Application of Time Series Models in Forecasting Exchange Rate

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ABSTRACT

This thesis will attempt to compare the forecasting performance of alternative forecasting models in relation to exchange rates. The models will be applied will include Naïve, Moving Averages, Simple Exponential Smoothing and Time Series Regression. Forecasting the accuracy of each model will be evaluated by calculating Mean Squared Error of each model based on forecasting errors over the past actual data.

Keywords: Exchange Rate, Forecast Accuracy, Naïve, Moving Averages, Simple Exponential Smoothing and Time Series Regression

ÖZ

Bu tez döviz kurları ile ilgili olarak alternatif öngörü modellerinin öngörü performansını karşılaştırmak için çalışır.Modelleri naif, Hareketli Ortalama, Basit Üstel Düzeltme ve Zaman Serisi Regresyon içerecektir uygulanacaktır. Her modelin doğruluğunu Tahmini son gerçek veriler üzerinde tahmin hataları göre her modelin ortalama kare hata hesaplanarak değerlendirilecektir.

Anahtar Kelimeler: Döviz Kuru, Tahmini Doğruluk, Naif, Hareketli Ortalama, Basit Üstel Düzeltme Ve Zaman Serisi Regresyon

This study is dedicated to my parents with their support and kindness

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Chapter 1

INTRODUCTION

One of the most important and interesting subjects to study in financial markets is fluctuation modeling and forecasting. Now a days financial markets around the world are affected by globalization and going out of governments control. The demand for better forecasts of price trends is growing. Because companies, traders and investors use these forecasts as a valuable data to inject in models of decision making and risk management and finally make more profits.

Some researchers have studied exchange rate behavior in qualitative analysis based on their experience to predict exchange rate according to some economic factors. The others have studied it in quantitative analysis based on some mathematical techniques and models according to historical data.

This thesis will attempt to compare the forecasting performance of alternative forecasting models in relation to exchange rates.

Chapter 2

LITERATURE REVIEW

2.1 Appearance of Capital Markets

Currency conversion goes back to five thousand years BC when people in Persia and Egypt used coins in their deals. After 1944, an international agreement named Bretton Woods governed monetary policy between countries. Based on that agreement the US dollar was the only currency to be convertible to gold, and other currencies would set their exchange rates relative to the dollar. This agreement prevented volatilities in exchange rate of major currencies. Bretton Woods agreement collapsed in 1971. Today in most countries exchange rate of currency is determined based on supply and demand in the market. (Abuaf & Schoess, 1988)

2.2 Growth of Currency Markets

Large financial institutions dominated financial markets for decades. Today, after globalization, everyone can trade in Forex market to buy and sell global currencies.

Currency trade per day was $ 5 billion in 1977. Due to emergence of the Internet, it increased to one trillion dollars in 1992 (Singh, 1997).

2.3 Fundamental and Technical Analysis

2.3.1 Fundamental Analysis

Method of forecasting price changes and market trends by studying related economic, financial, social and other qualitative and quantitative factors.

2.3.2 Technical Analysis

Estimation of future price trends by focusing on past trends, patterns and waves as reasonable predictors. Traders use different types of charts, models and indicators to do this kind of analysis.

2.4 Previous Studies

Oberlechner (2001) studied about forex market traders in four European cities. He found most of them use both of technical and fundamental analysis in forecasting European exchange rates (Oberlechner, 2001).

Lui & Mole (1998) studied about forex market traders in Hong Kong; he found 85% of traders conduct fundamental and technical analysis, for both mid and medium terms (Lui & Mole, 1998).

Kirikos(2012) found naïve model had superiority in forecasting exchange rates before the 2008 financial crisis and has regained a part of its forecasting ability after 2011. The performance of a model in forecasting is affected by presence of financial calmness or turbulence (Kirikos, 2012).

Chapter 3

MODEL, DATA and METHODOLOGY

3.1 Data

The data for this study contains monthly and daily prices on the foreign exchange rate between the Turkish Lira, US dollar and Euro. The data set covers the time interval of June 2011 to June 2013.

