



Optimizing Stock Portfolio of Investment Companies Operating in Field of Petrochemical and Refinery Based on Multivariate GARCH Models

Abbas Alimoradi

Assistant Professor of Accounting, Department of Accounting and Finance, Petroleum University of Technology, Tehran
Faculty of Petroleum, Tehran, Iran
(Corresponding Author)
Alimoradi@put.ac.ir

Gholamreza Keshavarze Haddad

Associate Professor of Economics, Department of Oil and Gas Economics, Petroleum University of Technology, Tehran
Faculty of Petroleum, Tehran, Iran
Keshavarz@gmail.com

Soheib Ahadi

Master of Finance, Financing and Investment in Oil and Gas Industry, Department of Accounting and Finance, Petroleum University of Technology, Tehran Faculty of Petroleum, Tehran, Iran
sohaib.ahadi@gmail.com

ABSTRACT

The main objective of this research is to optimize the stock portfolio of investment companies operating in the field of petrochemical and refining industries through minimizing risk with respect to the expected return. In this regard, first of all, the compositions of sample firm's portfolios were investigated during 2013 to 2016 and high-weight industries were selected. Then, the risk of return on each selected industry over time was estimated using the multivariate GARCH model in form of Diagonal BEKK method. Further, considering the expected returns, the optimal risk was calculated for each portfolio. Then, the effective factors on portfolio risk-return such as the currency rate, crude oil price, and stock liquidity risk of the selected industries, was taken into accounts and the above steps were repeated and the risk of optimized portfolios was recalculated. Findings of the research show that the optimized portfolios have been more optimized by considering effective factors, and whenever there was a lower risk in each of the industries, the corresponding weights have been higher. Also, most portfolios are made up of industries such as the petroleum products, chemicals, rubber and plastics. Therefore, it is appropriate for investment companies to consider the prioritization of industries and the factors affecting risk and return in order to minimize the risk of their stock portfolios at any time, as well as gaining higher expected returns.

Keywords:

Optimization, Stock portfolio, M-GARCH, Petrochemical & Refining industries



1. Introduction

Increasing growth in financial markets has led to some complications, uncertainties and in general, risks which makes it difficult for investors to make choices about asset types. In such markets, shareholders are constantly looking to achieve high returns with lower risk exposure (Ebrahimi, 2014). Prior to any investment, the creation of a portfolio, the investment policy, the expected risk- return level, and other limitations under which the portfolio should be formed, shall be determined and this is essential before selecting a stock or determining the composition of a portfolio (Mendes, et al., 2016). From the general point of view, fluctuations in returns and stock prices are influenced by many systematic and unsystematic factors, and the sensitivity of each share varies to these factors; hence, one of the main proposed solutions in financial discussions is the creation of a portfolio of assets to eliminate fluctuations caused by non-Systematics. In fact, one of the tools for risk management for investment portfolios is the diversification approach presented by Markowitz. This model is based on expectations of return performance and portfolio risk and portfolio diversification, which is essentially a theoretical framework for analyzing risk and return options. Investment management involves two main issues of securities analysis and portfolio management. An analysis of securities involves estimating the benefits of a single investment, while portfolio management involves analyzing the composition of investments and managing the holding of a set of investments. In the last decade, the trend of investment topics has changed from stock selection (portfolio analysis) into portfolio management. What has been done in the field of financial calculations, stock selection and investment portfolio has been to prioritize existing investments in terms of risk and return, in order to enable investors to take into account their financial resources and their risk appetite for making up their preferred portfolio. Therefore, an investment should lead to a maximum return potential, and this return must be constant and stable. Measuring this stability shows the risk of investing (Strong, 2009).

The diversification and formation of stock portfolios and their optimization is one of the conditions for success in efficient capital markets. The implementation of scientific and systematic methods in this growing market is of great importance. In the

same way, many efforts have been made in the capital markets which have led to the emergence of new methods that along with past methods, seek an answer for the problem of Maximizing profits in capital markets. Assigning and allocation of different assets in a profitable portfolio is one of the most interesting and common issues in managing each market, especially the energy market. As stated, one of the most important issues facing the investor in the stock exchange is the investment risk. Mostly, the investor seeks to endure less risk and maintain a stock with high returns and low risk. On the other hand, the results of many previous studies have shown that there is a positive relationship between risk and returns (Jalilian, et al., 2008). Hence, one of the most important challenges in creating stock portfolios is to determine the ratio or optimal weight of the stock in portfolio to reduce risk. The purpose of this study is to use GARCH family models and linear programming to estimate the risk and returns of the portfolio of investment companies in the field of petrochemical and refining industries. By calculating the risk of the Portfolio of shares in petrochemical and refining companies, the optimal composition of stock in the portfolio of petrochemical and refining companies is to be determined. The reason behind selection of investment companies in field of petrochemical and refining is that Iran's industry is mostly dependent on oil and gas resources and the country's main source of income is also the supply of oil and gas and their derivatives. Therefore, the oil, gas and petrochemical industries are the most important economic activities in the country which can create a huge burden on Iran's economic development by creating appropriate employment opportunities. Therefore, efforts to improve the management of these industries and investment companies should be among the economic priorities of the country. On one hand, petrochemical companies are considered as one of the main actors in the field of oil and gas industry of the country, whose role in the economic development and the future of the country is not overlooked, on the other hand, for many years, they as the leading companies, have provided the necessary infrastructures and basic platforms on strategic issues.

Considering the above mentioned issues, it is possible to recognize the important role of investment companies and holdings in the field of oil, gas and petrochemicals industries. Therefore, performance and

measurement of investment and financing management of these companies is of great importance. The present study seeks to provide mechanisms for measuring investment performance and sustainable profitability in the oil, gas, and petrochemical industries, in particular petrochemical and refining companies, and add to the richness of the scientific works written in this field. The performance and efficiency of the management's team of investment companies in field of petrochemical and refining can be measured in different dimensions. However, in this study, taking into account the same conditions and influencing several effective factors on the activities of these companies, as well as analyzing the prices and returns and risk of their shares during the period under review, the performance of these companies will be measured. It is necessary to use scientific and academic resources and also to use the opinions of the experts of the capital market and the leaders of the oil industry of Iran to select the indicators that have the most direct and indirect effects on the prices of petroleum, petrochemical and refining products, and finally the price of shares in petrochemical and refining companies. Eventually, it will be possible to increase the competitiveness of petrochemical and refining companies, increasing their efficiency and effectiveness, which will lead to the development and prosperity of our country. The paper has been organized as follows: section two examines the theoretical foundations and background. The third and fourth sections are devoted to methodology and empirical findings. The final section is also dedicated to summarizing of results, conclusions and suggestions.

2. Literature Review

The field of investment is usually divided into two sections: "Securities Analysis" and "Investment Management". The major task of analyzing securities is the valuation of financial assets and the value of a function of risk and return. Therefore, in the investment study, these two concepts are of particular importance, or else it can be said that the most important concepts in investment decision making are risk and returns. Each share or any portfolio of stocks, if purchased, maintained, and sold at a certain interval of time, yields a certain return. This return includes price changes and the benefits of ownership, such as dividends per share. The term "return" is used to

