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Applied-Research Paper

A Combination of FSAW and DOE Method with an Application to Tehran Stock Exchange

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ABSTRACT

Stock market is considered as the most profitable and valuable areas of investment in any country. In this regard, high return depends on the correct choice of stock portfolio. That's why today different methods of mathematical planning and decision-making have been proposed to solve such problems. Aiming to present a new method, the study designates 10 criteria for selecting the best stock portfolio options among the 21 most viewed options in the stock market. The method is a combination of fuzzy SAW and experimental design (2^k factorial design). Analysis of variance results for the response variable is calculated. The value of R^2 obtained from the response variable of 70% value, shows that this model has selected suitable options by removing ineffective criteria and analysing the results and discovering the relationships between criteria and ranking the criteria and presenting simpler solutions in addition to high accuracy. As a result, by considering and comparing the real values of the stock market in one-month and quarterly intervals, the model presents more capabilities for providing accurate ranking and higher portfolio returns than fuzzy TOPSIS in the capital and stock markets. The response surface method and the regression equation obtained in the proposed method are used to rank the options. In addition, Pareto method, which ranks the criteria based on the effectiveness of the criteria in the final result and regard to the surfaces of experiments and weights of capital market and stock market experts, is used for ranking the factors (criteria).

1 Introduction and Literature Review

In recent years, many developed countries have paved the way for financing institutions and economic enterprises and consequently economic development, by developing their capital markets and stock markets and by directing small and scattered capitals of society towards productive investments [1]. Furthermore, investors seek to make more profit by investing in more successful and superior companies and achieve the expected return [2]. The development of capital markets has led to the creation and expansion of financial services institutions. These institutions publish some general information about the economic situation, especially business, and also provide advisory services to

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investors at various levels. Larger financial services institutions also provide ranking services [3]. The purpose of ranking services is to rank companies based on capability, efficiency quality, and productivity. Ranking services are remarkable not only for investors but also for shareholders, creditors, etc. [4]. The studies carried out on these lines demonstrate that Tehran Stock Exchange has weak efficiency. Therefore, separating and ranking the companies accepted in the Stock Exchange are of particular importance to meet the needs of investors to select the optimal companies for investment and prevent them from making inappropriate decisions [5]. Actually, these surveys make it possible for investors and users of information to more easily distinguish the companies that are more efficient than other companies and to make more reasonable investments. In other words, this possibility is a step in the direction of moving the capital market towards efficiency [6]. It is also considered as a criterion for investors' investment and is used with more reliability [7]. In the Iranian capital market, due to the lack of financial services institutions, the common and reputable ranking is the stock exchange ranking and one of these reports is related to the top 50 companies listed on the stock exchange. It should be noted that the identification of top companies in the Tehran Stock Exchange is carried out based on a combination of stock liquidity, the impact of companies on the market and the company's position in terms of financial superiority within the three criteria and the following six indicators based on the Harmonic Mean Method [8, 9].

A) The amount of stock trading in the trading hall, including: the number and value of traded shares.

B) Frequency of stock trading in the trading hall, including: the number of days and times traded.

C) Variables of the indicator scale of the amount of impact on the market, including: the average number of issued shares and the average current value of the company's shares in the review period.

The first study on the subject of stock selection decisions and financial studies was carried out by Potter [10], which showed six variables, including: dividends, rapid price and profits growth, investment objectives such as savings, trading profits, investment management and long-term growth are effective in stock selection. Baker and Haslem [11] in their studies also examined the factors that are important to shareholders. The results showed that investors are primarily concerned about the future of their stock prices, and the most important issue for investors is the studies that help them plan for the future of their stocks. William O'Neill [12] in his study entitled "How to get rich in common stock?", advised shareholders to take account of the criteria such as current quarterly earnings and annual earnings per share, system management, supply and demand, stock leaders, number of shares owned by financial and investment institutions, and general market direction. Wang Joo and Quick [13] examined the nervous and fuzzy systems for selecting stocks in different stock exchanges. In this system, first the assets are allocated, then the country is chosen and finally the stock is selected. Alang Chen [14] in a study entitled "What factors change stock prices" addressed the factors that change stock prices and concluded that cash flows have the greatest impact on stock prices and there is a direct and significant relationship between them.

Wing Xiongli et al. [15] explained a model for investment decisions using Gordon model criteria (dividend rate, discount rate and dividend growth rate) through multi-criteria decision making (ANP) techniques. According to their review, projected dividends are influenced by industry outlook, net profit, operating cash flows and dividend payout ratio, beta-affected discount rate and risk-free rate of return, and dividend growth rate is affected by revenue growth rate and the growth rate of dividend payment. The research results show that according to experts, among the eight studied criteria, market beta, dividend growth rate and risk-free rate of return are respectively the most important factors influencing investment decisions. In a similar study, Wenranger Jerry [40] explained a model for investment decisions using elements of the capital asset pricing model (CAPM) through multi-criteria decision-making techniques (DEMATEL, ANP, VIKOR). Criteria studied in this research are government budget deficit, discount rate and exchange rate (sub-criteria of risk-free rate of return); country risk, industrial structure and macroeconomic factors (sub-criteria of expected market returns);

corporate risk and financial risk (beta sub-criteria). The results of the study show that according to experts, macroeconomic factors, exchange rate and company risk are the most important factors influencing investment decisions, respectively. Akbarpour Shirazi [16] used multi-criteria decision-making techniques to examine the criteria affecting the selection of stocks in pharmaceutical companies listed on the Tehran Stock Exchange. In this study, the effective criteria for stock selection are: Price-to-Earnings ratio (P / E), Earnings Per Share (EPS), Dividend Per Share (DPS), Market Value-to-Book Value ratio (MV / BV), Price to Sell ratio (S / P), Liability to Equity Ratio (L / E), Return on Assets (ROA), Return on Equity (ROE), Market Capitalization (MC), Dividend Trend (DT) , Transaction Volume (VOL), disclosure and transparency of company information. The research results show that the volume of transactions and market capitalization have the greatest weight and importance. Decision making is a process that involves choosing a path or method from two or more available methods. Decision making means a conscious choice that allows the individual to examine, based on a set of given conditions, the specific behavior and way of thinking of that set, and then find an acceptable option and implement it. For many managers, good decision-making is a decision that leads them to the target much better. In the world we live in, most things that seem right are relatively true, and there is always a degree of uncertainty about the accuracy of real phenomena.

In many cases, information cannot be quantified, but can be evaluated in linguistic (descriptive) terms. To solve this problem, the theory of fuzzy set was introduced by Lotfizadeh [17]. In all fuzzy multi-criteria decision making (FMCDM) methods, we select, prioritize or evaluate options according to various criteria in a fuzzy environment [41, 18]. This is an important research topic, so that it is studied with extensive theory and the theoretical and practical literature of MCDM fuzzy methods in articles and books [18, 19, and 20]. The simplest fuzzy multi-criteria decision making (FSAW) techniques that are commonly used in papers, based on weighted averages, are also known as linear weight combinations. Actually, by simulating the ideal solution, the fuzzy TOPSIS technique makes the option closest to the ideal solution and farther away from the negative ideal solution. A wide range of FSAW programs have been reported in the literature to solve real-world problems [22, 23, 24, and 25]. Furthermore, various cases have been reported that have solved a problem in the real world in the following topics: supplier selection [31, 32], site selection [33], hiring a method [26], risk analysis [34], support for negotiations [35, 36, 37, and 38], group decisions in the field of manufacturing and production [42]. It should be noted that, design of experiment (DOE) helps researchers determine which of the test parameters has the greatest impact on the selection process [39].

In DOE TOPSIS method, evaluation of criteria is considered as a design parameter and TOPSIS solution is considered as the response level. Hatami-Marbini and Kangi [49] in their study made an attempt to present a group MCDM framework for selecting undervalued stocks using financial ratios and subjective judgments of experts in financial markets. In this regard, they developed three versions of fuzzy TOPSIS; fuzzy C-TOPSIS, fuzzy A-TOPSIS and fuzzy M-TOPSIS methods to determine a ranking order of companies in a particular industry in the TSE based on financial factors in fall 2014. The proposed fuzzy TOPSIS methods are featured from several simultaneous positive characteristics involving linguistic variables, group decision-making process, fuzzy distance measure, the degrees of confidence of expert’s opinion as well as fuzzy ranking method so as to strengthen the comprehensiveness and reasonableness of the decision making process. Amin and Hajjami [50] have investigated the role of alternative optimal solutions existing in the data envelopment analysis (DEA) models for cross-efficiency evaluation in portfolio selection. Their research results show that incorporating alternative optimal solutions for constructing cross-efficiency matrix improves the result of the mean-variance portfolio selection method. This improvement means that building portfolios with lower risk and higher expected return is possible when alternative optimal solutions are considered. The proposed method in their study is applied to stock portfolio selection in the Tehran stock market. Chen et al. [51] discuss the fuzzy portfolio selection problems in multi-objective frameworks. A comprehensive model for multi-objective portfolio selection in fuzzy environment is proposed by incorporating mean-semi variance model and data envelopment analysis cross-efficiency model. In the proposed model, the cross-efficiency model is formulated within the framework of Sharpe ratio; bounds on holdings, and cardinality constraints are also considered. Ma et al. [52] have adopted a three-pillar concept: economic, environmental, and social sustainability to investigate and measure sustainability. The main purpose of their study was to target project selection from the perspective of sustainability in an uncertain decision-making environment. Therefore, they used a fuzzy logic model based on the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) approach to incorporate sustainability under uncertainty to obtain the most sustainable solution. A large-scale paper manufacturing company case study was presented to demonstrate the applications .

Chang et al. [53] proposed new NDN DEA models to help investors evaluate the performance of their target portfolios. The proposed DEA models can handle multi-period portfolio performance assessment and open the “black box”, and thus can measure the multi-period efficiency of a portfolio and its comprised financial assets, in contrast to the portfolio evaluation DEA models . Frej et al. [54] on their study have presented a new model for selecting a portfolio of projects based on the benefit-to-cost ratio with incomplete information provided by DMs. The benefit of a project is calculated according to the multi attribute value function, based on the multiple criteria through which candidate projects are evaluated. Pairwise dominance relations between projects are computed using the benefit-to-cost ratio concept, in order to rank the projects using incomplete information about criteria scaling constants values, whose exact values are considered to be unknown . Pejman Peykani et al. [55] have proposed several robust fuzzy data envelopment analysis (RFDEA) models by the use of different fuzzy measures including possibility, necessity and credibility measures. Despite the regular fuzzy DEA methods, the proposed models are able to endogenously adjust the confidence level of each constraints and produce both conservative and non-conservative methods based on various fuzzy measures. The developed RFDEA models are then linearized and numerically compared to regular fuzzy DEA models .

Pejman Peykani et al. [56] on their paper have proposed possibilistic range directional measure (PRDM) model to measure the efficiencies of stocks in the presence of negative data and uncertainty with input/output parameters. Using the data from insurance industry, this model is also implemented for a real case study of Tehran stock exchange (TSE) in order to analyze the performance of the proposed method.

