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# Money Supply and Inflation Relationship in the Turkish Economy

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**Abstract:** The relationship degree between money supply and inflation is one of the important element in macroeconomic policy as governments try to control inflation. In this study, this relationship and its inflation forecasting potential is investigated for the Turkish Economy. The multilayer perceptron neural network model is constructed for the monthly data set from 1996:2 to 2006:1. Broad money supply plus foreign demand deposits (M2Y), seasonal dummy, time trend dummy and previous inflation (auto-regressive term) are used as input variables and inflation is used as output variable of the model. Sensitivity analysis is applied to discover the cause and effect relationship between input and output variables. Results show that the model predicts the level of the inflation with a reasonably good degree of accuracy.

**Key words:** Money supply, inflation, forecasting, neural network

## INTRODUCTION

Forecasting or announcing a target range for the inflation rate for some predefined period of time serves as important guidelines for the private and public sector. If economic players can predict future changes in inflation rates, they can allocate their resources more efficiently. In order to so, many developed and developing economies have move to policy of formal inflation targeting regime during the last decade. Central Bank of Turkey announced that it would move to formal inflation targeting in January 2005.

This growing adoption of an inflation targeting framework continues to encourage economists to search out methods of accurately forecasting inflation. Because, central banks adopting an inflation targeting regime must be able to generate reasonably accurate forecasts of future inflation. In order to be successful in this regime, understanding and measuring the significance of the determinants of inflation are important.

One of the determinants of future inflation is money supply. If there is a stable relationship between money supply and inflation, money supply can be used as an indicator for future inflation.

Although the reported relationships between money and inflation in Turkey and other countries vary from one study to another, there is a consensus about the role of money supply growth either as the main driving force behind inflation or as a necessary element in accommodating inflation triggered by other factors.

In the context of studies on the Turkish Economy, recognizing the differences in their sample periods and data frequencies, there are conflicting results in identifying the relationships among budget deficits, money supply and inflation (Cavusoglu, 2003).

Lim and Papi (1997), using multi-sector macroeconomic model, found that money supply growth plays a central role in the inflationary process in Turkey for the period from 1970 to 1995. Exchange rates and inertial factors are important and public sector deficits are found to have an important direct effect on inflation.

Gazely and Binner (2000) investigate money-inflation link for USA, UK and Italian economies using quarterly data from 1980:1 to 1996:1. The results show that The application of neural network methodology to examine the money-inflation link is highly experimental in nature and, hence, the overriding feature of this research is one of simplicity. In the study, superior inflation forecasting models are achieved when a Divisia M2 measure of money is used in the majority of cases.

Kibritcioglu (2001) surveys the existing empirical studies on Turkey's inflation up to 1998, considering their sample period, empirical methods, modeled macroeconomic variables and main results.

Altimari (2001) investigates the properties of monetary and credit aggregates as indicators for future price developments in the euro area. He uses linear bivariate and multivariate models for the quarterly data from 1980:1 to 2000:2. The results support the idea that monetary and credit aggregates provide significant and independent information for future price developments in the euro area, especially at medium term horizons.

Dibooglu and Kibritcioglu (2004) study output and inflation in Turkey in the last two decades (quarterly data

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from 1980:1 to 2002:3) using a dynamic aggregate supply and aggregate demand model with imperfect capital mobility and structural Vector Autoregressions. Empirical results show that terms of trade, monetary and balance of payments shocks figure prominently in the inflationary process.

Us (2004) analyzes the dynamics of inflation in the Turkish Economy, using monthly data from 1990:01 to 2002:04. By conducting a Vector Autoregression analysis, variance decomposition and the impulse response functions. The results show that inertial inflation is not a monetary phenomenon in Turkey, but rather an outcome of a political misconduct, which therefore shows the fiscal dominance.

