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Prediction of saffron contract yield using the meta-heuristic algorithm

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Abstract

The main purpose of this study is to predict saffron's binding efficiency using the meta-heuristic algorithm. This collection of information is a documentary research library and the result is quantitative research. The time period from 2018 to 2021 was 5 years and the frequency of daily frequencies of the Ministry of Agricultural Jihad and Customs of Iran were collected from the Iran Mercantile Exchange (JPI). The meta-heuristic algorithm consisting of a combination of birds, bats, and cuckoos was designed. The proposed methods were modelled by coding in a MATLAB environment using normal data. The results of the computational analysis show that all models were approved; And the artificial neural network shows that price fluctuations, cash price, the volume of transactions and liquidity are of the most importance, respectively, on the yield of saffron contracts.

Keywords: Saffron Binding Efficiencies, Metaheuristic Algorithm, Bird Algorithm, Bat Algorithm, Cuckoo Algorithm
2020 MSC: 60G25, 68T20

1 Introduction

A successful futures contract is performed according to the type of property, which is also associated with contracts in several different stages. Accordingly, the first and most important step in designing commodity futures contracts is the determination of appropriate and consistent goods for exchange in such markets. For example, one of the famous methods used by Black in the determination of the specifications of successful futures contracts was that of "Characteristics of goods" [2], based on this approach, in choosing appropriate goods, as well as future contracts, such as the ability to sustain, homogeneity, fluctuation in prices, the large size of the cash market, low cost of supply of goods, and the history of fracture in futures markets, are considered. He considered this definition of futures contracts and concluded that the success of futures contracts depends on cash market size, fluctuations in cash prices, the ability to reduce such risks, and the cost of their eligibility. Considering Iran's economy is heavily dependent on oil revenues, it is important to pay attention to non-oil exports of the country and recognizing non-oil products that have a relative advantage and are capable of competing in the international arena, is an important step in the development of this sector. Among these, agriculture has dominated the non-oil exports and futures contracts, although saffron also has an important role [7].

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Working with AI in the 1950s by pioneers in statistics, neuroscience, psychology and ... began. In such ways, humans try to conquer the universe and use the best and most efficient natural methods. So far, different techniques have been proposed for prediction, each of which has its own advantages and disadvantages. These techniques fall into two categories: traditional methods and artificial intelligence-based methods [9]. In the world around humans, where phenomena are often of non-linear behavior, identification and prediction of these phenomena require the use of modern predictive and evaluation methods. This is because these techniques are precise tools for prediction in their brain environments and for tracking nonlinear behaviors. Overall, the review of the literature showed that in Tehran Stock Exchange, more traditional methods are used for forecasting. Given that traditional patterns should be used in static time series (static), and since most economic time series are static, these traditional patterns have a significant difficulty in predicting, whereas AI methods have no major difficulty in traditional patterns of static behavior in time series. Although no guarantee is possible, the test of these methods in technical and engineering, economic, financial and etc. has shown that in case of proper implementation and proper selection of internal parameters relative to the type of problem, by using these methods, more suitable solutions of their classical peers can be obtained. In other words, the principles of these methods were created to compensate for the shortcomings of the classical methods. They are programmed to jump out of local optimizations when possible, not to be caught in, and to reach comprehensive optimal. However, in recent years, many studies have been conducted on the comparison of intelligent methods and classical statistical methods in modelling forecasting problems, and their results have shown the high accuracy of intelligent methods in predicting problems. During the last decade, a significant literature has emerged in the field of bioinspired algorithms. These powerful algorithms are used for prediction and classification and have clear applications for use in financial modelling and the development of business systems. Financial markets represent a complex and ever-changing environment, an environment in which investors are competing for profit. Environmental organisms have lived in such environments for a long time and compete for the necessary resources to ensure their survival. It is natural that financial market actors turn to algorithms inspired by biological processes to preserve their survival in financial forests. Financial issues such as bankruptcy, financial distress, the optimal choice of portfolios, stock price index, the credit risk of banks, etc. Some research has been done using innovative and metaheuristic methods both within and outside the country. Two main problems of the heuristic algorithms for getting stuck in local optimal points are early convergence to these points. Metaheuristic algorithms are presented for solving the problems of heuristics algorithms. In fact, meta-heuristic algorithms are one of the types of approximation optimization algorithms that have extrapolation solutions from local optimal points and can be used in a wide range of problems. Different classes of such algorithms have been developed in recent decades [10], since exact-time algorithms have a high computation and only they find an optimal solution, heuristic algorithms try to find the ideal solution at a reasonable time; however, they do not guarantee the achievement of ideal solutions such as differential evolution, pattern evolution rhythm, Tabu search, simulated annealing; Therefore, heuristic algorithms are used in this study to solve the problems of future efficiency, we and our colleagues (1992) developed a two-phase model which indicates that an exact solution needs more attention in choosing the parameter of the system because of complex models.