Pejman Peykani et al. [57] in their research, have presented a robust data envelopment analysis (RDEA) model for performance measurement of a decision making units (DMUs) in the presence of negative data and uncertainty. The robust DEA of paper is proposed based on Variant of Radial Measure (VRM). Also, for solving and validating the robust VRM model, this model was implemented for a real case study of Tehran stock exchange (TSE). This study tries to optimize the decision making in stock selection or the optimization of the portfolio by means of the artificial colony of honey bee algorithm.[60]. In the Jamei.R study prioritizes the accepted pharmaceutical companies in Tehran stock exchange, during 2013-2017 bt Topsis and Saw method.[61] In the Zanjirdar.M study, while comprehensively reviewing the literature on the subject and the developments and expansions made in the area of portfolio selection and optimization, reviews the types of problems and optimization methods.[62]. In the article Arash Pazhouhandeh et al, nine important criteria are considered to select the best supplier in supply chain risk management. For this purpose, to address the unspecified criteria and the results analysis, the combination approach of fuzzy TOPSIS and Design of Experiments (DOE) were presented and a 2k factorial design for factor analysis was used at two low and high levels.[63]. In this paper, we intend to use fuzzy systems instead of quantitative and precise methods to design a consistent and efficient model based on reality (uncertain world). So far, various methods have been introduced for decision making, the disadvantages of which are the accuracy of the solution method or the inability to analyze sensitivity or the inability to detect incorrect information or the inability to rank criteria and eliminate inefficient and irrelevant criteria or re-solve if a new criterion or option is added. It can be said that no method has been introduced so far that can solve all these problems at the same time. Therefore, we presented a combination of fuzzy SAW and test design so that we can fully cover these problems and get more accurate answers. Using the design of experiment method along with the fuzzy SAW method has many advantages, including the possibility of discovering the relationship between decision makers' weights and thus discovering the effect of criteria on each other, having no need to recalculate the steps of decision models if a new option is added, ranking the criteria, discovering the criteria that were not selected correctly and have little effect on the final response, and analyzing the sensitivity of model solving by increasing or decreasing the mentioned number of surfaces and experiments. These advantages will make the fuzzy SAW method more practical and effective than all MCDM methods.

Finally, we solved the case study with the proposed method and compared the results with the fuzzy TOPSIS method. The main reason for choosing the fuzzy TOPSIS method for comparison is that the fuzzy TOPSIS method, in addition to its ability to solve uncertain problems, is one of the most important and efficient decision-making methods and has more flexibility than other methods in solving various problems. In addition, this method is popular and the answers obtained from this method can be trusted and selected for comparison. As mentioned, these methods and similar methods all have high weaknesses that may provide a good answer, but due to the shortcomings of these methods, the accuracy of the answer is not necessarily the highest. In cases where high accuracy in solving the problem is essential, all the methods introduced so far are not efficient and the proposed method is more appropriate.

2 Introductory

2.1 Multi-Attribute Models

Decision making with multiple indicators deals with several issues. In fact, the decision maker wants to select or rank one of several options based on multiple factors; including the selection of the best job from the available positions according to criteria such as salary and benefits, work environment, social dignity and distance from work to home. These models are basically selective and are used to identify the available m options among the various options. The methods considered for modelling the problem with a multi-criteria approach are FUZZY TOPSIS and Fuzzy SAW methods as well as the proposed model (Fuzzy SAW DOE).

2.1.1 Fuzzy SAW Method

This method(step1-11 and equations 1-3) is developed by Chou et al. (2008)[59]. SAW multi-criteria decision-making method with fuzzy numbers includes the following steps:

Table 1: Fuzzy Value of Descriptive Variables

Row	*Impact Rate (Descriptive Variable)*	*Equivalent fuzzy value*
1	Very Low	(4, 2 ,1)
2	Low	(5, 3 , 1)
3	Middle	(7, 5 , 3)
4	High	(9, 7 , 5)
5	Very High	(10, 9 , 7)

Step 1: Formation of fuzzy decision matrix:

The first step in this technique is to form a decision matrix. The decision matrix in the fuzzy SAW method is based on criteria and options, i.e., the columns of the matrix are criteria, and the rows of the matrix are options, and each cell evaluates each option relative to each criterion. Basically, different spectra are used to complete the fuzzy decision matrix, one of which is the 5-phase fuzzy spectrum shown in Table 1.

Step 2: Decision matrix normalization:

In almost all multi-criteria decision-making methods, the process of normalization takes place. In this method, in order to normalize the fuzzy decision matrix, if the criterion is positive, we divide each column number by the third largest value of the fuzzy number and if the criterion is negative, we divide the minimum value of the first fuzzy number by each number.

If the fuzzy decision matrix is as Equation 3:

$$\tilde{R} = [\tilde{r}_{ij}]_{m*n}, i = 1,2,\ldots,m; j = 1,2,\ldots,n \tag{1}$$

Then Equation 2 is for normalizing the positive criteria and Equation 3 is for normalizing the negative criteria.

$$\tilde{r}_{ij} \quad | \frac{l_{ij}}{u_j}, \frac{m_{ij}}{u_j}, \frac{u_{ij}}{u_j} \quad ; \; u_j \quad \max_i \; u_{ij} : i \quad 1,2,\ldots,m \tag{2}$$

$$\tilde{r}_{ij} \quad \frac{l_j}{u_{ij}}, \frac{l_{ij}^{-}}{m_{ij}}, \frac{l_{ij}}{l_{ij}} \quad ; \; l_j \quad \min_i \; l_{ij} : i \quad 1,2,\ldots,m \tag{3}$$

Step 3: Forming a weight matrix:

In this step, we multiply the weights of the criteria specified by the decision makers in the normal matrix.

Step 4: Final ranking of options:

In this step, we add the fuzzy numbers of each row in a fuzzy way to calculate the fuzzy score of each option, then we diffuse these numbers and rank the options based on them.

2.1.2 Fuzzy TOPSIS Method

The fuzzy TOPSIS technique (step1-6 and equation 4-16) is a generalization of the TOPSIS technique was introduced by Hwang and Yoon [58]. TOPSIS underlying logic is the definition of positive and negative ideal solutions. The positive ideal solution maximizes profit criteria and minimizes cost criteria. The negative ideal solution maximizes cost criteria and minimizes profit criteria. The optimal option is the closest option to the positive ideal solution and the farthest option from the negative ideal solution. In short, the positive ideal solution is a combination of the best available criteria values, while the negative ideal solution contains the worst available criteria values.

$$\tilde{D} \quad \begin{matrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{m3} \end{matrix} \; ; \; i \quad 1,2,\ldots,m \; ; \; j \quad 1,2,\ldots,n. \tag{4}$$

$$\tilde{x}_{ij} \quad \frac{1}{p}(\tilde{x}_{ij}^{(1)} \quad \tilde{x}_{ij}^{(2)} \quad \cdots \quad \tilde{x}_{ij}^{(m)}) \tag{5}$$

$\tilde{x}_{ij}$ is the effect of the Cj criterion on the Ai option based on the opinions of k experts and is displayed

as Equation 6.
To evaluate financial performance, we first formulate an FMCDM problem. The FMCDM problem consists of a set of m options that are evaluated in n indices and related weights. The problem can be modelled as follows.
Step 1: Formation of fuzzy decision matrix with dimensions m * n using fuzzy values of descriptive variables

$$\tilde{x}_{ij}^{(k)} \quad (l_{ij}^{(k)}, m_{ij}^{(k)}, u_{ij}^{(k)}) \tag{6}$$

Step 2: The normal decision matrix should be formed:

$$\tilde{R} \quad \tilde{r}_{ij \; m*n}, \; i \quad 1,2,...,m \; ; \; j \quad 1,2,...,n \tag{7}$$

Equations 2 and 3 in the fuzzy SAW method are used here.
Step 3: The weighted normalized decision matrix $\tilde{V}$ is formed, then the maximum and minimum values are determined for each level of the triangular fuzzy values of the criteria.

$$\tilde{V} = [\tilde{v}_{ij}]_{m*n}, i = 1,2,...,m; j = 1,2,..,n \tag{8}$$

$$\tilde{v}_{ij} \quad \tilde{v}_{ij} \quad \tilde{w}_j \tag{9}$$

Step 4: Identifying the positive and negative ideal points

$$A^+ = (\tilde{v}_1{}^+, \tilde{v}_2{}^+, ..., \tilde{v}_n{}^+) \tag{10}$$

$$A^- = (\tilde{v}_1{}^-, \tilde{v}_2{}^-, ..., \tilde{v}_n{}^-) \tag{11}$$

$$\tilde{v}_j{}^+ = (1,1,1) \otimes \tilde{w}_j = (lw_j, mw_j, uw_j); \tilde{v}_j{}^- = (0,0,0); j = 1,2,...,n. \tag{12}$$

Step 5: Calculating the distance of each option from the positive and negative ideal points

$$d_i{}^+ = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j{}^+), i = 1,2,...,m; j = 1,2,...,n \tag{13}$$

$$d_i{}^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j{}^-), i = 1,2,...,m; j = 1,2,...,n \tag{14}$$

$$d(\tilde{A}, \tilde{B}) = \sqrt{\frac{1}{3}[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2]} \tag{15}$$

Step 6: Finally, the equation 16 is calculated for each option and the options are ranked accordingly.

$$CC_i = \frac{d_i{}^-}{d_i{}^- + d_i{}^+}, i = 1,2,...,m \tag{16}$$

2.1.3 Design of Experiment Method and Response Surface Method

Design of Experiment Method, abbreviated as DOE, is a statistical method that is used simultaneously to determine the individual and interaction effects of factors on the response variable. [44] The Response Surface Methodology (RSM) is a set of mathematical techniques based on the relation of polynomials to experimental data obtained from design of experiment. [45] RSM was first introduced by Box and Wilson. [46]. In addition to analysing the effects of each factor, RSM can also create a mathematical model. [47] Factorial design and RSM can be widely used for optimization. These two methods are often used to discover an unknown design space and create a mathematical model based on statistics. Design of experiment is essential before using RSM. The results are used to create a response surface model.

$$Y = \beta_0 + \sum_{i=1}^{k} \beta_i X_i + \sum_{1 \le i \le j}^{k} \beta_{ij} X_i X_j + \varepsilon \tag{17}$$

Y represents the response (Fuzzy SAW values), Xi represents the design variables; k is the number of variables; β0 is the fixed sentence; βi and βij represent the coefficient of principal effects and interaction, respectively, and ε is the error related to experiments. The coefficients of β are calculated using the least squares method. In this study, a 2^k factorial design is used to investigate the linear effect of the index k on Fuzzy SAW ranking scores. This factorial design also makes it possible to examine the interactions between selected indicators influencing ranking scores. (see Fig. 1)

