Predicting the Price of Fruit Using Neural-fuzzy and ARIMA[1] Systems

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Abstract: Using the two models of neural-fuzzy and ARIMA network the present research is to predict the price of different kinds of fruits (yellow apple, red apple and banana) in Ardebil province. For this purpose related data for the price of these fruits during the time period July, 2007 – August, 2010 has been used. Results from the research show that neural-fuzzy network model has offered better results than ARIMA model in predicting the price of under consideration fruits and has been able to predict future procedure of the price of these items with less error compared to ARIMA model.

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[1] -Auto Regressive Integrated Moving Average

1. Introduction

Prediction plays an important role in implementing appropriate policies in economy. Economic forecasts cause the path for future movement to be clearer and authorities take effective measures in relation to the future. In addition to effective allocation of resources to aim-activities at operational level, prediction causes reduction in probability at the time when future strategies are developed. Since one of the most important aims of government is supporting the low-income class of society and maintaining their purchase power as well as their health and fruit consuming plays an important role in individuals' health, planning for regulating the market for these products are among the important necessities for the purpose of preventing fluctuations in their prices and obtaining the propounded aims. The issue of optimized and applicable planning cannot be realized unless accurate predictions concerning the general conditions and prices are available. Due to accurate predictions, performing the policies for market regulation of these items will be possible for provincial authorities bearing the least costs.

Performing accurate predictions concerning the fruit price in Ardebli province has made the ground ready for provincial authorities to take appropriate measures for preventing irrational increase or decrease in their prices, consequently decreasing their negative effects on low-income class of society in province. That is why executing this plan is of considerable importance in this regard. The purpose of the present research is to predict the price for different kinds of fruits (yellow apple, red apple, and banana) using neural-fuzzy networks to be used in market regulation planning for Ardebli province and to offer suggestions for preventing the sectional fluctuations of the prices of different kinds of fruits at provincial level.[2]

[2] - The reason why these fruits were chosen is that price time-series data relating to these fruits have been available at provincial level. Another reason for choosing the fruit prices as the only variable to be used in this research is the lack of information on other variables that are effective in fruit price at provincial level.

According to Box-Jenkinz methodology, since an economical variable includes all of the self-related data and it manifests all of the actions and relations that lead to its forming, it is considered in itself the most powerful resource for describing other variables, and thus in the present research fruit prices have been used as variables of the research. The assumption of the present research is that compared to ARIMA method, neural-fuzzy networks have better function in predicting the fruit price at provincial level. Data required for performing the research has been prepared using statistical resources of Commerce Organization of the province, Organization for Supporting the Consumers and Producers, and Agriculture Jihad Organization of Ardebil Province. Since the data related to the prices of different kinds of fruits has been available since July, 2007, this research uses data related to the prices of under consideration fruits from the beginning of July, 2007 to August, 2010. It should be mentioned that because of availability for 15-day data concerning the price of banana at provincial level, 15-day data for this fruit have been used, however, in order to predict the price and estimate the models related to yellow apple and red apple prices monthly data have been used. In order for analyzing the information and estimating neural-fuzzy networks and ARIMA models toolbox of neural fuzzy network, Matlab software, and also Eviews4 and Excel software have been used.

2. Research Literature

2.1.1: Theoretical Literature:

2.1.1.1. Auto Regressive Integrated Moving Average Process(ARIMA)

MA, AR and ARMA time-series models are based on the assumption that time-series are durable. But in practice most of the economical time-series are non-durable so these series are integrated. If an integrated time-series is of I(1) order, its first order difference will be durable I(0). In general if a time-series is of order I (d), after doing the act of finding differences for d times, the first order of the series I (0) will be obtained.

Therefore, if after d times of first-order differentiating, a time-series become durable and then using ARMA (p,q) process it is modeled, in this case the main time-series, will be Auto Regressive Integrated Moving Average ARIMA (p,d,q) time-series, where p is the number of auto regressive terms and d is the number of first order differentiating for durability of time-series, and q is the number of items of moving average. Thus, an ARIMA (2,1,2) time-series after one time first order differentiating (if d=1, then series is durable) should be modeled by an ARIMA (2,2) process (that is, it should include two items of auto regressive AR (2) and two items of MA (2). If d = 0 (that is, time-series is at first durable), then ARIMA (p,d = 0, q) process is the same as ARMA (p,q) one. Also a process of ARIMA (p,0,0) is a durable process of pure AR (p) , and a process of ARIM (0,0,q) is a durable process of pure MA (q). Therefore, if p,d and q are known, it will be possible to say which process should be modeled. The considerable point to be mentioned is that in order to use Box-Jenkinz methodology there should be a durable series or a time-series that has been changed into durable time-series after applying one time (or more than once) of differentiation process. The reason for this can be expressed as follows.

