Estimating Equilibrium Real Exchange Rates of the Rupiah

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Abstract

In this paper we estimate equilibrium real exchange rate of the rupiah. Using quarterly data from 1993:Q1 to 2005:Q2, we find that productivity differential, terms of trade, and net foreign assets significantly determine the long-run equilibrium real exchange rate of the rupiah. In the short run, the change in the equilibrium real exchange rate is significantly determined by terms of trade, productivity differentials, net foreign assets, inflation differentials, and interest rate differentials. Based on the estimates of the equilibrium real exchange rate we find that in the period shortly before the 1997's crisis, the actual real exchange rate of the rupiah overvalued substantially relative the equilibrium real exchange rate, and since 2004 the rupiah tends to overvalue, but to the extent that lower than the overvaluation before the crisis.

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1. Introduction

One of the key questions facing economists in policy-making processes at central banks is regarding equilibrium exchange rates. In other words, economists are often confronted with a question: Given the observed fluctuations in exchange rates, what is the equilibrium of the exchange rates? This question is not unreasonable considering the important roles of the real exchange rate in adjustment processes. On the one hand, the real exchange rates can reflect the balance of the economy, and on the other hand, the movements of the real exchange rates have important implications for economic activities. The effects of real exchange rate on trade balance, for example, have been widely investigated both theoretically as well as empirically. Theoretically, Marshall (1923) and Lerner (1944) have provided an important framework in predicting the implication of the real exchange rate on trade balance. And based on the Marshall and Lerner framework, a large number of empirical studies have examined how the real exchange rate affects trade balances in certain countries.

The estimates of the equilibrium exchange rates also give a benchmark for assessing misalignments of currencies. And many studies have shown deleterious causes and effects of the exchange rate misalignments. As noted by Black (1994), for example, there are a number of reasons to avoid exchange rates misalignments including: "undesired fluctuations in absorption, the costs of adjusting to widely fluctuating exchange rates, unemployment associated with major adjustments, erosion of manufacturing capacity during misalignments, ratchet effects on inflation during depreciations, and protectionism generated in response to trade deficit."

The purpose of this paper is to examine the equilibrium real exchange rate of the rupiah. Specifically, we estimate equilibrium real exchange rate of the rupiah based on various economic fundamentals. Then, we assess the misalignments—overvaluations or undervaluations—of the rupiah using the deviation of the actual real exchange rate from the equilibrium real exchange rate.

The literature on real exchange rate provides a large number of empirical studies on the equilibrium exchange rate in developing countries. Alamsyah et al (2000), for example, estimate the nominal equilibrium exchange rate of the rupiah during the period of 1990-2000. Their model is based on the Fundamental Effective Exchange Rate

Equilibrium (FEER) framework. Manzie (1997) provides productivity-based explanation of the real exchange rate behavior in a number of East Asian countries including Indonesia. While Alamsyah et al provides the estimates of the equilibrium exchange rate of the rupiah in nominal terms, this paper provides evidence on the equilibrium real exchange rate. Relative to the Manzie, the equilibrium real exchange rate analyzed in this paper is not only based on productivity differential, but also based on other real variables such as terms of trade, capital flows, and international real interest rates. Moreover, this paper estimates the equilibrium real exchange rates using more up to date data that cover the periods from 1993 to 2005.

The remainder of the paper is organized as follows. In section 2 we present a review of various concepts of equilibrium real exchange rates, and discuss factors determining the movements of real exchange rates. In section 3 we discuss empirical models, data, estimation results, and policy implications. Finally, we conclude this paper with section 4.

2. Equilibrium Real Exchange Rate

2.1 Concepts

The fundamental concepts of the equilibrium exchange rate is Purchasing Power Parity (PPP) given by

$$P = SP^{*} \qquad (1)$$

where P represents domestic prices, P^{*} represents foreign prices, and S represents nominal exchange rate in terms of domestic currency per foreign currency. Referring to equation (1), PPP says that price levels in different countries are equal if measured in a common currency.

