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Forecasting Foreign Exchange Rate by using ARIMA Model: A Case of VND/USD Exchange Rate

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Abstract
Forecasting foreign exchange rate is one work that supports to foreign exchange rate risk of commercial joint stock banks in Vietnam. By using real foreign exchange rate data from the first day of 2013 to the last day of 2015, this paper introduces Arima model with four steps to forecast foreign exchange rate between VND/USD in the next twelve months of 2016. After having forecasted foreign exchange data, we compare them with real foreign exchange rate data to check the suitable level of Arima model for forecasting foreign exchange rate in Vietnam and the results show that Arima model is suitable for estimating foreign exchange rate in Vietnam in short-time period.
Keywords: Arima, Exchange Rate, Exchange Rate Forecasting, Stationary.

1. Introduction

Foreign exchange rate is one topic that is interested by board managers of banks. How to forecast foreign exchange rate in the next year is one subject that all managers care when planning. The more accurate the forecast result is, the more effective the plan is. In this paper, by using Arima model with foreign exchange rate VND/USD data from 2013 to 2015, we estimate foreign exchange rate VND/USD in the next twelve months of 2016, whereby try to answer the question "Is Arima model suitable for estimating foreign exchange rate in Vietnam?".

2. Literature Review

Time series forecasting model are based on analysis of historical data. These methods support the assumption that past patterns in data can be used to forecast future data points. There are many researches about forecasting foreign exchange rate was carried out in the world. Until now, there are a lot of forecasting model, each model possesses private strong-point as well as private weak-point, models can be listed as using neutral networks (Verkooijen, 1996), Arima model (Tseng, 2001), (Znaczko, 2013), Least Squared model (Hongxing et al., 2007) or Purchasing Power Parity model and Balassa-Samuelson channel (David et al., 2010).

(Meyler, 1998) used Arima model for forecasting inflation in Irish, (Mondal, 2014) used Arima model for forecasting stock price. Arima is also used for predicting stock price in the research of (Jarrett, 2011), (Adebiyi, 2014), (Isenah, 2014). It is also used for forecasting the price of gold (Guha & Bandyopadhyay, 2016). With object is foreign exchange rate, Arima is also a good solution for prediction, some authors used it for forecasting such as (Appiah & Adetunde, 2011), (Nwankwo, 2014), (Tlegenova, 2014).

After examining the results of these studies above, we decide to choose Arima model as the main methodology for forecasting foreign exchange rate between Vietnam Dong and US Dollar. There are two issues that we used in our research:

Arima model: Arima model is one method for forecasting time series, it is assumed that past value of the series plus previous error terms contain information for the purpose of forecasting. The main advantage of Arima forecasting is that it requires data on time series in question only. However, Arima model are essentially backward looking, they are generally poor at predicting turning points, unless the turning point represents a return to a long-run equilibrium (Meyler et al., 1998).

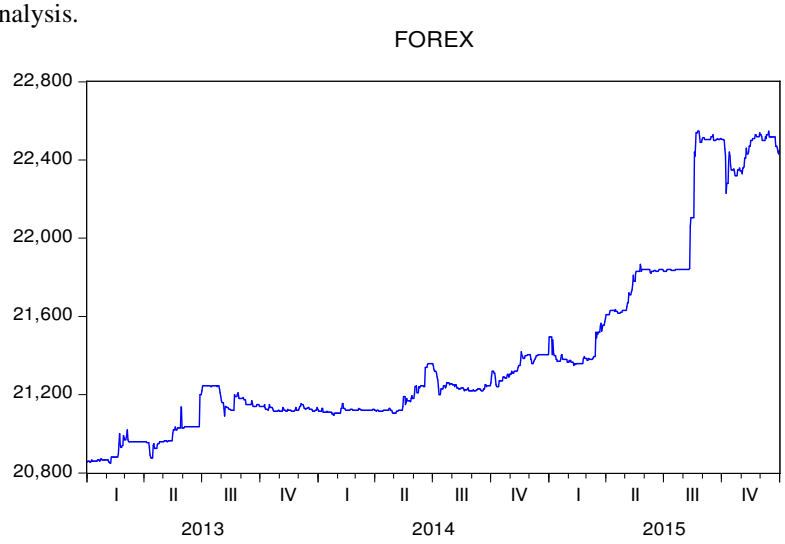
Exchange rate forecasting: Exchange rate forecasting means estimating the rate which will be any of future time.

