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Comparative Evaluation of the Performance of Selected Portfolios Based on AHP and TOPSIS Multi-Criteria Decision-Making Techniques with Markowitz Mean-Variance Model

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ABSTRACT

In this research, using Analytic Hierarchy Process (AHP) and TOPSIS method (TOP) based on financial criteria, earnings per share, dividend per share, operating cash flow growth, earnings per share growth, beta (systematic) risk, volatility Operating profit, stock liquidity and price-to-earnings ratio selected according to the opinions of investment experts, formed a portfolio. Then, the criteria for evaluating the performance of risk-adjusted portfolios according to modern portfolio theory (Sharp, Trainer and Alpha Jensen) were calculated based on monthly stock prices during the 5-year period from 2015 to 2019 and compared with the criteria for evaluating portfolio performance according to Markowitz model. The results showed that the selection of stock portfolio using the mentioned financial criteria and using the Analytic Hierarchy Process (AHP) model leads to the acquisition of adjusted returns with more risk than the Markowitz optimization model and the TOPSIS model.

1 Introduction

The main purpose of choosing a portfolio is to choose the best combination of financial assets and the highest expected return; while providing an acceptable level of risk. Choosing a portfolio can be classified as one of the risky decisions [16]. Much research has been done on how to choose the right stock portfolio. Markowitz is one of the pioneers in this field with his theory of stock portfolio analysis based on the mean-variance formula. After him, based on his research, researchers proposed new methods for doing so [26]. In choosing his standard portfolio, Markowitz assumes that all investors make their choices based on two criteria: return and risk. However, the investor usually uses conflicting goals such as return, risk and liquidity when selecting a portfolio [22]. In recent decades, the development of new techniques in operational research and management science in parallel with advances in computer science and information technology has led to the emergence of new models for stock portfolio selection. Many researchers use multi-criteria decision making methods to select a portfolio [26]. Multi-criteria decision making is a set of methods that help a person to prioritize the items under consideration using

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several factors. Hierarchical analysis (AHP) is one of the most common methods in multi-criteria decision making that examines complex issues based on interactions and reflects them simply. Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is another multi-criteria decision-making method in which quantitative and qualitative criteria are involved simultaneously, ranking options based on the proximity of the distance to the positive ideal and the distance from the negative ideal [5].

2 Theoretical Foundations and Literature Review

Most investors attach their wealth to stock exchange markets, and most prefer combinations of different stocks since single stocks carry inherent risks. Portfolio selection aims to assess a combination of securities from a large quantity of available alternatives. It aims to maximize the investment returns of investors [23]. The issue of choosing the optimal stock portfolio is an issue that is always faced by all investors, both individual and Institutional. The issue of stock selection involves creating a stock portfolio that maximizes investor utility. The method of creating such a portfolio has always occupied the minds of financial researchers and analysts [19]. There are some literatures to handle the stock portfolio decision problem. Markowitz proposed the mean-variance method for the stock portfolio decision problem in 1952. In his method, an expected return rate of a bond is treated as a random variable. Stochastic programming is applied to solve the problem. According to Markowitz [33], investors must make a trade-off between return maximization and risk minimization. Investors can maximize the return for a considered risk level, or they can focus on risk minimization for a predetermined level of return [21]. In Markowitz [33] stock portfolio selection approach, stock portfolio selection criteria were reduced to only two criteria of risk-taking (variance) and average return. According to this approach, the balance between risk-taking and returns of stock portfolio components is important in forming a portfolio [6]. Markowitz defined stock portfolio variance as a weighted sum of stock variances and covariance's within the portfolio and showed that portfolio diversification could reduce its risk [19]. In Markowitz [33] model, risk is measured by the variance of historical returns and assuming a normal distribution of expected stock returns [22]. In his portfolio selection theory, Markowitz assumes that all investors make their choices based on both risk and return criteria. Many studies, however, have criticized the ignorance of other investor preferences in the Markowitz model.

Typically, the investor pursues conflicting preferences and goals such as return, risk, liquidity, etc. in the issue of stock portfolio selection [26]. Thus, one of the criticisms of Markowitz's model is that he uses only two criteria, risk and return, in his theory to select a portfolio. Also, among all the criticisms of the modern portfolio model, that variance is not the correct measure of risk, and that the mismatch of the return on assets with the normal distribution is even more important. Because two categories of appropriate criteria for measuring risk and distributing returns play a key role in selecting the optimal portfolio. On the other hand, with increasing uncertainty in complex economic environments, the use of statistical indicators to achieve acceptable results seems insufficient. Also, investing in a portfolio is not a linear, one-dimensional decision-making process, but a multi-criterion decision-making (MCDM) issue. A successful decision maker is one who examines the subject matter from different angles and uses several criteria simultaneously and simultaneously. Multi-criteria decision-making approaches make this possible for investors. The most frequently used and well known method for weighting of different criteria is the analytical hierarchy process method (AHP). The AHP method was introduced by Tomas Saaty (1980) and is widely employed in different multi-criteria decision-making areas. Following the hierarchy formation, the criteria are ranked via paired comparisons. The advantage of a

