Analyzing Stock in a Complex Market in accordance with the Portfolio Optimization Using Network Architecture

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Submit: 30/12/2020 Accept: 11/04/2021

ABSTRACT

The present research was carried out aiming at analyzing stock in a complex market on the basis of portfolio optimization using network architecture. The statistical population of the study included 50 top stock firms in the last three months of 2019-2020(first three months 2020) and the financial information of these firms was analyzed. The present study calculated the centrality measures of each firm and then ranked them based on those results in regard to the total performance difference of each firm in comparison to all top firms including the performance of the firm under assessment and by emphasizing the standardized integrated performance criteria. Thus, the yield spread of the assessed item was used in making an investment decision in comparison to all other justified options. With reference to the centrality measure ranks, investing in Bandar Abbas Oil Refining Company with the first rank centrality measure was considered to be the best investment option, and investing in Glucosan company with the rank of 50 was the last choice for investment. In accordance with the former studies, the variables of profit volatility, capital return, firm value, market risk premium, stock profitability, financial structure, liquidity, and survival index were used in the model of the present research as the important factors affective stock portfolio optimization.

Keywords:

Portfolio Optimization, Stock Portfolio, Risk, Return, Network Architecture, Stock Centrality.

1. Introduction

Stock assessment based on risk and return pertinent to stock firms is among the important issues that affect the status, value, and companies' reflection in the stock market momentarily. If return and risk are assessed properly, the management decision makings of choosing the investment combination of firms can be studied and help the potential and actual investors of this firm to make the decision. Besides, new economic conditions such as the restrictions for accessing banking resources, unit beneficiary issue, variations of foreign exchange rate together with development plans with huge expenditures of the stock ownership projects resulted in the decrease of return and increase of the risks of the firms in Iran.

The modern portfolio theory (MPT) was proposed by Markowitz (1952), and then expanded by his students such as Sharp (1964) and Lintner (1965), which was finally, resulted in suggesting the Capital Assets Pricing Model (CAPM). Furthermore, the efficient Capital Markets hypothesis was presented by Fama (1970), along with Arbitrage Pricing Theory (APT) that was proposed by Ross (1967), which lead to the design of the three-factor model by Fama & Ferench (1996). As an acceptable and effective idea, the three-factor model by Fama & Ferench (1996), became the foundation of the studies of the financial researchers from the early 80s forward. In the financial markets these theories were employed as a guide by the investment managers and other activists of the market. However, the complexities of the financial markets and the studies regarding the contradictions appeared in the results of other research due to their execution in the financial markets, made the financial scholars investigate and revise the fundamental hypotheses of these theories.

Considering the weaknesses of the modern theories of the portfolio and efficient capital market and daily reduction of their acceptability, within the recent years, the financial knowledge adopted a new approach regarding the complex realities of the financial markets especially the capital market. The reasons for the reduction of the acceptability of these theories were the complexity of the real world and the impact of the various economic values, and the individual and social psychology on the financial markets. The aforementioned items make the traditional portfolio and efficient capital market theories to be unable to provide acceptable responses to the financial questions of the scholars such as the arbitrage opportunities, the extensive domain of pricing the financial assets, the impact of information on the stock price, etc.

Dai et al. (2020), is the origin of criticizations of the traditional portfolio and efficient capital market theories that lay the foundation for the new financial knowledge. Each of these researchers mentioned some deficiencies of the traditional theories. In regard to the financial markets' failure to move toward complete efficiency, Han & Wong (2020), are of the opinion that the financial markets can be inefficient with respect to pricing the financial assets. Since in case the market is assumed to be efficient, the information will enter the market immediately after production and their entrance into the market will be random, however, the information might not be the same impact on determining the prices as the quality of that information. Wrong interpretation of the information can result in misleading the market and affect determining the firm value. Analyzing the input information and the amount and level of a person's optimism and pessimism regarding the aforesaid information can impact determining the price of a stock. Thus, merely random and fast entry of information, the presence of specialists, and random movement of the prices cannot lead to market efficiency. The market efficiency with regard to stock pricing is an issue that accessing it is more difficult than just the issue of information efficiency in the market.

Even though the information reaches the market fast, the investors must pay the cost to obtain that information. What happens if the information entered the market is technical and enjoys a specific complexity which is above the market's understanding? Considering this condition is it possible that the prices of the stocks are affected within a moment and change into new prices? The studies demonstrated that the answer to this question is no and the impact of information on stock price is slower than what was proposed by the efficiency hypothesis.

In accordance with the discussed issues regarding forecasting the stock price in the capital markets, the researchers proposed a new model and examined their capability of forecasting in the capital markets. In some of the aforesaid models, the data of accounting were considered to be quite important since this was caused by the distortion of the efficient market hypothesis. When the market efficiency hypothesis is accepted, it can be assumed that the accounting information has very little informative content. However, as already mentioned the results of the new studies indicated that the efficient market does not materialize in the real world as it was discussed in financial texts. Therefore, accounting information can possess proper information in the field of stock pricing. The results of a research carried out with regard to the accounting data in forecasting the stock price such as the research by Ohlson (1995), and the subsequent complementary models plus the research by Mansour et al. (2019), regarding the accounting information and stock return revealed the capability of the accounting data in forecasting the stock return. The important issue in using the aforesaid data in forecasting the stock return is to find the appropriate variables as the effective factors that can explain the variations of risk and return properly.