"The aim of BJ (Box-Jenkinz) is identifying and determining a statistical model that may be interpreted as a producer model for data of real sample from random process. If this model is used for prediction, its features should be fixed during the passage of time (specially during the future periods). Thus, the reason for the need for durable data is that each model resulted from these data can be considered fixed and it can be taken as a reliable basis for prediction"[3]

2.1.1.2. Neural Fuzzy Systems:

The basis of neural networks and Fuzzy systems pointed out in this subject is functional approximation, that is, one or more input model can result in an output model. Thus, problems in which a model can result in some output models are not studied here. If there are some data for teaching, then neural network can be used without knowing about the mathematical model governing the problem or without any previous knowledge about the problem. But, on the other hand, the solution that neural network had learned during the learning process, is not extractable or interpretable. Therefore, neural network is a black box and it isn't possible to recognize that up to how extent the solution it has found is rational. In other words, it is the final phase that cannot be interpreted in the form of rules. Also, if the previous knowledge about the problem is available, it can hardly be added to the solution to make the learning process take place quickly. Learning process may take long time and there isn't also a guarantee to its success.

Fuzzy logic can be used for solving a problem only when some knowledge in the form of lingual rules is available concerning the solution. By defining the appropriate fuzzy groups for expressing lingual phrases that are used in rules, these rules can be used in constructing a fuzzy system. But in order to regulate these rules so that the lead to appropriate answers, there isn't any codified method. So, only trial and error methods are useable. Table (2-2) shows advantages and disadvantages of artificial fuzzy and neural methods[4]. It is observable that an appropriate combination of these two methods can bring together their advantages and prevent their disadvantages. The most important reason for combination of fuzzy logic with neural network is learning capability of neural networks. This combination should be able to learn lingual rules, membership functions, and/or both of them, and learning about the construction of a base for rules and membership functions by the help of a problem is considered as or limited learning. In order to construct a base for rules at least a series of primary membership functions should be provided[5].

[3] -The same reference

[4] - Dini, Mahdi, 2005

[5] - the same reference

Table 1- Advantages and disadvantages of of neural and fuzzy logic networks

fuzzy logic	neural networks
advantages	
it doesn't need to mathematical process previous knowledge is useable in the form of rules. Interpreting the expression for solution is a simple task.	doesn't need any mathematical processing model doesn't need transferring knowledge through the rules several learning models are provided
disadvantages	
rules should be provided it cannot learn there isn't any codified method for its compiling regulation process may not be successful	black box rules cannot be extracted from it previous knowledge cannot be used (learning from zero) there isn't any guarantee for convergence in learning

Learning or optimizing the membership functions is not as complex as comparing the base for rules. Membership functions can simply be described by parameters that can be optimized in relation to one universal error measure. By the help of appropriate limitations certain conditions can be created. For example, overlapping of membership functions and comparing parameters for neural network is a simple task and thus, in most of the neural network combinations it does the learning process of membership functions. Two different solutions are available for learning about membership functions:

a) membership functions whose parameters are optimizing in learning process.
b) using sample data, neural network learns to produce membership amounts in lieu of input amounts.

The difficulty present in the second solution is that membership functions are not explicitly determined and so, the first solution is used.

While the advantage of neural-fuzzy over fuzzy logic is in its capability for learning, neural fuzzy bears more advantages over neural network. Neural fuzzy system is based on lingual rules and so previous knowledge can easily be combined with system. This knowledge in the form of rules or membership rules can be a beginning point for system learning and decrease the time needed for learning. On the other hand, by studying the rules and membership functions it becomes clear that up to how extent, the found solution by learning process is acceptable. By applying these rules, new knowledge about under consideration problem is obtainable. This recent feature is one of the most interesting features of neural fuzzy systems. But, through combining neural network with fuzzy logic, there also remains one failure and that is difficulties about the learning process, and its success has not been guaranteed.

- Definition of Neural Fuzzy System:

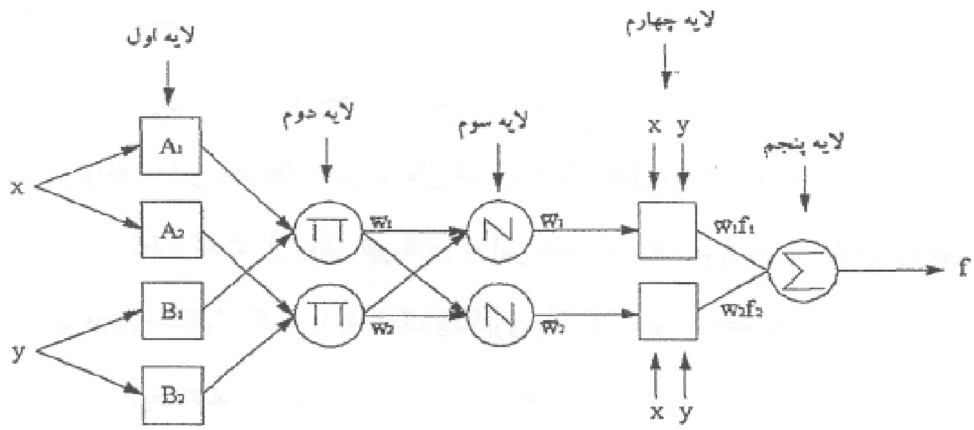
Neural Fuzzy system is finding parameters of a fuzzy system with the help of learning methods resulted from neural networks through expressing fuzzy system in the form of a special architecture of neural networks and then applying a learning algorithm, such as error back propagation for system learning. This task is not free of difficulty, because learning algorithms of neural networks are usually on the basis of gradient descent method and so, they can't directly be applied on neural networks, because functions used in fuzzy interrogation process are not usually derivable. There are two solutions for this problem:

