# MEASURING SHOCKS TO EXCHANGE RATE UNDER FLOATING REGIME

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## ABSTRACT

*The effect of nominal and real shocks to real exchange rates under floating exchange rate system was examined. The real exchange rates in this study were measured in terms of domestic currency relative to the U.S. dollar. Thailand was used as an event study during the economic crisis. Ever since the floating exchange rate system was in effect in the third quarter of 1997, some policymakers have called for policies designed to keep the exchange rate within the target range. A vector autoregression (VAR) was employed to investigate the joint behavior of real and nominal exchange rates in order to identify the nominal and real shocks that caused fluctuations in the real exchange rate. Based upon the results of a bivariate VAR model, the impulse response functions showed that real shocks had a thriving impact on changes in real exchange rates in the twelve- month forecast horizon. Furthermore, variance decompositions revealed that real shocks were much more robust than nominal shocks during the period under study.*

## INTRODUCTION

At the pinnacle of the Southeast Asian economic crisis, nominal and real shocks that affect real exchange rate have become more prevalent in macroeconomic policy analysis. Nominal shocks are typically referred to a shock from monetary policy, while real shocks stem from economic fundamentals, such as changes in preferences, productivity, and inflation expectations. If the real shocks to real exchange rate dominate nominal shocks, monetary policy measures alone cannot be used to cope with fluctuations in the real exchange rate, especially in the long run. Nominal exchange rate in Thailand had long been pegged, with occasional interrupting devaluation until the second quarter of 1997. The gradual decline in international reserves coupled with the attack on domestic currency (Thai baht) by speculators forced the Bank of Thailand to float the exchange rate. After entering the floating exchange rate regime, the nominal exchange rate in terms of baht per U.S. dollars depreciated sharply until the end of 1997. Consequently, data from Bank of Thailand (2002) showed that the net flows of portfolio investment, especially investment in equity securities, substantially decreased in 1998. Furthermore, short-term external debts gradually fell from 1997 to 2001. These events might be attributed to the short-run exchange rate risk faced by local and foreign economic agents. In early 1998, the baht began to appreciate and accelerated by the end of the year. In recent years, the nominal exchange rate has fluctuated to a lesser extent with an upward trend. This substantially improved the trade balance. Thus, the country has begun to experience a trade surplus.

According to international finance literature (Gan, 1994), movements in the real exchange rate can be viewed as a random walk process during a period of floating nominal exchange rate. Short-term capital flows can cause exchange rate volatility. This phenomenon is common in recent developments in Asia and Latin America. Bodnar, Dumas, and Marston (2002) found that exchange rate changes had a substantial impact on the pricing behavior of exporting and importing firms. One approach to alleviate exchange rate volatility is to measure and investigate the sources of fluctuations in real and nominal exchange rates.

## REVIEW OF RELATED LITERATURE

The studies of movements in real exchange rates are generally related to the notion that prices in different countries move towards equality in common currency term. The empirical works devoted to purchasing power parity (PPP) are motivated by the presence or absence of unit roots in real exchange rates and cointegration between nominal exchange rates and different measures of relative prices, such as wholesale prices versus consumer prices. If the null hypothesis of stationarity for the bilateral real exchange rate or real effective exchange rate is rejected, it is unlikely that PPP will hold. Bahmani-Oskooee (1993) and Liu (1992) presented contradictory results regarding the validity of the PPP hypothesis. Detailed PPP puzzle can be found in Rogoff (1996). Recently, Culver and Papell (1999) investigated long-run Purchasing Power Parity (PPP) with short-run floating exchange rate data by using tests where stationarity and cointegration were the null, rather than the alternative, hypotheses. The results show that the null hypothesis of stationarity of the real exchange rate or the cointegration between the nominal exchange rate and the domestic and foreign prices cannot be rejected in most cases. Therefore, there exists the evidence of PPP. Another empirical work by Papell (1997) employed 20 observations of quarterly data from 21 countries to test for real exchange rate stationarity. The results as a whole were consistent with log-run PPP.

