ความผันผวนของอัตราแลกเปลี่ยน ภายใต้ระบบอัตราแลกเปลี่ยนลอยตัว: หลักฐานเชิงประจักษ์จากประเทศไทย

Exchange Rate Volatility under Floating Exchange Rate Regime: Empirical Evidence from Thailand

Komain Jiranyakul, Ph.D.* **and Timothy P. Opiela, Ph.D.****

บทคัดย่อ

บทคัดย่อ การศึกษานี้เป็นการใช้เทคนิคทางเศรษฐมิติที่เรียกว่า GARCH เพื่อแสดงความผันผวนของอัตราแลกเปลี่ยนระหว่างเงินบาทและเงินสกุลแข็งสี่สกุลที่มีการแลกเปลี่ยนหรือซื้อขายในประเทศไทย ผลจากการวิเคราะห์ตัวเลขแสดงให้เห็นว่าการที่ประเทศไทยจำเป็นต้องปล่อยให้ระบบอัตราแลกเปลี่ยนเปลี่ยนเป็นระบบอัตราแลกเปลี่ยนลอยตัวจะทำให้เกิดความผันผวนมากในช่วงแรก ๆ ของระบบอัตราแลกเปลี่ยนลอยตัว โดยเฉพาะอัตราแลกเปลี่ยนในรูปเงินบาทต่อเงินดอลลาร์สหรัฐ แม้ว่าการเปลี่ยนจากระบบอัตราแลกเปลี่ยนคงที่เป็นระบบอัตราแลกเปลี่ยนลอยตัวจะทำให้เกิดความไม่แน่นอนสำหรับผู้ส่งออกและผู้นำเข้ารวมทั้งนักลงทุนต่างชาติ แต่ความไม่แน่นอนที่เกิดจากความผันผวนของอัตราแลกเปลี่ยนลดลงอย่างมากในช่วงระยะเวลา 2 ปีหลังจากการใช้ระบบอัตราแลกเปลี่ยนลอยตัว

* Associate professor of economics, National Institute of Development Administration, Thailand

** Associate professor of economics, DePaul University, Chicago, Illinois, USA.

Abstract

In this study we use a GARCH representation to investigate the volatility of four hard currencies that have been traded in Thailand. The results indicate that adopting a floating exchange regime has caused excess volatility of nominal exchange rates in the early period with the highest volatility level for the baht/U.S dollar exchange rate. The switch from fixed to floating regime causes uncertainty in the nominal exchange rate series, but the level of uncertainty subsides within two years.

INTRODUCTION

Early empirical works regarding short-run fluctuations in foreign exchange rates have focused on explanations of the distribution of the movements in nominal exchange rates. Friedman and Vandersteel (1982) examine daily movements of nine major currencies quoted in terms of the U. S. dollar. The main finding in this study indicates that the standard statistical procedures, such as ARIMA model, which based upon stationarity and normality are not applicable. The fluctuations in exchange rates are not normally distributed, but rather show the presence of leptokurtosis. The data seem to support the hypothesis that there is an underlying normal process that causes such fluctuations, but the process is time varying. Hsieh (1988) examines the statistical properties of daily foreign exchange rates for five currencies by extending previous papers in several ways. He finds that the distributions of exchange rates differ across days of the week, and that their means and variances also shift over time. Thus the models of time-varying means and variances are applicable. Furthermore, previous empirical studies suggest that the search for an appropriate distribution is necessary since the exchange rate changes are not necessarily independent and identically distributed.

Since ignoring heteroskedasticity of disturbances in econometric model typically entails inefficient point estimators and hypothesis test with sub-optimal asymptotic local power, Robinson (1987) develops a multiple linear regression model that will give efficiency in estimation and testing. The study on the statistical properties of daily changes in foreign exchange rates has shown that daily-return distribution is approximately symmetric and leptokurtic. In addition, there are weak autocorrelations in daily returns. Hsieh (1989a) finds that there is evidence of residual non-linearity in exchange rates after controlling for conditional heteroskedasticity. Therefore, it is possible that there exists nonlinear conditional-mean dynamics in exchange rates.

