Exchange Rate of Indonesia: Does Rupiah Overshoot?

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Abstrak

This research attempts to analyze whether Rupiah overshoots when the crisis hit Indonesia in mid of 1998. It also try to find out the fundamental macroeconomic factors that influence exchange rate when economic crisis hit Indonesia. It uses ordinary least square method and also cointegration in order to see long-term relationship. Furthermore, in order to examine the stability of exchange rate when the exchange rate system changed from managed floating to free floating, this paper apply Chow Test. The result shows that when the economic crisis hit Indonesia, Rupiah overshoots and there has been a structural change of exchange rate after 1998.

I. Introduction

Indonesia economic reforms began in the mid 1980s, when government made a financial deregulation in 1983. Over the next decade, reforms were expected at opening the real economy by promoting direct investment flows and liberalizing the financial sector, increasing competition, and promoting growth.

The government aimed to support these reforms with improved macroeconomic management, including through an attempt to maintain a competitive and stable exchange rate. The exchange rate policy was first changed in December 1978 from a pegged regime to a managed floating exchange rate system. The rupiah was linked to a basket of currencies consisting of Indonesia's main trading partners.

Until the mid 1980's, Indonesia's export trade was dominated by crude petroleum and natural gas. Hence, government's earnings were influenced seriously by oil price. The collapse of oil price in 1986 led to a devaluation and government was pushed to boost non-oil/gas exports.

After the two major devaluations in 1983 and 1986, Bank Indonesia strived to intervene the foreign exchange market in order to stabilize the exchange rate, country's foreign exchange reserves and monetary system.

When the financial crises occurred in 1997, rupiah depreciated and continued to slide and exceeded the upper limit of the intervention band. Bank Indonesia decided to float the rupiah on August 14, 1997. Indonesia was the worst sufferer in the Asian crisis. The nominal exchange rate jumped from Rp 2,400 per US dollar to almost Rp 17,000 in mid 1998.

This paper attempts to analyze and to test the monetary approach and the overshooting hypothesis in Indonesia. It emphasizes the effect of financial liberalization to the exchange rate of Indonesia before and after the economic crisis. The model of exchange rate determination is expressed as a function of the relative money supply, relative income level, the nominal interest differential and the expected long-run inflation differential. We use the *ordinary least square* (OLS) method in the analysis and applying *the Chow test* in order to explore the stability of rupiah before and after economic crisis.

II. Literature Review

As the fixed exchange rate system had terminated, many of literatures began to explain the exchange rate changes. These literatures are laid on monetary or asset view. The older theories of exchange rate are focused more on trade of account of the balance of payments, while new theories; that are called "asset view", focused on a stock approach.

Frankel (1979) suggests that there are two very different approaches in new theories. The first approach might be called the Chicago theory. It assumes that prices are perfectly flexible. If there is a change in nominal interest rate it will reflect changes in expected inflation rate. When the domestic interest rate rises relative to the foreign interest rate, there will be a decrease in domestic currency through inflation and depreciation. So there will be a positive relationship between the exchange rate and the nominal interest rate differential.

The second approach might be called the Keynesian theory. It assumes prices are sticky, at least in the short run. If there is a change in the nominal interest rate it will reflect changes in the tightness of monetary policy. When the domestic interest rate rises relative to the foreign rate, it will attract a capital inflow, which causes the domestic currency to appreciate. So there will be a negative relationship between exchange rate and the nominal interest differential.

The monetary approach to exchange rate determination focuses on the money market. The interaction between money demand and money supply results an equilibrium exchange rate. Thus, the exchange rate is seen as the equilibrium price between two stocks of money.

In the monetary model, there are some assumptions applied. Firstly, the money supply is assumed to be stable and exogenous. Secondly, assets are perfectly substitutable, therefore UIP (Uncovered Interest Parity) holds continuously. Thirdly, the demand for money is a stable function of fundamental variables such as income and interest rate. Fourthly, income is assumed to be at its full employment level. Finally, PPP is assumed to hold continuously.