Beyond the PPP hypothesis, there are attempts to investigate the causes of fluctuations in real exchange rates and to pinpoint the relative importance between transitory and permanent shocks. Economic theory does not generally offer a concrete specification of the dynamic relationship among variables. Furthermore, the case where endogenous variables may appear on both sides of the equations also makes the estimation and inference more complicated. A vector autoregression (VAR) is thus an alternative approach to deal with such problems. The three varieties of VARs are reduced form, recursive, and structural models. See Stock and Watson (2001) for further details. Blanchard and Quah (1989) proposed the long-run restriction on a structural VAR that nominal shocks have no permanent effects on the real exchange rate. This restriction is widely used in the literature. Lastrapes (1992) distinguishes real versus nominal sources of fluctuations in real and nominal exchange rates under a flexible exchange rate period using the bivariate vector autoregression (VAR) model. The restriction that nominal shocks had no permanent effect on real exchange rate was imposed. Using data from the United States, Germany, United Kingdom, Japan, Italy, and Canada, the results showed that real shocks dominate nominal shocks for both exchange rate series over short and long frequencies. Chen and Wu (1997) used the same restriction to investigate the relative importance between nominal and real shocks to fluctuations in real exchange rates. Employing quarterly data from Japan, Korea, Taiwan, and the Philippines, their findings from the long-run structural VAR approach indicated that real shocks were more important only in two cases, Japan and Korea. A recent study by Alexius (2001) showed that the movements in real exchange rates in the Nordic countries were mainly due to real supply shocks. In addition, the permanent component dominates the variances of changes in real exchange rates in most cases.

A bivariate VAR model is applied in this paper to capture the relationship between nominal and real exchange rates and to assess the influence of shocks on the fluctuations of real exchange rates in Thailand under the floating exchange rate system. This reduced form VAR is widely used as a reliable tool in data description, and forecasting. The VAR analysis reports results from impulse responses and forecast error variance decompositions (Stock and Watson, 2001). The next section deals with methodology, data description and empirical results. The conclusions, and research and practical implications are presented in the last section.

## MODEL AND METHODOLOGY

To measure fluctuations in exchange rates, the fluctuations affected by nominal shocks must be isolated from the part affected by real shocks. In general, these shocks (or disturbances) are not directly observable, but can be inferred from the joint behavior of the exchange rate series characterized by a vector autoregression (VAR) as employed in Lastrapes (1992), and Chen and Wu (1997). A reduced form VAR framework is formulated with zero restrictions on the coefficients of the lags of a subset of variables. If some restrictions are imposed, lack of sufficient observations will not provide sufficient degrees of freedom to obtain reliable estimates. This unrestricted VAR involves two equations:

| | |
|---|---|
| (1) | level or first differences of real exchange rates as a function of past values of level or first differences of real and nominal exchange rates and |
| (2) | level or first differences of nominal exchange rates as a function of past values of level or first differences of nominal and real exchange rates. |

In essence, a reduced form VAR representation is shown as:

$$(1)\ q_t = a_0 + \Sigma_i^k a_i s_{t-i} + \Sigma_i^k b_i q_{t-i} + u_{1t}$$
$$(2)\ s_t = \alpha_0 + \Sigma_i^k \alpha_i s_{t-i} + \Sigma_i^k \beta_i q_{t-i} + u_{2t}$$

where
q = s + p* - p

| | |
|---|---|
| *q* | is the level or first differences of the logarithm of the Thai baht/U.S. dollar real exchange rates. |
| *s* | is the level or first differences of the logarithm of the Thai baht/U.S. dollar nominal exchange rates. |
| *p** | refers to the logarithm of U.S. wholesale price indices. |
| *p* | denotes the logarithm of Thai wholesale price level. |

In summary, five main procedures are undertaken:

| | |
|---|---|
| (1) | Unit Root Test |
| (2) | Predictive Causality |
| (3) | Variance Decompositions |
| (4) | The Impulse-Response Functions |
| (5) | Integrated Autoregressive Moving Average |

**(1) Unit Root Tests**

Because VAR approach is suitable when each series is stationary, I(0), or integrated of order one, I(1), it is imperative to test whether each series contains a unit root in its level or first differences. The unit root tests such as the ADF (Dickey and Fuller, 1979) and PP (Phillips and Perron, 1988) are applied at level and first differences of each series.