Ma et al. (2020), recently suggested a model that measures risk using the fundamental accounting data as the base information for assessing the capital assets. The main approach of the proposed model by this researcher is considering the factors causing risk. These researchers argued that in the market information-based models such as the capital assets pricing model and Fama and French's three-factor model measuring risk is carried out on the basis of the return volatility, while this type of measurement based on emphasis is on the effect (return volatility) rather than the main factor causing risk Taking into account the discussed factors, the present research aims at analyzing the stock in a complex market based on portfolio optimization using network architecture.

2. Literature Review

2.1. Optimized Portfolio & Network Centrality

Carrying out the literature review indicated that there is an expansive discussion regarding the network. Especially in the field of Sociology about the manner of measuring the centrality of a specific factor that is placed in a network of relations. The importance of such criteria is resulting from the implicit assumption of the added power or a status pertinent to highly concentrated individuals. Despite the existence of its intuitive meaning, the whole concept of centrality is quite ambiguous and its measurement can be used depending on a specific major process. For instance, in a social network, when a factor is connected to other central factors it is considered as a central factor as well. While, as opposed to that, during a process of haggling, the centrality of i factor is a result of its relation with other non-central factors. In their article, Peralta & Zareei (2016), suggested a criterion of centrality that has become a standard in determining the centrality in the network texts. The present research will discuss this concept in the capital market and explain its relationship with the weights employed in determining an optimized portfolio.

2.2. Measuring Centrality

In general, network is an ordered pair of G= {N & Ω} set, in which N= {1, 2, …, n} is defined as a set of nodes and Ω is defined as a set of relations between each ordered pair of this set. Now assume that there is a relation from i node to j node, thus, there will be (i, j) ∈ ̃Ω. One of the proper ways to arrange information in ̃Ω is using the mean values that are called adjacency matrix points, in which Ω= [Ωij]. Ω is defined as n*n matrix in which Ωij ≠ 0 is an indication of a relation between i and j nodes.

If $\Omega \neq \Omega^T$, then, the network will be called a directed network. Therefore, if (i, j) ∈ ̃Ω, automatically ∈ ̃Ω (i, j). Bear in mind that there is no causal relation between links for unwanted networks and these relations are visually displayed as (j – i) line. On the other hand, if $\Omega \neq \Omega^T$ is called a directed network and Ωij expresses the causal relation from j node to i node, which is not necessarily reverse. In this case, the relations between the nodes is shown with an arrow, i.e. (j → i). Furthermore, if ،1}،Ωij ∈ {0, then, G is called non-weighted. When $\Omega ij \in \mathbb{R}$, they transfer the relations between nodes in information network pertains to the intensity of interaction between the nodes that leads to a weighted network. For a detailed discussion in this regard refer to the article by Li et al. (2018). As mentioned in the research by Zhong & Enke (2017), in expressing the real centrality, we assume that centrality of i node was vi and is defined proportionate to the sum of the central weights of its adjacency point in relation 1 and is written as follows:

(1) $$v_i \equiv \lambda^{-1} \sum_j \Omega_{ij} v_j$$

By replacing relation 1 in a matrix format, the special centrality of an assessed source, v, is defined based on a specific input Ω in relation to the specific amount λ. While the largest real value in this regard is the preferred option and is written as relation 2:

(2) $$\lambda v = \Omega v$$

Definition 1: Assume that there an undirected network and a weighted network G = {N , Ω}, and N considered as a set of nodes and Ω as the adjacency points matrix. In this case, the centrality of the specific i gram with i part of the specific Ω gram is pertinent to the largest specific value λ_1. While λ_1^{-1} is the proportionality factor.

It should be noted that any node can be considered as the centrality of the network on the contingent that it has relation with other nodes (positive range) or to be in relation with a limited number of central nodes. This proportionate value will be calculated for weight and non-weight networks as well. For the aforementioned directed structure, such a central weighting included some deficiencies, which is not recommended for its execution.

2.3. The Main Result of Selection of Optimized Portfolio

The review of the literature demonstrated that for the first time the fundamentals of the theory of portfolio optimization (stock portfolio), were invented by Markowitz (1952), and it was considered as a basis for designing the proposed model. Assume that in a portfolio, risk assets include an expected return gram as μ and covariance as Σ. In this case, portfolio optimization will be defined in form of a problem of determining the desirable weights as w that the variance has minimized this portfolio as the risk portfolio set on the condition that the total weights attributed to each asset form a portfolio equal to 1, i.e. $w^T\mathbf{1} = 1$. This strategy is normally identified as the minimization strategy of the total variance (total risk) or defined as m-var. Therefore, the aforementioned strategy in the form of minimization planning is defined as relation 3 as follows:

(3) $$\text{Min}\sigma_p^2 = w^T\Sigma w \quad \text{S. T:} \quad w^T 1 = 1$$

The optimized solution of the mathematical model defined in relation 4 as the quantity and calculated as follows:

(4) $$w^*_{mv} = \frac{1}{1^T\Sigma^{-1}1}\Sigma^{-1}1$$

Assume the return correlation matrix as Ω, the standard deviation of stock return i defined as σ_i and $\Delta = \text{diag}(\sigma_i)$. Finally, the relation between the correlation and covariance matrix is achieved by $\Sigma = \Delta\Omega\Delta$. In this case relation 4 can be defined in terms of Ω and as relation 5:

$$\hat{w}^*_{mv} = \varphi_{mv}\Omega^{-1} \in$$

(5) $$\hat{w}^*_{mv} = w^*_{mv} * \sigma_i, \varphi_{mv} = \frac{1}{1^T\Sigma^{-1}1} \text{ and } \epsilon_i = \frac{1}{\sigma_i}$$

