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Interest Rate, Inflation, and Public Debt: What Is Causing Exchange Rate Volatility in Indonesia?

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Abstract

The exchange rate is one of the most essential factors of a country's economic stability measurement. In the world open market economy, the exchange rate shows how strong a country's bargaining of trade, which is precarious to determine cost and volume of goods n services to create a profit. This paper seeks to present macroeconomic variables that affect the exchange rate movement, given that Indonesia's exchange rate is very volatile and has a significant impact on economic conditions. In order to identify the influential variables, the VECM method is exercised, using time series data that consist of Indonesia's exchange rates, interest rates, inflation and public debt for the 1990Q1 to 2018Q4 period. This research findings are: *first*, the exchange rate appreciation is influenced by increasing in interest rate, and exchange rate depreciation is influenced by rising of inflation and public debt; *second*, prediction of the exchange rate, can be do with interest rate and public debt, while exchange rate can be used to predict interest rate, inflation and public debt; *third*, needs about 9 (nine) periods or 2 1/4 (two and a quarter) year for stabilizing exchange rate that influenced by other variables. Hence, It is critical to keep inflation rate, interest rate, and the level of public debt steady to utilize the exchange rate volatility.

Keywords: exchange rate; interest rate; public debt; VECM.

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1. Introduction

Exchange rate is one of the macroeconomic variables that is very curious to study. It almost all economic activities are influenced by fluctuations of the exchange rate. The present economy is preoccupied with monitoring exchange rates from day to day, since the Indonesian Rupiah exchange rate follows the flexible rate regime, the rate of IDR to another currency is volatile.

The exchange rate volatility, greatly affects the condition of a country's public debt. Especially if the debt is carried out in a foreign currency. The turmoil that drives the depreciation of the domestic currency will make public debt a heavy burden. So then it is stated that foreign public debt is the real burden on the economy [12,4,13]. Even so, it is volatile and endangers the economic condition, of course the exchange rate is influenced by many macroeconomic variables, some of which can be used to control it.

Indonesian Rupiah, as one of currency of the emerging market countries had have a bad experience regarding the exchange rate. Precisely in 1998, at the same time with the Asian crisis, the value of IDR against US Dollar experienced a terrible value of depreciation. In that time, in the mid of year 1997, the rate of IDR per US Dollar was 2,450, but it immediately, one year later, rocketed to IDR 14,900 in 1998, otherwise it increasing value up to 600%. Evidently Indonesia's public debt level soared since the value determined into other currencies, or US Dollars. Indeed Indonesia was later mentioned as an Asian country, which suffered the most from the 1998 crisis [5].

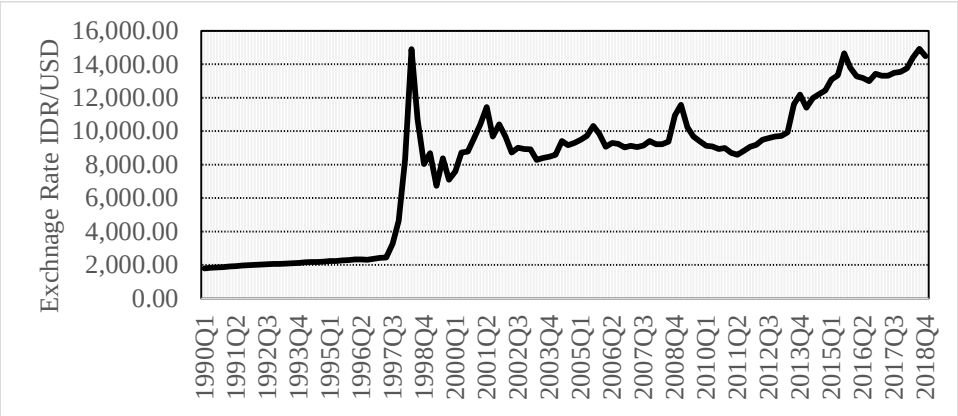

Figure 1: Indonesia Exchange Rate (IDR to USD) 1990 – 2018

After that moment, the condition of Indonesian exchange rate continued to fluctuate, compared to the pre-crisis period. The ups and downs of the exchange rate after the crisis, are in the range of IDR 9,000 up to IDR 14,000 per USD. Although in the period before the crisis, the exchange rate only moved in the range of IDR 2,000 per USD. Generally, the trend of IDR continues to be depreciated. For that reason, it needs several effort to control the exchange rate fluctuations.