However, the most widely used VAR is based upon the condition that economic variables are known to be integrated of order one, I(1), with no cointegration. Therefore, unit root test is performed on both level of and first differenced series of nominal and real exchange rates.

**(2) Predictive Causality**

After testing for unit root, the standard Granger-causality tests as employed in Chow (1987) were employed to examine whether lagged values of one variable help predict the other. If variations of nominal exchange rates do not help predict variations of real exchange rates, the coefficients on lags of real exchange rate series will all be zero in the reduced-form nominal exchange rate series equation, and vice versa.

**(3) Variance Decompositions**

The next step is to estimate the reduced form model in two stages: *Stage 1*: each variable is regressed on its lags and past values of other variables and, *Stage 2*: the Cholesky factorization technique is used to obtain the residuals from each reduced form equation. The Cholesky factorization of the reduced form VAR covariance matrix can be computed. For detail discussion and derivation of this topic, see Hamiliton (1994).

The reduced form VAR is used to generate the error terms in each equation. These error terms are the unanticipated movements in the variables after taking into account past values. The stochastic error term in the first equation is monetary innovation or impulse in the language of VAR, while one in the second equation is real innovation.

**(4) The Impulse-Response Functions**

In practical applications of impulse-response analysis, estimates replace unknown parameters (Diebold, 2001). This immediately yields point estimates of the impulse-response functions that can be shown on graphs to ease interpretation.

**(5) Integrated Autoregressive Moving Average**

Moreover, the method of fitting real exchange rate changes to the ARIMA (p, 1, q) based on Beveridge and Nelson (1981) is employed because changing order of variables in VAR representation can alter the results. If the real exchange rate series is I(1) process, an ARIMA model of the first difference of the series is estimated. As a result, the importance of real shocks using the impulse response from the simple VAR model can be confirmed.

## DATA

Data were collected from International Financial Statistics CD ROM of International Monetary Fund (IMF). They include the monthly nominal exchange rate, which is the ratio of domestic currency to foreign currency (Thai baht/U.S. dollar), and Thailand and the US's wholesale price indexes (WPIs) with the base period of 1995. The empirical analysis in the present paper is based only on short-term series since the nominal exchange rate has just been floated in July 1997. So, data under this study ranges from July 1997 through 2002. Data for computing effective real exchange rate are not available on the monthly basis. Instead, the real exchange rate is computed as the product of the nominal exchange rate and the relative price levels between the US and Thailand, as usually defined in macroeconomic literature such as Culver and Papell (1999). This is justified by the fact that transactions in terms of U.S. dollars are dominant in the global market, as U.S. dollars are widely used in all parts of the world, including Latin America, the Middle East, and East Asia.

## EMPIRICAL RESULTS

### (1) Unit Root Test

With a critical value of 5 percent, Table 1 shows that both ADF and PP tests indicate nonstationarity of the log of real exchange rate (q) at level while yielding contradictory results in the nominal exchange rate (s) at level. However, with critical value of 10 percent, the ADF test shows stationarity of log of real exchange rates while the PP test rejects the null hypothesis of stationarity. The contradictory of these two tests yields inconclusive results on real exchange rate series. Furthermore, ADF and PP statistics show that first differences of nominal and real exchange rate series are stationary. They are I(1), at 1 percent level of significance, according to MacKinnon critical values (MacKinnon, 1990). In other words, the first differences of nominal and real exchange rate series are not affected by seasonality and structural breaks. Both series at level and first differences do not exhibit a deterministic trend as coefficient of the trend term is insignificant.

**Table 1: Unit Root Tests for Nominal and Real Exchange Rates**

| Variables | ADF Test | | PP Test | |
|---|---|---|---|---|
| | No Trend | Trend | No Trend | Trend |
| Log of s | -3.223* | -3.434 | -3.266* | -3.277 |
| Log of q | -2.611 | -2.851 | -2.485 | -2.633 |
| Log of s | -5.635* | -5.614* | -6.407* | -6.377* |
| Log of q | -5.952* | -5.917* | -6.847* | -6.805* |
| Critical Value at 5% | -2.912 | -3.486 | -2.911 | -3.486 |

Note: *significance at 5 percent level.