3.2 Forecasting Models

The models compared in this thesis are:

1) *Naïve Model*
2) *Moving Averages (M.A)*
3) *Simple Exponential Smoothing*
4) *Time Series Regression*

By using past data, we calculate mean squared error of each model to determine the best model to use.

Steps in calculating the Mean Squared Error (MSE)

Steps 1: collecting data as much as possible

Steps 2: when we have enough data, we use 2nd half of it. When we don't have enough data, we use all of them.

the 1st half is called the *Warm-Up Sample* and 2nd half is called the *Forecasting Sample*.

Steps 3: forecasting error (e_t) for each period is the difference between actual and forecasting data.

MSE = $\frac{\sum e_t^2}{n}$, n: number of error terms.

Steps 5: Best model is the one with smallest MSE.

3.2.1 Naïve Model

The formula is: $F_{t+1} = X_t$

F_t= Forecast in period t

X_t= Actual price in period t

e_t= Forecasting error in period t

$e_t = X_t - F_t$

3.2.2 Moving Averages Model

Moving average (MA) methods are widely used in time series forecasting. In this thesis a moving average of length m where m= 2,3,20 days is used. The reason for selecting 20 is the number of days that market is open in a month.

Formula:

Two- Period M.A Model:

$$\boldsymbol{F_{t+1} = \frac{(X_t + X_{t-1})}{2}}$$

Three- Period M.A Model:

$$\boldsymbol{F_{t+1} = \frac{(X_t + X_{t-1} + X_{t-2})}{3}}$$

n- Period M.A Model:

$$\boldsymbol{F_{t+1} = \frac{(X_t + X_{t-1} + X_{t-2} + \ldots + X_{t-n+1})}{n}}$$

3.2.3 Simple Exponential Model

Formula: $\mathbf{F_{t+1} = F_t + \alpha e_t}$, $0 < \alpha < 1$, α = smoothing parameter

To apply this model, first we need to find F1 and the best value of α

Note:

Usually in most of the books, the possible values of α are 0.1, 0.2, 0.3… 0.9

Important Steps

Step 1: F_1 is equal to the MEAN (average) of the warm-up sample.

If we do not have enough data, F_1 is taken as the MEAN of ALL of the data.

Step 2: To find the Best Value of α, we should calculate MSE by all possible values of α.

The best α value is the one which yields smallest MSE.

3.2.4 Time Series Regression Model

In this method we study exchange rate as a linear function of time.

Exchange rate: dependent variable

Time: independent variable

Formula: $\mathbf{F_t = a + bt}$

$$b = \frac{\sum tX - n\bar{t}\bar{X}}{\sum t^2 - n\bar{t}^2} \qquad a = \bar{X} - b\bar{t}$$

b= slope of the linear trend line

a= intercept of the linear trend line

X= values of dependent variable (exchange rate)

t = values of the independent variable (time)

Least- square formulas utilize past data about dependent and independent variable.

Note: You can start the values of t from any number as long as they are consecutive.

$\overline{X}$ = mean of the X values

$\bar{t}$ = mean of the t values

Important Points

1) If we have enough data, we use only the warm-up sample data for "X" and "t" to get "b" and "a". If we do not have enough data, we use all of the data.

2) First we calculate b and then a.

3) After we calculate b and a, we apply $F_t = a + bt$, on *forecasting sample* to find MSE of the model and obtain forecasts for the future periods.

