Journal of Mathematics and Modeling in Finance (JMMF)
Vol. 3, No. 2, Summer & Autumn 2023
Research paper

The artificial neural networks for investigation of correlation between economic variables and stock market indices

Mehdi Rezaei[1], Najmeh Neshat[2], Abbasali Jafari Nodoushan[3], Amir Mohammad Ahmadzade semeskande[4]

[1] Department of Industrial Engineering, Engineering Faculty, Meybod University, Yazd, Iran
rezaeimehdi619@gmail.com

[2] Department of Industrial Engineering, Engineering Faculty, Meybod University, Yazd, Iran
neshat@meybod.ac.ir

[3] Department of Industrial Engineering, Engineering Faculty, Meybod University, Yazd, Iran
a.jafari@meybod.ac.ir

[4] Department of Industrial Engineering, Engineering Faculty, Meybod University, Yazd, Iran
amirahmadzadeu73@gmail.com

Abstract:
In this research, we investigated the interactive effects between the macroeconomic variables of currency, gold, and oil on two indicators of total and equal weighted indices considering the importance of correlation between economic variables and stock market indices. In this regard, the analysis of Pearson correlation and regression coefficients have been used to investigate the existence of an interactive effect among them, and a Multi-Layer Perceptron Neural Network (MLP NN) model has been used to simulate this effect. The models have been fitted as a time series based on the daily data related to the economic variables and the mentioned indicators during march 2016 to that of 2021. Investigating the interactive effects between variables has been done using SPSS statistical software, and Artificial Neural Network (ANN) simulation developed in MATLAB programming environment. The extracted results indicate the existence of an interactive effect among these economic variables. The simulation results show the high ability of ANN in modeling and predicting the total price and equal-weighted indices, and this model has been able to make more accurate predictions by considering these interactive effects as well.

Keywords: Interactive effect, Total index, Equal weighted index, Modeling, Artificial neural network
Classification: C22, C58, R2

1 Introduction

Investment is a process in line with economic growth and development, and the country's economic stability is considered as of the most important factors in the

[2]Corresponding author
Received: 17/09/2023 Accepted: 13/12/2023
https://doi.org/10.22054/JMMF.2023.75800.1104

decision to invest; so that the fluctuations of economic variables are among the common factors in volatility and instability in the capital market [1]. Therefore, the way of interaction and mutual influence of this element with the same others of economic systems and the other micro and macroeconomic variables has always been raised as of the significant challenges in the capital market [2]. As by providing liquidity, reducing the cost of transactions, searching, and reducing the cost of information are a suitable place to move people's stagnant savings towards investment in production and supplying companies, financial markets are considered as a suitable place for investment [3]. Recognizing the way of connecting financial markets and their effects on other investment markets is important from the point of views of both the investors and market participants which most of them are seeking for portfolio and risk management of financial markets, and of policy makers for the stability of economic fluctuations. Recognizing and investigating the impact of factors affecting indices are the most important tools for deciding to invest in the stock exchang [4]. Many practical researches indicates the correlation between the price fluctuations of macroeconomic variables and the stock market; therefore, it is useful to investigate any possible fluctuations and the way they affect the stock market in order to make a right investment decision for the future [2]. Although there is a wide range of modelling and prediction approaches in the national and international literature, recent studies have shown the superiority of computational intelligence models in this field. Features such as the ability to model nonlinear and conditional relationships, and the ability to support non-deterministic data make Computational Intelligence-based models among the best. Therefore, the interactive effects of three macroeconomic parameters i.e., crude oil prices in the world market, the world gold prices, and the exchange rate on each other, and also modelling how these interactions affect two indicators of the total price and equal-weighted index in the Tehran stock exchange are considered in this study using ANNs.

The results of this research have been arranged in five sections, and the theoretical basis and background will be introduced in section 2. In section 3, the methods and tools used to reach to the answers of desired questions are described. Section 4 is related to the findings and outputs obtained from the implementation of the models which are summarized, and suggestions for their development are described in section 5.

2 Research background

The stock market plays a vital role in the economic growth of each country, and the status of this market has an effect on various economic sectors and is also affected by the others [5]. It is of the most important financial markets in most countries [3]. Reasonably, to examine the background of some studies, up-to-date articles and reliable resources have been investigated as much as possible in order to be able to

compare the results and use the best methodology compared to previous researches in the current one in the literature review.

