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Տնտեսագիտություն

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WCDM METHOD ASSIGN WEIGHTS OF CRITERIA BY DECISION MATRIX: EVIDENCE OF TEHRAN STOCK EXCHANGE

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ՆՇԱՆԱԿԵՔ ՉԱՓՈՐՈՇԻՉՆԵՐԻ ԿՇԻՌՆԵՐԸ ՈՐՈՇՄԱՆ ՄԱՏՐԻՑՈՎ (WCDM). ԹԵՀՐԱՆԻ ՖՈՆԴԱՅԻՆ ԲՈՐՍԱՅԻ ԱՊԱՑՈՒՅՑ

MCDM խնդիրը մի շարք այլընտրանքներ է, որոնք գնահատվում են մի քանի չափանիշների համաձայն՝ լավագույն այլընտրանք(ներ)ը ընտրելու համար. Այդ նպատակով չափանիշների կշիռը որոշելը MCDM մեթոդների կիրառման կարևոր նյութերից մեկն է. Նախևառաջ, չափանիշները բացահայտվում են որոշում կայացնողի կողմից, այնուհետև զույգ-զույգ համեմատությունները չափորոշիչների և այլընտրանքների միջև են, որոնք կառուցում են որոշումների մատրիցը. Տարբեր չափանիշների նկատմամբ այլընտրանքների կշիռները ստացվում են MCDM մեթոդներից մեկի կիրառմամբ. TOPSIS-ը զույգ համեմատության վրա հիմնված մեթոդ է այլընտրանքներին կշիռը բաշխելու համար. Համաձայն TOPSIS մեթոդի, լավագույն այլընտրանքն է՝ ելնելով դրանց քաշից.

Այս հետազոտությունն առաջարկում է WCDM մեթոդը որպես նոր մեթոդ՝ MCDM խնդիրներում օգտագործվող չափանիշներին կշիռ տալու համար. Արդյունքները ստացվել են Թեհրանի ֆոնդային բորսայում ցուցակված ընկերությունների իրական նմուշից. Այս հետազոտության որոշման մատրիցը բաղկացած էր տարբեր ոլորտների քսան ընկերություններից և երեք չափանիշներից՝ վերադարձը, հուսալիությունը և ռիսկը. TOPSIS-ը որպես MCDM մեթոդ ընտրված է WCDM-ի Shannon-ի հետ համեմատելու համար. երկարաժամկետ հեռանկարում այն ավելի լավ է գործում.

Բանալի բառեր՝ *Պորտֆոլիո, MCDM, չափանիշներ, Shannon, TOPSIS, որոշումների մատրիցա*

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ПРИСВОЕНИЕ ВЕСОВ КРИТЕРИЯМ ПО МАТРИЦЕ РЕШЕНИЙ (WCDM): ДАННЫЕ ТЕГЕРАНСКОЙ ФОНДОВОЙ БИРЖИ

Проблема MCDM представляет собой ряд альтернатив, которые оцениваются по нескольким критериям для выбора наилучшей альтернативы (альтернатив). С этой целью определение веса критериев является одним из важных материалов для использования методов MCDM. Прежде всего, лицо, принимающее решение, определяет критерии, а затем проводится парное сравнение между критериями и альтернативами, которые составляют матрицу решений. Веса альтернатив по разным критериям получаются с помощью одного из методов MCDM. TOPSIS — это основанный на парных сравнениях метод присвоения веса альтернативам. По методу TOPSIS выделяется лучшая альтернатива на основе их веса.

Это исследование предлагает метод WCDM в качестве нового метода для придания веса критериям, используемым в задачах MCDM. Результаты получены из реальной выборки компаний, котирующихся на Тегеранской фондовой бирже. Матрица решений в этом исследовании состояла из двадцати компаний из разных отраслей и трех критериев доходности, надежности и риска. TOPSIS в качестве метода MCDM выбран для сравнения WCDM с Shannon. Эффективность WCDM на Тегеранской фондовой бирже такая же, как у Entropy Shannon при тех же условиях; он работает еще лучше в долгосрочной перспективе.

Ключевые слова: *Портфолио, MCDM, Критерии, Шеннон, TOPSIS, Матрица решений.*

An MCDM problem is a number of alternatives that are evaluated with respect to several criteria to select the best alternative(s). For this purpose, determining the weight of criteria is one of the important materials for using MCDM methods. First of all, criteria are identified by the decision-maker then pairwise comparisons are between criteria and alternatives that construct the decision matrix. The weights of the alternatives with respect to different criteria are obtained by using one of the MCDM methods. TOPSIS is a pairwise comparison-based method for allocating weight to alternatives. According to the TOPSIS method, the best alternative based on their weight is allocated.