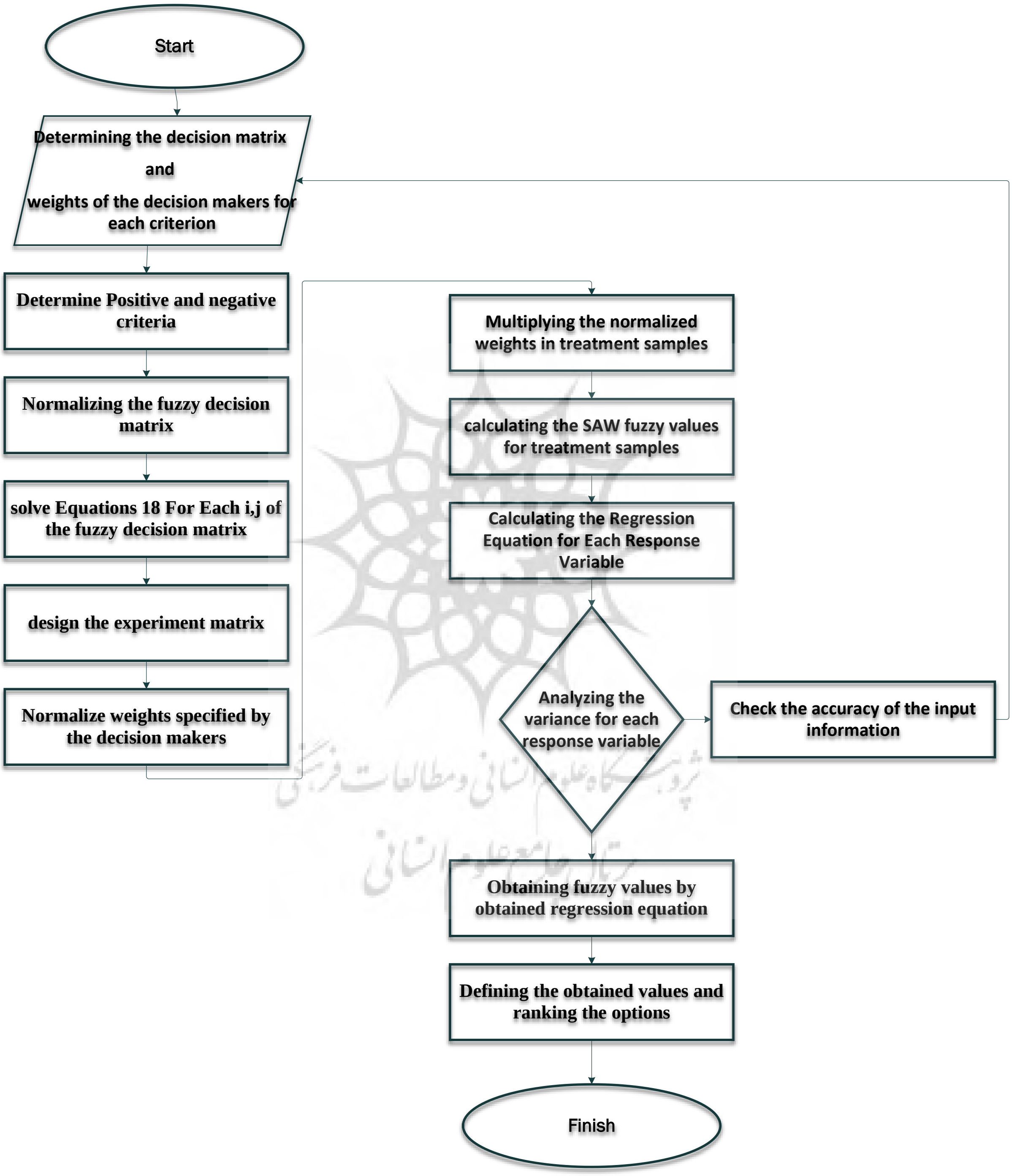

Fig. 1: Design of Experiment Method and Response Surface Method Flowchart

Step 1: Determining the decision matrix and specifying the weights of the decision makers for each criterion

Step 2: Identifying the positive and negative criteria

Step 3: Normalizing the fuzzy decision matrix

Step 4: Defining the fuzzy decision matrix by considering whether the criteria are positive or negative.

$$x_{ij} = \frac{l_{ij}+4m_{ij}+u_{ij}}{6} \quad (18)$$

Step 5: Formatting the experiments matrix based on two-surface factors

Step 6: Normalizing the weights assigned to each decision maker

Step 7: Multiplying the normalized weights in the experiments matrix (treatment samples) and calculating the SAW fuzzy values

Step 8: Calculating the Regression Equation for Each Response Variable (SAW Fuzzy Values)

Step 9: Analysing the variance for each response variable

Step 10: Obtaining fuzzy values by obtained regression equation

Step 11: Defining the obtained values and ranking the options

3 Numerical Examples

In this research, a capital market study has been conducted with the aim of selecting the optimal stock portfolio using fuzzy criteria and decision-making methods. The information of the decision table is related to a 12-month period of information from Iran Stock Exchange from which a number of popular shares have been selected and among them the stock portfolio is optimized.

3.1 Problem Solving by Fuzzy TOPSIS Method:

We first solve the problem by fuzzy TOPSIS method and presented the results below. This is to compare the answers with the answers of the proposed method.

Step 1: Formatting fuzzy decision matrix:

The decision table (Table 2) is obtained using the information of the site of the Iran Stock Exchange Organization and as the period is a 12-month one, the reviewing of the information is carried out in a fuzzy manner

Table 2: Descriptive fuzzy decision matrix

Symbol Selection	Percentage of negative days in the last 12 months	Percentage of positive days in the last 12 months	Mean value of transactions in the last 12 months	Mean number of buyers in the last 12 months	Mean number of sellers in the last 12 months	Ranking of real purchase volume in the last 12 months	Ranking of legal purchase volume in the last 12 months	Ranking of real sales volume in the last 12 months	Ranking of legal sales volume in the last 12 months	Company's P / E to the group
Khodro	L	VL	M	H	L	Vl	L	VL	L	VH
Khesapa	L	VL	M	M	L	Vl	L	VL	L	VH
Khegostar	H	VL	M	M	L	L	H	VL	M	L
Zob	VH	M	M	M	M	L	L	VL	M	H
Femli	M	VH	VH	H	M	M	L	M	L	M
Foolad	H	H	VH	H	M	L	VL	L	VL	M
Kegol	VH	M	VL	VL	VL	H	M	H	H	M
Kedma	VL	VH	VL	VL	VL	VH	VH	VH	VH	H
Vebmelat	M	VL	H	M	M	L	VL	L	L	L
Vebsader	H	H	M	L	M	Vl	VL	VL	VL	VH
Vetejarat	VH	M	H	H	M	Vl	VL	VL	VL	VH
Dey	H	H	M	L	L	M	H	M	H	M
Shepna	H	L	VH	H	M	L	L	L	L	M
Shebandar	H	M	H	M	M	M	M	M	H	H
Shetran	H	L	M	L	L	M	M	M	M	M
Vemhan	L	M	L	VH	VH	H	H	H	H	VL
Saba	L	VL	L	VH	VH	M	M	M	M	VL
Shesta	VL	M	VH	VH	VH	L	L	L	VL	VL
Fars	M	H	L	VL	L	H	M	H	H	L
Petrol	VL	VL	L	L	L	M	M	M	M	VL
Tapiko	M	M	L	VL	VL	H	L	H	M	M

Then the decision table was prepared by fuzzy values according to Table 1. Table 3 shows this issue.

Table 3: Fuzzy Decision Matrix

Symbol Selection	Percentage of negative days in the last 12 months			Percentage of positive days in the last 12 months			Mean value of transactions in the last 12 months			Mean number of buyers in the last 12 months			Mean number of sellers in the last 12 months			Ranking of real purchase volume in the last 12 months			Ranking of legal purchase volume in the last 12 months			Ranking of real sales volume in the last 12 months			Ranking of legal sales volume in the last 12 months			Company's P / E to the group		
Khodro	1	3	5	1	2	4	3	5	7	5	7	9	1	3	5	1	2	4	1	3	5	1	2	4	1	3	5	7	9	10
Khesapa	1	3	5	1	2	4	3	5	7	3	5	7	1	3	5	1	2	4	1	3	5	1	2	4	1	3	5	7	9	10
Khegostar	5	7	9	1	2	4	3	5	7	3	5	7	1	3	5	1	3	5	5	7	9	1	2	4	3	5	7	1	3	5
Zob	7	9	10	3	5	7	3	5	7	3	5	7	3	5	7	1	3	5	1	3	5	1	2	4	3	5	7	5	7	9
Femli	3	5	7	7	9	10	7	9	10	5	7	9	3	5	7	3	5	7	1	3	5	3	5	7	1	3	5	3	5	7
Foolad	5	7	9	5	7	9	7	9	10	5	7	9	3	5	7	1	3	5	1	2	4	1	3	5	1	2	4	3	5	7
Kegol	7	9	10	3	5	7	1	2	4	1	2	4	1	2	4	5	7	9	3	5	7	5	7	9	5	7	9	3	5	7
Kedma	1	2	4	7	9	10	1	2	4	1	2	4	1	2	4	7	9	10	7	9	10	7	9	10	7	9	10	5	7	9
Vebmelat	3	5	7	1	2	4	5	7	9	3	5	7	3	5	7	1	3	5	1	2	4	1	3	5	1	3	5	1	3	5
Vebsader	5	7	9	5	7	9	3	5	7	1	3	5	3	5	7	1	2	4	1	2	4	1	2	4	1	2	4	7	9	10
Vetejarat	7	9	10	3	5	7	5	7	9	5	7	9	3	5	7	1	2	4	1	2	4	1	2	4	1	2	4	7	9	10
Dey	5	7	9	5	7	9	3	5	7	1	3	5	1	3	5	3	5	7	5	7	9	3	5	7	5	7	9	3	5	7
Shepna	5	7	9	1	3	5	7	9	10	5	7	9	3	5	7	1	3	5	1	3	5	1	3	5	1	3	5	3	5	7
Shebandar	5	7	9	3	5	7	5	7	9	3	5	7	3	5	7	3	5	7	3	5	7	3	5	7	5	7	9	5	7	9
Shetran	5	7	9	1	3	5	3	5	7	1	3	5	1	3	5	3	5	7	3	5	7	3	5	7	3	5	7	3	5	7
Vemhan	1	3	5	3	5	7	1	3	5	7	9	10	7	9	10	5	7	9	5	7	9	5	7	9	5	7	9	1	2	4
Saba	1	3	5	1	2	4	1	3	5	7	9	10	7	9	10	3	5	7	3	5	7	3	5	7	3	5	7	1	2	4
Shesta	1	2	4	3	5	7	7	9	10	7	9	10	7	9	10	1	3	5	1	3	5	1	3	5	1	2	4	1	2	4
Fars	3	5	7	5	7	9	1	3	5	1	2	4	1	3	5	5	7	9	3	5	7	5	7	9	5	7	9	1	3	5
Petrol	1	2	4	1	2	4	1	3	5	1	3	5	1	3	5	3	5	7	3	5	7	3	5	7	3	5	7	1	2	4
Tapiko	3	5	7	3	5	7	1	3	5	1	2	4	1	2	4	5	7	9	1	3	5	5	7	9	3	5	7	3	5	7

Step 2: Decision matrix normalization:

Data normalization was performed using Equations 1 to 3. Table 4 shows this.

