An Empirical Analysis of Turkish Financial Crises in the Early 2000's.

İsmail ÖZSOY
Prof. Dr., Fatih University, Dept.of Economics, Turkey
iozsoy@fatih.edu.tr, ismailozsoy@yahoo.com

Birol GÖRMEZ
Research Asst., Fatih University, Dept.of Economics, Turkey
bgormez@fatih.edu.tr, bgormez@hotmail.com

Abstract: The financing scheme has a crucial function in an economy since it enables fund-owners to transfer their funds to those in need. Unless the financing scheme operates effectively, economic growth is hampered severely due to the inadequacy or immobility of capital. The world finance history has experienced many financial crises, the case of malfunction of the financing scheme, repeatedly so far. Many theories and models have been developed to give an insight into the reasons and dissemination mechanisms of, and precautions against the financial crises. This paper is intended to find out the explanatory variables of the Turkish financial crises that took place in November 2000 and February 2001 with the help of the method of Artificial Neural Network (ANN) and within the framework of the models of financial crises. To this effect, the models of financial crises are briefly dealt with; the Turkish financial crises in the early 2000's are analyzed subsequently by making use of ANN.

Key Words: Turkish Financial Crisis, Financial Crisis Models, Artificial Neural Network

Introduction

Nearly all people would like to have an uninterrupted prosperous life. This demand can only be met as long as some specific conditions are established. For instance, the efficient utilization of the existing scarce resources in the production of goods and services and the fair and uninterrupted distribution of the produced goods and services are two of the specific conditions that have to be established so as to ensure high and sustainable personal welfare. However, it is impossible to state that these conditions can be met any time since sometimes there may be such ups and downs in the economic activities as crisis, which may have drastic economic, social and political effects.

Due to its devastating effects, foreseeing financial crises, a type of economic crisis, and taking measures to minimize the length and impacts of them are of crucial importance. Many financial crises models have been developed to guide the institutions that try to achieve these goals. Theoreticians have made different comments on the reasons and eruption processes of the crises, thus, they have suggested different solutions to this problem.

The aim of the this paper is to find out the explanatory variables of the financial crises that took place in the early 2000's in Turkey. To this end; after a short explanation about financial crisis, financial crisis models are explained very briefly, then the financial crises in question are examined empirically by making use of the method of Artificial Neural Network.

Financial Crisis

Theoreticians define financial crisis from their own perspective in different ways. To one of the definitions, financial crisis is the nonlinear disruption in which asymmetric information problems of adverse selection and moral hazard become much worse, so that financial markets are unable to channel funds to those with the most productive investment opportunities. (Mishkin 2003) However, in its broadest meaning, financial crises are the big problems suddenly arising in money, foreign debt and banking areas of the financial sector. In the light of this definition, it is possible to classify financial crises into groups of "banking crisis", "monetary crisis" and "foreign debt crisis." (Bastı 2006) The definitions of the concerned types of financial crises are as follows:

"A banking crisis refers to a situation in which actual or potential bank runs or failures induce banks to suspend the internal convertibility of their liabilities or which compels the government to intervene to prevent this by extending assistance on a large scale." (IMF 1998)

A monetary crisis or a currency crisis erupts if the attacks on the national currency of a country end up with devaluation or a sharp depreciation or if the Central Bank is forced to protect the value of the currency by selling huge amount of reserves or increasing interest rates sharply. (Delice 2003)

Foreign debt crisis is the declaration by a country of the fact that it can not pay "capital+interest" of the public or private foreign debt (that it can not pay debt service) due to the foreign payment problems it encounters. (Seyidoğlu 2001)

Financial Crisis Models

Some models and theories have been developed to explain the nature of financial crises. The classification of financial crisis models as First Generation Financial Crisis Models and Second Generation Financial Crisis Models has been widely accepted. Some models have also been introduced into the literature, which aim at explaining the financial crisis named as "Asian Financial Crisis", which erupted on 2 July 1997 with the devaluation of Thailand's national currency. These last group models are called Third Generation Financial Crisis Models or the Models Explaining Asian Crisis.