Conditional heteroskedasticity has been repeatedly employed in the study of exchange rate fluctuation. Diebold (1988) finds little evidence that there is linear predictability, but strong autoregressive conditional heteroskdastic (ARCH) effects in nominal exchange rates. If conditional-mean nonlinearity is present, using nonlinear model should improve a point prediction of exchange rates. The notion that real exchange rate is conditional heteroskedastic is supported by empirical studies by Engle (1982), Bollerslev (1986), Baillie and Bollerslev (1989), Hseih (1989a, b), Lumsdaine (1995), Zhou (1996), and Dominguez (1998).

Lumsdaine (1995) concludes that the estimates for the exchange rate data using different forms of a GARCH(1,1) process correspond to those of Engle and Bollerslev (1986). A study by Zhou (1996) uses high-frequency data to explore volatility in exchange rates. Unlike low-frequency data, high-frequency data have extremely high negative first-order autocorrelation in their return. The results from this study show that the daily and hourly volatility estimates of exchange rates exhibits some interesting patterns. However, Zhou admits that one disadvantage of using his method is that the estimator is not consistent when sample frequency increases and time span is fixed.

Theoretically, the nominal exchange rates are affected by several economic disturbances under flexible exchange rate system. When economic disturbances are assumed to be white noise, the equilibrium exchange rates are conditionally homoskedastic. This might be a misinterpretation of the behavior of exchange rates and contradictory to the empirical evidence. The exchange rate series may be characterized by heteroskedasticity with some weak serial correlation in returns. The ARCH error processes can affect the behavior of exchange rates as evidenced by many empirical studies. Weymark (1999) using quarterly data from 1960 to 1995 and finds that Canadian exchange rate series can be characterized as a GARCH(1,1) process.

The present study aims to investigate the volatility in nominal exchange rates using weekly data from the Bangkok Bank Company Limited. A recent study of exchange rate volatility by Hurley and Santos (2001) using the data during 1974-1999 of Association for Southeast Asian Nations (ASEAN), including Thailand as a member suggests that five currencies show volatility at varying degrees even under the crawling peg exchange rate regime. This result is investigated by using a variance decomposition and impulse response functions from the VAR-related estimation. Our study uses a GARCH(p, q) process to assess the volatility of four hard currencies being traded in Bangkok Metropolitan area of Thailand. If fluctuations in the exchange rate are excessive after introducing floating exchange rate regime, the implication is that domestic importers and exporters as well as investors in the financial market should be engaged in financial derivatives such as currency futures to hedge against the exchange rate risk.

This paper is organized as follows: Section 2 describes the data and techniques used in the study, section 3 gives some empirical results, and the last section gives a summary and a discussion.

METHODOLOGY

End-of-the-week data on the ratio of domestic currency (baht) to four main hard foreign currencies which are U.S. dollar

(USD), British pound (BP), Deutsch mark (DM), and Japanese Yen (JY) are collected from Bangkok Bank Public Company Limited during July 1997 to June 2000. The switch from the fixed to flexible exchange rate regime has begun since July 2, 1997, so we start from the floating exchange rate with 157 observations.

An autoregressive conditionally heteroskedastic (ARCH) process of Engle (1982) is used to model heteroskedasticity in time series. Once the ARCH disturbances are employed in the analysis of exchange rate behavior, we can test whether the response coefficients in the estimation are constant over time or the equilibrium exchange rate series are homoskedastic. Another version of this model is called a generalized autoregressive conditionally heteroskedastic (GARCH) process.

Traditionally, it is believed that heteroskedasticity will occur in cross-section analyses only. Engle (1982) pointed out the possibility that heteroskedasticity can be present in time series analyses. The recent past may give information about the conditional disturbance variance, of e_t which is conditional on information available at time t-1, and this can be expressed as

$$\sigma_t^2 = E(e_t^2 \mid e_{t-1}, \ldots, e_{t-p})$$
$$= E_{t-1}(e_{t-2})$$

where E_{t-1} is an expectation conditional on all information up to the end of period t-1.

The ARCH (p) process can be expressed as

$$\sigma_t^2 = a_0 + a_1 e^2_{t-1} + \ldots\ldots + a_p e^2_{t-p} \qquad (2.1)$$

When p=1, an ARCH(1) process is $e_t = u_t((a_0 + a_1 e^2_{t-1})^{1/2}$.