3. Data and Methodology

3.1. Data

The most important purpose of this research is serving foreign exchange business of commercial joint stock banks in Vietnam, therefore time-series that we choose for research is denoted FOREX, this is monthly selling foreign exchange rate VND/USD of Commercial Bank for Foreign Trade of Vietnam - one bank with a long standing reputation in foreign exchange business in Vietnam. We could see here the data of monthly exchange rate of VND/USD from the beginning of 2013 till the end of 2015, total 60 observations, in which the highest value of foreign exchange rate VND/USD is in October of 2015 and the lowest is in January of 2013. The curve of VND/USD rate shown below tells the history of exchange rate VND/USD in Vietnam. From 2013 to 2015, 1 United State dollar was almost around 19.500 to 22.500 Vietnam dong. The rate went down in the second and third quarter of each year and went up at the beginning and in the last months of each year. In generally, we see

that an chronological increment of foreign exchange rate VND/USD. We use linear time series analysis as one tool for empirical analysis.



3.2. Methodology

Arima model is used as the main methodology of this research. Arima can be fully written as Autoregressive Integrated Moving Average. This model was showed in publish by Box and Jenkins in 1970. Arima is constructed by three parts: AR (autoregressive part), I (integrated part), MA (moving average part) first show in publish. In order to estimate Arima model, we have to do 4 steps as follow: Recognizing model, estimating variables and choosing model, testing model and forecasting (Gujarati, 2014).

Step 1: Recognizing model

As introduced above, Arima model includes 3 parts. Let's denote AR (autoregressive part) is p, I (integrated part) is d, MA (moving average part) is q, the new have Arima (p, d, q). In order to apply Arima model, we have to define p, d, q first.

Integrated part of the model can be defined by stationary test of a time-series. If the time-series integrate at level 0, we have I(d=0). If the time-series integrate at level 1, we have I(d=1). Or if the time-series integrate at level 2, we have I(d=2). The popular method is used for stationary test is Dickey-fuller.

After stationary test, we define p and d by using autocorrelation function (ACF) and partial correlation function (PACF).

With moving average part (q), we have equation:

$$Y_t = \mu + \gamma_0\mu_t + \gamma_1\mu_{t-1} + \gamma_2\mu_{t-2} + \ldots + \gamma_q\mu_{t-q} \quad (1)$$

If time-series belongs to type MA, the coefficients of ACF have statistical meaning from 1 to q and the values decrement quickly to 0. With PACF, partial coefficients will also decrement to 0.

With autoregressive part (p), the relationship between past values and present values is shown through the equation below:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_p Y_{t-p} \quad (2)$$

If time-series belongs to type AR, the coefficients of PACF have statistical meaning from 1 to p and the values decrement quickly to 0. With ACF, partial coefficients will also decrement to 0.

Combining (1) and (2) to form Arima model:

$$Y_t - \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_p Y_{t-p} + \gamma_0\mu_t + \gamma_1\mu_{t-1} + \gamma_2\mu_{t-2} + \ldots + \gamma_q\mu_{t-q}$$

Step 2: Estimating variables and choosing model

All variables of Arima model will be estimated by Eview software. The process of choosing model is the process of comparing adjusted r-squared and p-value of models until having the best model with p-value of each variables are smaller than 0.05. This model is the best model for forecast.

Step 3: Testing model

In order to guarantee the coherence of Arima model, the error of this model have to be white noise. We can use autocorrelation function or Breusch-Godfrey test to check autocorrelation of errors. We use White test to check whether the residual variance of a errors in this model is constant. If any result is not meet the requirement, such as there is autocorrelation between errors or error of this model is not white noise, then we have to do step 2 again.

Step 4: Forecasting

After step 3, if model is suitable, we continue forecasting. Arima model will be:

$$Y_{t+1} = \beta_0 + \beta_1 Y_t + \cdots + \beta_p Y_{t-p+1} + \gamma_0 \mu_{t+1} + \gamma_1 \mu_t + \ldots + \gamma_q \mu_{t-q+1}$$

4. Results and Findings

As analyzing above, foreign exchange rate VND/USD in Vietnam will be forecasted by Arima model following 4 steps

4.1. Recognizing model

First, stationary test is done by using Dickey-Fuller test. This time, we just focus on one center variable, this is foreign exchange rate data in the past, named FOREX. The null hypothesis is still "FOREX has a unit root" and on the opposite area we have alternative hypothesis is "FOREX does not have a unit root".