To predict the fluctuations of the exchange rate, It could be examined by observing couple of macroeconomic variables. They affect positive influence or encourage appreciation the value of currency, then they have a

negative influence or depreciated the value of currency. This has been proven in several previous studies regarding the exchange rate relationship with macroeconomic variables using the VECM approach, some variables that are positively correlated, namely, inflation [6], interest rates [3,11], import [19]. While the variables that are negatively correlated are inflation [3,11], money supply and export [19].

From the several studies that have been conducted, there are several interesting variables, namely inflation and interest rates. Inflation is interesting because it has a positive effect [6] and negative [3,11]. Interest rate has the advantage of being able to restraint exchange rate fluctuations [3], and this variable can be controlled by the government. There is no less curious at the public debt variable, because it greatly affects the economic condition of a country. Hence this study will evaluate the relationship between currency exchange rates and macroeconomic variables consisting of inflation, interest rates, and public debt.

2. Methods

The model is identified as four hypothesized variables that the exchange rate is a function of interest rates, the inflation rate and public debt.

$$LEXC_t = F(INT_t, INF_t, LDEBT_t) \quad (1)$$

Where, $LEXC$ is log natural quarterly exchange rate of IDR per US Dollar (USD/IDR), INT is quarterly Bank Indonesia interest rate, INF is quarterly inflation, and $LDEBT$ is log natural quarterly Indonesian public debt. The sample data used consists of 116 quarterly data, ranging from year of 1990 to 2018, obtained from the website of the Bank Indonesia statistical report. The exchange rate and public debt data are in the average form, while the interest rate and inflation are in percent. All data is changed in the form of logs for time series processes. The coefficient can be interpreted as elasticity.

Stationarity is important in a data series, because it can affect the behavior in it. In this tests were carried out with the Augmented Dickey-Fuller test. This test is done to ensure the use of the right model, between VAR or VECM. If the data is stationary, then the VAR model is used. VECM is used for data that is not stationary in level but has integration.

Augmented Dickey-Fuller (ADF) test done using the following formula:

$$\Delta y_t = \alpha_0 + \alpha_1 trend + \delta_1 y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta y_{t-i} + \varepsilon_t \quad (2)$$

Where Δy_t indicate first difference from y_t and m is amount of lag and ε_t is error. The equation tests whether the variable y_t is stationary series. In addition to the ADF test, a Philips Perron (PP) test is also carried out, because it is a more comprehensive unit root test theory model. Generally the ADF test results will be the same as PP, but the statistical test calculations are more complex [2].

Null hypothesis for ADF are:

H_0: $\delta = 0$, variable has unit root

H_A: $\delta < 0$, variable has no unit root

If the null hypothesis can be rejected, then a cointegration test is carried out and then using the VAR model. Conversely, if the null hypothesis cannot be rejected (there is a unit root) then the VECM model is used, provided that the variable used has a cointegration relationship.

Cointegration test is important, because it helps to identify the existence of long-term economic relationships between variables. In this study Johansen's cointegration test will be used. [9] and [10] developed two statistical tests to determine the number of cointegration vectors. Trace and maximal Eigenvalue statistic. The first is known as trace statistics:

$$\lambda_{Trace}(r) = -T \sum_{i=r+1}^{k} \ln(1 - \hat{\lambda}_i) \quad (3)$$

And the second, called as Maximal Eigenvalue:

$$\lambda_{Max}(r, r+1) = -T\ln(1 - \hat{\lambda}_i) \quad (4)$$

Where T is the number of observations, r is the number of cointegration vectors and λ is *estimated eigenvalue*. To determine the length of the lag, a criterion test is carried out which helps to choose the right value. The common criteria used are: Schwarz's Bayesian information criterion (SBIC or SC), Akaike's information criterion (AIC) and Hannan & Quinn information criterion (HQIC). The optimal lag length is chosen by looking at the three criteria. If the three criteria choose the same number, then the length of the lag that is used according to the choice of the three criteria. But if there are different results, according to [8], AIC is more accurate for monthly data, HQIC is more precise in predicting quarterly data with more than 120, and SBIC works for all types of quarterly data for the VECM model. If cointegration has been identified, it can be ascertained that there is a long-term relationship between variables and Vector Error Correction Model (VECM), can be applied. The VECM regression equation, calculated by the following formulation:

$$\Delta y_t = \Pi y_{t-1} + D_1 \Delta y_{t-i} + \cdots + D_{p-1} \Delta y_{t-p+1} + \varepsilon_t \quad (5)$$

Where Δ is differentiating operator, Π- long-term parameters (error cointegrating), $D_1, \ldots, D_{p-1}$ are short-term parameters. Rank Π describe the existence of a cointegration:

- Rank (Π) = 0; there is no cointegration
- Rank (Π) = r; 0<r<k, r cointegration
- Rank (Π) = k; I(0) the process that must use the VAR model at the level

General specifications of the Granger causality in bivariate (X, Y) test can be expressed as:

$$Y_t = \alpha 0 + \alpha 1 Y_{t-1} + \cdots + \alpha i Y_{t-i} + \beta 1 Y_{t-1} + \cdots \beta i Y_{t-i} + \mu \quad (6)$$

$$X_t = \alpha 0 + \alpha 1 X_{t-1} + \cdots + \alpha i X_{t-i} + \beta 1 X_{t-1} + \cdots \beta i X_{t-i} + \mu \quad (7)$$

t symbolize the period and μ is white noise error. The constant parameter "0 represents the constant growth of Y in equations 6 and X in equation 7 and the trend of the two variables can be interpreted as general movements of cointegration X and Y that follow the unit root process. The test results can be obtained by examining the null hypothesis that X is not Granger-cause Y and the second tests the null hypothesis that Y is not Granger-cause X. If it fails to reject the first and second null hypotheses, it can be concluded that the Granger-caused X changes by changes Y. Unidirectional causality will occur between two variables if the two null hypotheses of equations (6) and (7) are rejected. Bidirectional casusality will occur if both null hypotheses are accepted.

3. Results and Discussion

In this research, the VECM designed with the cointegrated variables series that shows the relationship between variables, It urgently needed in terms to ascertain the dynamic relationship of volatility of currency exchange rates triggered by the movement of three variables, those are inflation rate, interest rate, and level of public debt on Indonesia. Overall analysis, It starts from stationarity test, table 1, it is clear that all data with ADF and PP testing are stationary at first difference, because the null hypothesis of no unit roots for time series is rejected at the value of 1% significances. Then all variables become stationary and there is no unit root at first difference.

Table 1: ADF and PP unit root test

ADF						
	Level			First Difference		
	Intercept	Intercept and Trend	None	Intercept	Intercept and Trend	None
LEXR	-1.643247	-2.186700	1.133367	-8.015564***	-8.015564***	-7.893011***
INT	-3.540965***	-4.221327***	-1.803278**	-9.067091***	-9.025398***	-9.104204***
INF	-4.139251***	-4.604587***	-1.974633**	-5.923610***	-5.898657***	-5.950888***
LDEBT	-1.263491	-1.768565	1.912398	-4.673484***	-4.701709***	-4.140103***
PP						
	Level			First Difference		
	Intercept	Intercept and Trend	None	Intercept	Intercept and Trend	None
LEXR	-1.531728	-1.918788	1.422971	-7.700786***	-7.686355***	-7.656539***
INT	-3.118073**	-3.736635**	-1.942053**	-8.960074***	-8.908493***	-9.004758***
INF	-2.603821*	-2.701063	-2.039813**	-7.486322***	-7.539917***	-7.457394***
LDEBT	-1.503619	-1.830400	2.629335	-15.54817***	-15.72662***	-14.30191***

Description: ***, **, * each indicates significance at α = 1%, 5% and 10%

The optimal lag length is chosen by looking at the three criteria: AIC, SC and HQ. Table 2 shows that all criteria

choose lag length 4. So that lag, will be make for the next test.