paired comparison is that the decision-maker deals with the prioritization of only two options under comparison, irrespective of the other options [13]. The AHP is a logical multi-criteria decision-making technique that allows decision makers to model a complex problem based on mathematics and psychology, helping in the choice and justification. It is defined as an approach to decision making that involves criteria structured in hierarchy [18]. In fact, that is a measurement method via pair-wise comparisons and relies on the judgments of experts to derive priority scales. It has been used by several researchers and decision makers due to mathematical properties of the method. In fact, the hierarchical structure of AHP methodology is able to provide a comprehensive framework for making multi-criteria decisions by organizing problems into a hierarchical structure [21]. As to the advantages of the AHP, it can help an investor easily select investment stocks while simultaneously considering multiple financial indexes and arbitrarily altering their relative importance according to an individual's preferences based on financial reports [15]. Also the TOPSIS method is developed by Hwang and Yoon [34], which is one of the well-known MCDM methods. The basic idea of TOPSIS is that the chosen alternative should have the shortest geometric distance from the ideal solution and the longest geometric distance from the anti-ideal solution [12]. The TOPSIS method simultaneously considers the distance between the positive ideal and the negative ideal solution Considers alternatives and chooses the closest relative proximity to the ideal solution as the best alternative. A comparative advantage for TOPSIS is its ability to quickly identify the best alternative [24]. TOPSIS is capable of ranking the companies' performance by using financial ratio as the evaluation criteria. Financial ratios are important tool to predict the performance of a company [11]. Based on the above, this study intends to compare the performance of the selected portfolio using the Markowitz model based on risk and return with the performance of the selected portfolio by AHP and TOPSIS based on variables. Evaluate and compare finance. Studies have shown that some of the studies that are directly or indirectly related to the subject of the present study and somehow examine and evaluate, are as follows:

Safari et al. [25] in a study selected the optimal stock portfolio using experimental modelling and hierarchical analysis process. Calculation and data of 10 companies from the top 30 companies of Tehran Stock Exchange were used in the model. Using SPSS and LINGO software, statistical data analysis and model solving were performed. According to the results, the ideal planning model offers more returns to the investor compared to the Markowitz model. Also, based on the volatility reward ratio, stock portfolio selection based on dividends is preferable to economic value added. Heibati et al. [15] in a study evaluated the stock portfolio selection model using the Analytic Hierarchy Process (AHP). In this study, among the companies listed on the Tehran Stock Exchange, based on investment criteria based on expert opinions, several companies were selected and the required information per share was calculated. Then, using gray relational analysis, the selected companies were prioritized and finally, according to the priorities and aspirations of the investor, ideal planning was used and a model for selecting the optimal portfolio was presented. Based on this model, a portfolio of stocks was formed and its performance was compared with the market portfolio using a statistical test. The results of this study indicate that in the study period, the average performance of the portfolio obtained from the research model is much higher than the market portfolio and the portfolio of the top 50 companies. Pakizeh and FallahTalab [22] in a study used a fuzzy multi-criteria decision approach in stock valuation and portfolio formation. In their research, they used a hierarchical method to determine the weight of criteria according to the priorities of the two investors. The results show that the expected annual rate of return of the portfolio formed by the above method is higher than the return of the Tehran Stock Exchange index during 2010. Amiri et al. [2] in a study using TOPSIS and AHP methods to select the optimal stock

portfolio of the top 40 companies of the Stock Exchange Organization in the years 2006-2008. In this study, 4 categories of criteria are: profitability cluster (including criteria of return on assets, return on equity, net profit margin, operating profit margin, earnings per share) growth cluster (including income growth rate, net profit growth rate, rate They used earnings per share, sustainable growth rate), risk clusters (including business risk, financial risk, systematic risk) and market clusters (including market value to book ratio, price-to-earnings ratio, dividend-to-earnings ratio).

In this study, the weight of the criteria was calculated using the network analysis process method and ranked using the companies' TOPSIS. The empirical findings of this study show that companies with lower ratings have experienced better performance. Abzari et al. [1] in their research entitled "Study of effective criteria on stock selection in Tehran Stock Exchange based on AHP hierarchical analysis process model to study the criteria affecting stock selection in the stock market from the perspective of investment companies' experts based on chain analysis process model" He has paid a lot. The results of their research show that dividend per share has the most important role from the perspective of experts in stock selection. Chen and Pan [8] proposed a method for portfolio selection based on a combination of fuzzy and promethee hierarchical analysis process. The results show that the mentioned method reduces the complex calculations of the fuzzy hierarchical analysis method and obtains more reasonable results. In a study using the TOPSIS technique, Jenani et al. [17] investigate the factors affecting portfolio selection in the Tehran Stock Exchange over a period of five years. The findings of this study indicate that the variables of dividend ratio, systematic risk, transaction volume and price-to-income ratio are the variables affecting portfolio selection. Lee et al. [20] identified a combination of multi-criteria decision making (MCDM) techniques for stock selection based on Gordon's model point of view, criteria affecting stock prices. In this study, they extracted the criteria affecting the three key elements of the Gordon model according to a review of the research literature. Criteria affecting the three main criteria of the Gordon model (projected dividends, discount rate and growth rate) including industry outlook, revenues, operating cash flow, dividend pay-out ratio, market beta, risk-free returns, revenue growth rate and earnings growth rate They were divided.

