International Journal of Economics and Finance; Vol. 5, No. 5; 2013
ISSN 1916-971X E-ISSN 1916-9728
Published by Canadian Center of Science and Education

Study on Correlation between Different NDF Data and Fluctuations of RMB Exchange Rate

Wang Nan[1] & Hou Tieshan[1]

[1] Department of Finance and Management, School of Economics, Dalian University of Technology, Dalian, Liaoning, China

Correspondence: Wang Nan, 551 Shao Xing Road No.18, Heping District, Shenyang Liaoning Province, China, 110003, China. Tel: 86-139-9834-0386. E-mail: nancy.22@163.com

Received: March 14, 2013 Accepted: March 28, 2013 Online Published: April 18, 2013

doi:10.5539/ijef.v5n5p55 URL: http://dx.doi.org/10.5539/ijef.v5n5p55

Abstract

Forecasting of exchange rate is a nonlinear problem. In this paper, we use Nonlinear Auto Regressive model which is named NARX for short with exogenous Inputs to forecast RMB exchange rate. Due to the selecting of external input X can influence the accuracy of forecasting, we choose non-deliverable forward exchange rate, which is known as NDF, to be X and achieved good results. There are many kinds of NDFs in different time spans, this paper contrasts the differences of network performance when using different NDFs as X, and get the result that the correlation of using different NDFs is not that big. We can always get very good result when using any time spans' NDF. And NDF is effective when using it to exchange rate forecasting.

Keywords: RMB exchange rate, forecasting, NDF, NARX

1. Introduction

Exchange rate forecasting is an important and challenging task for both academic researchers and business practitioners.

Theoretical and empirical research on exchange rate behavior is mainly carried out from two aspects: one is from the various factors that affecting exchange rate, looking for a relationship that exists between exchange rate and those factors; on the other hand, is from the exchange rate movement itself, for example, its stochastic nature as a time series.

It's a long history of research on macro structure model of exchange rate, but found the performances of these models are not satisfactory, since the implementation of floating exchange rate system in many advanced industrial countries after the collapse of the Bretton Woods system. Large magnitude and high frequency of exchange rate fluctuations in international foreign exchange market cannot be explained by these models. Therefore, some researchers turn to microstructure models, to analysis the actual behavior of market characteristics and market traders, such as Krugman and Miller (1992), Allen and Taylor (1992), Frankel and Froot (1990) etc.

Previous assessments of forecasting performance of exchange rate models have focused upon a narrow set of models typically of the 1970's vintage. The canonical papers in this literature are by Meese and Rogoff (1983, 1988), who examined monetary and portfolio balance models. Succeeding works by Mark (1995) and Chinn and Meese (1995) focused on similar models.

In recent twenty years, with the rapid development of computer hardware, and continuous improvement of econometrics theories, people can analysis historical data on economic and financial variables using econometric models. Researchers often use autoregressive time series models to simulate their movements. Some researchers also use this method for the study of exchange rate. For example, Michael, Nobay and Peel (1992), Sarantis (1999) and Taylor, Peel and Sarno (2000) use STAR model to do the research, Obstfeld and Taylor (2002), O'Connell, Pippenger and Goering (2000) use TAR model.

Neural networks have successfully been used for exchange rate forecasting. Hu (1998) examines the effects of the number of input and hidden nodes as well as the size of the training sample on the in-sample and out-of-sample performance using neural network. The British pound/US dollar is used for detailed examinations. It is found that neural networks outperform linear models, particularly when the forecast horizon is short. In

addition, the number of input nodes has a greater impact on performance than the number of hidden nodes, while a larger number of observations for reduce forecast errors.

Cheung and Chinn (2003) assessed the predictive capabilities of models developed during the 1990's systematically. And conclude that the answer to the question "Are Empirical Exchange Rate Models of the Nineties Fit to Survive?" is a bold "perhaps." That is, the results do not point to any given model/specification combination as being very successful. On the other hand, some models seem to do well at certain horizons, for certain criteria. And indeed, it may be that one model will do well for one exchange rate, and not for another.

Jamal and Sundar (2011) applied the neural network model to forecast bilateral exchange rates between the US and Germany and US and France. The predictions from the neural network model were compared to those based on a standard econometric model. Their results suggest that the neural network model may have some advantages when frequent short term forecasts are needed.