The variance of e_t depends on post volatilities going back a large number of periods when using daily or weekly data. The precision in the case of a large number of estimated parameters is not guaranteed, and thus the generalized autoregressive conditional heteroskedasticity (GARCH) model should be used instead, and this model can be estimated by maximum likelihood procedure. The simplest form is the GARCH(1,1) model that is expressed as

$$\sigma^2_t = \alpha_0 + \alpha_1 e_{t-1} + \lambda_1 \sigma^2_{t-1} \qquad (2.2)$$

When λ_1 takes the value of one, Eq. (2.2) can be expressed as

$$\sigma^2_t = [\alpha_0/(1-\lambda_1)] + \alpha_1 \Sigma_{j=1}^{\infty} \lambda_{j-1} e^2_{t-j} \qquad (2.3)$$

According to Eq. (2.3), the variance today will depend on all past volatilities, but with geometrically declining weights. One can also add one or more exogenous or predetermined variables as additional determinants of the error variance. If X_t is an exogenous variable of the GARCH(1,1) model, the model can be expressed as

$$\sigma^2_t = \alpha_0 + \alpha_1 e_{t-1} + \lambda_1 \sigma^2_{t-1} + \gamma_1 X_t \qquad (2.4)$$

However, if X_t takes on negative values, the variance could be negative for some observations.

A generalization of the univariate GARCH model proposed by Engle et al. (1990) is employed by some researchers to study the volatility of intra-day exchange rate, i.e., the yen/dollar and deutsch mark/dollar exchange rates from the New York interbank market. Weymark (1999) used quarterly data to analyze heteroskedasticity in exchange rate and other variables. Within the context of GARCH(1,1) process, σ^2_t is the conditional variance of exchange rate change series or the volatility (or uncertainty) of the rate of change in exchange rate expected to prevail given currently available information.

Besides heteroskedasticity in exchange rates employed, Lagrangian multipliers proposed by Engle (1982), Box-Pierce Q-statistic (Box and Pierce, 1970, and Ljung-Box statistic (Ljung and Box, 1978) as relevant diagnostic tests for the model are used in this study.

EMPIRICAL EVIDENCE

We first test the stationarity properties of changes in each nominal exchange rate series using the standard unit root tests. The series of variable are stationary time series as indicated by the augmented Dickey and Fuller (1979) test (ADF test) and the Phillips and Perron (1988) Test (PP test) as shown in Table 1. The number of lags for ADF test is four as suggested by Schwert (1987) using the formula L4 = $int[4(T/100)^{0.25}]$, where T is the number of observations and *int* is an integer. The number of lags for PP test (Phillips and Perron is four as suggested by Newey and West (1987) criterion, and the critical values are from McKinnon (1990).

Table 1 Unit Root Tests for Stationarity of Changes in Exchange Rates

Exchange Rate	ADF Test without Trend	ADF test with Trend	PP test without Trend	PP test with Trend
Baht/Dollar	-4.084	-4.184	-10.242	-10.326
Baht/Pound	-2.371	-2.687	-17.640	-17.784
Baht/Mark	-4.099	-4.330	-10.222	-10.357
Baht/Yen	-4.408	-4.393	-9.677	-9.641

Note: Critical values at 1% level are -3.483, -4.033, -3.481, and -4.034 respectively.

For the ADF test, we cannot reject the null hypothesis of a unit root for every series except for the series of changes in bath/pound. However, the results for the PP test strongly reject the null hypothesis of a unit root for all series of increments in nominal exchange rate. We therefore conclude that the test results suggest that there is no unit root in each series of changes in the nominal exchange rates.

Since all series we work with are stationary, we proceed to model each stationary time series as an ARIMA process of order (p,0,q). The lag length in the right-hand side of each equation is determined by including lags up to 10 lags and those lags with insignificant parameter estimates after the significant ones are eliminated. The results of ARCH estimates are reported in Table 2.

