The Comparative Analysis

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The Comparative Analysis between Real Variable and Monetary Approach in Estimating and Forecasting Foreign Exchange Rate of Rupiah

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Abstract:

This paper aims to compare forecasting foreign exchange rate between real variable approach and monetary approach. Estimation model of ECM is used to estimate and forecast through those approaches. Completing the comparison, We also involve estimating and forecasting through adaptive expectation, we run ARIMA model to estimate and forecast real exchange rate. We utilize data of Indonesia in 1979 – 2000 to estimate the models. Parameter resulted is used to forecast (*ex post*) real exchange rate in interval 2001-2009. Empirical analysis shows that ARIMA's prediction trend follows nearest the actual. The analysis supports the fact which is provide by step by step forecasting and explain that ARIMA outperform than others in 1st three years (2001-2003), the 2nd (2004-2006), the 3rd (2007-2009), and all of nine years horizon forecasting. It also shows that MON consistently outperforms REAL. One of interesting points, REAL outperforms all method in the longer observation (all observation in estimating parameters).

Keywords: adaptive expectation; ARIMA; ECM.

JEL Classification: C53; F31; O24.

Introduction

There are some approaches to estimate foreign exchange rate. Most of them are divided to be two approaches in rational expectation. One is based on monetary approach and other is using real variable approach.

There is a long story in evolution in monetary approach. It tells that most of the researchers were not satisfied using the model (Neely, and Sarno 2002). This result can be concluded from long history since the basic model till using data generating process or GDP. On the other hand, estimating foreign exchange of the currency using real variable can be one of phenomena in estimating the currency. Most of them were using trade balance approach.

Estimating using real variable was carried out by Bergvall (2004) with concerning in long run co movement among real exchange rate, relative labor productivity, the trade balance, and term of trade. He intended that using this approach outperform while using PPP hypothesis all movement in real exchange rate are transitory. Bergval was also deepening his research by adding impact from supply and demand factors that effect on real exchange rate determination.

Bergvall (2004) resulted that a country with faster relative output growth per unit of labor input in the tradable sector, trade deficits or improved terms of trade should experience a real appreciation. The empirical analysis resulted that most of the variables important in long run co movement with real exchange rate. With four country sample, the research concluded that exogenous terms-of-trade shocks are found to be the most important determinants of long-run in Denmark and Norway. While for the Finland, most of the long-run variance in the real exchange rate is due to demand shocks. For Sweden, most of the long- run variance is due to demand shocks, although supply and exogenous terms-of- trade shocks also have a substantial influence on the long-run variance in the real exchange rate.

In the earlier research, Lane, and Milesi-Faretti (2002) explored the relation among variables such as net foreign assets and the trade balance to the real exchange rate. It focused on sample OECD country economies in 1970-1998 by selecting the group of countries whose data had higher quality. Through controlling other determinants, the research captured negative relationship between trade balance and real exchange rate. Moreover, magnitude of the coefficient is

increasing in country size and it proved direct evidence that the relative price of non-tradable co-move with the trade balance even controlling for relative sectoral productivity.

On Monetary approach, Neely, and Sarno (2002) had reviewed the evolution of the research of exchange rate estimation and forecast through the way. The monetary approach to exchange rate determination emerged as the dominant exchange rate model at the outset of the recent float in the early 1970s and remains an important exchange rate paradigm. This paper also reviewed research finding which was carried out by Meese, and Rogoff (1983). They found that monetary models' forecasts could not outperform a simple no-change forecast was a devastating critique of standard models and marked a watershed in exchange rate economics. Moreover, even with the benefit of 20 years of hindsight, evidence that monetary models can consistently and significantly outperform a naïve random walk is still elusive.

This paper has purpose to compare estimation and forecasting foreign exchange rate between real variable approach and monetary approach. Completing the comparison, we also involve estimating and forecasting through adaptive expectation. These approaches are carried out in Indonesia by estimating and forecasting bilateral foreign exchange rate between domestic currency and US dollar.