Table 2: Lag-order selection criterion

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-826.7994	NA	32.59627	14.83570	14.93279	14.87510
1	-426.1788	765.4715	0.033919	7.967479	8.452925	8.164440
2	-286.1259	257.5974	0.003706	5.752248	6.626051	6.106778
3	-243.2470	75.80369	0.002300	5.272269	6.534429	5.784367
4	**-183.1590**	**101.9350***	**0.001052***	**4.484983***	**6.135500***	**5.154650***

*) shows significance at α = 5%

Cointegration tests are carried out using the Johansen method. This method uses two approaches to likelihood estimators, namely a trace statistics and a maximum Eigenvalue. The Null hypothesis states that there is no cointegration relationship. The test results are shown in table 3, using VAR (4) lag (4) from the trace statistics and maximum eigen value, the most restrictive is model 3 in rank 2.

From the results of the cointegration test, the most significant model is model 3 where it is assumed that there is an intercept in a long-term relationship and a linear trend in the data level. The number of linkages in the modeling system is 1 with a degree of significance α = 1% and 5%. The cointegration shows that the VECM test can be done, so the next step is to do the VECM test using model 3.

Table 3: Results of co-integration tests

LR Test	Null	Alternative	Model2	Model3	Model4
Trace Statistic	r = 0	r = 1	89.02581**	74.31140**	94.59590**
	r <= 1	r = 2	25.78931	20.01530	29.49007
	r <= 2	r = 3	10.42883	4.797894	11.48816
	r <= 3	r = 4	4.326941	0.437926	4.267475
Maximum Eigen Value	r = 0	r = 1	63.23649**	54.29610**	65.10583**
	r <= 1	r = 2	15.36048	15.21741	18.00191
	r <= 2	r = 3	6.101890	4.359968	7.220686
	r <= 3	r = 4	4.326941	0.437926	4.267475

Description: **, * rejects the null hypothesis at α = 1% and 5%

The existence of a cointegration relationship between variables shows a long-term relationship. So the VECM model can be exercised. The long-term relationship between exchange rate, interest rate, inflation and public debt for the two cointegration relations for Indonesia in the period 1990 - 2018 is as follows (standard errors are shown in parentheses).

LEXR = 0.082277INT - 0.203748INF - 0.527690DEBT - 0.637951

(0.05808) (0.04377) (0.15392)

In table 4, based on the t-stat value, it appears that all the variables except INT, have 5% significant, indicated by the t-stat value that is more than 1.96. INT have positive relationship, where increase 1% of INT, will be followed 8.22% LEXR appreciation. While INF and LDEBT have a negative relationship with LEXR. Where a decrease of 1% INF, it will result in an increase in EXR of 20.37%. Then, decrease of 1% LDEBT, it will increase LEXR of 52.77%.

High interest rates will attract many investor, so that domestic currency will appreciate [3,11]. While, high inflation will reduce people's purchasing power, and low inflation increases people's purchasing power. Increased purchasing power, will appreciate domestic currencies [15,3,16]. Low public debt affects market valuation in the long run, so that it can appreciate domestic currency [22], and high government debt will result in depreciation of the domestic currency [14].

Table 4: Vector Error Correction Model

	Coeffisien	Std. Error	t-stat
LEXR	1	-	
INT	0.082277	0.05808	1.41673
INF	-0.203748*	0.04377	4.65487
LDEBT	-0.527690*	0.15392	3.42826
Const	-0.637951		

*) shows significance at $\alpha = 5\%$

Cointegration between variables cannot indicate the direction of the causal relationship between them. Economic theory guarantees that there is always a Granger Causality, even if only in one direction [17]. So that the Granger Causality is also tested on LEXR, INT, INF and LDEBT. The Null hypothesis states that there is no Granger Causality relationship, between two variables, with a real level of 5%.