describe the rate of increase or decrease in investment over the asset maintenance period. The goal is to maximize expected returns, although they intend to reduce the risk (Rae & Pouyanfar, 2012). Return on investment (dividend and capital gains) is a driving force that motivates and rewards investors. The expected return is the estimated return on an asset that investors expect in the future, or, on the other hand, the expected return rate informs the investor of the average reward that he / she is expected to receive over a specific period (Rae & Pouyanfar, 2012). The difference between expected returns and realized returns may be due to events and sudden and unexpected factors, which are called uncertainty in stock returns that is a source of risk. Risk and return are two important factors that affect investors' decisions. Risk is a future phenomenon that cannot be accurately predicted because of uncertainty. The more uncertainty will result more risk (Dianati, et al., 2010). Stock returns vary in different periods, and do not have a stable and steady trend. Therefore, volatility is an integral part of stock returns over time. Due to the volatility and fluctuation of prices and returns on stocks, returns on future periods are not cautious. Most of the securities that can be invested in them are uncertain returns and are therefore risky. If the securities are risky, the main issue for each investor is to determine the portfolio of securities that its utility is maximized. This is equivalent to selecting the optimal portfolio from a portfolio group, which is called portfolio selection problem. The model was presented in March 1952 by Markowitz. In the traditional portfolio theory approach, the investor should estimate the expected returns of the various papers at time $t = 0$, and then invest in the securities with the most expected returns. Therefore, investors who seek to maximize expected returns and minimize uncertainty have two conflicting goals that must be balanced against each other. One of the most striking results of these two opposite goals is that the investor must diversify through the purchase of several types of securities. Markowitz states that investors should make their portfolios decisions based on expected returns and standard deviations. This means that the investor must estimate the expected returns and standard deviations of each portfolio, and then choose the best combination. Based on the Markowitz approach, investors should focus on increasing their final wealth in deciding to buy a portfolio of their initial investment

wealth (the first period) and assess their investment portfolio with criteria such as expected returns and risk (standard deviation). Expected asset return is equal to the weighted average return from a group of assets. The weight used for each return is a proportion of the investment made in the asset (Elton, et al., 1995). We can form unlimited number of securities of the investment portfolio with a set of N-type security. Each investment can allocate a share of its capital to each of the N securities. They may assign a specific security of 0%, 100%, or any percentage of their capital. Do investors need to evaluate all these investment portfolios? Fortunately, the answer is negative. A key reason that the investors need to review a subset of portfolios of investments are available in case of efficient frontiers, in this case, as the investor's portfolio optimization will choose among portfolios of investment choices that provide the highest expected return rate at the various risk levels and the minimum risk at the various levels of expected returns. The set of investment portfolios that have these two conditions are called efficient frontiers (Shariatpanahi & Jafari, 2012).

According to Markowitz's theory, if a person holds N asset that $r_{(i,t)}$ and $\sigma_{(i,t)}^2$ respectively represent the expected return and expected return variance of the investment in moment t and also $\rho_{(ij,t)}$ is equal to the correlation coefficient between i^{th} and j^{th} investment at the moment t, then the expected returns and the variance of the investment portfolio are defined as follows:

$$r_{p,t} = \sum_{i=1}^N r_{i,t} X_{i,t}$$

$$\sigma_{p,t}^2 = \sum_{i=1}^N X_{i,t}^2 \sigma_{i,t}^2 + \sum_{i \neq j} 2X_{i,t} X_{j,t} \sigma_{i,t} \sigma_{j,t} \rho_{i,j,t}$$

In this case, based on the Markowitz portfolio theory, the optimization of the asset portfolio with two approaches to minimizing risk at a certain level of expected returns and maximizing expected returns at a constant level of risk is defined as follows:

A) risk minimization approach

$$\begin{aligned} &Min \quad \sigma_{p,t}^2 \\ &s.t. \\ &\sum_{i=1}^N r_{i,t} X_{i,t} = \bar{r}_{p,t} \end{aligned}$$

$$\sum_{i=1}^N X_{i,t} = 1 \quad X_{i,t} \geq 0 \quad i = 1.2. \dots N$$

B) Maximizing the expected return on portfolio

$$\begin{aligned} &Max \quad r_{p,t} \\ &s.t. \\ &\sigma_{p,t}^2 = \bar{\sigma}_{p,t}^2 \\ &\sum_{i=1}^N X_{i,t} = 1 \quad X_{i,t} \geq 0 \quad i = 1.2. \dots N \end{aligned}$$

The two proposed optimization problems are of a non-linear programming problem with unequal constraints. Markowitz, in 1952, pointed out that by creating a portfolio at a certain level of risk, it would be possible to achieve higher returns, or vice versa at a certain level of efficiency, it was less risky to solve the challenge. Markowitz designed and solved the problem of optimization in order to obtain the optimum weight of existing portfolio investments (which satisfies the condition of maximum returns at a certain level of risk or at least risk at a certain level of return on the investment portfolio of the investor) By that, we can obtain the optimal weight vector of the portfolio (Motavasseli, 2002). In fact, Markowitz determined the optimal allocation of the wealth of an investor to various investments that they want to maintain by maximizing returns, at a constant level of risk, or minimizing portfolio risk, at a certain level of return. Markowitz's most important idea was to use the standard deviation of the return on investment portfolio as a measure of risk. Therefore, in order to use the Markowitz theory, it is necessary to first calculate the standard deviation of the investment portfolio, which involves the estimation of the conditional covariance matrix for the investments in the portfolio. In econometric literature, the conditional covariance matrix is estimated by using the generalized multivariate homogeneous regression model of variance (MGARCH) (Brock, 2008). One of the drawbacks of the Markowitz model is the lack of distinction between different market conditions and the allocation of distinctions between different market conditions and the allocation of equal weights to the current and past events of the market. In econometric literature, in order to adapt to the dynamic structure of variance in the market, in order to estimate the conditional covariance matrix, the Generalized

Multivariate models of Auto-regressions with Conditional Homoscedasticity of variance (GARCH) are used (Messaud, et al., 2015). The most important feature of these models is the time-variable conditional covariance matrix estimation. Also, the most important results from the MGARCH models is that by using the conditional covariance matrix over time, the optimization of the investment portfolio can be applied at any given time (Baillie & Myers, 1991). In fact, at any given time, the conditional covariance matrix and the expected return on investments in the portfolio can be determined by optimizing the weight of investments in the portfolio (Hammoudeh, 2009). Basically, if the conditional covariance matrix changes over time, then the need to estimate optimal weights is no longer constant and should be sought after finding the optimal time weights (Tansuchat, et al., 2010). In measuring portfolio performance, investors need to consider realized returns and risks. Therefore, whenever a criterion or technique is used, these two factors (risk and return) should be included in the analysis. When portfolio performance is evaluated, the total return on portfolio, which includes dividends and the increase (or decrease) of the stock price, is used. In addition, two major deviation and beta factors will be used as two criteria for risk analysis. In 1960, Williams Sharpe introduced and applied a new indicator called Sharpe ratio that measures the rewards versus variabilities. He used this ratio as the standard combination of return and standard deviation to measure portfolio performance based on capital market theory. It must be considered that higher the RVAR, implies the better the portfolio's performance. Also the RVAR measures the excess return for each unit of associated total risk with the returns. In addition to estimating expected returns and risk (SD), in this research, Sharpe's benchmark is also calculated for each stock portfolio of investment companies in the field of petrochemicals and refining.

First of all, Heydari and Molabehrami (2010) optimized the investment portfolio consisting stocks of petroleum products, automobiles and parts manufacturing, electrical machinery and extraction of mineral metals in Tehran Stock Exchange. They estimated the variable time conditional covariance matrix based on heterogeneous variance model of variance Diagonal-Vech (1,1) and CCC (1, 1), Diagonal-BEKK (1,1), and then optimized the portfolio with the risk minimization approach of the

stock investment portfolio based on the Markowitz portfolio theory and the optimal weights of the selected quadruple industries were specified over time. The results of this optimization showed that in all three models, more weight in the investment portfolio is devoted to industries which have fewer fluctuations in the stock returns of those industries. Also, optimal weight over time is decreasing for industries whose volatility has increased, and vice versa, when the volatility in returns is reduced and over time, the optimal share of the portfolio is increased. Bidgoli and Khan Ahmadi (2012) have investigated the risk-capitalization feasibility of a portfolio based on the variance model of generalized conditional variance in Tehran Stock Exchange. The researchers said that in optimizing with the aim of risk minimization, the two factors of covariance matrix and the individual risk, the returns of each asset are the main determinants of optimal weights. Asgari and Asgari (2013), investigated the appropriate allocation of investment portfolio consisting of shares of selected industries of the automobile and manufacturing of components, pharmaceutical products, chemical products, Tile, Ceramic and Sugar among listed companies through MGARCH models. In this research, the variable time conditional covariance matrix is estimated using four models of GARCH models called Diagonal-BEKK, Diagonal-Vech, CCC and DCC were estimated. Then, the portfolio optimization was done with the investment risk minimization approach and the optimal weight of the industries is provided over the course of time for each model. The results of this study showed that more weight was allocated from the investment portfolio to the industries that had fewer fluctuations in their stock returns. Mousavi et al. (2016), optimized the investment portfolio of Sepah Bank Investment Company using the combination of Markowitz and multivariate GARCH models. Then, the risk of the efficiency of each of these four industries over time was estimated using the multivariate GARCH model as Diagonal-BEKK and the researchers suggested that Sepah Bank as Investment Bank should consider such prioritization in order to minimize its risk at any time, and to achieve the expected returns.