Taking into account the defined problem including a risk-free asset with a return of rf. Therefore, the defined portfolio is a combination of n+1 asset, n risky assets, and one risk-free asset. In this case, the extra asset return i (r_i - r_f) is indicated as r_i^e and the expected extra return gram reaches μ^e. The problem of minimization of portfolio variance for a specific level of R^e extra return is determined as follows in relation 6:

(6) $$\text{Min}\sigma_p^2 = w^T\Sigma w \quad \text{S. T:} \quad w^T \mu^e = R^e$$

The investment strategy defined in relation 6 is known as a mean-variance strategy or M-var. It should be noted that $w^T1 = 1$ is not a limitation in relation 1, because a part of the investor's wealth can be allocated to the risky assets, in this case, $wf = 1 - w^T1$. However, when the set of the investment portfolio is taken into account it will be as $wf = 0$. The optimized solution for M-var strategy will be on the basis of relation 7 and as follows:

(7) $$w^* = \frac{R^e}{\mu^{eT}\Sigma^{-1}\mu^e}\Sigma^{-1}\mu^e$$

Following a similar logic as mentioned earlier, relation 7 can be changed into correlation matrix format and as relation 8:

(8) $\hat{w}^* = \varphi \Omega^{-1} \hat{\mu}^e$ در حالي كه $\hat{w}_i^* = w_i^* * \sigma_i, \varphi = \frac{R^e}{\mu^{e^T} \Sigma^{-1} \mu^e}$ و $\hat{\mu}_i^e = \mu_i^e / \sigma_i$.

3. Methodology

The present research conducted based on the theoretical inference method and seeks to find a new and local model suitable for the capital market of Iran in order to analyze stock in a complex market on the basis of portfolio optimization using network architecture (Case Study: Iran Stock Exchange). Therefore, the present research can be considered a theoretical research. On the other hand, the model was designed and employed with the purpose of helping investors and activists of the capital market make better decisions regarding investment. Therefore, the present research is considered as an applied research. The statistical population of the present research will be discussed later (50 top stock exchange firms in the fourth (first) three-months of 2020). As mentioned earlier, the statistical population of this research is selected based on statistical sampling and the random sampling was not successful and the mathematical optimization method was employed to select the optimized portfolio of stock. Accordingly, through inferring, the purpose was not to generalize and spread the results. The required tools were descriptive, in other words, it was a descriptive inferential method. The general definition, measuring, and determining the relation between variables and in other words, explaining the proposed model of research is described hereinbelow.

3.1. Centrality Determining Factors

At first, the main financial factors and effective market on stock return, i.e. centrality determining factors were identified and clarified. Accordingly, a four-step process was employed that is as follow:

First Stage: Identifying the factors affecting stock return based on the analysis of the field of knowledge.

Second Stage: Categorizing the factors and initial clarification on the basis of the content analysis model.

Third Stage: Carrying out a survey from the experts in accordance with the persuasive Delphi method.

Fourth Stage: Final clarification of the factors according to Fuzzy Topsis.

In accordance with the above logical and ordered process: 1. At first, through analysis of the field of knowledge, i.e. according to the investigation based on the literature review, various factors that were mentioned as effective factors on price or stock return were all identified. 2. Afterward, through the content analysis model, the similarities and differences were studied during the research to count the factors, the repetitive factors were eliminated, non-weight factors in Iran were eliminated, and finally, a list from the remaining factors affecting the stock return were all provided and identified based on a logical categorization. 3. Among the professors, professional experts, and affairs administrators in the capital market, at least 15 people were selected through purposive sampling and the detected factors and their importance will be categorized through a survey-based on the persuasive Delphi method. 4. In the Delphi method, the most important factors are clarified and categorized as effective factors on stock return. The clarified factors will be considered as effective factors on stock centrality.

3.2. Calculating Centrality

In order to calculate stock centrality, the relations introduced in the literature review were employed. Therefore, the return matrix and correlation matrix were calculated per the model suggested by Ledoit and Wolf (2004), in accordance with the extra return of stock (stock risk premium or extra return in relation to industry average). According to the calculations, the covariance matrix and return correlation matrix were defined as Σˆ and Ωˆ, respectively. When Ωˆ takes the adjacency matrix status in the market network, its main diameter becomes zero to prevent the meaningless rings. In the present research, centrality and real center are considered as synonyms.

Reviewing the literature demonstrated that based on the findings of the previous studies, disregarding that most of the transactions and investments in the capital market were carried out by production and commercial firms, the maximum centrality of stock of each firm is related to firms that activate in the financial industry (banks, mutual funds, investment companies, and insurance institutions) (Iorio et al., 2018).

Following the model by Peralta & Zareei (2016), in order to understand stock ranking on the basis of stock centrality, the scattergrams that: A. Centrality and beta of stock in which the horizontal axis is the centrality measure and the vertical axis is the stock beta. B. The rank of centrality and average correlation in which the horizontal axis is the rank allocated for each firm can be illustrated with respect to centrality average and the vertical axis is the correlation average.