The exchange rate of monetary model is determined by relative money demands and money supplies. If domestic income increases relative to foreign income, then the demand of money for domestic increases relatively to the supply. Consequently, this causes the exchange rate appreciates. By contrast, an increase in the domestic money supply causes to raise in exchange rate. The excess supply of money results in depreciating the exchange rate respectively. Similarly, if expected domestic inflation rises about the expected in the foreign country, then the demand for money falls and the exchange rate will depreciate.

Dornbusch (1976) introduced his sticky-price monetary model, which contained an overshooting hypothesis. The main feature of his model is that since prices are sticky in the short-run, an increase in money supply will result in lower interest rate and thus capital outflow, will cause currency depreciation. In the short run the currency will overshoot itself. However, over time, commodity prices will rise and result in a decrease in real money supply and higher interest rate. In the end, the currency will appreciate.

The empirical researches about the exchange rate determinants are varied. Frankel (1979), Driskill (1981) , and Papel (1998) do provide the overshooting model, while Backus (1981) and Flood and Taylor (1996) do not. Hairault et. al. (2004) finds that an expansionary monetary policy implies an increase in interest rate and a depreciation of the exchange rate.

Obstfeld and Rogoff (2000) have recently underlined the difficulty in estimating the exchange rate volatility. Any models are underlying fundamentals such as interest rates, outputs and money supplies but no model seems to be very good at explaining exchange rates even ex-post.

III. Model

The theory of monetary approach begins with two fundamental assumptions. The first is the interest rate parity. The market is efficient which bonds of different countries are substitutable.

$$d = r - r^* \qquad (1)$$

where r is defined as the log of one plus the domestic rate of interest and r* is defined as the log of one plus the foreign rate of interest. If d is considered to be the forward discount, defined as the log of the forward rate minus the log of the current spot rate then equation (1) is a statement of covered (or closed) interest parity. However d will be defined as the expected rate of depreciation; then equation (1) represents the stronger condition of uncovered interest rate parity.

The second is that the expected rate of depreciation is a function of the gap between the current spot and an equilibrium rate, and of the expected long-run inflation differential between the domestic and foreign countries:

$$d = -\theta(e - \bar{e}) + \pi - \pi^* \qquad (2)$$

where e is the log of the spot rate and π and π^* are the expected inflation home and foreign country. The log of the equilibrium exchange rate $\bar{e}$ is defined to increase at the rate of $\pi - \pi^*$. Equation (2) says that in the short run the exchange rate is expected to return to its equilibrium value at a rate which is proportional to the current gap, and in the long run when $e = \bar{e}$, it is expected to change at the long run rate $\pi - \pi^*$. The rational value of θ will be seen to be closely to the speed of adjustment in the good market.

Combining equation (1) and (2) gives:

$$e - \bar{e} = -\frac{1}{\theta}[(r - \pi) - (r^* - \pi^*)] \qquad (3)$$

the equation in the bracket shows the real interest rate differential. When a tight monetary policy in one country causes the nominal interest differential to rise above its long run level, an incipient capital inflow causes the value of the currency to rise proportionally above its equilibrium level.

Assuming that in the long run, purchasing power parity holds:

$$\bar{e} = \bar{p} - \bar{p}^* \tag{4}$$

where p and p* are defined as the logs of the equilibrium price level at home and foreign country.