Table 4: Normalized Fuzzy Decision Matrix

Symbol Selection	-			+			+			+			-			-			-			+			+			-		
	Percentage of negative days in the last 12 months			Percentage of positive days in the last 12 months			Mean value of transactions in the last 12 months			Mean number of buyers in the last 12 months			Mean number of sellers in the last 12 months			Ranking of real purchase volume in the last 12 months			Ranking of legal purchase volume in the last 12 months			Ranking of real sales volume in the last 12 months			Ranking of legal sales volume in the last 12 months			Company's P / E to the group		
Khodro	0.2	0.3	1.0	0.1	0.2	0.4	0.3	0.5	0.7	0.5	0.7	0.9	0.2	0.3	1.0	0.3	0.5	1.0	0.2	0.3	1.0	0.1	0.2	0.4	0.1	0.3	0.5	0.1	0.1	0.1
Khesapa	0.2	0.3	1.0	0.1	0.2	0.4	0.3	0.5	0.7	0.3	0.5	0.7	0.2	0.3	1.0	0.3	0.5	1.0	0.2	0.3	1.0	0.1	0.2	0.4	0.1	0.3	0.5	0.1	0.1	0.1
Khegostar	0.1	0.1	0.2	0.1	0.2	0.4	0.3	0.5	0.7	0.3	0.5	0.7	0.2	0.3	1.0	0.2	0.3	1.0	0.1	0.1	0.2	0.1	0.2	0.4	0.3	0.5	0.7	0.2	0.3	1.0
Zob	0.1	0.1	0.1	0.3	0.5	0.7	0.3	0.5	0.7	0.3	0.5	0.7	0.1	0.2	0.3	0.2	0.3	1.0	0.2	0.3	1.0	0.1	0.2	0.4	0.3	0.5	0.7	0.1	0.1	0.2
Femli	0.1	0.2	0.3	0.7	0.9	1.0	0.7	0.9	1.0	0.5	0.7	0.9	0.1	0.2	0.3	0.1	0.2	0.3	0.2	0.3	1.0	0.3	0.5	0.7	0.1	0.3	0.5	0.1	0.2	0.3
Foolad	0.1	0.1	0.2	0.5	0.7	0.9	0.7	0.9	1.0	0.5	0.7	0.9	0.1	0.2	0.3	0.2	0.3	1.0	0.3	0.5	1.0	0.1	0.3	0.5	0.1	0.2	0.4	0.1	0.2	0.3
Kegol	0.1	0.1	0.1	0.3	0.5	0.7	0.1	0.2	0.4	0.1	0.2	0.4	0.3	0.5	1.0	0.1	0.1	0.2	0.1	0.2	0.3	0.5	0.7	0.9	0.5	0.7	0.9	0.1	0.2	0.3
Kedma	0.3	0.5	1.0	0.7	0.9	1.0	0.1	0.2	0.4	0.1	0.2	0.4	0.3	0.5	1.0	0.1	0.1	0.1	0.1	0.1	0.1	0.7	0.9	1.0	0.7	0.9	1.0	0.1	0.1	0.2
Vebmelat	0.1	0.2	0.3	0.1	0.2	0.4	0.5	0.7	0.9	0.3	0.5	0.7	0.1	0.2	0.3	0.2	0.3	1.0	0.3	0.5	1.0	0.1	0.3	0.5	0.1	0.3	0.5	0.2	0.3	1.0
Vebsader	0.1	0.1	0.2	0.5	0.7	0.9	0.3	0.5	0.7	0.1	0.3	0.5	0.1	0.2	0.3	0.3	0.5	1.0	0.3	0.5	1.0	0.1	0.2	0.4	0.1	0.2	0.4	0.1	0.1	0.1
Vetejarat	0.1	0.1	0.1	0.3	0.5	0.7	0.5	0.7	0.9	0.5	0.7	0.9	0.1	0.2	0.3	0.3	0.5	1.0	0.3	0.5	1.0	0.1	0.2	0.4	0.1	0.2	0.4	0.1	0.1	0.1
Dey	0.1	0.1	0.2	0.5	0.7	0.9	0.3	0.5	0.7	0.1	0.3	0.5	0.2	0.3	1.0	0.1	0.2	0.3	0.1	0.1	0.2	0.3	0.5	0.7	0.5	0.7	0.9	0.1	0.2	0.3

Table 4: Normalized Fuzzy Decision Matrix

Symbol Selection	-			+			+			+			-			-			-			+			+			-		
	Percentage of negative days in the last 12 months			Percentage of positive days in the last 12 months			Mean value of transactions in the last 12 months			Mean number of buyers in the last 12 months			Mean number of sellers in the last 12 months			Ranking of real purchase volume in the last 12 months			Ranking of legal purchase volume in the last 12 months			Ranking of real sales volume in the last 12 months			Ranking of legal sales volume in the last 12 months			Company's P / E to the group		
Shepna	0.1	0.1	0.2	0.1	0.3	0.5	0.7	0.9	1.0	0.5	0.7	0.9	0.1	0.2	0.3	0.2	0.3	1.0	0.2	0.3	1.0	0.1	0.3	0.5	0.1	0.3	0.5	0.1	0.2	0.3
Shebandar	0.1	0.1	0.2	0.3	0.5	0.7	0.5	0.7	0.9	0.3	0.5	0.7	0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3	0.3	0.5	0.7	0.5	0.7	0.9	0.1	0.1	0.2
Shetran	0.1	0.1	0.2	0.1	0.3	0.5	0.3	0.5	0.7	0.1	0.3	0.5	0.2	0.3	1.0	0.1	0.2	0.3	0.1	0.2	0.3	0.3	0.5	0.7	0.3	0.5	0.7	0.1	0.2	0.3
Vemhan	0.2	0.3	1.0	0.3	0.5	0.7	0.1	0.3	0.5	0.7	0.9	1.0	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.5	0.7	0.9	0.5	0.7	0.9	0.3	0.5	1.0
Saba	0.2	0.3	1.0	0.1	0.2	0.4	0.1	0.3	0.5	0.7	0.9	1.0	0.1	0.1	0.1	0.1	0.2	0.3	0.1	0.2	0.3	0.3	0.5	0.7	0.3	0.5	0.7	0.3	0.5	1.0
Shesta	0.3	0.5	1.0	0.3	0.5	0.7	0.7	0.9	1.0	0.7	0.9	1.0	0.1	0.1	0.1	0.2	0.3	1.0	0.2	0.3	1.0	0.1	0.3	0.5	0.1	0.2	0.4	0.3	0.5	1.0
Fars	0.1	0.2	0.3	0.5	0.7	0.9	0.1	0.3	0.5	0.1	0.2	0.4	0.2	0.3	1.0	0.1	0.1	0.2	0.1	0.2	0.3	0.5	0.7	0.9	0.5	0.7	0.9	0.2	0.3	1.0
Petrol	0.3	0.5	1.0	0.1	0.2	0.4	0.1	0.3	0.5	0.1	0.3	0.5	0.2	0.3	1.0	0.1	0.2	0.3	0.1	0.2	0.3	0.3	0.5	0.7	0.3	0.5	0.7	0.3	0.5	1.0
Tapiko	0.1	0.2	0.3	0.3	0.5	0.7	0.1	0.3	0.5	0.1	0.2	0.4	0.3	0.5	1.0	0.1	0.1	0.2	0.2	0.3	1.0	0.5	0.7	0.9	0.3	0.5	0.7	0.1	0.2	0.3

Steps 3 and 4: Then the normalized fuzzy matrix is multiplied by the weight of each decision maker and the lower, middle and upper limits are calculated for different criteria and each option (Equations 8 to 15) and after specifying the positive and negative ideal points and calculations regard to the distance of each option from the positive and negative ideal points using the equation of 16, fuzzy TOPSIS index is calculated. These calculations are performed for each decision maker and are calculated based on the defined weights. Finally, the mean is obtained from the index values and ranking is carried out. Table 5 shows this.

Table 5: Values of Distance from Positive and Negative Ideals and Values of Fuzzy TOPSIS Index

Symbol Selection	DM1				DM2				Ave	Rank
	D+	D-	Ci	Rank	D+	D-	Ci	Rank		
Khodro	0.65	0.37	0.36	8.00	0.66	0.36	0.35	10.00	0.36	9.00
Khesapa	0.67	0.36	0.35	12.00	0.67	0.35	0.34	15.00	0.35	13.00
Khegostar	0.67	0.34	0.34	15.00	0.66	0.36	0.35	11.00	0.34	14.00
Zob	0.67	0.32	0.32	17.00	0.67	0.31	0.32	19.00	0.32	18.00
Femli	0.59	0.38	0.40	4.00	0.59	0.37	0.38	5.00	0.39	5.00
Foolad	0.61	0.38	0.39	6.00	0.61	0.37	0.38	6.00	0.38	6.00
Kegol	0.65	0.30	0.31	19.00	0.65	0.31	0.32	17.00	0.32	19.00
Kedma	0.58	0.39	0.40	3.00	0.58	0.39	0.40	3.00	0.40	3.00
Vebmelat	0.64	0.38	0.37	7.00	0.64	0.38	0.37	7.00	0.37	7.00
Vebsader	0.67	0.30	0.31	20.00	0.68	0.29	0.30	21.00	0.30	20.00
Vetejarat	0.65	0.33	0.33	16.00	0.66	0.31	0.32	18.00	0.33	16.00
Dey	0.64	0.32	0.34	14.00	0.63	0.33	0.35	14.00	0.34	15.00
Shepna	0.64	0.35	0.35	11.00	0.64	0.35	0.35	12.00	0.35	11.00
Shebandar	0.64	0.30	0.32	18.00	0.63	0.31	0.33	16.00	0.32	17.00
Shetran	0.68	0.28	0.29	21.00	0.67	0.29	0.30	20.00	0.29	21.00
Vemhan	0.58	0.40	0.41	2.00	0.58	0.40	0.40	2.00	0.41	2.00
Saba	0.63	0.36	0.36	9.00	0.63	0.35	0.36	9.00	0.36	10.00
Shesta	0.56	0.46	0.45	1.00	0.57	0.45	0.44	1.00	0.45	1.00
Fars	0.61	0.38	0.39	5.00	0.60	0.40	0.40	4.00	0.39	4.00
Petrol	0.64	0.36	0.36	10.00	0.63	0.37	0.37	8.00	0.36	8.00
Tapiko	0.64	0.34	0.35	13.00	0.64	0.34	0.35	13.00	0.35	12.00

3.2 Problem Solving by the Proposed Method (Experiment Designing of Factorial Design in Combination with Fuzzy SAW)

After solving the problem by fuzzy TOPSIS method, we solve the problem once by the proposed model. Using the design of experiment method along with the Fuzzy SAW method has many advantages, including the possibility of discovering the relationship between decision makers' weights and thus discovering the effect of criteria on each other, having no need to recalculate the steps of decision models if a new option is added, ranking the criteria, discovering the criteria that were not selected correctly and having little effect on the final response, and analyzing the sensitivity of model solving by increasing or decreasing the mentioned number of surfaces and experiments. These advantages will make the fuzzy SAW method more practical and effective than all MCDM methods. In the following, we will describe the solution of the case study by the proposed method:

Step 1: The decision matrix is formed as Tables 2 and 3.