The rest of this paper has structure as follows. Section II explains theoretical framework that discuss real variable approach, monetary approach, and adaptive expectation. Section III describes the methodology carried out to analyze the real exchange determination and compare the accuracy among three methods. Section IV reports results of the data analysis, the estimation, and the forecasting. Some conclusions are reported in the last section.

1. Real Variable Approach

Bergval (2004) assumed that the world consist two countries domestic and partner country, the domestic country is a small country relative to the partner (rest of the world). He also divides goods to be tradable and non tradable. The tradable goods consists imported goods and domestically produced goods. Based on the assumptions, Bergvall derived function equation of determination to real exchange rate.

$$q = \left(\frac{n\varpi^{n\varpi}(1-\varpi)^{n(1-\varpi)}}{n^n} \right) \bullet \left(\left(P_t^T\right)^{\gamma} \frac{y^T y^{N*}}{y^N y^{T*}} \left(\frac{\left(\frac{IM_t}{EX_t}\right)}{\varpi + \frac{(1-\varpi)}{P_t^T}} \right)^{1-\gamma} \right)^{n-1} \bullet \left(P_t^T\right)^{-n(1-\varpi)} \qquad (1)$$

According to the equation (1), the function constructed by Bergval (2004), the effects of variables such as the ratio of imports to exports (im-ex), relative GDP per number of employees domestic to foreign country (y-y*) and the real price of oil (oil) on the real effective exchange rate (q) can be hypothesized with the sign like the function below where the expected sign is given in parentheses:

$$\underset{(-)}{q_t} = f\left(\underset{(+/-)}{(y-y^*)}, \underset{(-)}{oil}, \underset{(+/-)}{(im-ex)}\right) \qquad (2)$$

It mean that when the ratio of imports to exports (im-ex) or relative GDP per number of employees (y-y*) from domestic country increase so it will create appreciation of domestic currency. The sign of oil can be positive or negative because its effect depends on the characteristic of the country to the resources.

2. Monetary Approach

In Neely, and Sarno's literature review (2002), the paper tell that the seminal work use monetary model was conducted by Meese, and Rogoff (hereafter MR) in 1983. MR use some relative variables of domestic to foreign like domestic money supply (m), output (y), interest rate (i), expected inflation (π), and the trade balance (tb) to predict the exchange rate. The basic prediction equation of MR follows the equation below:

$$S_{t+k} = a_0 + a_1(m_t - m^*_t) + a_2(y_t - y^*_t) + a_3(i_t - i^*_t) + a_4(\pi_t - \pi^*_t) + a_5 tb_t + a_6 tb^*_t + \upsilon_t \qquad (3)$$

But the model has many problems. An important problem is the explanatory variables are all endogenous variables. Hence, it can result simultant bias parameter. Finally the seminal work of MR showed that the monetary model cannot outperform than a no-change forecast in predict exchange rate.

To resurrect the monetary approach Mark and other researchers focused the deviation of exchange rate to combination of relative money and relative output. Later is called the fundamental value of exchange rate.

$$f_t = \left[\left(m_t - m^*_t\right) - \left(y_t - y^*_t\right)\right] \quad (4)$$

Based on the theory, Rapach, and Wohar (2002) explicitly write that a long-run or steady-state model of exchange rate determination follows the equation:

$$e_t = \left(m^*_t - m_t\right) - \alpha\left(y^*_t - y_t\right) \quad (5)$$

Where $\alpha > 0$, e_t is the nominal exchange rate measured in the number of units of foreign currency per unit of domestic currency. Most recent prediction equations of exchange rate in monetary approach are based on this fundamental value.