Assume that the function of money demand equation:

$$m = p + \phi y - \lambda r \tag{5}$$

where *m, p* and *y* are defined as the logs of the domestic money demand, price level and output. Assume also money demand equals to money supply. A similar equation holds abroad, and the different between the two equations for home and foreign are:

$$m - m^* = p - p^* + \phi(y\text{-}y^*) - \lambda(r\text{-}r^*) \tag{6}$$

Considering that in the long run $e = \bar{e}, \bar{r} = \bar{r}^*, \pi - \bar{\pi}^*$, we get

$$\bar{e} = \bar{p} - \bar{p}^* \tag{7}$$

$$\bar{e} = \bar{m} - \bar{m}^* - \phi(\bar{y} - \bar{y}^*) + \lambda(r - r^*) + \beta(\pi - \pi^*) \tag{8}$$

This equation illustrates the exchange rate of monetary theory is determined by the relative supply of and demand for two currencies. The equation (8) shows that exchange rate will increase if rising in domestic money supply, falling in income and increasing in inflation.

With Dornbusch-Frankel sticky-price monetary model and modified money demand function, this paper specifies the fundamentals for nominal exchange rate determination model:

$$\bar{e} = \gamma(\bar{m} - \bar{m}^*) - \phi(\bar{y} - \bar{y}^*) + \lambda(r - r^*) + \beta(\pi - \pi^*) + \mu \quad (9)$$

where $\gamma, \beta, \phi > 0$; and $\alpha < 0$; * denotes a variable of the foreign country, *s* is the logarithm of the spot exchange rate (Rupiah per US$), *m* is the logarithm of money supply (M2), *y* is the logarithm of real income, *r* is the short term interest rate, π is the expected inflation rate, and μ is the disturbance term. Indeed monetarist would predict estimate of $\gamma = 1$, while in overshooting hypothesis, $\gamma > 1$

IV. Methodology

This paper uses *ordinary least square* method in order to see the factors that influence the exchange rate of Indonesia. Some tests have been set up to give the best estimation. Before estimating the regression, the data will be tested to make sure that the data is valid and reliable, by using such as the normality test, linearity test, and stationarity.

After that, this paper implements a cointegration technique to detect whether a stable long-run relationship between exchange rates and fundamental variables exists. Cointegration methodology allows researchers to test for the presence of equilibrium relationships between economic variables.

Prior to testing for cointegration, we need to examine the time series properties of the variables. They should be integrated of the same order to be cointegrated. In other words, variables should be stationary after differencing each time series the same number of times. Therefore, at the first step we develop unit root test to find non-stationary level.

Unit Root Test

Ganger and Newbold (1974) suggested that in the presence of nonstationary variables, there might be a spurious regression. A spurious regression has a high R^2 and t-statistics that appear to be significant, but the results are without any economic meaning.

The time series of *m, y, r,* and π are in fact nonstationary time series, that is generated by random process and can be written as follow:

$$Z_t = Z_{t-1} + \varepsilon_t \quad (10)$$

where ε_t is the stochastic error term that follows the classical assumptions, which means, it has zero mean, constant variance and is nonautocorrelated (such an error term is also known as white noise error term) and Z is the time series. Since we need to use the stationary time series for the next cointegration test and we also need to solve this unit root problem, therefore, we will run the regression of unit root test based on the following equation:

$$\Delta Z_t = a + bZ_{t-1} + c\Delta Z_{t-1} + \varepsilon_t \qquad (11)$$

where we add the lagged difference terms of dependent variable Z to the right-hand side of equation (2). This augmented specification is then used to test:

H_o: b= 0 H_1: b < 0

Therefore, both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) statistics are used to test the unit root as the null hypothesis.

Cointegration Test

Engle and Granger suggested that cointegration refers to variables that are integrated of the same order. If two variables are integrated of different orders, they cannot be cointegrated.

Under the unit root test, the results show that the variables of exchange rate, money supply, output, interest rate and inflation are stationary at the first difference [I(1)]. Continuously, all the variables will be tested in cointegration test, by using the Johansen test statistics, imply that if exchange rate and macroeconomic fundamental are cointegrated, so there is a long term equilibrium relationship between these variables.

At the end of the analysis, We use Chow Breakpoint Test in order to check the stability of rupiah after government implement the free floating exchange rate in the third quarter of 1998.