First Generation Financial Crisis Models are named as Traditional Crisis Models, Canonical Crisis Models or Speculative Attack Models as well. Main starting point of these models is the fact that foreign currency can exhaust and its supply can not be increased easily. The first financial crisis modeling developed by Paul Krugman in 1979 has been considerably improved, and today it is named as "First Generation Financial Crisis Models".

According to the first generation models, main reasons behind monetary crises are macroeconomic structural imbalances and unsustainable policies. High and increasing budget deficits, high inflation, high domestic interest rates, high rates of money supply increase, huge current deficits, extremely valuable exchange rate and decreases in international reserves can be given as examples of macroeconomic structural imbalances. (Kuran 2006) Issuing money to finance budget deficits in a country where fixed exchange rate system is implemented can be given as an example for unsustainable and unstable policy. According to these models; covering of financial deficits while implementing a fixed exchange rate policy or increasing money supply drastically to balance a weak banking system causes financial crises. In other words, incompliance of economy policies -which are divided into two groups of monetary and fiscal policy- with foreign currency target results in financial crises.[1]

According to first generation models, financial crises erupt as follows: Assume that fixed exchange rate policy is implemented in an economy; that the budget of the economy has a deficit and; that the units implementing macroeconomic policies prefer issuing money to finance the budget deficit and the only tool they have to fix the deficit is to intervene in the foreign exchange market. In such case, interest rates fall on one hand and inflation rises on the other hand due to increase in money supply. The fall in interest rates and the rise in inflation cause reduction of economic reserves and, thus, result in crisis. First of all, foreign investors demand foreign currency (as the interest rates fall) and then export foreign currency. In addition, shadow price[2] of the foreign currency exceeds the official foreign exchange rate due to increasing foreign currency demand. Secondly, national currency is valued due to fixed exchange rate policy. This has a decreasing effect on export and increasing effect on import. The rise of inflation has negative impacts on export as well. As a result, foreign trade deficit gradually increases. The increase in the foreign trade deficit means a reduction in economic reserves. Moreover, these two developments bring along another development that reduces reserves more: In an economy where foreign trade deficit increases (i.e., where balance of payment is deteriorating), speculators foresee that fixed exchange rate policy will be abandoned and, thus, foreign currency rate will increase. Therefore, speculators who want to maximize their profits sell their reserves in national currency and buy foreign currency. Together with the above-mentioned factors, this situation plays a role in the depletion of the reserves as well. Speculative Attack plays an important role in the first generation models. The most important characteristic of Speculative Attack is that investors decrease the relative share of the national currency and increase the share of the foreign currencies and foreign assets in their portfolios. Central Bank, which tries to maintain fixed exchange rate, puts its foreign currency reserves on the foreign currency market. Central Bank, the reserves of which decreases to a critical level, has to abandon fixed exchange rate regime. As a consequence of this process, a financial crisis (monetary crisis) erupts. To summarize according to Krugman's approach; variables such as financial and monetary expansion result in reserve losses when there is no parity to prevent loss of foreign currency reserves. This situation creates an increasing pressure on the foreign exchange rate. (Kaminsky, et al 1998)

[1]For more detailed information: See; Krugman, Paul (1979), "A Model of Balance of Payment Crises", Journal of Money, Credit, Banking" pp: 311-325

[2]Shadow price is the price determined by the supply-demand status of any good when the price is not fixed by the authorized institutions. Shadow price of any foreign currency is the price that is determined when the exchange rate is not fixed.