Ledoit O, Santa-Clara.P, Wolf.M (2001) in their study of flexible multivariate GARCH modeling with emphasis on its application in financial markets, concluded that the most important results from MGARCH models is that by using the conditional

covariance matrix over time, one can consider the optimization of the investment portfolio at any time, and also introduce a flexible multivariate GARCH model. They compared the proposed model to estimate the conditional covariance matrix for optimizing the portfolio of international stock markets, and compared the results with BEKK and CCC models. In fact, at any given time, the conditional covariance matrix and the expected return on investment in the portfolio can be determined by the optimal weight of the investment in the portfolio. Bauwens et al, (2006) In their research indicated that GARCH's multivariate analysis can be a major improvement over dimensional problems in financial modeling. MGARCH models can be used for asset pricing, portfolio management, volatility estimation and risk management or diversification. Tansuchat R, Chang CH. L, McAleer M (2010) used the CCC, BEKK and DCC models to estimate the optimal weights of an investment portfolio of two Brent and Texas oil markets. The results of this study indicate that, based on all three models, the share of the portfolio is allocated to the Texas oil market. Also, in another section of their research, it was concluded that if the conditional covariance matrix changes over time, then the need for estimating optimal weights is not constant and should be sought after the optimal time weights. Luis Miralles, et.al. (2013) investigated the correlation between stocks of large, small and medium size companies using GARCH models in the Spanish stock market, and found that these groups, directly or indirectly, are related to each other's and the portfolio of small and medium-sized companies including majority of medium-size stocks has the

minimum risk. Thalassinos, et.al (2015) examined the correlation between government bonds and the stock market in three countries, Germany, France and Greece, using GARCH family models, and tried to create an optimal portfolio of bonds and stocks. The results of the research show that the weights of these assets are approximately equal, and despite the low and negative non-conditional correlation, conditional correlation is different and very significant. As the research background shows, there are some theoretical and implicational gaps in the literature. At the best of my knowledge, researches have not focused on optimizing the investment portfolio constituted from petrochemical and refineries, so far. The present study seeks to bridge these gaps. This study, for the first time, addresses the issue of optimizing portfolio consisting of petrochemical and oil refining companies' stocks, which will be theoretically effective for researchers and academics, and can be implicated by investment companies operating in oil and gas industry to solve some of portfolio selecting and optimization problems. Considering the contents of the theoretical foundations and the conceptual framework of this study, important indicators such as stock liquidity, global oil prices and exchange rates that affect stock prices and performance will be taken into account. It should be noted that numerous researches, both inside and outside of Iran, have supported the impact of these indices on stock prices and performance, which have been mentioned in several studies in this study. Finally, we can present the conceptual framework of this research as follows:

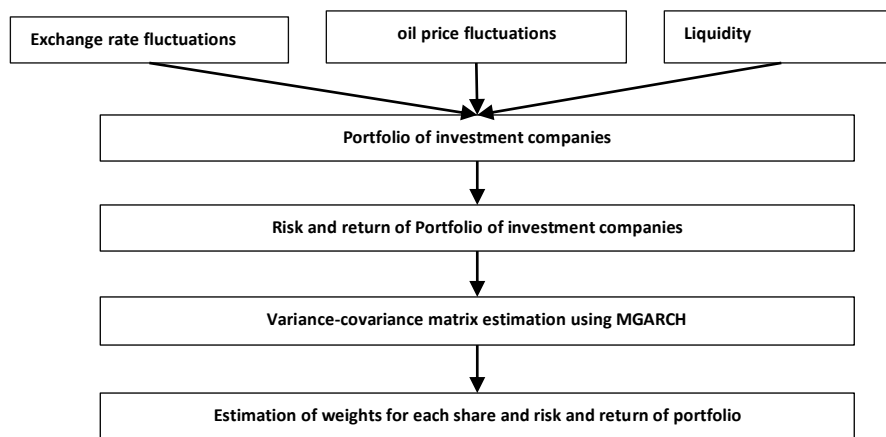


Figure 1: conceptual framework

3. Methodology

The present research is applied one in terms of the purpose and is a quantitative research in terms of research choice. The strategy of this research is a kind of surveying study that uses a deductive approach to generalize the results. The data used in this study were extracted from the investment portfolio information of the investment companies in the field of petrochemical and refining disclosed in the audited financial statements in the second half of the year 2017 on 20/03/2018, as well as the daily data of the stock return logarithm of stocks included in the portfolio of investigated investment companies during the period from 25/03/2014 to 28/02/2018 were collected from the official website of the Tehran Stock Exchange at www.tse.ir. In order to test the research hypotheses and answer the questions, the GARCH family model are used along with the Eviews 10 software (in order to estimate variance-covariance matrix) as well as Matlab software package (for linear programming). Due to the limited statistical population of the research, sampling is discarded. the statistical population is limited to four investment companies operating in the field of petrochemicals and refineries that are active within the timeframe. So, the statistical population will be exactly the same as the statistical sample (four investment companies) and due to the limited statistical population, sampling is not necessary. Keep in mind that the empirical portfolio consists of all stocks of petrochemicals and refineries that weigh each of them equally or we assign a weighted ratio in proportion to the price of each stock. All stocks of the mentioned companies will be existed in the primary empirical portfolio. The investment companies that have been analyzed in this research are as follows:

- 1) Parsian Oil and Gas Expansion (Parsan)
- 2) Oil Industry Investment (Vanaft)
- 3) Tamin Oil and Gas and Petrochemical (Tapiko)
- 4) Persian Gulf petrochemical holding

To capture the return variable, we used daily data of the stock return logarithm of stocks included in the portfolio of investigated investment companies during the period from 25/03/2014 to 28/02/2018. In order to calculate the stock returns of the industries that are included in the investment portfolio of the companies being studied, if the price of i^{th} investment is displayed

at the time t with $P_{i,t}$, then the logarithm of the return on that investment at time t is calculated as follows:

$$r_{i,t} = \log\left(\frac{P_{i,t}}{P_{i,t-1}}\right)$$

The liquidity risk of assets, which is also referred to as the product market liquidity risk, is created when the transaction does not occur at current market prices. In other words, the asset will not be sold at market prices (is sold at below market prices). Market liquidity can be considered as the transaction cost of an asset relative to its fair value (Liu,2006). The fair value is the average price gap of sales (mid-price). The liquidity cost can be summarized as a combination of the following three components, based on the function of the order of volume q and the time t :

$$L_t(q) = T(q) + PI_t(q) + D_t(q)$$

Where:

$L_t(q)$: liquidity costs

$T(q)$: transaction costs that include brokerage fees, taxes, etc.

$PI_t(q)$: The effective price, or the difference between the transaction price and the middle price. The costs of effective price increases with increasing transaction volume.

$D_t(q)$: The cost of delaying a quick deal in a trading position. This includes the cost of a trading party's search and the cost of risk imposed on the investor, which may occur due to changes in the prices and cost of the effective price of delay in the transaction.