## (2) Predictive Causality

The standard Granger-causality tests were implemented in this step. Since the series of real exchange rates is I(1), and the series of nominal exchange rates is I(0) resulting from unit root tests with the level of significance of 5 percent, a reduced form bivariate VAR was performed by using first differences of real exchange rates and nominal exchange rates at level. If variations of the nominal exchange rate at level do not help predict variations of first differences of the real exchange rate, the coefficients on lags of first difference real exchange rate series will all be zeros in the reduced-form level nominal exchange rate series equation, and vice versa.

These equations were estimated using lag lengths of 2, 4, and 6 months. However, the lag length of 6 provided the best estimates of coefficient from causality test under Akaike Information criterion (AIC, see

Pindyck and Rubinfeld, 1997). The results of the standard Granger causality tests showed bi-directional causation between the two series. This implied that level of nominal exchange rates caused changes in real exchange rates at 1 percent level of significance, and changes in real exchange rates caused level of nominal exchange rates at 5 percent level of significance. In other words, the series of level nominal exchange rates help predict the series of changes in real exchange rates, and the series of changes in real exchange rates also help predict the series of level nominal exchange rates.

### (3) Variance Decompositions

Variance decompositions and impulse response function using the lag length of four according to AIC criterion are described below.

Table 2 presents the variance decompositions of changes in real exchange rates and the level of nominal exchange rates. The results give the fraction of the forecast error variance for each variable that is attributable to its own innovations and to innovations in another variable. The forecast error variances are reported for forecast horizons over twelve months. Two columns under (a) of Table 2 shows within the first two months, 96.168 percent of the error in the forecast of changes in the real exchange rate is due to real shocks ( q). When compared with six and twelve months, the percentages of forecast error increase to 95.479 and 95.327 percent, respectively. In Table 2, the last two columns under (b) also reports the variance decompositions of level nominal exchange rate due to real ( q) and nominal shocks (s). The forecast error variances for level nominal exchange rate are similar to shocks to real exchange rate changes, but with a somewhat higher percentage point. For example, within the first two months, 96.861 percent of the error in the forecast of level nominal exchange rates is due to real shocks. The percentages of forecast error increase to 97.066 and 96.423 percent in 6 and 12 months, respectively. The salient feature of the variance decomposition results is that the predominant source of fluctuations in real exchange rate changes and level nominal exchange rates is due to real shock.

**Table 2: Variance Decomposition**

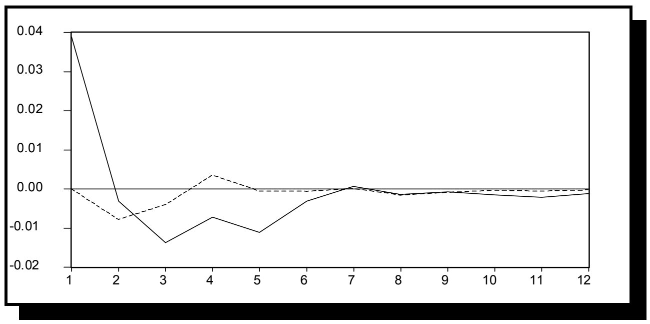
| Forecast Horizon | a. Changes in Real Exchange Rate (Δ q) | | | b. Level of Nominal Exchange Rate (s) | | |
|---|---|---|---|---|---|---|
| | Standard Error | % from Δ q | % from s | Standard Error | % from Δq | % from s |
| 1 | 0.0388 | 100.000 | 0.000 | 0.0423 | 94.273 | 5.727 |
| 2 | 0.0397 | 96.168 | 3.832 | 0.832 | 96.861 | 3.139 |
| 3 | 0.0422 | 95.715 | 4.285 | 0.285 | 97.567 | 2.433 |
| 4 | 0.0429 | 95.190 | 4.810 | 0.810 | 97.566 | 2.434 |
| 5 | 0.0443 | 95.474 | 4.526 | 0.526 | 97.318 | 2.681 |
| 6 | 0.0444 | 95.479 | 4.521 | 0.521 | 97.066 | 2.934 |
| 7 | 0.0444 | 95.479 | 4.521 | 0.521 | 96.742 | 3.258 |
| 8 | 0.0445 | 95.364 | 4.636 | 0.635 | 96.597 | 3.403 |
| 9 | 0.0445 | 95.330 | 4.670 | 0.670 | 96.534 | 3.466 |
| 10 | 0.0445 | 95.329 | 4.671 | 0.670 | 96.484 | 3.516 |
| 11 | 0.0446 | 95.326 | 4.674 | 0.674 | 96.452 | 3.548 |
| 12 | 0.0446 | 95.327 | 4.673 | 0.672 | 96.423 | 3.577 |