This research proposes the WCDM method as a new method to give weight to criteria used in MCDM problems. The results are obtained from a real-world sample from companies listed on Tehran Stock Exchange. The decision matrix in this study consisted of twenty companies from different industries and three criteria Return, Reliability, and Risk. TOPSIS as an MCDM method is selected to compare WCDM with Shannon The efficiency of the WCDM in the Tehran Stock Exchange is the same as Entropy Shannon under the same conditions; it performs even better in the long term.

Key words: *Portfolio, MCDM, Criteria, Shannon, TOPSIS, Decision Matrix*

1. Introduction

The relative weights of the criteria are necessary for the issue solution process when dealing with multi-criteria decision-making challenges. The methods LINMAP, least squares, specific vector techniques, Shannon entropy, CRITIC method, and others can be mentioned as the techniques for figuring out the weights of the criterion.

Making decisions usually involves some factors and possibilities. In making decisions, all factors are not equally important. In these situations, it is vital to determine the weight or coefficient of the relevance of each factor in the decision-making process. Each criterion's relative weight is determined by how it is important to other criteria. Reaching the targeted objective will be greatly aided by the thoughtful and appropriate selection of weights of criteria. For this purpose, it will be useful to utilize WCDM for weighing criteria. The following three techniques each have a different way of weighing the criteria [Odu 1449]:

1.Applying specialist knowledge

The right criteria are identified and weighed using this technique, which also considers the features of the research area and the expertise and knowledge of subject-matter specialists. This method's simplicity and documentation are two benefits. However, this approach has drawbacks, including the risk of the expert estimating the weight incorrectly and the challenge of harmonizing their mental units of measurement. By using a range or percentage, professionals may gauge the significance of several aspects.

2.Making use of data expertise

Data knowledge depends on the information that may be used to solve the issue. The weight of each element may be calculated using this technique by taking the answers to the issue and estimating the degree to which each factor depends on the solution. The likelihood of error is lower when using the data knowledge approach, but the quality of the initial replies determines how well it performs.

3.Combining data and professional knowledge

Weight is assigned to each criterion in this technique by the findings of the expertise and experience of specialists and the usage of the available information. In this manner, the weights are first individually computed using expertise and expert data, and the desired weight is decided by comparing the results. As a result, there is a lower chance of error, and the weights are more accurate.

A crucial area of decision-making theory is multi-criteria decision-making (MCDM). Regarding the problem's solution space, MCDM issues are often split into two categories: Multi-Attribute Decision Making (MADM) and Multi-Objective Decision Making (MODM). The typical matrix representation of an MCDM issue is as follows:

$$DM = \begin{array}{c} A_i \\ A1 \\ \vdots \\ Am \end{array} \begin{array}{c} \begin{array}{ccc} C1 & \dots & Cn \end{array} \\ \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix} \end{array} \qquad (1)$$

Aij is the score of alternative ***i*** in relation to criterion ***j***, where ***A1, A2,..., Am*** is a collection of workable alternatives, ***C1, C2,..., Cn*** is a set of decision-making criteria. The objective is to choose the best overall value alternative, such as the most desired or significant alternative.

There are several ways to determine the total worth of the alternative ***i***. The basic model for the majority of MCDM approaches, the simple additive weighted value function [Keeney et al. 403], may be used to calculate ***Vi*** in a general form as follows:

$$V_i = \sum_{j=1}^{n} w_j \, a_{ij} \qquad (2)$$

How the weights of the criteria or vectors ***w = w1, w2,..., wn*** are produced is crucial and has served as the inspiration for the launch of numerous MCDM systems over the past several decades. Several MCDM techniques have been put out in recent years, with AHP being the most well-liked (Analytic Hierarchy Process, ANP(Analytic Network Process), TOPSIS(Technique for Order of Preference by Similarity to Ideal Solution), ELECTRE (Elimination Et Choix Traduisant la REalité), VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), and PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations), also can cite to some recent developments in the study and comparison of different MCDM methods like the SIR method (superiority and inferiority ranking), SWARA (step-wise weight assessment ratio analysis), multi-attribute evaluation using imprecise weight estimates (IMP), and subjective weighting method using continuous interval scale [Hasan et al. 15-29]. Some methods like TOPSIS need the weight of criteria. For this purpose, some methods like SWARA, SHANNON, BWM, and AHP can compute the weight of the criteria.

<u>This paper proposes a new method called WCDM for computing the weight of criteria. The remainder of this paper is organized as follows. Section two is methodology. In section three, a new method (WCDM) is proposed, the WCDM is applied to a real-world problem, and it is comprehensively compared to the ENTROPY</u>

SHANNON considering several evaluation criteria. Section four explains the scientific novelty of the research. Section five illustrates the result of the real-world problem and compares WCDM and SHANNON and uses weights of criteria obtained from them in the TOPSIS method to find the weight of alternatives and the result of portfolios. The conclusions and suggestions for future research are represented in section six.