On the other hand, the present study tries to evaluate the efficiency of futures contracts in order to reach practical findings that are in accordance with the previous findings in Iran, and somehow contribute to the relevant empirical studies and causes them to upgrade. The reason of this is that Iran's economy is dependent on the stock market. In such a way, when the economic situation is good, investment increases and the growth rate of economic indicators increases and financial indicators decreases. Thus, predicting future efficiency is important for buyers, manufacturers, processors and users. Therefore; So far, the debate about the development of contract outcomes has always been an open topic, as most researchers nowadays tend to use intelligent approaches instead of using simple and statistical approaches like regression to identify variables that effect on return prediction as well as estimating the outcomes of contracts. The predictability of futures contracts in different fields has generated considerable interest from academics and specialists.

So far, different techniques have been proposed for prediction, each of which has its own advantages and disadvantages; these techniques are divided into traditional (linear) and non-traditional (including metaheuristic algorithm and artificial intelligence) techniques, in the past, heuristic and artificial intelligence techniques are used... They were not common, to perform predictive identification processes from simple and linear methods such as regression, simple smooth curve, moving average, etc. Used [5]. These models have weaknesses that do not allow researchers to identify complex and nonlinear factors. But today, with the growth of mathematical techniques and computers, innovative methods and artificial intelligence, like the algorithms of birds, bats and cuckoo... It has been observed that there is an important place in the literature on identification and classification and in the world around humans, where phenomena often have nonlinear behavior, identification and prediction of these phenomena require the use of new methods of prediction and evaluation. This is because these techniques are precise tools for prediction in brain environments and intercepting nonlinear behaviors. Overall, the review of the literature showed that in Tehran

Stock Exchange, more traditional methods are used for forecasting. Since most economic time series are stationary, these traditional patterns have significant problems for forecasting, as well as metaheuristics and artificial intelligence, the main problem of traditional patterns is not static in time series. However, in recent years, many studies have been conducted on the comparison of intelligent methods and classical statistical methods in modelling forecasting problems, and their results have shown the high accuracy of intelligent methods in forecasting problems. During the last decade, a significant literature has emerged in the field of bioinspired algorithms. These powerful algorithms are used for prediction and classification and have clear applications for use in financial modelling and business system development. Financial markets represent a complex and ever-changing environment, an environment in which investors are competing to make a profit. Environmental organisms have lived in such environments for a long time and compete for the necessary resources to ensure their survival. It is natural that financial market practitioners are turning to algorithms inspired by biological processes to maintain their survival in financial forests. Financial issues such as bankruptcy, financial distress, the optimal choice of portfolios, stock price index, the credit risk of banks and ... Some research have been done by using innovative and metaheuristic methods within and around the country and the main advantages of them are the flexibility to estimate the huge range of relationships and functions between the data and the outputs, the need to apply special statistical assumptions about the behavior of variables and provide better performance than traditional methods in discovering complex and nonlinear relationships. In comparison with traditional methods, the algorithms of birds, bats and turtledoves are more efficient in the presence of missing data and financial data disturbances. In addition, according to the advantages and disadvantages of each type of algorithm for birds, bats, and cuckoos, the research has been oriented towards hybrid models.

2 Theoretical foundations and research background

Bredin, et al. [4], in their research titled Does it help to predict the future returns of the so-called WTI structure? Nelson-Siegel factors were extracted from the structure of future oil terminology to predict the next storage period of crude oil in the sample. This model was able to predict the future period of the crude oil market with increasing macroeconomic indicators or specific predictors of the oil market and not reduce it. Their research model was a combination of leading indices with NS and a LASSO model with macroeconomic indicators and special forecasts of the oil market. These models reduce prediction errors in relative terms, and are a non-modification criterion in a range of return horizons and future transaction overhead contracts, with evidence stating that models using NS agents lead to higher Sharp-ratio trading strategies and better properties than Buy-and-Maintain strategies and historical medium strategies.

Zhao, et al. [14], began to optimize particle swarm optimization to solve the problem of portal optimization with cardinality constraints, and since the efficient selection of these shares to achieve higher returns and lower risk has become a hot topic of research in financial management, usually called portfolio optimization problem (POP). When the cardinality constrained (CC) is added to a certain amount to limit the number of shares selected, the resulting CCPOP is more challenging with two of the following problems: i) due to the complexity of the cardinality constraint in the final market, the effective handling of the cardinal restriction in the optimization sample problem is difficult and time-consuming to achieve a practical solution. The mutual goals of return and risk of securities are always in conflict and their balance is difficult. To better deal with the above problems, the paper focuses on CCPOP multi-objective(Mo) and proposes an evolutionary particle swarm optimization algorithm for several communities, which is based on several frameworks for MPMO, and has the following four advantages: In the first step, a hybrid binary and rea (HBR) encryption strategy (to better display the stock selection and asset weight of solutions in MoCCPOP are introduced. In the second stage, an innovative return risk ratio heuristic (R3) H (based on the return and historical risk of each stock), as a rapid control method (CC), has been suggested to achieve practical solutions. Thirdly, a new particle updating method based on the bi-directional local search strategy is designed to increase the chance of improving the solution accuracy and approaching to Pareto front (PF). The latest, but not most important, is an elite hybrid competition strategy to help update archiving, which offers more promising solutions and creates diversity to avoid the local Pareto World Front. The first two strategies help effectively deal with the CC challenge, while the last two strategies are efficient in solving the multi-objective challenge. The optimization algorithm for particle swarm optimization shows the superior performance of the MoCCPOP solution by comparing the recent multi-objective optimization algorithms with good and advanced performance.