3. Adaptive Expectation

This approach states that change ($X^e_{t+1} - X^e_t$) in next expectation of variable X has certain proportion to the error made the last expectation ($X_t - X^e_t$). Mathematically (Hill et al, 1997; Pindyck and Rubenfeld, 1998), it has equation:

$$(X^e_{t+1} - X^e_t) = (1-\lambda)(X_t - X^e_t) \quad (6)$$

Through mathematical engineering, the equation evolutes step by step follows:

$X^e_{t+1} = (1-\lambda)X_t + \lambda X^e_t$

$X^e_{t+1} = (1-\lambda)X_t + \lambda(1-\lambda)X_{t-1} + \lambda^2 X^e_{t-1}$

$X^e_{t+1} = (1-\lambda)X_t + \lambda(1-\lambda)X_{t-1} + \lambda^2(1-\lambda)X_{t-2} + \lambda^3 X^e_{t-2}$

$X^e_{t+1} = (1-\lambda)X_t + \lambda(1-\lambda)X_{t-1} + \lambda^2(1-\lambda)X_{t-2} + \lambda^3(1-\lambda)X_{t-3} + \lambda^4 X^e_{t-3}$

$X^e_{t+1} = (1-\lambda)(X_t + \lambda X_{t-1} + \lambda^2 X_{t-2} + \lambda^3 X_{t-3} \quad .\lambda^i X_{t-i})$ (7)

We can see from the equation above that larger lag included in the equation smallest proportion to the expectation of the next value of variable since $0 < \lambda < 1$.

Hence, the simple function equation:

$X^e_{t+1} = f(X_t, X_{t-1}, X_{t-2}, X_{t-3} \quad X_{t-i})$ (7)

When we expect real exchange rate (RE) then:

$RE^e_{t+1} = f(RE_t, RE_{t-1}, RE_{t-2}, RE_{t-3} \quad RE_{t-i})$

or

$RE^e_t = f(RE_{t-1}, RE_{t-2}, RE_{t-3}, RE_{t-4} \quad RE_{t-i})$ (8)

Technically, we can carry out estimate the expectation through regressing the variable by its variable itself (autoregressive regression). Though trial and error, we can add more and more lag (autoregressive distributed lag) then we can select the most efficient equation by selection criteria statistic. This approach is used to get most parsimony model.

Other alternative, we can run ARIMA model to estimate and forecast real exchange rate. Before we detect the order AR and MA, we should ensure stationarity of the variable. When the variable has no I(0) we can differentiate to achieve the order integration. To detect the order of RA and MA, we can use ACF and PACF. We make sure that the best model whose plots of ACF and PACF from residuals of model ARIMA (p,q,r) not significantly out of the bound of the SE.

4. Method

The purpose of the paper is to examine comparative analysis between two approach estimation. The one is estimate real exchange rate through real variable approach and the other is using monetary variable approach. Completingthe comparison, it also estimates the exchange rate through adaptive expectation.

This empirical analysis is based on the equation (2), (5), and (8). Where equation (2) explains a function in a function in real variable approach, (5) is a function in monetary approach and (8) is a function in adaptive expectation. The Three econometric models which can be drawn from the equations are:

$RE_t = \alpha_0 + \alpha_1 RGDPEM_t + \alpha_2 OIL_t + \alpha_3 RXM_t + \varepsilon_{1t}$ (9)

$RE_t = \beta_0 + \beta_1 RMS + \beta_2 RGDP + \varepsilon_{2t}$ (10)

$RE_t = \gamma_0 + \gamma_1 RE(-1) + \gamma_2 RE(-2) + \quad \gamma_i RE(-i)\ \varepsilon_{3t}$ (11)

Where:

RE: real exchange rate (Rp/US$)

RGDPEM: relative ratio of GDP to number employment between Indonesia to US,
OIL: crude oil price in average and constant price
RXM: export to import ratio
RMS: relative real money supply between Indonesia to US
RGDP: relative real GDP between Indonesia to US

The estimation use data annualy time series, 1979-2009. Relative data of the variable has proxy US data since US is a major partner in international trade of Indonesia.The data such as GDP, money supply, price index, exchange rate, employment, and export import can be retrieved from IFS (little part of them got form BPS Indonesia and BI). List of crude oil price sourced from U.S. Department of Energy, Energy Information Administration. Most of them are derived to real or constant price.