The bid-ask price gap of assets is in fact the cost of asset liquidity. The most practical and applied criterion is as follows:

$$S = \frac{[P_{ask} - P_{bid}]}{P_{mid}}$$

Where P_{bid} , P_{ask} and P_{mid} are quoted bid price, quoted ask price and mid-range price, respectively. Mid-price is calculated as:

$$P_{mid} = \frac{P_{ask} + P_{bid}}{2}$$

In this study, to calculate the bid-ask price gap for industries stocks, we use the average quoted ask price and average quoted bid price for limited orders inserted into the trading system for companies in each industry, then to calculate the bid-ask price gap for each industry, the price gap for existing companies in each industry was used. Using the index formula provided by the TSE, the price gap was calculated for each industry. First of all, we must ensure that the collected data have normal distributions. In order to test normality of the data used in this research the Jarque–Bera test has been used. We also used Augmented Dickey Fuller test (called unit root test) to investigate the stationary of logarithm of investment returns time series. Information sources for the unit root test or the Dickey Fuller test are reports and organizational statistics published by the Stock Exchange, Central Bank and other information institutions in the capital market (magazines, information websites, etc.).

In this research, the Mean-Variance Markowitz model has been used to reach the optimal investment portfolio of each investment company in the field of petrochemical and refining. Based on this model, optimal risk values are obtained at a certain level of return on the basis of the minimum risk of investment portfolio (Basher & Orrey,2016). Considering the assumption of the normal distribution of return on assets, the complete market without taxes (without transaction costs), the prohibition of the short-sell (the positivity of asset weights), and the division of assets, the Markowitz model is expressed as follows:

$$\begin{aligned}
 & \text{Min} \quad \sigma_{p,t}^2 \\
 & s \cdot t \cdot \\
 & \sum_{i=1}^N r_{i,t} X_{i,t} = \bar{r}_{p,t} \\
 & \sum_{i=1}^N X_{i,t} = 1 \quad X_{i,t} \geq 0 \quad i = 1,2, \dots, N
 \end{aligned}$$

Where:

$X_{i,t}$, is the weight of the industry i in the corporate portfolio, $\sigma_{p,t}^2$ the return risk of the portfolio, $r_{i,t}$ the expected return on investment in the industry i and $\bar{r}_{p,t}$ Return on investment portfolio.

As it is known, the above model is a linear programming whose objective function is the risk of

return on investment portfolio and must be minimized with respect to the investment returns constraint, while the decision variable also has the weight of the various industries in each investment portfolio of investment companies in the field of petrochemicals and refineries. Hence, optimum weights are determined by solving this problem. However, to solve this problem, there is a need for the risk of return on investment for the period in question. The calculation of these two variables are presented in the next sections.

In this study, Diagonal-Vech (1.1), CCC (1.1) and Diagonal-BEKK (1.1) models will be used to estimate conditional covariance matrices over time. Initially, time series, stationary and white noise, Auto Regression processes and Moving Average processes will be introduced, and finally GARCH and MGARCH models are presented. In order to determine the mean equations, the optimal interruption for AR models based on the correlation functions and Partial Auto-Correlation Functions as well as Akaike criterion is used for all-time series. After specifying the mean equations, the multivariate models are estimated with the EViews 10 software. To specify a MGARCH model, it is necessary to state that the model is flexible enough to show the dynamics of the covariance matrix, and since the number of the parameters of a MGARCH model increases rapidly with the next dimension of the model, so the model stipulation must satisfy be the condition of cost-effectiveness. Of course, it should be noted that the condition of cost-effectiveness is often associated with a false stipulation of the model (Cgang, C.-L., McAleer and R. Tansuchat, 2009). Furthermore, another condition of the MGARCH model is that the conditional quantum matrix must be positive. The conditional covariance matrix is a $N \times N$ matrix calculated using each model separately, and then the weight of each group is calculated (Toengchai Tansuchat 2010).

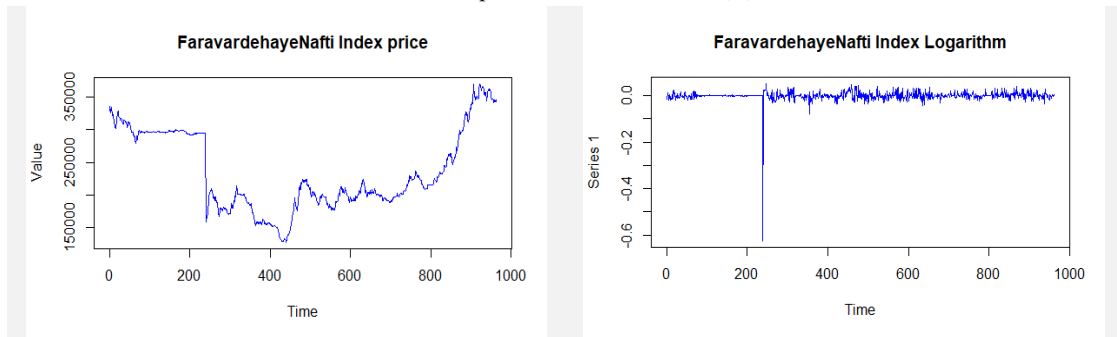
4. Results

The main objective of this research is to optimize stock portfolio of investment companies in the field of petrochemical and refining, based on GARCH multivariate models. To this end, the research is going to determine the optimal portfolio of before mentioned investment companies through considering financial and macroeconomic indicators. Then, it compares and categorizes the stock portfolios of these companies in

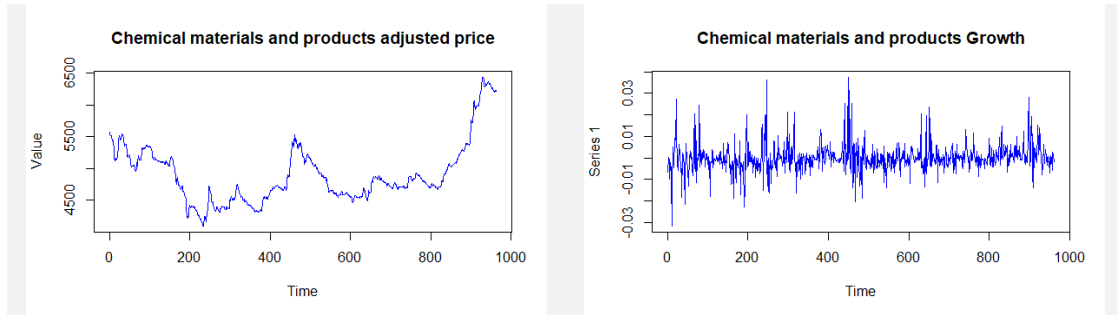
terms of return and risk, as well as the Sharp index with respect to the indicators affecting their performance. To study the investment portfolio behavior using MGARCH models, especially CCC and DCC methods, a large number of data (at least 20 years) is required. In this study, due to the limited data of the studied population, the CCC, DCC and methods were not meaningful on the time series tests, so the variance of covariance variables were calculated for investment firms' portfolios through applying the Diagonal method -BEKK (p, q), only. So, the

descriptive statistics of stock returns of various industries in the portfolios of investment companies were calculated individually, as well as graphs of time trends of return on the price of each industry stock are presented separately. Panels of Figure 2 show volatilities in price index and logarithmic price change rates for each of the industrial groups in the portfolios of investigated investment companies. For each panel, the right hand figure represents the logarithmic price change rates trends and in turn, the left side figure shows the price index changes for the industries.