1. replacing fuzzy logic functions (such as maximum and minimum) with derivable functions
2. not using a learning algorithm based on deriving and applying a more appropriate process.

Modern neural fuzzy systems are often introduced in the form of feed forward multi-layer neural networks. For example, ANFIS model (fig. (9.2)) uses a feed forward model fuzzy system in network structure and uses a combination of error پس انتشار method with the least squares method. Since Sogno system uses only derivable functions, ANFIS has chosen the first solution. Using soft minimum derivable function, the first solution has also been selected in GARIC model. But the difficulty present in the first solution is that, for example, in case of Mamdani type fuzzy systems it is not of use. In case of models such as NEFCON that use Mamdani fuzzy system, the second solution is selected and special learning algorithms are used in them. In addition to feed forward multi-layer neural networks other combinations of neural methods or architectures of neural networks are also available from among them fuzzy associative memories can be pointed out. Some strategies also prevent introducing fuzzy system to network architecture and apply only one learning method for fuzzy system parameters and / or determine these parameters with the help of neural network[6].

[6] -Jang, J.S.R, 1993

Fig. 1- Sogno Fuzzy Equivalent System with two Inputs, one output and two ANFIS rules



Totally, general features of neural fuzzy systems can be summarized as follows:

- Neural fuzzy system is the one that results from a learning algorithms that has usually been extracted from neural networks theory. Learning process is based on extraction from input data and not on explicit knowledge.

- Neural fuzzy systems can always (before, during and after learning) be expressed in the form of a system of fuzzy rules. One may construct a system of learning data using previous knowledge and/or from zero.

- Learning process of neural fuzzy system considers semantic features of its underlying fuzzy system and this causes some limitations in correcting the system parameters.

- Neural fuzzy system estimates an unknown n dimensional function that has been introduced by educational data.

- Neural fuzzy system can be imagined as some special kind of feed forward three-layer system whose units use S norms and even norms of t instead of activation functions common in neural networks. The first layer expresses input variables, the middle layer expresses fuzzy rules and the third layer expresses output variables. Fuzzy sets are saved in (fuzzy) weights of communications. Some neural fuzzy models use more than three layers and apply fuzzy sets as activation function, however, these models can also be changed into a three-layer model.

Finally, it can be said: neural fuzzy method is used for the purpose of extracting a fuzzy system from data, or with the help of learning through data, to upgrade its input. Although this definition can be interpreted in several ways, a wide range of solution is available that the title “neural fuzzy” is applicable for them. The only exception in this regard is fuzzy neural networks in which techniques of fuzzy logic are used to promote the learning ability and / or neural network function that can be realized by using the fuzzy rules for changing the learning rate and/or constructing a network that works with fuzzy inputs.

Different kinds of neural fuzzy systems:

a) cooperative neuro-fuzzy systems

In this system, neural network and fuzzy system work separate from each other, but neural network determines some parameters of fuzzy system. This system has also been offered in different kinds:

1) Neural network determines membership functions using educational data that can take place in the form of determining appropriate parameters or their forming.
2) Neural network determines fuzzy rules from educational data that can be done by a clustering approach and required membership functions should separately be determined for the system. Fuzzy clustering algorithms can also be used instead of neural networks.
3) With the help of a limited learning problem and / or during using the fuzzy system with the help of an error measure, system can optimize the membership functions. Fuzzy rules and primary membership functions should be given to this system. In this system, neural network doesn't literally exist, rather, a neural learning algorithm such as error پس انتشار is used.
4) Neural network (or an algorithm similar to neural network) determines the weights of fuzzy rules. These weights are multiplied by the realization degree of the rule. However, rules being weighted can make semantic interpretation of the base for rules difficult, for example a lingual phrase in different rules appears in different forms. At the same time, the idea of such a system is correct, because it also assumes the rules as fuzzy, in addition to input and output. Pre-requisites for this system are like the ones in system three. With the help of data, also in this system membership functions can be corrected.
5) b) Hybrid Neural Fuzzy Systems:
6) In this system, the combination of neural network and fuzzy system is offered in the form of a homogeneous architecture and usually similar to neural network architecture that can be done by interpreting a fuzzy system in the form of some special kind of network or by expressing a fuzzy system by using the neural network. The reason why these systems are called hybrid is that the system can be seen in both forms of neural network and fuzzy system. The advantage of this system is in its integrated structure. In that structure, fuzzy sets and input and output variables can be interpreted as weights of communications and neoron, respectively, and learning algorithm corrects the structure, parameters and/or both of them (adding and deleting neorons and changing the weights). Changes made in learning process can be interpreted from the two view points of neural network and fuzzy logic. This last feature is of very importance because the system is not in the form of black box either. A successful learning process is like an increase in explicit knowledge that is expressed in terms of a base for fuzzy rules. If a solution has already been available in neural form, it can be used as the teacher of neural fuzzy system. If learning is successful, a solution is obtained that, despite the neural network, is interpretable in the form of lingual rules[7].