Chapter 4

RESULTS

4.1 Results for Daily Data

4.1.1 Application of Models on USD/TRY

1) Naïve Model

MSE	3.90438E-05

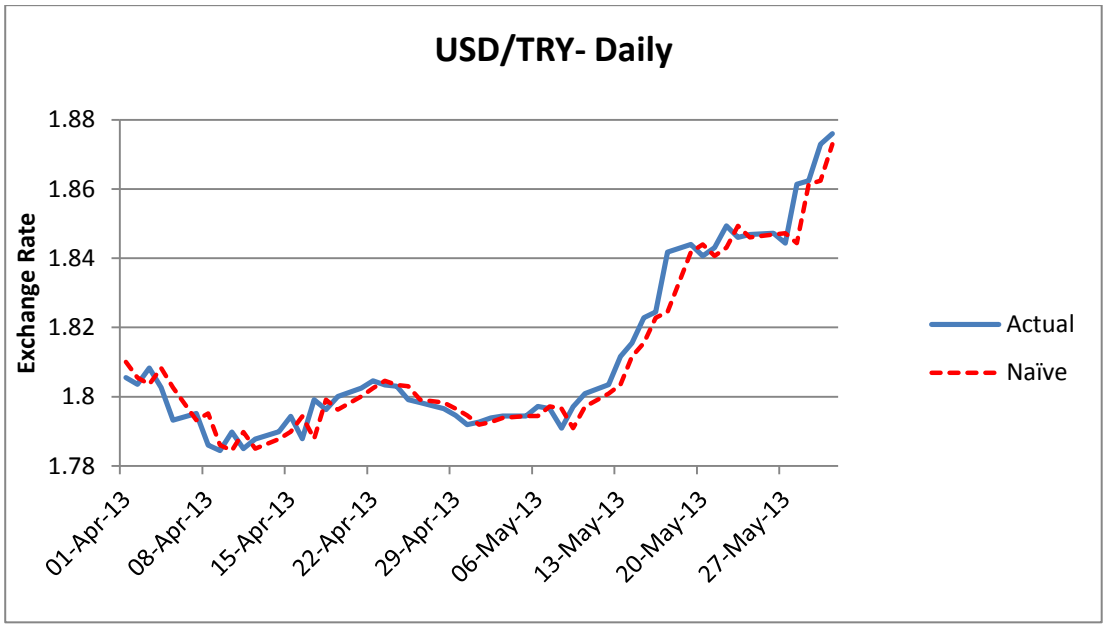

Figure 1. Naïve Model Forecasting Ability

2) Moving Averages Model

Number of periods	MSE
2	4.74196E-05
3	5.75472E-05
20	2.21628E-04

3) Simple Exponential Model

α	MSE
0.1	1.5000E-04
0.2	9.2931E-05
0.3	6.9059E-05
0.4	5.6332E-05
0.5	4.8700E-05
0.6	4.3936E-05
0.7	4.1012E-05
0.8	3.9375E-05
0.9	3.8715E-05