In practice, the concept of nominal exchange rates itself is of important interest in economics and finance. However, nominal interest rates do not give a complete picture of the price competitiveness of the domestic goods relative to foreign goods. For instance, a country’s trade competitiveness can decrease even though its nominal exchange rate depreciates; this can take place if the depreciation is accompanied by a higher in domestic price increases than foreign price increases. The real exchange rate is used to deal with this problem. By definition, real exchange rate (Q) is nominal exchange rates weighted by the ratio of foreign goods' prices relative to domestic goods' prices, that is

$$Q = \frac{SP^*}{P} \tag{2}$$

Based on equations (1) and (2), if the concept of equilibrium exchange rate refers to the PPP, then the equilibrium real exchange rates have to be constant and equal to one.

Even though the concept of PPP is appealing in determining the equilibrium exchange rate, unfortunately, many studies have shown that the PPP hardly—if ever at all—hold empirically[2]. As pointed out by Black (1994), for example, the notion of the PPP only accounts for *monetary* part of the exchange rate fluctuations while the fluctuations of exchange rates can also be driven by real factors. In line with the rejections of the PPP, a number of economists have tried to explain why the real exchange rate deviates from the PPP concept, and different concepts of equilibrium real exchange rate beyond the PPP have been proposed. In Table 1 we present various concepts of equilibrium exchange rate summarized by Driver and Westaway (2004).

Definition of time horizons of the equilibrium real exchange rate provided by Driver and Westaway (2004) in Table 1 is as follows[3]. Let equilibrium real exchange rate be determined by

$$q_t = \alpha' X_t + \beta' Y_t + \varepsilon_t \tag{3}$$

where X_t be a vector of factors determining equilibrium real exchange rate in the short-run, Y_t be a vector of economic fundamentals, ε_t be random disturbances, and α and β be vectors of coefficients. Short-run equilibrium exchange rate is exchange rate determined by variables in vector X and vector Y. Medium-run equilibrium exchange rate is exchange rate that is compatible with internal and external balance. Long-run equilibrium exchange rate is the equilibrium where stock-flows equilibrium for all agents has been achieved. In medium-run equilibrium there is no cyclical or bubbles effects, but adjustments of asset

[2] In a collection of papers on equilibrium exchange rate edited by Williamson (1994), there is an agreement among the authors to reject the PPP as the best possible criterion in determining equilibrium real exchange rate.

[3] Driver and Westaway define this time horizon based on Clark and MacDonald (1997).

stock still take place. In the long-run equilibrium, on the other hand, there is no more adjustment of asset stock.

Table 1: Approaches to Equilibrium Real Exchange Rate

Name	Theoretical Assumptions	Time Horizon
CHEERs: Capital Enhanced Equilibrium Exchange Rate	PPP plus nominal UIP without risk premia	Short-run
ITMEERs: Intermediate Term Model Based Equilibrium Exchange Rates	Nominal UIP including risk premia and real exchange rate movements based on fundamentals	Short-run
BEERs: Behavioral Equilibrium Exchange Rates	Riel UIP with risk premia and riel exchange rate movements based on fundamentals	Short run
FEERs: Fundamental Equilibrium Exchange Rates	Real exchange rate compatible with internal and external balance	Medium-run
DEERs: Desired Equilibrium Exchange Rates	As with FEERs, except that the definition of external balance based on *optimal policy*	Medium-run
APEERs: Atheoretical Permanent Equilibrium Exchange Rates	None	Medium/Long run
PEERs: Permanent Equilibrium Exchange Rates	As BEERs	Medium/Long run
NATREX: Natural Real Exchange Rates	As with FEERs, but with portfolio balance assumption	Long Run

Source: Driver dan Westaway (2004)