2.2. Experimental Literature of the Research:

2.2.1. Studies done in Foreign Countries:

- Using artificial neural system, Kohzadi et al (Kohzadi, N., Boyd, M. S., Kermanshahi, B. and L. Kaastra (1996) evaluated the power of the two models of neural network and ARIMA process in extracting the return points in addition to predicting wheat and alive cow prices and comparing neural network and ARIMA process. In the present research, monthly prices of wheat and beef for time periods of 1950-90 were used. Results from the research show that the average of MSE measure of neural networks in predicting the wheat and cow prices was 27 and 56 percent less than ARIMA process, respectively. Also, neural network enjoys more capability in extracting the return points.

- Moshiri et al. (Moshiri, S., Cameron, N. and D. Scuse (1999)) predicted inflation rate in Canada using different models of neural network such as three-layer and radial pile feed forward neural network and also a structural econometrics and vector auto regressive model (VAR) in three time horizons and evaluated and compared results from these predictions. Results show that neural network models with back propagation algorithm act at the same surface and/or better than other networks and econometrics models used in this study in static predictions. Also, in dynamic predictions error back propagation neural network has generally better function than structural econometrics model but in

[7] - The same reference

comparison with VAR model, except for the time horizon of three months later, its function, is weaker in other time horizons.

- Using artificial neural network, Tkacz, G., (2001) has predicted gross domestic production growth (GDP) of Canada. Results from the study showed that artificial neural network bears less error compared to linear and single variable models in yearly predictions for gross domestic production growth (GDP). However, such a superiority is less observed in seasonal predictions. This researcher has used different methods from MSE and MAE (Mean average error) measures to compare the prediction power.

- Unlike other and previous studies, Olson, D. and C. Mossman (2003) used neural network in grouping the financial markets in addition to prediction. In the present research artificial neural network of error back propagation was compared with Lojit model and the ordinary least square method. Data used in this research includes stock yields of 2352 Canadian companies for period 1976-1993. Results from the research show that neural network enjoys more capability in identifying non-linear relations between dependent and independent variables and thus, it produces more accurate predictions. Also, neural network grouped the companies according their yields more accurate than other methods.
- Heravi, S., Osborn, D. R. and C. R. Birchenhall, (2004) have compared the capability of artificial neural network with an Auto Regressive (AR) process in predicting technical production of the three European contries Germany, France, and England. In doing so, Root Mean Square Error measure was used. Results from the research showed that artificial neural network bears less prediction errors compared with auto regressive process in time horizons less than 12 months.

2. 2. 2. Domestic Researches:

- In a research on auto regression neural network with ectogenic inputs (NNARX) in predicting three future time horizons Fahimi Fard et al. (2009) have compared retail prices of rice, chicken and egg and its use and efficiency with ARIMA model - as the most common linear method for prediction. For this purpose weekly data from supporting company of farm animals affairs and Refah shopping center of the country (related to the time period 1381:1-1387;4) and measures for evaluating the efficiency of models such as MAD R^2 and RMSE have been used. Results from evaluation of model efficiencies show that non-linear model neural network – NNARX auto regression in predicting the retail prices of agricultural products and during the under consideration time horizons, compared with ARIMA linear model is more efficient.
- Azar Aadel, Afsar Amir (2006) have modeled prediction of stock price with neural fuzzy networks approach. In this research, neural fuzzy networks model for predicting stock price has been designed and concerning the six functional evaluations it has been compared with ARIMA method. Results from the research shows that neural fuzzy networks in all of the six functional evaluation criteria have had superiority over ARIMA method and they enjoy unique features of rapid convergence, high accuracy, and more ability to function approximation and are appropriate for predicting the index of stock price.
- In a research, Abrishami Hamid et al. (2010) has used GMDH neural network for predicting gas oil price based on technical analysis rules including Short term and long term moving average as network input during different market periods. In this study, exchange costs and exogenous factors have not been considered. In technical analysis approach, predictions take place according to the past behavior of the price in the same market (here gas oil of Persian Gulf). Results show that the best prediction function has been obtained in stable market conditions. Also, compared to time series approach, neural network predictions enjoy less error and high accuracy.
- In a research titled “ Predicting the Egg Price in Iran” Tibi Seiyed Komeil et al. (2009) have compared ARCH and artificial-neural networks. Because of the importance of predicting the price of protein products such as egg, the present research predicted this product’s price using ARCH and artivictial neural networks for the time horizons of one-month, six-month and twelve-month. In this regard the assumption “ Artificial neural network is more efficient than ARCH approach

in predicting the egg price." was studied. Data used here include the variables of egg price and period of study including 1992-2006. Results show that in most of the time horizons artificial neural networks offer more accurate predictions than ARCH approach. Thus, using price prediction approaches that are mainly based on artificial neural networks can be helpful to influence price policy and even to set the market using prediction of different oscillations.