Dynamic OLS model such as ECM is used to estimate and forecast real exchange rate in real variable and monetary approach. Completing process before estimation, it needs test statistic to evaluate behavior the data. Unit root stationary test is conducted to see whether the data is stationer or not. This test is needed to avoid spurious regression while the data is not stationer (Gujarati 2004). In line with the ECM, it is also carried out Johansen Cointegration test. The last test is needed as necessary condition to do ECM estimation.

In estimating parameter in the three equations, the paper use data interval in 1979-2000. Parameter resulted is used to forecast (*ex post*) real exchange rate in interval 2001-2009. Through this way, we can compare the accuracy of three estimation parameter in forecasting. We can use Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE) to measure the best forecasting among the three estimation parameter.

5. Results and Discussion

Based on (9) and (10) estimation model for real variable (REAL) and monetary approach (MON), we can select functional form of both model. Conducting MacKinnon, White, and Davidson (MWD) test we can examine to choose the best form model between linear and log-linear model (Gujarati 2004). After conducting MWD test for both model, it results that log-linear model is outperform linear. This result is based on significantly Z1 and not for Z2 for both models. So all variable will used in the model is log values of the variable.

5.1. Data Analysis

The data used annually time series in interval 1980-2009. According the result test explained Table 1, most variables has unit root. Only LRXM and LRGDP is stationer in level (denoted as I(0)). To evaluate data that integrate in certain degree, sequence test is conducted test of integration degree. The test result that all the variable integrated in 1 degree. It show that the variable will stationer when it difference once or denote has I(1).

Table 1. Stationary Test

Var	LOIL		LRE		RXM		LRGDPEM		RMS		RGDP	
Result	Sig	Lag	Sig	Lag	Sig	Lag	Sig	Lag	Sig	Lag	Sig	Lag
N	U Root	0	U Root	0	*	0	U Root	0	U Root	1	U Root	0
C	U Root	0	U Root	0	*	0	U Root	0	U Root	0	***	12
C+T	U Root	0	U Root	0	*	0	U Root	0	U Root	12	U Root	12

Note: N, C, C+T: sequential are ADF test using no constant and trend, constant, constant and intercept; U Root: the data has unit root or not stationer; Lag: number of efficient lag used in ADF test; ***, **, *: significance level of rejection H0 where the H0 is having unit root.

Table 2. Integration Test

Var	D(LOIL)		D(LRE)		D(LRMS)		D(LRGDPEM)	
Result	Sig	Lag	Sig	Lag	Sig	Lag	Sig	Lag
N	***	0	***	0	**	0	***	0
C	***	0	***	0	*	0	***	0
C+T	***	1	***	0	U Root	12	**	0

Using Johansen Cointegration Test, It results that variables involved in real variable (LRE = f(LRGDPEM, LOIL, LRXM)) and monetary approach (LRE = f(LRMS,LRGDP)) cointegrates. It means that the variables in models have linear combination or has long run relationship. This long run relationship is needed as precondition to carry out ECM estimation.

5.2. ECM Estimation for REAL and MON

Using basic estimation in static model in equation (9) and (10) we can derived ECM model equation. Because not all variable in the model has I(0) so we just can estimate ECM in Domowitz and Badawi equation Model. The result has ECT sign expected and coefficient significantly influence dependent variable. It shows that variables in the model cointegrate and the model specified well. With the adjusted sample 1982-2000, both estimations have result as shown in Table 3 and 4.

Table 3. Short Run and Long Run Coefficient of ECM EstimationLog Real Exchange Rate with Real Variable

Variable	ShortRun	Long Run
C	0	9.0747
LOIL	0	-0.5464
LRGDPEM	0	0.2736
LRXM	0	1.1444

Note: Coefficient show while significant at 1%, 5%, and 10% except in the long run.

