "YJH" had poor performances as well. Nonetheless, when we evaluate the performances of funds together with the latest portfolio allocation reports, our analysis yields striking findings. The compositions of various funds are given in Table 19.

Table 19. Compositions of good – performing and bad – performing funds

Fund Code	Equity	Foreign Equity	Mutual Fund Participation Share	Money Markets	Futures Cash Cover	Corporate Bill	Financial Bond	Foreign ETF
BHS	60,75%	24,76%	-	-	2,06%	4,02%	-	1,74%
GHH	52,25%	38,87%	-	7,32%	0,08%	-	-	-
HMS	91,95%	-	-	3,92%	4,13%	-	-	-
IFN	93,70%	-	-	3,00%	3,30%	-	-	-
AOY	-	96,57%	-	1,13%	-	-	-	-
APG*	3,85%	-	70,98%	-	3,02%	-	-	21,02%
IKP	10,07%	64,03%	-	-	2,00%	13,74%	8,12%	-
GZH	21,92%	43,75%	-	2,56%	4,62%	3,91%	-	20,12%
YJH	12,18%	65,24%	-	0,04%	-	16,85%	-	-
OLD	13,77%	6,19%	-	2,43%	-	-	-	72,16%

As of 31 December 2023. Percentages may not add to total 100 since all assets in the fund compositions are not listed in the table.

Source: TEFAS Portfolio Breakdown, https://fundturkey.com.tr/TarihselVeriler.aspx, (October 9, 2023)

Table 19 shows that funds such as "IFN" and "HMS" which perform better than the other funds and are ranked in the top decile invest heavily in domestic stocks. On the contrary, poor performing funds, especially "AOY", mainly hold foreign stocks or foreign ETFs in their portfolio compositions. In Table 5, the average returns of the top ranked funds are significantly higher than the funds ranked in the bottom quartile. Considering that Borsa Istanbul reached its historical peak and was in an uptrend during the time period under consideration, it is concluded that funds investing in domestic equities differentiated themselves from funds investing almost entirely in foreign equities, like "AOY", by providing high average returns. Therefore, when evaluating the findings of the present paper, it should be noted that the funds have such different portfolio compositions. The investment strategies for the funds are given in Table 20.

Table 20. Strategies of good – performing and bad – performing funds

Fund Code	Fund Strategy
BHS	At least 80% of the fund portfolio is continuously invested in the partnership shares in domestic/foreign sustainability indices, American Depository Receipts (ADR) and/or Global Depository Receipts (GDR).
GHH	At least 80% of the fund portfolio is continuously invested in the partnership shares in domestic/foreign sustainability indices.
HMS	At least 80% of the fund portfolio is continuously invested in the partnership shares in the BIST Sustainability index and the exchange-traded fund participation shares established to follow the BIST Sustainability Index.
IFN	At least 80% of the fund portfolio is continuously invested in the partnership shares in the BIST Sustainability index and the exchange-traded fund participation shares established to follow the BIST Sustainability Index.

AOY	At least 80% of the total fund worth is invested in American Depository Receipts (ADR), Global Depository Receipts (GDR), and stocks of the companies that are constantly operating in the field of new, developing, clean, renewable and sustainable energy that is included in the head of alternative energy.
APG	At least 80% of the fund portfolio is continuously invested in the participation shares of sustainability – themed investment funds and exchange-traded funds established to track ESG practices.
IKP	At least 80% of the Fund's total value is invested in shares of domestic/foreign renewable energy companies and/or bonds, American Depository Receipts (ADR) and/or Global Depository Receipts (GDR).
GZH	At least 80% of the fund portfolio is invested in domestic/foreign partnership shares, American Depository Receipts (ADR), Global Depository Receipts (GDR), debt instruments and lease certificates issued by companies operating as producers, developers, distributors and/or founders in clean, renewable, sustainable and/or alternative energy technologies.
YJH	At least 80% of the fund portfolio is invested in domestic/foreign partnership shares, American Depository Receipts (ADR), Global Depository Receipts (GDR), debt instruments and lease certificates issued by companies operating as producers, developers, distributors and/or founders in clean, renewable, sustainable and/or alternative energy technologies.
OLD	At least 80% of the fund portfolio is continuously invested in the domestic/foreign mutual fund participation shares and exchange-traded fund participation shares investing in clean energy and water themes.