Sahin *et al*. (2004) investigate driving forces of inflation in Turkey developing an artificial neural network model using monthly data from 1994:1 to 1998:12. In the study; interest rate, exchange rate, money stock, short-term capital flow, wages, capacity utilization ratio, public sector debt, budget deficit, employment, net foreign assets, devaluation and inflation expectations are used as input variables and inflation is used as the output variable of the model. The results show that the most important driving forces are devaluation, inflation expectation, wages and budget deficit.

Grauwe and Polan (2005), using a sample of about 160 countries over the last 30 years, find that a strong positive relation between long-run inflation and the money growth rate. According to results of the study, the relation is not proportional, however. The strong link between inflation and money growth is almost wholly due to the presence of high inflation countries in the sample. The relationship between inflation and money growth for low-inflation countries is weak.

## MATERIALS AND METHODS

In this study, growth rates of M2Y (broad money supply plus foreign demand deposits) is used as monetary aggregates. M2Y monthly series data were obtained from Central Bank of Turkey. Monthly growth rates of WPI (whole price index) is used as inflation variable. Monthly WPI data were obtained from Turkish Statistical Institute. M2Y and WPI series data from December 1995 to January 2006 yielded 120 monthly sample after catering a one month time lag and calculating the increase rates of money supply and inflation. Historical data are randomly divided into two parts; 100 rows for training set and 20 rows for testing set.

Multilayer perceptron (MLP) neural network model is developed for the monthly data set to analise the relationship money supply and inflation. Developed network is fully connected. In other words, there are connections between every node of one layer and every node of the next layer. The multilayer perceptron (MLP) is one of the most widely implemented neural network topologies (Lippman, 1987).

**The model:**

$$P_t = f\,(P_{t-1}, M_{t-1}, S, T)$$

which takes inflation in the current month to be a function of four elements:

$P_t$ : Inflation rate in the current month (monthly growth rate of WPI).
$P_{t-1}$ : Inflation rate of previous month, an auto-regressive term.
$M_{t-1}$ : M2Y growth rate of previous month.
S : Seasonal dummy variable (from 1 to 4).
T : Time (from 1 to 120)

One of the reason of the fluctuation of the inflation rates in Turkey is seasonal factors. So, seasonal dummies are included as input variables to the model. Seasonal dummy variables are as follows:

- September, October, November.
- December, January, February.
- March, April, May.
- June, July, August.

Time variable is also included to the model in order to explain the external factors affecting the inflation.

Some experiments are carried out to find the best configuration of the neural network. The size of the Mean Square Error (MSE) is used to determine how well the network output fits the desired output. The selected model contains one hidden layer with three neorons. Thus, the network configuration used in this study contains one input layer with four neurons, one hidden layer with three neurons and one output layer with one neurons (Fig. 1). Hyperbolic tangent activation function, which is most widely used with MLP networks, is used in the model.

In this model, the relationship between inputs and output, however, need not be direct. In the relationship between money supply growth rates and inflation, for example, one can argue that there are most likely several intermediate variables in the transmission from money supply rates to inflation changes. Money supply growth rate changes can first affect interest rate, exchange rates, consumption and ultimately inflation. In neural network models, these intermediate stages can be captured by neurons in the hidden layers.

The network is trained 20,000 iterations with training data set using Neuro Solutions software. The testing set is used to test the performance of the network. After the network is trained the weights are then frozen, the testing set is fed into the network and the network output is compared with the desired output.

Mean-squared Error (MSE), Normalized Mean-squared Error (NMSE), Mean Absolute Error (MAE), minimum absolute error, maximum absolute error and correlation coefficient (r) values are used to express within-sample (training data set) and out-of sample (testing data set) performances of the model.

Sensitivity tests are applied to discover the cause and effect relationship between input and output variables. This testing process provides a measure of the relative importance among the inputs of the neural model and illustrates how the model output varies in response to variation of an input. The first input is varied between its mean a defined number of standard deviations while all other inputs are fixed at their respective means. The network output is computed for a defined number of steps above and below the mean. This process is repeated for each input. As a result, the variation of output with respect to the variation in each input is found.