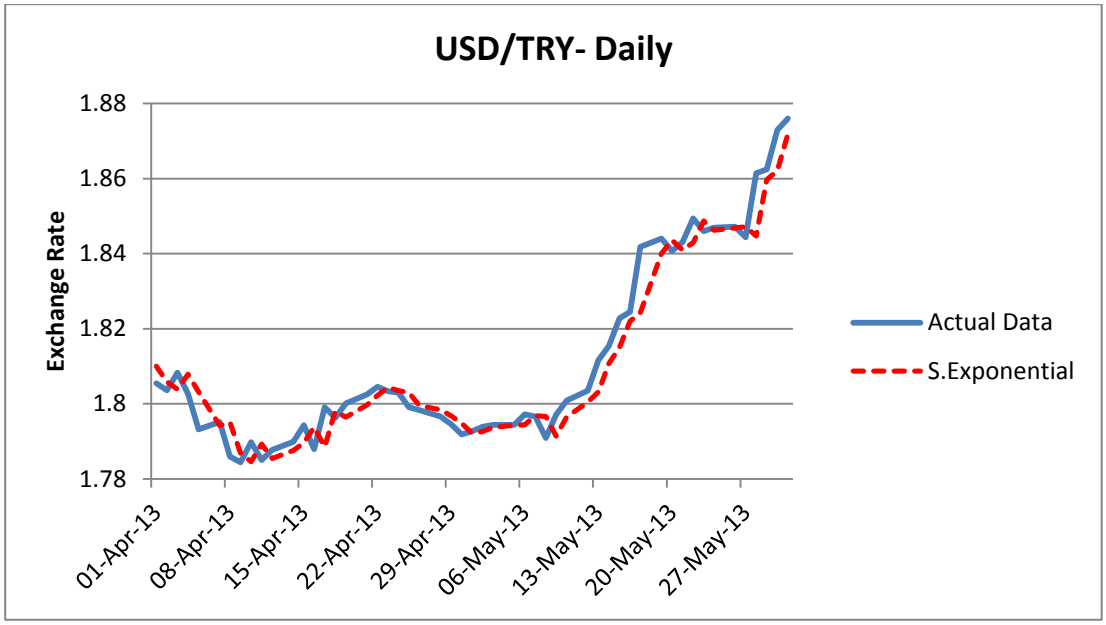

Figure 2. Simple Exponential Model (α=0.9) Forecasting Ability

4) Time Series Regression Model

MSE	0.019622

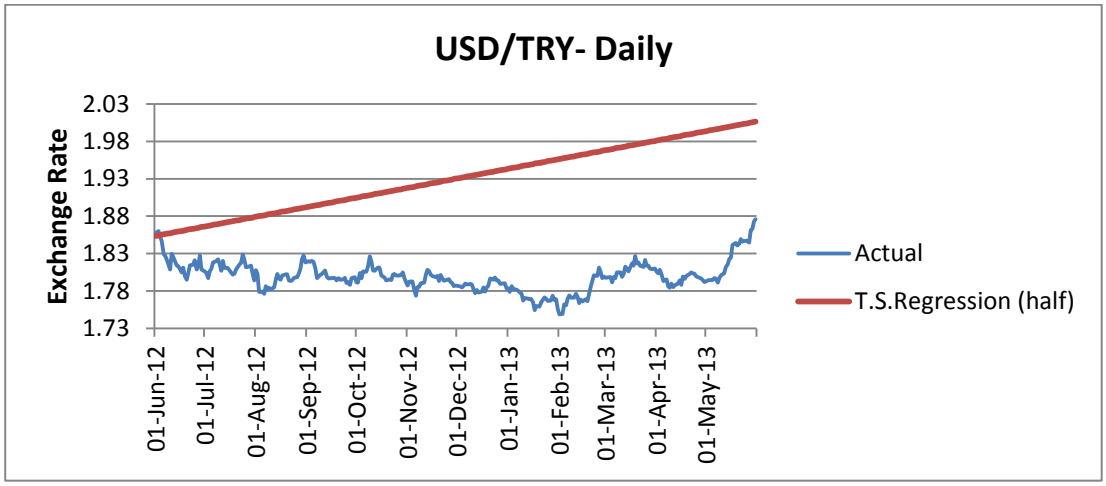

Figure 3. Time Series Regression Model Forecasting Ability

4.1.2 Application of Models on EUR/TRY

1) Naïve Model

MSE	7.98629E-05

2) Moving Averages Model

Number of periods	MSE
2	1.05223E-04
3	1.34244E-04
20	6.15659E-04

3) Simple Exponential Model

α	MSE
0.1	4.58000E-04
0.2	2.44000E-04
0.3	1.71000E-04
0.4	1.35000E-04
0.5	1.14000E-04
0.6	1.00000E-04
0.7	9.13817E-05
0.8	8.54034E-05
0.9	8.17072E-05

4) Time Series Regression Model

Equation	F_t = 2.448944527-0.000289483* t
MSE	0.005383

4.1.3 Application of Models on EUR/USD

1) Naïve Model

MSE	3.06800E-05

2) Moving Averages Model

Number of periods	MSE
2	4.58260E-05
3	5.43680E-05
20	2.24000E-04

3) Simple Exponential Model

α	MSE
0.1	1.65507E-04
0.2	9.06206E-05
0.3	6.64115E-05
0.4	5.45099E-05
0.5	4.76455E-05
0.6	4.34485E-05
0.7	4.09115E-05
0.8	3.95389E-05
0.9	3.90710E-05

4) Time Series Regression Model

Equation	F_t =1.414873925-(0.000387051* t)
MSE	0.006949

4.2 Results for Monthly Data

4.2.1 Application of Models on USD/TRY

1) Naïve Model

MSE	1.36651E-03

2) Moving Averages Model

Number of periods	MSE
2	1.54785E-03
3	1.50116E-03
20	4.46252E-03

3) Simple Exponential Model

α	MSE
0.1	2.22854E-03
0.2	1.98111E-03
0.3	1.83804E-03
0.4	1.69528E-03
0.5	1.56368E-03
0.6	1.45350E-03
0.7	1.36614E-03
0.8	1.29873E-03
0.9	1.24774E-03