Mehri et al. [7] assessed the integrated models using Meta-Heuristic Algorithms (ANFIS) and Genetic Algorithm (GA) to predict the pollutant diffusion coefficient in rivers (NME). To predict this coefficient, in the framework of MATLAB (119 normal) data was presented. Parameters of free surface width, flow depth, shear rate and flow velocity in the river were selected for model input and longitudinal diffusion coefficient for the objective parameter. Finally,

according to the PSO results, the ANFIS model is more accurate than the model and finally, the ANFIS-PSO method can be a more suitable method for predicting the longitudinal diffusion coefficient.

Ahmadvand and Colleagues [2] provide a model to predict the price of gold coins in Iran using neural, fuzzy and genetic algorithms. Different methods for predicting variables each have their own intrinsic nature and unique characteristics of the method. Therefore, researchers attempted to use these properties in order to achieve more efficient, optimal and faster models. Therefore, the combination of different models has become a new approach for modelling and prediction of different variables that their usage is increasing day by day.

3 Method

Question:

What is the comparative analysis of saffron's binding performance based on the meta-heuristic algorithm (Birds, Bats, Cuckoo) and the neural network?

This research is documentary library research after information collection. This means that all necessary information is obtained from sources written in books, writings, or prior research contained in libraries or archives of organizations. This article is applied research and is a useful one. The quantitative period of study is a 5-year period from 2018 to 2021 which was collected daily by the Ministry of Agricultural Jihad and Customs of Iran on the Iran Mercantile Exchange website. For designing a hybrid model based on a combination of bird, bat and cuckoo models, the Matlab software is used and multiple and pair comparisons of different samples are used, that these kinds of problems are not precisely solved due to their complexity and meta-heuristic algorithms can achieve the appropriate solution set at an acceptable time for the multi-sentence nonlinear problems that after parameter setting, a meta-heuristic algorithm with analysis in data sets experiments (Freidman test, Bookmark test and Wilcoson test) and ... The results of the proposed methods are modelled by coding in a Matlab environment with normal data, and finally, the results of the computational effort for each test problem as well as statistical tests are presented to the competitive performance of the hybrid algorithm.

3.1 The basic steps of the birds algorithm

1. Randomly determine the initial velocity and location of particles;
2. Calculating the value of the objective function for each particle according to the position of each particle;
3. Comparison of the present location of i particle with the best place of each particle;
4. Detection of the most successful neighboring particle and the best particle location in the group up to this stage of search;
5. change the speed and location of the particle in accordance with relations (3.1) and (3.2);
   (a)

$$V_{it} = W_{ij}V_{ij} + C_1 r_{1t}(P_{it} - X_{it}) + C_2 r_{2t}(P_{gt} - X_{it}) \tag{3.1}$$

$$X_{it+1} = X_{it} + V_{it} \tag{3.2}$$

   (b) View stop condition;
   (c) If conditions are not met, go to step 2;

3.2 Basic Steps of Bat Algorithm

The following three main assumptions are used to develop the bat algorithm [8]:

1. All bats use sound reflectivity to detect distance and know the difference between obstacles, forwards, and food.
2. Random-speed bat flight and location. Also, they automatically adjust the frequency or wavelength of their emitting pulses and the output pulse depending on the proximity of their target.
3. Although the volume level varies in different ways, it is assumed that the volume level is different from one. Large to a Minimum Value. It changes.

In this algorithm, each bat has the speed and place criteria in repetition. I will be measured. Among all solutions in the population, the best solution exists; Therefore, using the equations (3.3) to (3.5), frequency, speed and location are updated in each iteration:

$$f_i = f_{\min} + (f_{\max} - f_{\min}) \times \beta \tag{3.3}$$

$$v_i^{t+1} = v_i^t + (x_i^t - x_*) \times f \tag{3.4}$$

$$x_i^{t+1} = x_i^t + v_i^{t+1} \tag{3.5}$$

That we have in the high relationship:

$\beta \in [0, 1]$ is a random vector with a distribution, uniform;

The frequency of each bat between $f_{\min}$ and $f_{\max}$. The amount of these two variables will depend on the size of the problem and usually considered [13].

3.3 Cuckoo's algorithm

After a few replications, the entire population of the cuckoo will reach an optimal point with the maximum similarity of the eggs to the host birds' eggs, and also to the most important source of food. The site will have the highest total profit, with the lowest number of eggs eliminated. Therefore, the main steps of COA can be expressed as follows [11]:

Step 1: Define the current location of the cuckoo by accident.

Step 2: Assign a number of eggs to each cuckoo.

Step 3: Determine the hatching radius of each cuckoo.

Step 4: The hornets lay eggs in the nests of the hosts within their hatching radius.

Step 5: The eggs that are detected by the host birds are eliminated.

Step 6: The eggs of undetected organisms are cultivated.

Step 4: Evaluate the location of new cells.

Step 8: Specify the maximum number of cells that can live in any place and eliminate those in the wrong place.

Step 9: Cluster the cells using K-means method and specify the best cell group as target habitat.

Step 10: The new population of cuttlefish moves towards the target location.

Step 11: If the hold condition is stopped, otherwise go to step 2.