Source: Public Disclosure Platform The Prospectuses of Funds https://www.kap.org.tr/en/YatirimFonlari (October 22, 2023).

The underperforming funds such as "GZH", "IKP", "OLD" and "YJH" consist of foreign stocks (shares of energy companies and especially green energy companies) and foreign ETFs and invest in the theme of environmental sustainability while high performing funds such as "IFN" and "HMS" adopt an investment strategy based on the BIST Sustainability Index, which includes 77 companies from a broad range of different sectors. As it is seen, although all funds in the study are defined and classified as "sustainability" funds by TEFAS, we determined that the fund compositions can vary considerably and some funds focus on "green energy" theme and some adopt "corporate sustainability" as the core theme. This reveals the fact that some Turkish sustainability funds do not pursue environmental sustainability which first comes to mind when the word "sustainability" is heard. Also, funds targeting environmental sustainability theme lag behind other funds in terms of performance and hence sustainability profiles of funds and whether they are truly sustainable or not become highly questionable.

So much so that the existence of Turkish sustainability funds which include shares of carbon – intensive companies and even enter into hedging transactions such as taking a long position in the USD/TRY currency with approximately 45% of the fund portfolio indicates the need to review the definition of sustainability funds and to make sub – categories. In this sense, it would be fruitful to examine the sustainability fund practices in the world.

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5. Sensitivity Analysis

In this paper, sensitivity analysis was carried out to examine the effect of the change in criterion weights on the alternative rankings obtained with both the maximum and arithmetic mean approaches.

Doğan (2021) suggested criteria weight in the range of 0-1 for a total of 11 different values, increasing by 0.1, and accordingly, all other criteria weights were changed proportionally to keep the sum of the weight vectors as 1. Accordingly, 77 scenarios were created separately for the maximum and arithmetic mean methods by taking into account 7 criteria.

The results of sensitivity analyses for both maximum and arithmetic mean approaches were presented in Fig. 2-8. Although both methods revealed similar rank changes for C1, BHS ranked second at point C1 = 0.1 for the maximum approach. On the other hand, as C1 increases, the ones that increased the most were ESG and APG, rising to 1st and 12th, respectively. The results of the sensitivity analysis for C2 showed that the DLD and KSR swaps, which do not occur at the maximum, are seen in the arithmetic mean, but as C2 increases, no dramatic increases or decreases were observed, and only for high C2 values, HMS came to the fore. Both methods reveal similar rank changes for the change of C3 value. On the other hand, as C3 increased, KPI increased the most in the rankings, while ESG decreased the most. The sensitivity analysis results for C4 indicated that CVF and YLO changes, which did not occur in the arithmetic mean, were seen at the maximum. Meanwhile, as C4 increases, the ones that increased the most were ESG and APG, rising to 1st and 11th, respectively. In C5 value changes, the increase of ESG was observed faster in the arithmetic mean approach, while APG was the alternative with the highest increase in C5 increase in both methods. For C6, while BHS decreased more slowly at maximum approach, KSR increased faster. ESG and KPG provided the highest increase at C6. While IUT and DNY exchanged their places in the maximum approach and DLD and KSR in the arithmetic mean approach, RPC was the alternative that was most positively affected by the C7 increase.

While the most common alternative rank changes were observed with C3, C6 and C4 criterion changes, respectively, for generally acceptable criterion importance values (between 0.1 and 0.2), close to this range, ESG can only come to the top when C3 = 0. At the extreme values of the criteria, except for C2 and C7, APG climbs to the middle ranks, while ESG comes to the fore except for C3 and C5.

