Mining Multiple Markets' Exchange Rate: An Artificial Intelligence Tools Survey

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ABSTRACT

Foreign exchange rate prediction is an expanding industry with various commercial services throughout the world, employed various techniques providing foreign exchange rate predictions. This paper examined the daily exchange rate data from six different countries and used that data to discover the correlation relationship among them. In this study, we used five of the exchange markets' daily data to predict the sixth market's exchange rate of the next day. We used four different artificial intelligence algorithms as our tools and our experiments yield quite interesting results.

Keywords: Exchange rate, Prediction, Artificial Intelligence.

1. INTRODUCTION

It is often argued that it is futile to attempt to predict foreign exchange rates because the foreign exchange market is an efficient market. The market is efficient in that the major participants are believed to have access to all the current information that may impact on price or at the assumption that the historic exchange rate information contains no useful information that can be used to predict the future exchange rates.

Many empirical studies of the exchange rate market have used statistical analysis or more sophistic models such as artificial intelligence algorithms in an effort to uncover significant pattern in the historical exchange rate data. These studies have found that the exchange rate data appear to have no significant pattern.

A couple of studies have found evidence through their research marginally profitable in the foreign exchange market. Our study, in using five foreign exchange rate markets and predicting the future exchange rate of sixth market produced quite accurate results. We compared the performance of four different artificial intelligence algorithms through our data set and found that all have very high predictive accuracy.

2. RELATED WORKS

Based on the concept of speculative runs Alexander [6] shown that a currency that has risen significantly is likely to continue its upward trend and a currency that has fallen significantly will continue to follow its downward trend. Bleaney [5] examined the claim that error-correction models of exchange rates can perform well in out-of-sample forecasting tests at long horizons. Rose and Selody [1] performed a test on daily data on five mature exchange rate markets shown that the data reject the joint hypothesis of exchange rate market informational efficiency and no risk premium. Logue and Sweeney [3] in their study of the Franc/Dollar spot rate found that while the data seemed to be white noise using spectoral analysis, there were a number of simple trading rules which yielded at least marginal profits. The k percent rules are used which buy a currency after it has risen k percent from its previous low and see it after it has fallen k percent from previous high. Logue, Sweeney and Willet [4] later came to a different conclusion that the foreign exchange markets are at least weakly efficient. From their results shown that k percent rules yielding substantial profits as compared with a buy and hold strategy. In a recent study by Chen, Kuo and Hoi [7] found contradicting evidence that the hypothesis that GP can generate profitable trading strategies in the foreign exchange markets does not win strong support.

In this paper we evaluated the predictive accuracy of foreign exchange rate markets using a variety of artificial intelligence algorithms providing a good test of market efficiency and correlativity in the foreign exchange markets.

3. EXCHANGE MARKETS

The foreign exchange market exists whenever one currency is trade for another. Capital wise it is by far the largest trading market in the world. The parties involve are banks, corporations, governments, traders, etc. The foreign exchange market is unique because of its several characteristics:

- Large trading volume
- Liquidity of the market
- Large participants in the market
- Geographical diverse
- Long trading hours due to the different time zone
- Variety factors that affect exchange rates

There is no single unified foreign exchange market due to its over the counter nature of the currency trading, different currency instruments are traded on a number of interconnected markets. The main trading centers are in London, New York and Tokyo, but banks throughout the world participate. As the Asian trading hours end, the European hours begin, then the US and back to Asia. It is a non stop trading throughout the world. Traders can react to the news as it become available, rather than wait and response during the market hours.

There is little or no inside information in the foreign exchange markets as the rates are fluctuate due to various factors such as GDP growth, inflation, interest rates, deficits or surplus and other macroeconomic conditions.

Controversy about currency speculators and their effect on currency devaluations and national economics recurs regularly. Many economists argue that speculators perform the important function of providing a market for hedgers and transferring risk from the one to another. Others consider this argument to be based more on politics and free market philosophy than on economics. Currency speculation is considered a highly suspect activity in many countries. While investing in traditional financial instruments like bonds or stocks often is considered to contribute positively to economic growth by providing capital, currency speculation does not.