In developing countries like Iran, macroeconomic variables have a high degree of volatility and instability. Naser Seifollahi and Hamed Seifollahi [6] have investigated the fluctuations of exchange rate, crude oil price, and economic growth rate three macroeconomic variables on the total index of the stock market using conditional heterogeneity variance auto-regression method monthly data during 2009 to 2018. The results showed that the fluctuations of the total index of the Tehran stock exchange are significantly influenced by the fluctuations of exchange rates, crude oil prices, and economic growth. In another study that investigated the contagion of the total index of the Tehran stock exchange from the price of parallel assets by using dynamic ANN to perform calculations, the price of residential building square per meter, the exchange rate of the US dollar against the Rial and their conditional fluctuations, the time series of the price of the gold coin, and the price of a barrel of Iranian crude oil as input variables and the total index of the Tehran stock exchange and its conditional fluctuation as the target variable during the years 2008 to 2018 are investigated with daily frequency, and the results indicated that the Tehran stock exchange has contagion from the competing markets with a maximum of two time intervals, which indicates the weak efficiency of the Tehran stock exchange. The results also showed that the developed Neural Network (NN) has a high ability in forecasting the total index of Tehran stock exchange and its fluctuations during years 2008 to 2018 as an in-sample forecast and of 2019 as an out-of-sample forecast [7]. In the following, some studies are discussed in which the researchers investigated the effect of economic variables and also the effect of some indicators on the total index. Riyadhi Nia investigated the effect of a set of parameters affecting the general index with the help of Bayes approach in 2020, and concluded that oil price, general price index, and consumer services have a significant effect on the total price index of the Tehran stock exchange. Also, based on selecting the Best Bayesian model, the best model to explain the changes in the total index of the Tehran stock exchange is a model that includes the variables of dollar, oil, and consumer goods and services price indices with a probability of 0.656. Also, all independent variables were able to explain the total changes in Tehran stock exchange with a probability of 0.241 [8].

Another study was conducted on the purpose of forecasting the total index changes. In this research, the decision to present a model for forecasting changes in the total index with consideration to the behavioral and macroeconomic factors governing the monetary and financial markets of the country was considered, which showed that the continuation of the economy with the same trend by 2021 will increase the currency value of all the competing assets of the stock with consideration to the Tehran stock exchange total index, and this can lead to economic crises for the country [9]. Another research was conducted with the purpose of comparing the MLP NN models with the back-propagation algorithm and the Image Alge-

bra NN model. The purpose of this research was to propose a model that could be efficient in the short and long-term duration forecasting for the closing price of the S&P500 index in the US market. The simulation results showed that the MLP model provides better forecast than the Image Algebra NN model [10]. In the study of Fernando Villada-Duque et al. [11] an ANN model was proposed to forecast prices in the Colombian financial markets. This model was applied to two stocks in the Colombian stock market and three commodities, and the gold, oil, and electricity price were trained with different configurations of NNs and time series of prices of about five to six months; so that the first months were used as training patterns and the last month as test data. The results showed that the NN with least error of training and testing has a good performance in the direction of the desired forecasts. Nurwulandari [12] investigates the impact of several micro and macroeconomic variables such as the interest rate, the exchange rate, the world gold price, and various indicators such as Dow Jones, Euronext Amsterdam (AEX), Blue Chip, and Shanghai index on the Indonesia stock market index exchange during 2012 to 2018. The results indicated that the exchange rate had a significant negative effect while Dow Jones, AEX, and the Blue Chip stock market index had a significant positive effect. The interest rate and the world price of gold have had a significant negative impact while the impact of the Shanghai index was positive and insignificant. It can be concluded that the foreign exchange markets, gold, and oil are among the most important financial markets and their price fluctuations are also used as an indicator to show the economic status of each country.

2.1 Artificial Neural Networks (ANNs)

The NN is based on the biological model of the animal brain. These networks are an information processing system that has performance characteristics similar to animal NNs, which were created by generalizing their mathematical models. Due to these characteristics, ANNs are a suitable method for detecting unknown patterns [29]. The purpose of these models is to provide a series of information to the computer in a way that is understandable and can be used for human goals. NNs can help investors to make the right investment decision by receiving and analyzing data in their hidden layers to provide an appropriate output, and then, by analyzing the results of the model, the investor can make a right decision for a safe investment [13]. The input data in the NN is classified and different information can be grouped based on similarity to a specific example. Perceptron Neural Network is one of the widely used networks in applied sciences, which belongs to the category of ANNs. A network consists of at least three layers of nodes: an input, a hidden, and an output layer. Except for the input nodes, each node is a neuron that uses a non-linear activation function. The MLP uses a supervised learning technique called back-propagation for training. Its multiple layers and non-linear activating distinguish the MLP from a linear-perceptron. The important issue in MLP NN is to divide the existing data into training and test data; in this context,