In a study called "Selecting a Portfolio Based on Financial Power Index Using Data Envelopment Analysis," Edirisinghe et al. [9] used a series of financial ratios to estimate companies' financial strength and correlate these metrics with actual stock returns. The financial ratios used in this study are divided into 6 categories, which include profitability criteria including return on capital, return on assets, net profit margin, earnings per share, operational efficiency criteria including accounts receivable turnover, inventory turnover, asset turnover. Liquidity criteria including current ratio, instantaneous ratio and debt to equity ratio, leverage criteria including leverage ratio, total debt to total assets ratio, total debt to equity ratio, company outlook criteria including price to income ratio and value ratio Market by book and growth metrics include earnings growth rate, net profit growth rate and earnings per share growth rate. Ertugrul and Karakasoglu [10] evaluated the performance of Turkish cement companies using fuzzy hierarchical analysis and TOPSIS method. They stated that the purpose of this study was to create a fuzzy model to evaluate the performance of firms using financial ratios. The FAHP method was used to determine the weight of criteria by decision makers and then the final ranking was done by TOPSIS method.

3 Research Methodology and Hypotheses

This research has three hypotheses as follows:

Hypothesis 1: The performance of the selected portfolio based on the Analytic Hierarchy Process (AHP)

model and the selected portfolio based on the Markowitz model are significantly different.
Hypothesis 2: The performance of the selected portfolio based on the TOPSIS model and the selected portfolio based on the Markowitz model are significantly different.
Hypothesis 3: The performance of the selected portfolio based on the Analytic Hierarchy Process (AHP) model and the selected portfolio based on the TOPSIS model are significantly different.
Since the present study intends to present a new model using financial variables based on multi-criteria decision-making methods to form a portfolio and the results will be usable in the field of practice and investment analysis, so in terms of the goal is practical. In this study, because the data collected is related to events that have occurred in the past, it is a retrospective study in terms of time and due to the use of quantitative data of the quantitative research type. This research is inductive because it leads to a general conclusion through analysis and inference from observations. Also, this research is descriptive based on its nature. The library method is used to formulate the theoretical foundations and research background, and the field research method is used to select the financial indicators affecting the selection of stocks and to determine the relative importance (weight) of the mentioned indicators. Also, to collect model data to test hypotheses, the documentary method of announcements and reports published on the Codal site will be used. In order to collect the theoretical foundations and research background and financial data, the Fish tool has been used and to collect the opinions of experts, a questionnaire has been used. In order to perform calculations and prepare data and information required for the research, Excel 2016, TOPSIS 2005, Expert choice11 and MATLAB 2013 software were used and SPSS25 software was used for statistical analysis of research data.
In this study, in terms of easier access to information of companies listed on the Tehran Stock Exchange and the high reliability of information, the statistical population includes all companies listed on the Tehran Stock Exchange in 2015 until the end of 2019. To determine the statistical sample, a targeted (systematic) elimination method will be used and for this purpose, those companies of the statistical community that have the following conditions will be selected as a statistical sample and the rest will be removed:

- Has been listed on the Tehran Stock Exchange since the beginning of 2009.
- The financial year of the company is the end of March of each year.
- Has not changed activity or changed fiscal year during the research period.
- To be present in the stock exchange continuously during the research period.
- Their financial information is available for the entire period under review.
- The company's shares in each of the years of the research period should not have a trading interval of more than three months.

After applying the above restrictions on the statistical population, 171 companies were selected as the statistical sample.

4 Research modelling

First, by studying the theoretical foundations and research background, 15 financial criteria were selected that are expected to potentially influence the investor's decision to select stocks to form a portfolio. Then, by distributing a questionnaire among 20 investment experts, 8 financial criteria that had an average of at least 3 according to the scores by the respondents based on a 5-point Likert scale, including earnings per share (EPS), dividends per share (DPS), operating cash flow growth (CFGRO), growth Earnings per share (EPSGRO), beta (systematic) risk (BETA), operating profit volatility (OPVOL),

stock liquidity (LIQU) and price-to-earnings ratio (PE) were selected as financial criteria for ranking and selecting stocks of companies in the portfolio. Then, according to multi-criteria decision-making methods including TOPSIS methods and hierarchical analysis (AHP), companies' stocks were ranked and weighted for placement in the portfolio.To select stocks to form a portfolio according to TOPSIS method, first data related to 8 financial criteria selected by investment experts from the databases of companies listed on the Tehran Stock Exchange for a period of 5 years from 2009 to 2013 were collected and in Excel software, the trend or their average was calculated.