Step 2: Positive and negative criteria are determined. It is clear that the percentage of positive days in the last 12 months, the mean value of transactions in the last 12 months, the mean number of buyers in the last 12 months, the ranking of real sales volume in the last 12 months and the ranking of legal sales volume in the last 12 months are positive criteria and the mean number of sellers in the last 12 months, the ranking of real purchase volume in the last 12 months, the ranking of legal purchase volume in the last 12 months, percentage of negative days in the last 12 months, the company's P / E compared to the P / E of the group are considered as the negative criteria.

Step 3: The initial decision matrix formed in step 1 is normalized using Equations 2 and 3. (Table 4)

Step 4: Next, we convert the fuzzy decision matrix to algebraic numbers [48]. For this purpose, we use Equation (18).

Step 5: design of experiment matrix based on 2k factorial design (considering 2 surfaces of -1 and +1) is formed to test the effects of factors (criteria) on experiments (response variables). This 2-level matrix has 2 decision makers. Every decision maker means the repetition of experiments and calculation of the response variable based on the weight of each decision maker, once. The number of experiments is considered 128, which reaches 256 experiments due to 2 repetitions. This value is obtained based on 2×2^(10-3).
In cases where higher accuracy is required, response surface or Taguchi methods with a higher number of surfaces can be applied.

Step 6: The weights specified by the decision makers are normalized.
Step 7: Then it is multiplied in the treatment table and the response variable is obtained by combining it with SAW method; the results can be seen in Table 6.

Table 6: Treatment Values of Design of Experiment and Calculated Response Variable

Std	**Run**	**A:A**	**B:B**	**C:C**	**D:D**	**E:E**	**F:F**	**G:G**	**H:H**	**J:I**	**K:J**	**R1**
1	132	-1	-1	-1	-1	-1	-1	-1	1	1	1	-0.142957
2	205	-1	-1	-1	-1	-1	-1	-1	1	1	1	-0.2
3	37	1	-1	-1	-1	-1	-1	-1	-1	1	-1	-0.492163
4	105	1	-1	-1	-1	-1	-1	-1	-1	1	-1	-0.633333
5	170	-1	1	-1	-1	-1	-1	-1	-1	-1	1	-0.460417
6	182	-1	1	-1	-1	-1	-1	-1	-1	-1	1	-0.666667
7	154	1	1	-1	-1	-1	-1	-1	1	-1	-1	-0.365179
8	214	1	1	-1	-1	-1	-1	-1	1	-1	-1	0
9	88	-1	-1	1	-1	-1	-1	-1	-1	-1	-1	-0.866667
10	131	-1	-1	1	-1	-1	-1	-1	-1	-1	-1	0
11	74	1	-1	1	-1	-1	-1	-1	1	-1	1	-0.3
12	243	1	-1	1	-1	-1	-1	-1	1	-1	1	0
13	100	-1	1	1	-1	-1	-1	-1	1	1	-1	-0.266667
14	12	-1	1	1	-1	-1	-1	-1	1	1	-1	0
15	251	1	1	1	-1	-1	-1	-1	-1	1	1	0.142757
16	137	1	1	1	-1	-1	-1	-1	-1	1	1	-0.166667
17	183	-1	-1	-1	1	-1	-1	-1	1	-1	-1	-0.555656
18	139	-1	-1	-1	1	-1	-1	-1	1	-1	-1	-0.566667

Table 6: Treatment Values of Design of Experiment and Calculated Response Variable

Std	**Run**	**A:A**	**B:B**	**C:C**	**D:D**	**E:E**	**F:F**	**G:G**	**H:H**	**J:I**	**K:J**	**R1**
19	125	1	-1	-1	1	-1	-1	-1	-1	-1	1	-0.333433
20	237	1	-1	-1	1	-1	-1	-1	-1	-1	1	-0.466667
21	120	-1	1	-1	1	-1	-1	-1	-1	1	-1	-0.365179
22	188	-1	1	-1	1	-1	-1	-1	-1	1	-1	0
23	97	1	1	-1	1	-1	-1	-1	1	1	1	0.133333
24	40	1	1	-1	1	-1	-1	-1	1	1	1	0
25	121	-1	-1	1	1	-1	-1	-1	-1	1	1	-0.1
26	16	-1	-1	1	1	-1	-1	-1	-1	1	1	0
27	14	1	-1	1	1	-1	-1	-1	1	1	-1	-0.0666667
28	147	1	-1	1	1	-1	-1	-1	1	1	-1	0
29	189	-1	1	1	1	-1	-1	-1	1	-1	1	0.0792651
30	38	-1	1	1	1	-1	-1	-1	1	-1	1	-0.1
31	81	1	1	1	1	-1	-1	-1	-1	-1	-1	-0.269941
32	75	1	1	1	1	-1	-1	-1	-1	-1	-1	-0.533333
33	127	-1	-1	-1	-1	1	-1	-1	1	-1	1	-0.396725
34	163	-1	-1	-1	-1	1	-1	-1	1	-1	1	-0.3
35	244	1	-1	-1	-1	1	-1	-1	-1	-1	-1	-0.745932
36	73	1	-1	-1	-1	1	-1	-1	-1	-1	-1	0
37	152	-1	1	-1	-1	1	-1	-1	-1	1	1	-0.166667
38	133	-1	1	-1	-1	1	-1	-1	-1	1	1	0
39	13	1	1	-1	-1	1	-1	-1	1	1	-1	-0.133333
40	1	1	1	-1	-1	1	-1	-1	1	1	-1	0
41	102	-1	-1	1	-1	1	-1	-1	-1	1	-1	-0.366667
42	150	-1	-1	1	-1	1	-1	-1	-1	1	-1	0
43	204	1	-1	1	-1	1	-1	-1	1	1	1	0.206449
44	47	1	-1	1	-1	1	-1	-1	1	1	1	0.2
45	79	-1	1	1	-1	1	-1	-1	1	-1	-1	-0.333233
46	144	-1	1	1	-1	1	-1	-1	1	-1	-1	-0.366667
47	149	1	1	1	-1	1	-1	-1	-1	-1	1	-0.111011
48	192	1	1	1	-1	1	-1	-1	-1	-1	1	-0.266667
49	218	-1	-1	-1	1	1	-1	-1	1	1	-1	-0.301487
50	67	-1	-1	-1	1	1	-1	-1	1	1	-1	0
51	53	1	-1	-1	1	1	-1	-1	-1	1	1	0.0333333
52	196	1	-1	-1	1	1	-1	-1	-1	1	1	0
53	3	-1	1	-1	1	1	-1	-1	-1	-1	-1	-0.533333
54	246	-1	1	-1	1	1	-1	-1	-1	-1	-1	0
55	247	1	1	-1	1	1	-1	-1	1	-1	1	0.0333333
56	202	1	1	-1	1	1	-1	-1	1	-1	1	0
57	203	-1	-1	1	1	1	-1	-1	-1	-1	1	-0.301487
58	176	-1	-1	1	1	1	-1	-1	-1	-1	1	-0.2
59	60	1	-1	1	1	1	-1	-1	1	-1	-1	-0.206249
60	161	1	-1	1	1	1	-1	-1	1	-1	-1	-0.166667
61	32	-1	1	1	1	1	-1	-1	1	1	1	0.333433
62	98	-1	1	1	1	1	-1	-1	1	1	1	0.4
63	124	1	1	1	1	1	-1	-1	-1	1	-1	-0.015773
64	92	1	1	1	1	1	-1	-1	-1	1	-1	0
65	126	-1	-1	-1	-1	-1	1	-1	1	1	-1	-0.233333
66	146	-1	-1	-1	-1	-1	1	-1	1	1	-1	0
67	185	1	-1	-1	-1	-1	1	-1	-1	1	1	-0.133333
68	56	1	-1	-1	-1	-1	1	-1	-1	1	1	0
69	224	-1	1	-1	-1	-1	1	-1	-1	-1	-1	-0.7
70	7	-1	1	-1	-1	-1	1	-1	-1	-1	-1	0
71	29	1	1	-1	-1	-1	1	-1	1	-1	1	0.142757
72	128	1	1	-1	-1	-1	1	-1	1	-1	1	-0.133333
73	162	-1	-1	1	-1	-1	1	-1	-1	-1	1	-0.206449
74	217	-1	-1	1	-1	-1	1	-1	-1	-1	1	-0.366667

Table 6: Treatment Values of Design of Experiment and Calculated Response Variable

