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Exchange Rate Volatility, Trade and "Fixing for Life" in Thailand

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CIES DISCUSSION PAPER 0212

Exchange Rate Volatility, Trade and "Fixing for Life" in Thailand

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ABSTRACT

At the outset of the 1997 financial crisis in East Asia, the quest to find a more suitable exchange rate policy has become an urgent policy challenge facing the East Asian economies. One of key policies agreed under Thailand's August 1997 Letter of Intent (LOI) with the IMF was to adopt a more flexible exchange rate policy. The implementation took place in the early months of the crisis, but most of these Southeast Asian economies, including Thailand, have re-adopted their pre-1997 crisis rigid exchange rate policy in early 1999 (McKinnon, 2001). To grasp this "fixing for your life" phenomenon (Calvo and Reinhart 2000a and 2000b), we test the impact of real exchange rate volatilities of Thailand's baht against the Japanese yen and the US dollar on the performance of the country's bilateral exports and imports with Japan and the U.S. from 1970 to first quarter of 1997.

JEL Classifications: F19, F31

1. Introduction

Most of the empirical works have confirmed that the rise in the volatility of exchange rate in general does have some consequences on the trade flows. Yet, despite the best efforts of economists, a basic paradox as to whether the exchange rate volatility benefits or adversely affects trade flows remains unresolved (McKenzie (1999)).

Among the studies reported in Table 1, only Chowdhury (1993) and Caporale and Doroodian (1994) show consistently adverse consequences of exchange-rate volatilitiy on exports and imports. Other studies such as Klein (1990), McKenzie (1998), Bailey, Tavlas and Ulan (1987), Koray and Lastrapes (1989), Aseery and Peel (1991), Kroner and Lastrapes (1993), McKenzie and Brooks (1997), McKenzie (1998), Daly (1998), Wei (1998) and Chou (2000) have found cases where a rise in exchange-rate volatilities may have both positive and negative implications on exports and imports. As far as the rest of studies listed in Table 1, we observe few cases where exchange-rate volatility plays an insignificant role in explaining exports and imports. This includes a most recent study by Aristotelous (2001) that finds the exchange rate volatility does not have any effect on the performance of the British exports to the United States during the period of 1889 – 1999.[1]

[1] As with the empirical works, the theoretical studies to date have also not reached any consensus on the impacts of exchange rate volatility on trades. Hooper and Kohlhagen (1978) found that if the traders were risk averse, an increase in exchange rate risk would unambiguously reduce the volume of trade. If importers bear the risk, the price will fall as import demand falls. Where as if exporters bear the risk, the price will raise as exporter charge an increasingly higher risk premium, consequently export volume will fall . Recognizing the facts that an increase in market risk has both substitution and income effects, De Grauwe (1988) comes to a set of contrasting conclusions. Very risk-averse individuals worry more about the worst possible income when the risk increases. They will export more to avoid the possibility of a drastic decline in their revenues. However, less risk-averse individuals are less concerned with extreme outcomes. They view the return on export activity as less attractive given the increase in risk and decide to export less. Giovannini (1988) presents a partial equilibrium model that looks into the role of exchange rate uncertainty and expectations in influencing the determination of domestic and exports prices by a monopolistic competitive firm. The study concludes that when export prices are set in a foreign currency, an increase in exchange rate risk will not affect domestic and export prices. Therefore, it will have no effect on export. However, if export prices were set in domestic currency, an increase in exchange rate risk would have an ambiguous effect on the level of domestic and exports prices. Bringing in the role of forward markets in their model, Viaene and Vries (1992) derive two possible scenarios. In the absence of forward

Given the nature of their economic developments and levels of economic openness, it was the developed countries that immediately had to face the new uncertainties associated with higher exchange rate volatilities of a more flexible regime during the early part the post-Bretton Woods system. This partly explains as to why, since early 1970s, most of the empirical debates around the role of exchange rate uncertainty have centered on the experiences of developed economies in Western Europe and North America (Table 1).

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Table 1

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However, at the outset of the 1997 financial crisis in East Asia, the quest to find a more suitable exchange rate policy has also become an urgent policy challenge facing the East Asian economies. Letter of Intents (LOIs) signed between the International Monetary Fund with the crisis-effected economies such as Thailand and Indonesia have specified the commitment of these economies to shift their exchange regimes to a more flexible one. In its LOI dated August 14, 1997, the government of Thailand has expressed its new policy to:

> "……allow the (nominal exchange) rate to adjust flexibly and we will not seek to defend any particular rate in the face of sustained market pressures".[2]

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markets, an increase in exchange rate volatility reduces both imports and exports. However, when the forward market exists, the impact of exchange rate volatility on trade depends on whether the net aggregate foreign currency position of the individual or the firm is positive or negative.