Then, through TOPSIS 2005 software, decision matrices are formed and earnings per share, dividend per share, operating cash flow growth, earnings per share growth, stock liquidity and price-to-earnings ratio as positive indicators and indicators. Beta (systematic) risk and operating profit volatility were defined as negative indicators in the matrix. In the TOPSIS process first Create an evaluation matrix consisting of m alternatives and n criteria, with the intersection of each alternative and criteria given as $x_{i,j}$, we therefore have a matrix $(x_{i,j})$ m*n . then matrix $(x_{i,j})$ m*n normalized to form the matrix R= $(x_{i,j})$ m*n , using the normalization method and determine the worst alternative and the best alternative. For rank the alternatives we calculate the distance between the target alternative and the worst condition and best condition. In this way there making a number of options and the number of criteria to decide who should be the criteria, the rating option, or performance to be allocated to each of them a score. One of these options is a collection of the best values observed in the decision matrix. The ideal option called positive (best possible) call. While one option is defined assumption that the worst conditions possible. The ideal option is negative. Benchmark scores on TOPSIS is an option as possible ideal option close positive and negative is far from ideal option. Accordingly, a score is calculated for each option and options are ranked according to the scores [3]. In this research, through Shannon entropy method, the weight of each index is determined and finally, the output of TOPSIS 2005 software presents the relative proximity index (Cl_i^*) of the negative ideal option of each option (stock) and is ranked according to the descending order of the relative proximity index (Cl_i^*) of companies. The first 40 companies were selected as the top companies to form a portfolio. The reason for selecting the first 40 companies is that according to previous research (Gupta 1981 [14], Tang 2004 [27], Bandari and Talaizadeh 2014 [4]) with a portfolio of 40 shares, the non-systematic risk is almost zero and further diversification is not necessary. The following normalization method was used to determine the percentage of each stock in the portfolio.

$$w_i = \frac{Cl_i^*}{\sum_{i=1}^{n} Cl_i^*} \tag{1}$$

Equation (1) is:

Cl_i^*= relative proximity index i stock

w_i= stock weight i in the stock portfolio

In the next step, the portfolio is formed based on selected stocks and percentages determined according to TOPSIS method and based on monthly stock prices during the 5-year period 2015 to 2019 using MATLAB 2013 software, risk and return of each portfolio and then criteria. Risk-adjusted portfolio performance evaluation was measured according to modern portfolio theory (Sharp, Trainer and Jensen Alpha). Also for selecting stocks to form a portfolio according to the Analytic Hierarchy Process (AHP) from data related to 8 financial criteria selected by investment experts from the databases of companies listed on the Tehran Stock Exchange for a period of 5 years 2009 to 2013 has been collected, has been

used. In the Hierarchical Analysis (AHP) method, first, the Group Hierarchy Analysis (GAHP) approach was used by distributing a pairwise comparison questionnaire among 20 investment experts to determine the degree of relative importance or weight of different pair criteria in determining the top stocks. Investment experts were asked to compare the criteria set in the first phase of the research, by assigning numerical scores (1 to 9), which indicate the preference or importance between the two criteria. Then, using the geometric mean, the average scores related to the opinions of experts regarding the preference or importance between the two elements of the decision were calculated and entered in the matrix of pairwise comparisons in the Expert choice11 software, which is described in Fig. 1.

Compare the relative cost with respect to: Goal: STOCK RANKING CRITERIA

ESP	DPS	CFOGR	EPSGR	B	OPVOL	LIQU	P/E
	4.0	8.0	(4.0)	4.0	3.0	4.0	(4.0)
		6.0	(6.0)	2.0	2.0	2.0	(9.0)
			(9.0)	(3.0)	(3.0)	(2.0)	(8.0)
				8.0	8.0	7.0	3.0
					(2.0)	(3.0)	(9.0)
						2.0	(9.0)
							(9.0)
Incon: 0.07							

Fig.1: Matrix of pairwise comparisons
Source: research findings

Then, Expert choice11 software calculates the total weight vector by normalizing the pairwise comparison matrix and calculating the special vector and multiplying both in each other, and then calculates the final score of each index by dividing the total weight vector by the special vector and merging relative weights. And ranks the indicators. Finally, the compatibility rate of the pairwise comparison matrix is determined, which indicates the extent to which the priorities obtained from the comparisons can be trusted. As shown in Figure 1 for the pairwise comparison matrix, the mismatch rate for the pairwise comparisons of the indices are 0.07, and since it is less than 0.1, the rate is acceptable and indicates that the pairwise comparisons of the indices, Has compatibility and reliability. Finally, the output of Expert choice11 software presented the ranking and the relative importance of the effective indicators in stock selection, which have been done through pairwise comparisons by investment experts, as shown in Fig. 2.