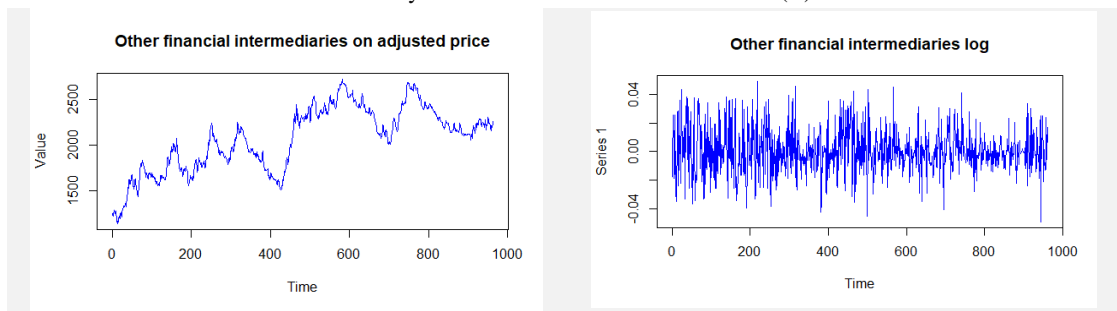
Petroleum products & nuclear fuels (A)



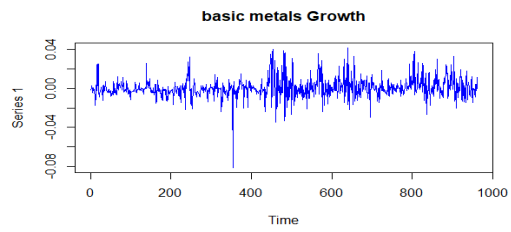
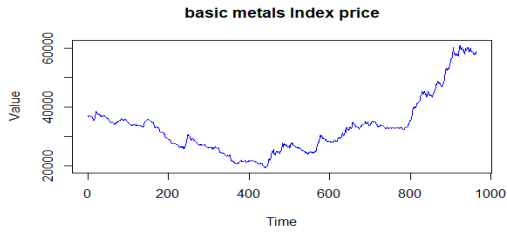
petrochemical products (B)



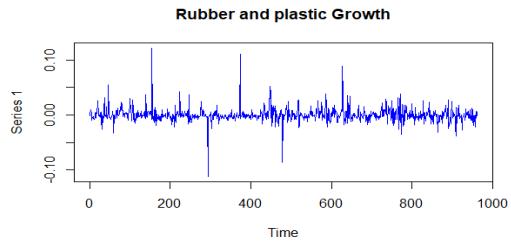
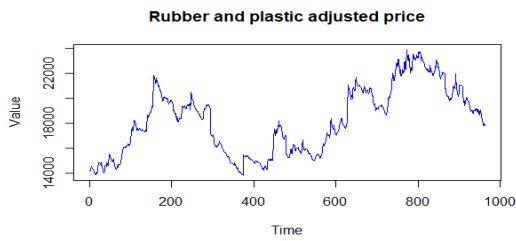
Subsidiary activities of financial intermediation (C)



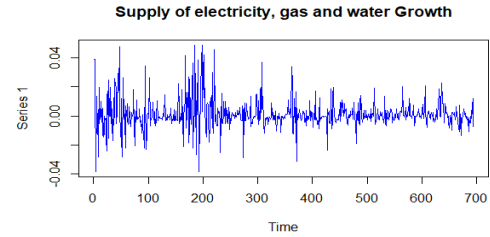
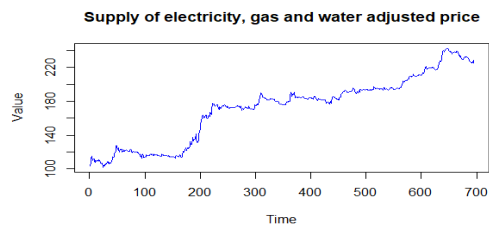
Essential metals (H)



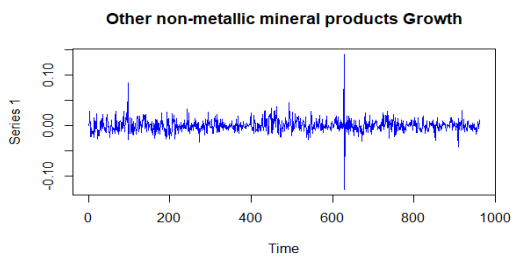
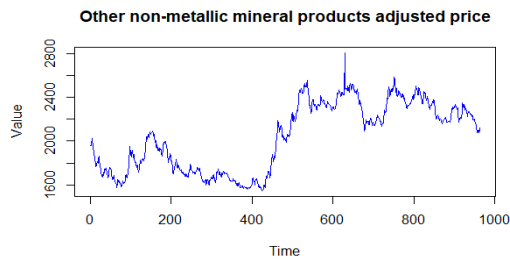
Rubber and plastic (F)



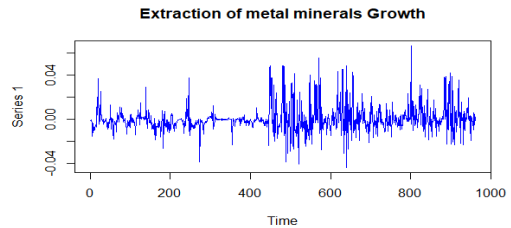
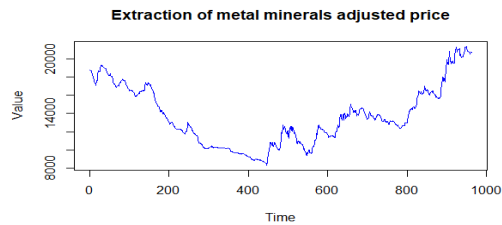
Electricity, gas, steam and hot water supply (E)



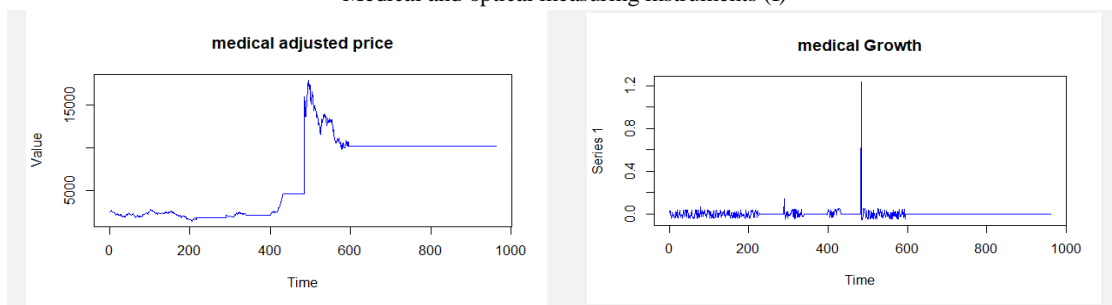
Other non-metallic mineral products (G)



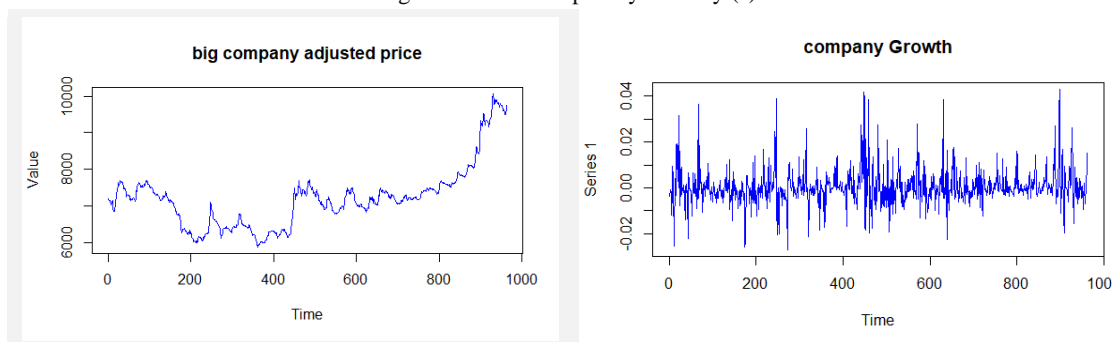
Extraction and oil and gas service activities (L)



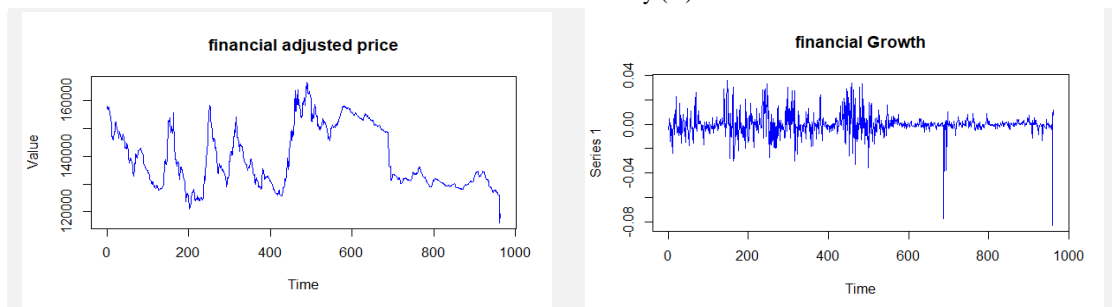
Medical and optical measuring instruments (I)