V. The Data Set and Test Results

Data used in this paper relating to the rupiah per U.S. dollar and the Indonesia and U.S. fundamental macroeconomic variables. The sample of this research is quarterly data taken from International Financial Statistics from 1997 until 2004. The chosen exchange rate is quarterly market exchange rate. The income measure is quarterly Gross Domestic Product. The chosen money supply is quarterly M2. The interest rate chosen variables is three months deposit rate. Last not but least, variable

CPI is quarterly consumer price index. All of data is expressed in logarithm except interest rate.

Stationarity Test

The estimated regression will be more precisely if using stationary data. In order to check the stationary data, this paper uses the unit root test.

Table 1
Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) Statistics
For Exchange Rate and Macroeconomic Fundamental

Indonesia Case: 1997 – 2004				
Level			**1st difference**	
Var.	**ADF**	**PP**	**ADF**	**PP**
	k=1	k=1	k=3	k=1
E	-4.4634*	-3.1982*	-4.1555*	-3.8044*
	k=1	k=1	k=3	k=1
y	-2.6127	-1.7949	-3.2460*	-4.4573*
	k=1	k=1	k=1	k=1
m	-3.4703*	-3.4130*	-2.1976**	-3.8066*
	k=1	k=3	k=2	k=2
r	-2.5838	-1.7612	-2.9427**	-2.8500**
	k=2	k=3	k=2	k=1
π	-3.3422*	-2.4152	-5.6122*	-5.1864*

Note: The ADF and PP statistics were generated by model with constant and trend.
k is the lag length and was determined by Akaike info criterion and Schwarz criterion for the ADF test. The PP test use the automatic lag length that suggested by Newey-West. All variables were tested in log form.
* denote rejection of the null at 5% level
** denote rejection of the null at 10%level

Table 1 presents the results of both unit root tests for the exchange rate of rupiah per US dollar and measure of fundamental macroeconomic variables for Indonesia and United States in levels and first difference. The ADF test fails to reject the null hypothesis at the 5% level for some variables such as output (*y*) and interest rate (*r*). Similarly, the PP test also fails to reject the null hypothesis for the same variables.

However, the ADF and PP test reject the null hypothesis for all variables in the first difference at 5% level, except variable interest rate (*r*), which is at 10% level. Since all variable are stationary at first difference, therefore, it is an I(1) stochastic process. The finding implies that it is reasonable to proceed with test for cointegrating relationship among combination of these series.

Estimated Regression

To predict the factors influencing exchange rate determination of Indonesia, then the regression is built using OLS method. The result using the data 1997.3 until 2004.1 is as follows:

$$e = 0.1214y + 2.443m^{*} - 0.0001r + 1.2692i^{**}$$

(0.845) (6.338) (-0.002) (2.028)

$R^2 = 0.748$ F = 16.366 DW = 2.136

* denote rejection of the null at 5% level
** denote rejection of the null at 10%level

The data of variable *y, m, r* and *i* are domestic minus foreign data. The result shows that the sign of variables are the same as hypothesis, except output. The sign of this variable should be negative, however this data is insignificant. The other variable that is insignificant is interest rate, but it has the right sign. The implication of this finding is the interest rate is not a proper instrument in order to influence the exchange rate. When the central bank of Indonesia increases the interest rate will only make exchange rate appreciate a little bit and it is insignificant.