Second Generation Financial Crisis Models suggest financial crises can erupt even when there is no deterioration in the economic indicators. These models explain how speculative attacks targeting national currency can result in crises even when the monetary and fiscal policies are consistent. (Özer 1999)

Second generation models emphasize that when there are inconsistencies between fixed exchange rate and some important economic figures, politicians may prefer to float the exchange rate and not respond to the speculative attacks even when there is sufficient amount of foreign currency reserve. (Bilgin, et al 2002) To the second generation models pioneered by Maurice Obtsfel, governments have grounds both to continue and to abandon the fixed exchange rate policy. Governments make benefit-costs analysis when deciding on whether to continue or abandon the fixed exchange rate policy. The benefit of the fixed exchange rate system is that it decreases the inflation pressure and creates an economic environment that promotes trade and investment. On the other hand, the cost of the fixed exchange rate system is that it causes an increase in the real interest rates. In case downward inertia is observed together with the high interest rates, unemployment rate increases and growth rate decreases. As can be understood from the context, increasing real interest rates may lead to failure to sustain the fixed exchange rate system and, in turn, to eruption of crisis. Since it will not be rational to keep the exchange rate at its current level in case costs exceed benefits, the exchange rate is floated. To reduce unemployment and current transaction deficits and to promote growth; governments prefer to switch to the floating exchange rate system although foreign currency reserves are sufficient to protect the exchange rate.

Third Generation Financial Crisis Models are also called "The Models Explaining Asian Crisis". Two main suggestions have been made to explain the reasons of Asian Crisis.

The first suggestion is that Asian Crisis can be explained on the basis of the second generation models. To this suggestion, the countries that faced crisis were exposed to a self-fulfilling pessimism by the international investors. That is, the pessimism of the creditors and investors created a pessimist atmosphere for the other investors as well. The resulting cycle caused the Asian Crisis.

To the second suggestion, the weak economic structure produced by the wrong policies and structural problems resulted in the Asian Crisis. These structural problems can be summarized as follows:

The first problem was the presence of the microeconomic problematic implementations such as implicit deposit insurances and confidential public guarantees. These implementations have been suggested to pave the way for the crisis due to moral hazard and excessive borrowing.

The second problem was the insufficient auditing of the financial sector and particularly the banks. When the system is not properly audited, banks can enable use of funds by their affiliated companies at such huge amounts to increase financial fragility. In addition, in weak systems, huge amount of funds inflowing to the country result in not only high amount of domestic fund transfers via poorly-managed banks but also domestic demand boom. The loans granted without any risk analysis can not be paid back in economic shrinkage times and result in crises.

The third problem was the unreliable balance sheets of the banks and non-bank financial institutions. The problems in the balance sheets of the banks mainly result from mismatch. When the banks borrow money in foreign currency and lend in national currency and when they make short-term borrowing and make lending for long-term investments; it means that they encounter both monetary and term mismatch problems. (Yay, et al 2001) Wrongly-valued foreign currencies and unpaid debts are the other balance sheet problems. Such situations create the appropriate environment for the financial crisis to occur.

Empirical Analysis with Artificial Neural Network (ANN)

"An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information." (Stegiou, et al 2009) In the information processing system of ANN, there may be huge number of highly interconnected processing elements, neurons, just like in a brain. The neurons in question are organized into the layers of input, output and hidden. The input layer is connected to the output layer through junctions with a hidden layer. (Cravener, et al 2001) Input, hidden, output layers and the neurons constitute the network of ANN. The brief explanation of the learning process of ANN is as follows: Firstly, the network tries to find linear relationships between the inputs and the output. The links between the neurons in input and output layers are assigned weight values. At this phase, there is no hidden layer. After the linear relationships are found, non-linear relationships are found by adding neurons to the hidden layer. The values in the input layer, namely the inputs, are multiplied by the weights assigned by the system automatically and then sent to the hidden layer. The hidden layer produces some outputs, inputs of the output layer, and sends them to the output layer. Lastly, the output layer produces the predictions. The network of ANN is adaptive. Because the predicted values are compared with the actual values, and if there is any error, then the connecting weights are adjusted and/or new hidden neurons are added to capture all features of the data set and to make accurate predictions, namely to minimize the error.