Table 4. Short Run and Long Run Coefficient of ECM Estimation Log Real Exchange Rate through Monetary Approach

Variable	ShortRun	Long Run
C	16.8722	18.1992
LRMS	0.9497	0.7674
LRGDP	-4.0568	-2.4464

5.3. Adaptive Expectation Estimation

Because LRE is not stationer so the adaptive expectation cannot run. We can use Autoregressive Integrated Moving Average (ARIMA) to resolve the problem. After identification process through ACF and PACF analysis for once difference, we got that the variable should be estimated using ARIMA (1,2,2). The result is shown in Table 5.

Before accomplishing the parameter, earlier we examine residual of the model ARIMA (1,2,2). Since the residual is stationer and none of autocorrelation and partial autocorrelation is individually statistically significant, we need not to look for another ARIMA model (Gujarati 2004:847).

Table 5. Estimation Real Exchange Rate through ARIMA

Dependent Variable: D(LRE)				
Sample: 1982 2000				
Included observations: 19				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.066536	0.049018	1.357397	0.1935
AR(2)	-0.64828	0.876186	-0.73988	0.4701
MA(2)	0.547448	0.940294	0.582209	0.5685
R-squared	0.030975	Mean dependent var		0.067074
Adj. R-squared	-0.09015	S.D. dependent var		0.21898
F-statistic	0.255718	Durbin-Watson stat		2.60697
Prob(F-statistic)	0.777466			

5.4. Forecasting ex Post for 2001 – 2009

The prior stage before we use the parameters resulted form ECM, we should examine diagnosis test to see whether the estimation result fulfil the assumption. There are some important assumptions to evaluate econometrically the parameters.

Table 6. Diagnosis Test of the Assumption

Assumption	Test	ECM Real Variable		ECM Monetary Approach		Note
		Result	Indi-cator	Result	Indi-cator	
Non Autocorrelation	Breusch-Godfrey Serial Correlation LM Test dan DW	Obs*R-squared= 3.878423 Prob= 0.1438	OK	Obs*R-squared= 1.582092 Prob= 0.4534	OK	
Homo-scedasticity	White Heteroskedasticity Test	Obs*R-squared= 11.58314 Prob= 0.1151	OK	Obs*R-squared= 3.435625 Prob= 0.6331	OK	
Non Multicollinearity	CorelasiVarIndependen	Corelasihanya= -0.14566, -0.243645dan0.080566	OK	Corelasi = 0.898792	Not OK *	R2 partial only 0.807829, it is smaller than the R2 in the model so it indicate the multicollinearaty could be tolerated
The model Specified well	Ramsey RESET Test	F-statistic= 4.387731Prob= 0.0468	Not OK *	F-statistic= 4.975954Prob= 0.0289	Not OK *	*ECT(-1) has significant and correct sign coefficient so it indicate that the model specified well
Error Normally distributed	JB test	JB=0.764843Prob=0.682207	OK	JB=0.173813Prob=0.916763	OK	

After examined by diagnosis test, the parameter resulted can be used to forecast real exchange rate. To examine the accuracy the prediction, we can conduct RMSE, MAE, and MAPE to compare prediction resulted by the three model. The accuracy comparison among three methods shown in Table 7.

