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Predicting exchange rates using a novel "cointegration based neuro-fuzzy system"

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ABSTRACT

The present study focuses upon the applications of currently available intelligence techniques to forecast exchange rates in short and long horizons. The predictability of exchange rate returns is investigated through the use of a novel cointegration-based neuro-fuzzy system, which is a combination of a cointegration technique; a Fuzzy Inference System; and Artificial Neural Networks. The Relative Price Monetary Model for exchange rate determination is used to determine the inputs, consisting of macroeconomic variables and the type of interactions amongst the variables, in order to develop the system. Considering exchange rate returns of three ASEAN countries (Malaysia, the Philippines and Singapore), our results reveal that the cointegration-based neuro-fuzzy system model consistently outperforms the Vector Error Correction Model by successfully forecasting exchange rate monthly returns with a high level of accuracy.

1. Introduction

The foreign exchange market is the largest and most liquid of financial markets. The issue of whether exchange rates are linear or non-linear remains controversial (Brooks, 1996; Satchell and Timmermann,

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1995; Zhang et al., 1998; Khashei et al., 2009; Zhang and Hu, 1998). However, empirical international finance literature demonstrates a growing interest in nonlinear models of exchange rate behavior (Clements and Yihui, 2010; Yu et al., 2005; Leung et al., 2000). Hence, efforts to predict exchange rates beyond monthly horizons remain a worthwhile endeavor. Forecast modeling continues to have great importance in the field of economics and is widely applied in various other fields.

Exchange rate return forecasting is a highly complicated and arduous task because many factors exist that may influence exchange rates, including relative price levels, balance of payments, interest rates, risk, real income, economic growth, government expenditure and other economic factors (Isard, 1980; Hopper, 1997; Kia, 2013). Furthermore, exchange rate series are generally nonlinear, dynamic, noisy, complicated, chaotic, and nonparametric in nature, as demonstrated in Yudong and Lenan (2009). The present study examines exchange rate predictions that are obtained using a cointegration-based neuro-fuzzy system. The predictions are premised upon data collected in regards to exchange rates in Malaysia, the Philippines and Singapore. In order to strengthen the constructed system and improve the output, the Relative Price Monetary Model (RPMM) (Balassa, 1964; Samuelson, 1964; Chinn, 1998) for exchange rate determination is used. The RPMM is tested using the Johansen–Juselius cointegration technique (J–J test) in order to determine the long-run relationship between the exchange rate series and the selected macroeconomic variables. The principal contribution of the present paper is a cohesive presentation and classification of soft computing techniques applied to selected ASEAN exchange rates that may be used for further analysis and evaluation; and future comparative studies. An obvious benefit of the present study is that the results obtained under the cointegration-based neuro-fuzzy system may offer additional information regarding market behavior. Exchange rate forecasters focus on developing approaches to successfully predict exchange rate prices with the ambit of maximizing profits. The success of a model utilized for the purpose of exchange rate prediction is effectively premised upon the accuracy of the results; the minimization of required inputs; and the reduction of the complexity of the model itself.

The *cointegration-based neuro-fuzzy system* developed in the present paper is constructed based upon the following procedure and techniques. First, the cointegration technique is implemented using RPMM to determine the long-run relationship among the variables, as well as the sign of long-run coefficients. Second, once the presence of cointegrating vectors is demonstrated, the sign of coefficients in the long-run equation is used to construct the fuzzy inference system (FIS). Finally, the generated fuzzy inference system produces the values required for the artificial neural network (ANN) to predict the exchange rate. Therefore, the present investigation can be distinguished from extant studies on two principal bases. First, in this paper, the neuro-fuzzy system is constructed based upon a cointegration approach, whereas neuro-fuzzy systems in extant studies are constructed without taking cointegration among the variables into account (Tahmasebi and Hezarkhani, 2010; Atsalakis and Valavanis, 2009b; Esfahanipour and Aghamiri, 2010; Boyacioglu and Avci, 2010; Liang et al., 2011). Second, the neuro-fuzzy system considered here is not adaptive since the rules do not change while the system is trained, unlike the commonly applied adaptive neuro-fuzzy inference system (ANFIS) where rules are adapted. Our empirical results indicate a unique cointegrating vector for all three currencies, as well as a significant improvement in prediction results using the *cointegration based neuro-fuzzy system*.

The remainder of the paper is organized as follows. Section 2 outlines the extant literature, while Section 3 introduces the basic theory underlying the cointegration approach, the FIS and ANNs. Section 4 describes the data, and our empirical findings are presented in Section 5. Section 6 concludes the paper.

2. Previous studies

The exchange rate forecastability puzzle suggests that macroeconomic fundamentals contain a negligible predictive content about the movements of nominal exchange rates. Since the seminal papers by Meese and Rogoff (1983a, 1983b) and numerous scholars have attempted to refine theoretical models or improve estimation techniques to explicate the puzzle (Mark, 1995; Manzan and Westerhoff, 2007; Sarmidi, 2010). However, the empirical evidence consistently fails to overturn this