it should be paid attention to the characteristics of the problem, the type of the data, and the available data. These two collections must have the characteristics of society which is very important issue in time series forecasting [14]. In general, there are two types of NN training, i.e., supervised and unsupervised learning, and the difference between these two is that in the first case, it is assumed that the desired answer of the learning system is already known in each step of repeating the training algorithm; in other words, education has access to the real and desired answer, and it will also have access to the learning error, which is the error between the desired and the real value [15]. Contrarily in the second case, the optimal answer for the learning system is not available; in other words, we do not have access to the learning error to improve the behavior of the learning system [16]. NN can be used as an expert in information fields for data analysis in case to be trained. The NN organizes the information receives during the learning period to use this information when needed. The NN is less sensitive to the correlation of input data as well as missing ones compared to previous classical regression models. In the MLP method, each neuron or nerve cell processes and transmits information to another cell after receiving them. This process continues until the desired result will obtained. Forecasting is an important feature of the set of applications of ANNs. Unlike traditional methods, the self-adaption of ANN methods extracted from the data is the reason for suitability of NN for forecasting, or in other words, they are in the form of a free model. The NN learns from the training data and discovers the unknown relationships between them. The usefulness and efficiency of the NN model becomes more apparent when we face such problems as the complexity and difficulty of the problem or the existence of interactive and conditional effects between the variables in that, as for ANNs are of the non-parametric nonlinear multi-variate statistical methods that have the ability to learn and correct errors [17]. Figure 1 shows the structure of the MLP model. This structure indicates that the layers are connected in order that the outputs of the first layer are the inputs of the second layer, and so on until the outputs of the last layer form the main outputs and the real response of the network [18].

In traditional methods such as Box Jenkins, it is assumed that there is an explicit relationship for a time series without having knowledge of the basic rules governing inputs and outputs. In fact, the formulation of a non-linear model with constant coefficients for a given set of data is a limiting assumption; because there are many and diverse non-linear models with variable parameters that may be the data source. Unlike the above-mentioned non-linear methods, ANNs are of the nonlinear forecasting methods that do not require assumptions about the relationships between inputs and outputs [14].

2.2 Oil

All countries' demand for petroleum materials has made crude oil as an effective factor in the world economy. Several factors such as political events and instability

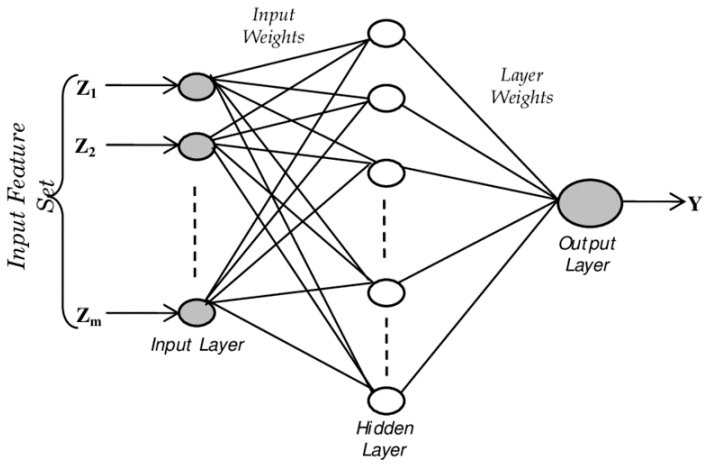

Figure 1: Structure of MLP

cause disturbances in the export and supply of oil in the producing and exporting countries, and this has a considerable impact on the price of this commodity. These extreme oil price fluctuations reduce the planning horizon of oil-related companies [19]. The dependency of countries on this commodity has made the oil market to be considered as of the main global markets and affects other economic markets and usually plays as the leading role rather than other markets. Oil price fluctuations cause changes in other markets including the currency market, and it is important to note that the opposite is not usually true. Because different markets are affected by this economic variable and likewise, the high dependence of the stock market on other markets has made it necessary and important to investigate the effect of oil price fluctuations on the performance of the stock market. In oil producing countries, this dependency is more noticeable [2]. The most effective factors on the oil price are outside the financial markets, and much are related to political issues in the producing and demand in the consuming country. According to the analysis of some economic analysts, the gold and the stock market e.g., automobile factories are among other markets that are affected by oil price fluctuations. As mentioned earlier, the oil market affects the currency market, but oil plays a dual role in this market. That is, in some cases, the price changes of the oil market depends on the changes in the exchange rate of dollar, and in some cases, it depends on the changes in the world's major currencies [20].