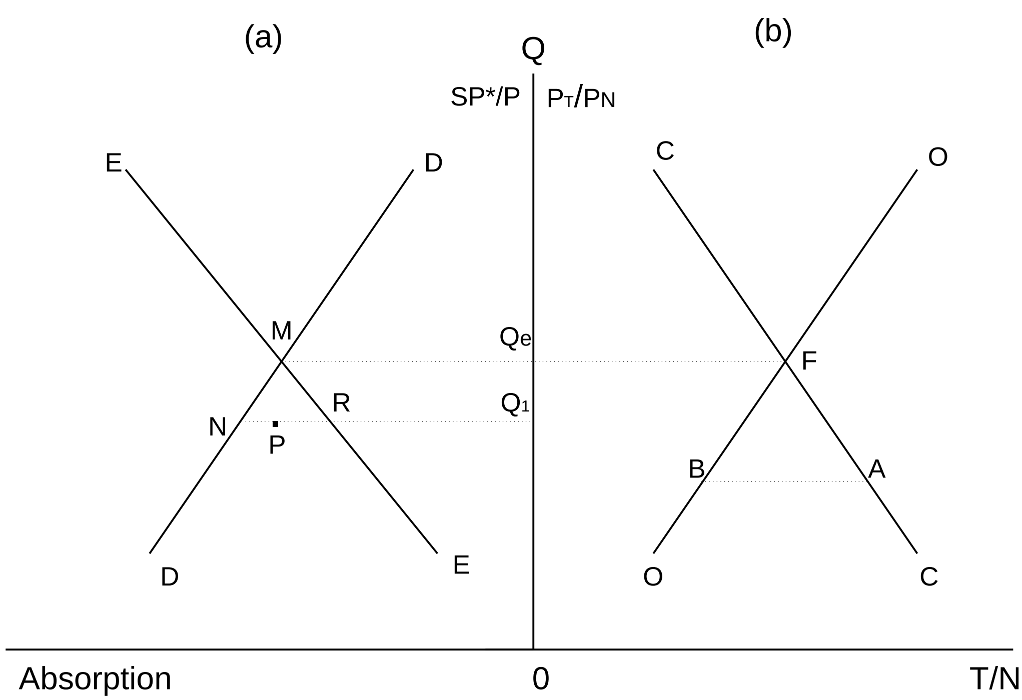
As noted by Hallwood and MacDonald (2000), regardless of the estimation methodology employed, the concepts of equilibrium real exchange rate refer to the real exchange rate that gives internal and external balance of the economy, and optimal allocation between tradable goods and non-tradable goods. This view is also found in Williamson (1994), where he pointed out that FEER, DEER, and ERER mean the same thing: all refers to the real exchange rate characterized by internal and external balance.

Besides the definition of the real exchange rate as in equation (2), the real exchange rate can also be defined as a ratio of tradable goods' prices (P_T) relative to non-tradable goods prices (P_N). Thus, a higher P_T/P_N ratio reflects real exchange rate depreciation; and a lower P_T/P_N ratio reflects real exchange rate appreciation. In Figure 2, the real exchange rate is depicted in terms of internal and external balance, both using the definition of the real exchange rate in terms of foreign goods prices relative to domestic goods prices, and in terms of tradable goods prices relative to non-tradable goods prices.

In Figure 2(a), DD represents internal equilibrium curve, while EE represents external equilibrium curve. Internal equilibrium DD has a negative slope and that a lower Q (appreciation in real exchange rate) results in a decreasing demand for exports. On the left hand side of DD, domestic absorption is too large and then there exists excess demand. External equilibrium curve EE has a positive slope: a larger absorption causes an increase in imports that in turn results in real exchange rate depreciation (a larger Q). On the left hand side of EE is an area where there exists trade deficit.

In Figure 2(b), CC represents the ratio of domestic consumption of tradable goods with respect to domestic consumption of non-tradable goods, OO represents the ratio of domestic production tradable goods with respect to domestic production non-tradable goods. To the right of CC is the area where there is excess demand for tradable goods relative to non-tradable goods. To the left of OO is the area where there is excess supply of tradable goods relative to non-tradable goods.

Figure 1: Equilibrium Real Exchange Rate
(source: Hallwood & MacDonald, 2000)



2.2 Factors Determining Equilibrium Real Exchange Rate

The explanation of the real exchange rate fluctuations has been provided by Harrod, Balassa, and Samuelson, henceforth HBS. Based on HBS, the main factor affecting long-run equilibrium real exchange rate is productivity differential. The HBS model predicts that a higher productivity of domestic tradable sector relative to that of domestic non-tradable sector causes expansion of tradable sector, and this in turn results in an appreciation of domestic real interest rate.

