Economic Variable Forecasting Using Artificial Neural Network: A Case Study in Turkey

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Abstract: Since financial and economic time series are nonlinear, neural networks can be efficiently used in the financial and economic time series forecasting. In this paper we used machine learning technique for data mining to evaluate the predictive relationships of economic variables of Turkey. Neural network models are examined for their capability to provide an efficient forecast of future values. For illustration and confirmation purposes, the proposed model is conducted on typical economic time series. Empirical results obtained show that the proposed neural-network-based nonlinear modeling technique is a very promising approach to economic time series forecasting.

Keywords: ANN, Turkey, Economic time series forecasting.

1.   Introduction

Several factors impact financial markets, including political events, general economic circumstances, and even traders' expectations. Due to the high degrees of irregularity and nonlinearity, financial and economic time series forecasting is regarded as a rather challenging task (Lai/Yu/Wang/Zhou, 2006; Yu/Wang/Lai, 2005; Yu//Lai, 2009). The non-stationary characteristic of financial and economic time series implies that the distribution of these time series is changing over time. As a result, for traditional linear models such as autoregressive integrated moving average (ARIMA), it is very complicated to capture the irregularity and nonlinearity hidden in financial and economic time series. Recently, artificial neural Networks (ANNs) were effectively used in financial and economic time series modeling and forecasting (Yu/Wang/Lai, 2005; Yu//Lai, 2009; Yu,Wang/Lai 2007; Cheng/Wanger/Lin 1996; Sharda/Patil 1994; Van/Robert 1997; Kaastra/Milton 1995; Francis/Lijuan 2001). Unlike traditional statistical models, neural networks are data-driven, non-parametric models. Therefore, neural networks are less vulnerable to the problem of model misspecification as compared to most of the parametric models. As a result, if compared to traditional statistical models, neural networks are more efficient in describing the dynamics of financial and economic time series Francis/Lijuan 2001; Zhang/Michael 1998; Chiang/Urban/Baildridge 1996). Actually, neural networks suggest a novel technique that does not necessitate a pre-specification during the modeling procedure because they independently learn the relationship inherent in the variables. Moreover neural networks suggest the flexibility of several architecture types, learning algorithms, and validation procedures (Enke/Thawornwong 2005).

With the increasing globalization process and technological improvement in the information technology sector the movement of factors over the globe raises. Technology, capital stock and labor force is the factor that determines economic output, according to the literature on growth (Jones 1997). Without any doubt, there exist a considerable gap between developing and developed countries when qualified labor force, technology advance and capital stock as well is considered. Consequently the immense gap between the annual output levels of developed and developing countries are assigned to the differences in these factors. For developing countries it is much more exhaustive to meet the very expensive Research and Development activities. Researchers have long been concerned with the underlying data-generating process for key macroeconomic variables such as GNP, GDP and inflation. There have been various macroeconomic time-series studies based on ANN models. In these models, one set of parameters governs the evolution of the dependent variable. In this work, we used a neural network approach for the prediction of gross national product (GNP) of TURKEY. Hence we will briefly review and discuss the economic structure of Turkey in the next section. In section three, we will briefly review and discuss the artificial neural network (ANN) model. The resulting data selection and model development, empirical results, and conclusion will then be presented, respectively.

2. Economic Development of Turkey

The flows of factors of production over the globe increases with the ongoing globalization process and additional improvements of the information technology. Technology, capital stock and labor force is the factor that determines Economic output according to the literature on growth. (Jones 1997) Without any doubt, there exist a considerable gap between developing and developed countries when qualified labor force, advanced technological utilities and capital stock as well is considered. It can be concluded that the immense gap between the annual output levels of developed and developing countries are assigned to the differences in these factors.