2.3 Gold

While occurring financial crises, the stock and the gold market can be used as an indicator to outline the country's economic situation which are considered as important financial markets of a country [21]. These financial crises in Iran can also

be fully interpreted when the economic sanctions are intensified, in a way that to maintain the value of their money, investors turn it into valuable goods such as gold and this causes the price of gold to rise. In contrast, the stock market will experience a large decrease [4]. Due to the different behavior of gold against negative shocks, this commodity has a special position and popularity among investors [22]. According to the portfolio theory, it can be concluded that the economic variable of gold can influence the stock index [23]. As mentioned earlier, oil plays a leading role to the currency market; but on the contrary, the gold market is not like that, and in some cases plays the leading role and sometimes follower. While the dollar is in the leading role, the changes in gold are affected by the changes in dollar, and while follower, gold obeys the dollar and the changes in dollar are due to the changes in the price of gold. The first rules governing the gold market state that the price of gold has a negative correlation with the value of dollar and they move in the opposite direction, and in some cases as in the case of 2005, the changes of both variables moved in the same direction. The occurrence of these behaviors can be related to the existence of conditional effects of other effective variables (gold, coin, and currency information network, 2014). There are many factors affect the supply and demand of gold as a sensitive and strategic commodity, which cause fluctuations in the price of gold [24].

2.4 Exchange rate

Stock and currency markets are always sensitive parts of the financial market. These two markets are quickly affected by fluctuations and business epochs in the economy and reflect economic changes quickly; yet, turbulent in one or both markets causes concerns among market policymakers. Currency stability in the country will create high confidence in the domestic economy environment for investment and decision making for the future of capital [25]. The dynamic interaction between these two markets has encouraged researchers, policy makers, and analysts to conduct accurate and detailed analysis. Considering the dependency of companies included in the stock exchange market on imports, it is expected that these companies lose their competitiveness with the increase in the exchange rate, and therefore, face a decrease in the real value of securities. Therefore, it is assumed that there is a negative correlation between the exchange rate and the total index of the stock market in Iran [26].

3 Research methodology

The current research is considered practical in terms of purpose, and exploratory of method. The fundamental concepts were obtained through the study of library resources. According to the literature review, the variables of exchange rate, gold,

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and oil prices was chosen as three affecting the total and equal weighted index to check the existence of interactive effects and its modeling. A purpose of this research is to model the interactive effects between known regressor variables; therefore, the used approach should be able to model conditional relationships with non-linear and non-deterministic patterns. The modeling approach based on ANNs is of the modeling approaches developed as a subcategory of Machine Learning by simulating the brain system and NN of living organisms. These non-parametric models are able to model the interactive effects between the regressor and the response variables well by creating network connections [7].

According to the conceptual model of Figure 2 in this research, the inputs of the NN model include the exchange rate, the price of gold, and oil, and the output the total and equal weighted indices. As it can be seen from the daily price information of currency, gold, and oil from the website of the gold, coin, and currency information network and daily information in order to educate this network. Fipiran site has been used regarding the total and equal weighted index in the period of four years during Mar, 2016 to that of 2020.

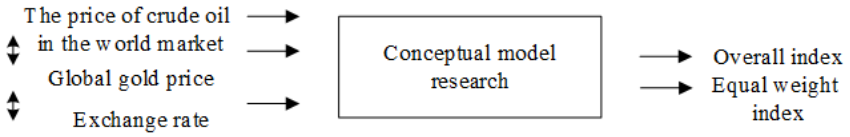

Figure 2: Conceptual model of the research

In order to describe how to develop and apply the proposed model, the research steps are summarized as follows:

- Extracting the data related to the daily price of input and output variables in the considered period.
- Sorting and organizing the available data.
- Pre-processing the data before submitting to the model.
- Investigating the existence of interactive effects between the input variables through the analysis of Pearson correlation coefficients and standardized auto-variance.
- Modeling the interactive effects among economic variables by controlling the desired indicators.
- Analyzing the results obtained from the models developed in the fifth step.

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It should be noted that NN models are simulated by MATLAB programming language. The NN was trained and will be able to provide acceptable and accurate results for the future value of the total and equal-weighted index by modeling and learning from the interactive relationship between the input and output variables that was existed in the historical period. The validity of the model is measured by evaluating the training performance of the model, and its reliability by testing the trained network.