In China, Wei and Jiang first established the Mark/dollar exchange rate forecasting model using neural network method in 1995, the results shows that its accuracy of forecasting is higher than time series model.

2. Forecasting of NARX Network

Computing ability of recurrent neural network has been widely validated. Usually neural network's working process can be summed up as input data into neural network, compute after neural network being trained, and get calculating result which expressed by neural element through threshold function ultimately.

Nonlinear Auto Regressive models with exogenous inputs, which is known as NARX model for short, is an important kind of offline nonlinear system, it can be expressed as:

$$y(t+1) = f[y(t),y(t-1),\ldots, y(t-n_y+1),u(t),u(t-1),\ldots, u(t-n_u+1,W)]$$
$$=f[y(t),u(t),W] \quad (1)$$

U (t) and y (t) represents input and output of the network at time t. 1, ... t presents the order of input and output sequence wherein $u(t)\in R$, $y(t)\in R$ express model's input and output in time t; $n_u\geq 1$, $n_y\geq 1$ ($n_u\geq n_y$) stand as input memory vector and output memory vector, W is weight matrix, f is a nonlinear function simulation by multilayer perceptions. The following figure shows the structure chart of NARX network.

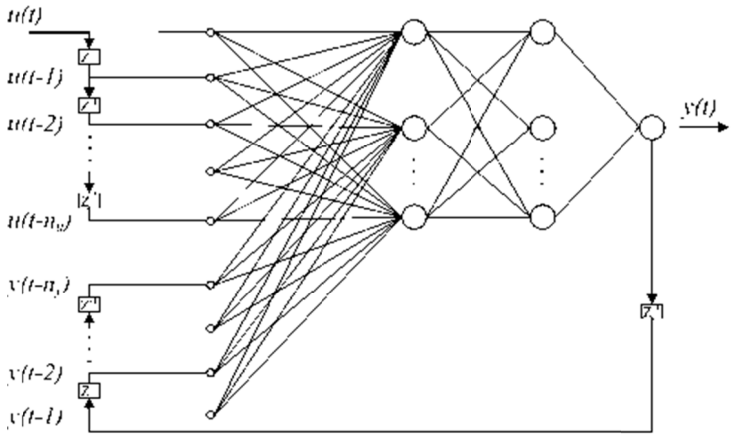

Figure 1. Structure of NARX network

Unlike other recurrent neural network, feedback of NARX network is got from the output layer only, and the network do not accept feedback from hidden layers. Computation ability of NARX neural networks with parameters has been verified in theory. Although NARX network get feedback value only from output layer, the use of NARX network will not decline its computing ability compare with other traditional recurrent neural networks. NARX network has shown its applicability in modeling of many nonlinear systems. Moreover, researchers found that NARX network has advantages of faster convergence and better normalization compared with other neural networks.

As the name suggests, NARX network needs an external input X, and obviously the greater correlation of external input x (T) and time series y (T), the more accurate of the prediction value. When x (T) is a constant value (such as zero), the NARX network can be regarded as nonlinear autoregressive network without exogenous inputs, i.e. NAR network.

When we try to do forecast the trend of RMB exchange rate using NARX network scientifically, we need to select a helpful variable x, in order to join in the NAR network for forecasting. As the financial market is a dramatic market that can be impacted by policy and news fiercely, artificial neural network can not make these data quantified and put them into network, and the question comes out: Is there a variable on behalf of policy that always change?

In recent years, the offshore RMB non-deliverable forward (NDF) market has attracted more and more attention. NDF market provides a lot of references to exchange rate forecasting.

3. Non-Deliverable Forward

A non-deliverable forward referred to as NDF, is a kind of forward exchange transaction, and also is a kind of derivative financial instruments. Mainly refers to that customer and Bank get a agreement with the forward exchange rate and amount of the transaction, and take the delivery of the contract according to the price spread between the exchange rate that previously agreed on contract and the spot exchange rate, without having to pay the principal at a specified maturity date in the future. So it is called "non" delivery. The settlement currency is convertible currencies, usually dollars.