4 Analysis

Independent variable coefficients help determine how much values predicted by the network will change by changing the independent variable values. Table 1 shows the coefficients of each independent variable. Price fluctuations, cash price, trading volume and liquidity are the most important, respectively, according to the table.

In order to determine the best neural network model with high predictive capability and also with minimum MSE (mean square error), the most parameters of network should be determined. The parameters of artificial neural networks for model design include the number of hidden layers, the number of neurons in each hidden or intermediate layer, the conversion function, the learning function, the learning rate and the number of iterations of the training.

The objective function of the hybrid algorithm (bird-bat-cuckoo flight) is as follows:

$$\min f(x) = \frac{1}{n} \sum_{i=1}^{n} \left| E_{actual} - E_{forecasted} \right| / E_{forecasted}$$

It should be noted that at first, using the k-mean algorithm (by selecting the random point as the centers of the clusters), each data was assigned to the corresponding cluster in the following steps: Random selection k sample for

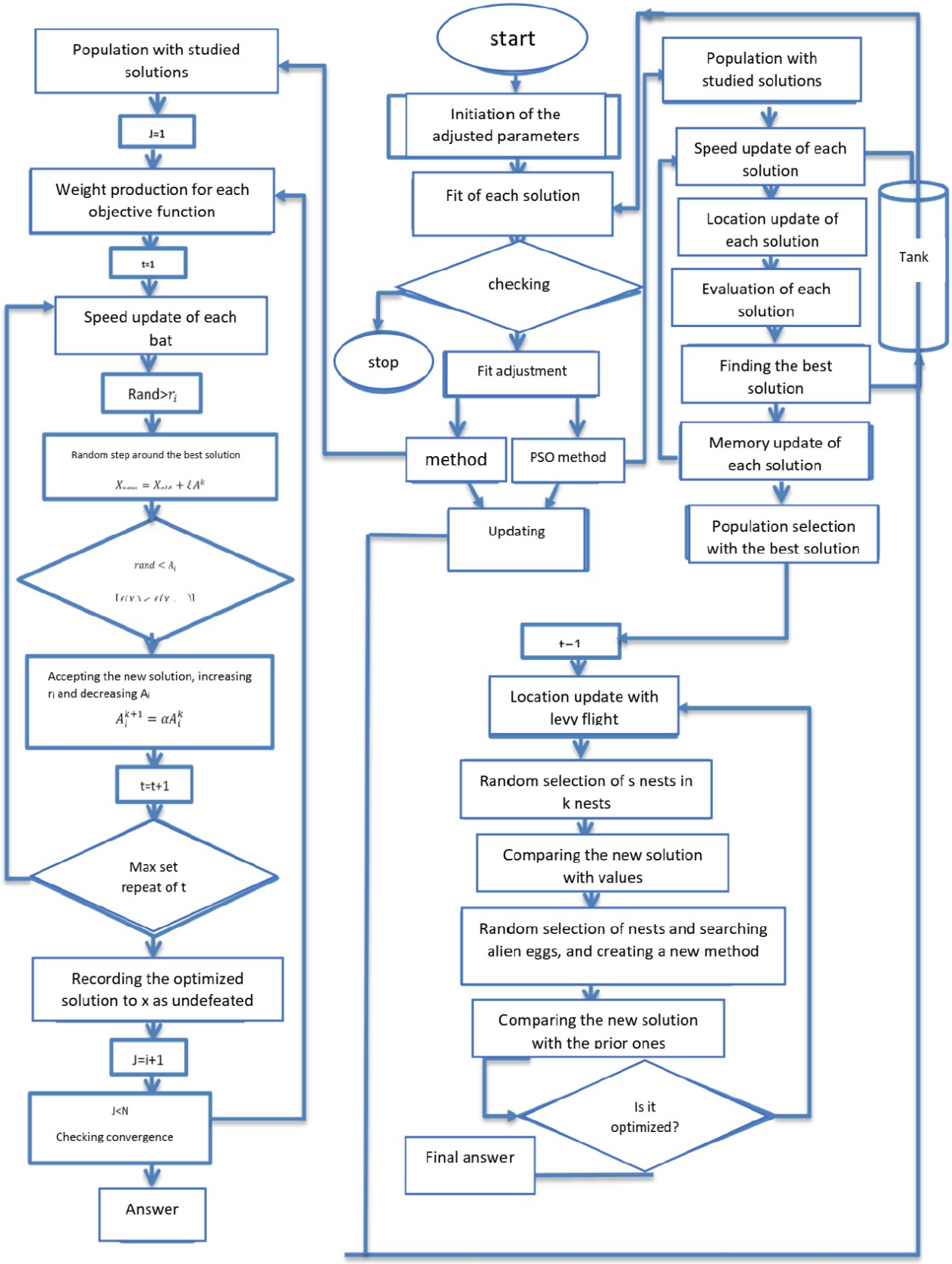

Figure 1: Metaheuristic Hybrid Algorithm (Birds, Bats, Cuckoo)