4 Research findings

In order to investigate the existence of interactive effects between the input variables by calculating Pearson and standardized auto-covariance coefficients, SPSS statistical software was used. Due to the normality of the data distribution which was proven by using the Kolmogorov-Smirnov and Shapiro-Wilk tests, Pearson coefficient was used to check the effects of the variables. In order to investigate and determine the existence of mutual interactive effects between the three aforementioned variables, it is necessary to first check the correlation by calculating the Pearson coefficient in pairs between.

Table 1: The effect of variables used on each other

		Oil	**Gold**	**Dollar**	**Overall index**	**Equal weight index**
Oil	Pearson correlation 1	0.21	0.403	0.143	0.177	
	Sig.(2-tailed		0.468	0.000	0.000	0.000
Gold	Pearson correlation	0.21	1	0.878	0.885	0.899
	Sig.(2-tailed	0.000	0.000		0.000	0.000
Dollar	Pearson correlation	0.403	0.878	1	0.932	0.924
	Sig.(2-tailed	0.000	0.000		0.000	0.000
Overall index	Pearson correlation	0.143	0.885	0.932	1	0.986
	Sig.(2-tailed	0.000	0.000	0.000		0.000
Equal weight index	Pearson correlation	0.117	0.899	0.924	0.986	1
	Sig.(2-tailed	0.000	0.000	0.000	0.000	

According to Table 1, by assuming constant changes in the dollar variable, the changes in the economic variable of oil are in line with the changes in the gold and considering the high correlation of 0.87% between the dollar and gold. This will also be true between dollar and oil. By fitting the regression model of the oil variable in terms of the gold by controlling the dollar, more detailed information can be obtained about how these variables affect each other in different value ranges. Table 2 shows the results of this regression fitting model:

As can be seen, the value of -0.68 for the standardized auto-covariance coefficient indicates the negative correlation between the gold and oil variables in this phenomenon can be considered to indicate the existence of the mutual interactive effects between dollar and gold variables. It should be noted that the VIF, which

Table 2: The results of examining the variable correlation of gold and dollar in the vicinity of oil

Model	Unstandardized coefficients		Standardized coefficients	t	Sig	Collinearity statistics	
	Std. Error	B	Beta			Tolerance	VIF
(Constant)	3.799	99.184	-	26.107	0.000	-	-
Gold	0.003	-0.040	-0.687	-12.360	0.000	4.371	0.299
Dollar	0.000	0.001	0.806	14.503	0.000	4.371	0.299

stands for variance inflation factor, is (1/tolerance) and as a rule of thumb, a variable whose VIF value is greater than 10 is problematic and Sig. (2-tailed) represents the two-sided p-value that corresponds to the t-student distribution. In this way, the results of fitting the regression model of the gold variable in terms of the oil by controlling the dollar indicate negative correlation between these two, which can be concluded according to Table 3:

Table 3: The results of examining the variable correlation between oil and dollar in the vicinity of gold

Model	Unstandardized coefficients		Standardized coefficients	t	Sig	Collinearity statistics	
	Std. Error	B	Beta			Tolerance	VIF
(Constant)	13.967	1306.064	-	93.509	0.000		-
Dollar	0.000	0.027	0.911	68.709	0.000	1.043	0.959
Oil	0.229	-2.835	-0.164	-12.360	0.000	1.043	0.959

The mutual interactive effects between the variables affecting a dependent variable causes the effects of the regressor variables on the response variable to be inconstant in different value intervals, and therefore, makes it impossible to model them through parametric methods. Therefore, in this research, the ANN model is used as a powerful non-parametric method. Despite of high correlation, three variables are used to provide more accurate predictions for the total and equal-weighted indices. Determining the best ANN topology is obtained through trial and error. In this way, it is necessary to develop different models according to different parameters and to evaluate their performance according to defined criteria. The best topology will be selected based on the values of these criteria.

In this research, all the input parameters of the NN except the number of neurons of the hidden layer are considered constant in the modeling stage, and the modeling was done to determine the best model topology for each part by changing the parameter of the number of hidden layer neurons in Table 4. The important point is that the reason for choosing the initial parameters for the proposed network is based on the literature review.

The suitability of model fitting in NN modelling is determined by stopping the neural model training process. Therefore, stopping the training process can be

Table 4: The value of NN's parameters

Algorithm used	Number of time lags	Neuron's number	Test data (percentage)	Training data (percentage)
Leveneberg Marquardt algorithm	2	10	15	70
Leveneberg Marquardt algorithm	2	11	15	70
Leveneberg Marquardt algorithm	2	15	15	70

based on one of the insignificant criteria changes in successive repetitions in the soft gradient of the error, decreasing the value of the Mean Square Error (MSE) in each epoch than the previously determined value, decreasing the value of the soft gradient of the error than determined value, or increasing the number of repetitions than the previously ones.