3.3. Stock Centrality & Its Stability

In the present research, on the basis of the model by Peralta & Zareei (2016), the stock stability is interpreted as the tendency of the firm's stock to be supplied in the market without any variation in its relative status. Thus, two measures were employed. First, the average scores of the stock centrality in a period of time, e.g. monthly. Second, the result pertinent to the nature of the asset switched according to the various situations in the market network was investigated.

The first examination studied the stock tendency to the market with regard to its importance. Therefore, a 20-year-old moving return window was studied for the calculation of the central distribution for the total list of active stocks in that period. Afterward, the stock was grouped into three general categories through winsorization, in which on the basis of the return level the firms are divided into: 1. High, 2., medium, and 3. Low. This grouping was determined based on the three-month average return through moving average. The stock stability was carried out in accordance with a company lasting in various stages in the categorization.

In the second analysis, the variation of the stock nature was analyzed in terms of centrality with emphasizing the moving window approach. Therefore, this analysis focused merely on a stock that remained in the market. Thus, the created moving window in the respective time period was divided into two equal periods and these time periods were employed for the initial and final classification of stock with respect to being cross-border. In this analysis, in accordance with centrality through the winsorization method, the firms were classified into firms with 1. High, 2. Medium, 3. Low centrality. Variation in the firm status is an indication of switching and remaining in the group during the subsequent period was considered as the relative stability of the firm.

3.4. Analyzing the Process & Optimized Portfolio

Considering that in the systematic and individual performance analysis of the stock in the capital market the daily data were employed, the process analysis can be used to determine the relationship between centrality and optimization strategies of investment. In this case, if MC and WC are considered as average centrality and stock weight average, then, the mentioned parameters in relation 9 will be defined as follows:

$$\mathrm{MC_t} = \frac{1}{n}\sum_{i=1}^{n} \mathrm{Centrality_{it}}$$

(9) $\mathrm{WC_t} = \sum_{i=1}^{n} w^*_{it}\mathrm{Centrality_{it}}$ for $w^*_{it} = w^*{}_{it,mv}$ و w^*_{it}

The optimized investment strategy was expected to get closer to the simple rule of 1/n as the weight focus was getting closer to the average center. On the other hand, when the weight centrality is distant from the average centrality (higher or lower), the optimized investment strategy was drawn to the network centrality. Investigating the theoretical foundations indicated that weight concentration is more than the average concentration. Thus, the best resource allocation was inclined to the outside of the network (Zhang et al., 2020). However, some stages of the time period can be assumed to have weight concentration close to the average center. This behavior that depends on time can be explained through the correlation between individual performance and systematic performance of investments in the equity market network.

Assume that on the basis of the m-var model, the combination of optimized investment based on a set of stocks with the lowest standard deviation (lowest volatility of return) was selected. In this situation, investment in non-central assets is the best option. On the other hand, when the low-return central assets had the highest stability, it appears that there have been an agreement and a desirable portfolio equilibrium holds a balance between these two dimensions. On the other hand, when there was a relationship between the standard deviation of return and return stability was positive, the investment was desirable. This was due to the relationship between π and ρ with stock balance centrality. However, when π was negative, environmental resources were no longer the best investment restraints. With regard to the M-var strategy, the relation between the Sharp ratio and stock centrality was defined as ρ. Accordingly, as before, for ρ<0, the highest Sharp ratio was in the network range.

Therefore, there is no trade and wealth must be allocated to the market. Until ρ is assumed to be positive in terms of value, the central stock will enjoy the best individual performance and a desirable balance is required.

3.5. Ranking & Optimized Portfolio on the basis of Centrality

The research carried out by DeMiguel et al. (2013), revealed that the simple combination of investment based on an equal proportion of various investment options was closer to the results obtained from Sharp and Markowitz models. Furthermore, based on the results of the study by Zhong & Enke (2017) and Peralta & Zareei (2016), similar results were manifested in this regard.

Therefore, the stock ranking was carried out in accordance with the previous results provided hereinabove using weights of stock average centrality and these weights were employed to determine the desirable strategy for investment. Consequently, if the weight of average centrality of each stock is divided into the sum of the average values, as a relative quantity, the relative share of each stock in total investment or optimized portfolio will be demonstrated as a relative quantity between zero to 1 or in terms of percentage in the distance or zero to 100.

4. Results

In research by Zamanpour (2014), by using the judgmental method in the survey conducted on experts and the quantitative and multi-variable model of fuzzy network analysis, the level of importance was assessed, ranked, and the effective factors on portfolio optimization were clarified and the results were used in this article. In accordance with the analysis of this research, at this stage, the findings of the survey on the experts, and fuzzy network analysis in the field of clarifying the effective factors on portfolio optimization were summarized and used as the final measures in measuring the variables and the relations between them, which are defined as follows in Table 4-7:

Table 1: Effective Factors on Portfolio Optimization based on Fuzzy Delphi Separation Technique