Other factors that can drive the real exchange rate fluctuations include capital flows, international real interest rate, terms of trade, tariffs, quotas, and other restrictions on imports, change in domestic consumer preference, and so forth. Capital inflows can result in the real exchange rate appreciation through an increase in domestic absorption. A higher real international interest rates results in a higher interest payment of net-debtor countries. On the contrary, for net-creditor countries, a higher international real interest rate results in a higher interest receipts from abroad. Thus, a rise in international real interest rates causes in depreciation of currency of debtor countries and appreciation of currency of creditor countries. The effects of the terms of trade on the equilibrium exchange rate can be positive or negative, depending on income effects and substitution effects (Elbadawi, 1994). On the one hand a rise in terms of trade results in larger revenues from exports, but on the other hand, a rise in terms of trade can also results in shifting away foreign demand for domestic exports. If income effects of the terms of trade dominate its substitution effects, an improvement in terms of trade results in real exchange rate appreciation, and vice versa.

3. Empirical Analysis

3.1 Empirical Model

While there are many factors that potentially contribute to the movements of real exchange rate, not all potential factors in empirical work can be included due to difficulties in measuring the variables. For example, although the shift in the preferences of domestic consumers potentially affect real exchange rate, but there is no accurate proxy to measure such a shift. In this paper, empirical model employed is closely related to Feyzioğlu (1997). To capture the long-run relationship between equilibrium real exchange rate and explanatory variables we use a reduced-form equation in which dependent variable is real effective exchange rate. The independent variables include terms of trade, productivity differentials between domestic and foreign countries, international interest rates, and net foreign assets. In this model, terms of trade, productivity differentials, international interest rates, and net foreign assets are exogenous considering that Indonesia is a small open economy.

Specifically, the empirical model we estimate to obtain the long-run ERER is given by equation:

$$erer = \beta_0 + \beta_1 tot + \beta_2 prodif + \beta_3 rfril + \beta_4 nfa + \beta_5 D97 \tag{4}$$

where, *erer* is real effective exchange rate, *tot* is terms of trade, *prodif* is productivity differential, *rfril* is international real interest rates, *nfa* is net foreign assets, and D97 is a dummy variable to capture the 1997's crisis. Based on the explanation in section II we expect β_2 and β_4 to be negative, and β_3 to be positive. The sign of β_1 cannot be determined *a priori* since two opposite effects are at work for the effects of terms of trade on the real exchange rate. The estimation of this long-run equilibrium relationship is conducted by employing cointegration model[4].

Given that variables in the reduced form (equation 4) are cointegrated, then the adjustment to the long-run equilibrium is captured using error correction mechanism given by equation

$$\begin{aligned} \Delta reer = \theta z_{t-1} + \alpha_0 + \alpha_1 \sum_{i=1}^{2} \Delta reer_{t-i} + \alpha_2 \sum_{i=0}^{2} \Delta tot_{t-i} + \alpha_3 \sum_{i=0}^{2} \Delta prodif \\ + \alpha_4 \sum_{i=0}^{2} \Delta rfril_{t-i} + \alpha_5 \sum_{i=0}^{2} \Delta nfa + \alpha_6 \sum_{i=0}^{2} cpidif_{t-i} + \alpha_7 \sum_{i=0}^{2} rdif_{t-i} \end{aligned} \tag{5}$$

where z_t be error correction terms. The values of z_t measure misalignment of the actual real exchange rate relative to equilibrium real exchange rate, and coefficient of z_t measures the speed of adjustment towards the long-run equilibrium.

[4] This model is widely used in estimating long-run relationships between macroeconomic variables; the details of the cointegration analysis can be found in econometric as well as empirical macroeconomics literature.

