Study of the Behavior of the Indonesian Rupiah/US Dollar Exchange Rate and Policy Implications

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Abstract This paper examines four major exchange rate models for the IND/USD exchange rate. These four models include the purchasing power parity model, the uncovered interest parity model, the monetary model, and the extended Mundell-Fleming model. According to the empirical results, in the purchasing power parity model, the sign of the coefficient has the expected positive sign and is significant at the 1% level. It appears that the use of the relative PPI has a better performance than the use of the relative CPI based on the explanatory power. In both versions, the proportionality hypothesis cannot be rejected. In the uncovered interest parity model, the coefficient of the relative interest rate is positive and insignificant at the 10% level, and the coefficient of the expected exchange rate is positive and significant at the 1% level. In the monetary model, the Bilson model and the Frenkel model are confirmed whereas the Dornbusch model and the Frankel model are not applicable to Indonesia. These results suggest that an increase in the relative interest rate or the relative inflation rate would lead to a depreciation of the rupiah. In the extended Mundell-Fleming model, more real money aggregate, a higher domestic interest rate or a higher expected inflation rate would cause real depreciation of the IDR/USD exchange rate whereas a higher ratio of government spending/GDP or a higher stock price would lead to real appreciation.

Keywords: IDR/USD exchange rate, PPP, UIP, monetary models, extended Mundell-Fleming model

JEL Classification: F31, O53

1. Introduction

Indonesia implemented foreign exchange restrictions during 1949-1965 to control limited foreign exchange reserves. In response to rampant inflation in the early 1960s, it introduced a new rupiah worth of 1,000 units of the old rupiah in 1965 and pursued a stabilization program during 1966-1970 to enhance economic growth, exports, and the value of the rupiah. Indonesia adopted a fixed exchange rate regime at a rate of 415 rupiah per U.S. dollar during most of 1971-1978 and switched to a managed float exchange rate regime during 1978-1997. During the 1997-1998 Asian financial crisis, the rupiah plunged substantially by approximately 508% from a low of 2,450 IDR/USD in 1997.M6 to a high of 14,900 IDR/USD in 1998.M6 based on the end-of-period exchange rate or 471% from a low of 2,447 IDR/USD in 1997.M6 to a high of 13,963 IDR/USD in 1998.M7 based on the average exchange rate. To stabilize the exchange rate, the Bank of Indonesia raised the overnight rate to a high of 80.01% in 1998.M8, and the deposit rate
and the lending rate followed suit to rise to a high of 54.64% and 35.68% in 1998. Very high interest rates reduced investment spending, dampened household credit purchases, and increased business failures. As a result, real GDP plunged by approximately 19.3% during 1997.Q3 – 1998.Q4. The International Monetary Fund provided a rescue plan in 1998 to stabilize the rupiah exchange rate and the macroeconomic condition.

This paper attempts to examine the behavior of the rupiah/USD exchange rate and has several focuses. First, four different models are considered. They consist of the purchasing power parity model (Taylor and Taylor, 2004; Taylor 2006; Breitung and Candelon, 2005; Yotopoulos and Sawada, 2006; Alba and Papell, 2007), the uncovered interest parity model (Dekle, Hsiao, and Wang, 2002; Chinn and Meredith, 2004), the monetary models (Meese and Rogoff, 1983; Chinn, 1999, 2000; Cheung, Chinn, and Pascual, 2005), and the extended Mundell-Fleming model (Romer, 2001; Hsing, 2005, 2007). Second, in the monetary models, four different versions developed by Dornbusch (1976), Frenkel (1976), Bilson (1978), and Frankel (1979) are compared. Third, in the extended Mundell-Fleming model, comparative-static analysis is applied to determine the impact of a change in an exogenous variable on the equilibrium exchange rate. Fourth, the Newey-West (1987) method is applied in order to address the issue of both autocorrelation and heteroskedasticity simultaneously when their forms are unknown.

The paper is organized as follows. In the second section, we survey the literature related to exchange rates. In the third section, the theoretical models are presented. Following the third section, data sources and empirical results are described and explained. A summary and conclusion is made in the last section.