Inputs, Output (Variables) and the Dataset

The studies analyzing the Turkish financial crisis of 1994, 2000 and 2001 empirically were examined to determine the inputs and output. The leading indicators that were found significant in the analysis were used as the inputs in our study besides the inputs emphasized by the financial crisis models. 96 pieces of monthly data of each input, between the dates of Janury, 1996 and December, 2003 were used in the analysis. The monthly percentage changes of each input were used. The data were collected from the Electronic Data Delivery System of Central Bank of Turkey and the website of Turkish Statistical Institute**.**

About the Inputs

The inputs used in the analysis are as follows:

✓ *M2 (Money Supply)/Gross Currency Reserves of Central Bank (M2/CBER):* The rise of this rate means that the financial system is vulnerable to shocks. To the third generation financial crisis models, an increase in this rate increases the probability of financial crisis to occur.

✓ *Total Deposit of Commercial Banks (TDCP)*: It was observed that bank deposits had declined before the crisis. The fall in commercial bank deposits mean that bank balance sheets contract and the trust in banks decline. It is the crisis indicator of the third generation financial crisis models.

✓ *Domestic Credit Amount (DCA)*: Empirical findings obtained heretofore have proved that domestic credit amount increases before crisis. Before the financial crisis in November 2000, domestic credit amount, particularly the amount of consumer credits, increased substantially.

✓ *Consolidated Budget Income/ Consolidated Budget Expenditure (CBI/CBE)*: To the first generation financial crisis models, an increase in budget deficit raises the financial crisis risk. In other words, there is a positive relation between budget deficit and financial crisis risk. Therefore the probability of financial crisis risk is expected to increase as the value of this input declines.

✓ *Real Exchange Rate (RER)*: Overappreciation of local currency, that is, the change of exchange rate in favour of local currency is interpreted as a leading indicator of financial crisis.

✓ *Deposit Rate (DR)*: There is a positive relation between deposit rate and the probability of financial crisis.

✓ *Consumer Price Index (CPI)*: It was observed that inflation rates raised before financial crisis to have occured.

✓ *Current Account Balance/ Gross Domestic Product (CAB/GDP)*: An increase in this ratio is accepted as an indicator of financial crisis. To the former president of IMF, Stanley Fischer, high current deficient and banking sector caused the November 2000 crisis. (Fischer 2001) To some international finance institutions, CAB/GDP ratio of Turkey was unsustainable as of fall of 2000.

✓ *Export Coverage Import Ratio (EX/IMP)*: In an economy implementing fixed exchange rate system, the fall of export and the rise of import effect the foreign trade balance, thus the current account balance negatively. Current account deficit increases the pressure on exchange rate and causes speculative attacks.

About the Output

To design the output, a pressure index and a threshold were calculated. The formulas used to find out the pressure index and the threshold are as follows:[1]

The pressure index used is Foreign Exchange Market Pressure Index (EMP). “EMP is calculated as the weighted average of the monthly percentage changes in the gross currency reserves of the central bank and of the monthly percentage changes in the devaluation rate of TL against US dollar.” (Şen 2005) EMP is formulated as follows:

$$EMP_T = \%\Delta e_t - \alpha_1 \%\Delta r_t$$

Where

e_t denotes the nominal buying rate of TL/$ at time t

r_t denotes the amount of gross foreign currencies of Central Bank at time t

$\% \Delta e_t$ denotes the monthly percentage change in the nominal buying rate.

[1] The formulas used to design the output were taken from the following dissertation: Şen, Ali (2005), Finansal Krizlerin Tahmin Edilebilirliği: Türkiye Uygulaması, İstanbul University.