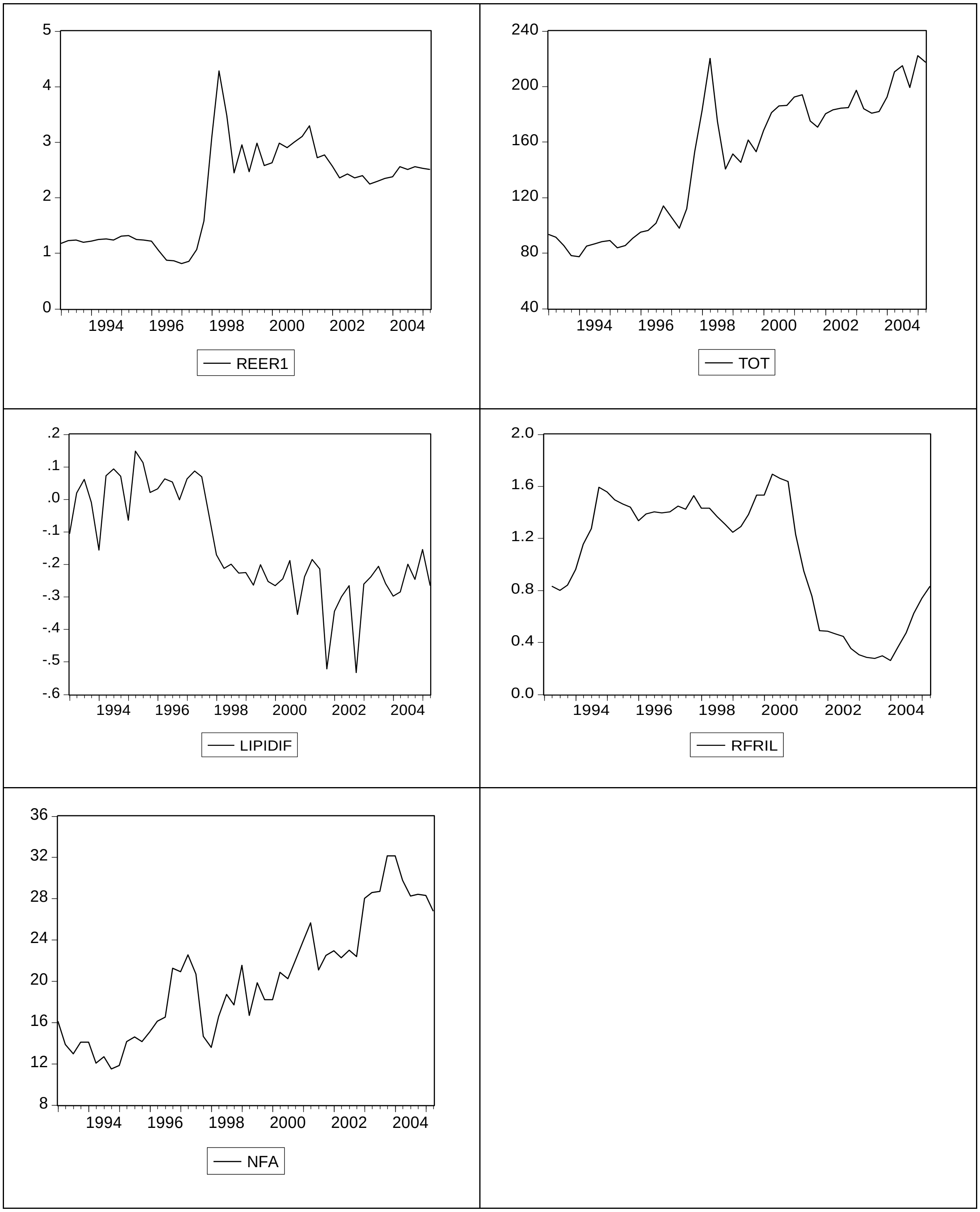
3.2 Data

The measures of real exchange rate cannot be constructed straightforward using equation (2). In practice, the prices of the same goods that can be compared across countries are not available, and the best measure available for price data comparable across borders is price index. In this paper, the real exchange rate is real effective exchange rate calculated using equation (2), where data for prices and exchange rate are in index form with the same base year[5]. Thus, an increase (decrease) in real exchange rate reflects a depreciation (an appreciation). As the proxy for productivity differential is the difference between Indonesian industrial production index and the US industrial production index. Terms of trade are calculated using the ratio of exports price index relative to imports price index. As the proxy for the international real interest rate is the difference between the US 3-months deposit interest rates and the US inflation rate. And finally, to capture capital flows we use net foreign assets.

To give some idea on the dynamics of the variables used in the model, we plot each of the variables over the period from 1993 to 2005. As shown in Figure 2, a number of facts observed are as follows. First, over the period studied the terms of trade tend to increase, and there was a jump in the terms of trade in the 1997's crisis. Second, following the crisis in 1997, productivity differentials plummeted and then the significant decreases took place again in the forth quarter of 2000 and in the forth quarter of 2001. A sharp decrease in net foreign assets is also observed in 1997. Finally, starting in 2001, the international real interest rates decreased substantially, and there is a tendency to increase since the beginning of 2004.