NDF contract can be divided into two kinds, offshore NDF and onshore NDF. The so-called offshore NDF refers to NDF that use freely convertible international currencies to delivery, which is usually US dollar. Onshore NDF market appears only once in the history in Australia in 1973 on a large scale. The only onshore NDF market should be the world's earliest record of NDF market. From a global perspective, NDF transactions are mainly concentrated in offshore market. Onshore NDF market similar to Australia's NDF market is relatively rare. The offshore NDF transactions occur mainly in international financial center that have developed finance and are less regulated cities like Hong Kong, Singapore and London. Delivery of their offshore NDF is usually in US dollar. Won and RMB offshore NDF transactions mainly occur in Hong Kong and Singapore; Poland's Zloty offshore NDF transaction occurs mainly in London. NDF that people usually say is offshore NDF.

4. Hedging Use NDF

The appearance of NDF provides a good way of hedging and arbitrage for investors and users of funds. The principle of hedging that NDF can provide to the enterprise is that it can lock the cost of purchase or sale in advance, as it is a kind of forward exchange transaction.

Before RMB is freely convertible and the RMB forward market is more developed, NDF is very useful to foreign-related enterprises to guard against the risk of RMB exchange rate because of its low cost and high efficiency. Import enterprises can use a NDF contract to lock the risk of RMB exchange rate by purchasing NDF contract of suitable duration and matchable amount. When the export enterprises need to convert dollars into RMB some time in the future, they can make use of a NDF contract to prevent the exchange rate risk of RMB by selling it at suitable time and matchable amount.

For example, on January 1st, 2006, 1-years period NDF of RMB is 8.08 Yuan/dollar on offshore market. A foreign enterprise expected the appreciation of RMB will continue within a year, in order to protect itself from the loss of translation risk, the company hopes to hedge through a 1-year contract of NDF. They can buy a nominal amount of RMB-NDF contract, such as a contract of one million US dollars for a period of one year. The forward rate is 7.91 Yuan/dollar. After one year, three cases may occur, i.e. RMB spot and forward exchange rate are not changed; RMB spot exchange rate appreciate, and devaluation of RMB. If the maturity of 1-year RMB/ US dollar spot exchange rate is 7.91, then the trader's bank will pay him $ 1,000,000 / (7.91/8.08) - 1,000,000 = $ 21,491.78; if RMB / USD spot is 8.11, then the trader's bank will pay 1,000,000 / (8.11/8.08) - $ 1,000,000 = -3,699.14, which means the trader must pay 3,699.14 dollars to the bank. Thereby avoid the risk of RMB appreciation successfully. The specific results are shown below in the following table.

Table 1. Three Situations of NDF contract when maturity

	Depreciation	flat	appreciation
RMB/USD	8.11	8.08	7.91
Dollar equivalent	1,021,491.78	1,000,000.00	996,300.86
Bank liquidation paid	21,491.78	0.00	-3,699.14

In China, including Hong Kong and Macao, the start up of NDF business is from foreign banks that have Branches in Hong Kong or Singapore, and the RMB NDF market is mainly in Singapore and Hong Kong. The main market participants are big banks and investment institutions, their customers are mainly multinational

companies who have large amounts of RMB income in China. These multi-national corporations avoid the exchange rate risk of their RMB revenues and profits by participating in the RMB NDF transactions.

Generation of NDF is derived from controlling of currency speculation, and thus speculative arbitrage is also an important function of NDF in addition to hedge.

5. Forecasting of RMB Exchange Rate with NDF

NDF is formed early from the financial crisis of Mexico in 1995, the earliest contract is Mexico Peso NDF contract in dollar. In Asian markets, the three largest NDF trading markets are Korean Won, Taiwan Dollar and RMB transaction.

The RMB NDF began from June 1996 in Singapore with the longest transaction of 6-months period. Market liquidity is poor at that time, so that the market is not very active initially. NDF transaction has become increasingly active after the Asian financial crisis in 1997. The RMB NDF market has formed for more than ten years till now. In Singapore and Hong Kong, RMB NDF market has become one of Asia's most important offshore RMB forward markets now. Daily trading volume increased to billions of dollars from tens of millions dollars gradually. NDF market prices reflect the expectations for RMB exchange rate of international community. According to the statistics of Emerging Market Traders Association, the Korean won NDF, Brazilian real NDF, new Taiwan dollar NDF and RMB NDF are most traded currencies.

According to the estimates of International Settlements bank, the RMB NDF accounted for 90% of the RMB forward transactions both at home and abroad, which is mainly concentrated in five varieties: three months, six months, nine months, one year and three years.