2. Methodology

This section includes of Research type, Sources, Variables, Tools and Assumptions
.

2.1 Type of research

The current study is a hybrid of the two types of research Basic and Applied because its goal is to develop knowledge and apply it in the present.

2.2 Statistical population

The statistical population of this research is all companies listed on the Tehran Stock Exchange. Because it is very difficult to conduct a study on all companies, even though the results are more realistic, some companies working in different industries have been selected as a sample.

2.3 Sources of data collection

All information in this study is obtained through the financial journals and sites of the Tehran Stock Exchange .

2.4 Variables

The independent variables of the study consist of the return, reliability and risk of companies. These are the criteria of the decision matrix that are used in the WCDM, Shannon and TOPSIS methods.

2.5 Tools

Microsoft Excel is used as the software.

2.6 Assumptions

· Buy stocks of each company on the first of the year and sell them at the end of the year.

· The daily stock price of companies that are used to calculate criteria include capital increment, DPS and transaction commission.

· The beginning of the year in the solar calendar is from March 21. For example, the solar year 1395 is equivalent to March 21, 2016

· Annual interest on bank deposits is assumed 20 percent.

3. Literature review

In today's corporate activity, decision-making is crucial. Making a choice requires taking into account a variety of factors, many of which may be at odds with one another.

The Entropy Shannon was selected to compare with the WCDM method. Step-by-step of the WCDM process is covered in the first section. This study uses some strategies and techniques to weight criteria in WCDM. The three basic techniques used for calculating the weight of criteria and alternatives in this research are WCDM, Shannon, and TOPSIS.

3.1 Criteria

This section describes the criteria utilized in this study. Return, Reliability, and Risk are the criterion employed.

Return

The return is the most significant idea in investment decision-making. Each share or portfolio of shares provides a particular return to the holder if purchased, held, and sold at a specified distance from the moment of acquisition. This return reflects price fluctuations as well as ownership advantages.

We need a metric of the return on investment to evaluate investments effectively. Most financial studies utilize asset returns rather than prices [Beattie 1].

$$Percentage\ of\ \ Stock\ Return = \frac{last\ trading\ day\ \ -\ first\ trading\ day\ of\ the\ year}{Share\ price\ on\ the\ first\ trading\ day\ of\ the\ year} \times 100 \quad (3)$$

Reliability

Reliability engineering is a branch of systems engineering that focuses on the capacity of the equipment to operate without failure. The capacity of a system or component to work under defined conditions for a certain amount of time is referred to as reliability. The capacity of a component or system to work at a specific moment or interval of time is commonly referred to as reliability.

The Reliability function, abbreviated R, is theoretically defined as the likelihood of success at time ***t***. This likelihood is evaluated using comprehensive analysis, past data sets, or reliability testing and modelling. In reliability projects, availability, testability, maintainability, and maintenance are frequently characterized as components of "reliability engineering." The cost-effectiveness of systems is frequently determined by reliability.

The majority of the methodologies used to determine dependability criteria are employed in a variety of sciences. This study employs the following methodology [Jahan Biglari 282]:

$$MDF = \frac{\sum(Fail\ days)}{total\ number\ of\ trading\ days} \quad (4)$$

Risk

Risk denotes future uncertainty regarding earnings or results deviating from expectations. Risk quantifies the degree of uncertainty an investor is willing to accept to profit from an investment. Risks come in many forms and occur in various settings.

The beta (or market beta or beta coefficient) in finance is a measure of how an individual asset moves (on average) when the entire stock market rises or falls. As a result, beta is also known as an asset's systematic risk or market risk. Beta is not a measure of individual risk. The beta equation is as follows:

$$\beta = \frac{Cov(r_p, r_b)}{Var(r_b)} \quad (5)$$

$\boldsymbol{r_b}$ is the return of the market and $\boldsymbol{r_p}$ is the company's return [Kenton 1].

3.2 Shannon Entropy

One of the multi-criteria decision-making strategies for estimating the weight of criterion is the entropy method. A criterion-option matrix is required for this approach. Shannon and Weaver suggested this approach in 1974. The level of uncertainty in a continuous probability distribution is expressed by entropy. The primary assumption behind this strategy is that the greater the spread in the values of a criterion, the more significant the criterion [Hosseinzadeh Lotfi , F and Fallahnejad 55].

Shannon demonstrated that high-probability occurrences yield less information, but low-probability events provide more information. Uncertainties are decreased when new information is acquired, and the value of new knowledge is proportional to the degree of uncertainty eliminated. As a result, uncertainty and information are inextricably linked characteristics [Azar 8].