## (4) The Impulse-Response Functions

The impulse-response function is another device of interest to forecasters that verifies the dynamic properties of VAR. Hence, they are reported in Figures 1 and 2.

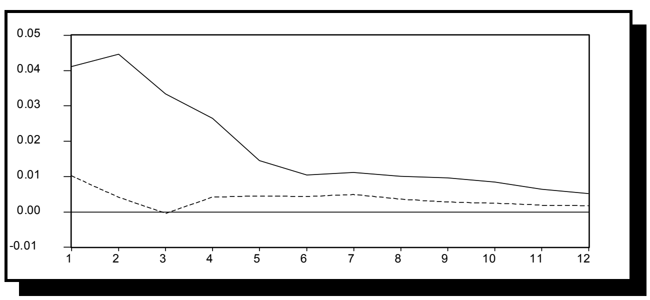
Figure 1 shows impulse responses that trace out the responses of current and future values of real exchange rate changes to a one-unit increase in the current value of real and nominal shocks. In view of the fact that the reduced form VAR model is estimated in first differences of real exchange rates but at level of nominal exchange rates, a one-time shock to its first differences is a permanent shock to its level. A nominal shock to the real exchange rates seems to dissipate within 12 month forecast horizon while a real shock still causes fluctuations in changes in the real exchange rate. The finding indicates that even though initial responses of changes in the real exchange rate to real shocks have a strong positive effect, a negative effect can be observed within two months and thereafter. Figure 2 confirms that real shocks as compared with nominal shocks clearly cause more variations in the nominal exchange rate.

**Figure1: Responses of Changes in Real Exchange Rate to Real and Nominal Shocks**




Forecast Horizon (months)
_______ Real Shocks ------- Nominal Shocks

**Figure 2: Responses in Level of Nominal Exchange Rate to Real and Nominal Shocks.**




Forecast Horizon (months)
_______ Real Shocks ------- Nominal Shocks

## (5) Integrated Autoregressive Moving Average

The result of fitted and actual first differences of real exchange rates is shown in Figure 3. Figure 3 shows that the fitted and actual first differences of the real exchange rate move closely in concert. The maximum variations vary from about 0.08 to -0.14.

In addition, using Beveridge and Nelson's (1981) technique, the ARIMA (6, 1, 0) is found to be the most suitable model for the first differences of the exchange rate series. Figure 4 shows the impulse-responses from the ARIMA (6, 1, 0) model. The response of changes in the real exchange rates to real shocks is quite similar to what depicted in Figure 1.

**Figure 3: Actual, Fitted, and Residuals of Changes in Real Exchange Rate.**

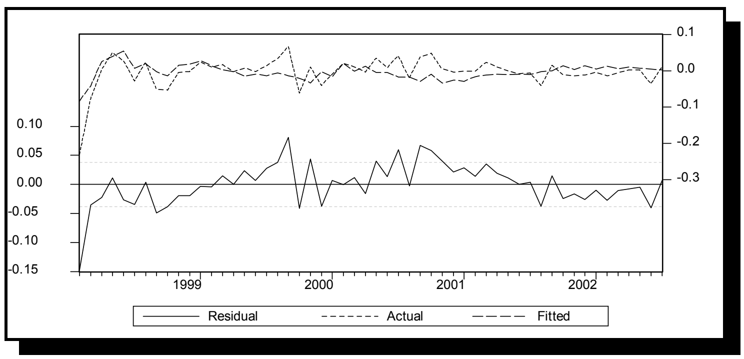
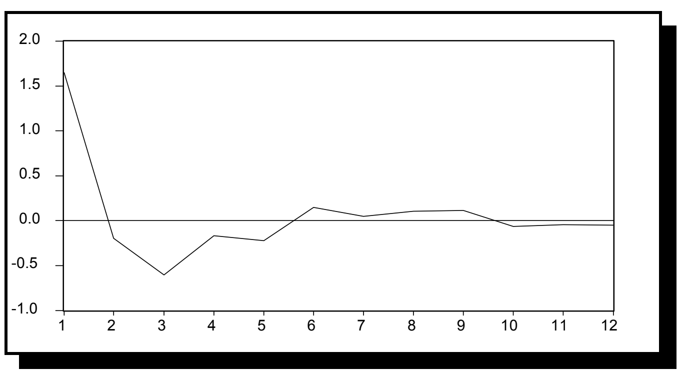