4) Time Series Regression Model

Equation	F_t =1.708230769+(0.010018681*B3)
MSE	0.01088

4.2.2 Application of models on EUR/TRY

1) Naïve Model

MSE	2.62610E-03

2) Moving Averages Model

Number of periods	MSE
2	3.52877E-03
3	4.24613E-03
20	7.24945E-03

3) Simple Exponential Model

α	MSE
0.1	6.10969E-03
0.2	5.24057E-03
0.3	4.50551E-03
0.4	3.99567E-03
0.5	3.64637E-03
0.6	3.38700E-03
0.7	3.17907E-03
0.8	3.00754E-03
0.9	2.86926E-03

4) Time Series Regression Model

Equation	$F_t = 2.4744-(0.01222* t)$
MSE	0.011348

4.2.3 Application of Models on EUR/USD

1) Naïve Model

MSE	8.09745E-04

2) Moving Averages Model

Number of periods	MSE
2	7.49718E-04
3	9.07090E-04
20	4.64759E-04

3) Simple Exponential Model

α	MSE
0.1	1.50906E-03
0.2	1.09646E-03
0.3	9.44795E-04
0.4	8.54392E-04
0.5	7.93705E-04
0.6	7.56378E-04
0.7	7.39958E-04
0.8	7.43092E-04
0.9	7.65737E-04

4) Time Series Regression Model

Equation	F_t = =1.448038462-(0.014767033*t)
MSE	0.026799

Chapter 5

CONCLUSION

1- Based on above calculations, in daily time frame, the best models with respect to the smallest MSE are:

Table 1. Comparison of Models in Daily Time Frame

Currency pair	*Rank*	*Model*	*MSE*
USD/TRY	1	Simple Exponential (α= 0.9)	3.8715E-05
	2	Naïve	3.9044E-05
	3	Two-period -Moving Averages	4.7420E-05
	Rank	*Model*	*MSE*
EUR/TRY	1	Naïve	7.9863E-05
	2	Simple Exponential (α= 0.9)	8.17072E-05
	3	Two-period -Moving Averages	1.0522E-04
	Rank	*Model*	*MSE*
EUR/USD	1	Naïve	3.0680E-05
	2	Simple Exponential (α= 0.9)	3.9071E-05
	3	Two-period -Moving Averages	4.5826E-05

2- in monthly time frame, the best models with respect to the smallest MSE are:

Table 2. Comparison of Models in Monthly Time Frame

Currency pair	Rank	Model	MSE
USD/TRY	1	Simple Exponential (α= 0.9)	1.24774E-03
	2	Naïve	1.3665E-03
	3	Three-period - Moving Averages	1.5012E-03
	Rank	Model	MSE
EUR/TRY	1	Naïve	2.6261E-03
	2	Simple Exponential (α= 0.9)	2.86926E-03
	3	Two-period - Moving Averages	3.5288E-03
	Rank	Model	MSE
EUR/USD	1	20-period - Moving Averages	4.6476E-04
	2	Simple Exponential (α= 0.7)	7.3996E-04
	3	Naïve	8.0975E-04

3- Comparison of two, three, twenty-period moving averages and Naïve models shows that if we give more weight to the recent data, we usually have more accurate forecasts.

4- Time Series Regression is not an appropriate model to forecast exchange rate at all (figure3).

5- The ability of time series models in daily time frame is more than in monthly time frame. In daily time frame, Naïve model has the best performance in forecasting EUR/USD exchange rate.

6- As you can see in figures 1and 2, time series models have good performance when the price chart makes a sideways movement (1-5May 2013). But these models are not good predictors in time intervals with high range of fluctuation in price (13-17May 2013). Therefore when there is more stability in the market and less fluctuation in the price, these models have better performance in forecasting exchange rate.

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