% Δr_t denotes the monthly percentage change in the amount of the gross foreign currencies of Central Bank

α_1 is the proportion of the standard deviation of the series of the monthly percentage changes in the nominal exchange rate to the standard deviation of the series of the monthly percentage changes in the amount of the gross foreign currencies of Central Bank. Namely,

(σ_e / σ_r)

The value of the threshold is calculated by making use of the following formula

$$\beta\sigma_{emp} + \mu_{emp}$$

Where

β denotes the coefficient of EMP

σ denotes the standard deviation of EMP series

μ denotes the mean of EMP series

If $EMP_{it} > \beta\sigma_{EMPit} + \mu_{EMPit}$, It is deemed that financial crisis occured in the corresponding month

If $EMP_{it} \leq \beta\sigma_{EMP_{IT}} + \mu_{EMP_{IT}}$, It is deemed that no financial crisis occured in the corresponding month.

In the light of these information, the values of the pressure index in November 2000 and February, March, April and June 2001 were found greater than the value of the threshold. That is to say, it is inferred from the data that financial crisis occured in the mentioned months. This inference highly overlaps with the conclusions of some other empirical studies and the crisis experience of Turkish economy. June 2001 crisis could be accepted as the aftershock of February 2001 crisis.

In analysis, the values of the pressure index, changing from month to month naturally, were used as output. The values of threshold, standard deviation, mean of the pressure index, and the ratio of (σ_e / σ_r) were found equal to 2.514596, 1.6010, 0.4491, and 0.1172 respectively. The coefficient of "β" is 1.29. It is important to determine the value of the coefficient of the standard deviation of the pressure index series, namely "β" while calculating the value of the threshold. Because deciding whether the financial crisis occured is effected by this value. To determine the value of the threshold, the values of "σ" ve "μ" were calculated by making use of the data whereas we assigned the value of "β". We calculated the value of "β" as 1.29. Because the financial crises dates found out in case of determining the value of "β" as 1.29 overlapped with the actual financial crisis mentioned above. It is possible to give various values to the coefficient of "β". For instance, in some studies[1], it was given the values of 1.5, 2.5, and 2.54 respectively.

Model Building (Learning/Training Phase)

In this subsection, an ANN model is built for November 2000 and February 2001 financial crises. All data were used for learning and validation purposes. The data were not separated as learning or validation data. That is, the data used to validate the built model was chosen within the sample. Testing phase was skipped. What desired to achieve with this model is only to find out the effects of inputs on the output, namely the pressure indice, which are used to specify whether financial crises occurred between 1996 and 2003. The number of the hidden neurons is 70. Because the model yielded lower R-squared values in case of the utilization of less number of hidden neuron. The model with the highest value of R-squared was chosen as the best model. NeuroShell ® Predictor software was used for the analysis.

The summaries of the statistical outcomes of the built model and importance of the inputs are as follows:

R-Squared: R-squared takes a value between 0 and 1. The closer the value is to 1, the better the net is able to make predictions. The closer the value is to 0, the net is not able to make good predictions. The R-squared value of the neural network model is 0.966431, which confirms the closeness of fit between the actual and trained pressure index. Figure 1 in Appendix shows the plot between the actual and trained pressure indice.

[1] Please refer to the following articles: Aziz, Jahangir, Caramazza, Francesco, Salgado, Ranil (2000), "Currency Crises: In Search of Common Elements", IMF Working Paper, No.67; Edison, Hali J. (2000), "Do Indicators of Financial Crises Work? An Evaluation of an Early Warning System", Board of Governors of the Federal Reserve System, International Finance Discussion Paper No. 675; Esquivel, G., Larrin F. (1998), "Explaining Currency Crisis", HIID, No.666

The blue points represent the actual, the red points represent the predicted indice. From the figure, we infer that the model is very good at learning the indice, namely the existence or non-existence of the crises.

*Minimum Square Error (MSE)***:** MSE is the statistical measure of the differences between the actual and predicted values of the output. MSE has the value of 0.002832 in our analysis, which is also a good indicator of the closeness of fit between the actual and trained pressure index.