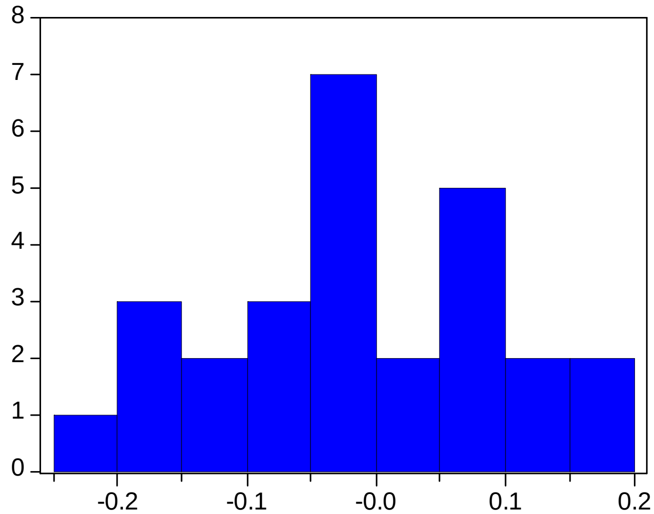
Money supply and price are significant in influencing exchange rate of Indonesia. The increase of money supply and interest rate makes the exchange rate depreciates. An increase 1.0 percent of money supply in Indonesia will depreciates rupiah to 2.4 percent. This means rupiah is very sensitive to money supply. The implication of this finding is the central bank has to control the exchange rate in order to stabilize rupiah.

As can be seen, the elasticity obtained for relative money supply *m* is greater than unity (2.443) indicating that one percent increase in Indonesia relative money supply will cause a long-run depreciation of the rupiah by 2.443%, a result consistent with overshooting hypothesis.

Price is also significant influencing the exchange rate. Indonesia’s inflation in 1998 has been worsen the the exchange rate. An increase 1.0 percent of inflation will stimulate depreciation of rupiah about 1.2 percent .

Normality Test

One of the assumption of classical normal linear regression model is the residual has to be normally distributed. This paper uses the Jarque-Berra (JB) test of normality in order to find out whether the residual is normally distributed or not.



Series: Residuals	
Sample 1997Q3 2004Q1	
Observations 27	
Mean	-0.015806
Median	-0.009402
Maximum	0.187661
Minimum	-0.249931
Std. Dev.	0.111547
Skewness	-0.136473
Kurtosis	2.380648
Jarque-Bera	0.515358
Probability	0.772843

Graph 1. Histogram of Residuals from Estimated Regression

From the histogram it seems that the residuals are normally distributed. The Jarque Berra value is 0.5153 with *p* value 0.773. If the computed p value of JB statistic in application is reasonably high, we do not reject the normality assumption. Therefore the residual of this estimated regression is normally distributed.

Multicollinearity Test

The other the assumption of classical normal linear regression model is that there is no multicollinearity among the variables. In order to fulfill this purpose, this paper uses eigenvalues and condition index. From the regression we obtain 2.009 as the maximum eigenvalues and 0.292 for minimum eigenvalues. We use the formula of condition index, which is as follows:

$$CI = \sqrt{\frac{\text{Max Eigenvalues}}{\text{Min Eigenvalues}}} = \sqrt{\frac{2.009}{0.292}} = 2.622$$

According to the rule of thumb, if CI less than 10, so there is no multicollinearity among the variables.

Serial Correlation Test

The time series data of economics is usually threatened by a serial correlation. The consequences of serial correlation is variance of the parameter is no longer the smallest, so it will make standard error becomes large and the estimation is not BLUE (*Best Linear Unbiased Estimator*) anymore.

A general test of autocorrelation is the Breusch-Godfrey (BG) Test, which is also know as the LM test. We regress the residual of the regression ($\hat{\mu}_t$)on the original independent variables and the residual variables ($\hat{\mu}_{t-1}, \hat{\mu}_{t-2},..., \hat{\mu}_{t-p}$). The result of LM test is as follows:

Table 2. The result of Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.588787	Probability	0.563904
Obs*R-squared	0.900587	Probability	0.637441

If an application, (n-p)R^2 below the critical chi-square or *p* value is high, at a chosen level of significance, we accept the null-hypothesis. This means there is no autocorrelation in the estimated regression.