#	Variable	Symbol	Significance	Type	Definition & Measurement
1	Profit Volatility	VOL_{it}	0.1011	Minimum	Variation of stock price ratio within a year
2	Capital Return	ROE_{it}	0.1321	Maximum	Ratio of the net profit to book value of stockholders' salary
3	Firm Value	QTB_{it}	0.1425	Maximum	Book value of stock plus book value of debt per stock book value at the end of year
4	Market Risk Premium	$SMB_{i,t}$	0.1181	Maximum	Annual firm stock return difference & risk-free return rate (long-term bank interest)
5	Stock Profitability	$CMA_{i,t}$	0.1552	Maximum	Profit of each stock at spot price of the stock at the end of the period
6	Financial Structure	LEV_{it}	0.1047	Minimum	Total debts to total assets at the end of the period
7	Amihud Liquidity	$LVD_{i,t}$	0.1612	Maximum	In accordance with Amihud (2002) & Gopalan (2009)
8	Survival Index	$SUP_{i,t}$	0.0851	Minimum	Altman Z-score

In the present study, the stock illiquidity criterion was employed, which was proposed by Amihud and optimized by Gopalan due to its skewness correction. This criterion was used as one of the crucial stock transaction liquidity indices based on the purchase and sell price spread, and distribution of zero profit. Examining the literature review revealed that Amihud illiquidity criterion (2002), that was expanded by Gopalan et al. (2009), is as described in relation 10:

$$Illiq_{i,t} = \frac{1}{N_{i,t}} \sum_{j=1}^{N_{i,t}} \sqrt{\frac{|R_{ij}|}{Vol_{ij}.P_{i,j-1}}} \quad (10)$$

In this relation, $Illiq_{i,t}$ was the illiquidity of the investment in i stock during t year, $N_{i,t}$ was the number of transaction days pertinent to i stock during t year, and $R_{i,t}$ was pertinent to i stock during t year, which was calculated on the basis of the price logarithm difference at the time of t and t-1 (Dan et al., 2020), $VOL_{i,t}$ was the trading volume or the volume of the stocks traded pertinent to i stock during t year, finally, $P_{i,j}$ was the close prices pertinent to i stock during t year (Gopalan et al., 2009).

4.1. Choosing an Acceptable Decision-Making Space

In this stage, on the basis of the final ranking of the stock exchange, 50 firms accepted in Tehran stock exchange were defined as the basis for selecting the investment options and the investment volume in each firm was defined relatively as zero to 1 or in terms of percentage between 0 to 100 percent from the total capital in these firms.

4.2. Calculating Centrality

In this section of the analysis of the findings in accordance with the approach of "analyzing stock in a complex market on the basis of portfolio optimization using network architecture" and with respect to the model proposed in the present research, the centrality criterion was calculated for each firm and the results were described based on the ordered and logical algorithm employed in the present research:

4.3. Calculating Sub-Criteria

At this stage, for the performance data, through analysis of the field of knowledge and using content analysis model, the detected sub-criteria were clarified through Delphi survey on the experts, the multi-criteria model of fuzzy network analysis was collected in the performance span of 1 year ending on 19/03/2020, the required calculations were carried out, and the final results are included in Table 2.

4.4. Normalization

At this stage, due to the difference in the scales and to measure, each sub-criteria calculated at the first stage were provided with a relative same-scale quantitative definition and in other words, they were normalized. Accordingly, first: for each sub-criteria with a maximum criterion, the sub-index volume for each firm was divided into the maximum volume of the same sub-index in the 50 top firms and was defined as a number between zero and one with four decimal places.

Second: For each sub-criteria with a minimum criterion, the lowest volume of sub-index was selected among the 50 top firms and divided into the volumes pertaining to the firm and were defined as a number between zero and one with four decimal places. The results are summarized in Table 3.

4.5. Integration

At this stage, taking into account the differences in the result of assessment and ranking of the firms depending on using each sub-criterion, the sub-criteria with regard to their degree of significance (Table 4-7) was integrated in the survey on the experts as weight average and defined as a standardized value index and summarized in Table 4 as follows.

4.6. Determining the Centrality

At this stage, the centrality measure of each firm was calculated and then ranked, since based on the total performance difference in each firm in comparison to all top firms and among the performance of the firm under assessment and by emphasizing the standardized integrated criterion of performance. In other words, the yield spread of the respective option was employed in comparison to other acceptable options in investment decision-making.

Accordingly, first: The integrated index difference was calculated for each firm and including the firm itself and determined to be a positive number (absolute value). Second: the sum of the performance differences was calculated by summing the calculated volumes for 50 firms. Third: by dividing the obtained sum of each firm into the total obtained sum for all firms (rounded and controlled with four decimal places). Fourth: considering that the most desirable performance status for the minimum calculated volume in the previous stage was complemented, i.e. the obtained numbers in the former division were deducted from the maximum of the former column and introduced as a positive number. Finally, standardized, i.e. the obtained complementation is divided into the sum complements of 50 firms and controlled and is divided as the centrality measure of the assessed firm. The obtained numbers were positive with five decimal places and in total was one and was standardized.

It is worth noting that the centrality measure for each firm as a relative quantity between zero to one and totally or for each firm equaled one. The results of the centrality measure and firm ranking based on integrated and standardized criteria (the highest centrality measure is rank 1 and respectively other centrality measures attained rank 2), are summarized in Table 5.

Based on the ranking of the centrality measures, investment in Bandar Abbas Oil Refining Company with respect to the centrality measure holds the first rank and is the top investment option and Glucosan Company with the rank of 50 is the last priority of investment.