4. ARTIFICIAL INTELLIGENCE ALGORITHMS

Artificial intelligence algorithms have been widely utilized for computational intelligence in the field of finance and economic. In this study, we applied four different artificial intelligence algorithms: multi-layer perceptron, radial basis functions, support vector regression model and regression by discretization model. Here is a brief description of each:

Multi-layer perceptron - This neural network uses backpropagation to train. A neural network is a powerful data modeling tool that is able to capture and represent complex input/output relationships. The motivation for the development of neural network technology stemmed from the desire to develop an artificial system that could perform "intelligent" tasks similar to those performed by the human brain. Neural networks resemble the human brain in the following two ways:

1. A neural network acquires knowledge through learning.
2. A neural network's knowledge is stored within inter-neuron connection strengths known as synaptic weights.

The true power and advantage of neural networks lies in their ability to represent both linear and non-linear relationships and in their ability to learn these relationships directly from the data being modeled.

The most common neural network model is the multilayer perceptron (MLP). This type of neural network is known as a supervised network because it requires a desired output in order to learn. The goal of this type of network is to create a model that correctly maps the input to the output using historical data so that the model can then be used to produce the output when the desired output is unknown. A graphical representation of an MLP is shown below in Figure 1.

In neural networks, an activation function is the function that describes the output behaviour of a neuron. The most common activation functions are sigmoid and Gaussian functions.

- Sigmoid function $f(\mu_i) = \frac{1}{1+e^{-\mu_i/\sigma}}$
- Gaussian function $f(\mu_i) = e^{-\mu_i^2/\sigma^2}$

Radial basis functions - a normalized Gaussian radial basis functions network. It uses the k-means clustering algorithm to provide the basis functions and learns either a logistic regression (discrete class problems) or linear regression (numeric class problems) on top of that. Symmetric multivariate Gaussians are fit to the data from each cluster. If the class is nominal it uses the given number of clusters per class. It standardizes all numeric attributes to zero mean and unit variance. Radial basis functions (RBFs) are the natural generalization of coarse coding to continuous-valued features. Rather than each feature being either 0 or 1, it can be anything in the interval , reflecting various degrees to which the feature is present. A typical RBF feature, i, has a gaussian (bell-shaped)response, $\phi_s(i)$,dependent only on the distance between the state, s, and the feature's prototypical or center state, ci , and relative to the feature's width, $\phi_s(i)$:

$$\phi_s(i) = \exp\left(-\frac{||s - c_i||^2}{2\sigma_i^2}\right).$$

The norm or distance metric of course can be chosen in whatever way seems most appropriate to the states and task at hand. Figure 2 shows a 1-dimensional example with a euclidean distance metric.

An RBF network is simply a linear function approximator using RBFs for its features. The primary advantage of RBFs over binary features is that they produce approximate functions that vary smoothly and are differentiable. In addition, some learning methods for RBF networks change the centers and widths of the features as well. Such nonlinear methods may be able to fit the target function much more precisely. The downside to RBF networks, and to nonlinear RBF networks especially, is greater computational complexity and, often, more manual tuning before learning is robust and efficient.

Figure 1. A MLP neural network model

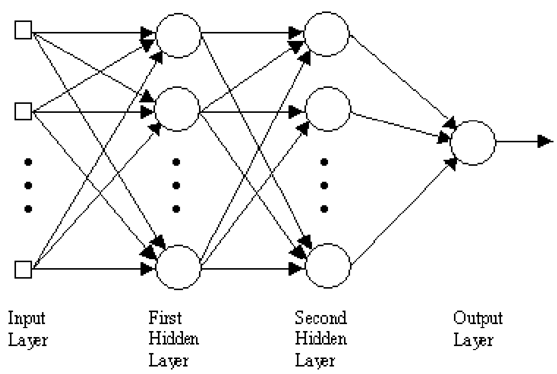
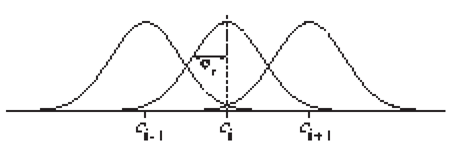