2. Literature Survey

This section reviews several recent articles of exchange rate determination for Indonesia and related countries. Taylor and Taylor (2004) and Taylor (2006) review major previous works, present issues and challenges in verifying PPP, and maintain that long-run PPP has gained more support as the gap between theory and data and the deviation of exchange rates from PPP have narrowed. Breitung and Candelon (2005) show that before 1997, PPP holds for Asian countries but not for Latin American countries and that long-run PPP holds for Asian countries owing to flexible exchange rate systems and breaks down for South American countries due to long-time pegging to the dollar. Yotopoulos and Sawada (2006) reveal that PPP holds for 132 countries in a 20-year time period and for 105 countries in a 10-year time period. Using a sample of 30 LDCs including Indonesia, Holmes (2006) shows that 16 out of 30 countries exhibit nonlinearity in the real exchange rate. Based on a sample of 88 LDCs including Indonesia and a new unit root test (KSS, 2003), Bahmani-Oskooee, Kutan and Zhou (2008) reveal that the number of countries that PPP holds are doubled, that there is nonlinear adjustment toward PPP in LDCs, and that PPP is more likely to hold for countries with relatively high exchange rate flexibility and high inflation. Alba and Papell (2007) indicate that PPP is valid for Latin American and European panel data, but not for Asian and African panel data. They also found stronger evidence of PPP for countries with more openness, lower inflation rates, moderate volatility of exchange rates, similar rates of economic growth as the U.S., and less distance from the U.S.
Chinn (1999) reveals that the five Asian currencies under study are consistent with the specifications of some types of monetary models, that exchange rates do most of the adjustments toward equilibrium for the Indonesian rupiah, the Korean won, and the Singapore dollar except for the New Taiwan dollar and the Thai baht, and that out-of-sample forecasts work well for the Korean won, the New Taiwan dollar, and the Singapore dollar. In another study, Chinn (2000) uses different models to evaluate currency overvaluation for several Asian currencies. A monetary model reveals that the Indonesian rupiah and the Thai baht are overvalued whereas the New Taiwan dollar, the Korean won, and the Singapore dollar are undervalued. As of May 1997, the PPP model shows that the Malaysian ringgit, the Thai baht, the Hong Kong dollar, and the Philippine peso were overvalued.

Applying an extended Mundell-Fleming model, Hsing (2005) finds that the real exchange rate in Slovakia is positively influenced by deficit spending/GDP ratio and the stock price index and negatively associated with real M2, the US Treasury bill rate, country risk, and the expected inflation rate. The error variance can be characterized by the GARCH process. Hsing (2007) shows that the US dollar/kuna exchange rate for Croatia is negatively associated with real M1, the US T-bond rate, the euro interest rate, the expected inflation rate, and the relative price and positively influenced by the expected exchange rate. Deficit spending does not affect the exchange rate. Most of the variation in exchange rates can be explained by the open economy model and uncovered interest parity.

Based on a monetary model, Basurto and Ghosh (2001) study the interest rate-exchange rate relationship for Indonesia, Korea, and Thailand and find that a higher interest rate leads to exchange rate appreciation and that there is lack of evidence that risk premium would rise due to a higher real interest rate.

Using a sample of four Asian countries including Indonesia, Hashimoto (2001) shows that an increase in the interest rate differential would have a significant impact on the exchange rate appreciation and that the cost of a higher interest rate for a low-inflation and low-budget deficit country far outweighs the benefit.

Miyakoshi (2003) examines the determination of the real exchange rate for five selected Asian countries including Indonesia. He reveals that the productivity-bias model applies to Indonesia and the Philippines whereas the real interest rate-bias model applies to Indonesia, Korea, Malaysia and the Philippines and that there is lack of support for the political risk premium model.

Based on a sample of six countries including Indonesia, Chen (2004) indicates that higher interest rates cause higher exchange rate volatility, that a higher interest rate policy would not defend the exchange rate, and that when the nominal interest rate is raised, the probability of a crisis regime increases.