[5] This approach is widely used in empirical studies on real exchange rate.

Figure 2: Dynamics of the Variables



To test whether the series follow the unit root or not we conduct Augmented Dickey Fuller (ADF) as well as Phillips-Perron (PP) tests. As presented in Table 2, based on the ADF and PP unit root tests, the terms of trade, productivity differentials, and international real interest rates, and net foreign assets follow the unit root process. Except for productivity differentials, the PP tests fail to reject the null hypothesis of the unit root at 5 percent significance level. Nevertheless, based on ADF tests for all variables we fail to reject the null hypothesis of the unit root at 5 percent significance level. These properties of the data provide us the basis for estimating the long-run equation of the real exchange rate using cointegration analysis.

Table 2: Unit Root Tests

Variable	ADF Test	PP Test
Reer	-1.59	-2.14
tot	-2.28	-3.01
lipidif	-1.31	-4.18
rfril	-1.43	-2.11
nfa	-3.02	-2.35

Notes: 5% critical value for ADF test: -3.49
5% critical value for PP test: -3.49

3.3 Estimation Results and Policy Implications

Using model specification (equation 4), the estimate of the long-run equilibrium real exchange rate is given by (numbers in the brackets are t-statistics):

$$\underset{}{erer} = \underset{(0.82)}{-0.325} + \underset{(5.15)}{0.015}tot - \underset{(-1.99)}{1.140}prodif + \underset{(1.54)}{0.238}rfril$$

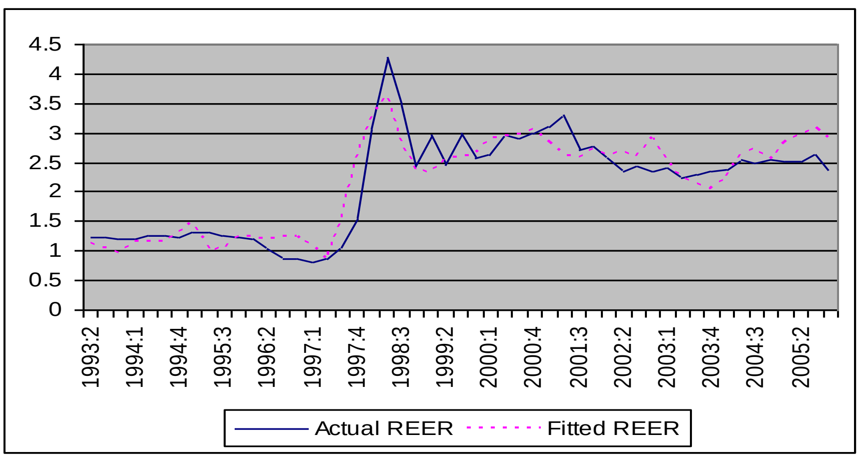
$$\underset{(-3.28)}{-0.053}nfa + \underset{(1.24)}{0.307}D97 \qquad (6)$$

$R^2 = 0.859$; R^2-adj. = 0.842

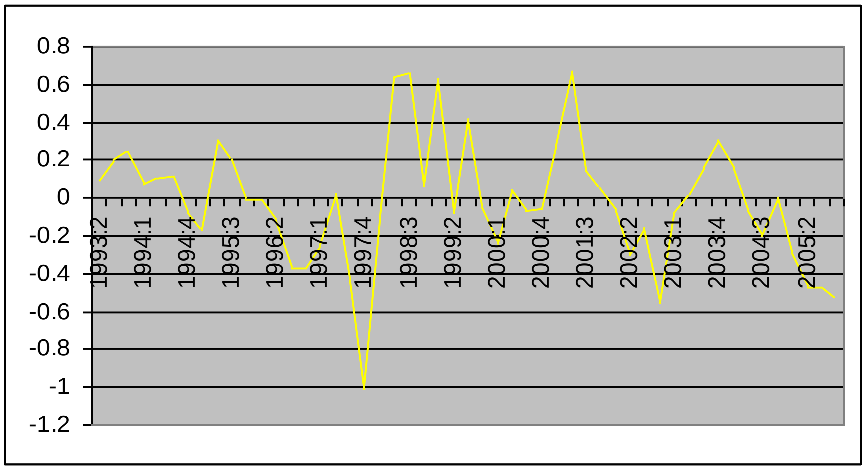
The estimation results show that terms of trade, productivity differential, and net foreign assets are significant at 5 percent significance level. The signs of productivity differential and net foreign assets support theoretical predictions. That is, a higher productivity differential between domestic and foreign countries results in appreciation of the equilibrium real exchange rate; and higher net foreign assets result in appreciation of the equilibrium real exchange rate. Coefficient of the terms of trade is positive and significant at 5 percent significance level. This indicates that in Indonesia, the substitution effects of higher terms of trade are stronger than the income effects. Therefore, an improvement in the terms of trade results in depreciation of the equilibrium real exchange rate. The international real interest although has the predicted sign, but only weakly significant, that is with 13 percent significance level.