Relative Importance of Inputs: In Table 1 is given the relative importance of each input. Besides, Figure 2 in Appendix illustrates the importance of each input in predicting the value of output. The corresponding number of each input indicates the importance of the input in predicting the output. The relative importance numbers take a value between 0 and 1, The higher the number, the more important that input is in predicting the output. "The relative importance numbers are "normalized" so that for all inputs they add up to approximately 1. Therefore, we may think of these numbers as a percent contribution to the model of the respective inputs." (Ward 1997) In view of the results, it is inferred that the input of domestic credit amount has the highest importance in predicting the output, whereas the input of CAB/GDP has the lowest.

Table 1: Relative Importance of Inputs

INPUT	IMPORTANCE
Domestic Credit Amount	0.242
Export Coverage Import Ratio	0.240
Real Exchange Rate	0.208
Consumer Price Index	0.153
Total Deposit of Commercial Banks	0.092
Deposit Rate	0.047
Consolidated Budget Income/Consolidated Budget Expenditure	0.008
M2 (Money Supply)/Gross Currency Reserves of Central Bank	0.005
Current Account Balance/ Gross Domestic Product	0.004

Model Validation (Validation Phase)

In this subsection, the built model is validated with the same data in order to check whether the built model is capable enough to predict the actual values of the outcome, pressure indice. R-Squared value and MSE were found as 0.917785 and 0.006935 respectively. These results prove that the model is strong enough to predict the values of outome. Figure 3 in Appendix shows the plot between the actual and trained pressure indice at validation phase. The blue points represent the actual, and the red points represent the predicted indice. The performance of the model at validation phase proves that the model can predict the pressure indice, namely the existence or non-existence of the crises almost accurately.

Concluding Remarks

Financial crises, whatever their types are, have been on the agenda of many economists for nearly three decades. Because they leave destructive affects on the social and economic structures of the countries. As a result of the studies, empirical and theoretical, to gain an insight into the nature of financial crises, many theories and models have been suggested. Artificial Neural Network is one of those empirical analysis tools that could be used. In this study, ANN was used to analyze the economic reasons of November 2000 and February 2001 Turkish financial crises. The inputs and output were determined by making use of the leading indicators of financial crisis models, and some empirical analyses related to the Turkish financial crises of interest. The variables found significant in the empirical analyses were added to our study. The time interval, January of 1996 and December of 2003, was selected on purpose to analyze the Turkish crisis in the early 2000's particularly. If the time interval had been determined longer, it would have been improper to mention about the economic causes of the crisis in question due to the inclusion of causes of the Turkish financial crisis in 1994.

To the results at learning and validation phases, a strong model is built to find out the explanatory variables of November 2000 and February 2001 financial crises. Because the R-squared values of the model at training/learning and validation phases are 0.966431 and 0.917785 respectively. Besides, MSE values are 0.002832 and 0.006935. Moreover, the plots in figure 1 and 3 also prove the power of the model. It is concluded that the trained network model is a good fit to explain the reasons of the financial crises in question. In addition, it is inferred that the input of domestic credit amount played the greatest role in the crises in question whereas the input of Current Account Balance/ Gross Domestic Product played the smallest.