The least-squares results for the series of changes in exchange rates in terms of bath/US dollar, bath/pound, and bath/mark follow an AR(2) process. However, this process cannot be applied to the exchange rate in terms of bath/yen. The bath/yen follows an ARMA(2,1) process. In all four estimated equations, the diagnostic statistics by Q-statistic test show no autocorrelations for the residuals. However, the Q^2-statistic shows that all four equations have autocorrelations in the residuals. We thus perform the ARCH(1) process on the four series of changes in exchange rates. The results show an increase in log-likelihood in all cases, and the ARCH term in each equation is highly significant for the first two equations, but the ARCH term is significant at the 10 percent level in the last two equations. The number in parenthesis of ARCH-LM indicates the order of the lagged residuals employed in the test. The p-value of the ARCH-LM test indicates that the null hypothesis of ARCH disturbances cannot be rejected at the 5 percent level in most cases.

Table 2 Estimates under ARCH Process

Baht/Dollar:

Least Squared Results:

$$\Delta E_t = 0.001 + 0.067\Delta E_{t-1} + 0.229\Delta E_{t-2}$$

(0.525) (0.846) (2.914)

R^2 = 0.061 Log-likelihood = 348.661

Q(4) = 0.971 Q(8) = 3.441 Q(16) = 19.987

$Q^2(4)$ = 41.928 $Q^2(8)$ = 64.854 $Q^2(16)$ = 101.750

ARCH(1) process:

$$\Delta E_t = 0.002 + 0.536\Delta E_{t-1} - 0.052\Delta E_{t-2}$$

(2.110) (12.199) (-1.326)

$$\varepsilon^2_t = 0.0001 + 1.761\varepsilon^2_{t-1}$$

(5.784) (5.552)

R^2 = -0.217 Log-likelihood=367.741 ARCH-LM(12) = 21.117

Baht/Pound:

Least Squared Results:

$$\Delta E_t = 0.007 + 0.092\Delta E_{t-1} + 0.171\Delta E_{t-2}$$

(0.345) (1.155) (2.153)

R^2 = 0.042 Log-likelihood = 345.234

Q(4) = 1.021 Q(8) = 3.703 Q(16) = 17.806

$Q^2(4)$ = 32.904 $Q^2(8)$ = 57.119 $Q^2(16)$ = 114.970

ARCH(1) process:

$$\Delta E_t = 0.001 + 0.249\Delta E_{t-1} + 0.242\Delta E_{t-2}$$

(0.658) (3.281) (3.980)

$$\varepsilon^2_t = 0.0003 + 0.717\varepsilon^2_{t-1}$$

(7.871) (3.607)

R^2 = 0.009 Log-likelihood=357.129 ARCH-LM(4) = 10.318

Baht/Mark:

Least Squared Results:

$$\Delta E_t = 0.005 + 0.097\Delta E_{t-1} + 0.185\Delta E_{t-2}$$
(0.254) (1.126) (3.321)

R^2 = 0.048 Log-likelihood = 342.000

Q(4) = 0.549 Q(8) = 2.727 Q(16) = 11.506

$Q^2(4)$ = 25.049 $Q^2(8)$ = 42.547 $Q^2(16)$ = 86.460

ARCH(1) process:

$$\Delta E_t = 0.002 + 0.182\Delta E_{t-1} + 0.1772\Delta E_{t-2}$$
(0.835) (1.937) (3.268)

$$\varepsilon^2_t = 0.0004 + 0.484\varepsilon^2_{t-1}$$
(5.823) (2.495)

R^2 = 0.039 Log-likelihood = 347.276 ARCH-LM(10) = 29.964

Baht/Yen:

Least Squared Results:

$$\Delta E_t = 0.002 - 0.784\Delta E_{t-1} + 0.136\Delta E_{t-2} + 0.954\varepsilon_{t-1}$$
(0.775) (-8.820) (1.723) (23.218)

R^2 = 0.081 Log-likelihood = 329.527

Q(4) = 0.289 Q(8) = 1.922 Q(16) = 10.515

$Q^2(4)$ = 10.447 $Q^2(8)$ = 12.137 $Q^2(16)$ = 28.026

ARCH(1) process:

$$\Delta E_t = 0.002 - 0.704\Delta E_{t-1} + 0.202\Delta E_{t-2} + 0.947\varepsilon_{t-1}$$
(0.661) (-8.111) (2.431) (22.911)

$$\varepsilon^2_t = 0.0006 + 0.257\varepsilon^2_{t-1}$$
(7.033) (1.660)

R^2 = 0.075 Log-likelihood = 331.109 ARCH-LM(10) = 13.944

The results of ARCH-LM test suggest that the volatility of nominal exchange rate can be characterized by some form of heteroskedasticity. We thus use the GARCH(1,1) process to obtain conditional variances of the four exchange rate series. The results of the GARCH(1,1) process are reported in Table 3.