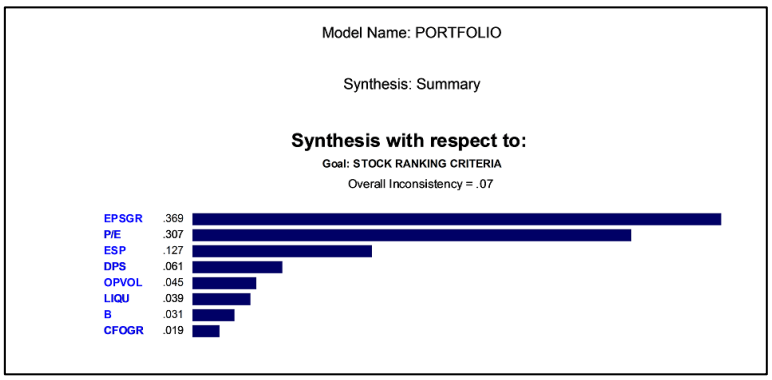

Fig.2: Ranking and importance of indicators
Source: research findings

As shown in Figure 2, the earnings per share growth (EPSGR) has the highest relative importance

weight of approximately 0.37 and the operating cash flow growth (CFGRO) has the lowest relative importance weight of approximately 0.02. Be. In the next step, the weights of the effective indicators in stock selection, which are the result of Analytic Hierarchy Process (AHP) as shown in Figure 2, in the ratio of variables obtained from data related to a 5-year period from 2009 to 2014, each company to the total sample. Statistically multiplied and one point is obtained for each company, which is in fact the weighted average of the 8 stock selection indices. Then the companies were ranked in descending order based on the score (weighted average of 8 indices) and the first 40 companies with the highest score were selected as the top companies to form a portfolio and according to the ratio of each company to the total score top 40 companies, stock percentage was calculated to form a portfolio. After ranking, the top-ranked stocks (first 40 shares) are selected to form the proposed model portfolios. To determine the amount of investment in each of the stocks of the proposed model portfolios, first the Competitive Relative Position Index (CRPI) for each stock is defined as follows:

$$CRPI_i = \frac{R_i - min\, R}{max\, R - min\, R} \tag{2}$$

Equation (2) is:

R_i= stock i rank among the top rated stocks (first 40 shares)

min R= Lowest ranking among top rated stocks (40th rank)

max R= Highest ranking among top rated stocks (Rank 1)

The higher the competitive relative position index (CRPI) of a stock, the greater its ability to compete with other stocks in order to be in the portfolio [7]. After determining the number of top ranking stocks to be included in the portfolio, the amount of investment per share can be calculated as follows:

$$W_i = \frac{CRPI_i}{\sum_{i=1}^{n} CRPI_i} \tag{3}$$

Equation (3) is:

W_i= Stock weight i in stock portfolio

In the final stage of forming the portfolios of the research, first the end-of-month stock prices of 171 statistical sample companies during the 5-year period from 2015 to 2019 were collected and the monthly stock returns of the companies in each year were calculated separately. Then, according to the monthly return, the geometric average annual return of each stock during the 5-year period from 2015 to 2019 is calculated and entered into MATLAB13 software and coded by portfolio optimization according to the average-variance Markowitz model and by forming 50 portfolios with Considering the covariance between the returns of each pair of stocks in the portfolios and the different weights, the Markowitz efficient frontier was drawn and the optimal portfolio was selected using the Sharp criterion. The general form of the Markowitz optimization model is as follows:

$$Minimize \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{ij} \tag{4}$$

Subject to:

$$\sum_{i=1}^{n} w_i \mu_i = R^*$$

$$\sum_{i=1}^{n} w_i = 1 \rightarrow 0 \le w_i \le 1 \rightarrow i = 1, 2, ..., n$$

Equation (4) is:

σ_{ij} : Covariance of stocks i and j
w_j, w_i : Stock weight i and j
μ_i : Average stock returns i
R : A certain level of efficiency

The Markowitz model is based on the following assumptions: Investors are risk averse and have expected incremental utility, and the final utility curve of their wealth is declining. Investors choose their portfolio based on expected mean-variance returns. Therefore, their indifference curves are a function of the expected rate of return and variance. Every investment option is infinitely divisible. Investors have a time horizon and this is the same for all investors. Investors prefer a higher return on a given level of risk, and on the other hand, investors consider two factors in their choice [28]. After calculating the annual performance evaluation criteria (Sharp, Trainer and Jensen alpha) for the years 2015 to 2019 for each portfolio in three models TOPSIS, Analytic Hierarchy Process (AHP) and Markowitz Mean-variance model During the research period, the annual performance of each portfolio was compared with the performance of the portfolios formed according to the other two models separately using appropriate statistical methods and SPSS25 software.

5 Data analysis

5.1 Descriptive statistics

Table 1 shows the descriptive statistics of the research variables, which include information about the central indicators (average) and the dispersion index (maximum, minimum and standard deviation).