**Figure 4: Impulse Response of Changes in Real Exchange Rate from ARIMA (6, 1, 0)**




## CONCLUSIONS

In retrospect, it has long been recognized in the international finance literature that the domestic currency should be pegged to the U.S. dollar or to a basket of hard foreign currencies so as to avoid excessive instability and to attract foreign capital into the country. However, if the banking sector is poorly supervised, capital inflows for bank lending to business under the pegged exchange rate regime can be large and over-investment or over-consumption can be the consequences. Careless short term bank lending can essentially be problematic. When there are large outflows of capital, this can harm the country by depleting its international reserves, especially, the amount of U.S. dollars at the Bank of Thailand. Control on inflows can be fruitful in that it protects the country from the vulnerability to sudden reversals of capital flows and diminish vulnerability to speculative attack.

As one of the hardest hit countries from the Asian crisis, the real exchange rate had sharply depreciated during the last two quarters of 1997. This drastic depreciation of baht against U.S. dollar caused uncertainty in both exports and imports. Moreover, there is a large discrepancy between estimated and actual values of the balance of trade at that time. Exchange rate instability typically occurs as nation enters into the floating exchange rate regime as Thailand experienced in mid-1997. Therefore, the sources of exchange rate fluctuations should be identified and monitored.

**Contributions**

(1) The importance of identifying the sources of exchange rate fluctuations is that the validity of PPP can be established (Chen and Wu, 1997). The most appropriate approach to the estimation of exchange rate determination relies on the validity of the PPP theory. The PPP theory is valid when the real exchange rate series is stationary. Otherwise, cointegration between nominal exchange rate and the relative prices should be obtained. According to these tests performed, the level nominal exchange rate and the first difference of real exchange rate series yielded the best fit for VAR under this event study.

(2) Most research on sources of real exchange rate fluctuations finds mixed results of the role of nominal shocks compared to that of real shocks. This study confirms the crucial role of real shocks to real exchange rate.

According to the Purchasing Power Parity (PPP), real shocks have permanent effects on the observed real exchange rate in the long run. However, nominal shocks might be able to explain real exchange rate fluctuations in the short and intermediate terms. The crucial role of real shocks to changes in real exchange rate movement was observed.

(3) Moreover, this study represented a model of short-run exploration of the issue concerning shocks to real exchange rates because only data from mid-1997 to 2002 are available as a representation of floating regime.

(4) VAR model was used to investigate nominal and real shocks to changes in real and level nominal exchange rates measured in terms of U.S. dollar. The results concluded that changes in real exchange rate movements and the level nominal exchange rate were mainly caused by real shocks during the period under investigation.

**Research Implications**

Given these findings, yet there is room for future research to identify key sources and treatment of real shocks. There should also be more studies across national markets for generalization of these results. Such research will contribute significantly toward our understanding of how policy makers deal with a phenomenon of unstable exchange rates that comes with increased globalization.

**Practical Implications**

The results in this study also provide a clear policy implication. Like other developing countries, authorities in Thailand should not be complacent with exchange rate movements. The government in concert with the central bank should take certain measures to minimize the real exchange rate fluctuations that can disrupt economic decision-making, especially those in the foreign sector of the economy. Nevertheless, extra bank reserve could be accumulated by the central bank. In view of the fact that exercising monetary measures alone may not be adequate to maintain real exchange rate stability, attention to economic fundamentals such as changes in productivity, inflation expectations and preference should also be included as part of the stabilization package.

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