Table 3 Estimates under GARCH(1, 1)

Baht/Dollar:

$$\Delta E_t = 0.001 + 0.063\Delta E_{t-1} + 0.221\Delta E_{t-2}$$
$$(0.859)\quad(0.734)\qquad(2.792)$$

$$\sigma^2_t = 0.0001 + 0.144\varepsilon^2_{t-1} + 0.841\sigma^2_{t-1}$$
$$(0.384)\quad(3.114)\qquad(21.859)$$

R^2 = 0.060 Log-likelihood = 422.333

Q(4) = 1.819 Q(8) = 5.091 Q(16) = 12.702

$Q^2(4)$ = 7.950 $Q^2(8)$ =11.858 $Q^2(16)$ = 15.443

Baht/Pound:

$$\Delta E_t = -0.0007 + 0.035\Delta E_{t-1} + 0.145\Delta E_{t-2}$$
$$(-0.578)\quad(0.423)\qquad(1.919)$$

$$\sigma^2_t = 0.0005 + 0.092\varepsilon^2_{t-1} + 0.877\sigma^2_{t-1}$$
$$(1.181)\quad(2.230)\qquad(22.056)$$

R^2 = 0.034 Log-likelihood = 386.018

Q(4) = 1.011 Q(8) = 3.285 Q(16) = 12.190

$Q^2(4)$ = 2.395 $Q^2(8)$ =3.852 $Q^2(16)$ = 10.773

Baht/Mark:

$$\Delta E_t = -0.001 + 0.062\Delta E_{t-1} + 0.123\Delta E_{t-2}$$
$$(-0.620)\quad(0.698)\qquad(1.507)$$

$$\sigma^2_t = 0.0008 + 0.061\varepsilon^2_{t-1} + 0.877\sigma^2_{t-1}$$
$$(1.181)\quad(1.359)\qquad(17.219)$$

R^2 = 0.038 Log-likelihood = 365.252

Q(4) = 0.996 Q(8) = 1.165 Q(16) = 5.826

$Q^2(4)$ = 3.835 $Q^2(8)$ =7.237 $Q^2(16)$ = 18.505

Baht/Yen:

$$\Delta E_t = 0.002 - 0.827\Delta E_{t-1} + 0.105\Delta E_{t-2} + 0.926\varepsilon_{t-1}$$
(0.918) (-8.284) (1.203) (15.587)

$$\sigma^2_t = -0.0004 + 0.042\varepsilon^2_{t-1} + 0.956\sigma^2_{t-1}$$
(-0.564) (1.578) (31.281)

R^2 = 0.072 Log-likelihood = 340.324

Q(4) = 0.499 Q(8) = 2.955 Q(16) = 9.009

Q^2(4) = 6.686 Q^2(8) =9.024 Q^2(16) = 12.790

It is apparent from the improvement of the values of Log-likelihood that increase when we model heteroskedasticity as a GARCH(1,1) process, i.e., the GARCH process improves the fit in the model. The GARCH terms in all four equations are highly significant. In addition, Q-statistic and Q^2-statistics show no autocorrelations and partial autocorrelations. Therefore, we can conclude that the estimated GARCH process captures heteroskedasticity quite well. The exchange rate volatilities generated from the estimated GARCH(1,1) process are shown in Figure 1 - 4.