Table 1: Descriptive statistics of research variables

Descriptive Statistics									
		EPS	DPS	CFGRO	EPSGRO	BETA	OPVOL	LIQU	PE
N	Valid	171	171	171	171	171	171	171	171
	Missing	0	0	0	0	0	0	0	0
Mean		.0887	.1332	.2193	.0466	.4047	.0840	176.2939	6.3750
Std. Error of Mean		.01220	.00576	.43451	.25060	.04320	.00463	5.54611	.93198
Median		.1140	.1290	.2790	.1000	.3280	.0610	188.3330	5.7170
Std. Deviation		.15950	.07527	5.68191	3.27697	.56492	.06052	72.52477	12.18719
Variance		.025	.006	32.284	10.739	.319	.004	5259.842	148.528
Minimum		-.83	.00	-44.52	-21.58	-.73	.01	10.20	-85.55
Maximum		.33	.42	38.92	21.82	2.31	.28	349.00	64.36

Source: research findings

The main central indicator is the average, which indicates the equilibrium point and center of gravity of the distribution, and is a good indicator to show the centrality of the data. For example, the average earnings per share (EPS) is -0.887 - the closing price of companies' shares. Dispersion parameters are also a criterion for determining the degree of dispersion of data from each other or their degree of dispersion relative to the mean. One of the most important scattering parameters is the standard deviation. Among the research variables, operating profit volatility (OPVOL) has the lowest and stock liquidity (LIQU) has the highest scatter.

5.2 Inferential statistics

Given that the main purpose of this study is to compare the average adjusted return with the risk of selected portfolios according to TOPSIS models, Analytic Hierarchy Process (AHP) and Markowitz

mean-variance, so if the criteria are normal, Performance evaluation according to modern portfolio theory (Sharp, Trainer and Jensen alpha criteria) used parametric test to compare the mean of two independent samples (t of two independent groups) and if the variables were not normal, he used non-parametric Mann–Whitney U test. Therefore, first the normality of performance evaluation criteria of portfolios are checked through Kolmogorov-Smirnov and Shapiro-Wilk tests and then the appropriate method is selected.

Table 2: Test the normality of portfolio performance evaluation criteria

Tests of Normality							
	MODEL	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
RVAR	TOPSIS	.255	5	.200*	.938	5	.649
	AHP	.316	5	.114	.851	5	.197
	Markowitz	.203	5	.200*	.936	5	.636
RVOl	TOPSIS	.302	5	.154	.853	5	.205
	AHP	.311	5	.130	.815	5	.107
	Markowitz	.302	5	.154	.853	5	.205
Alpha	TOPSIS	.240	5	.200*	.958	5	.794
	AHP	.209	5	.200*	.941	5	.675
	Markowitz	.334	5	.072	.802	5	.085
*. This is a lower bound of the true significance.							
a. Lilliefors Significance Correction							

Source: research findings

Table 3: t-test of performance evaluation criteria of Hierarchical Analysis Model (AHP) and Markowitz model portfolios

Group Statistics					
	MODEL	N	Mean	Std. Deviation	Std. Error Mean
RVAR	AHP	5	.2731753	.17082804	.07639662
	Markowitz	5	.0276004	.12221830	.05465769
RVOl	AHP	5	.0110687	.01347343	.00602550
	Markowitz	5	-.0138635	.00269093	.00120342
Alpha	AHP	5	.078520	.0358049	.0160124
	Markowitz	5	-.013331	.0659557	.0294963

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
RVAR	Equal variances assumed	1.438	.265	2.614	8	.031	.24557491	.09393565	.02895891	.46219091
	Equal variances not assumed			2.614	7.245	.034	.24557491	.09393565	.02496466	.46618516
RVOl	Equal variances assumed	3.161	.113	4.058	8	.004	.02493221	.00614450	.01076296	.03910146
	Equal variances not assumed			4.058	4.319	.013	.02493221	.00614450	.00835741	.04150700
Alpha	Equal variances assumed	4.538	.066	2.737	8	.026	.0918509	.0335623	.0144561	.1692457
	Equal variances not assumed			2.737	6.169	.033	.0918509	.0335623	.0102698	.1734320

Source: research findings

Given that in Table 2 the significance level of the Kolmogorov-Smirnov and Shapiro-Wilk test statistics

is more than 0.05, the null hypothesis that the variables are normal will not be rejected with 95% confidence and the result will be distributed. Criteria for evaluating the performance of portfolios are normal. Therefore, to compare the performance of portfolios in the three groups, the parametric test of comparing the mean of two independent samples (t of two independent groups) should be used. The results of the test comparing the means of two independent samples (t of two independent groups) to test the first hypothesis are as shown in Table 3. As can be seen in Table 3, the value of the significance level of Levin test F statistic for the three performance evaluation criteria in the two models is greater than 0.05, so the null hypothesis that the Variance is equal in the two societies will not be rejected with 95% confidence. And it follows that the variance of the two societies is equal.