Figure 2. One-dimensional radial basis functions



Support vector regression model - Implements Alex Smola and Bernhard Scholkopf's [2] sequential minimal optimization algorithm for training a support vector regression model. This implementation globally replaces all missing values and transforms nominal attributes into binary ones. It also normalizes all attributes by default. (Note that the coefficients in the output are based on the normalized/standardized data, not the original data.)

SMO was proposed [9] that puts chunking to the extreme by iteratively selecting subsets only of size and optimizing the target function with respect to them. It has been reported to have good convergence properties and it is easily implemented. The key point is that for a working set of 2 the optimization subproblem can be solved analytically without explicitly invoking a quadratic optimizer. While readily derived for pattern recognition by Platt

[1999], one simply has to mimic the original reasoning to obtain an extension to Regression Estimation. The modifications consist of a pattern dependent regularization, convergence control via the number of significant figures, and a modified system of equations to solve the optimization problem in two variables for regression analytically.

Note that the reasoning only applies to SV regression with the insensitive loss function - for most other convex cost functions an explicit solution of the restricted quadratic programming problem is impossible. Yet, one could derive an analogous non-quadratic convex optimization problem for general cost functions but at the expense of having to solve it numerically. The exposition proceeds as follows: first one has to derive the (modified) boundary conditions for the constrained 2 indices (i, j) subproblem in regression, next one can proceed to solve the optimization problem analytically, and finally one has to check, which part of the selection rules have to be modified to make the approach work for regression.

Regression by discretization- A regression scheme that employs any classifier on a copy of the data that has the class attribute (equal-width) discretized. The predicted value is the expected value of the mean class value for each discretized interval (based on the predicted probabilities for each interval).

5. EXPERIMENTS AND RESULTS

We used the exchange rate date of US/UK, US/Italy, US/Canada, Us/Japan, US/Singapore and US/Taiwan markets from 1990 to 2004. We selected the date from 1990 to 2003 as our training/validating data and 2004 as our testing data. We selected the daily data of US/UK, US/Italy, US/Canada, Us/Japan, US/Singapore as our input and the next day's US/Taiwan data as our predicted target.

We used an artificial intelligence software package called WEKA from University of Waikato. It is a data mining environment that provides various artificial intelligence and statistical algorithms and a unify format for input and output data.

We used ten folds cross validation on our training data and here are the training results.

In our training data, we can see that the regression by discretization (decision tree) algorithm is the most accurate.

We then applied the 2004 test data to the trained models. Here are the results.

Table 1. Training result from 10-fold cross validation

Algorithms	Correlation coefficient	Mean absolute error	Root mean square error
Multilayer perceptron	0.9803	0.0006	0.0008
Radial Basis Networks	0.993	0.0003	0.0005
Support Vector by Regression	0.9405	0.001	0.0013
Regression by discretization (decision tree)	0.9944	0.0003	0.0004

Table 2. Testing results (next day's predictive accuracy) from the 2004 data.

Algorithms	Mean absolute error	Root mean square error
Multilayer perceptron	0.0007	0.001
Radial Basis Networks	0.0044	0.0058
Support Vector by Regression	0.0029	0.0031
Regression by discretization (decision tree)	0.0053	0.0065