3.3 TOPSIS

The TOPSIS technique rates alternatives using a multi-criteria decision-making (MADM) process. The terms "perfect solution" and "near to ideal solution" are employed in this procedure. The best possible answer in every aspect seldom exists in practice; thus, the ideal solution strives to get as near as possible. The distance of an alternative (or choice) between a positive ideal and a negative ideal solution is assessed to assess how similar they are to one another. The alternatives are then weighed and ranked according to the negative ideal solution's distance to the overall distance between the positive ideal and negative ideal solutions.

TOPSIS sees a MADM issue with m alternatives as a geometric system with m points in the next n spaces. The approach is based on the assumption that the alternative should be closest to the perfect solution in terms of distance, and the furthest from the worst ideal solution in terms of distance. Similarity with a positive-ideal solution and avoidance of a negative-ideal solution are indicators according to TOPSIS. The alternative approach with the greatest resemblance to the perfect solution is then chosen [Pavić and Novoselac 5-12].

The alternative receives a better score if it resembles the perfect answer. We attempt to approach the ideal answer, which is virtually perfect in all respects but does not exist. We take into account the distance of an alternative from the ideal and non-ideal solution to gauge how comparable an alternative is to an ideal and non-ideal level. The method's fundamental presumptions are:

· Every criterion should be equally desirable, either more or less desirable. In other words, increasing the value of a criterion always makes it more desirable, whether qualitative or quantitative. The best value that is now accessible must be evenly declining or growing for the greatest value to be deemed ideal and the worst value to be deemed anti-ideal.

· The criteria should be created such that they are distinct from one another (being independent means the absence of internal relations).

· The alternatives' distances from the ideal and anti-ideal solutions are measured using the Euclidean distance formula since the exchange rate between the criteria is often a number other than one.

3.4 Assigning weights of criteria by decision matrix (WCDM)

Suppose we have *n* criteria and *m* alternatives. We want to construct a decision matrix of these criteria and alternatives. If $\boldsymbol{a_{ij}}$ is quantity, use numbers without any changes. The resulting matrix would be:

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix} \qquad (6)$$

Where $\boldsymbol{a_{ij}}$ is a relative preference of alternative with criterion $\boldsymbol{j}$ *th*

The figure below shows companies as a vector in three dimensions *Return*, *Reliability*, and *Risk*. These dimensions are the criteria used in the research.

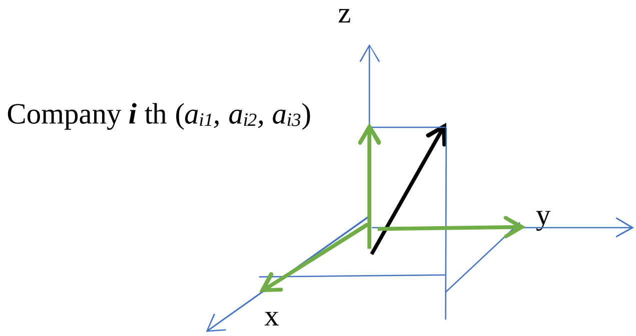


Figure 1. Shows Companies as a vector in three dimensions (Return, Reliability, and Risk)

This part explains the process of the WCDM method in seven steps as follows:

Step1. Normalize decision matrix with Rumina method

There are several positive (benefit) and negative (loss) criteria. Rumina approach is a normalization technique that has been suggested in this sector. Divide each criterion's value for positive criteria by the greatest value for that criterion. In negative direction criteria, the values of each criterion are divided by the least value of the criterion [Habibi 1].

$$n_{ij} = \begin{cases} \dfrac{a_{ij}}{max\ a_{ij}}, & C_j > 0 \\ \dfrac{min\ a_{ij}}{a_{ij}}, & C_j < 0 \end{cases} \qquad (7)$$

Step2. Construct a non-scale matrix with the linear sum method

The computation of eigenvectors is a straightforward Saaty normalization technique. In this strategy, dividing each integer in a set by the total number of its components suffices. After normalization, the total number of elements in this scenario will equal one [Vafaei, Nazanin and Ribeiro, Rita A. and Camarinha-Matos 264-265].

$$n_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \qquad (8)$$

Step3. Find the maximum and minimum rows value of the matrix

This step computes the maximum and minimum of the matrix obtained from the previous step**.**

Step4. Give a score to columns: Count the number of ones on each column

To give grades to criteria, find the number of times each criterion has the best value (number one is the best value) for alternatives. In a simple word, count the number of ***1*** for each column. The sum of number ***1*** of each column is equal to the number of alternatives. The same way must be done for the worst value.