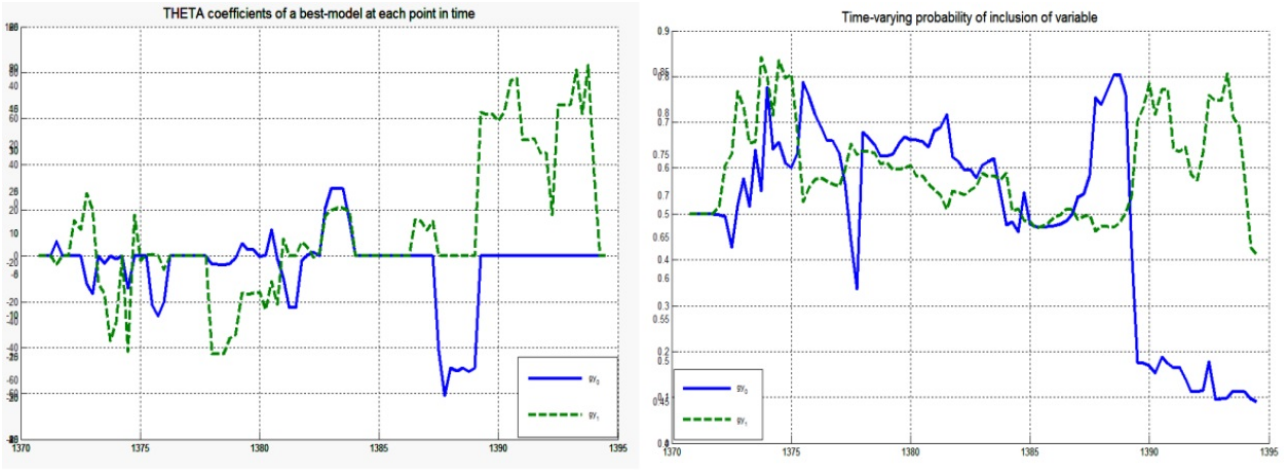

Figure 2: The probability that the best model will occur and the probability that price fluctuations will affect the efficiency

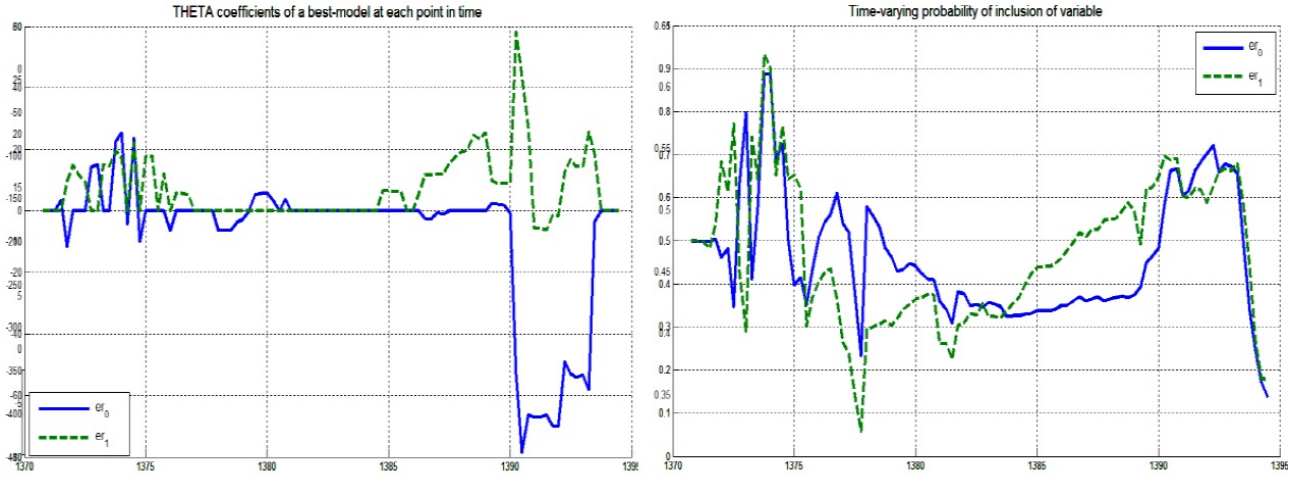

Figure 3: The probability of the best model occurrence and the probability of the trade volume affecting the prediction of efficiency