In sensitivity analysis, it is normal to observe changes in the rankings at the extremes of the weight values. However, the rankings changes at a very limited level in the problem within the acceptable range changes of the criteria revealed that the robust level of the proposed approach is sufficient for the criteria weights. Therefore, the weights of the criteria obtained with the proposed approach have a high degree of stability.

Figure 2. Re-ranking of alternatives according to importance changes on C1 for both of the approaches

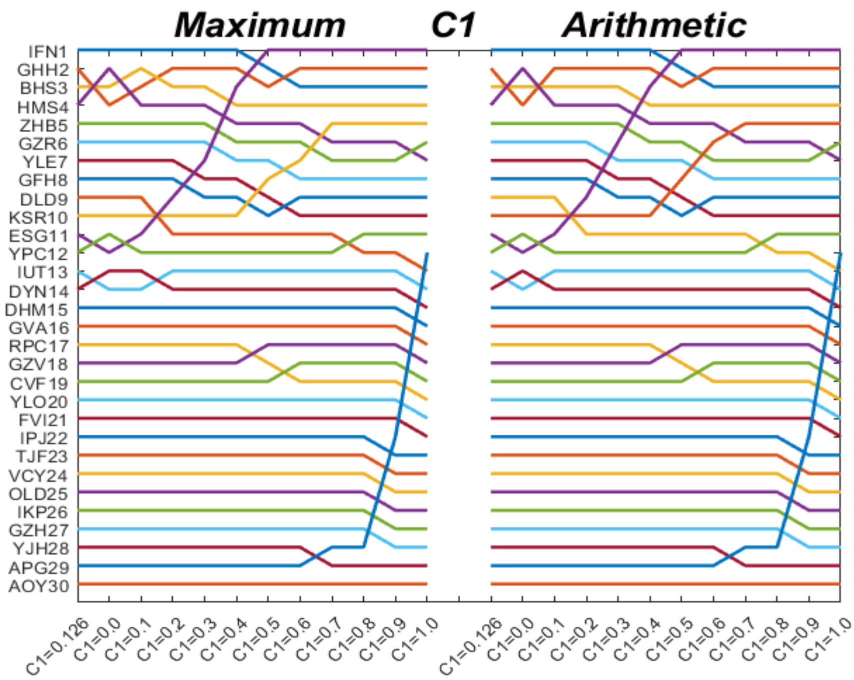

Figure 3. Re-ranking of alternatives according to importance changes on C2 for both of the approaches

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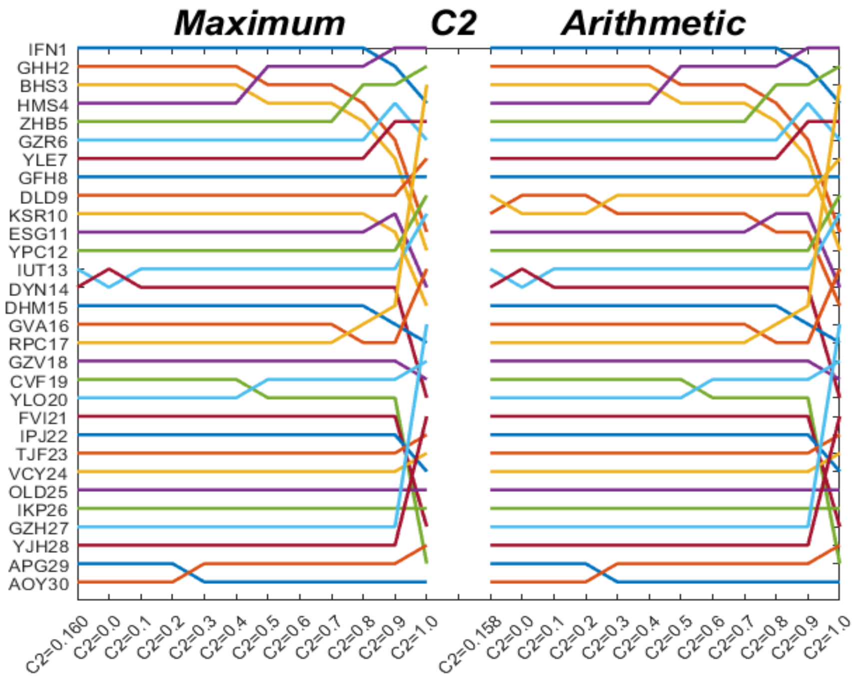