Studying the relationships among the exchange rate, the interest rate, and economic activity for five Asian countries including Indonesia, Kim and Ratti (2006) find that a higher interest rate leads to exchange rate depreciation for Korea, the Philippines, and Thailand and that a higher interest rate leads to rupiah appreciation first but depreciation next and little impact later, and
that higher interest rates and exchange rate depreciation would increase business failures and deepen the crisis. Hence, the IMF’s recommendation to raise the interest rate sharply to stabilize the exchange rate may increase business failures and intensify the crisis.

3. The Model

This section presents four exchange rate models, namely, the purchasing power parity model, the uncovered interest parity model, the monetary models, and the extended Mundell-Fleming model.

3.1 The Purchasing Power Parity Model

In the purchasing power parity (PPP) model, the nominal exchange rate is a function of the relative price:

\[ e = V(P / P^*) \]  

where \( e \), \( P \), and \( P^* \) denote the IDR/USD exchange rate, the price level in Indonesia, and the price level in the U.S. The sign of the relative price in equation (1) is expected to be positive, suggesting that a higher relative price would cause the IDR/USD exchange rate to rise or the Indonesian rupiah to depreciate against the U.S. dollar.

3.2 The Uncovered Interest Parity Model

In the uncovered interest parity (UIP) model, the interest rate differential can be offset by the exchange rate depreciation or appreciation under the assumption of perfect capital mobility. If the domestic interest rate is less than the foreign interest rate, then the domestic currency is expected to appreciate by the same magnitude. If the domestic interest rate is greater than the foreign interest rate, then the domestic currency is expected to depreciate by the same magnitude. The UIP model can be written by

\[ R = R^* + (e^* - e) / e \]  

where \( R \), \( R^* \), and \( e^* \) stand for the interest rate in Indonesia, the interest rate in the U.S., and the expected exchange rate. Expanding the second term on the right-hand side and moving \( e \) to the left-hand side and other terms to the right-hand side in equation (2), the nominal exchange rate in general form is a function of the interest rate differential and the expected exchange rate:

\[ e = U(R - R^*, e^*) \]  

The sign of the interest rate differential is expected to be negative, and the sign of the expected exchange rate would be positive, suggesting that when the interest rate differential rises, the Indonesian rupiah would appreciate against the U.S. dollar.
3.3 The Monetary Models

Several versions of the monetary models include:

\[ e = X_1(M - M^*, Y - Y^*, R - R^*) \] (4)

\[ e = X_2(M - M^*, Y - Y^*, \pi^e - \pi^{e*}) \] (5)

\[ e = X_3(M - M^*, Y - Y^*, R - R^*, \pi^e - \pi^{e*}) \] (6)

where \( M, Y, \pi^e, M^*, Y^*, \) and \( \pi^{e*} \) denote money supply in Indonesia, real GDP in Indonesia, the expected inflation rate in Indonesia, money supply in the U.S., real GDP in the U.S., and the expected inflation rate in the U.S.

Equation (4) describes the Dornbusch model and the Bilson model. The sign of the relative interest rate is negative in the Dornbusch model and positive in the Bilson model. Equation (5) illustrates the Frenkel model. The sign of the expected inflation rate is positive. In the Frankel model in equation (6), the nominal exchange rate is expected to have a positive relationship with the relative money supply and the relative expected inflation rate and a negative relationship with the relative output and the relative interest rate.

3.4 The Extended Mundell-Fleming Model

Extending Romer (2001), Hsing (2005, 2007) and others, we can express the equilibrium in the goods market and the money market as:

\[ Y = F(Y, R - \pi^e, G, T, S, \epsilon) \] (7)

\[ M / P = L(Y, R, \epsilon) \] (8)

where \( \epsilon, G, T, S, L, \) and \( \pi^e \) are the real exchange rate, real government spending, real government taxes, the stock price, the demand for money. Solving for \( Y \) and \( \epsilon \), we have the equilibrium real exchange rate as:

\[ \bar{\epsilon} = \bar{\epsilon}(M / P, G, T, S, R, \pi^{e*}) \] (9)

