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Comparing the forecasting performance of neural network and purchasing power parity: The case of Turkey

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ABSTRACT

Investors consider foreign exchange as being among the most significant financial markets. Many discussions regarding economic development, growth strategies and stabilization policies place real exchange rate to play the most important role in the macroeconomic adjustment mechanism. This study compares a structural model and a statistical model, namely, purchasing power parity and artificial neural network models respectively, for the long term forecasting of exchange rates. Monthly data sets for the US dollar during the period of 1986–2010 and euro during the period of 1999–2010 are used. ANN has been confirmed as an effective tool in forecasting exchange rates through the evaluation of the empirical results. A possibility of extracting hidden information from the exchange rates and using this information to predict the future has been investigated by this technique. The average behavior of the above stated loss functions are estimated to form the basis for evaluating the proposed model.

1. Introduction

Investors consider foreign exchange as being among the most significant financial markets. Nevertheless, the rapid changes in exchange rate over short periods of time in addition to possessing a highly volatile structure make this market an option for which the investors or the hedgers yearn for the determination of effective methods that evaluate the dynamic tendency of the changes and thereby reduce the risk (Chen et al., 2008). The efforts for improving currency forecast accuracy have been catalyzed by this property of the foreign exchange market which is being extremely volatile (Shady and Shazly, 1997). A still important issue that requires improvement is the exchange rate forecasting accuracy even though many financial models, which attempted to explain and analyze the exchange rate behavior have been presented (Thaski, 2004; Yu, 2004). The non-linear structure of the exchange rate behavior has been reported in many research studies. Therefore, the conventional methods utilizing statistical and economical approaches would not be used properly to present forecasts of the exchange rate (Chen and Wu, 2000; Chen et al., 2008; Ma and Kanas, 2000; Pippenger and Geppert, 1997). Several techniques including the purchasing power parity (PPP), interest rate parity, flexibility approach, income–expenditure approach, Mundell–Fleming approach, monetary approach, portfolio balance approach and the balance of payments approach have been proposed for predicting exchange rates.

The use of the economic theory is also encountered in the provision of a benchmark for the evaluation of the exchange rate level in the context of the policy discussions. The basis of this approach is that the theory assumes same or similar purchasing powers for the currencies of different countries. The worth of the currency for purchasing goods and services can be defined as the purchasing power parity (PPP). The fluctuations in the prices of the goods and the services lead to corresponding fluctuations in the value of a currency as indicated by the PPP theory. For that reason, the relative value of two currencies would be defined as the exchange rate (Hallwood and Macdonald, 1986). The studies on PPP have been uninterruptedly continued by many researchers although the outcome of these studies presented conflicting results since PPP has been a significant foundation for many exchange rate models as well as being an equilibrium exchange rate equation and a reference for policy making decisions (Arize et al., 2010; Cheung and Lai, 1993a). There are many notorious discussions being held for the validity of PPP in the long run even though in the short run deviations from PPP have been reported in many studies. For instance, the notion that in the long run the PPP is valid since the real exchange rate follows closely a random walk has been proposed by Cheung and Lai (1993b), Cheung et al. (2004) and Johansen and Juselius (1992). On the contrary, the long run PPP is evidenced against by Cushman (2008), Serletis and Zimonopoulos (1997) and Crowder (1996) as not supporting the previous notion.

ANN models have found many important applications in financial modeling and forecasting in the recent literature. Some researchers investigated the use of ANN for forecasting financial and economic time series (Elçin et al., 2010; Kryzanowski et al., 1993; Refenes et al., 1995; Zhu et al., 2008). Artificial intelligence is an emerging approach to forecast exchange rate and can achieve acceptable results. Most researchers apply a genetic algorithm or neural network on

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technical analysis or on fundamental analysis to develop forecasting models (Lisi and Schiavo, 1999; Majhi et al., 2009; Zhang, 2003; Zhang et al., 1998).

The organization and the functioning of the biological neurons have set the motivation for the construction of artificial neural networks implemented as mathematical models. The nature of the specific task that the network is assigned to perform would determine which network variation would be selected among the numerous artificial neural network (ANN) variations. It is able to perform the approximation characterizing the most suitable functional form. Artificial neural networks may be categorized as being multivariate, nonlinear, nonparametric, data driven and model free techniques of inference (Azoff, 1994). The term 'multivariate' in the definition corresponds to the input values possessing a multi-variable containing nature and these causality effects as well as the interdependences between these variables constitute the specific property that makes these networks usable in the future value prediction.

The paper is organized as follows: Section 2 describes the data and the exchange models, Section 3 displays the empirical result and the discussion, and Section 4 comprises of a conclusion regarding a comparative study of the ANN and the PPP models for the exchange rate forecasting. In this study PPP and ANN methods are employed to forecast the foreign exchange rate of the US dollar and Euro in Turkey. This study provides a comparison of the forecasting powers of the two approaches.