High-tech multidisciplinary industry (J)



Financial intermediary (K)



Real estates (M)

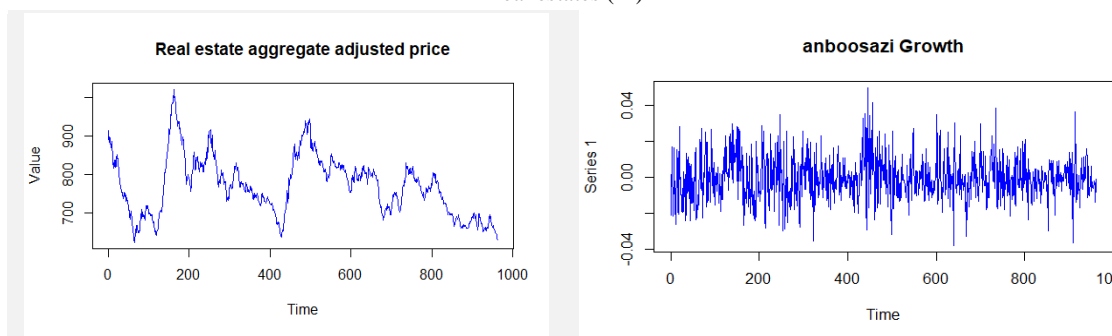


Figure 2: changes in price index and logarithmic price change rates for industries
(source: research findings)

Based on the methodology of the GARCH family models, first of all, the time series reliability (stationarity) of the expected returns on the portfolios of the investigated investment companies must be confirmed. This could be examined using the Dickey Fuller test and results state that all variables are stationary. Then, it was necessary to determine the average equation and the optimal interruption of the expected return time series based on auto-correlation and partial auto correlation functions as well as the Akaike criterion. The conditional distribution of a time series such as stock return is characterized by conditional variance homoscedasticity, and because of this, the ability to achieve the maximum likelihood-estimators is efficient. On the other hand, it is observed in some cases that the residual component of an ARIMA fitting equation, despite the stationarity of returns (random walk process), is not white noise for different p and q , which means that the residual component contains an ARCH effect, suffers from a conditional auto correlated variance. Therefore, the necessity of time series estimation using GARCH family models is the existence of ARCH effects in the time series. So, the ARCH LM-test has been applied to investigate the existence or absence of ARCH effects in the research variables. The results of the model estimation in Diagonal-BEKK (1.1) are presented in Tables 1,2,3 and 4.

In above tables, the coefficients can be interpreted in the form of three matrices. The estimation results showed that, none of the stocks included in the portfolios have a steady state behavior over time, therefore a multivariate GARCH model could be used to estimate variance/covariance. After estimating the risk, as well as calculating the returns of all investment portfolios and stock returns, it is possible to determine the optimal weights for the industries included in each of the investment portfolios over time to obtain minimum risky portfolios with constant yield. This is in fact the same as the Markowitz optimization problem, which is extracted by linear programming method using the Matlab Toolbox software. The optimal weights of industry stocks related to each portfolio of investment companies were determined using this mechanism.

Risk, return and Sharpe index of the optimized portfolios: Without effective factors

After determining the optimal weights of the stocks in each of portfolios, the turning point is

tracking the performance of each portfolio in terms of risk and return. The results of the calculations performed for the investment portfolio of the Parsan (Portfolio 1) are presented in Table 5.

As it is shown, the returns obtained from the optimized portfolio are approximately three times greater than the actual average returns. However, the calculated standard deviation (Risk) of the optimal portfolio is higher than the standard deviation of the actual portfolio. The Sharpe index for the optimized portfolio is almost twice that for the actual portfolio. Considering that the p-value of the test it can be said that the return variance of the actual portfolio is less than the optimized one. we can judge that the average return on the optimized portfolio is higher than actual. We performed this test for three other investment portfolios and concluded the same results. The results of the calculations performed for the investment portfolio of the Vanaft (Portfolio 2) are presented in Table 6.

Table 1: the variance/covariance matrix for the stocks included in the portfolio of Parsan

Transformed Variance Coefficients				
	Coefficient	Std. Error	z-Statistic	Prob.
M(1,1)	22.66200	16.94095	1.337706	0.1810
M(1,2)	8.118813	5.859457	1.385591	0.1659
M(1,3)	17.24160	9.576436	1.800419	0.0718
M(2,2)	8.654576	14.30692	0.604922	0.5452
M(2,3)	7.429563	8.079354	0.919574	0.3578
M(3,3)	16.16786	8.855270	1.825789	0.0679
A1(1,1)	0.285751	0.138867	2.057734	0.0396
A1(2,2)	-0.098640	0.078323	-1.25936	0.2079
A1(3,3)	-0.413200	0.131747	-3.13633	0.0017
B1(1,1)	0.823172	0.094004	8.756791	0.0000
B1(2,2)	0.9225	0.102433	9.00591	0.0000
B1(3,3)	0.330816	0.49505	0.668248	0.5040

Table 2: the variance/covariance matrix for the stocks included in the portfolio of Vanaft

Transformed Variance Coefficients				
	Coefficient	Std. Error	z-Statistic	Prob.
M	0.637185	0.399869	1.593487	0.1111
A1(1,1)	0.21623	0.074327	2.909186	0.0036
A1(2,2)	0.336351	0.084217	3.993864	0.0001
A1(3,3)	0.129849	0.12326	1.053457	0.2921
A1(4,4)	0.028951	0.046029	0.62898	0.5294
A1(5,5)	-0.23879	0.049016	-4.87172	0
A1(6,6)	-0.03201	0.072868	-0.43927	0.6605
A1(7,7)	0.100201	0.071868	1.394237	0.1632
A1(8,8)	-0.14906	0.036053	-4.13438	0
A1(9,9)	3.078434	1.256409	2.450184	0.0143
A1(10,10)	0.054025	0.059872	0.902346	0.3669
A1(11,11)	-0.04305	0.017025	-2.5287	0.0114
A1(12,12)	-0.49819	0.220683	-2.25746	0.024
B1(1,1)	0.957811	0.01456	65.78366	0
B1(2,2)	0.959606	0.021614	44.39773	0
B1(3,3)	0.985277	0.014582	67.5679	0
B1(4,4)	1.022227	0.004575	223.4513	0
B1(5,5)	0.979588	0.013263	73.8596	0
B1(6,6)	0.990373	0.006466	153.1676	0
B1(7,7)	0.997284	0.009607	103.8109	0
B1(8,8)	0.990122	0.006522	151.8154	0
B1(9,9)	0.48116	0.053592	8.978213	0
B1(10,10)	0.983033	0.004269	230.2925	0
B1(11,11)	1.014431	0.014374	70.57519	0
B1(12,12)	-0.87324	0.054373	-16.0602	0

Table 3: the variance/covariance matrix for the stocks included in the portfolio of Tapiko

Transformed Variance Coefficients				
	Coefficient	Std. Error	z-Statistic	Prob.
M(1,1)	8.205861	19.83314	0.413745	0.6791
M(1,2)	3.33638	5.298352	0.629701	0.5289
M(1,3)	11.63981	16.9737	0.685756	0.4929
M(2,2)	12.14023	11.54651	1.05142	0.2931
M(2,3)	2.797417	4.462464	0.626877	0.5307
M(3,3)	36.33739	17.21464	2.110843	0.0348
A1(1,1)	0.357324	0.135626	2.634634	0.0084
A1(2,2)	0.209454	0.136514	1.534308	0.125
A1(3,3)	-0.10897	0.13406	-0.81282	0.4163
B1(1,1)	0.630549	0.997749	0.631972	0.5274
B1(2,2)	0.854859	0.140526	6.083284	0
B1(3,3)	0.848417	0.055253	15.35505	0