Pricing of NDF is different from that of forward. Opposed to China's RMB exchange rate formation mechanism, RMB NDF exchange rate is fully market-oriented. It depends on market expectations of exchange rate entirely. RMB NDF market can reflect the expectations of appreciation and devaluation of RMB exchange rate. For example, from the beginning of 2005 to July 21st 2005, before the appreciation of RMB, the premium remained within 3000 to 4000, equivalent to 3 percent to 4 percent, which means that the overseas market expected RMB exchange rate appreciated by 3 to 4 percent against the US dollar in one year. That is, the market expectation of RMB exchange rate is from 8.28 at that time to about 7.88 one year later.

This is because RMB exchange rate is an official exchange rate, and NDF exchange rate is equivalent to a floating exchange rate shows market expectations. Although there is not substantial impact on the value of the RMB, but it can show the pressure of appreciation from international community, as well as the changes of the market on RMB supply and demand.

Although majority trades of NDF market is to speculate, it can not reflect the real price fully. When the domestic market becomes more and more important, the importance of NDF decreased. But NDF has been an important reference for foreign exchange departments of domestic bank and foreign investors. Arbitrage conduct makes the NDF market and the forward market close again once deviated from each other. This makes more accurately when forecasting exchange rate movements by using the two prices.

6. Effectiveness of NDF

Exchange rate changes can be regarded as a dynamic time sequence Y (t), the NARX network mentioned before, in the presence of an associated variable X (t), can be used for the forecasting of Y (t). Clearly, the change of X (t) and Y (t) associate with each other better, and then the more accurate the prediction result of the Y (t) is. We establish a model using NDF as the external input x of the NARX network to forecast the RMB exchange rate movements.

As mentioned before, there are a lot of RMB NDF transaction varieties, including 1-week NDF, 1-month NDF, 3-month NDF, 1-year NDF and so on. Which varieties of the NDF data should we choose as the external input x of NARX network to get the best result of exchange rate forecasting?

In this paper, we selected several varieties of NDF that have larger trading volume as the external input to forecast, respectively, the results are as follows:

We generated a NARX network by selecting the 1-month NDF as X (T), select the exchange rate of the RMB from January 1, 2005 to December 31 2010, against the US dollar as Y (T) for a total of 1469 exchange rate data. Select corresponding NDF as X (T), choose 1323 of them (90%) randomly used for training, 73 (5%) of them to verify normalized degree of the network to prevent over training of the network, the other 73 (5%) are used to sample testing. A total of 98 data used to the Promotion of testing samples from January 2011 to the end of May 2011 to test the generated network. Set 10 as the number of hidden layer neuron network, delay parameter is 2,

and use BP algorithm to train the network.

The performance of NARX network is shown in figure below:

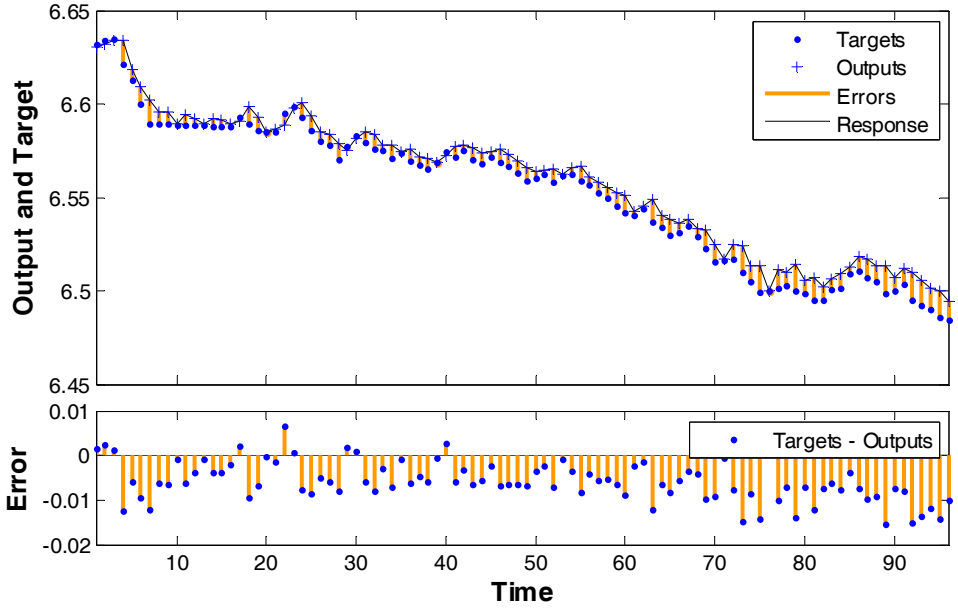

Figure 2. Response of output element when using 1-month NDF

To further validate if there is a different performance when using different kind's NDF during forecasting. We selected 2-month NDF, 6-month NDF, and 1-year NDF values for training, testing, and the following results were obtained respectively.