2. Model specification and methodology

2.1. Data collection

In this study, the monthly data in Turkey on the US dollar between the 1985 and 2010 period and on Euro between the 1999 and 2010 period are used. According to the PPP model, the "consumer price index" was employed, which is used to determine the long-term equilibrium exchange rate by establishing a direct relationship between prices and the exchange rate. The native country consumer price index and the foreign country consumer price indices (USD and EU) are used in forecasting the exchange rate. All consumer price index series were analyzed after trend effects were removed. The data regarding the variables are obtained from the International Financial Statistics (IFS) internet database.

2.2. The PPP model

The PPP theory is the least recent and the most straightforward model that has been developed to explain the exchange rate phenomenon. Gustav Cassel (Officer, 1976) is the first person to develop, implement and empirically test the theory. In addition to being considered as an equilibrium condition, an efficient arbitrage condition in goods or assets, and a theory of exchange rate determination, the international comparison of income and expenditures has also been carried out by considering the PPP as a basis (Dornbusch, 1987; Frenkel, 1976a,b, 1978; Helmers, 1990; Isard, 1987; Officer, 1976; Summers and Heston, 1991). The notion that the currency of different countries possesses the same or similar purchasing powers forms the foundation for the theory. The value of the currency to buy goods and services is defined as the PPP. The changes in the prices of goods and services lead to changes in the value of a currency according to this theory. For this reason, the relative price of the currencies of two countries is the definition of the exchange rate (Hallwood and Macdonald, 1986).

Two different notions called the absolute and the relative PPP are used to explain the relationship between the exchange rates and the price levels in the PPP theory. According to the absolute PPP theory, the ratio of the general price levels of two nations equals the equilibrium exchange rates between two currencies and according to the relative PPP theory, the change in exchange rates is proportional to the relative price changes in the two nations (Frenkel, 1976b). The obstacle that no common index possessing the same weight for the same goods in all countries can be attained leads to the solution that the consumer price index (CPI) is used to indicate foreign and domestic price levels in the estimations carried out by the PPP theory. The absolute PPP can never lead to the exchange rate equilibrating the trade as it is not possible to assign the same weights to the same goods in two different countries (Officer, 1976). On the other hand, even under the conditions of high inflation, high monetary emissions and supply shocks, the relative PPP can largely explain exchange rate changes since the relationship between an exchange rate and the price level is modeled using the relative prices (inflation rates) in two countries (Enders, 1989). Therefore, the relative PPP estimations are carried out in this study rather than the absolute PPP estimations.

The relative PPP theory is modeled in many studies as shown below (Chen and Wu, 2000; Enders and Dibolu, 2004; Fritsche and Wallece, 1997; Officer, 1980; Xu, 2003):

$$e = b_o + b_1 p + b_2 p^* + u_{(1)} \tag{1}$$

where e is an exchange rate that refers to a domestic price of a foreign currency; p is a domestic inflation rate; p^* is a foreign inflation rate and u is a stationary error term. The coefficients of the model are expected to be, $b_1 = 1$ and $b_2 = -1$. It is expected that while an increase in the value of the domestic currency leads to a positive effect on exchange rate, an increase in the value of the foreign currency leads to a negative effect on exchange rate.

2.3. The ANN model

A number of neurons constitute a neural network (NN). These highly interconnected processing units are typically arranged into layers. The efficacy of the biological synapses taking part within the brain is simulated by each connection between these units and they each have an associated real valued weight. The feed-forward models allow the connections to proceed only in the forward direction and other connections between the units belonging to the same layer and feed-back connections are not allowed (Lisi and Schiavo, 1999).

The most widely used training algorithm for multi-layered feed-forward networks is the back-propagation (BP) algorithm. The BP algorithm basically involves two phases. The first one is the forward phase where the activations are propagated from the input towards the output layer. The second one is the backward phase where the error between the observed actual value and the desired nominal value in the output layer is propagated backwards in order to modify the weights and the bias values. The inputs and the outputs of the training and the testing sets must be initialized prior to the training of a feed work network. The artificial neural network (ANN) model is carried out by means of the following formulation.

$$y_t = G(w_t;\psi) = \beta_0 + \sum_{j=1}^{q} \beta_j \psi(y' w_t) + \upsilon_t \tag{2}$$

where $\beta = (\beta_1, \ldots \beta_q)'$, $\gamma_j = (\gamma_{j0}, \gamma_{j1}, \ldots \gamma_{j,k-1}, c_j)'$, and $j = 1 \ldots q$ is the number of input nodes; $w_t = (w_{1t}, w_{2t}, \ldots w_{kt}, 1)' = (y_{t-1}, y_{t-2}, \ldots y_{t-k}, 1)'$, υ_t is n.i.d. and $\psi(\gamma'_i w_t)$ is the sigmoid function defined as

$$\psi(y'_i w_t) = \frac{1}{1 + e^{-y_i w_t}}. \tag{3}$$

The network is trained by adjusting the weights and this process is carried out by making use of a large number of training sets implemented in many training cycles. The decision on an optimal set of weights that would provide the correct output for any input for the ideal case is aimed by the training procedure. The network