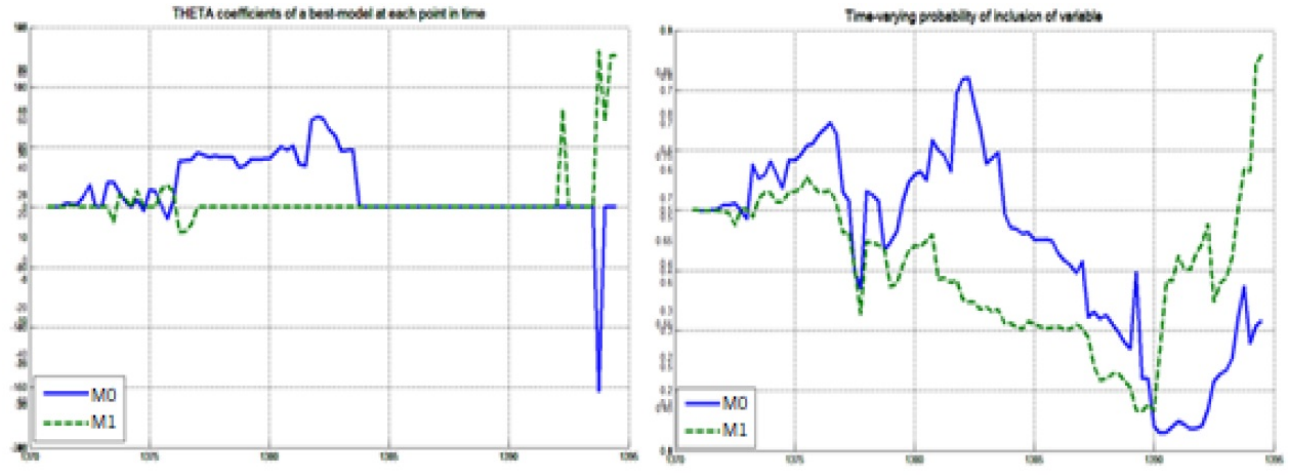

Figure 4: The probability that the best model will occur and the effective probability of cash prices in forecasting returns

the initial value of the centers of the clusters, selecting the nearest cluster center for each sample using Euclidean distance (at the end of this stage all samples will be in k clusters) and calculation and update the new center of gravity for each cluster and its value until the defined square criterion is minimized. Then the hybrid algorithm, as diagram

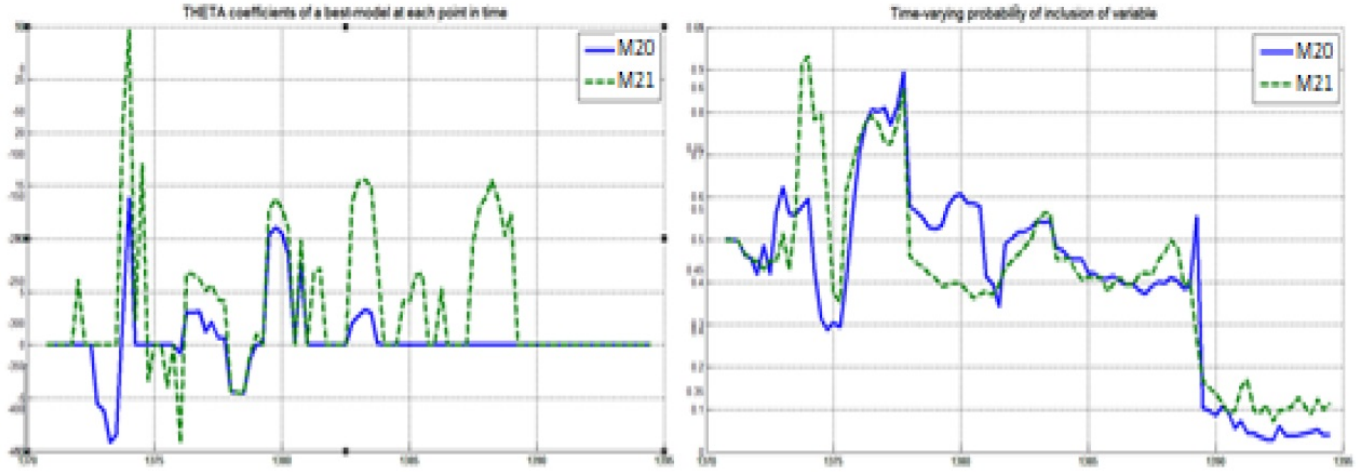

Figure 5: The probability of the best model and the probability of welfare effects on efficiency

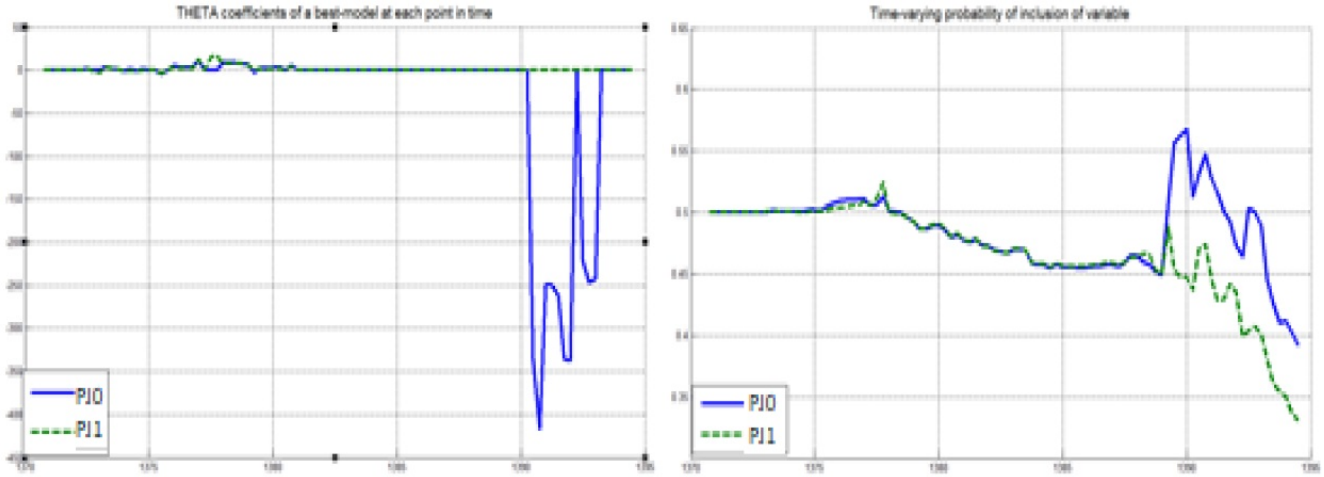

Figure 6: The Probability of Best Model Occurrence and the Probability of Market Liquidity Effectiveness in Prediction of Return

