

## Chapter 85

# Forecasting Exchange Rates: A Chaos-Based Regression Approach

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### ABSTRACT

*Accurate forecasting for future events constitutes a fascinating challenge for theoretical and for applied researches. Foreign Exchange market (FOREX) is selected in this research to represent an example of financial systems with a complex behavior. Forecasting a financial time series can be a very hard task due to the inherent uncertainty nature of these systems. It seems very difficult to tell whether a series is stochastic or deterministic chaotic or some combination of these states. More generally, the extent to which a non-linear deterministic process retains its properties when corrupted by noise is also unclear. The noise can affect a system in different ways even though the equations of the system remain deterministic. Since a single reliable statistical test for chaoticity is not available, combining multiple tests is a crucial aspect, especially when one is dealing with limited and noisy data sets like in economic and financial time series. In this research, the authors propose an improved model for forecasting exchange rates based on chaos theory that involves phase space reconstruction from the observed time series and the use of support vector regression (SVR) for forecasting. Given the exchange rates of a currency pair as scalar observations, observed time series is first analyzed to verify the existence of underlying nonlinear dynamics governing its evolution over time. Then, the time series is embedded into a higher dimensional phase space using embedding parameters. In the selection process to find the optimal embedding parameters, a novel method based on the Differential Evolution (DE) genetic algorithm (as a global optimization technique) was applied. The authors have compared forecasting accuracy of the proposed model against the ordinary use of support vector regression. The experimental results demonstrate that the proposed method, which is based on chaos theory and genetic algorithm, is comparable with the existing approaches.*

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## 1. INTRODUCTION

Accurate forecasting of future events constitutes a fascinating challenge for theoretical researchers and practitioners. One of the largest domains that share this problem is economy or more specifically financial markets. Predicting a financial series, as a stock market index or an exchange rate, remains however a very challenging task. The foreign exchange (FOREX) market (our case-study in this research) is one of the largest financial markets in the world.

For more than four decades, Box and Jenkins' Auto-Regressive Integrated Moving Average (ARIMA) model (Box & Jenkins, 1970) has been widely used for time series forecasting. However, some problems arise when forecasting financial time series with ARIMA models, as follows. First is the characteristic linear limitation of ARIMA models, in contrast to real-world financial time series, which are often nonlinear [ (Lin et al., 2012), (Huang et al., 2010), (Ding et al., 2009)& (Gradojevic & Yang, 2006) ] and are rarely pure linear combinations. Second is the robustness limitation of ARIMA models—the ARIMA model selection procedure depends greatly on the competence and experience of the researchers to yield desired results. Unfortunately, choice among competing models can be arbitrated by similar estimated correlation patterns and may frequently reach inappropriate forecasting results (Lin et al., 2012).

Chaos theory is dealing with a time series as a realization of a nonlinear dynamical system with a degree of determinism. Random input is not the only possible source of irregularity in a system's output: nonlinear, chaotic systems can produce very irregular data with purely deterministic equations of motion in an autonomous way. Of course, a system which has both, nonlinearity and random input, will most likely produce irregular data as well (Kantz & Schreiber, 2003).

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combination of these states. More generally, the extent to which a non-linear deterministic process retains its properties when corrupted by noise is also unclear. The noise can affect a system in different ways even though the equations of the system remain deterministic. Since a single reliable statistical test for chaoticity is not available, combining multiple tests is a crucial aspect, especially when one is dealing with limited and noisy data sets like in economic and financial time series. In this research, a preliminary study was carried out with the aim of detecting non-stationarity and non-linearity in exchange rates time series. An analysis of the underlying dynamical system was also applied to study the existence of a chaotic behavior. Finally, different techniques of forecasting based on both theories of Chaos and stochastic process were executed then a comparison of the prediction accuracy was held between the two forecasting methods.

The remainder of this paper is organized as follows: Section 2 presents a review of existing approaches for research efforts that have been focused on the hypothesis that financial markets behavior is non-linear. The problem definition is described in section 3. The proposed method for a non-linear system and the applicability of chaos theory are presented in section 4. Section 5 discusses how to apply the proposed method on financial markets data especially such as FOREX data. Section 6 provides the results and discussion of the proposed system. Finally, we summarize our main results and outline future directions of further methodological developments based on our proposed technique.

## 2. RELATED WORK

In the past two decades, considerable research efforts have been focused on the hypothesis that financial markets behavior is non-linear. In this section, we will briefly review some of the previous work in this area. Indeed, there is a continu-

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