Promotion performance chart is shown as below when using 2-month NDF to train and promote the NARX network:

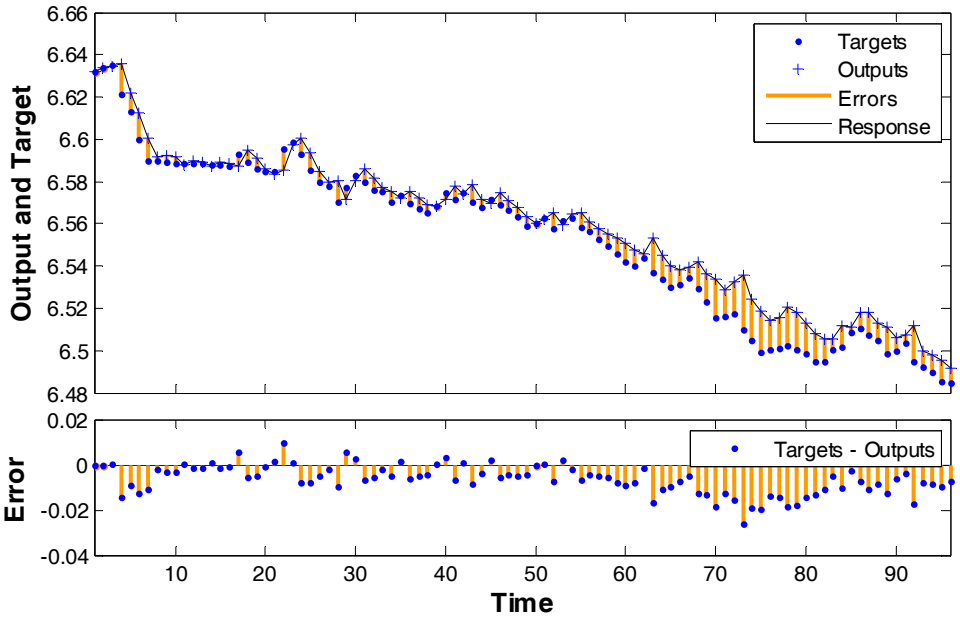

Figure 3. Response of output element when using 2-month NDF

Promotion performance chart is shown as below when using 3-month NDF to train and promote the NARX

network:

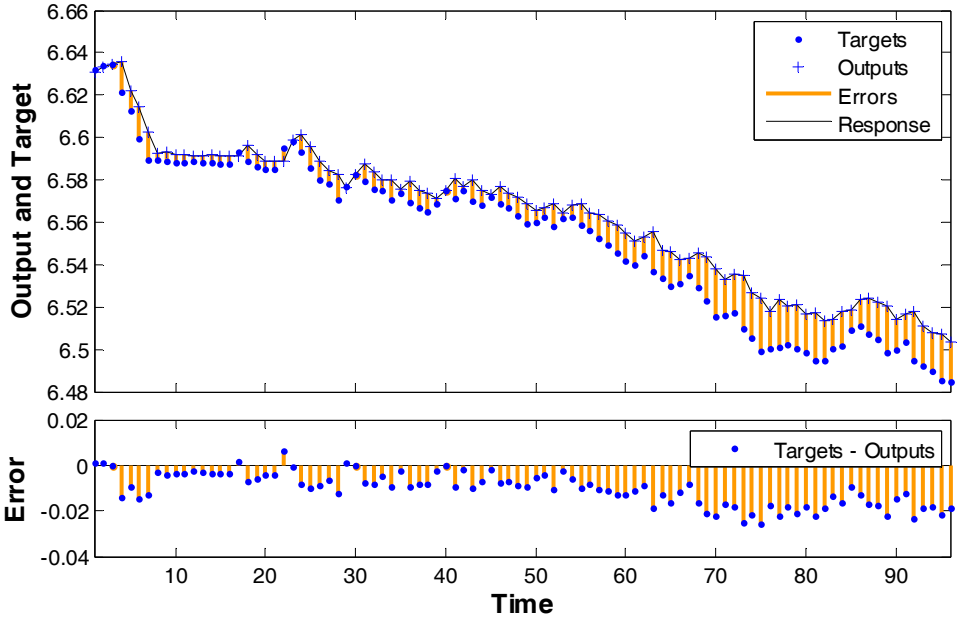

Figure 4. Response of output element when using 3-month NDF

Promotion performance chart is shown as below when using 6-month NDF to train and promote the NARX network:

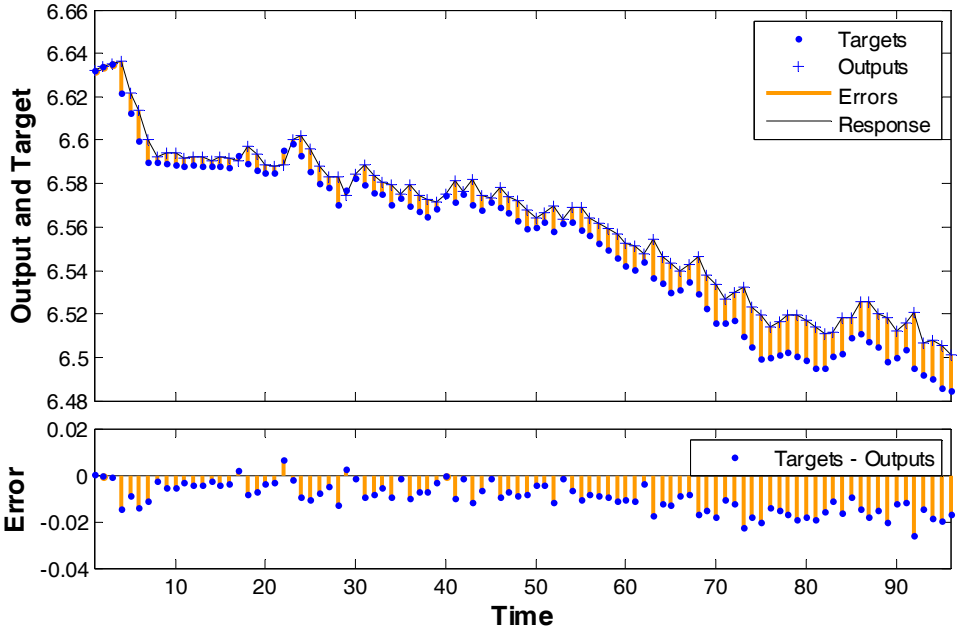

Figure 5. Response of output element when using 6-month NDF

Promotion performance chart is shown as below when using 1-year NDF to train and promote the NARX network:

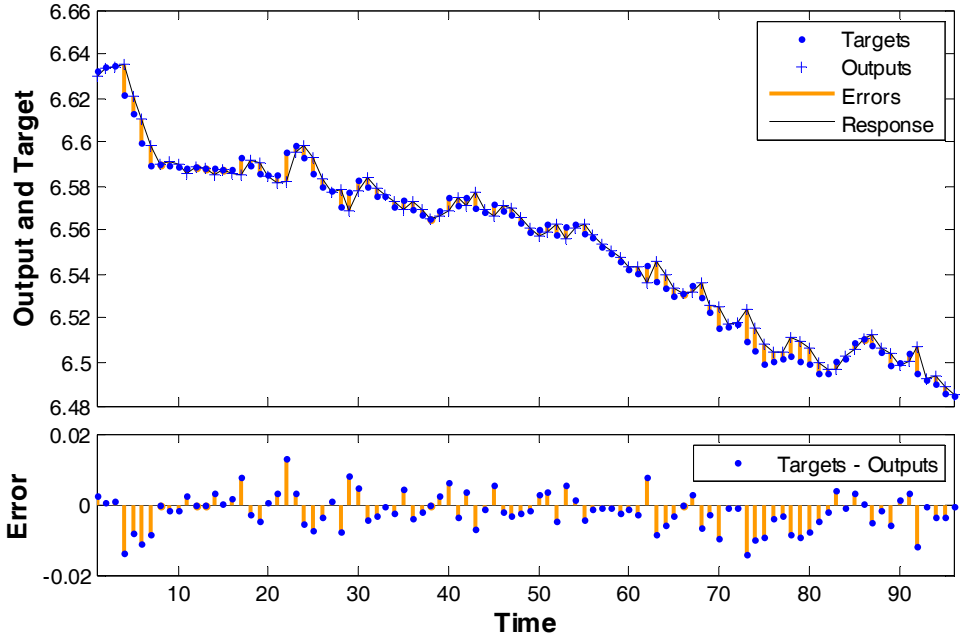

Figure 6. Response of output element when using 1-year NDF

Through observation of the experimental results, it is found that smaller error shown on the graph when using NDF dates of 1-month and 1-year, following by using 2-month NDF and data of 3-month. When using 6-month NDF, it has larger error comparing with the others. Then compare MSE and R of each model.

Table 2. MSE and R of each NARX network

	MSE	R
1-month NDF	2.59019e-5	9.92369e-1
2-month NDF	3.00343e-5	9.92839e-1
3-month NDF	7.79260e-5	9.93217e-1
6-month NDF	7.85540e-5	9.93457e-1
1-year NDF	2.75900e-5	9.91852e-1

We observed MSE and R of each NARX model when using different time period's NDF data as external inputs. MSE is mean square error, also known as standard deviation, which is the square root of the average variance, which shows how the data deviate from the mean distance. Standard deviation can reflect the discrete degree of a data set. MSE is on behalf of data variance of input data and output data. Lower value represents smaller deviate of forecasting. So we use MSE to distinguish forecasting results of each model.

Consistent with the observed results of each chart, 1-month data and 1-years data get lowest MSE, 2-month data is a bit poor, 3-month and 6-month's MSE are slightly inferior. Although MSE has slight difference, this distinction is very little at the levels of E-5.

7. Conclusions

7.1 NARX Network Is Suitable for Exchange Rate Forecasting

Neural network models have a long history of application to financial time series data. Nonlinear Auto Regressive models with exogenous inputs, which is known as NARX model is an important kind of offline nonlinear system. Researchers seldom use NARX network to forecast RMB exchange rate. In this paper, we get expected result by using NARX network for RMB exchange rate forecasting. Although the Chinese government does not allow free movement of the RMB/dollar exchange rate in the past, RMB exchange rate has become more and more freely after RMB exchange rate reformation on July 21st 2005. That can avoid training model using a highly constrained dataset.

7.2 Effectiveness of NDF in Forecasting

Artificial neural network is a new interdisciplinary subject related to biological science, mathematics, computer

science and some other subjects. Its value has been widely recognized, especially when people has difficult in modeling. Financial market is a market can be drastic influenced by policy and news. These data can not be quantified into artificial neural network, so we need a variable that can represent changes in policy. To a certain extent, NDF can represent the reaction of the market when new policies published. Thus NDF can be used as an input of NARX network in order to improve the performance of NARX network of exchange rate forecasting when emergency policy published. From the research in this paper, the slightly errors can also prove that selecting NDF as a combination factor in exchange rate forecasting is a very successful choice, and verify the effectiveness of NDF in forecasting.

7.3 1-Year NDF Is Not the Best One for Research of Forecasting

From the experimental results, the shorter duration is the stronger interaction it has with the spot market, because of its largest trading volume and highest mobility. 1-year NDF, which is often chosen to study the association between spot market and forward market, does not have the strongest relationship with spot market. NDF trading volume and liquidity have a certain impact on the interaction between the NDF market and the spot market, but not decisive.

7.4 All NDF Can Get Good Result When Forecasting

NARX network is a branch of artificial neural network, selection of external variable X has significant influence on the accuracy of forecasting results. When forecasting the trend of RMB exchange rate using NARX network, NDF is effective as an input. Above all, it can all achieve excellent results whichever time span of NDF we choose.

References

Allen, H., & Taylor, M. (1992). The Use of Technical Analysis in the Foreign Exchange Market. *Journal of International Money and Finance, 11,* 304-314. http://dx.doi.org/10.1016/0261-5606(92)90048-3

Chen, R., Zheng, Z., & Gong, J. (2008). China should open the RMB NDF market? A comparative study of Yuan and won. *Xiamen University working paper*, 79-89.