The purpose of training is to adjust the internal parameters of the network (weights and biases). The share of training and validation data in this network is determined as respectively 70 and 15 per cent, and the remaining 15 percent data are randomly selected from the total data as the test data. The learning data is first entered into the network in the process of network learning, and the initial weights of connections between neurons are randomly selected by the network, then, first group of data is applied as an input to the network after loading the training data set and adjusting the weights of the network. Here, the stop condition is to reach six consecutive repetitions. Tables 9, 10, 11, and 12 show the results of each stage of the simulation using the Levenberg-Marquardt algorithm at the stop moment for the desired topology.

Model one is related to the simulation of the interactive effect of two economic variables i.e., the oil and gold price on two total and equal-weighted indices. The best model for this stage according to Table 5 is related to the first topology with ten hidden layer neurons, which shows better performance than the other two models with eleven and twelve hidden layer neurons based on MSE measures i.e., MSE= 95738778.81e-10 and R= 9.99808e-10, Where R-squared correlation measures the changes between the dependent variable and the independent variable, which varies in the interval [0,1] with a best value of 1 meaning that estimated values are the same as real values and MSE is one of the most widely used criteria represents means square of errors in this estimation.

Table 5: Network information related to model one as stopping the training process

	Test data				Training data		
Row	**Hidden layer neuron**	**Data ratio**	**MSE**	**R**	**Data ratio**	**MSE**	**R**
1	10	15%	91577147.51e-10	9.99809e-1	15%	95738778.81e-10	9.99808e-1
2	11	15%	90020494.54e-10	9.99818e-1	15%	115276277.47e-10	9.99769e-1
3	12	15%	85954880.84e-10	9.99825e-1	15%	123838747.49e-10	9.99755e-1

To model the influence of dollar and oil variables on the total and equal weight indices next to each other (model two), the topology with twelve hidden layer

Mean Squared Error

neurons based on MSE measures for the test data compared to two models shows less error according to Table 10. The best NN model related to investigating the interaction effect between these variables is a model with MSE= 85971360.47e-10 and R= 9.97820e-1.

Table 6: Network information related to model two as stopping the training process

	Test data		Training data				
Row	**Hidden layer neuron**	**Data ratio**	**MSE**	**R**	**Data ratio**	**MSE**	**R**
1	10	15%	78741740.71e-10	9.99842e-1	15%	107035282.49e-10	9.99791e-1
2	11	15%	81075030.37e-10	9.99837e-1	15%	110419025.71e-10	9.99765e-1
3	12	15%	77647992.43e-10	9.99841e-1	15%	85971360.47e-10	9.97820e-1

Model three is related to the situation where the variables of dollar and gold, which have the greatest interactive effect on the total and equal weighted indices, are placed next to each other, with MSE= 85971360.47e-10 and R= 9.99720e-1 and twelve hidden layer neurons is the best and most appropriate model to display this interactive effect. As can be seen from the MSE and R related to the modeling of each stage, the models that have the greatest effect on the indicators have a lower square error percentage and R is closer to one; therefore, topologies three, two, and one were introduced as the best topologies of this model respectively.

Table 7: Network information related to model three as stopping the training process

	Test data		Training data				
Row	**Hidden layer neuron**	**Data ratio**	**MSE**	**R**	**Data ratio**	**MSE**	**R**
1	10	15%	78741740.71e-10	9.99842e-1	15%	107035282.49e-10	9.99791e-1
2	11	15%	81075030.37e-10	9.99837e-1	15%	110419025.71e-10	9.99765e-1
3	12	15%	77647992.43e-10	9.99841e-1	15%	85971360.47e-10	9.97820e-1

In model 4, all three variables will be placed in the vicinity of two indicators, and in this case according to Table 12, the topology with twelve hidden layer neurons using Lunberg's algorithm has a better result based on MSE measures and includes MSE= 93769819.36e-10 and R= 9.99802e-1 compared to other two models with ten and eleven hidden layer neurons. Figure 3 shows the final topology of the proposed network.