Std	Run	A:A	B:B	C:C	D:D	E:E	F:F	G:G	H:H	J:I	K:J	R1
75	64	1	-1	1	-1	-1	1	-1	1	-1	-1	-0.111211
76	69	1	-1	1	-1	-1	1	-1	1	-1	-1	-0.333333
77	255	-1	1	1	-1	-1	1	-1	1	1	1	0.428471
78	194	-1	1	1	-1	-1	1	-1	1	1	1	0
79	210	1	1	1	-1	-1	1	-1	-1	1	-1	-0.2
80	91	1	1	1	-1	-1	1	-1	-1	1	-1	0
81	208	-1	-1	-1	1	-1	1	-1	1	-1	1	-0.0666667
82	24	-1	-1	-1	1	-1	1	-1	1	-1	1	0
83	17	1	-1	-1	1	-1	1	-1	-1	-1	-1	-0.5
84	59	1	-1	-1	1	-1	1	-1	-1	-1	-1	0
85	143	-1	1	-1	1	-1	1	-1	-1	1	1	0.142757
86	180	-1	1	-1	1	-1	1	-1	-1	1	1	0.0666667
87	256	1	1	-1	1	-1	1	-1	1	1	-1	0.237995
88	43	1	1	-1	1	-1	1	-1	1	1	-1	0.1
89	242	-1	-1	1	1	-1	1	-1	-1	1	-1	-0.111211
90	50	-1	-1	1	1	-1	1	-1	-1	1	-1	-0.133333
91	94	1	-1	1	1	-1	1	-1	1	1	1	0.555456
92	83	1	-1	1	1	-1	1	-1	1	1	1	0
93	200	-1	1	1	1	-1	1	-1	1	-1	-1	-0.133333
94	52	-1	1	1	1	-1	1	-1	1	-1	-1	0
95	84	1	1	1	1	-1	1	-1	-1	-1	1	-0.0333333
96	138	1	1	1	1	-1	1	-1	-1	-1	1	0
97	111	-1	-1	-1	-1	1	1	-1	1	-1	-1	-0.333333
98	141	-1	-1	-1	-1	1	1	-1	1	-1	-1	0
99	142	1	-1	-1	-1	1	1	-1	-1	-1	1	-0.237995
100	96	1	-1	-1	-1	1	1	-1	-1	-1	1	-0.233333
101	95	-1	1	-1	-1	1	1	-1	-1	1	-1	-0.269741
102	221	-1	1	-1	-1	1	1	-1	-1	1	-1	-0.2
103	51	1	1	-1	-1	1	1	-1	1	1	1	0.396925
104	153	1	1	-1	-1	1	1	-1	1	1	1	0.366667
105	158	-1	-1	1	-1	1	1	-1	-1	1	1	0.047719
106	108	-1	-1	1	-1	1	1	-1	-1	1	1	0
107	159	1	-1	1	-1	1	1	-1	1	1	-1	0.166667
108	250	1	-1	1	-1	1	1	-1	1	1	-1	0
109	104	-1	1	1	-1	1	1	-1	1	-1	1	0.133333
110	199	-1	1	1	-1	1	1	-1	1	-1	1	0
111	33	1	1	1	-1	1	1	-1	-1	-1	-1	-0.3
112	206	1	1	1	-1	1	1	-1	-1	-1	-1	0
113	140	-1	-1	-1	1	1	1	-1	1	1	1	0.206449
114	134	-1	-1	-1	1	1	1	-1	1	1	1	0.433333
115	164	1	-1	-1	1	1	1	-1	-1	1	-1	-0.142757
116	45	1	-1	-1	1	1	1	-1	-1	1	-1	0
117	113	-1	1	-1	1	1	1	-1	-1	-1	1	-0.111011
118	46	-1	1	-1	1	1	1	-1	-1	-1	1	-0.0333333
119	28	1	1	-1	1	1	1	-1	1	-1	-1	-0.015773
120	112	1	1	-1	1	1	1	-1	1	-1	-1	0
121	99	-1	-1	1	1	1	1	-1	-1	-1	-1	-0.233333
122	213	-1	-1	1	1	1	1	-1	-1	-1	-1	0
123	165	1	-1	1	1	1	1	-1	1	-1	1	0.333333
124	9	1	-1	1	1	1	1	-1	1	-1	1	0
125	107	-1	1	1	1	1	1	-1	1	1	-1	0.366667
126	129	-1	1	1	1	1	1	-1	1	1	-1	0
127	106	1	1	1	1	1	1	-1	-1	1	1	0.492163
128	77	1	1	1	1	1	1	-1	-1	1	1	0.466667
129	186	-1	-1	-1	-1	-1	-1	1	-1	1	1	-0.174703

Table 6: Treatment Values of Design of Experiment and Calculated Response Variable

Std	**Run**	**A:A**	**B:B**	**C:C**	**D:D**	**E:E**	**F:F**	**G:G**	**H:H**	**J:I**	**K:J**	**R1**
130	160	-1	-1	-1	-1	-1	-1	1	-1	1	1	-0.133333
131	212	1	-1	-1	-1	-1	-1	1	1	1	-1	-0.0794651
132	173	1	-1	-1	-1	-1	-1	1	1	1	-1	-0.1
133	220	-1	1	-1	-1	-1	-1	1	1	-1	1	-0.047719
134	191	-1	1	-1	-1	-1	-1	1	1	-1	1	0
135	226	1	1	-1	-1	-1	-1	1	-1	-1	-1	-0.566667
136	253	1	1	-1	-1	-1	-1	1	-1	-1	-1	0
137	151	-1	-1	1	-1	-1	-1	1	1	-1	-1	-0.333333
138	72	-1	-1	1	-1	-1	-1	1	1	-1	-1	0
139	156	1	-1	1	-1	-1	-1	1	-1	-1	1	-0.233333
140	41	1	-1	1	-1	-1	-1	1	-1	-1	1	0
141	54	-1	1	1	-1	-1	-1	1	-1	1	-1	-0.111211
142	62	-1	1	1	-1	-1	-1	1	-1	1	-1	-0.2
143	22	1	1	1	-1	-1	-1	1	1	1	1	0.555456
144	198	1	1	1	-1	-1	-1	1	1	1	1	0.366667
145	123	-1	-1	-1	1	-1	-1	1	-1	-1	-1	-0.587402
146	55	-1	-1	-1	1	-1	-1	1	-1	-1	-1	-0.5
147	230	1	-1	-1	1	-1	-1	1	1	-1	1	0.0792651
148	249	1	-1	-1	1	-1	-1	1	1	-1	1	0
149	195	-1	1	-1	1	-1	-1	1	1	1	-1	0.1
150	118	-1	1	-1	1	-1	-1	1	1	1	-1	0
151	236	1	1	-1	1	-1	-1	1	-1	1	1	0.2
152	239	1	1	-1	1	-1	-1	1	-1	1	1	0
153	63	-1	-1	1	1	-1	-1	1	1	1	1	0.433333
154	36	-1	-1	1	1	-1	-1	1	1	1	1	0
155	228	1	-1	1	1	-1	-1	1	-1	1	-1	0.015773
156	157	1	-1	1	1	-1	-1	1	-1	1	-1	0
157	235	-1	1	1	1	-1	-1	1	-1	-1	1	0.047519
158	87	-1	1	1	1	-1	-1	1	-1	-1	1	-0.0333333
159	178	1	1	1	1	-1	-1	1	1	-1	-1	0.142757
160	223	1	1	1	1	-1	-1	1	1	-1	-1	0
161	175	-1	-1	-1	-1	1	-1	1	-1	-1	1	-0.428471
162	6	-1	-1	-1	-1	1	-1	1	-1	-1	1	0
163	116	1	-1	-1	-1	1	-1	1	1	-1	-1	-0.2
164	76	1	-1	-1	-1	1	-1	1	1	-1	-1	0
165	2	-1	1	-1	-1	1	-1	1	1	1	1	0.366667
166	44	-1	1	-1	-1	1	-1	1	1	1	1	0
167	5	1	1	-1	-1	1	-1	1	-1	1	-1	-0.0666667
168	197	1	1	-1	-1	1	-1	1	-1	1	-1	0
169	169	-1	-1	1	-1	1	-1	1	1	1	-1	-0.047519
170	245	-1	-1	1	-1	1	-1	1	1	1	-1	0.166667
171	193	1	-1	1	-1	1	-1	1	-1	1	1	0.174703
172	187	1	-1	1	-1	1	-1	1	-1	1	1	0.266667
173	34	-1	1	1	-1	1	-1	1	-1	-1	-1	-0.364979
174	177	-1	1	1	-1	1	-1	1	-1	-1	-1	-0.3
175	234	1	1	1	-1	1	-1	1	1	-1	1	0.301687
176	109	1	1	1	-1	1	-1	1	1	-1	1	0
177	215	-1	-1	-1	1	1	-1	1	-1	1	-1	-0.333233
178	211	-1	-1	-1	1	1	-1	1	-1	1	-1	0
179	15	1	-1	-1	1	1	-1	1	1	1	1	0.566667
180	110	1	-1	-1	1	1	-1	1	1	1	1	0
181	201	-1	1	-1	1	1	-1	1	1	-1	-1	-0.206249
182	115	-1	1	-1	1	1	-1	1	1	-1	-1	0
183	90	1	1	-1	1	1	-1	1	-1	-1	1	0.015973
184	171	1	1	-1	1	1	-1	1	-1	-1	1	0.1
185	181	-1	-1	1	1	1	-1	1	1	-1	1	0.111211

Table 6: Treatment Values of Design of Experiment and Calculated Response Variable

Std	**Run**	**A:A**	**B:B**	**C:C**	**D:D**	**E:E**	**F:F**	**G:G**	**H:H**	**J:I**	**K:J**	**R1**
186	148	-1	-1	1	1	1	-1	1	1	-1	1	0.333333
187	114	1	-1	1	1	1	-1	1	-1	-1	-1	-0.237995
188	240	1	-1	1	1	1	-1	1	-1	-1	-1	-0.1
189	167	-1	1	1	1	1	-1	1	-1	1	1	0.301687
190	119	-1	1	1	1	1	-1	1	-1	1	1	0
191	216	1	1	1	1	1	-1	1	1	1	-1	0.5
192	80	1	1	1	1	1	-1	1	1	1	-1	0
193	227	-1	-1	-1	-1	-1	1	1	-1	1	-1	-0.166667
194	254	-1	-1	-1	-1	-1	1	1	-1	1	-1	0
195	4	1	-1	-1	-1	-1	1	1	1	1	1	0.4
196	18	1	-1	-1	-1	-1	1	1	1	1	1	0
197	209	-1	1	-1	-1	-1	1	1	1	-1	-1	-0.111211
198	103	-1	1	-1	-1	-1	1	1	1	-1	-1	-0.166667
199	252	1	1	-1	-1	-1	1	1	-1	-1	1	0.111011
200	232	1	1	-1	-1	-1	1	1	-1	-1	1	-0.0666667
201	61	-1	-1	1	-1	-1	1	1	1	-1	1	0.206249
202	166	-1	-1	1	-1	-1	1	1	1	-1	1	0.166667
203	93	1	-1	1	-1	-1	1	1	-1	-1	-1	-0.142957
204	229	1	-1	1	-1	-1	1	1	-1	-1	-1	0
205	19	-1	1	1	-1	-1	1	1	-1	1	1	0.3
206	39	-1	1	1	-1	-1	1	1	-1	1	1	0
207	31	1	1	1	-1	-1	1	1	1	1	-1	0.333333
208	48	1	1	1	-1	-1	1	1	1	1	-1	0
209	135	-1	-1	-1	1	-1	1	1	-1	-1	1	-0.0794651
210	57	-1	-1	-1	1	-1	1	1	-1	-1	1	0
211	248	1	-1	-1	1	-1	1	1	1	-1	-1	0.015773
212	207	1	-1	-1	1	-1	1	1	1	-1	-1	0.0333333
213	86	-1	1	-1	1	-1	1	1	1	1	1	0.555456
214	172	-1	1	-1	1	-1	1	1	1	1	1	0.6
215	65	1	1	-1	1	-1	1	1	-1	1	-1	0.206249
216	168	1	1	-1	1	-1	1	1	-1	1	-1	0.166667
217	27	-1	-1	1	1	-1	1	1	1	1	-1	0.301487
218	49	-1	-1	1	1	-1	1	1	1	1	-1	0
219	10	1	-1	1	1	-1	1	1	-1	1	1	0.5
220	8	1	-1	1	1	-1	1	1	-1	1	1	0
221	30	-1	1	1	1	-1	1	1	-1	-1	-1	-0.0666667
222	238	-1	1	1	1	-1	1	1	-1	-1	-1	0
223	85	1	1	1	1	-1	1	1	1	-1	1	0.5
224	130	1	1	1	1	-1	1	1	1	-1	1	0
225	82	-1	-1	-1	-1	1	1	1	-1	-1	-1	-0.491963
226	89	-1	-1	-1	-1	1	1	1	-1	-1	-1	-0.266667
227	233	1	-1	-1	-1	1	1	1	1	-1	1	0.174703
228	122	1	-1	-1	-1	1	1	1	1	-1	1	0.3
229	71	-1	1	-1	-1	1	1	1	1	1	-1	0.142957
230	68	-1	1	-1	-1	1	1	1	1	1	-1	0.333333
231	23	1	1	-1	-1	1	1	1	-1	1	1	0.365179
232	11	1	1	-1	-1	1	1	1	-1	1	1	0
233	26	-1	-1	1	-1	1	1	1	1	1	1	0.666667
234	241	-1	-1	1	-1	1	1	1	1	1	1	0
235	58	1	-1	1	-1	1	1	1	-1	1	-1	0.233333
236	179	1	-1	1	-1	1	1	1	-1	1	-1	0
237	136	-1	1	1	-1	1	1	1	-1	-1	1	0.2
238	184	-1	1	1	-1	1	1	1	-1	-1	1	0
239	35	1	1	1	-1	1	1	1	1	-1	-1	0.238195
240	101	1	1	1	-1	1	1	1	1	-1	-1	0.233333