The result shows that absolute value of augmented Dickey-Fuller test statistic smaller than absolute value of test critical at 5% and p-value is larger than 5%, therefore rejecting the null hypothesis, accepting alternative hypothesis that FOREX does not have unit root.

In order to meet the requirement of Arima model, FOREX must have unit root. The solution for this problem is to take first difference of FOREX, we have D(FOREX). Doing Dickey-Fuller test again, the result shows that absolute value of augmented Dickey-Fuller test statistic larger than absolute value of test critical at 5% and p-value is smaller than 5%, therefore D(FOREX) is stationary time-series, is suitable for research.

Null hypothesis: Variable has a unit root Alternative hypothesis: Variable does not have unit root					
		FOREX		D(FOREX)	
		t-Statistic	Prob.*	t-Statistic	Prob.*
Test critical values		0.504288	0.9869	-10.37291	0.0000
ADF test statistic	1% level	-3.436111		-3.436149	
	5% level	-2.863972		-2.863989	
	10% level	-2.568116		-2.568125	
*MacKinnon (1996) one-sided p-values.					

After taking first difference, D(FOREX) is stationary, we have d = 1

Next, we use correlation graph. Looking at Autocorrelation and Partial correlation function, with the confidence level is 95%, D(FOREX) is autocorrelation at lag 2 and 7 or we have AR(2, 7), D(FOREX) is Partial correlation at lag 2, 7 and 34, means we also have MA(2, 7, 34) for estimating.

Lag	AC	PAC	Q-Stat	Prob
1	-0.007	-0.007	0.0545	0.815
2	0.067	0.067	4.9525	0.084
3	0.001	0.002	4.9530	0.175
4	-0.045	-0.049	7.1472	0.128
5	-0.047	-0.048	9.5628	0.089
6	0.041	0.048	11.452	0.075
7	0.167	0.176	42.159	0.000
8	0.010	0.006	42.265	0.000
9	0.013	-0.018	42.456	0.000
10	0.010	0.009	42.575	0.000
11	0.010	0.033	42.682	0.000
12	0.031	0.049	43.747	0.000
13	0.012	-0.006	43.900	0.000
14	-0.007	-0.046	43.957	0.000
15	-0.029	-0.032	44.912	0.000
16	-0.031	-0.022	45.956	0.000
17	-0.006	-0.001	45.999	0.000
18	-0.008	-0.017	46.071	0.000
19	0.005	-0.017	46.095	0.000
20	0.011	0.006	46.218	0.001
21	-0.031	-0.023	47.316	0.001
22	-0.007	0.003	47.365	0.001
23	-0.009	0.002	47.464	0.002
24	0.007	0.010	47.515	0.003
25	0.019	0.025	47.939	0.004
26	-0.003	-0.002	47.946	0.005
27	-0.001	-0.002	47.947	0.008
28	-0.041	-0.029	49.810	0.007
29	-0.038	-0.036	51.458	0.006
30	0.008	0.015	51.535	0.009

31	-0.015	-0.016	51.802	0.011
32	-0.028	-0.044	52.656	0.012
33	-0.003	-0.010	52.667	0.016
34	0.045	0.054	54.974	0.013
35	0.012	0.032	55.129	0.016
36	-0.024	-0.029	55.778	0.019

4.2. Estimating variables and choosing model

To find the most suitable model, we have to compare P-value of each model at correlative lags.
First, we estimation model according to result of task 1, model 1 will be:

$$D(FOREX) = \alpha + \beta_1 AR(2) + \beta_2 AR(7) + \beta_3 MA(2) + \beta_4 MA(7) + \beta_5 MA(34)$$

After once time of estimation, based on P-value of independent variables, we form new model by take variable that has largest P-value away, then estimation regression model again until all variables have P-value smaller than 0.05 and we can find the best model for forecasting. By this way, independent that have P-value larger than 0.05 is deleted in order as follow:
Estimating D(FOREX) according to AR(2, 7) and MA(2, 7, 34)

First model:

$$D(FOREX) = \alpha + \beta_1 AR(2) + \beta_2 AR(7) + \beta_3 MA(2) + \beta_4 MA(7) + \beta_5 MA(34)$$