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Appendix

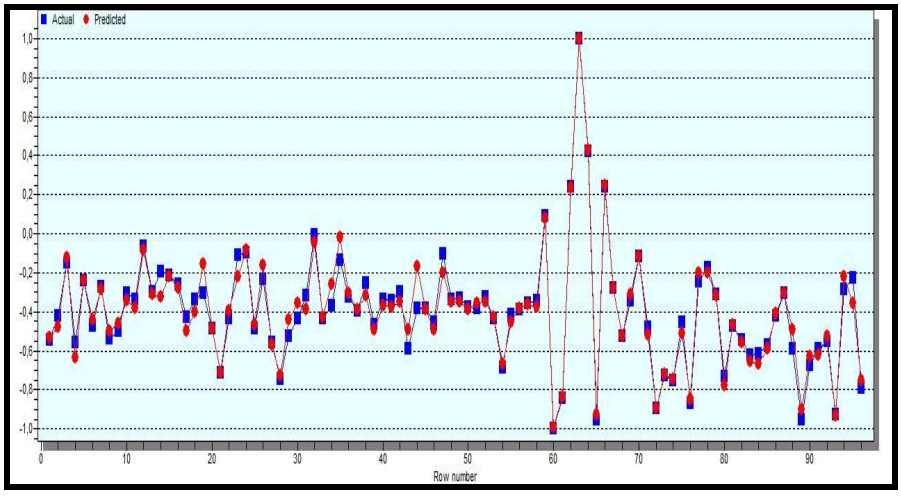

Figure 1: Actual and Predicted Values at Training/Learning Phase

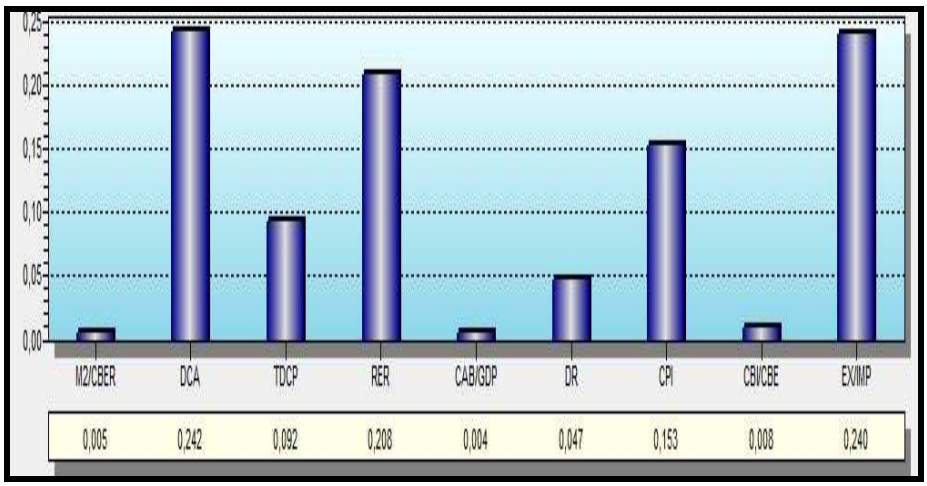

Figure 2: Importance of Inputs at Training/Learning Phase

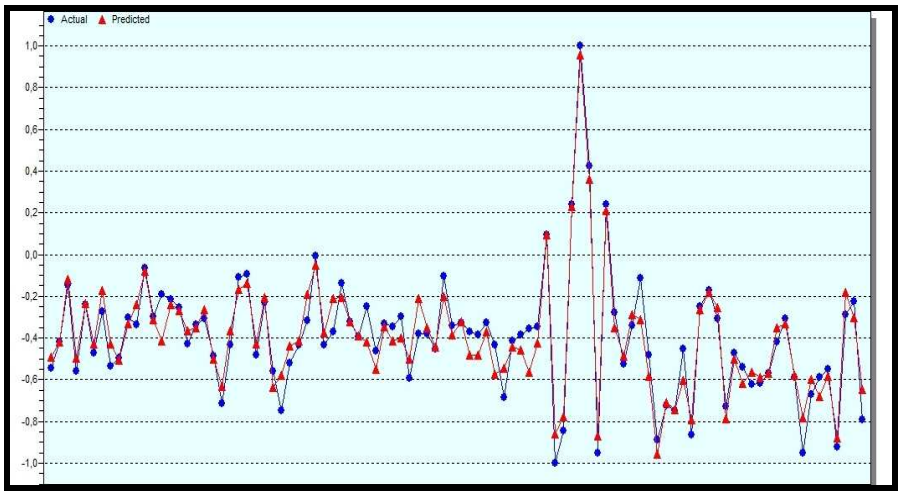

Figure 3: Actual and Predicted Values at Validation Phase