Cheung, Y. W., Chinn, M. D., & Antonio, G. P. (2003). Empirical Exchange Rate Models of the Nineties: Are Any Fit to Survive? *Other Recent Work, Department of Economics UCSC, 6,* 124-128.

Chinn, M., & Meese, D. (1995). Banking on currency forecasts: how predictable is the change in money? *Journal of International Economics, 38,* 161-178. http://dx.doi.org/10.1016/0022-1996(94)01334-O

Frankel, J., & Froot, K. (1986). Understanding the U.S. Dollar in the eighties: the expectations of chartists and fundamentalists. *Economic Record, 62,* 24-38.

Huang, X., & Wu, C. (2006). The offshore renminbi non-deliverable forward and interaction of territory of the spot exchange rate price: before and after the reform. *Financial research*, *11,* 83-89.

Jamal, A. M. M., & Sundar, C. (2011). Modeling Exchange Rates with Neural Networks. *Journal of Applied Business Research, 14*(1), 25-28.

Jiang, C., & Song, F. (2010). Hybrid forecasting model based on NARX neural network and ARMA. *Statistics and Decision, 8,* 33-35.

Krugman, P., & Miller, M. (1992). Why have a Target Zone? *Carnegie-Rochester Conference Series on Public Policy, 38,* 279-314. http://dx.doi.org/10.1016/0167-2231(93)90026-S

Lee, R. G. (2005). Foreign Exchange Intervention and Foreign Exchange Market Development in Korea. *BIS Paper, 24,* 196-209.

Lipscomb, L. (2005). An Overview of Non Deliverable Foreign Exchange Forward Markets. *Federal Reserve Bank of New York, Government Report,* 116-118.

Mark, N. (1995). Exchange rates and fundamentals: evidence on long-horizon predictability. *American Economic Review, 85*(3), 201-218.

Meese, R., & Rogoff, K. (1983). Empirical exchange-rate models of the seventies: do they fit out of sample? *Journal of International Economics, 14,* 3-24. http://dx.doi.org/10.1016/0022-1996(83)90017-X

Michael, P., Nobay, A., & Peel, D. (1997). Transaction cosets and non-linear adjustments in real exchange rates: an empirical investigation. *Journal of Political Economy, 105,* 862-879. http://dx.doi.org/10.1086/262096

O'Connell, P., & Goering. (2000). Market frictions and real exchange rates. *Journal of International Money and Finance, 17,* 71-95. http://dx.doi.org/10.1016/S0261-5606(97)00052-1

Obstfeld, & Taylor. (2002). Globalization and Capital Markets. In Bordo, M. D., Taylor, A. M., & Williamson, J. G. (Eds.), *Globalization in Historical Perspective*, *18*, 112-118.

Park, J. (2001). Information Flows between Non-deliverable Forward (NDF) and Spot Markets: Evidence from Korean Currency. *Pacific -Basin Finance Journal, 9,* 363-377. http://dx.doi.org/10.1016/S0927-538X(01)00012-9

Qian, X. (2005). NDF offshore market of RMB exchange rate expectations. *Journal of Shanxi University of Finance and Economics*, *6*, 116-120.

Ren, Z., & Ning, Z. (2005). The expected RMB exchange rate and RMB exchange rate: An Empirical Study of NDF. *Academic research*, *12,* 34-39.

Sarantis, N. (1999). Modeling non-linearities in real effective exchange rates. *Journal of International Money and Finance, 18,* 27-45. http://dx.doi.org/10.1016/S0261-5606(98)00045-X

Taylor, M. P., Peel, D. A., & Sarno, L. (2001). Nonlinear mean-reversion in real exchange rates: toward a solution to the purchasing power parity puzzles. *International economic reviews, 42,* 1015-1042. http://dx.doi.org/10.1111/1468-2354.00144

Wang, F. (2011). Research on the relation between RMB spot exchange rate and RMB NDF. Oriental enterprise culture. *The company and the industry, 9,* 76-77. http://dx.doi.org/10.1016/j.cie.2011.02.013

Zhang, G., & Michael, Y. H. (1998). Neural Network Forecasting of the British Pound/US Dollar Exchange Rate. *Journal of International Mangement Science, 26*(4), 495-506.

Zheng, O., & Lin, P. (2011). Information transmission and interaction of RMB NDF and spot market. *Study on the relationship between financial taxation, 4,* 81-84.