Table 2: Sub-Criteria Measures in the Top Firms Based on the Performance Data

Code	Profit Volatility	Capital Return	Firm Value	Market Risk Premium	Profitability	Liquidity	Survival Index	Financial Leverage
1	0.674	0.074	2.250	0.003	0.454	0.107	0.893	0.616
2	0.133	0.125	2.150	-0.027	0.177	0.062	2.514	0.355
3	0.788	0.658	1.569	-0.033	0.254	0.042	3.051	0.323
4	1.498	0.191	1.066	-0.031	0.160	0.187	0.151	0.919
5	0.735	0.760	15.866	-0.040	0.116	0.164	5.045	0.297
6	0.359	0.028	2.336	-0.076	0.099	0.206	1.324	0.434
7	1.897	-1.278	6.472	-0.070	-0.041	0.082	-1.497	1.484
8	1.523	0.105	1.380	-0.030	0.031	0.210	0.154	0.877
9	-0.012	0.584	2.323	0.045	0.106	0.212	4.354	0.407
10	0.784	0.711	3.158	-0.046	0.254	0.136	5.349	0.373
11	-0.487	0.417	2.868	0.047	0.054	0.294	4.583	0.484
12	-0.352	0.623	2.890	-0.013	0.062	0.274	4.718	0.574
13	1.530	0.031	1.354	-0.030	0.228	0.189	0.471	0.658
14	2.047	-0.035	1.583	0.120	0.112	0.183	-0.135	0.871
15	1.200	0.107	1.221	-0.039	0.140	0.198	4.843	0.128
16	0.317	0.438	2.633	-0.032	0.221	0.257	3.453	0.286
17	1.463	-0.557	2.340	-0.037	-0.102	0.125	-1.083	1.259
18	0.205	0.019	3.803	-0.034	0.153	0.086	2.321	0.211
19	0.541	0.324	1.746	-0.038	0.113	0.098	3.992	0.171
20	-0.104	0.451	2.314	0.00	0.023	0.216	0.221	0.853
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Min.	-0.565	-1.278	0.972	-0.083	-0.923	0.028	-2.519	0.077
Max.	9.156	5.309	18.953	0.300	0.756	0.294	8.334	1.484
Average	1.183	0.331	3.850	0.010	0.112	0.156		0.582
Standard deviation	1.583	0.832	4.360	0.088	0.206	0.079		0.313

Table 3: Normalization of Sub-Criteria in Top Firms

Code	Profit Volatility	Capital Return	Firm Value	Market Risk Premium	Profitability	Liquidity	Survival Index	Beta
1	0.0736	0.0139	0.1187	0.0106	0.6010	0.3645	0.1071	0.4153
2	0.0146	0.0236	0.1134	-0.0905	0.2341	0.2105	0.3017	0.2392
3	0.0860	0.1240	0.0828	-0.1087	0.3367	0.1418	0.3661	0.2178
4	0.1636	0.0360	0.0562	-0.1043	0.2112	0.6372	0.0181	0.6190
5	0.0802	0.1431	0.8371	-0.1317	0.1541	0.5566	0.6053	0.1998
6	0.0392	0.0054	0.1233	-0.2540	0.1312	0.7001	0.1588	0.2924
7	0.2072	-0.2407	0.3415	-0.2335	-0.0537	0.2785	-0.1797	1.0000
8	0.1664	0.0198	0.0728	-0.1007	0.0405	0.7151	0.0185	0.5910
9	-0.0013	0.1100	0.1226	0.1501	0.1399	0.7198	0.5224	0.2741
10	0.0857	0.1340	0.1666	-0.1534	0.3363	0.4607	0.6419	0.2516
11	-0.0531	0.0785	0.1513	0.1582	0.0720	1.0000	0.5500	0.3260
12	-0.0384	0.1173	0.1525	-0.0436	0.0827	0.9313	0.5661	0.3871
13	0.1671	0.0058	0.0715	-0.1014	0.3019	0.6430	0.0567	0.4437
14	0.2235	-0.0065	0.0835	0.3990	0.1477	0.6209	-0.0163	0.5873
15	0.1311	0.0201	0.0644	-0.1303	0.1847	0.6743	0.5811	0.0864
16	0.346	0.0825	0.1389	-0.1081	0.2920	0.8752	0.4143	0.1927
17	0.1598	-0.1050	0.1235	-0.1249	-0.1355	0.4250	-0.1300	0.8485
18	0.0224	0.0036	0.2007	-0.1138	0.2029	0.2911	0.2784	0.1422
19	0.0590	0.0610	0.0921	-0.1274	0.1501	0.3325	0.4790	0.1152
20	-0.0113	0.0849	0.1221	-0.0014	0.0301	0.7348	0.0265	0.5746
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Min.	-0.0617	-0.2407	0.0513	-0.2763	-1.2210	0.0962	-0.3022	0.0518
Max.	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Average	0.1292	0.0624	0.2031	0.0332	0.1486	0.5313	0.2541	0.3925
Standard deviation	0.1729	0.1567	0.2300	0.2938	0.2721	0.2696	0.2496	0.2112