Table 8: Network information related to model 4 as stopping the training process

	Test data		Training data				
Row	**Hidden layer neuron**	**Data ratio**	**MSE**	**R**	**Data ratio**	**MSE**	**R**
1	10	15%	91964781.37e-10	9.99817e-1	15%	103664700.88e-10	9.99782e-1
2	11	15%	78271780.98e-10	9.99841e-1	15%	96994299.46e-10	9.99814e-1
3	12	15%	77726736.14e-10	9.99842e-1	15%	93769819.36e-10	9.99802e-1

In the next step, you can see the quality of the training process for the four developed models according to Figure 4 (A to D) by means of MSE charts. In such

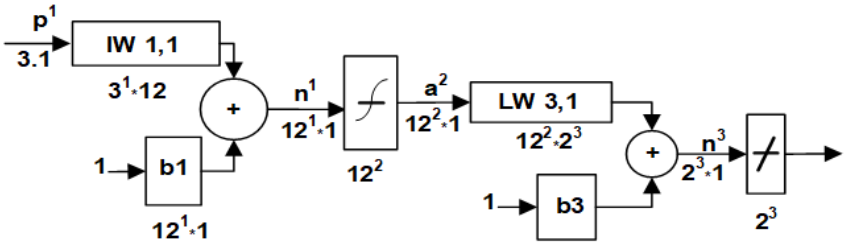


Figure 3: Topology of the proposed NN for model 4

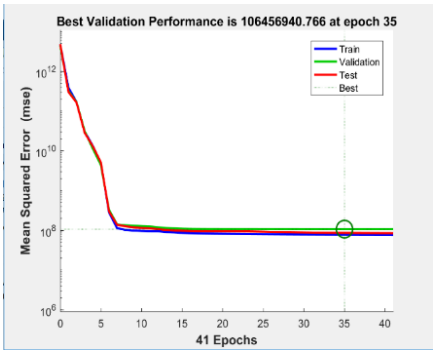
a way that the non-increasing trend of the MSE value, training, validation, and testing is displayed with blue, green, and red lines during the process of training respectively and it indicates that according to the state of the blue graph, the network will be trained optimally during each epoch. According to the green diagram, the network does not have the problem of overfitting or retaining too many patterns, and its generalization ability is favorable according to the red diagram. By examining these graphs, we can conclude that graphs (A to D) indicate favorable fitting. Generally speaking, as for not to occur the problem of memorizing the pattern during training, these topologies are capable of acceptable generalization due to the desirability of the results obtained from the implementation of the training and testing validation.

Also, from the comparison of the R performance criterion in the four developed models, it can be seen that the fourth model has a better performance than the other models despite its increase in dimensions. This superiority can be considered due to the existence of interactive effects between variables and their inclusion in this model.

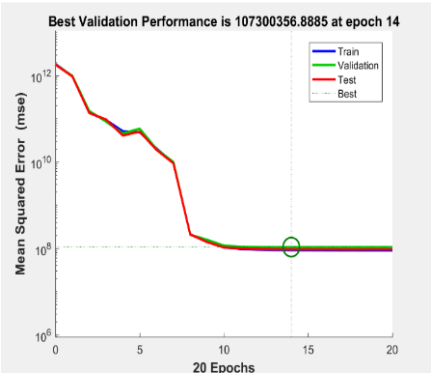
Also, the better performance of model 4, related to the case where all three economic variables are placed next to each other to calculate the indicators, can be seen well by considering the diagrams of outputs and actual values known as FIT diagram and according to the diagram regression found. As for in the graph of the actual values and the values predicted by the model, the points match well. In this diagram, the horizontal axis corresponds to the actual values and the vertical axis shows the corresponding values predicted by the model. Similarly, you can see the R diagram of the data related to each training and test section in the regression diagram, are close to each other and all the points are on the same line.

5 Summary, Conclusions and Suggestions

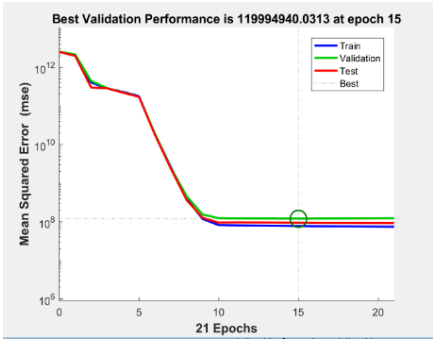
Considering the importance of accurate predicts of the macro indicators of the Iranian stock market for investors, the mission of this research was to identify and introduce a non-parametric model based on Artificial Intelligence to answer



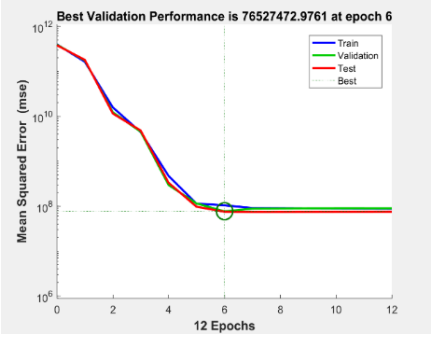
(a) (related to the first model)