Figure 4. Re-ranking of alternatives according to importance changes on C3 for both of the approaches

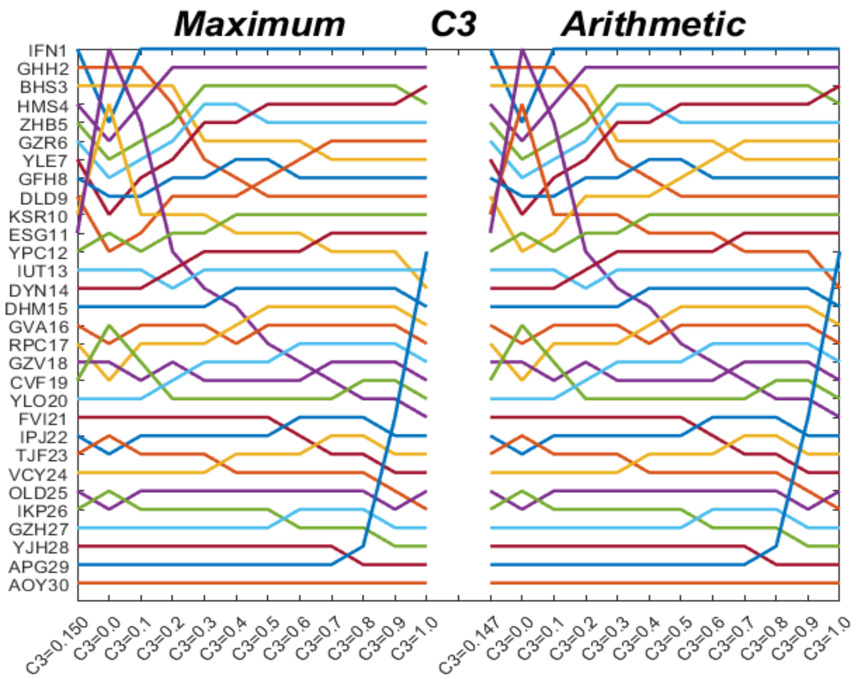


Figure 5. Re-ranking of alternatives according to importance changes on C4 for both of the approaches

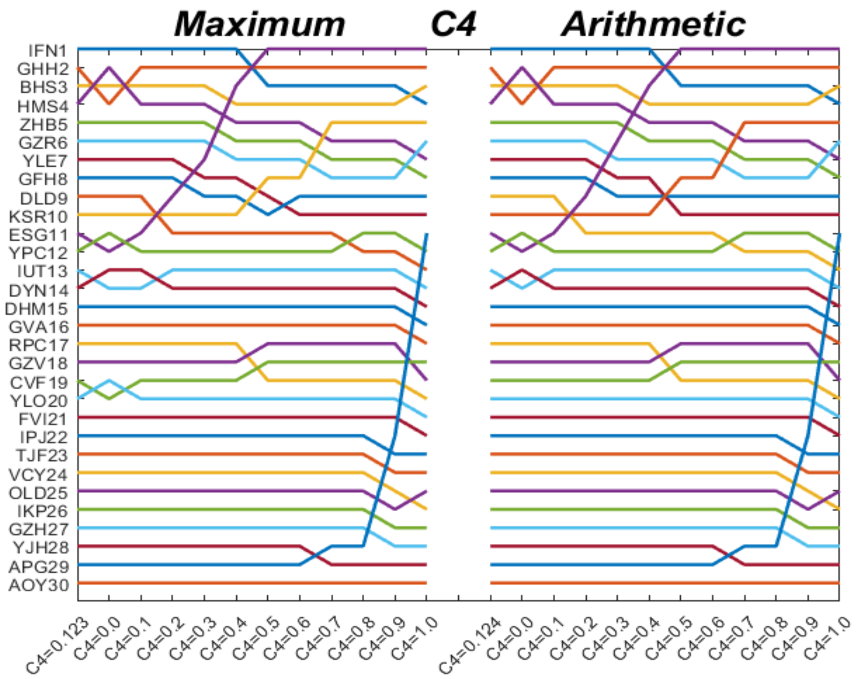


Figure 6. Re-ranking of alternatives according to importance changes on C5 for both of the approaches