Table 4: the variance/covariance matrix for the stocks included in the portfolio of Persian Gulf petrochemical holding

Transformed Variance Coefficients				
	Coefficient	Std. Error	z-Statistic	Prob.
M	2.97312	1.364138	2.179486	0.0293
A1(1,1)	-0.17349	0.220132	-0.78809	0.4306
A1(2,2)	0.462845	0.232774	1.988388	0.0468
B1(1,1)	0.885306	0.056726	15.60663	0
B1(2,2)	0.786819	0.120818	6.512403	0

Table 5: equality of variances test between the Parsan actual and optimized investment portfolio

Variance ratio test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
r1_real	47	.7744196	.4810445	3.297875	-.1938728	1.742712
r1_opt1	47	2.041951	.7882386	5.403892	.4553094	3.628593
combined	94	1.408186	.4639048	4.497724	.4869626	2.329408

ratio = sd(r1_real) / sd(r1_opt1) f = 0.3724
 Ho: ratio = 1 degrees of freedom = 46, 46

Ha: ratio < 1 Ha: ratio != 1 Ha: ratio > 1
 Pr(F < f) = 0.0005 2*Pr(F < f) = 0.0011 Pr(F > f) = 0.9995

Table 6: equality of variances test between the Vanaft actual and optimized investment portfolio

Variance ratio test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
r2_real	47	.7076472	.4644268	3.18395	-.2271955	1.64249
r2_opt1	47	1.751543	.6580992	4.511701	.4268579	3.076228
combined	94	1.229595	.4042054	3.918917	.4269232	2.032267

ratio = sd(r2_real) / sd(r2_opt1) f = 0.4980
 Ho: ratio = 1 degrees of freedom = 46, 46

Ha: ratio < 1 Ha: ratio != 1 Ha: ratio > 1
 Pr(F < f) = 0.0100 2*Pr(F < f) = 0.0199 Pr(F > f) = 0.9900

As it is shown, the returns obtained from the optimized portfolio are greater than the actual average returns. However, the calculated standard deviation (Risk) of the optimal portfolio is higher than the standard deviation of the actual portfolio, so it is better to apply the Sharp's well-known ratio for comparison between two portfolios. The Sharp index for the optimized portfolio is also greater than the actual portfolio. Given that the p-value of the test was less than 10%, so the null hypothesis stating that the two means are not different is rejected in favor of the hypothesis stating that the average mean of the optimized portfolio is higher than the actual.

The results of the calculations performed for the investment portfolio of Tapiko (Portfolio 3) are presented in Table 7. As it is shown, the returns obtained from the optimized portfolio are greater than the actual average returns. However, the calculated standard deviation (Risk) of the optimal portfolio is higher than the standard deviation of the actual portfolio but is not significant. The Sharp ratio of optimized portfolio is greater than the actual portfolio of the company. Since the expected average return on the actual portfolio is less than the risk-free rate of return, so the Sharp ratio for actual portfolio is negative.

Table 7: equality of variances test between the Tapiko actual and optimized investment portfolio

Variance ratio test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
r3_real	47	.5148559	.6285862	4.30937	-.7504225	1.780134
r3_opt1	47	.9464396	.8713733	5.973834	-.8075439	2.700423
combined	94	.7306477	.5347901	5.184982	-.3313394	1.792635

ratio = sd(r3_real) / sd(r3_opt1) f = 0.5204
 Ho: ratio = 1 degrees of freedom = 46, 46

Ha: ratio < 1 Ha: ratio != 1 Ha: ratio > 1
 Pr(F < f) = 0.0145 2*Pr(F < f) = 0.0290 Pr(F > f) = 0.9855

Table8: equality of variances test between the Persian Gulf petrochemical holding's actual and optimized investment portfolio

Variance ratio test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
r4_real	47	1.300737	.5982385	4.101316	.0965454	2.504928
r4_opt1	47	1.490718	.5217666	3.577052	.4404564	2.54098
combined	94	1.395728	.3948867	3.828569	.6115607	2.179894

ratio = sd(r4_real) / sd(r4_opt1) f = 1.3146
 Ho: ratio = 1 degrees of freedom = 46, 46

Ha: ratio < 1 Ha: ratio != 1 Ha: ratio > 1
 Pr(F < f) = 0.8215 2*Pr(F > f) = 0.3570 Pr(F > f) = 0.1785

The results of the calculations performed for the investment portfolio of Persian Gulf petrochemical holding (Portfolio 4) are presented in Table 8.

As it is shown, the returns obtained from the optimized portfolio are greater than the actual average returns. The calculated standard deviation (Risk) of the optimal portfolio is less than the standard deviation of the actual portfolio. Therefore, the Sharp ratio of optimized portfolio is greater than the actual portfolio of the company.

Risk, return and Sharpe index of the optimized portfolios: With effective factors.

In this section, mentioned factors are also considered to be effective in estimating the covariance/variance matrix using the BEKK method. In other words, these new variables were added to the previous variables and through the estimation of variance-covariance matrix, three new variables are also considered and estimated in the GARCH equations. Subsequently, the new variance-covariance matrices will have more dimensions, taking into account the effective financial and economic variables. The second hypothesis states that the optimized portfolios of investment companies in the field of petrochemicals and refining from the MGARCH model taking into account the factors affecting their stock returns outperform (greater returns and less risk) the optimized portfolios of these companies, regardless of the desired indicators. In order to test the second hypothesis, financial and macro-economic factors such

as stock liquidity (endogenous), crude oil price (exogenous), and free currency rates (exogenous) were considered in the optimized model. To avoid overwhelming, the new weights and outputs of the MGARCH model are ignored and the risk-return comparisons are only presented. The results of the calculations performed for the investment portfolio of Parsan (Portfolio 1) are presented in Table 9. As it is shown, the average return obtained from the optimized portfolio (with effective factors) is greater than those for optimized portfolio (without effective factors). The calculated standard deviation (Risk) and Sharpe's ratio of the optimized portfolio (with effective factors) are also greater than the standard deviation and Sharpe's ratio of the optimized portfolio (without effective factors).

The results of the calculations performed for the investment portfolio of Vanafit (Portfolio 2) are presented in Table 10. As it is shown, the average return obtained from the optimized portfolio (with effective factors) is greater than those for optimized portfolio (without effective factors). The calculated standard deviation (Risk) and Sharp's ratio of the optimized portfolio (with effective factors) are also greater than the standard deviation and Sharp's ratio of the optimized portfolio (without effective factors).

Table 9: equality of variances test between the Parsan with and without-optimized investment portfolios

Variance ratio test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
r1_opt1	47	2.041951	.7882386	5.403892	.4553094	3.628593
r1_opt2	47	3.331362	.5673654	3.889661	2.189315	4.473409
combined	94	2.686657	.4875855	4.727317	1.718408	3.654905

ratio = sd(r1_opt1) / sd(r1_opt2) f = 1.9301
 Ho: ratio = 1 degrees of freedom = 46, 46

Ha: ratio < 1 Ha: ratio != 1 Ha: ratio > 1
 Pr(F < f) = 0.9860 2*Pr(F > f) = 0.0279 Pr(F > f) = 0.0140

Table 10: equality of variances test between the Vanaft with and without-optimized investment portfolios

Variance ratio test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
r2_opt1	47	1.751543	.6580992	4.511701	.4268579	3.076228
r2_opt2	47	3.130343	.8261025	5.663473	1.467485	4.793201
combined	94	2.440943	.5300912	5.139425	1.388287	3.493599

ratio = sd(r2_opt1) / sd(r2_opt2) f = 0.6346
 Ho: ratio = 1 degrees of freedom = 46, 46

Ha: ratio < 1 Ha: ratio != 1 Ha: ratio > 1
 Pr(F < f) = 0.0634 2*Pr(F < f) = 0.1267 Pr(F > f) = 0.9366

The results of the calculations performed for the investment portfolio of Tapiko (Portfolio 3) are presented in Table 11. As it is shown, the average return obtained from the optimized portfolio (with effective factors) is greater than those for optimized portfolio (without effective factors). The calculated standard deviation (Risk) and Sharp's ratio of the optimized portfolio (with effective factors) are also greater than the standard deviation and Sharp's ratio of the optimized portfolio (without effective factors).