The respective impacts of a change in real money supply, real government deficit, and the domestic interest rate on the equilibrium real exchange rate can be written by:

\[ \frac{\partial \bar{\epsilon}}{\partial (M / P)} = -(1 - F_Y) / |J| > 0, \] (10)

\[ \frac{\partial \bar{\epsilon}}{\partial (G - T)} = (F_G + F_T) L_Y / |J| < 0, \] (11)
4. Data and Empirical Results

The data were collected from the International Financial Statistics published by the International Monetary fund. The nominal exchange rate is the average value during a quarter and measured as the Indonesian rupiah per U.S. dollar (IDR/USD). In estimating the PPP model, the relative consumer price index (CPI) and the relative produce price index (PPI) are both considered. In estimating the UIP model, the call market rate in Indonesia and the federal funds rate in the U.S. are used to measure the interest rate differential because lack of other proper interest rates for Indonesia. The lagged exchange rate is chosen to represent the expected exchange rate. In estimating the monetary models, M2 money, real GDP, the call money rate, and the lagged inflation rate for both Indonesia and the U.S. are used. In estimating the extended Mundell-Fleming model, the real exchange rate, real M2, the call money rate, the share or stock price index, and the lagged inflation rate are used. Government spending as percent of nominal GDP is employed because of lack of earlier quarterly data for government deficit. The consumer price index is used to derive real M2. Nominal M2 and real M2 are measured in billion rupiahs and billion dollars for the U.S. Real GDP is measured in billion rupiahs for Indonesia and billion dollars for the U.S. The log scale is used except for variables with negative values. Quarterly data are used. The sample ranges from 1997.Q1 or 1997.Q3 to 2007.Q4.

Estimated regressions and related statistics are presented in Tables 1. The Newey-West (1987) method is employed in empirical work in order to generate consistent covariance and variance when the forms of autocorrelation and heteroskedasticity are unknown. Figures in the parenthesis are t-statistics. In the PPP model, the coefficient of the relative CPI or PPI is significant at the 1% level. The Wald test shows that the null hypothesis that the coefficient of the relative CPI or PPI is equal to one cannot be rejected at the 5% level. Thus, the proportionality hypothesis is confirmed. The regression using the relative PPI has higher explanatory power than the one using the relative CPI. The relative PPI seems to perform better in forecasting as the mean absolute percent error (MAPE) is calculated to be 12.294 compared with 16.895 when the relative CPI is used.

In the UIP model, 77.5% of the behavior of the exchange rate can be explained by the two right-hand side variables. The coefficient of the interest rate differential has a positive sign and is insignificant at the 10% level, suggesting that the sign is opposite to what we would expect. The coefficient of the lagged dependent variable is positive and significant at the 1% level. If the expected exchange rate is deleted from the regression, the coefficient of the interest rate differential is still positive and insignificant at the 10% level.
In the monetary models, the nominal exchange rate has a positive relationship with the relative money supply, the relative interest rate and the relative expected inflation rate and a negative relationship with the relative real output. The values of adjusted $R^2$ vary with the model. Empirical results suggest that the behavior of the exchange rate can be characterized by the Bilson model or the Frenkel model because the Dornbusch model requires the sign of the relative interest rate to be negative and because the Frankel model requires the sign of the relative interest rate to be negative.

In the extended Mundell-Fleming model, the value of adjusted $R^2$ is 73.2%. The real exchange rate has a positive relationship with real M2, the domestic interest rate, and the expected inflation rate and a negative relationship with the ratio of government consumption spending to GDP and the stock price. These results suggest that more real money supply or a higher domestic interest rate would cause the Indonesian rupiah to depreciate. Hence, relying on a tight monetary policy with a relatively high interest rate to defend the rupiah would not work.