An increased allowance of less developed countries to the liberalization policies of the early 80s was an important matter for policy makers to integrate their own economy in the world. A rough division of the Turkish economic history can be seen from the perspective of macroeconomic reorientation from the import-led industrialization to trade liberalization and export oriented growth strategy dominated up to the 1980s. According to various influential factors in the history Turkey had put many barriers in front of international trade and investment and devoted herself to state-controlled enterprises before 1980s. Growth was based for a long-term on import strategy. After suffered economic disruptions the National Committee of the State Planning Unit has been established as a constitutional institution. With the five-year plans between 1963 - 1980 developing plans were that both the State as well as from the private sector constructive impulses of the Turkish economy should be accompanied (Mixed Economy). In order to control the high inflation, rising unemployment numbers, political violence the Government announced on 24.01.1980, with the support of international financial and economic organizations, the start of the necessary fundamental economical, legal and institutional change to strengthening the integration of Turkey into the global economy. (Ekinci 1990, Kepenek/Yentürk 1997, Metin-Ozcan/Voyoda/Yeldan 2001; Alici/Ucal 2003)

In the 80s began the liberalization of trade and financial deregulation, where the control of capital flows repealed and the Turkish currency from this time was fully convertible. In 1996 the customs union with the European Union continued. With the more integration Turkey's economy to the global capital and financial markets their serious consequences was felt in Turkey during the crisis in 1999. Following the two crises in 1991 and 1994 the macroeconomic environment, forced the government towards the end of 1999 to implement a stabilization program with the intention to reduce the rate of inflation, the real interest rate and the debt stock of Turkey. As a result of the 1994 crisis, the more expensive imported goods resulting from the nominal depreciation and the high short-term interest rates decreased the industrial production having an impact on the economic output. (Celasun 1994; Celasun/Denizer/He 1999) Hence the economic performance broke again with the crisis in 1991 and 1994.

Due to a dispute between the then Prime Minister Ecevit and President Sezer in February 2001 a new crisis sparked in Turkey. The main challenge for the government was the restore of macroeconomic balance subject to reduce inflation and sustained economic growth. With the launch of the new economic stabilization program after the 2001 crisis the positive trend continues. 2002 and 2003 were the years of economic recovery from the crisis of 2001. So far Turkey lacks low confidence, weak governance and informal sector in the past that prevented sustainable economic growth (OECD, Policy Brief: Economic Survey of Turkey 2004, October) with the retrieval of economic stability the focus was set on sustainable economic growth. After the short-lived coalition governments and coalition governments a single party government came to power with the 2004 elections. Political stability was obtained and provided huge external support as well as positive affects of the EU reforms economic stability has been further reinforced

Turkey is still in comparison to most existing EU members very weak, but is also dynamic. Since 2002 Turkey has had a robust economic growth. Investments (both private and public), industrial production as well as degree of capacity utilization have been increased during the time period between 2001-2007 as well. By closer contemplation there is a relationship between industrial production and economic growth. Foreign Direct investments can be quoted as another determinant that affected economic growth. (Alici/Ucal 2003) FDI plays a serious role in the development of closing the gap with industrialized nations (catch up) and the alignment with EU standards (convergence). Overall after the first crisis in Turkey there was a shift from the mainly public economy to the private sector's which put focus on effort to increase the efficiency in order to remain global competitive.

3. Artificial Neural Network (ANN) Model

The multilayer perceptron network is the most commonly used neural network in economic and financial time series modeling. In general, the network represents the way the human brain processes input sensory data, received as input neurons, into recognition as an output neuron. The interconnected neurons generate expectations or forecasts which lead to reactions and decisions in financial data. Mainly, actions come from forecasts based on the parallel processing of interconnected neurons (McNelis 2005). The input variables are fed into a layer of units making up the input layer for each training sample. The weighted outputs of these

units are then fed to a hidden layer. The weight outputs of the hidden layer are input to units making up the output layer which issues the network's prediction for a given set of samples. Back propagation is the most popular neural network algorithm. It is a method for assigning responsibility for mismatches to each of the processing elements in the network by propagating the gradient of the activation function back through the network to each hidden layer down to the first hidden layer. The weights are then modified so as to minimize the mean squared error between the network's prediction and the actual target (Enke/Thawornwong 2005).