## RESULTS AND DISCUSSION

Performance results of training and testing data are shown in Table 1. Correlation coefficient for training data and testing data are 0.9055 and 0.8961, respectively. This means that generalization capacity of the model is almost perfect, but the performance of the model is reasonably good.

Comparison of the model results versus the actual values are shown in Fig. 1 for training data and in Fig. 2 for testing data. In Fig. 1, y-axis values are inflation rate and x-axis values are training data (100 rows). In Fig. 2, y-axis values are inflation rate and x-axis values are testing data (20 rows). Mean-squared error term for training data and testing data are 1.1975 and 0.7226, respectively.

Summary results of the sensitivity analysis, given in Table 2 and Fig. 3, show that the contribution of each input to the output value. The reaction of the inflation to different input variations for each input are illustrated in Fig. 4-7.

As shown in Fig. 3, seasonal dummy variable has the most significant influence on inflation rate. While seasonal dummy value increases, inflation rate gradually decreases from autumn to summer (Fig. 5). The main factor

Table 1: Performance results of the model

| | Inflation rate (P) | |
|---|---|---|
| | Training | Test |
| Mean-Squared Error (MSE) | 1.1975 | 0.7226 |
| Normalized Mean-Squared Error (NMSE) | 0.1800 | 0.2180 |
| Mean Absolute Error (MAE) | 0.8874 | 0.6558 |
| Minimum absolute error | 0.0089 | 0.0292 |
| Maximum absolute error | 3.2164 | 1.5925 |
| Correlation coefficient (r) | 0.9055 | 0.8961 |

Table 2: Sensitivity results of the model

| Input variables | Inflation rate |
|---|---|
| Inflation rate in the current month ($P_{t-1}$) | 0.3187 |
| Seasonal dummy variable (S) | 0.4725 |
| M2Y growth rate of previous month ($M_{t-1}$) | 0.1112 |
| Time (T) | 0.0109 |

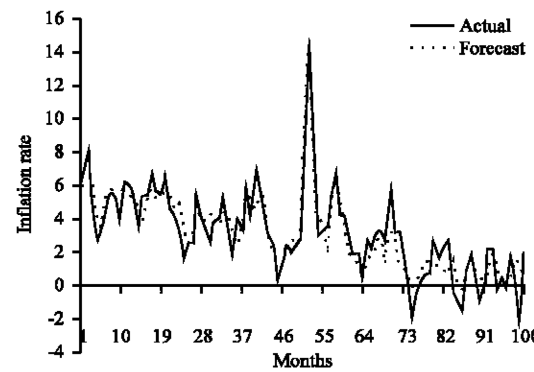


Fig. 1: Comparison of the model results versus the training data

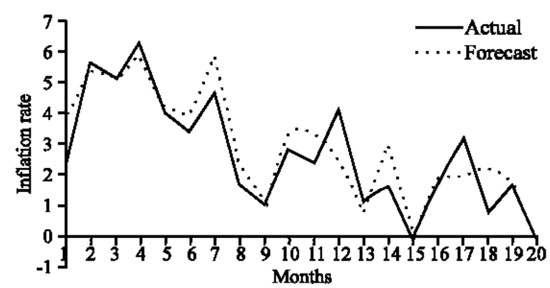


Fig. 2: Comparison of the model results of testing data

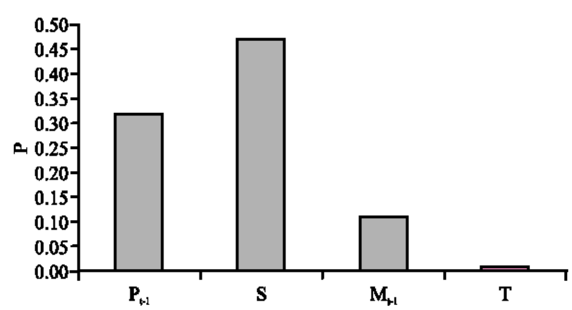


Fig. 3: Sensitivity results of the model

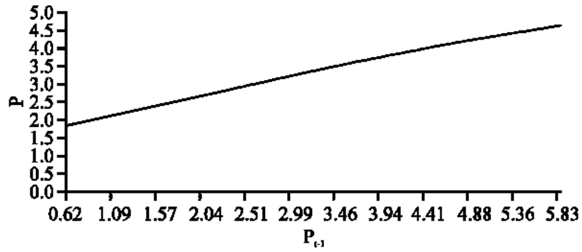


Fig. 4: Network inflation rate for varied previous inflation rates ($P_{t-1}$)