Heteroscedasticity Test

Another important assumptions of the classical linear regression model is that the variance of each disturbance term, ($\hat{\mu}_i$), conditional on the chosen values of the explanatory is some constant number equals to σ^2. The consequences of heteroscedasticity are variance of parameter is not minimum, and it leads to inefficiency and the estimated regression is not BLUE anymore.

This paper implies White's heteroscedasticity test (no cross term) in order to find out whether the heteroscedasticity is present or not. The results of White's test is as follows:

Table 3. The result of Heteroscedasticity Test

White Heteroskedasticity Test:

F-statistic	2.858582	Probability	0.030581
Obs*R-squared	15.10825	Probability	0.057075

If an application, $(n-p)R^2$ below the critical chi-square or *p* value is high, at a chosen level of significance, we accept the null-hypothesis.. Since the *p* value is above 5 % so, we can conclude that there is no heteroscedasticity at $\alpha = 5\%$.

Chow Test

When involving time series data, it may occur the structural change. By structural change, the values of the parameters of the model do not remain the same through period due to external forces. The crisis hits Indonesia may also cause the structural change of Indonesia's exchange rate. That is why, this paper uses Chow Test in order to see the stability of Rupiah after government change the exchange rate system from managed floating exchange rate to free floating exchange rate in 1998. The result of Chow test is as follows:

Table 4. The Result of Chow Test

Chow Breakpoint Test: 1998

F-statistic	3.677052	Probability	0.022186
Log likelihood ratio	15.47917	Probability	0.003804

The Chow test result shows that F values in the estimated model does exceed the critical F value at α=5%. We can also check to its p value which is lower than level of significant, and that means there is a structural change of rupiah before and after Indonesia choosing the free floating exchange rate system. The implication of this finding is rupiah is instable before and after economic crisis.

Cointegration

This paper implements a cointegration technique to detect whether a stable long-run relationship between exchange rates and fundamental variables exists.

Cointegration methodology allows researchers to test for the presence of equilibrium relationships between economic variables.

Table 5.
Cointegration results (with a linear trend)

Null r	Alternative r	Trace Statistic	95 % Critical Value	Max Eigen Statistic	95% Critical Value
0	1	151.24*	59.46	50.52*	30.04
≤1	2	100.72*	39.89	45.38*	23.8
≤2	3	55.35*	24.31	41.75*	17.89
≤3	4	13.60*	12.53	9.21	11.44
≤4	5	4.38*	3.84	4.38*	3.84

where r is the number of cointegration vectors
* denote rejection of the null at the 5% level with critical values from Oswald-Lenum (1992).

The parameter estimates of the cointegrating model are reported in Table 2. The Johansen test reject the null hypothesis at 5% which proves the existence of cointegrating relationship among exchange rate, output, money, interest rate and inflation. Therefore, this result indicates five cointegrating equations at 5% significant level using Trace Statistic. However, based on Max Eigen Statistic there are three cointegrating equations.

VI. Conclusion

This paper examines the nature of linkages between exchange rate and macroeconomic fundamentals. It also attempts to find out whether rupiah is stable or not after financial liberalization in 1998 when the government implement free floating exchange rate system.

We use conduct several econometrics' test in order to establish the appropriate estimated regression. We also test the stationarity of each time series in order to estimates the cointegrating relationship in the long run and short run. The findings have identified that all time series eare stationary at the first difference in the Augmented Dickey-Fuller and Phillip-Perron test. Consequently, the Johansen cointegrating test shows that the exchange rate and macroeconomic fundamentals are cointegrated in the long run. The latter, we use Chow test to prove that rupiah is instable after the financial liberalization. The finding shows that there is a structural change in rupiah.

Overall, the paper's finding suggests that money and interest rate influence exchange rate significant either in short run or long run. Therefore, the monetary institution of Indonesia should aware of these two variables in order to stabilize exchange rate, moreover the economic performance. The elasticity obtained for relative money supply *m* is greater than unity indicating that this result consistent with overshooting hypothesis.

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