- Khasheie Mahdi, Bijari Mahdi (2000) have used the combined model of artificial neural networks with fuzzy regression to aim to predict the gold price. In order to overcome limitations in the number of data required for the network and obtain more accurate results for predicting the gold price this paper has offered the combined model of artificial neural networks with fuzzy regression. Experimental results are indicatives of effectiveness of this approach in predicting the gold price.
- In a research Gadimi, Mohammad Reza and Moshiri, Saeed have predicted economic growth of Iran using artificial neural networks. They have compared the effectiveness of a neural network model with a linear regression model to predict the rate of economic growth in Iran. Results from their research show that artificial neural network is far more effective for predicting the economical growth in Iran.
- In a case study Ahmadi, Akbar has studied the prediction of non-oil exports of Iran using fuzzy neural networks. He has used the annual data non-oil exports of Iran, domestic price index, and GDP during the years 1961 to 1997 and has estimated a logarithmic and linear regression model and also an adaptive neural fuzzy system model. Results from the research show that compared to regression model, adaptive neural network model has shown less error in prediction of non-oil exports of the country.
- In a study and using artificial neural network, Najafi, Bahaodding and Tarazkar Mohammad Hassan (2006) have predicted the rate of Iran's pistachio exportation. They have used data provided by Iranian Customs during the years 1925 to 2003 and have estimated the artificial neural network and ARIMA. Their research shows that compared to ARIMA approach, artificial neural network bears effective function and is able to ---- the rate of ----. In a study Pour Kazemi et al. have predicted the demand for subscription of city-home gas in Tehran using ARIMA and fuzzy neural networks approaches and have compared the two methods concerning functional evaluation criteria. Results from their research shows that in predicting the demand for town gas subscription, fuzzy neural networks compared to all evaluative criteria have had better functions than ARIMA approach.

3- Research Method:

Estimation method for modeling the prices of different kinds of fruits has been offered using the two approaches of ARIMA and fuzzy neural network. It should be mentioned that the time series Szar, Sger and Moz stand for the prices of yellow apple, red apple and banana, respectively, during the time period beginning from July 2006 to the end of August 2009 that have been gathered using the site of Iran's Advocacy Organization of Consumers and Producers. It should be mentioned that prices relating to red apple and yellow apple are monthly prices and that of banana is fifteen day price. In order to estimate the models, time series related to the prices of these fruits have been classified into two periods in estimating the model. The first period beginning from July 2006 to the end of May 2009 in order to estimate the model and the second period beginning from June 2009 to August 2009 (a three-month period) to test the accuracy of models in predicting and comparing the models have been used. Expert systems as a powerful tool in creation of fittings and information classifications during the recent two decades have suitably progressed and together with the time elapse the amount of achieved innovations in this regard is increased. Furthermore, programming languages and pre-designed software as efficient tools play the most serious role on this development. Mtlab software package, because of its generality and having a series of ready-made tool boxes that have been written and added to the program for the purpose of modeling the artificial neural networks, fuzzy and fuzzy-neural systems, bears unique capability in modeling the information and its classification. Here, the ready-made tool boxes Fiseditor for modeling the fuzzy logic system, Anfiseditor for modeling the neuro-fuzzy logic system, and Anneditor for modelling the artificial neural network systems may be talked about. Using programming in Matlab program they can be combined with other optimizing algorithms to obtain the optimized models. Some of the basic problems concerning these programs are their low speed when running with the number of inputs, number of membership functions, and number of top hidden nodes. Since the present research aims to use ARIMA and fuzzy-neural approaches to estimate the price of different kinds of fruits, and because of ease and comprehensiveness in use, Matlab software and EViews software will be used for modeling fuzzy- neural networks and estimating the ARIMA model.