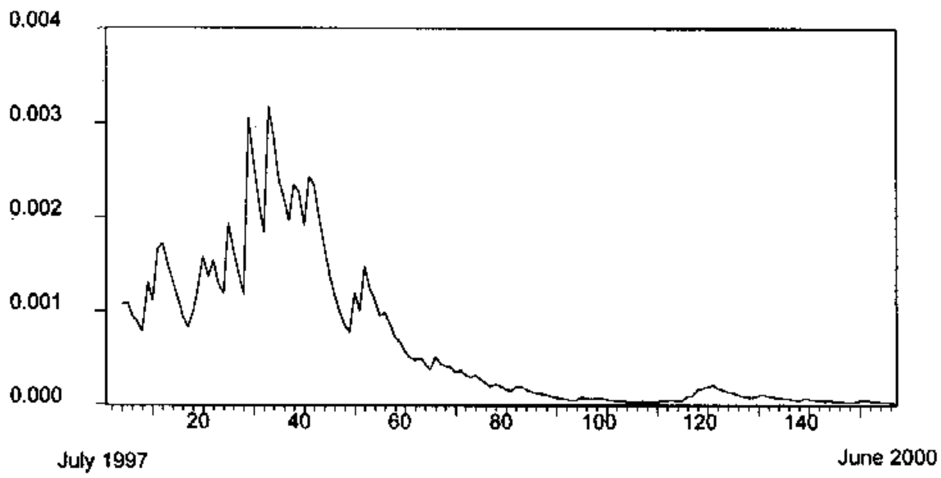

Figure 1. Volatility of Baht/U.S. Dollar Exchange Rate

From Figure 1., excess volatility in the exchange rates in terms of U.S. dollar are observed within a year after the Bank of Thailand allowed the exchange rate to float, and the volatility subsided thereafter.

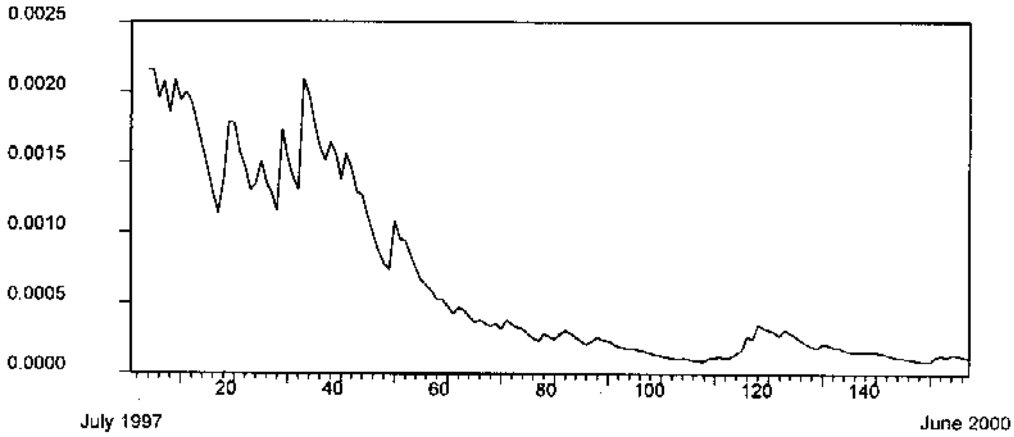

Figure 2. Volatility of Baht/British Pound Exchange Rate

Volatility of the British pound exchange rate shows a similar pattern to that of the US dollar, but with lower excess volatility.

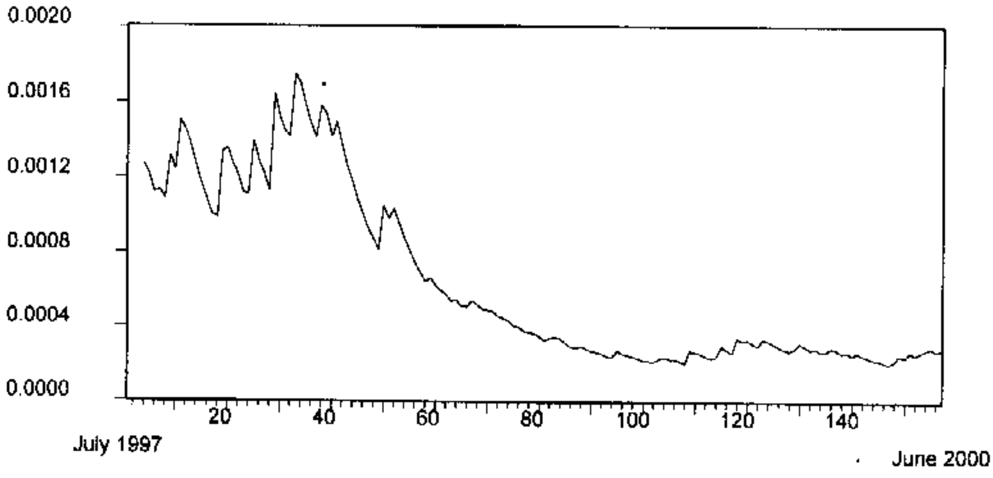

Figure 3. Volatility of Baht/Deutch Mark Exchange Rate

Lesser degree of volatility of the baht/deutch mark is observed as shown in Figure 3. The pattern of volatility is similar to that of the Baht/British Pound.