Table 6: Treatment Values of Design of Experiment and Calculated Response Variable

Std	**Run**	**A:A**	**B:B**	**C:C**	**D:D**	**E:E**	**F:F**	**G:G**	**H:H**	**J:I**	**K:J**	**R1**
241	219	-1	-1	-1	1	1	1	1	-1	1	1	0.174703
242	25	-1	-1	-1	1	1	1	1	-1	1	1	0.5
243	174	1	-1	-1	1	1	1	1	1	1	-1	0.269941
244	145	1	-1	-1	1	1	1	1	1	1	-1	0.533333
245	20	-1	1	-1	1	1	1	1	1	-1	1	0.301687
246	42	-1	1	-1	1	1	1	1	1	-1	1	0
247	155	1	1	-1	1	1	1	1	-1	-1	-1	0.0666667
248	70	1	1	-1	1	1	1	1	-1	-1	-1	0
249	21	-1	-1	1	1	1	1	1	1	-1	-1	0.3
250	231	-1	-1	1	1	1	1	1	1	-1	-1	0
251	117	1	-1	1	1	1	1	1	-1	-1	1	0.4
252	222	1	-1	1	1	1	1	1	-1	-1	1	0
253	66	-1	1	1	1	1	1	1	-1	1	-1	0.238195
254	225	-1	1	1	1	1	1	1	-1	1	-1	0.433333
255	78	1	1	1	1	1	1	1	1	1	1	0.904862
256	190	1	1	1	1	1	1	1	1	1	1	1

General information of the model and response surfaces are as shown in Tables 7 and 8:

Table 7: General Information of the Model

File Version	11.1.2.0		
Study Type	Factorial	Subtype	Randomized
Design Type	2 Level Factorial	Runs	256
Design Model	Reduced 4FI	Blocks	No Blocks
Center Points	0	Build Time (ms)	2.00

Table 8: Response Surface Information

Response	Name	Observations	Analysis	Minimum	Maximum	Mean	Std. Dev.
R1	R1	256	Factorial	-0.866667	1	-0.0042	0.2788

Step 8: Regression is calculated for each decision maker (response surface) and the results are as follows:

$$-0.004227 + 0.042 \times A + 0.044 \times B + 0.0502244 \times C + 0.0559652 \times D + 0.0492736 \times E + 0.0856775 \times F + 0.0871036 \times G + 0.0852295 \times H + 0.104565 \times I + 0.0893117 \times J + -0.00309903 \times A \times C - 0.00443987 \times A \times I + 0.0021054 \times C \times E - 0.0102009 \times C \times F + 0.00120249 \times C \times I + 0.00288743 \times E \times F + 0.0209942 \times A \times C \times I + 0.0217955 \times C \times E \times F$$

Step 9: Analysis of variance is performed for each response surface. The result of this analysis is the significance of the model and what criteria are effective.

Analysis of variance is calculated for each response surface (decision maker) and the results are according to Table 9:

Table 9: Analysis of Variance for all Decision Makers

Source	**Sum of Squares**	**df**	**Mean Square**	**F-value**	**p-value**	
Model	13.82	18	0.7677	30.32	< 0.0001	significant
A-A	0.4521	1	0.4521	17.86	< 0.0001	
B-B	0.5031	1	0.5031	19.87	< 0.0001	
C-C	0.6458	1	0.6458	25.50	< 0.0001	
D-D	0.8018	1	0.8018	31.66	< 0.0001	
E-E	0.6215	1	0.6215	24.54	< 0.0001	
F-F	1.88	1	1.88	74.21	< 0.0001	
G-G	1.94	1	1.94	76.70	< 0.0001	
H-H	1.86	1	1.86	73.44	< 0.0001	

Table 9: Analysis of Variance for all Decision Makers

Source	**Sum of Squares**	**df**	**Mean Square**	**F-value**	**p-value**	
J-I	2.80	1	2.80	110.53	< 0.0001	
K-J	2.04	1	2.04	80.64	< 0.0001	
AC	0.0025	1	0.0025	0.0971	0.7556	
AJ	0.0050	1	0.0050	0.1993	0.6557	
CE	0.0011	1	0.0011	0.0448	0.8325	
CF	0.0266	1	0.0266	1.05	0.3061	
CJ	0.0004	1	0.0004	0.0146	0.9039	
EF	0.0021	1	0.0021	0.0843	0.7718	
ACJ	0.1128	1	0.1128	4.46	0.0358	
CEF	0.1216	1	0.1216	4.80	0.0294	
Residual	6.00	237	0.0253			
Lack of Fit	1.28	109	0.0117	0.3180	1.0000	not significant
Pure Error	4.72	128	0.0369			
Cor Total	19.82	255				

The F-Value of the model is 30.32, which indicates that the model is significant. There is only a 0.01% chance that noise or error will occur due to this large F-Value.
The P-Values less than 0.05 indicate the model conditions. In this case, A, B, C, D, E, F, G, H, J, K, ACJ, CEF are significant. Values greater than 0.1000 indicate that the model terms are not significant.

Table 10: Calculations of Analysis of Variance Indices

Std. Dev.	0.1591	R^2	0.6972
Mean	-0.0042	Adjusted R^2	0.6742
C.V. %	3764.19	Predicted R^2	0.6467
Adeq Precision			29.2253

The predicted R^2 is the value of 0.6467 that is correctly spaced from the adjusted R^2 (0.6742). This means that the difference is less than 0.2 (Table 10).
Adeq Precision measures the signal-to-noise ratio. A ratio of more than 4 is desirable. The model ratio is 29.225, which indicates the appropriate signal.
At the end, using ready-made regressions and normalized fuzzy values of the decision table, the Fuzzy SAW DOE score is obtained. The results along with the comparison with the results by fuzzy TOPSIS method are as shown in Table 11. Finally, based on the presented scores and rankings of each method, the top 10 stocks of each method are selected and after forming a stock portfolio based on the scores of the recent one-month and three-month returns, we calculate each method. The results of the combined method of Fuzzy SAW and design of experiments show significantly improved results in market turmoil conditions of the Iranian stock market (Table 12).

Table 11: Options Ranking by Fuzzy Saw DOE

Symbol	**Fuzzy Value**			**Defused value**	**Ranking of proposed method**	**Fuzzy TOPSIS ranking**
Khodro	0.127986	0.22994	0.478101	0.254308	15	9.00
Khesapa	0.116793	0.218747	0.466908	0.243115	19	13.00
Khegostar	0.131114	0.220958	0.459282	0.245705	17	14.00
Zob	0.136362	0.225133	0.4222	0.243182	18	18.00

Table 11: Options Ranking by Fuzzy Saw DOE

Symbol	Fuzzy Value			Defused value	Ranking of proposed method	Fuzzy TOPSIS ranking
Femli	0.180913	0.276402	0.430878	0.286233	5	5.00
Foolad	0.162694	0.262546	0.448	0.276813	6	6.00
Kegol	0.165824	0.249379	0.374426	0.256294	14	19.00
Kedma	0.219981	0.305515	0.411336	0.308896	2	3.00
Vebmelat	0.130353	0.244417	0.486278	0.265716	8	7.00
Vebsader	0.121032	0.217949	0.38522	0.229675	21	20.00
Vetejarat	0.143848	0.239762	0.406073	0.251495	16	16.00
Dey	0.165794	0.255441	0.39332	0.26348	10	15.00
Shepna	0.140606	0.241067	0.441175	0.257675	13	11.00
Shebandar	0.175308	0.260959	0.368326	0.264578	9	17.00
Shetran	0.1298	0.22148	0.36571	0.230238	20	21.00
Vemhan	0.202754	0.305212	0.455597	0.3132	1	2.00
Saba	0.161467	0.263516	0.425627	0.273526	7	10.00
Shesta	0.173583	0.286979	0.526222	0.307954	3	1.00
Fars	0.179029	0.270731	0.45738	0.286556	4	4.00
Petrol	0.13496	0.24845	0.44472	0.262247	12	8.00
Tapiko	0.151669	0.249053	0.425605	0.262247	11	12.00

4 Analysis and Comparison of Results

As stated, Table 9 shows the results of analysis of variance for the first response variable. The model becomes significant and the criteria of the percentage of positive days in the last 12 months, the mean value of transactions in the last 12 months, the mean number of buyers in the last 12 months, the ranking of real sales volume in the last 12 months and the ranking of legal sales volume in the last 12 months are positive and the mean number of sellers in the last 12 months, the ranking of real purchase volume in the last 12 months, the ranking of legal purchase volume in the last 12 months, percentage of negative days in the last 12 months, the company's P / E compared to the P / E of the group are significant. In other words, they are the main effects on the first response variable (fuzzy SAW scores) based on decision makers' weights.

Drawing a normal probability diagram for residues [44] is a sensible way to test a hypothesis that observations are normal. When using the T distribution, the probabilistic normal diagram of the raw data is used to test the data normalization hypothesis. In analysis of variance, doing this through residues can usually be more effective, or in other words, easier. If the residual distribution is normal, the resulting design will be a straight line. Central values should be emphasized when evaluating this design. In general, in the analysis of variance of the fixed effects model, a small deviation from the normal distribution is not a serious problem.