4. Results and Discussion

The main objective of this study was to investigate the applicability of the ANN technique in the prediction of GNP time series. The selection of the input variables is a modeling decision that can significantly influence the model performance. In the neural network situation, the information gain data mining analysis was used to find good subsets of the full set of the first-period input variables. Thus, overall balance, foreign direct investment, gross fixed investment, labor force and gross national product (GNP) variables were consistently used as the input variables for training the neural networks throughout the modeling phase. The values of the input variables were first preprocessed by normalizing them to decrease the effect of magnitude between the inputs and thus increase the effectiveness of the learning algorithm. It is well known that most trading practices implemented by financial analysts rely on precise prediction of the financial instruments. After many experiments with various numbers of hidden layer neurons, learning algorithms, and learning rates, the feed-forward neural network employing 5 neurons in the input-layer, 10 neurons in the hidden layer, 0.05 learning rate, and a gradient descent back propagation training algorithm was found to be the best network architecture based on the lowest average root-mean squared error. ANN training is not firm since the training process may depend on the choice of a random start. Training is also computationally expensive in terms of the training times used to determine the appropriate network structure. The degree of success, therefore, may fluctuate from one training pass to another.

The focus of this section of the paper was to examine and discuss the results obtained from the ANN model. In this model, five basic economic variables were presented in the network as input parameters to determine the relationship between GNP properties and parameter. In order to develop an ANN model, the input parameters were also individually excluded from the input parameters. As previously mentioned, developed ANN models were tested by data sets from the State Planning Organization, which were not employed in the training stage. To evaluate how accurate the result of the developed ANN model is, the coefficient of correlation (R^2) was used as statistical verification tools. Estimated values were graphically compared with the actual values as in Figure1. As can be seen, the ANN models were found to be able to learn the relationship between the input parameters overall balance, foreign direct investment, gross fixed investment, laborforce and gross national product (GNP). Figure 2 gives the statistical performance of the ANN model. It appears that there is a relatively good agreement between the ANN predictions and the actual data. This can be interpreted from the R^2 value 0.976. R^2 value of the model reflects the overall error performance of the model. One can clearly see that ANN model gives good correlation between the estimated and real GNP values. Consequently, when the results in figures are evaluated, it can be concluded that ANN models can be used for the prediction of GNP.

The predictive performance of the developed model was estimated using the untouched out-of-sample (testing) data. This is due to the fact that the superior in sample performance does not always guarantee the validity of the forecasting accuracy. One possible approach for evaluating the forecasting performance is to investigate whether traditional error measure such as correlation coefficient (R^2) between the actual out-of sample returns and their predicted values are small or highly correlate, respectively. Hence, the prediction of the forecasting model must be adjusted for unbiased performance comparisons. The empirical results show that ANN can accurately estimate GNP because of the high correlation (R^2) relationship. This is due to the fact that the correlation (R^2) of these models indicates higher positive relationship between the actual and predicted values of GNP. The findings strongly support the non-linearity relationship between the past economic variables.

5. Conclusions

In this study we investigate the predictive power of economic variables by using ANN as machine learning technique for data mining. The study has focused on input data, forecasting methodology and measures used for performance evaluation. This approach seems suitable in selecting the variables when the usefulness of the data is unknown, especially when nonlinearity exists in the economic variables as found in this study. The observation is that neural networks model is suitable for GNP forecasting. ANN gives better results as trading systems and higher forecasting accuracy.

In conclusion, both researchers and practitioners have studied financial and economic time series prediction for many years. Many studies conclude that some economic variables can be predicted by using

ANN. To this end, our finding suggests that economic forecasting is always and will remain difficult since such data are greatly influenced by economical, financial, political, international, and even natural events. Obviously, this study covers only fundamental available information, while the technical analysis approach remains intact.