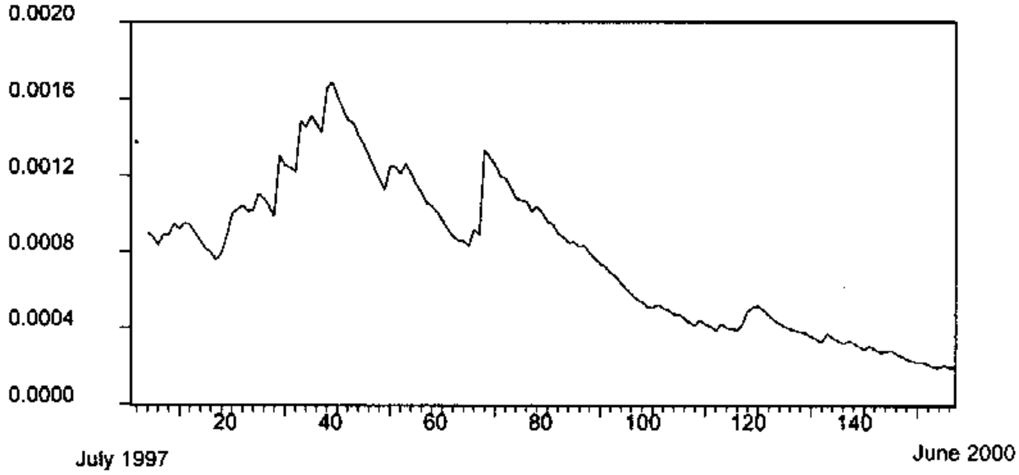

Figure 4. Volatility of Baht/Yen Exchange Rate

The exchange rate in terms of Japanese yen shows lesser excess volatility compared with the first three nominal exchange rates, but it took two years for its volatility to subside. Since the GARCH conditional variance is a measure of uncertainty of nominal exchange rate, lower uncertainty in the baht/yen exchange rate is observed during the period of investigation.

CONCLUSIONS

The results from this study show that volatility of nominal exchange rate subsided within a year for bath/dollar, bath/pound, and bath/mark, and within two years for the bath/yen exchange rate. This might be because traders and investors can adjust their speculation of exchange rate changes over time. In addition, the authorities might attempt to stabilize the nominal exchange rates.

Thailand's current account deficits declined in 1997 in response to financial crises. The current account became positive in 1998. Even though net capital inflows is negative in that year, reserves tended to increase. The Thai government has tended to use reserves as currency support.

The exchange rate in terms of the bath/U.S. dollar declined about 40 percent after floating exchange rate regime, but recovered in 1998 due to the reduction in the demand for imports, but exports did not significantly increase.

Kaminsky and Reinhart (1999) posit that the depreciation is often associated with defaults on bank loans and bank closures. This phenomenon causes interruption in the credit supply, and thus dampens private investment spending which leads to economic recession. The sharp depreciation of the bath in the second half of 1997 was followed by a recession that was caused by a decline in real income. As a result, real consumption declined, and the interest rates increased. Furthermore, domestic currency depreciation tended to reduce aggregate supply by raising the cost of imported inputs, especially in activities with high-content imported raw materials, semi-finished products, and capital goods.

To protect the exchange rate from a substantial depreciation caused by a sudden reversal of capital inflows to capital outflows, which depreciation may result in recession, inflation, and severe economic distortions, Mikesell (2001) recommends a dual exchange market which is a separation of the exchange rate market for capital account transactions from the exchange rate market for current account transactions. However, prudence in exercising a dual exchange rate market should be taken into account. The dual exchange market should not be put into operation except in the event of a financial crisis or an immediate threat of crisis.