Table 4: Integration of Sub-Criteria in Top Firms

Code	Firm Name	Index	Code	Firm Name	Index
1	Fars	0.149	26	Nouri Petrochemical Co.	0.183
2	Steel Co.	0.078	27	HiWEB	0.131
3	NICICO	0.097	28	BSI	0.071
4	Mellat Investment Company	0.129	29	Mobin	0.097
5	TAPPICO	0.207	30	VNovin	0.160
6	Golegohar Mining & Industrial Co.	0.108	31	ICIIC	0.152
7	Khodro	0.097	32	Pardis Petrochemical Co.	0.093
8	MAPNA Group	0.099	33	Sadr Tamin Investment Co.	0.168
9	Tehran Oil Refining Co.	0.141	34	Tabriz Petrochemical Co.	0.153
10	Pars	0.183	35	Kavir Motor Co.	0.167
11	Isfahan Oil Refinery	0.145	36	Khorasan Steel Complex Co.	0.117
12	Bandar Abbas Oil Refining Co.	0.125	37	Parsian Bank	0.118
13	I.R. TCI	0.112	38	State Retirement Fund Investment Co.	0.164
14	IRISL	0.118	39	Informatics Services Co.	0.128
15	Ghadir Investment Co.	0.142	40	Shazand Petrochemical Co.	0.080
16	Chadormalu Mining and Industrial Co.	0.134	41	Iran Transfo	0.135
17	SAIPA	0.083	42	Kharg Petrochemical Co.	0.141
18	Mines and Metals Development Investment Co.	0.072	43	Pars Khodro	0.088
19	Parsian Oil & Gas CO.	0.085	44	IKIDO	0.195
20	I.R. MCI	0.100	45	Persian Gulf Petrochemical Industries Co.	0.046
21	Khuzestan Steel Co.	0.141	46	Tehran Stock Exchange	0.146
22	Tejarat Bank	0.207	47	Machine Sazi Arak	0.026
23	Omid Investment Co.	0.108	48	Glucosan Co.	0.297
24	Jam Petrochemical Co.	0.124	49	NIDC	0.068
25	Persian Gulf Fajr Energy Co.	0.068	50	Fajr Petrochemical Co.	0.152
Minimum		0.257	Average		0.1266
Maximum		0.2972	Standard Deviation		0.0471

Table 5: Centrality Measure & Ranking Firms based on It

Code	Firm Name	Total Difference	Relative Difference	Complementary	Centrality Measure	Rank
1	Fars	2.019	0.0160	0.0516	0.02168	20
2	Steel Co.	2.644	0.0210	0.0466	0.01960	38
3	NICICO	2.087	0.0165	0.0511	0.02145	24
4	Mellat Investment Company	1.773	0.0141	0.0536	0.02250	3
5	TAPPICO	4.185	0.0332	0.0344	0.01447	47
6	Golegohar Mining & Industrial Co.	1.899	0.0151	0.0526	0.02208	16
7	Khodro	2.088	0.0165	0.0511	0.02145	25
8	MAPNA Group	2.046	0.0162	0.0514	0.02159	22
9	Tehran Oil Refining Co.	1.866	0.0148	0.0528	0.02219	14
10	Pars	3.183	0.0252	0.0424	0.01780	44
11	Isfahan Oil Refinery	1.942	0.0154	0.0522	0.02194	18
12	Bandar Abbas Oil Refining Co.	1.772	0.0140	0.0536	0.02250	1
13	I.R. TCI	1.859	0.0147	0.0529	0.02221	11
14	IRISL	1.802	0.0143	0.0533	0.02240	8
15	Ghadir Investment Co.	1.880	0.0149	0.0527	0.02214	15
16	Chadormalu Mining and Industrial Co.	1.801	0.0143	0.0533	0.02241	7
17	SAIPA	2.503	0.0198	0.0478	0.02007	34
18	Mines and Metals Development Investment Co.	2.906	0.0230	0.0446	0.01873	39
19	Parsian Oil & Gas CO.	2.420	0.0192	0.0484	0.02034	32
20	I.R. MCI	2.032	0.0161	0.0515	0.02164	21
21	Khuzestan Steel Co.	1.862	0.0148	0.0528	0.02220	13
22	Tejarat Bank	4.219	0.0334	0.0342	0.01435	48

Code	Firm Name	Total Difference	Relative Difference	Complementary	Centrality Measure	Rank
23	Omid Investment Co.	1.910	0.0151	0.0525	0.02204	17
24	Jam Petrochemical Co.	1.774	0.0141	0.0535	0.02250	4
25	Persian Gulf Fajr Energy Co.	3.042	0.0241	0.0435	0.01827	41
26	Nouri Petrochemical Co.	3.151	0.0250	0.0426	0.01791	43
27	HiWEB	1.783	0.0141	0.0535	0.02247	5
28	BSI	2.914	0.0231	0.0445	0.01870	40
29	Mobin	2.089	0.0166	0.0510	0.02145	27
30	VNovin	2.346	0.0186	0.0490	0.02059	31
31	ICIIC	2.088	0.0166	0.0511	0.02145	26
32	Pardis Petrochemical Co.	2.207	0.0175	0.0501	0.02105	29
33	Sadr Tamin Investment Co.	2.606	0.0206	0.0470	0.01973	37
34	Tabriz Petrochemical Co.	2.134	0.0169	0.0507	0.02130	28
35	Kavir Motor Co.	2.547	0.0202	0.0474	0.01992	35
36	Khorasan Steel Complex Co.	1.806	0.0143	0.0533	0.02239	9
37	Parsian Bank	1.797	0.0142	0.0534	0.02242	6
38	State Retirement Fund Investment Co.	2.458	0.0195	0.0481	0.02022	33
39	Informatics Services Co.	1.772	0.0140	0.0536	0.02250	2
40	Shazand Petrochemical Co.	2.574	0.0204	0.0472	0.01983	36
41	Iran Transfo	1.807	0.0143	0.0533	0.02238	10
42	Kharg Petrochemical Co.	1.861	0.0148	0.0529	0.02221	12
43	Pars Khodro	2.344	0.0186	0.0490	0.02060	30
44	IKIDO	3.653	0.0290	0.0387	0.01624	45
45	Persian Gulf Petrochemical Industries Co.	4.060	0.0322	0.0354	0.01488	46
46	Tehran Stock Exchange	1.950	0.0155	0.0521	0.02191	19
47	Machine Sazi Arak	5.046	0.0400	0.0276	0.01160	49
48	Glucosan Co.	8.530	0.0676	0.0000	0.00000	50
49	NIDC	3.53	0.0242	0.0434	0.01824	42
50	Fajr Petrochemical Co.	2.087	0.0165	0.0511	0.02145	23
	Minimum	1.7717	0.0140	0.0000	0.0000	-
	Maximum	8.5298	0.0676	0.0536	0.0225	-
	Average	2.5235	0.0200	0.0476	0.0200	-
	Standard Deviation	1.1466	0.0091	0.0091	0.0038	-
	Total	-	1.0000	-	1.0000	