MAXIMUM			***MINIMUM***		
C1	*C2*	*C3*	*C1*	*C2*	*C3*
Sum of One	*Sum of One*	*Sum of One*	*Sum of One*	*Sum of One*	*Sum of One*

Step5. Calculate coefficient

Calculate the distance between the best and the worst for each column.

n_j = (Number of best -Number of worst)		
$n_1 = C1_{best} - C1_{worst}$	$n_2 = C2_{best} - C2_{worst}$	$n_3 = C3_{best} - C3_{worst}$

Step6. ***Find the unit of weight***

First, compute the minimum distance between the best and worst that was obtained in the previous step, then calculate the distance between them with minimum call it $\boldsymbol{d_j}$. Now must find the unit weight for criteria $\boldsymbol{w}$ by equation $w = 100/\sum_{j=1}^{n} a_j$ where $\boldsymbol{n}$ is number of criteria.

Tip. If $\boldsymbol{d_j = d_{min}}$ then the coefficient of the weakest criteria is zero it will be removed.

Min n_j	n_{min}		
d_j = Distance n_{min} to other	$n_1 - n_{min}$	$n_2 - n_{min}$	$n_3 - n_{min}$
Coefficient	$a_1 = d_{min=0}$	$a_2 = d_2$	$a_3 = d_3$
w is the unit weight of criteria	$w = 100/\sum_{j=1}^{n} a_j$		

Step7. ***Weight of criteria:*** Multiple units of weight to the coefficient

Coefficient	a_1	a_2	a_3
w is unit of weight	w		
Weight of criteria	$C_1 = a_1 \times w$	$C_2 = a_2 \times w$	$C_2 = a_3 \times w$

3.5. Compute return of a portfolio

The return of a portfolio is defined by the formula (9) in the table below:

$$Portfolio\ return = \sum_{i=1}^{m} w_i r_i \qquad (9)$$

The return of each alternative is $\boldsymbol{r_i}$, the weight of each alternative in the portfolio is $\boldsymbol{w_i}$, and the number of alternatives is $\boldsymbol{m}$ [Esajian 1].

3.6 A real-world example

This section demonstrates WCDM through a real-world example. This paper uses an example to demonstrate the process in the real world. We applied this approach on the Tehran Stock Exchange for twenty businesses to determine the true price of each trading day with capital augmentation, DPS, and trading fees. The choice matrix contained twenty firms as options, as well as three criteria consisting of return, reliability, and risk.

As an example, this decision matrix was made from values from earlier portions for the year 1397. The table below pertains to 1397 (2018 to 2019), and it is used to explain the WCDM method.

Table 1. The Sample of a Decision Matrix

DECISION MATRIX							
1397	***Return***	***Reliability***	***RISK***	***Company***	***Return***	***Reliability***	***RISK***
Iran Mineral P.	*55.86*	*0.39*	*-0.68*	*Sobhan Pharm.*	*-4.78*	*1.00*	*1.07*
Behbahan Cement	*-12.66*	*0.97*	*-0.61*	*Iran Mobil Tele*	*30.11*	*0.50*	*0.57*
Dadeh pardazi Iran co	*15.86*	*0.24*	*1.28*	*Chadormalu*	*31.69*	*0.71*	*1.08*
Fanavaran Petr.	*54.68*	*0.59*	*0.07*	*Iran Khodro*	*0.75*	*1.00*	*1.56*
*S*North Drilling*	*-48.54*	*1.00*	*0.18*	*Khouz. Steel*	*57.45*	*0.31*	*1.14*
*S*IRI Marine Co.*	*-1.46*	*1.00*	*0.60*	*S*I. N. C. Ind.*	*65.43*	*0.50*	*0.76*
Butane Group	*49.16*	*0.81*	*0.77*	*Azar Refract.*	*-39.06*	*0.84*	*-0.41*
Shahroud Sugar	*5.87*	*0.13*	*2.08*	*S*Tehran Const.*	*-26.38*	*1.00*	*-1.26*
Yazd Jooshkab	*6.66*	*0.31*	*0.80*	*MAPNA*	*-11.28*	*1.00*	*0.84*
Sahand Rubber	*7.72*	*0.29*	*1.02*	*S*Mellat Bank*	*-10.53*	*1.00*	*0.39*

1397	***Return***	***Reliability***	***RISK***
Max Or Min of Criteria	*65.43*	*0.13*	*2.08*

In this stage, the WCDM method is used. First, construct a normalized decision matrix using three criteria explained in the previous section and the Rumina and Linear normalizing techniques for this aim.