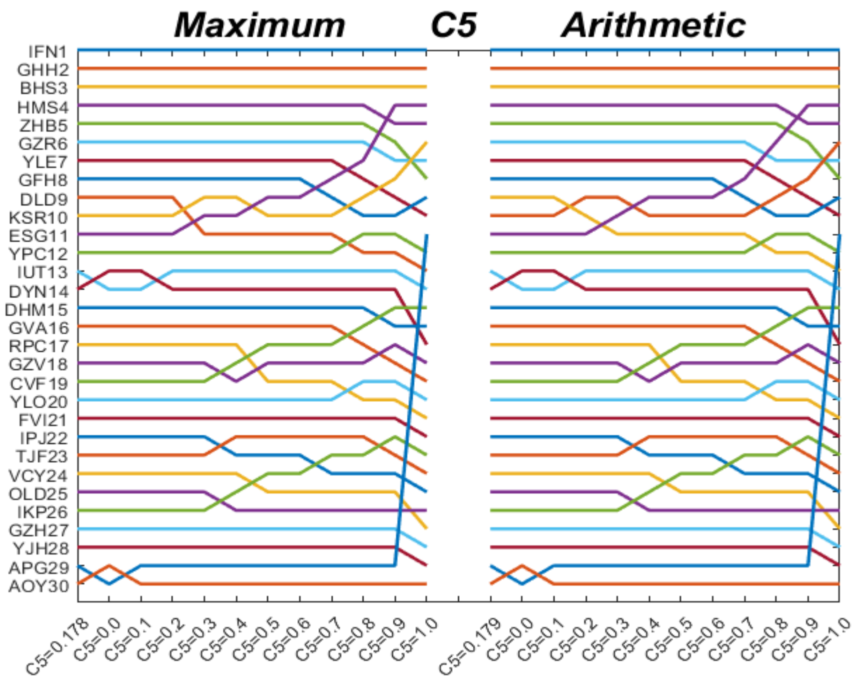


Figure 7. Re-ranking of alternatives according to importance changes on C6 for both of the approaches