Variable	Pro.F	R-squared
α	0.0529	0.038103
$AR(2)$	0.1996	
$AR(7)$	0.3573	
$MA(2)$	0.0490	
$MA(7)$	0.8352	
$MA(34)$	0.1023	

↓Take $MA(7)$ away

Second model:

$$D(FOREX) = \alpha + \beta_1 AR(2) + \beta_2 AR(7) + \beta_3 MA(2) + \beta_5 MA(34)$$

Variable	Pro.F	R-squared
α	0.0710	0.038090
$AR(2)$	0.1459	
$AR(7)$	0.0000	
$MA(2)$	0.0295	
$MA(34)$	0.0965	

↓Take $AR(2)$ away

Third model:

$$D(FOREX) = \alpha + \beta_2 AR(7) + \beta_3 MA(2) + \beta_5 MA(34)$$

Variable	Pro.F	R-squared
α	0.0882	0.036716
$AR(7)$	0.0000	
$MA(2)$	0.0029	
$MA(34)$	0.1285	

↓Take $MA(34)$ away

Fourth model:

$$D(FOREX) = \alpha + \beta_1 AR(2) + \beta_4 MA(4) + \beta_5 MA(5) + \beta_6 MA(6) + \beta_7 MA(7) + \beta_8 MA(12)$$

Variable	Pro.F	R-squared
α	0.0741	0.034549
$AR(7)$	0.0000	
$MA(2)$	0.0040	

After comparing R-squared and P-value of all six models, we recognize that sixth model is the best model for forecasting. To find the most suitable model, we have to compare adjusted r-squared of each model at correlative lags.

4.3. Testing Model

One model is suitable for forecasting when its residual is stationary. To check this requirement, we use Q-statistic and the result is given as follow:

Lag	AC	PAC	Q-Stat	Prob
1	-0.017	-0.017	0.3089	
2	-0.005	-0.005	0.3360	
3	0.015	0.015	0.5747	0.448
4	-0.053	-0.052	3.6261	0.163
5	-0.069	-0.071	8.8499	0.031
6	0.047	0.044	11.237	0.024
7	0.007	0.009	11.286	0.046
8	0.012	0.012	11.449	0.075
9	0.005	-0.003	11.478	0.119
10	0.007	0.007	11.535	0.173
11	0.020	0.027	11.955	0.216
12	0.043	0.045	13.983	0.174
13	0.004	0.007	14.000	0.233
14	-0.033	-0.034	15.197	0.231
15	-0.032	-0.031	16.297	0.233
16	-0.029	-0.024	17.226	0.244
17	-0.006	-0.002	17.270	0.303
18	-0.013	-0.020	17.443	0.357
19	0.003	-0.007	17.451	0.424
20	0.010	0.005	17.563	0.485
21	-0.025	-0.025	18.231	0.507
22	0.004	0.003	18.245	0.571
23	-0.007	-0.010	18.300	0.630
24	0.011	0.013	18.430	0.680
25	0.028	0.030	19.328	0.682
26	-0.000	0.003	19.328	0.734
27	-0.010	-0.005	19.450	0.775
28	-0.041	-0.041	21.350	0.724
29	-0.033	-0.030	22.570	0.708
30	0.024	0.025	23.201	0.723
31	-0.009	-0.012	23.299	0.763
32	-0.031	-0.039	24.376	0.755
33	-0.005	-0.017	24.407	0.794
34	0.047	0.050	26.925	0.721
35	0.019	0.028	27.351	0.744
36	-0.018	-0.026	27.727	0.768

Through the result table above, although residual still have P-value larger than 0.05 at lags 4 and 5, however, they are not too large. To be affirm that the fourth model is the most suitable model for forecasting, we test residual by ADF test.

Null hypothesis: Residual has a unit root Alternative hypothesis: Residual does not have unit root			
		t-Statistic	Prob.*
Test critical values		-33.46941	0.0000
ADF test statistic	1% level	-3.436154	
	5% level	-2.863991	
	10% level	-2.568126	
*MacKinnon (1996) one-sided p-values.			

Residual of the fourth model is stationary, means this model is a suitable model for forecasting.