Figure 3. Multi-layer perceptron

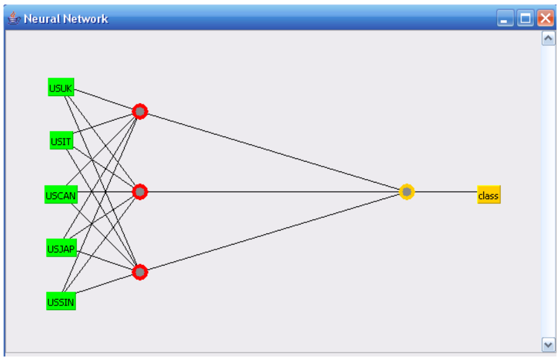
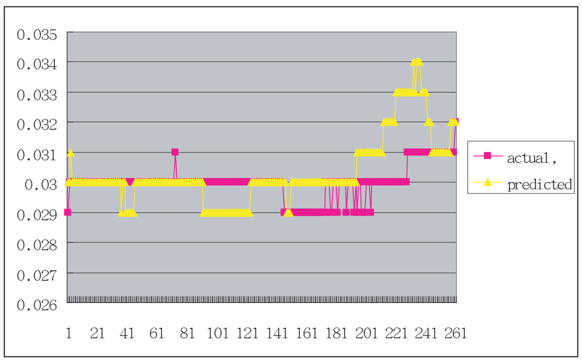


Figure 4. Actual and predicted output from 2004 testing data



From the above experiments we conducted, we found that for out of sample testing (year 2004) the multi-layer perceptron (neural network) (see Fig. 3) had the lowest mean square error and root mean square error. Here are the actual and predicted output data from multi-layer perceptron using the 2004 testing data. (Fig. 4)

6. CONCLUSIONS AND FUTURE WORKS

Our finding in this study is quite interesting that it contradict the hypothesis that the foreign exchange rate market is efficient. In this study, we can get very accurate prediction using the data from other related markets. For the future work, we would like to expand the system to provide investor an exchange rate trading strategy based on the predicted output. And we would like to also expand the algorithms used in the study to include other major artificial intelligence algorithms used by other researcher in this area.

7. REFERENCES

[1] A. Rose and J. Selody, "Exchange Market Efficiency: A Semi-Strong Test Using Multiple Markets and Daily Data", *The Review of Economics and Statistics*, Vol. 66, No. 4. pp 669-672, 1984.

[2] A. Smola, B. Scholkopf, "*A Tutorial on Support Vector Regression*". NeuroCOLT2 Technical Report Series - NC2-TR-1998-030, 1998.

[3] D. Logue and R. Sweeney, "White Noise in Imperfect Markets: The Case of the Franc/Dollar Exchange Rate", *Journal of Finance,* pp. 159-174, 1978.

[4] D. Logue, R. Sweeney and T. Willett, "Speculative Behavior of Foreign Exchange Rates During the Current Float", *Journal of Business Research*, pp. 761-768, 1978.

[5] M. Bleaney, "Exchange Rate Forecasts at Long Horizons: Are Error-Correction Models Superior", *The Canadian Journal of Economic*s, Vol. 31, No. 4. pp 852-864, 1998.

[6] S. Alexander, "Price Movement in Speculative Markets: Trends or Random Walks", *Industrial Management Review*, pp. 24-26, 1974.

[7] S. Chen, T.Kuo and K. Hoi, "Genetic Programming and Financial Trading: How Much about "What we Know"? *Handbook of Financial Engineering.*

[8] S. Goodman, "Foreign Exchange Rate Forecasting Techniques: Implications for Business and Policy", *The journal of Finance,* Vol. 34, No. 2, pp.415-427, 1978.

[9] J. Patt, "Fast training of support vector machines using sequential minimal optimization. In B. Scholkopf, C.J.C. Burges and A. J. Smola, editors, Advances in Kernel Methods-Support Vector Learning, MIT Press, pp. 185-208.

APPENDIX A.

The following graphs illustrated the daily data from six exchange markets from 1986 to 2004.