5. Summary and Conclusions

This paper has examined the behavior of the exchange rate of the Indonesian rupiah against the U.S. dollar. Four different models have been tested in empirical work. In the PPP model, based on the value of adjusted $R^2$, the standard error of the coefficient, and the mean absolute percent error, the regression with the relative PPI shows better results than the regression with the relative CPI. In the uncovered interest parity, the coefficient of the interest rate differential has a wrong sign and is insignificant whereas the expected exchange rate is positive and highly significant. In the monetary models, the Bilson model and the Frenkel model apply to the IDR/USD exchange rate whereas the Dornbusch model and the Frankel model are not applicable. In the extended Mundell-Fleming model, more real money supply, a smaller government spending/GDP ratio, a lower stock price, a higher domestic interest rate, and a higher expected inflation rate would cause the rupiah to depreciate. Excluding the UIP model, the monetary models and the extended Mundell-Fleming model exhibit smaller forecast errors than the PPP model. Based on the value of adjusted $R^2$ and the correct sign and significance of the coefficients, the Bilson model performs best.

There may be areas for future research. The positive insignificant coefficient of the interest rate differential in the UIP model may suggest that more work needs to be done in the study of exchange rate movements for Indonesia. The expected exchange rate and the expected inflation rate play important roles in the determination of the exchange rate and may need to be constructed with more advanced methodologies.

Endnote

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References


Table 1. Estimated Regressions for the IDR/USD Exchange Rate

<table>
<thead>
<tr>
<th>Model</th>
<th>Equation</th>
<th>$\bar{R}^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PPP Model:</strong></td>
<td>$e = 8.919 + 0.895 \ (CPI - CPI^*)$</td>
<td>0.583</td>
</tr>
<tr>
<td></td>
<td>$(112.289) (2.958)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$e = 8.971 + 0.915 \ (PPI - PPI^*)$</td>
<td>0.744</td>
</tr>
<tr>
<td></td>
<td>$(191.160) (5.403)$</td>
<td></td>
</tr>
<tr>
<td><strong>UIP Model:</strong></td>
<td>$e = 2.194 + 0.021 \ (R - R^<em>) + 0.757 \ e^</em>$</td>
<td>0.775</td>
</tr>
<tr>
<td></td>
<td>$(3.850) (0.695)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(12.083)$</td>
<td></td>
</tr>
<tr>
<td><strong>Monetary Model:</strong></td>
<td>Bilson or Dornbusch Version:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$e = 1.869 + 1.519 \ (M - M^<em>) - 1.343 \ (Y - Y^</em>) + 0.129 \ (R - R^*)$</td>
<td>0.856</td>
</tr>
<tr>
<td></td>
<td>$(3.176) (12.865)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$- (-3.693)$</td>
<td></td>
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<tr>
<td></td>
<td>$(2.752)$</td>
<td></td>
</tr>
<tr>
<td>Frenkel Version:</td>
<td>$e = 3.905 + 1.113 \ (M - M^<em>) - 1.224 \ (Y - Y^</em>) + 0.012 \ (\pi - \pi^*)$</td>
<td>0.685</td>
</tr>
<tr>
<td></td>
<td>$(6.532) (8.750)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$- (-3.831)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(2.600)$</td>
<td></td>
</tr>
<tr>
<td>Frankel Version:</td>
<td>$e = 3.009 + 1.284 \ (M - M^<em>) - 1.138 \ (Y - Y^</em>) + 0.075 \ (R - R^<em>) - 0.008 \ (\pi - \pi^</em>)$</td>
<td>0.706</td>
</tr>
<tr>
<td></td>
<td>$(3.712) (7.659)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$- (-2.856)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(2.156)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(2.018)$</td>
<td></td>
</tr>
<tr>
<td>Extended Mundell-Fleming Model</td>
<td>$\varepsilon = 7.199 - 3.14E06 \ M/P - 0.041 \ GY - 0.002 \ S + 0.004 \ R^* + 0.009 \ \pi^*$</td>
<td>0.732</td>
</tr>
<tr>
<td></td>
<td>$(17.640) (5.306)$</td>
<td></td>
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<tr>
<td></td>
<td>$- (-2.170)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(2.112)$</td>
<td></td>
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<tr>
<td></td>
<td>$(1.668)$</td>
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</table>

Notes:
Figures in the parenthesis are t-statistics.
CPI and CPI* are the consumer price indexes in Indonesia and the U.S., respectively.
PPI and PPI* are the producer price indexes in Indonesia and the U.S., respectively.
GY is ratio of government consumption spending to GDP.