Table 12: Comparison of Two Methods in the Event of Reality and the Return Rate of the Selected Portfolio Based on the Ranking of Each Method

	proposed method					Fuzzy TOPSIS					Real profit and loss			
Symbol	value of proposed method	Percentage share in the portfolio	Monthly return of basket	3-month return of basket	Ranking of the proposed method	Fuzzy TOPSIS values	Percentage of shares in the portfolio 2	Monthly basket return 2	3-month return basket3	Fuzzy TOPSIS ranking	1month stock return	Ranking	3-month share return	Ranking 3
Shesta	0.308	0.109	0	-2,293,601	3	0.436	0.113	0	-2,383,097	1	0	4	-10.5	5
Vemahan	0.313	0.111	-3,154,662	-6,242,677	1	0.403	0.105	-2,978,567	-5,894,207	2	-14.2	13	-28.1	12
Fars	0.287	0.102	-869,954	-1,654,538	4	0.391	0.102	-871,290	-1,657,080	3	-4.28	6	-8.14	4
Kedma	0.309	0.110	5,427,266	32,646,855	2	0.388	0.101	4,995,580	30,050,119	4	24.77	1	149	1
Vebmelat	0.266	0.094	-857,575	-3,863,798	8	0.382	0.099	-904,961	-4,077,297	5	-4.55	7	-20.5	9
Femli	0.286	0.102	-6,030,023	-7,248,209	5	0.380	0.099	-5,870,885	-7,056,922	6	-29.7	20	-35.7	15
Foolad	0.277	0.098	-5,203,256	-6,970,399	6	0.378	0.098	-5,213,749	-6,984,457	7	-26.5	19	-35.5	14
Khodro	0.254	0.000	0	0	15	0.363	0.095	1,369,170	-9,171,925	8	7.24	3	-48.5	20
Petrol	0.262	0.000	0	0	11	0.362	0.094	-1,967,550	308,488	9	-10.46	11	1.64	3
Shepna	0.258	0.000	0	0	13	0.360	0.094	-3,315,072	-7,577,039	10	-17.68	16	-40.41	16
Saba	0.274	0.097	-3,742,602	-2,976,232	7	0.360	0.000	0	0	11	-19.29	17	-15.34	8
Khegostar	0.246	0.000	0	0	17	0.356	0.000	0	0	12	-14.8	14	-55	21
Tapico	0.262	0.000	0	0	11	0.355	0.000	0	0	13	-2.6	5	-12.6	6
Khesapa	0.243	0.000	0	0	19	0.348	0.000	0	0	14	-7.22	10	-42.7	18
Dey	0.263	0.093	3,171,555	9,675,393	10	0.341	0.000	0	0	15	16.97	2	51.77	2
Vetejarat	0.251	0.000	0	0	16	0.334	0.000	0	0	16	-5.26	8	-27.49	11
Zob	0.243	0.000	0	0	18	0.331	0.000	0	0	17	-21.1	18	-47.2	19
Kegol	0.256	0.000	0	0	14	0.329	0.000	0	0	18	-31	21	-25	10
Shebandar	0.265	0.094	-3,190,402	-6,437,106	9	0.327	0.000	0	0	19	-17	15	-34.3	13
Shetran	0.230	0.000	0	0	20	0.302	0.000	0	0	20	-12.7	12	-41.9	17
Vebsader	0.230	0.000	0	0	21	0.301	0.000	0	0	21	-7	9	-13.1	7
Total			-14,449,652	4,635,688				-14,757,325	-14,443,418					

Fig. 2 shows the normal probability diagram for the three response variables. As you can see, in all three shapes, the graph is almost a straight line, indicating that the residual distribution is normal.

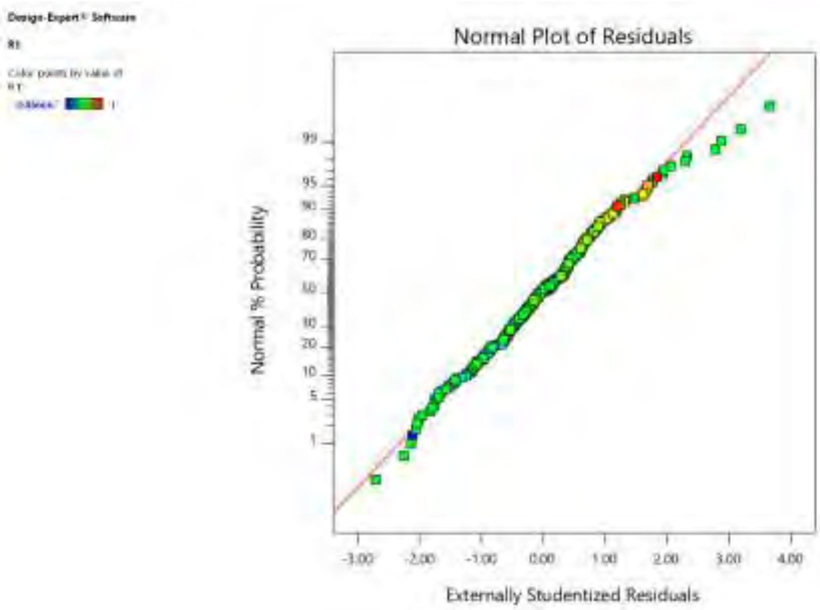

Fig. 2: Normal Probability of Residues

If the model and hypotheses are created correctly, then the residuals should not have a specific structure or have a specific relationship with other variables, including the predicted values of response surface. A speaker or funnel-like shape that indicates an increase in residual values due to an increase in prediction values proves the existence of a relationship in the structure. [44] Figure 3 shows the residual distributions relative to the predicted values for the first, second, and third variables, respectively. According to Figure 3, for both decision makers, the model is executed accurately and the analysis is correct.

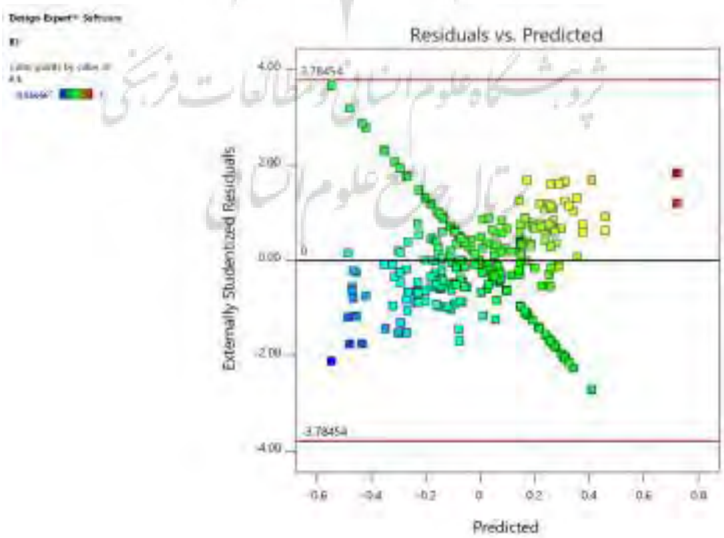

Fig. 3: Predicted Values in Terms of Residuals

After the analysis of the model accuracy, analysis of the criteria and values of each of them and their ranking can provide more comprehensive information to the decision maker. Figure 4 shows the Pareto diagram of the criteria based on the t-test.

In Pareto ranking, ranking and testing are performed based on the effect that a criterion has on the response surface variable, and this is a strength against other methods of weighting the criteria.

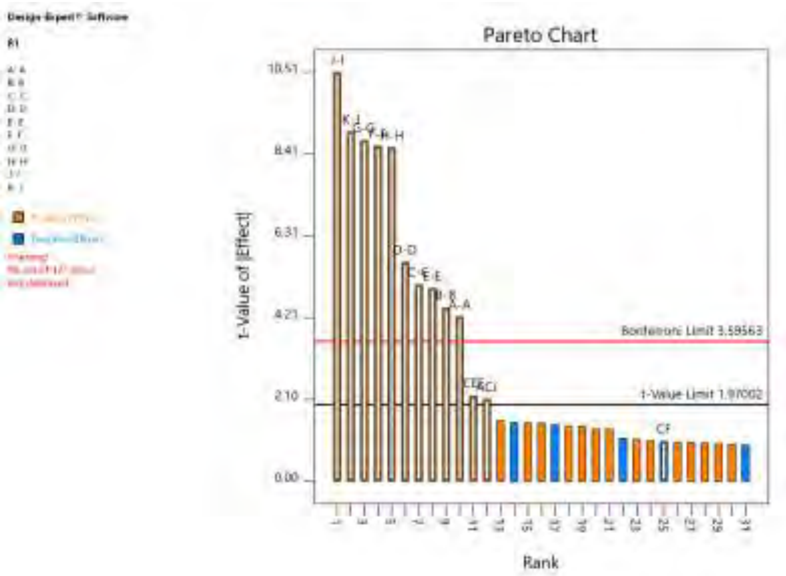

Fig. 4: Pareto Ranking Chart, the t-Value of Effects for Decision Makers

5 Conclusion

The ranking of companies in the Tehran Stock Exchange is a step towards market efficiency and is a useful guide for investors and market participants. It also increases market competition and capital market development. In this study, more than 20 most popular companies in Iran Stock Exchange were selected and 10 criteria related to the stock's foundation as well as the criteria of return and value of stock transactions were considered. The study aimed at determining the correctness of the selected criteria for decision making and also examining and analyzing the sensitivity of the criteria and their ranking as well as the ranking of stocks based on the value obtained. Therefore, in order to satisfy such an analysis, it was necessary to use a more complete method than general decision-making methods. Consequently, the new and innovative SAW method was used in a fuzzy environment in combination with the design of 2k factorial design experiments.

As previously mentioned, the case study was solved once by fuzzy TOPSIS method and once by Fuzzy SAW method combined with design of experiments and compared, which due to considering and discovering other factors influencing the final result, more accurate results were obtained in solving by the proposed method. Using the design of experiment method along with the fuzzy SAW method has many advantages, including the possibility of discovering the relationship between decision makers' weights and thus discovering the effect of criteria on each other (see table 9), having no need to recalculate the steps of decision models if a new option was added (see table 6 – Consider all possible options) , ranking the criteria (see figure 4), discovering the criteria that were not selected correctly and having little effect on the final response, and analyzing the sensitivity of model solving by increasing or decreasing the mentioned number of surfaces and experiments. These advantages will make the fuzzy SAW method more practical and effective than all MCDM methods.

The model was solved by the proposed method with R2 value of 0.7 for the response surface of decision makers. Then, it was ranked according to the response surface method. The combination of the fuzzy SAW model with the design of experiments provided very good strengths. If a new option was added to our model, there was no need to re-solve the fuzzy SAW and the ranking was carried out easily.

Experiments have shown us that the effects of which criteria on the response surface of each decision maker were significant and that the elimination or non-consideration of which criteria does not affect the model and the choice of appropriate strategy, and what other criteria were related and help to make the right decision. Finally, we compared the results of the proposed model with fuzzy TOPSIS method in the event of a reality (1-month and 3-month intervals) in the Iranian stock market at the end of October 1999. The rankings were slightly close to each other and the results of the proposed model show that this method of decision-making had a significant advantage over fuzzy TOPSIS, and the capabilities of sensitivity analysis and consideration of all effective parameters by the proposed model were very useful. For future studies, it is suggested that the authors develop the method proposed in this paper and examine the combination of experimental design method with other decision-making methods. In designing experiments, some methods are proposed to solve faster without creating a reduction in response quality, which is suggested to develop these methods to simplify the proposed model as much as possible.

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