The Granger Causality test results are shown in table 5. Denote rejection of the null hypothesis is a significant probability value. From the overall test, there are three bidirectional “Granger cause” relationship, two unidirectional “Granger cause” relationship, and one no “Granger cause” relationship.

Three bidirectional “Granger cause” are, INT to LEXR, LDEBT to LEXR, and INF to INT. That means, past value of interest has predictive ability to present value of exchange rate and vice versa. Then past value of public debt has predictive ability to present value of exchange rate and vice versa. While past value of inflation has predictive ability to present value of interest rate.

Two unidirectional “Granger cause” relationship, are INF to LEXR and LDEBT to INF. That means, past value

of exchange rate have predictive ability to present value of inflation, but inflation can't predict the exchange rate. And then past value of public debt have predictive ability to present value of inflation, but inflation can't predict the public debt.

One no "Granger cause" relationship is LDEBT to INT. That means, public debt have no predictive ability to interest rate, and vice versa. Or in the other word, this two variable have no "Granger cause" causality.

So the variable that can be used to predict the exchange rate are interest rate and public debt. While the variable that can be predicted by using the exchange rate are interest rate, inflation and public debt.

Table 5: Granger Causality Test

Null Hypothesis	F-Stat	Probability	Decisions
INT does not Granger Cause LEXR	10.9793	5.E-05	Reject
LEXR does not Granger Cause INT	49.9545	4.E-16	Reject
INF does not Granger Cause EXR	2.81273	0.0644	Do not Reject
EXR does not Granger Cause INF	57.9970	7.E-18	Reject
DEBT does not Granger Cause EXR	23.6827	3.E-09	Reject
EXR does not Granger Cause DEBT	8.25087	0.0005	Reject
INF does not Granger Cause INT	7.34406	0.0010	Reject
INT does not Granger Cause INF	28.5316	1.E-10	Reject
DEBT does not Granger Cause INT	2.52297	0.0849	Do not reject
INT does not Granger Cause DEBT	0.21177	0.8095	Do not reject
DEBT does not Granger Cause INF	32.0766	1.E-11	Reject
INF does not Granger Cause DEBT	0.28429	0.7531	Do not reject

Notes:***denote significant at 1%

The impulse response analysis is an additional check on the results of the cointegration test. The results of the analysis can also be used to determine the dynamic relationship between variables in the model, by referring to generalized conditions rather than orthogonality. IRF analysis shows the long-term response of each variable to a particular shock variable equal to one standard error in each equation.

The impulse response results are shown in figure 2. From the first column, that show impact of other variables shock to exchange rate. First, interest rate shock at the beginning responded by exchange rate devaluation since period one, then increase in period two, decrease again in period 5, then increase and reach stability since period 6, it has tendency to increase. Second, inflation shock at beginning responded by exchange rate devaluation till period 4, rise again in period 8, and then reach stability since period 9 and has tendency to decrease. Third, public debt shock at beginning responded by exchange rate increasing since period 2, then since period 4 decreased, and reached stability since period 8, it has tendency to decrease. From overall showed, that period exchange rate to become stable again after shock other variable, is about 9 period or 2,5 years.