Table 2. Normalized Decision Matrix

Rumina				***Normalizing (Linear)***		
1397	*Return*	*Reliability*	*RISK*	*Return*	*Reliability*	*RISK*
Iran Mineral P.	*0.85*	*0.34*	*-0.32*	*0.25*	*0.06*	*-0.06*
Behbahan Cement	*-0.19*	*0.13*	*-0.29*	*-0.06*	*0.02*	*-0.05*
Dadeh pardazi Iran co	*0.24*	*0.55*	*0.62*	*0.07*	*0.10*	*0.11*
Fanavaran Petr.	*0.84*	*0.22*	*0.03*	*0.24*	*0.04*	*0.01*
*S*North Drilling*	*-0.74*	*0.13*	*0.09*	*-0.21*	*0.02*	*0.02*
*S*IRI Marine Co.*	*-0.02*	*0.13*	*0.29*	*-0.01*	*0.02*	*0.05*
Butane Group	*0.75*	*0.16*	*0.37*	*0.22*	*0.03*	*0.07*
Shahroud Sugar	*0.09*	*1.00*	*1.00*	*0.03*	*0.18*	*0.19*
Yazd Jooshkab	*0.10*	*0.42*	*0.38*	*0.03*	*0.08*	*0.07*
Sahand Rubber	*0.12*	*0.45*	*0.49*	*0.03*	*0.08*	*0.09*

Sobhan Pharm.	*-0.07*	*0.13*	*0.51*	*-0.02*	*0.02*	*0.09*
Iran Mobil Tele	*0.46*	*0.26*	*0.28*	*0.13*	*0.05*	*0.05*
Chadormalu	*0.48*	*0.18*	*0.52*	*0.14*	*0.03*	*0.10*
Iran Khodro	*0.01*	*0.13*	*0.75*	*0.00*	*0.02*	*0.14*
Khouz. Steel	*0.88*	*0.42*	*0.55*	*0.25*	*0.08*	*0.10*
*S*I. N. C. Ind.*	*1.00*	*0.26*	*0.36*	*0.29*	*0.05*	*0.07*
Azar Refract.	*-0.60*	*0.16*	*-0.20*	*-0.17*	*0.03*	*-0.04*
*S*Tehran Const.*	*-0.40*	*0.13*	*-0.60*	*-0.12*	*0.02*	*-0.11*
MAPNA	*-0.17*	*0.13*	*0.40*	*-0.05*	*0.02*	*0.07*
*S*Mellat Bank*	*-0.16*	*0.13*	*0.19*	*-0.05*	*0.02*	*0.03*
SUM	*3.46*	*5.47*	*5.40*			

RUMINA'S NORMALIZATION CAN MITIGATE THE NEGATIVE EFFECT OF THE RELIABILITY CRITERION. IN THE TABLE BELOW, WE APPLIED THE LINEAR TECHNIQUE TO OBTAIN EACH ROW'S MAXIMUM AND LOWEST VALUE. THESE NUMBERS CAN ASSIST IN DETERMINING THE NUMBER ***'1'***.

TABLE 3. COMPUTING NUMBER OF ONES

1397	***Best***			***Worst***			
Max of Linear	***Return***	***Reliability***	***RISK***	***Return***	***Reliability***	***RISK***	***Min of Linear***
0.25	1.00	0.25	-0.24	-4.10	-1.02	1.00	-0.060
0.02	-2.27	1.00	-2.22	1.00	-0.44	0.98	-0.056
0.11	0.61	0.89	1.00	1.00	1.44	1.63	0.070
0.24	1.00	0.17	0.03	39.21	6.61	1.00	0.006
0.02	-8.95	1.00	0.67	1.00	-0.11	-0.08	-0.214
0.05	-0.12	0.45	1.00	1.00	-3.72	-8.23	-0.006
0.22	1.00	0.14	0.32	7.37	1.00	2.32	0.029
0.19	0.14	0.99	1.00	1.00	7.05	7.14	0.026
0.08	0.39	1.00	0.93	1.00	2.59	2.41	0.029
0.09	0.38	0.90	1.00	1.00	2.41	2.66	0.034
0.09	-0.22	0.25	1.00	1.00	-1.13	-4.49	-0.021
0.13	1.00	0.36	0.38	2.80	1.00	1.08	0.047
0.14	1.00	0.24	0.69	4.16	1.00	2.86	0.034
0.14	0.02	0.17	1.00	1.00	7.19	41.68	0.003
0.25	1.00	0.30	0.40	3.28	1.00	1.31	0.077
0.29	1.00	0.17	0.23	6.03	1.00	1.41	0.048
0.03	-6.08	1.00	-1.29	1.00	-0.16	0.21	-0.172
0.02	-4.86	1.00	-4.67	1.00	-0.21	0.96	-0.116
0.07	-0.67	0.32	1.00	1.00	-0.48	-1.50	-0.050
0.03	-1.33	0.69	1.00	1.00	-0.52	-0.75	-0.046

Number of 1 Best	*7*	*5*	*8*	*13*	*5*	*2*	***Number of 1 Worst***

The table above demonstrates how each alternative (companies) has performed in relation to each criterion. Compute the number of the best and worst (numbers '***1***') for each criterion at the end of the table. For example, the criteria ***Return*** contains eight greatest and ten lowest values.