Table 7. Comparison Analysis among the Method

	Method	ARIMA	Real	Mon	Result (Rank)
2001-2003	RMSE	0.319541	0.539742	0.440392	ARIMA Mon Real
	MAE	0.257296	0.53277	0.420427	
	MAPE	2.794415	5.740204	4.539411	
2004-2006	RMSE	0.23107	0.774322	0.371682	ARIMA Mon Real
	MAE	0.193146	0.708322	0.343104	
	MAPE	2.126218	7.781184	3.76877	
2007-2009	RMSE	0.171741	0.963228	0.558838	ARIMA Mon Real
	MAE	0.161546	0.878152	0.484912	
	MAPE	1.793745	9.749944	5.383046	
2001-2009	RMSE	0.681297	1.714804	1.086478	ARIMA Mon Real
	MAE	0.606346	1.470217	0.962026	
	MAPE	6.686253	16.21045	10.59901	

Forecasting is conducted in this paper is forecasting *ex post*. The type forecasting is implemented while we predict values of dependent variable if the values of dependent and independent are already exist (Pindyck, and Rubenfeld 1998:203). Through the forecasting type, values predicted can be evaluated by comparing with the actual value. Thus, we can really check the accuracy of the three methods.

We can see Table 7 that all of the horizon prediction ARIMA is succeeded predictor than resulted by real variable (REAL) and monetary approach forecasting (MON). Smaller indicator shows better prediction. Evaluate through the first three years horizon of time prediction, the second years, and the remaining years, ARIMA is outstanding from the others. The prominent is shown the smallest result of forecasting indicator such as RMSE, MAE, and MAPE.

The Figure 1 illustrates that ARIMA's prediction trend follow nearest the actual. This graph support the fact which is provide by step by step forecasting and explain that ARIMA outperform than others in 1st three years (2001-2003), the 2nd (2004-2006), the 3rd (2007-2009), and all of nine years horizon forecasting. The graph also shows that MON consistently outperforms REAL.

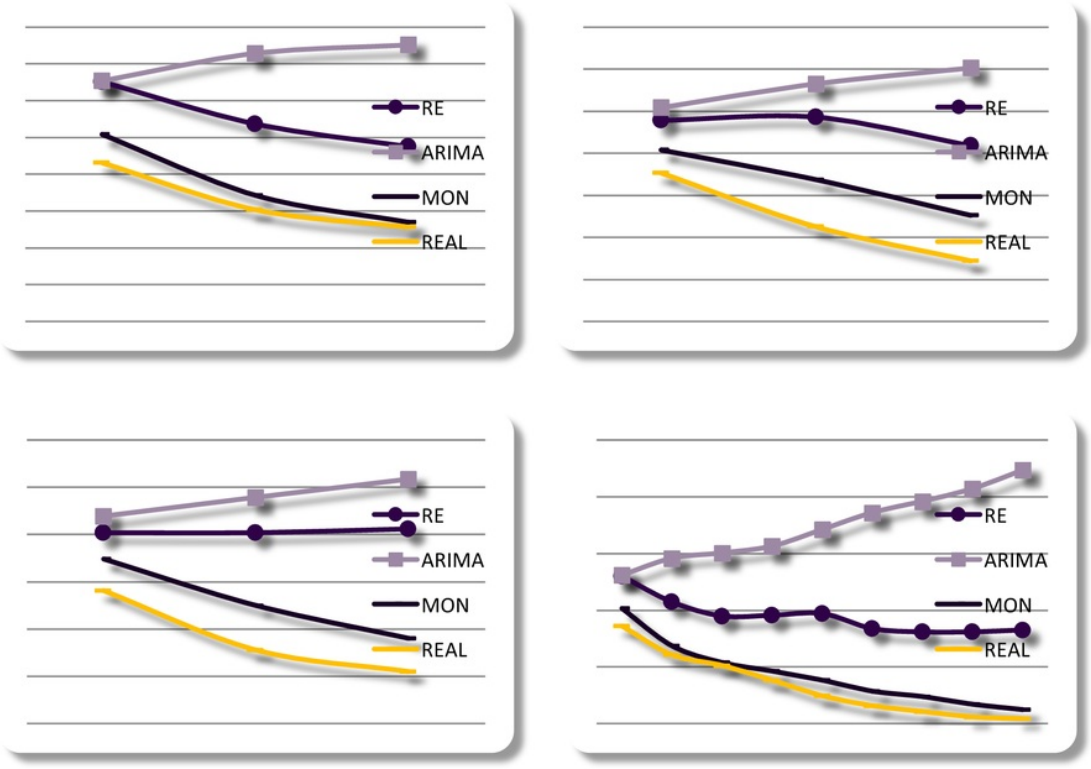

Figure 1. Comparison Graph between Prediction and Actual Real Exchange Rate 2001 – 2003, 2004 – 2006, 2007 – 2009, and 2001 – 2009