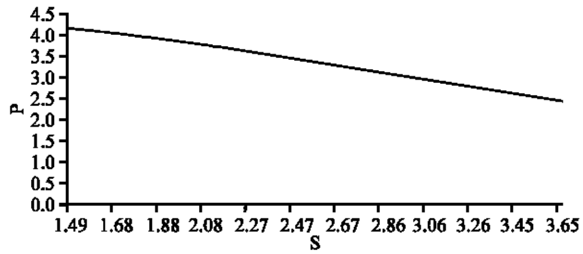


Fig. 5: Network inflation rate for varied season (S)

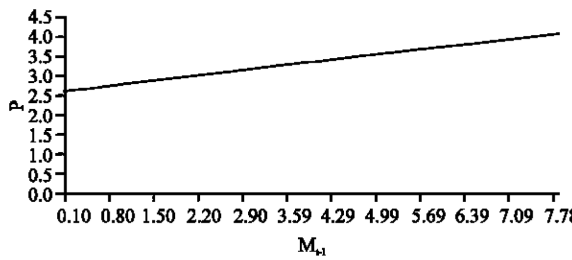


Fig. 6: Network inflation rate for varied money supply ($M_{t-1}$)

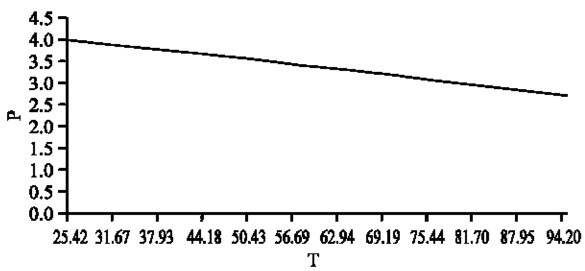


Fig. 7: Network inflation rate for varied time (T)

for this result must be due to the decreases in agricultural products' prices from autumn to summer season in Turkey.

Inflation rate of previous month is the second significant input variable in order of sensitivity. This autoregressive inflation term has a significant influence on inflation rate. From Fig. 3 and 4, we can infer that the inflationary process in Turkey has significant inertia for the sample period.

Money supply growth rate of previous month is the third significant variable relatively other input variables in the model. Money supply growth has a positive relationship to inflation (Fig. 6). If we ignore the seasonal dummy variable, money supply significantly improves the forecasting capabilities of the model.

The least significant input variable is the time trend. The dummy input variable time has an inverse relationship to inflation (Fig. 7). The variance of the time variable explains only a small portion of the variance in inflation. From start of the sample period to end, inflation gradually decreases. This result means that the other factors, which are depends to time and not included to the model, have put downward pressure on inflation over the sample period.

## CONCLUSIONS

In this study, a simple neural network model is constructed for the monthly data from 1996:2 to 2006:1 to forecast the monthly inflation rate for the Turkish Economy. According to the model, current inflation is a function of growth rate of money supply (M2Y) of previous month, inflation rate of previous month, seasonal factors and time trend variable. Simple and constant designs were chosen specifically to evaluate the information content of the money supply to forecast monthly inflation rate.

Our empirical results show that the model predicts the level of the inflation with a reasonably good degree of accuracy. Money supply growth has considerable impact on inflation rate in the Turkish Economy over the period ranges from 1996 to 2006. Seasonal factors are the most significant influence on inflation rate compared to other input variables in the model. Another important finding of this study, effects to inflation from itself have the most significant influence, suggesting that the inflationary process in Turkey has significant inertia. Another input variable in the model is the time trend which has the least and very small impact on inflation compared to other variables.

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