Figure 3: Equilibrium Real Effective Exchange Rate, and Misalignments

(a) Equilibrium Real Exchange Rate



(b) Misalignment



Based on the actual values and the fitted values of the real exchange rate estimated from equation (6) we calculate the misalignments of the actual real exchange rate from equilibrium real exchange rate during the period from 1993 to 2005. As depicted in Figure 3, shortly before the 1997's crisis the actual real exchange rate overvalued substantially, and then undervalued until 1999. In 2001 and 2003 the real exchange rate tended to be undervalued, and then since 2004 the real exchange rate tends to be overvalued.

The estimation result of the short-run dynamics of the model is given by (numbers in the brackets are t-statistics)

$$\Delta erer_t = \underset{(-3.17)}{-0.095} - \underset{(-2.06)}{0.211} Z_{t-1} + \underset{(7.97)}{0.017} \Delta tot + \underset{(2.14)}{0.505} \Delta prodif_{t-1} + \underset{(2.36)}{0.027} \Delta nfa$$

$$- \underset{(-2.16)}{0.027} \Delta nfa + \underset{(5.56)}{3.292} \Delta cpidif_{t-1} - \underset{(-1.98)}{0.012} \Delta rdif_{t-1} \qquad (7)$$

$R^2 = 0.863$; R^2-adj. = 0.839

As shown by equation (7), deviations from long-run equilibrium are driven by terms of trade, productivity differentials, net foreign assets, inflation differentials, and nominal interest rate differentials. Lower terms of trade, lower productivity differential, lower inflation differential, and higher nominal interest rate differential result in equilibrium real exchange rate appreciation. Net foreign assets has positive effect in the first period, but followed by negative effect in the second period. Coefficient of adjustment from short-run deviation to the long run equilibrium, which is captured by coefficient of error correction terms, is 0.211. This means that when there is a deviation from the long run equilibrium, about 20 percent of the adjustment occurs in the first quarter.

Policy Implications

The misalignments—undervaluation or overvaluations—of the rupiah's real exchange rate, as shown by the estimation results, have a number of policy implications. And to understand such implications we need to examine the sources of the misalignments through the dynamics of the fundamentals that significantly contribute to the movements of the real exchange rate. A sharp overvaluation of the real exchange rate before the crisis seems to be associated to the sharp drops in productivity differentials as well as net foreign assets. In the period since 2004, the overvaluation of the real exchange rate seems to be associated with the decline in net foreign assets together with the increase in international real interest rate. The implication is, in order to reduce the misalignments the real exchange rate is expected to depreciate or there needs an improvement in domestic productivity relative to foreign productivity.

4. Conclusions

This paper estimates the equilibrium real exchange rate of the rupiah using quarterly data from 1993 to 2005. The results show that productivity differentials, terms of trade, and net foreign assets are significant factors in determining the long-run equilibrium real exchange rate of the rupiah. In the short-run, the change in the equilibrium real exchange rate is significantly determined by terms of trade, productivity differentials, net foreign assets, inflation differentials, and interest rate differentials. In the period shortly before the crisis, the model shows that the real exchange rate of the rupiah overvalued substantially relative the equilibrium real exchange rate. And since 2004 the rupiah tends to overvalue again but to a lower extent than the undervaluation before the 1997's crisis.

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