An immediate threat of crisis occurs when there are net capital outflows and projected annual foreign debt obligations in excess of reserves. As long as the current account exchange rate is not overvalued, the exchange rate should be maintained by intervention, but no attempt should be made to support the capital exchange rate.

REFERENCES

Baillie, R. T. and Bollerslev, T. (1989) The message in daily exchange rates: a conditional variance tale," **Journal of Business & Economic Statistics**, 7, 297-305.

Bollerslev, T. (1986) Generalized autoregressive conditional heteroskedasticity," **Journal of Econometrics**, 52, 5-59.

Box, G. E. P., and Pierce, D. A. (1970) Distribution of residual autocorrelations in autoregressive integrated moving average time series models, **Journal of the American Statistical Association**, 65, 1509-1526.

Cheung, Y W. (1993) Long memory in foreign exchange rates, **Journal of Business & Economic Statistics**, 11, 93-101.

Dickey, D. A., and Fuller, W. A. (1979) Distribution of the estimators for autoregressive time series with a unit root, **Journal of the American Statistical Association**, 427-481.

Diebold, F. X. (1988) **Empirical modeling of exchange rate dynamics**, New York: Springer-Verlag.

Dominguez, K. M. (1998) Central bank intervention and exchange rate volatility, **Journal of International Money and Finance**, 17, 161-190.

Engel, R. F., (1982) Autoregressive conditional heteroskedasticity with estimates of the variance of U.K. inflation, **Econometrica,** 50, 987-1008.

______, and Bollerslev, T. (1986) Modeling the persistence of conditional variances, **Econometric Reviews**, 5, 1-50.

Friedman, D. and Vandersteel, S. (1982) Short-run fluctuation in foreign exchange rates, **Journal of International Economics,** 13, 171-186.

Hsieh, D. A. (1988) The statistical properties of daily foreign exchange rates: 1974-1983, **Journal of International Economics**, 24, 129-145.

_______ (1989a) Testing for nonlinear dependence in foreign exchange rates: 1947-1983, **Journal of Business**, 62, 339-368.

_______ (1989b) Modeling heteroskedasticity in daily foreign exchange rate, **Journal of Business & Economic Statistics**, 7, 307-317.

Hurley, D. T., and Santos, R. A., (2001) Exchange rate volatility and the role of regional currency linkages: the ASEAN case, **Applied Economics**, 33, 1991-1999.

Kaminsky, G. and Reinhart, C. (1999) The twin crises: the causes of banking and balance of payment problem, **American Economic Review**, 89, 473-500.

Ljung, G. M., and Box, G. E. P. (1978) On a measure of lack of fit in time series models, **Biometrika**, 65, 297-303.

Lumsdaine, R. L. (1995) Finite sample properties of the maximum likelihood estimators in GARCH(1,1) and IGARCH(1,1) models: A Monte Carlo investigation," **Journal of Business & Economic Statistics**, 13, 1-10.

MacKinnon, J. G. (1990) Critical Values for Cointegration Tests, in **Long-run Economic Relationships: Readings in Cointegration**, (ed.) R.F. Engle, and C.W. J. Granger. Oxford: Oxford University Press, 267-276.

Mikesell, R. F. (2001) Dual exchange markets for countries facing financial crises, **World Development**, 29, 1035-1041.

Newey, W., and West, K. (1987) A simple positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix, **Econometrica**, 55, 703-708.

Phillips, P. C. B., and Perron, P. (1988) Testing for a unit root in time series regression. **Biometrika**, 75, 335-346.

Robinson, P. M. (1987) Asymptotically efficient estimation in the presence of heteroskedasticity of unknown form, **Econometrica**, 55, 875-891.

Schwert, W. G. (1987) Effects of model specification on tests for unit roots in macroeconomic data, **Journal of Monetary Economics**, 20, 73-103.

Weymark, D. N. (1999) Heteroskdastic exchange rates and time-varying optimal intervention rules, **Canadian Journal of Economics**, 32, 1174-1190.

Zhou, B. (1996) High-frequency data and volatility in foreign-exchange rates, **Journal of Business & Economic Statistics**, 14, 45-52.