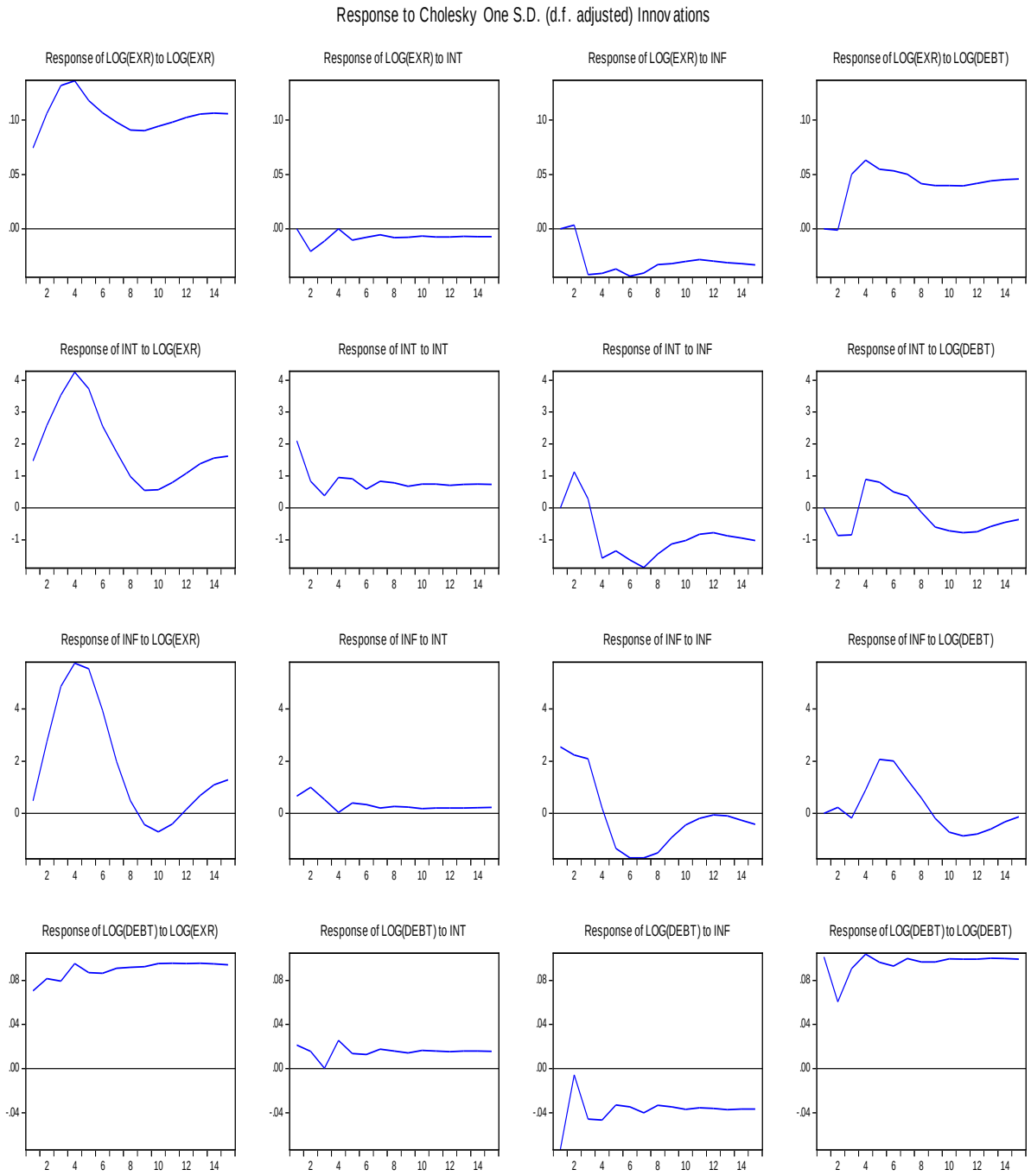

Figure 2: Impulse Response

4. Conclusion

From the results of the analysis it can be concluded, that exchange rate appreciation is influenced by increasing in interest rate, and exchange rate depreciation is influenced by rising of inflation and public debt. Prediction of the exchange rate, can be do with interest rate and public debt. While exchange rate can be used to predict interest rate, inflation and public debt. It needs about 9 (nine) periods or 2 1/4 (two and a quarter) year for stabilizing exchange rate that influenced by other variables.

5. Recommendations

Recommendation from this research is to utilize exchange rate volatility steady at certain level in away by controlling lower inflation and mantain the level of public debt targeted in terms of government fiscal policy, moreover by preserving the level of interest rate for central bank monetary policy. For the next research, to monitor the movement of currency exchange rate by adding another variable, such as GDP, to recognise the growth of country economic size, or the research is about comparison volatility of two or more currencies amongst neighborhood area.

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