Table 4. Process of assigning the weight to criteria after normalizing the decision matrix

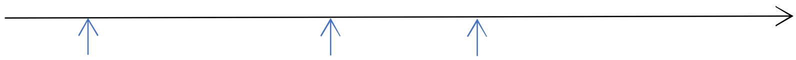
Criteria	*Return*	*Reliability*	*Risk*
n_j = (Number of '1' for Beat - Number of '1' for Worst)	*7 – 13 = -6*	*5 - 5 = 0*	*8 – 2 = 6*
Min n_j	*-6*		
d_{j} = Distance d_{min} to other	*0*	*6*	*12*
The sum of d_i + 1	*18*		
Coefficient a_i	*0*	*6*	*12*
w is the unit weight of criteria	*5.556*		
Weight of criteria	*0*	*33.33*	*66.67*

$\boldsymbol{n_j}$ is the difference between the number of the best and worst

$\boldsymbol{d_j}$ is a vector and shows the distance between $\boldsymbol{n_{min}}$ with other $\boldsymbol{n_j}$ from itself.

In the example above the distance between $\boldsymbol{n_1}$ and $\boldsymbol{n_{min}} = \mathbf{0}$ then $\boldsymbol{a_1}$ is zero and the weight of Return will be zero, too. Actually two criteria have weight, some times happen that there is only one criterion that has weight.

$\boldsymbol{n_1 = n_{min} = -2}$ $\boldsymbol{n_2 = 0}$ $\boldsymbol{n_3 = 2}$



4. Scientific novelty

This study introduces and evaluates a new method with high efficiency called WCDM for computing the rank of criteria and weighting. The WCDM method helps construct profitable portfolios with returns more than interest banks and stock market indexes by TOPSIS as the MCDM method for ranking alternatives. This method works as well as other methods like Shannon. In the long term, WCDM's performance is better than Shannon's.

5. Analysis

This section compares the results of giving weight by WCDM to criteria for six years with Shannon and further uses TOSIS techniques for calculating the return of each portfolio. The charts illustrate portfolio outcomes, and aid in determining which strategy performs best.

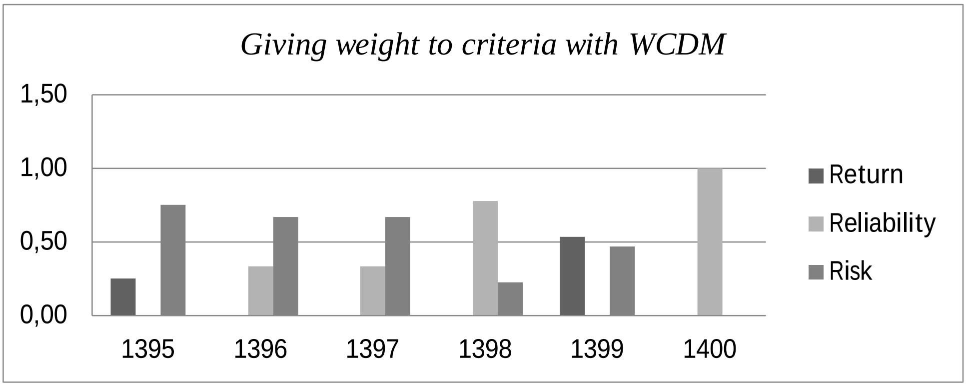


FIGURE 2. CRITERIA'S WEIGHT BY WCDM METHOD FOR SIX YEARS

Figure 2 depicts the weight of three criteria estimated with WCDM for each year from 2016 to 2021.

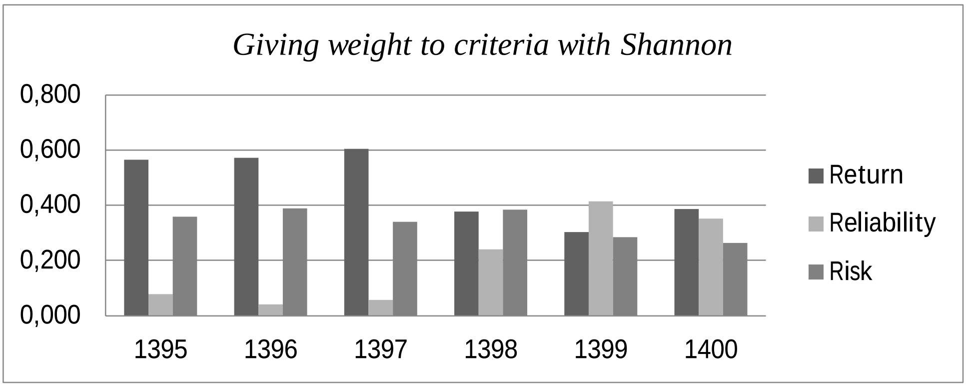


FIGURE 3. CRITERIA'S WEIGHT BY SHANNON FOR SIX YEARS

Figure 3 depicts the weight of three criteria determined with Shannon for each year from 2016 to 2021. Figure 4 depicts the weight of the criteria using two approaches, WCDM and Shannon.