Completing the analysis, we also implementing estimate real exchange rate in all observation, such as common sample of the variable that all exist in interval 1982 – 2009.

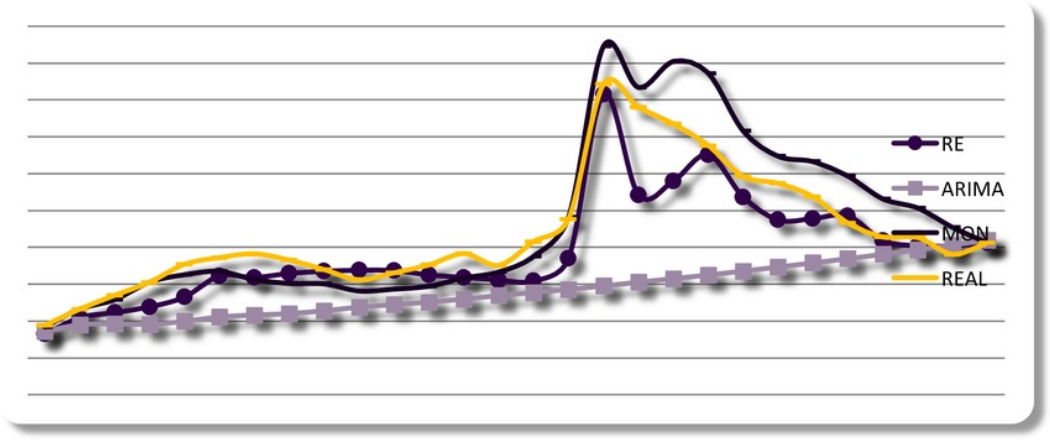

Figure 2. Comparison Graph between Prediction and Actual Real Exchange Rate (1982 – 2009)

Table 8. Comparison Analysis among the Method for Common Sample (1982 – 2009)

	Method	ARIMA	Real	Mon	Result (Rank)
1982-2009	RMSE	0.374347	0.16361	0.213237	Real Mon ARIMA
	MAE	0.299717	0.132191	0.179962	
	MAPE	3.309222	1.496161	2.001399	

According to the three indicators, REAL outperforms all method. It can be happened because REAL use more variable that can explain real exchange rate. With rational approach, estimating and forecasting by the REAL, the expected value more flexible near the actual value. MON results better predictor prominent to ARIMA. It explains us that all rational expectation approaches gives better prediction than adaptive expectation in the longer forecasting. We can ensure it later for observation and other context.

Conclusions

There are some approaches to estimate foreign exchange rate. Most of them are divided to be two approaches in rational expectation. One is based on monetary approach and the other is using real variable approach.

Most variables has unit root including LRE itself. Only LRXM and LRGDP is stationer in level (0). However, the variable will stationer when it difference once or denote has I(1) and variables involved in both approach (REAL and MON) cointegrate.

Empirical analysis result that ARIMA's prediction trend follow nearest the actual. The analysis support the fact which is provide by step by step forecasting and explain that ARIMA outperform than others in 1st three years (2001-2003), the 2nd (2004-2006), the 3rd (2007-2009), and all of nine years horizon forecasting. It also shows that MON consistently outperform REAL. One of interesting points, REAL outperforms all method in the longer observation (including observation in estimating parameters). The result also explains us that all rational expectation (REAL and MON) approaches gives better prediction than adaptive expectation in the longer forecasting.

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