Table 4: T-Test Performance Evaluation Criteria for TOPSIS Portfolios and Markowitz Model

Group Statistics					
	MODEL	N	Mean	Std. Deviation	Std. Error Mean
RVAR	TOPSIS	5	-.4032815	.57890393	.25889371
	Markowitz	5	.0276004	.12221830	.05465769
RVOl	TOPSIS	5	-.0138635	.00269093	.00120342
	Markowitz	5	-.0138635	.00269093	.00120342
Alpha	TOPSIS	5	-.032400	.0775146	.0346656
	Markowitz	5	-.013331	.0659557	.0294963

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
RVAR	Equal variances assumed	1.977	.197	-1.628	8	.142	-.43088184	.26460048	-1.04105165	.17928797
	Equal variances not assumed			-1.628	4.356	.173	-.43088184	.26460048	-1.14245478	.28069110
RVOl	Equal variances assumed	.000	1.000	.000	8	1.000	.00000000	.00170189	-.00392458	.00392458
	Equal variances not assumed			.000	8.000	1.000	.00000000	.00170189	-.00392458	.00392458
Alpha	Equal variances assumed	.017	.900	-.419	8	.686	-.0190691	.0455163	-.1240299	.0858917
	Equal variances not assumed			-.419	7.800	.687	-.0190691	.0455163	-.1245000	.0863618

Source: research findings

Therefore, the results of the comparison test of the mean of two independent samples (t of two independent groups) will be considered assuming equal variance of the two communities. Considering that the level of significance of the test statistic comparing the mean of two independent samples (t of two independent groups) with the assumption of equal variance of the two communities for the three performance evaluation criteria is less than the level of error accepted by the research is 0.05, so hypothesis H_0 is rejected. It is concluded that the average criteria for evaluating the performance of portfolios in the two models of Analytic Hierarchy Process (AHP) and Markowitz are not equal and the average

criteria for evaluating the performance of portfolios over 5 years in the Analytic Hierarchy Process (AHP) model Is larger from Markowitz model. Therefore, the first hypothesis of the research is confirmed at 95% confidence level. The results of the test comparing the means of two independent samples (t of two independent groups) to test the second hypothesis are as shown in Table 3.

Table 5: of t-test Evaluation criteria for portfolios of Analytic Hierarchy Process (AHP) and TOPSIS model

Group Statistics					
	MODEL	N	Mean	Std. Deviation	Std. Error Mean
RVAR	TOPSIS	5	-.4032815	.57890393	.25889371
	AHP	5	.2731753	.17082804	.07639662
RVOl	TOPSIS	5	-.0138635	.00269093	.00120342
	AHP	5	.0110687	.01347343	.00602550
Alpha	TOPSIS	5	-.032400	.0775146	.0346656
	AHP	5	.078520	.0358049	.0160124

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
RVAR	Equal variances assumed	1.319	.284	-2.506	8	.037	-.67645675	.26993036	-1.29891727	-.05399623
	Equal variances not assumed			-2.506	4.691	.057	-.67645675	.26993036	-1.38429177	.03137827
RVOl	Equal variances assumed	3.161	.113	-4.058	8	.004	-.02493221	.00614450	-.03910146	-.01076296
	Equal variances not assumed			-4.058	4.319	.013	-.02493221	.00614450	-.04150700	-.00835741
Alpha	Equal variances assumed	1.135	.318	-2.905	8	.020	-.1109200	.0381851	-.1989750	-.0228650
	Equal variances not assumed			-2.905	5.633	.029	-.1109200	.0381851	-.2058531	-.0159869

Source: research findings

As can be seen in Table 4, the significance level of Levin test F statistic for the three performance evaluation criteria in the two models is greater than 0.05, so the null hypothesis of equality of variance in the two populations with 95% confidence will not be rejected. And it follows that the variance of the two societies is equal. Therefore, the results of the comparison test of the mean of two independent samples (t of two independent groups) will be considered assuming equal variance of the two communities. Considering that the significance level of the test statistic comparing the mean of two independent samples (t of two independent groups) with the assumption of equal variance of the two communities for the three performance evaluation criteria is greater than the error level accepted by the research, i.e. 0.05, so hypothesis H_0 is not rejected. It is concluded that the average criteria for evaluating the performance of portfolios over 5 years is equal in the two models of TOPSIS and Markowitz. Therefore, the second hypothesis of the research is not confirmed at the 95% confidence level. The results of the test comparing the means of two independent samples (t of two independent groups) for testing the third hypothesis are described in Table 5. As can be seen in Table 5, the significance level of Levin test F

statistic for the three performance evaluation criteria in the two models is greater than 0.05, so the null hypothesis that the variance of the variables is equal in the two societies will not be rejected with 95% confidence. And it follows that the variance of the two societies is equal. Therefore, the results of the comparison test of the mean of two independent samples (t of two independent groups) will be considered assuming equal variance of the two communities. Considering that the level of significance of the test statistic comparing the mean of two independent samples (t of two independent groups) with the assumption of equal variance of the two communities for the three performance evaluation criteria is less than the level of error accepted by the research is 0.05, so hypothesis H_0 is rejected. It is concluded that the average criteria for evaluating the performance of portfolios in the two models of Analytic Hierarchy Process (AHP) and TOPSIS model are not equal and the average criteria for evaluating the performance of portfolios over 5 years in the Hierarchical Analysis Model (AHP) of TOPSIS model is larger. Therefore, the third hypothesis of the research is confirmed at 95% confidence level.