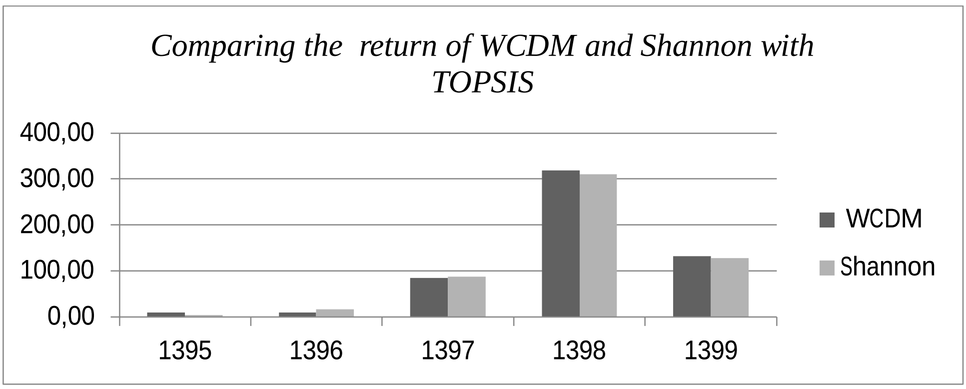


FIGURE 4. COMPARING THE ANNUAL RETURN OF WCDM AND SHANNON WITH TOPSIS

Figure 4 depicts TOPSIS outcomes as portfolio returns from 1395 to the end of 1399. When the findings are examined more closely, the yearly returns of each approach after one, two, three, four, and five years are fairly close by two WCDM and Shannon.

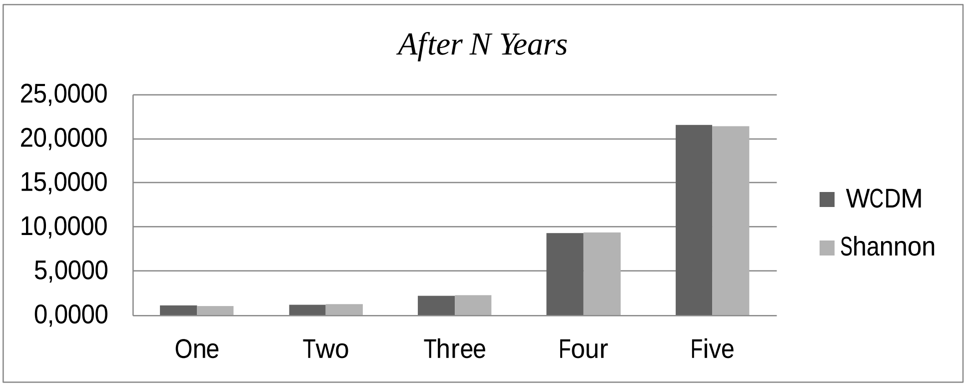


FIGURE 5. COMPARING THE RETURN OF WCDM AND SHANNON WITH TOPSIS AFTER N YEARS

Figure 5 depicts the performance of two approaches, WCDM and Shannon, for assigning weights to criteria and calculating each portfolio's return. TOPSIS is the approach used to weigh the alternatives. As a result, the data reveal that WCDM outperforms Shannon in the same circumstance five years.

6. Conclusions

This study attempts to create a novel strategy for ranking criteria and then assigns weight to them for use in the well-known method TOPSIS. TOPSIS is one of the most well-known MCDM strategies for ranking options. The findings are based on a real-world sample of firms registered on the Tehran Stock Exchange. The choice matrix included twenty companies from various industries as well as three criteria: return, reliability, and risk.

Figure 5 shows the return of each portfolio where WCDM and Shannon assigned the weight to criteria, and TOPSIS has computed the weight of alternatives and portfolio returns. The results indicate the performance of WCDM and Shannon. The performance of each approach is extremely near to each other. In the same circumstance, WCDM performs better than Shannon after five years. So WCDM performance is comparable to the well-known Shannon technique, which assigns a rank and weight to criteria.

Future studies can compare this WCDM approach to other methods such as BWM and LINMAP, as well as other ways that can weigh alternatives in different real-world scenarios.

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