(b) (related to the second model)



(c) (related to the third model)



(d) (related to the fourth model)

Figure 4: The trend of changes in the mean square error related to the top four best topologies (A to D in order from left to right)

this research question. Although there is a wide range of modeling and predicted approaches in domestic and foreign literature, but recent studies have shown the superiority of Computational Intelligence models in this field. Having features such as the ability to model non-linear and conditional relationships, as well as the ability to support non-deterministic data, has made the models based on Computational Intelligence to be frontier. Considering the point that Artificial Intelligence models have different topologies and functions for different problems. In this study, we developed four models to predict the total and weighted indices based on the dollar, gold, and oil price variables, as for the first three models, regressor variables are presented to the network in pairs, and for the fourth model, all three variables were included in the model and the performance results were examined and compared. We know that due to the number of weights and biases that exist in each layer, with the increase of the input dimension, their efficiency decreases and their need for historical data increases linearly in NN models, but it can be seen that despite the increase in dimension in model 4, which has three regressors (with high

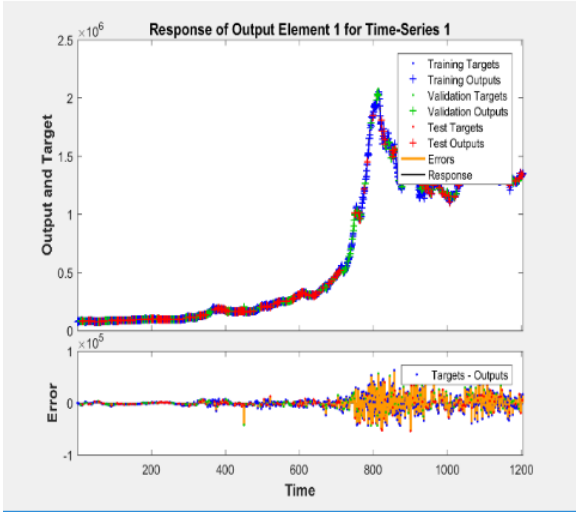


Figure 5: FIT chart related to the model 4

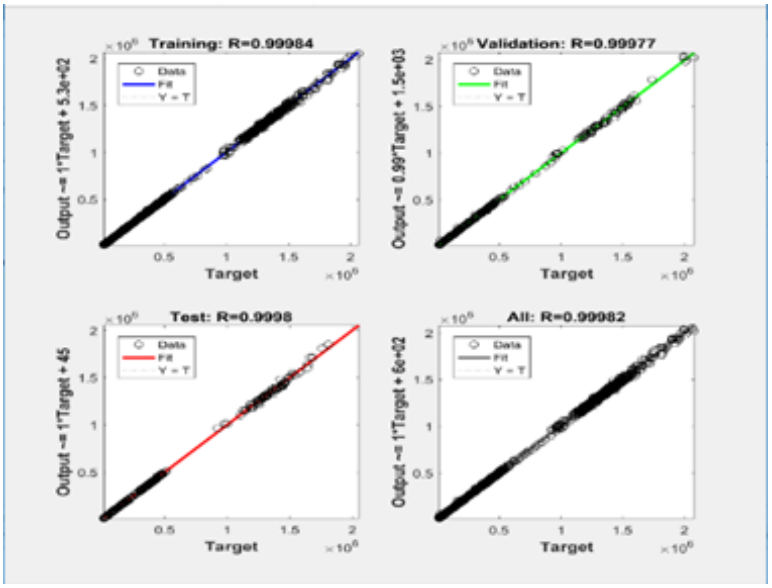


Figure 6: R chart related to model 4

correlation intensity) with comparison of the performance results of models one to 4. This model was better to the previous models based on performance and the result indicates that the prediction of the total and equal weighted index with the proximity of the three variables of exchange rate, gold price, oil price, and due to the presence of interactive effects have more accurate results than that of are

examined by controlling the representative(s) of these variables. It is suggested that in future studies, the effect of other macroeconomic variables such as trade balance, inflation, liquidity, interest rate, etc. on the desired indicators, and also the existence of interactive effects between them should be investigated.

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How to Cite: Mehdi Rezaei[1], Najmeh Neshat[2], Abbasali Jafari Nodoushan[3], Amir Mohammad Ahmadzade semeskande[4], *The artificial neural networks for investigation of correlation between economic variables and stock market indices*, Journal of Mathematics and Modeling in Finance (JMMF), Vol. 3, No. 2, Pages:17–33, (2023).