- different indexes have been considered to evaluate the models and they are described below.
- Root of Mean Square Error (RMSE) is defined as follows:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y_{actual} - y_{forcast})^2}{n}}$$

- in the above relation y_{actual} is the amounts of actual data for the price, $y_{forecast}$ is the amounts of predicted data for the price and n is the number of data.
- Mean Absolute Percentage Error: Absolute error is defined as difference of real data from predicted data divided by real data. Mean Absolute Error or Mean Absolute Percentage Error is obtained by finding the average among all absolute errors and is defined as follows:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\frac{|y_{actual} - y_{forecast}|}{y_{actual}}$$

4-Comparing the Models and Conclusion:

In this section models for the price of different kinds of fruit at provincial level were studied and the best model was selected for predicting the price of each kind of fruits and using the ARIMA models following results were obtained:

Estimated model for predicting the price of yellow apple: D(Szar)= 135/9 + 0/47 AR(3) – 0/86 MA(3)

Estimated model for predicting the price of red apple: D(Sger)= 70/39 - 0/61 AR(1)+0/997 MA(1)

Estimated model for predicting the price of banana: Moz= 10479/8 + 0/93 AR(1) – 0/4 MA(1)

In addition to estimation of above mentioned models for predicting the price of each one of the products, three models of fuzzy neural network (networks with one, two and three inputs) were estimated in 21 cases. Since this research aims to predict the price of fruit, from among estimated neural-fuzzy models those ones were selected for predicting and being compared with ARIMA model that bore the least amount of test error. Thus, in addition to comparing the error rate for each one of estimated neural fuzzy models, we will select the most appropriate neural-fuzzy model and will compare it with estimated ARIMA models.

Selecting the appropriate model for predicting the price of red apple:

Results related to the test least error of different estimated models for predicting the price of yellow apple at provincial level have been shown in table (4-1). According to this table among the three estimated neural-fuzzy models for predicting the price of yellow apple the least error of the test or of prediction is that of FNN2 model, that is, the model with two inputs (the price for the current month and for a month before for yellow apple) and one output (the price for next month for yellow apple). Therefore, this model will be used as the best neural-fuzzy model for predicting the price of red apple at provincial level. In this model, the least error of prediction is that of the case in which three membership functions of triangle type (trimf) have been used in each one of the rules.

Table 4-1 – Test error related to estimated neural fuzzy model

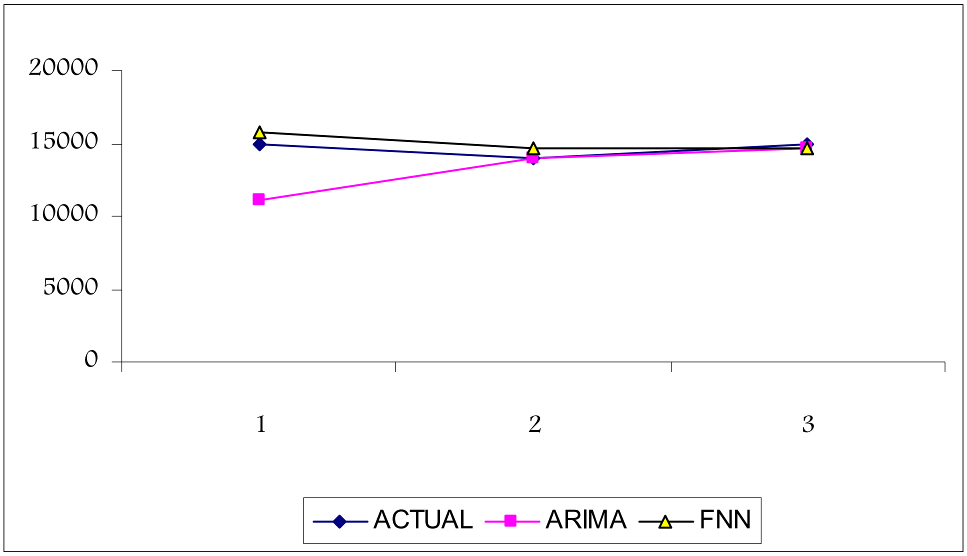
Model's Name	FNN3	FNN2	FNN1
The least Error of the Test	**0.150**	**0.121**	**0.150**

In table (4-2) results concerning the predicting the price of yellow apple in a three-month time horizon have been offered by the two ARIMA and neural-fuzzy network models. Results from comparing the prediction of the two models show that neural-fuzzy model has been able to predict and follow the changes in prices better than ARIMA model. Also, it becomes clear that error rate relating to the neural-fuzzy network model on the basis of RMSE and MAPE criteria is far lower than that of ARIMA model.

Table 4.2. Output and prediction error relating to the FNN and ARIMA models for test data

Date	Real data	Predicted data		**MAPE**		**RMSE**	
		ARIMA	**FNN**	**ARIMA**	**FNN**	**ARIMA**	**FNN**
1388:3	**15000**	**11154**	**15793**	**9.3**	**3.92**	**2228**	**609**
1388:4	**14000**	**14031**	**14629**				
1388:5	**15000**	**14694**	**14702**				

Fig. 4.1. Comparing results from estimation of FNN and ARIMA models with monthly real data related to the price of yellow apple in the province



- selecting the appropriate model for predicting the price of red apple:

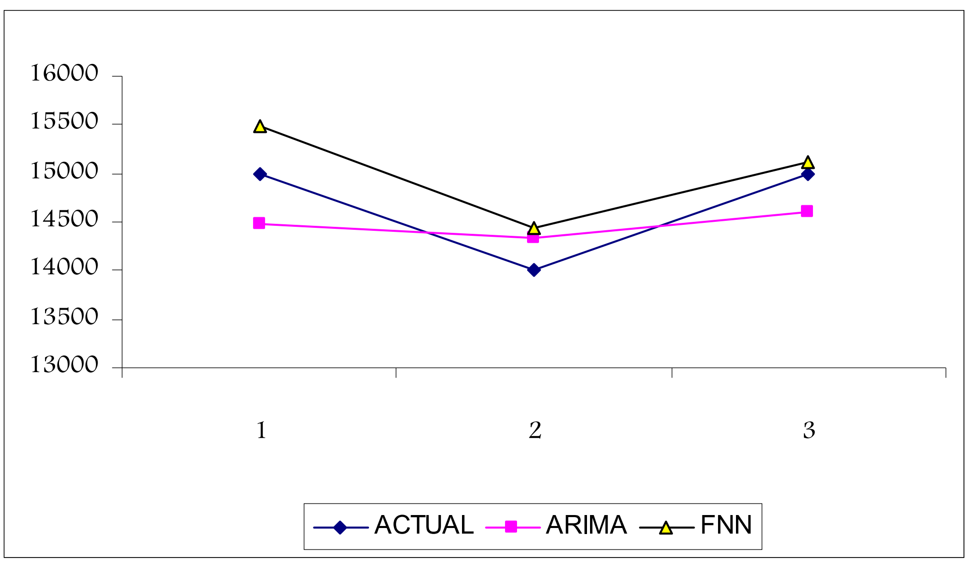
Results related to the least test error of the three FNN4, FNN5 and FNN6 models that have been considered for predicting the price of red apple have been offered in table (4-3). It can be seen that the least test error among these models is that of FNN6 model with test error equal to 0.094. Thus, this model is selected as the appropriate model for predicting the price of red apple at provincial level. This model predicts the next month's price for red apple at provincial levels using the current price, the price for one month before and the price for two months before. In this model membership functions are of Gaussian type (gaussmf) and their numbers in each rule is three. In table (4-4) results related to the prediction of red apple price at provincial level, using the two ARIMA and FNN6 models have been offered within a three-month time horizon. According to this table function of neural-fuzzy model in predicting on the basis of the two RMSE and MAPE criteria is better than that of ARIMA model, and this model has been able to predict the price amounts for red apple at provincial levels within the next three months with less error. In fig. (4-2) prediction results using the two models have been compared with real data. According to this fig. , compared to ARIMA model, neural-fuzzy network bears better function in prediction process.

Model's Name	**FNN4**	**FNN5**	**FNN6**
Test Error	**0.122**	**0.155**	**0.094**

Table 4-4. Output and prediction error related to FNN and ARIMA models for Test data

Date	Real data	Predicted data		**MAPE**		**RMSE**	
		ARIMA	**FNN**	**ARIMA**	**FNN**	**ARIMA**	**FNN**
1388:3	**15000**	**70414**	**77415**	**2.7**	**2.37**	**429.2**	**383**
1388:4	**14000**	**27314**	**14447**				
1388:5	**15000**	**14594**	**15113**				

Fig. 4-2. Comparing results from estimating FNN and ARIMA models with monthly real data related to the price of red apple in Province



- Selecting the appropriate model for predicting the price of banana

Results related to the test's least error of the three models FNN7, FNN8 and FNN9 that have been considered to predict the price of banana have been offered in table (4-5). This table shows that among the different estimated neural-fuzzy models for predicting the price of banana, the least prediction error is that of FNN8 model with prediction error equal to 0.068. Thus this model is selected as the appropriate neural-fuzzy model for this purpose. FNN8 model uses the current price and the price of fifteen days before in province to predict the price of the next fifteen days. In this model membership functions are of Gaussian type (gaussmf) and their numbers in each rule is three. In table (4-6) results related to prediction of the price of banana at provincial level using the ARIMA and FNN8 models have been offered in a three-month time horizon. According to this table the function of neural-fuzzy model in prediction on the basis of the two RMSE and MAPE criteria has been far better than that of ARIMA model and that, this model have been able to predict the amounts of banana price at provincial level during the next three months with less error. Comparing the prediction results of the two models with real data has been offered in fig. (4-3). According to this fig. neural-fuzzy network has been able to offer close estimations to real data. Also, according to table (4-6) error rate of ARIMA model in predicting process is for times greater than that of neural-fuzzy model.