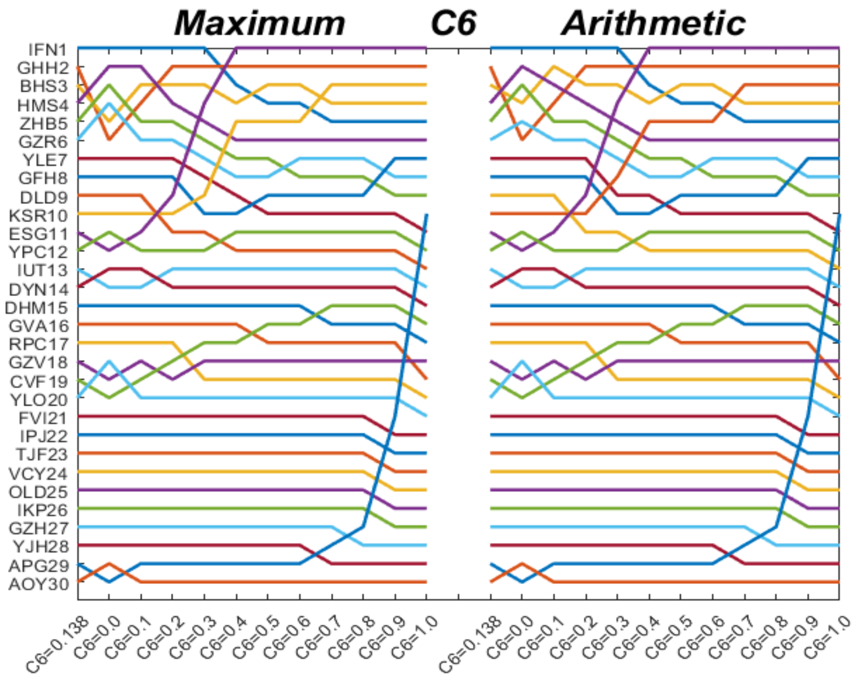
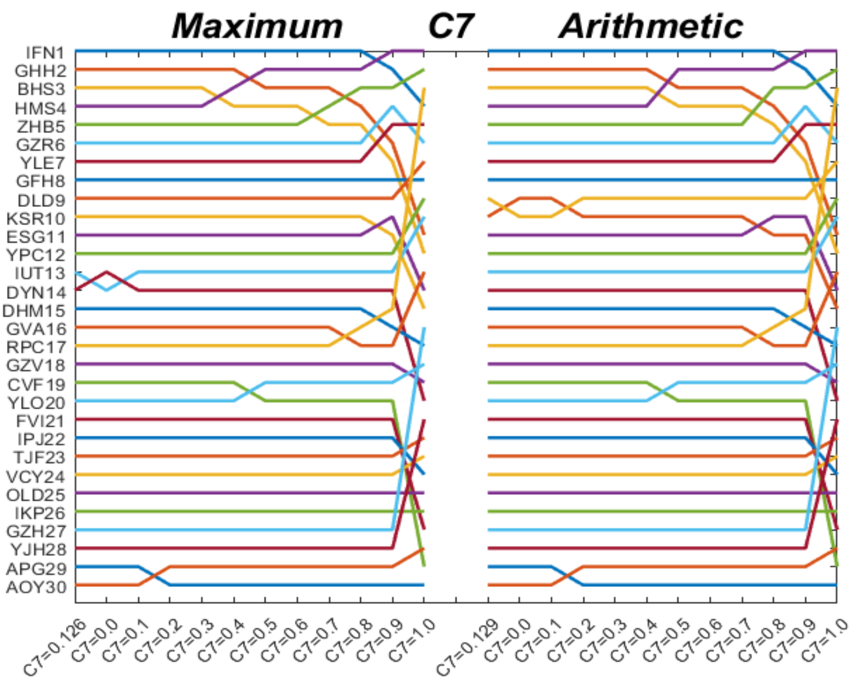


Figure 8. Re-ranking of alternatives according to importance changes on C7 for both of the approaches



6. Comparison Analysis

The comparison analysis needs to be made to test the validity and reliability of the decision models. For that aim, the ranking results of the IVCIF AHP-ERUNS method and other MCDM methods consisting of CoCoSo, MARCOS, ARAS, WASPAS, and AROMAN were considered in this study and the analysis results were evaluated according to the Spearman's rank correlation coefficient values in terms of max and arith mean. The results of the comparison analyses for max and arith mean are presented in Tables 21 and 22, respectively.

Table 21. Spearman's rank correlation coefficient values for max

Methods	ERUNS	CoCoSo	MARCOS	ARAS	WASPAS	AROMAN
ERUNS	1.000					
CoCoSo	0.973	1.000				
MARCOS	0.969	0.998	1.000			
ARAS	0.964	0.998	0.999	1.000		
WASPAS	0.972	0.999	0.998	0.998	1.000	
AROMAN	0.961	0.991	0.992	0.992	0.987	1.000

Table 22. Spearman's rank correlation coefficient values for arith mean

Methods	ERUNS	CoCoSo	MARCOS	ARAS	WASPAS	AROMAN
ERUNS	1.000					
CoCoSo	0.973	1.000				
MARCOS	0.968	0.998	1.000			
ARAS	0.965	0.998	0.999	1.000		
WASPAS	0.971	0.998	0.998	0.998	1.000	
AROMAN	0.961	0.991	0.992	0.989	0.987	1.000

According to the Tables 21 and 22, the obtained Spearman's rank correlation coefficient values are high (close to 1) for both max and arith mean. The result obtained via IVCIF AHP-ERUNS method is comparable and maintains statistically significant correlation with others. Additionally, the proposed model is valid and applicable.