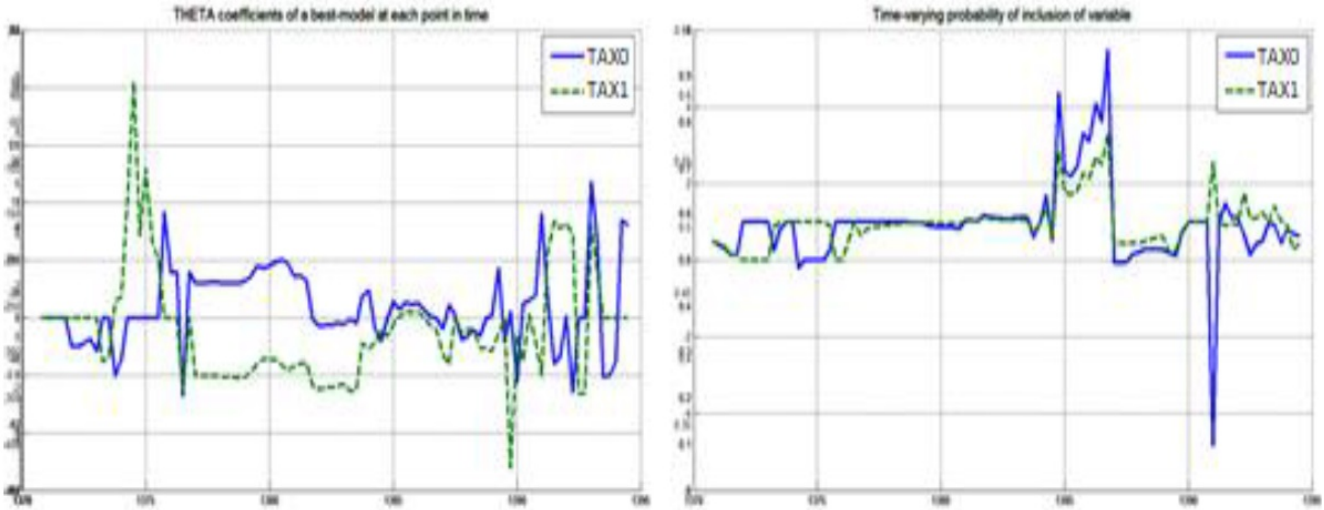

Figure 7: The probability that the best model will occur and the probability that the inflation rate will be effective to predict the efficiency

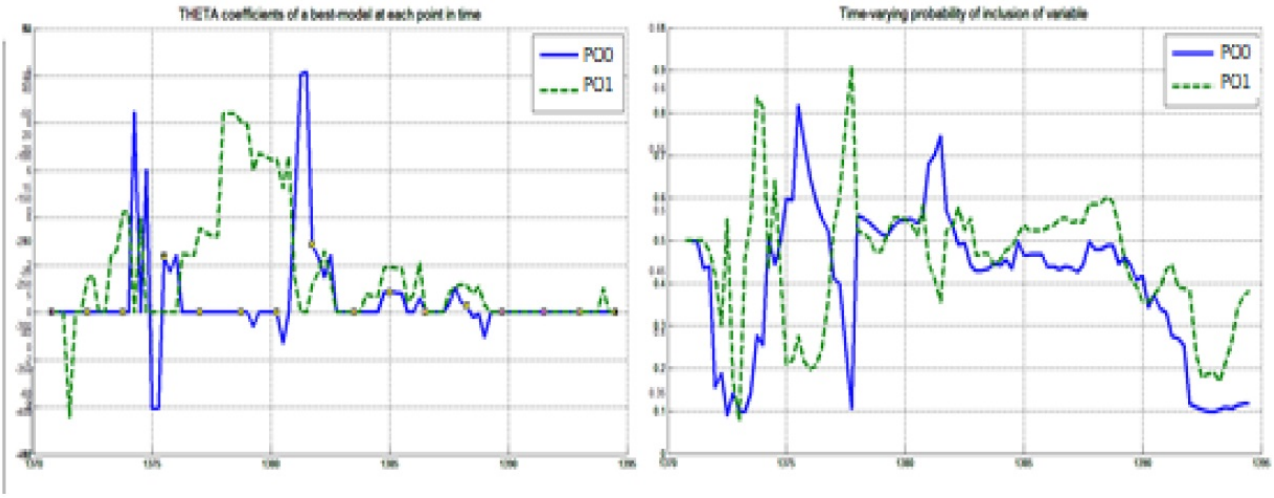

Figure 8: The probability that the best model will occur and the probability that the arbitrage efficiency will be effective in order to predict efficiency

Table 1: Coefficients of independent variables resulting from artificial neural network