Table 6: Analysis of Variance (ANOVA)

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
RVAR	Between Groups	1.173	2	.586	4.638	.032
	Within Groups	1.517	12	.126		
	Total	2.690	14			
RVOl	Between Groups	.002	2	.001	15.856	.000
	Within Groups	.001	12	.000		
	Total	.003	14			
Alpha	Between Groups	.035	2	.018	4.532	.034
	Within Groups	.047	12	.004		
	Total	.082	14			

Table 7: TUKEY test

Multiple Comparisons							
Tukey HSD							
Dependent Variable	(I) MODEL	(J) MODEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
RVAR	TOPSIS	AHP	-.67645675*	.22487012	.027	-1.2763796	-.0765339
		Markowitz	-.43088184	.22487012	.176	-1.0308047	.1690410
	AHP	TOPSIS	.67645675*	.22487012	.027	.0765339	1.2763796
		Markowitz	.24557491	.22487012	.537	-.3543479	.8454977
	Markowitz	TOPSIS	.43088184	.22487012	.176	-.1690410	1.0308047
		AHP	-.24557491	.22487012	.537	-.8454977	.3543479
RVOl	TOPSIS	AHP	-.02493221*	.00511228	.001	-.0385711	-.0112933
		Markowitz	.00000000	.00511228	1.000	-.0136389	.0136389
	AHP	TOPSIS	.02493221*	.00511228	.001	.0112933	.0385711
		Markowitz	.02493221*	.00511228	.001	.0112933	.0385711
	Markowitz	TOPSIS	.00000000	.00511228	1.000	-.0136389	.0136389
		AHP	-.02493221*	.00511228	.001	-.0385711	-.0112933
Alpha	TOPSIS	AHP	-.1109200*	.0393966	.039	-.216025	-.005815
		Markowitz	-.0190691	.0393966	.880	-.124174	.086036
	AHP	TOPSIS	.1109200*	.0393966	.039	.005815	.216025
		Markowitz	.0918509	.0393966	.089	-.013254	.196956
	Markowitz	TOPSIS	.0190691	.0393966	.880	-.086036	.124174
		AHP	-.0918509	.0393966	.089	-.196956	.013254
*. The mean difference is significant at the 0.05 level.							

Source: research findings

Then, the average performance evaluation criteria of portfolios in Analytic Hierarchy Process

(AHP), TOPSIS model and Markowitz model are compared with each other through Analysis of Variance (ANOVA) test to show the existence of significant differences. The TUKEY test was used in pairs between different groups, the results of which are presented in Tables 6 and 7. As can be seen in Table 6, the significance level of the Multi-Community Mean Comparison Test (ANOVA) is smaller than the accepted level of error, i.e. 0.05, so the H_0 hypothesis is rejected and concluded, the average performance evaluation criteria (Sharp, Trainer and Jensen Alpha) Portfolios are significantly different in the three models. Table 7 also shows that the Sharp average of the Analytic Hierarchy Process (AHP) model is larger than the TOPSIS model, the average of the Hierarchical Analysis Model of the Hierarchical Analysis Model (AHP) of the TOPSIS model and the Markowitz model. Is larger and the mean of the Jensen alpha hierarchical analysis model (AHP) is larger than the TOPSIS model.

6 Discussion and conclusion

Theoretically, the issue of stock portfolio in minimizing risk and keeping returns constant requires complex mathematical calculations and extensive planning. On the other hand, previous research shows that the issue of stock portfolio selection is a multi-criteria decision-making process that goes beyond the two criteria of average and variance of portfolio returns and optimization methods that are commonly common in the financial literature. Therefore, conducting research on portfolio optimization using multi-criteria decision making methods such as Analytic Hierarchy Process (AHP) and TOPSIS in which different financial and non-financial preferences of the investor in stock selection can be considered. In order to provide new methods to investors to consider different dimensions of stocks to select a portfolio through simpler calculations, it seems necessary. The present study compared the adjusted performance with the risk of portfolios formed based on the firms' core financial indicators according to the Hierarchical Analysis (AHP) models and the TOPSIS model with the Markowitz mean-variance model. The results of testing the hypotheses showed that the average criteria for evaluating the performance of portfolios in the Analytic Hierarchy Process (AHP) model is higher than the Markowitz model. The average criteria for evaluating the performance of portfolios in the two models of TOPSIS and Markowitz is equal. Also, the average criteria for evaluating the performance of portfolios in the Analytic Hierarchy Process (AHP) model is higher than the TOPSIS model.

Therefore, it can be concluded that stock portfolio selection using financial criteria (earnings per share, dividend per share, operating cash flow growth, earnings per share growth, beta risk (systematic), operating profit volatility, stock liquidity and price ratio Using the Analytic Hierarchy Process (AHP) model leads to higher risk-adjusted returns (Sharp, Trainer and Jensen Alpha) than the Markowitz optimization model based on risk and return, as well as the TOPSIS model Is based on the mentioned financial criteria. Therefore, according to the results of the research, investors are advised to consider other stock valuation criteria such as liquidity, earnings per share, etc. when selecting stocks to form a portfolio, and to optimize the portfolio. Use multi-criteria decision making methods that require less and simpler mathematical calculations and better performance than the Markowitz mean-variance mathematical model.

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