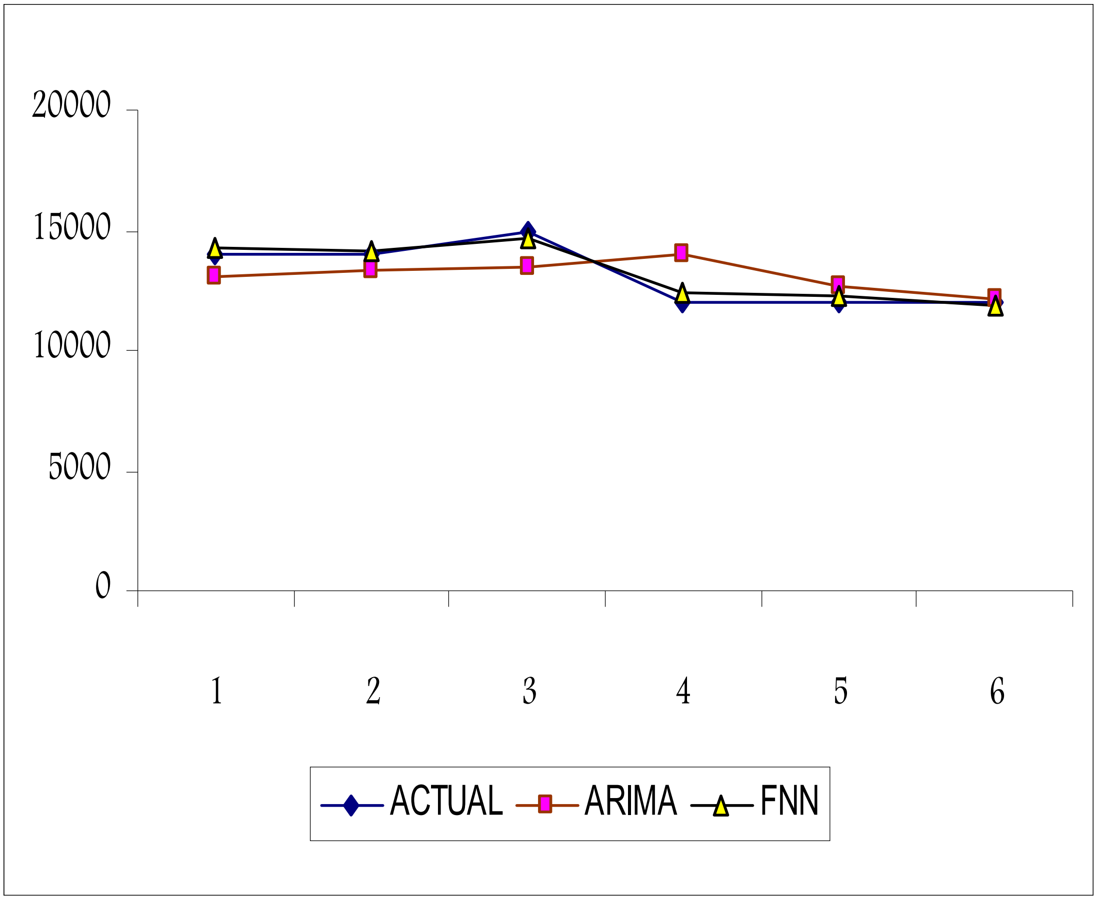
Table 4-5. Results related to the test error of different kinds of neural-fuzzy models

Model's Name	**FNN7**	**FNN8**	**FNN9**
Test Error	**0.111**	**0.068**	**0.097**

Table 4-4. Output and prediction error of FNN and ARIMA models for test data

Date	Real data	Predicted data		**MAPE**		**RMSE**	
		ARIMA	**FNN**	**ARIMA**	**FNN**	**ARIMA**	**FNN**
1388:2:2	**14000**	**13045**	**14258**				
1388:3:1	**14000**	**13361**	**14173**	**7.7**	**1.9**	**1184**	**266**
1388:3:2	**15000**	**13488**	**14673**				
1388:4:1	**12000**	**14066**	**12376**				
1388:4:2	**12000**	**12715**	**12246**				
1388:5:1	**12000**	**12175**	**11861**				

Fig. 4-3. Comparing the results from estimation of FNN and ARIMA models with monthly real data on the price of banana in the province



5- Summation:

At the present research regarding the available data on the price of the three different kinds of fruits, that is, yellow apple, red apple and banana at provincial level from July 2007, monthly and fifteen-day data at provincial level during the years from July 2007 to August 2010 were used. This data was gathered from Informative base of Advocacy Organization of Consumers and Producers.

In order to estimate neural-fuzzy network and ARIMA models and comparing their accuracy in predicting time series related to the price, fruits were classified into two periods. The first period was selected from July 2007 to June 20010 to estimate the model, the second period was selected from June 2010 to August 2010 to test the accuracy of the models in predicting the price of different kinds of fruits in a three-month period. In estimating the neural-fuzzy models nine different models were estimated to predict the price of different kinds of fruit (each one with three models). And finally, three models that had the least test error were selected from among them.

Results from the present research showed that the function of neural-fuzzy models in predicting the price of each kind of the fruits is far better than that of ARIMA model that is traditionally used in economic literature for the purpose of prediction. Thus, in order to predict the price of different kinds of fruits at provincial level, prevent oscillations in the price, and obtain the required result close to the real one, using neural-fuzzy model is proposed. Also, because of shortage of time in predictions, using methods offered for price predictions in the present research should be dynamic and continuous.

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