Figure 5. USA vs. Japan exchange rate

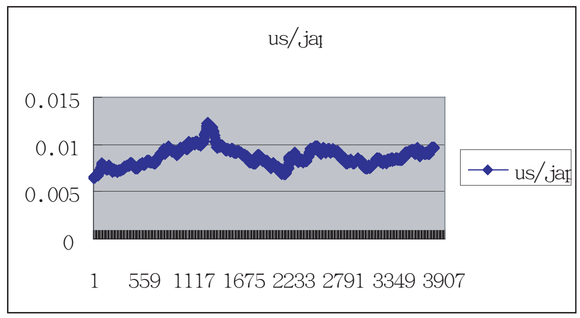


Figure 6. USA vs. UK exchange rate

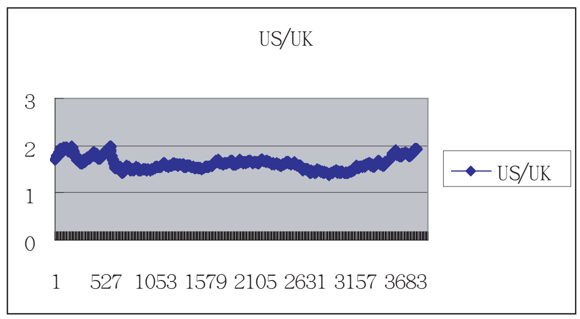


Figure 7. USA vs. Italy exchange rate

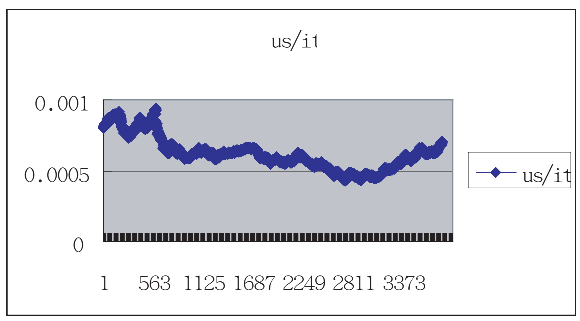


Figure 8. USA vs. Canada exchange rate

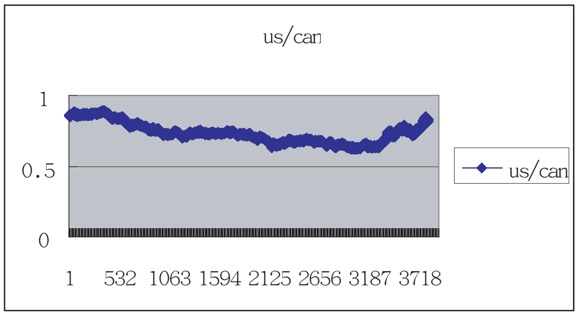


Figure 10. USA vs. Singapore exchange rate

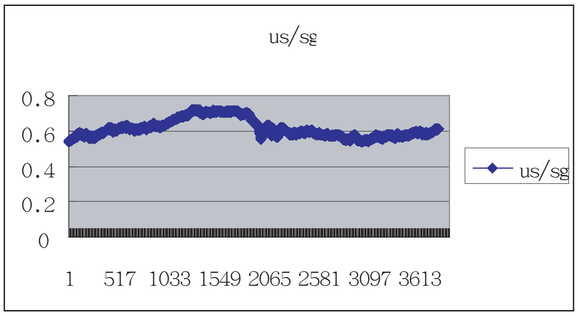
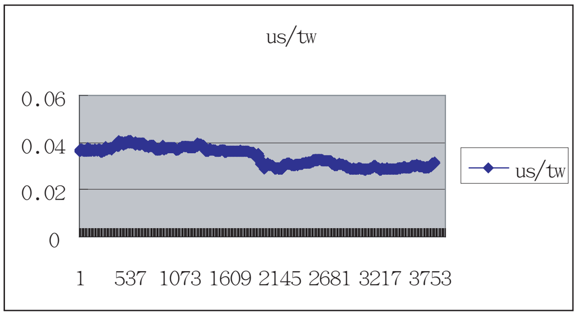


Figure 9. USA vs. Taiwan exchange rate



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