Normalized-cofficient	**cofficient**	**Variable**
26.7%	0.047	LTD
85.5%	0.151	VOL
94.4%	0.167	P
98.7%	0.177	CPF
89.2%	0.162	LIQ
20.1%	0.035	INF
42.36%	0.109	EXC
15.6%	0.028	INT
27.1%	0.048	CR
25.2%	0.044	ARB
41.5%	0.073	DRO
22.3%	0.06	PRO
39.2%	0.091	WELFE

Table 2: Results from artificial neural method

Prediction method	**MAD**	**MSE**	**RMSE**	**MAPE**
Artificial neural network	31.46082	55.18315	13.1049	0.9365

1, was implemented. The results of the present algorithm are as follows 3 and 4 tables:

Diagram 9 to 10 shows results from comparing different methods (Model prediction results and actual values):

5 Results

According to the results of the comparative test, the forecast efficiency of saffron contracts was confirmed by using of meta-heuristic algorithm and computed neural network using saffron's future data. In the present study, the comparative analysis of saffron adaptation results by using a meta-heuristic algorithm (Birds, Bats, Cuckoo) and neural network, the results obtained from an artificial neural network show that price fluctuations, spot price, trade volume and liquidity are the most important, respectively. The results of metaheuristic algorithms can provide two completely new solutions from a similar solution because they use tree structure problem solving with different options and because solving strategies can be fitted by a dynamic function; It gives better results, the closer the predicted value to the actual, the less error of the PID model is. Therefore, in the fourth chapter, by measuring the error of the research models (the metaheuristic algorithm (birds, bats, cuckoo) and the neural network), the prediction power can be evaluated based on the error rate of that model. The comparison between the two models based on MAPE

Table 3: The extracted factors from the combined algorithm (bird-bat-cuckoo flight)

Variable	**coefficient**
LTD	−1.36
VOL	1.583
P	0.987
CPF	2.324
LIQ	1.567
INF	0.0398
EXC	−0.821
INT	0.0716
CR	1.006
ARB	0.0151
DRO	0.934
PRO	0.0713
WELFE	0.345

Table 4: The Results of the Hybrid Algorithm

Prediction method	**MAD**	**MSE**	**RMSE**	**MAPE**
Hybrid algorithm	12.0069	7.2361	3.7206	0.6873

Figure 9: The Model Estimation Results by Artificial Neural Method

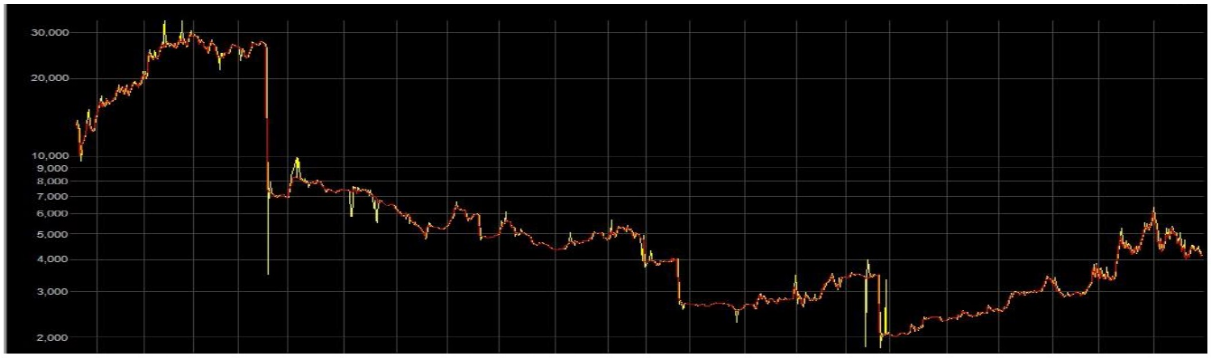

Figure 10: The results of the hybrid algorithm model (birds-bats-cuckoo).

and RSME statistics are presented. In fact, the fewer the MAPE and RSME errors, the more powerful the model is to predict the future efficiency of saffron.

In previous studies, some variables were investigated which matched with the question of this study and are mentioned below:

Adam et al. [1] found that the future returns of agricultural commodities are positively positive to the total return of stocks and negatively impacted by exchange rate changes, and [6] showed that economic policy uncertainty shocks

have a weaker impact on grains than other commodities, and UJI [12] revealed that the future price policymakers will consider both the dynamics of the market In 2016, the financial instruments were severely limited to factors such as changes in political scenarios, global effects and high inflation. Amerian et al. [3] to investigate financial crimes; the theoretical warm-up approach was used to design the model and explain the qualitative findings which were analyzed by MAXQDA software. Finally, the mathematical model of financial crimes was developed.

In many previous studies, variables such as interest rate, exchange rate changes, cash price, inflation, macroeconomic variables and risk as the present research are important and influential variables in futures and stock trading.

5.1 Recommendations

According to the research question based on comparative analysis, the forecast efficiency of saffron contractors is expressed by using a meta-heuristic algorithm (Birds, Bats, Cuckoo) and the neural network:

- Combining the neural network approach with particle swarm algorithm in the intelligent multi-objective algorithm;
- Identification and strengthening of suggestive mechanisms in the regulation of the key variables of the futures contracts and the possibility of asynchronous problems such as drought and inflation.

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