4.4. Forecasting

The graph illustrates one continuous increasing of foreign exchange rate from January, 1st, 2016 to the end of this year. Specifically, daily forecasting rate is listed as follow:

Foreign exchange rate VND/USD			
Date	Forecasted rate	Real rate	Different level
2016/01/01	22442.15	22450.00	7.85
2016/01/02	22445.15	22450.00	4.85
2016/01/03	22446.34	22450.00	3.66
2016/01/04	22445.80	22470.00	24.20
2016/01/05	22443.53	22435.00	-8.53
2016/01/06	22442.99	22440.00	-2.99
2016/01/07	22447.65	22470.00	22.35
2016/01/08	22447.48	22440.00	-7.48
2016/01/09	22449.19	22440.00	-9.19
2016/01/10	22450.59	22440.00	-10.59
2016/01/11	22451.69	22420.00	-31.69
2016/01/12	22452.49	22380.00	-72.49
2016/01/13	22453.59	22385.00	-68.59
2016/01/14	22455.59	22410.00	-45.59
2016/01/15	22456.76	22390.00	-66.76
2016/01/16	22458.25	22390.00	-68.25
2016/01/17	22459.68	22390.00	-69.68
2016/01/18	22461.07	22350.00	-111.07
2016/01/19	22462.40	22385.00	-77.40
2016/01/20	22463.78	22385.00	-78.78
2016/01/21	22465.32	22365.00	-100.32
2016/01/22	22466.72	22360.00	-106.72
2016/01/23	22468.17	22360.00	-108.17
2016/01/24	22469.61	22360.00	-109.61
2016/01/25	22471.05	22320.00	-151.05
2016/01/26	22472.47	22290.00	-182.47
2016/01/27	22473.90	22220.00	-253.90
2016/01/28	22475.36	22215.00	-260.36
2016/01/29	22476.80	22165.00	-311.80
2016/01/30	22478.24	22165.00	-313.24

According to the result of forecasting, foreign exchange rate VND/USD of 2016 tends to increase, this rate at the beginning of the year increases 4.4% in compare with the same time period of 2015. Looking backward the increasing rate of foreign exchange rate VND/USD from January, 2013 to January, 2014 is just 1.3% and from January, 2014 to January 2015, is just 1,8%, forecasting result shows that the foreign exchange rate VND/USD in 2016 increases with higher speed than in the past. One comparison increasing rate of foreign exchange rate VND/USD between two continuous months of 2016, the result shows a steady increasing with rate around 0,15%.

4.5. Is ARIMA model suitable for forecasting foreign exchange rate in Vietnam?

By using ARIMA model, we can forecast foreign exchange rate, the result shows in part 4.1.3.1 as above, however, one important target that this research aim is answer the question "Can ARIMA model give the approximate forecast value for foreign exchange rate in Vietnam?". In order to answer this question, we compare forecast value of foreign exchange rate VND/USD with the real foreign exchange rate VND/USD in time period of January, 1st, 2016 to March, 31th , 2016. The different value between forecast value and real value gives evidence that ARIMA model is suitable for forecasting foreign exchange rate just in short time period, not in long time period. Forecasting less than 15 days, the distance between two rates is small. Vice verse, forecasting more than 15 days, the distance between two rate increases. However, in business of commercial joint stock banks force them to give good plan for both short time and long time. Solving this problem, in order to give good plan, we propose one way for forecasting, by this way, ARIMA model still be applied, however, the forecast rate of tomorrow will be used as the real rate for forecasting rate of the day after tomorrow.

5. Conclusion

This research examines applied ability of Arima model in forecasting foreign exchange rate in Vietnam, in case of foreign exchange rate between Vietnam Dong and United State Dollar. The results show that Arima model is absolutely suitable for forecasting. The policy makers should apply Arima model in forecasting foreign exchange

rate in Vietnam. Specially, in foreign exchange business of the commercial joint stock banks in Vietnam, the financial planners should apply Arima model in forecasting as well as care the results of forecasting in measuring foreign exchange rate risk in order to make more benefit for their bank.

The forecasting results of our model show that foreign exchange rate VND/USD in 2016 tends to increase. In foreign exchange business, gain/loss from foreign exchange business depends on foreign exchange rate fluctuation and foreign currency position (Long, 2010). In condition of foreign exchange rate increase, one commercial joint stock bank will get gain in foreign exchange business if this commercial joint stock bank sustains long foreign currency and vice versa. According to forecasting results of this research, foreign exchange rate VND/USD increase continuously, therefore the managers of the commercial joint stock banks in Vietnam should care about this result and maintain long foreign currency position in foreign exchange business.

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