The results of the calculations performed for the investment portfolio of Persian Gulf petrochemical holding (Portfolio 4) are presented in Table 12.

As it is shown, the average return obtained from the optimized portfolio (with effective factors) is greater than those for optimized portfolio (without

effective factors). The calculated standard deviation (Risk) of the optimized portfolio (with effective factors) is also greater than the standard deviation of the optimized portfolio (without effective factors), but the corresponding Sharp's ratios are negligibly different (about one percent). Considering that the p-value of the test is less than 10%, therefore, at a significant level of 10%, it can be said that the with-optimized portfolio return variance is higher than the without-optimized portfolio. Given that the p-value of the test is more than 5%, then the null hypothesis stating that the two means are not different, is not rejected. So there is no statistical significant difference between the average return on the with and without-optimized portfolios.

Table 11: equality of variances test between the Tapiko with and without-optimized investment portfolios

```
Variance ratio test
```

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]
r3_opt1	47	.9464396	.8713733	5.973834	-.8075439 2.700423
r3_opt2	47	1.611584	1.254011	8.597068	-.9126098 4.135778
combined	94	1.279012	.7601841	7.370258	-.2305631 2.788587

```
ratio = sd(r3_opt1) / sd(r3_opt2)                f = 0.4828
Ho: ratio = 1                                   degrees of freedom = 46, 46

Ha: ratio < 1          Ha: ratio != 1          Ha: ratio > 1
Pr(F < f) = 0.0076    2*Pr(F < f) = 0.0151    Pr(F > f) = 0.9924
```

Table 12: equality of variances test between the Persian Gulf petrochemical holding with and without-optimized investment portfolios

```
. sdtest r4_opt1 == r4_opt2
```

```
Variance ratio test
```

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]
r4_opt1	47	1.490718	.5217666	3.577052	.4404564 2.54098
r4_opt2	47	1.599453	.6414522	4.397575	.3082769 2.89063
combined	94	1.545086	.4112411	3.98713	.7284424 2.361729

```
ratio = sd(r4_opt1) / sd(r4_opt2)                f = 0.6616
Ho: ratio = 1                                   degrees of freedom = 46, 46

Ha: ratio < 1          Ha: ratio != 1          Ha: ratio > 1
Pr(F < f) = 0.0825    2*Pr(F < f) = 0.1651    Pr(F > f) = 0.9175
```

5. Discussions and Conclusions

In this research, optimization of investment portfolio of four investment companies in the field of petrochemical and refining including the Parsan, Vanaft, Tapiko, and Persian Gulf petrochemical holding were investigated. To do this, first of all, the status of the investment portfolio of these companies in terms of consisting stocks during the financial period from January 2013 till December 2016 was reviewed. In order to achieve more optimal and consistent findings, the stock of industries that had little or no weight in investment portfolios were omitted. After determining the industries, in order to determine the optimum stock weights of these industries in each portfolio with the aim of achieving a

fixed income (return) with the minimum risk, the expected return risk of industries stocks was estimated. Of course, due to the limited observations in the CCC and DCC methods, the adequacy tests of model showed a lack of validity. Therefore, the variance/covariance matrixes for variables were estimated using the Diagonal-BEKK method. Then, the risk and returns of the investment portfolio comprised of the selected industries stocks for were calculated and, based on the Markowitz theory, the problem of linear planning of risk minimization with respect to monthly fixed returns was solved using Matlab software, which resulted in the extraction of optimal investment portfolios for investment companies. The results indicate that in periods where

there was more stability in the return and less risk in each industry, the weights of those would increase in the corresponding portfolio. For the Parsan portfolio we can say that industry C has a significant weight at the beginning of the period, but due to the price fluctuations as well as increasing expected returns and decreasing return fluctuations for other industries incorporated in the portfolio such as A and B, lost its weight, so that at the end of the period, its weight in the portfolio fell to zero. Also, for the remaining three investment portfolios (Vanaft, Tapiko and Persian Gulf petrochemical holding), the same thing holds true, where the weight of a particular industry has been diminished over time in the portfolio due to high volatility. Therefore, according to the results derived from the linear programming method, the first hypothesis cannot be rejected for all four investment portfolios. It should be noted that Persian Gulf petrochemical holding portfolio consists of only two industries, so the Markowitz model, which emphasizes the diversification of portfolios, has not been observed in this portfolio. According to the results, it can be said that the MGARCH model provides better results (weights). The expected returns for the four optimized portfolios are higher than actual ones. The risks of optimized portfolios for Parsan, Vanaft and Tapiko are more than those for empirical portfolios, but can be ignored in proportion to the increase in returns, because the corresponding Sharpe ratio confirms the optimized portfolios. Based on the results, it can be concluded that the empirical portfolio of all four companies is not optimal. Therefore, the investment managers and executives of these companies can perform better, so that the investment portfolios will yield higher returns and lower risk. It can also be inferred that the MGARCH model provides better results (weights). The expected returns for the four with-optimized portfolios are higher than without-optimized portfolios. The risks of with-optimized portfolios are higher than the risks of without-optimized portfolios, except for the Parsan but it can be ignored in proportion to the increase in returns, because the corresponding Sharpe ratio confirms the with-optimized portfolios. So, the second hypothesis also cannot be rejected.

The main contribution of research is incorporating the endogenous and exogenous financial criterion (stock liquidity) and economic factors (crude oil price and free currency rate) into portfolio optimization

model in order to determine the optimal weights. Regarding such factors that affect the price, return and risk of stocks will increase the model reliability and add to the optimizations of portfolios to be real. Putting aside this, the research literature has used the risk-free interest rate as the minimum return, but this research tried to extract the returns on each of industries through a deep archival study of stocks included in the portfolios, in order to calculate the expected monthly return on the Markowitz model. Calculating the minimum return will also increase the model reliability and validity. This research, like other research done in the field of optimizing investment portfolios, assigns much weights to the stocks with rising returns and low volatility in the portfolio and does not allocate considerable weights to stocks of highly fluctuating industries that account for low returns. Individual investors can use the results of this research to create and optimize their investment portfolio which consists of shares in investment companies in the field of petrochemicals and refining. Also companies and investment funds with a more sophisticated vision can use this research to invest in the shares of petrochemical and refineries such as Zagros petrochemical company; because the most important result of this research is the classification of the companies in terms of stability of their stock prices, feed rates and dollar prices, which reflects the efficient strategies of their management staff. According to the results of the research, petrochemical and refinery investment companies can use MAGARH optimization models to optimize their investment portfolios, because the assets available in the portfolios of these companies can be more benefited. Managers of these companies can also reduce the portfolio risk through diversifying the portfolio. Managers of other investment companies, investment fund managers and also legal investors can optimize the company's portfolio by using MGARCH models, and the results obtained in the decision-making process can be fruitful. In addition to legal investors, real investors can also use these models to get a better view of investing and making better investment decisions. Finally, it can be said that despite huge amount of capital investment absorbed in the field of petrochemicals and refineries in the country, these financial resources have not been well allocated. The research help executives and investment managers to make better performance for their portfolios. Limited

research has been conducted to optimize investment portfolios of investment companies, pension funds, mutual funds, etc., taking into account the factors influencing their performance. Therefore, researchers can contribute to the performance of companies and investment funds by conducting portfolio optimization studies in this field. Future researchers can optimize the investment portfolios by taking into account effective factors in line with methods such as neural network, genetic algorithm and fuzzy logic and compare the results, and finally introduce the optimized model that is consistent with the conditions governing the Tehran Stock Exchange.

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