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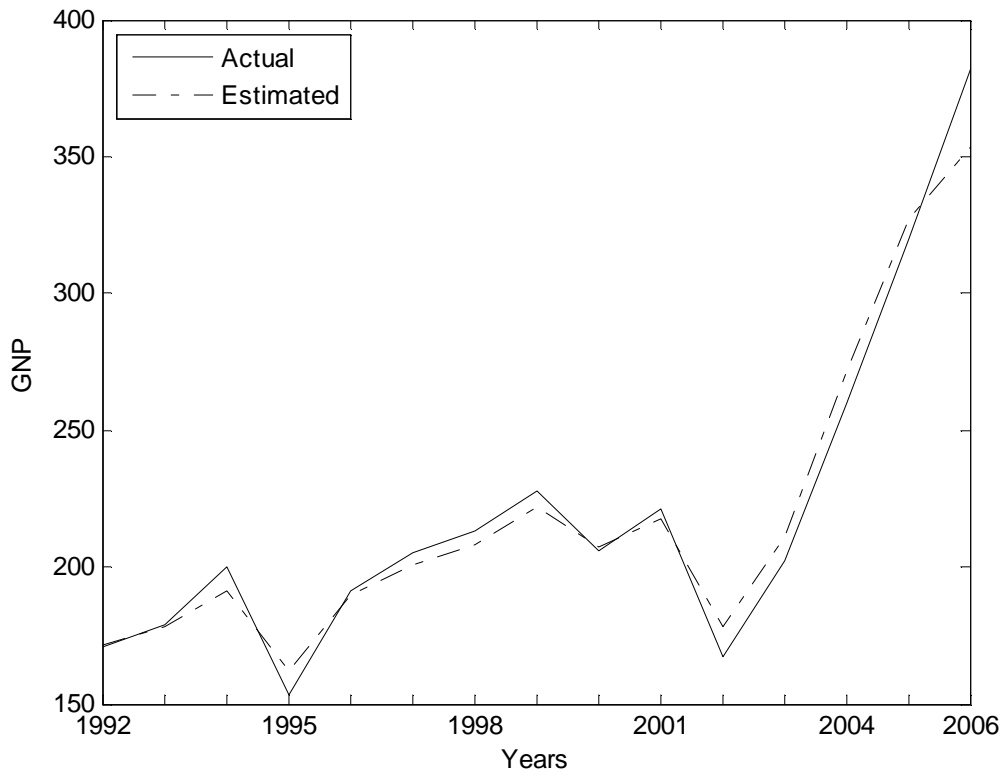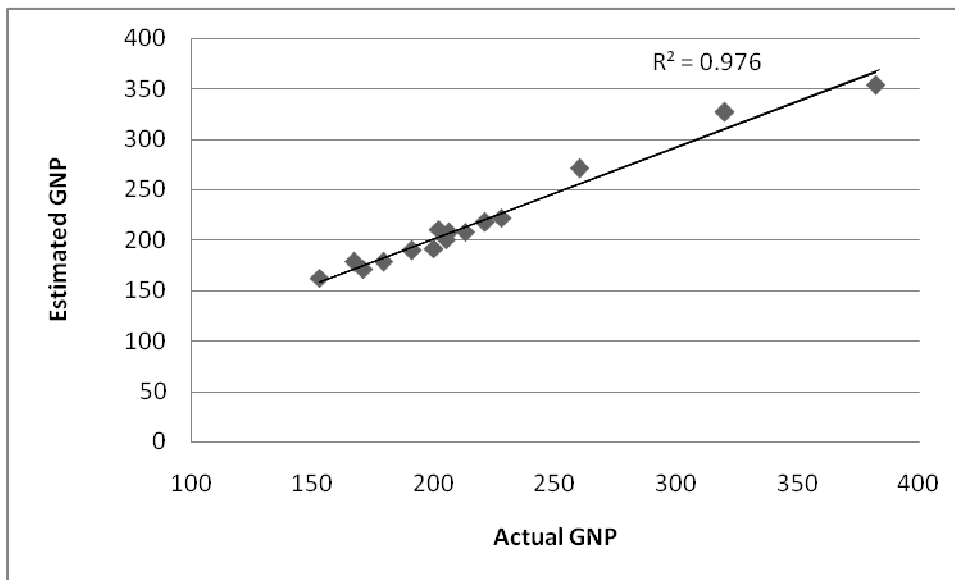**Figure 1.** Comparison of actual values with the results obtained from the ANN model

Figure 2. Performance of ANN model for testing dataset.