7. Conclusion

Socially responsible mutual funds, or sustainability funds as they are called in Turkey, emerged as financial instruments that are different from conventional funds since they consider ethical, environmental and social objectives as well as financial objectives. In particular, the increase in the number of investors willing to involve in ethical, social and environmental – based investments have enabled the growth of socially responsible investments worldwide. These types of funds are the subject of international academic research with their different risk – return profiles. Since they also consider non – financial aspects, one can argue that sustainability funds do not have acceptable levels of return performance. The main reason for this situation is that sustainability funds target similar themes and therefore cannot provide significant diversification benefits (Renneboog et al., 2008). Contrary to this, some suggests that these funds generate higher performance in the long – run with better reputation management activities (Fernández et al., 2019).

We computed daily returns and evaluated the performances of 30 Turkish sustainability funds. We, adopting IVCIF AHP-ERUNS method, found out that "IFN", "GHH", "HMS", "ZHB" and "BHS" are the best – performing funds and "IFN" appears at the top of a list in both r_{max} and $r_{arith.mean}$. The worst performers are "AOY" (which ranked last), "APG", "GZH" and "YJH". Results also documented that Fama ratio (C5) is the most important one among all criteria. Fama ratio is followed by Treynor (C2) and Jensen (C3). M^2 (C4) criteria, on the other side, seems to be the least important. To explore the influence of criteria weight changes, we ran sensitivity analysis following the approach suggested by Doğan (2021) and observed that the criteria weights obtained by applying the proposed procedure yielded a high degree of stability. Lastly, we employed comparison anaylsis in order to test the validity and reliability of the model and reported that the results of IVCIF AHP-ERUNS are comparable and significantly correlated with all other MCDM methods. We therefore claim that the proposed model is valid and applicable for comparison.

When we examine the performance rankings of funds along with fund compositions, we discovered that the best performers include predominantly domestic stocks and assets. Turkish sustainability funds that hold mainly foreign equities and foreign ETFs remain near the bottom of the rankings. The period between August 2022 and October 2023 is one of the periods of high inflation in Turkey. Considering the impact of inflation on capital markets, sustainability funds that consist of domestic securities achieved higher performance than the others. The best performers invest in assets like those in the composition of conventional funds and so abovementioned funds outperform other funds including foreign securities in the fund composition. Sustainability funds holding shares of domestic and foreign companies that operate in alternative energy or green energy sector lagged in terms of performance and even the average return of "AOY" were negative during the study period. In this vein, our findings are in line with prior studies emphasizing that the funds called "green funds" or "alternative energy funds" have worse performance than conventional or other sustainability funds (social responsibility funds, corporate governance funds) (Chang et al., 2012; Ibikunle and Steffen, 2017; Reboredo et al., 2017; Ielasi et al., 2018). Additionally, based on the above findings, we argue that the regulatory bodies in Turkey should review the definition of sustainability indices and funds by pursuing global sustainability index practices and create new categories or sub – categories.

Building on these findings, considering emerging behavioral patterns of investors toward sustainability themed funds we strongly point out the requirement for information mechanisms, transparency and standardization in these assets. Overall, one can conclude that from our results, supporting financial literacy, strengthening the implementation of ESG criteria, and reinforcing the credibility of green assets should be prioritized to foster the development of capital markets.

The results of the current study provided important insights into the performance of sustainability funds and also shed light on the factors that cause performance differences. We offer some recommendations for further research. It may be possible to compare the performances of environmental sustainability funds and carbon – intensive funds traded in Turkey. Moreover, fund performances can be reviewed using different asset pricing models that have an ability to explain various risk factors. Finally, we suggest investigating the time – varying fund performances or the main determinant of fund returns.

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