5. Conclusion

Optimization of the stock portfolio is numbered among the most significant research fields in Modern Risk Management. The researchers investigate this issue from different dimensions and test and propose various models. One of the main studies in the field of stock portfolio optimization is the mean-variance model proposed by Markowitz (1952). This model is considered as an equilibrium between mean and variance that indicated return and risk of a stock portfolio, respectively. In fact, managers and investors of the stock portfolio have a specific risk threshold and can tolerate up to that level. Markowitz's model should meet two conflicting criteria that decrease the risk for a predefined return value. Over the past two decades, the financial environment faced many changes. The development of powerful communications and trade facilities broadened the domain for selecting investors. The traditional theory of the market has changed and the economic analysis methods have been improved. Employing quantitative methods such as the purpose of forecasting financial markets, improvement of decision-making and investments has become an undeniable necessity in today's world. Furthermore, various approaches have been adopted for financial issues and especially the equity market. In general, these approaches are divided into two categories: statistical and artificial intelligence. The statistical methods are employed widely in forecasting stock and on the basis of the past time series. The traditional statistical approaches include ARMA, the threshold autoregressive model (TAR model), STAR model, and multi-variable regression model. These models are considered to be based on the assumption of being linear between variables and normal distribution. Although in statistical models, when the variance is increased in the times series or the non-linear processes or there are non-linear processes in the time series, it can lead to a problem. By the increase of the needs for more effective commercial models, it was proved that the artificial intelligence approaches have a better output than the traditional statistical models. Since they can overcome limits such as the above assumption. The present research is on one hand based on the theoretical inference methods to find a new and native model that is suitable for the status of the capital market in Iran in order to analyze stock in a complex market in accordance with portfolio optimization using network architecture (Case Study: Iran Stock Exchange). Therefore, the present study can be considered as a theoretical research. On the other hand, the purpose of designing a model and employing it was with the intention of helping investors and activists in the capital market regarding making better investment decisions. Thus, the present study can be considered as applied research. The statistical population which was already discussed (50 top stock exchange company during the fourth (first) three-month of 2020) was based on a statistical sample and using a random method in the present research, a part of the statistical population was considered as not materialized as a random sample and in selecting the optimized stock portfolio mathematical optimized methods were employed. Accordingly, through inference, the purpose was not generalizing and spread of the results and the tools used were descriptive, i.e. it was a descriptive-inferential method.

The results in relation to using analysis of the field of knowledge and content analysis were employed in detecting the financial individual operators affecting the stock return of the select stock exchange companies. Using the persuasive Delphi approach to survey experts and the fuzzy multi-capital network analysis was effective in clarifying the factors. Therefore, the investment companies, policy-makers, and the supervision divisions are recommended to assess the financial return of these firms to use the clarified final financial operators including 1. Profit violability, 2. Capital return, 3. Firm value, 4. market risk premium, 5. Stock profitability (profit of each stock at the price of the ends of the period), 6. Financial structure, 7. Amihud liquidity, and the survival rate. In case of assessing and rankings them simultaneously based on the multiple criteria will be facilitated. The results revealed that, combining the stock financial operators and systemic operator regarding the approach of network centrality a coherent and multi-dimensional criterion can be obtained for systemic assessment of performance in various financial and performance dimensions in the capital market. Therefore, it is recommended that the investment companies and financial analysts use this method to determined the rank and priority of stocks in determined the desirable investment combination.

For more study and completion of the present research, the following issues are recommended for future studies:

- Detecting the financial and non-financial operators affecting the determination of investment strategies on the basis of analysis in the field of knowledge and clarifying them in accordance with the quantitative algorithms such as stepwise regression, searching algorithms including decision tree algorithm, and comparing their explanatory power in a form a comparative study.
- Designing and employing expert system in order to determined the investment strategies based on integration of the approach of systemic centrality, mathematical modeling, and using meta-heuristic algorithms with emphasizing the algorithm and modeling used in the present research.
- Determining an initial acceptable decision-making space in determining investment strategies based on approaches of the data envelopment analysis or entropy criterion instead of focusing on the ranked firs as the top stock exchange firms.
- Determining investment strategies based on the abnormal criteria and return volatility and taking into account the macro limitations in decision-making such as the government’s economic policies.

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