[2] For a complete draft of the Letter of Intent, see http://www.imf.org/external/np/loi/081497.htm

In its recent advice to help China to integrate further into the world economy and promote structural changes, the IMF has also urged the country to gradually shift its exchange rate policy to a more flexible regime.

> "IMF encourages "full use" of the trading band. This then should be followed by a gradual widening of the band and its linkages to a basket of currencies. At the moment, China's currency is US-dollar linked, and trades at around 8.28 to the greenback". (The Business Times, Singapore, August 27, 2001)

McKinnon (2001) has warned however that the "old habit" of keeping a rigid exchange rate policy remains to be popular in most East Asian economies. The study shows that East Asian developing countries have pegged their currencies to the US dollar for more than a decade before the break of the 1997 financial crisis. Some of these economies had temporarily relaxed their rigid policy against the US dollar during the period immediately after the break of the 1997-crisis (from June 1997 to December 1998). However, driven by the needs to stabilize their national currencies and to shield the local markets from the volatilities of the foreign exchange market, the soft-dollar pegged has once again become the exchange rate regime of the East Asian economies since 1999.

Calvo and Reinhart (2000a and 2000b) argue that there is a "fear of floating" among developing economies. During January 1983 – April 1999, their study shows that the probability that the monthly percentage change of nominal exchange rates of selected East Asian currencies against the US dollar falls within $\pm$ 1 percent band and $\pm$ 2.5 percent band was in average above 96 percent, except for Philippines and Singapore with a probability of 75 percent and 89 percent, respectively.

Those two studies have also indicated that adverse consequences of exchange-rate volatilities on trade and inflation are found to be more damaging to the emerging market economies than developed economies. Therefore, the developing economies (such as the East Asian countries) are more reluctant to tolerate large exchange rate movements ---by adopting a more flexible exchange rate policy and abandoning the soft-US dollar pegged policy. Especially, since a large share of the total trade of the East Asia economies with the world markets is denominated in the US dollar (McKinnon 2001, Calvo and Reinhart, 2001b).

It is important to note here however that hardly any sufficient empirical works have been prepared by Calvo and Reinhart (2000a and 2000b) to support their conclusions on the damaging role of exchange rate volatility on trade in the East Asian economies. In fact their conclusions are based on other studies, which have not in general focused on the East Asian countries[3].

To partly fill in this void, our study offers some empirical evidences to help explain the fear of floating and fixing for life phenomena in Thailand. The paper hopes to address two related questions. "Had there been any significant evidences of adverse consequences of the baht's exchange rate volatilities on exports and imports of Thailand with its most important trading partners: Japan and the US?" More importantly, "had the impacts been favorable or harmful for the trade sectors?" While most studies only provide one measure of exchange-rate volatility, we construct two sets of nominal and real exchange rate volatility, applying the most commonly used measurements.[4] Unlike

[3] Some of these studies are listed in Table 1.

[4] In total we will have four measures of exchange rate volatilities (two for each nominal and real exchange rate series).

most of early studies in Table 1, having more than one measurement of exchange-rate volatility allows us to verify the robustness of our regression results.

The remainder of this paper will be organized as follows. The next section briefly reviews selected relevant stylized facts in Thailand. Section 3 introduces working models for both export and import demand functions. The measurements of volatilities will also be presented here. Data and test results are discussed in section 4. Brief concluding remarks end the paper.

2. Stylized Facts in Thailand

According to a report by Bank of Thailand (1998), the country has adopted two types of exchange rate regimes during the past three decades (Figure 1)[5]. From early 1970 to 1985, Thailand moved back and forth between pegged to US dollar policy and pegged to a basket regime. Starting the last quarter of 1984 to the second quarter 1997, the baht was officially pegged to a basket of major trading partners' currencies.

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Figure 1

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As will be elaborated in the next section, we construct several measurements of both nominal and real exchange rate volatilities of baht against the US dollar and the Japanese yen. Figure 2A-2D plot bilateral values of exports and imports of Thailand to Japan and United States against two measures of real exchange-rate volatilities starting early 1970s to early 1997. In addition, Figure 2E-2F plot the nominal exchange rate volatilities. Closely observing those figures, we can trace the following contrasting stylised facts.

[5] Bank of Thailand (1998), "Focus on Thailand Crisis", in Bank of Thailand Economic Focus.

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Figure 2A – 2F

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By breaking the observation into two periods: 1980s (1980 – 1989) and 1990s (1990 - quarter 1, 1997), we trace a substantial reduction in the volatilities of both nominal and real exchange rate volatilities of baht against the US dollar and the Japanese yen during the post-1990 when compare to the pre-1990 volatilities.[6] Our back of envelope calculations of the means find that the average nominal and real volatilities of baht against the yen have dropped by around 20 percent in post-1990 from its pre-1990 volatility rates. Similar trend we find with the nominal and real exchange rate of the baht against the US dollar. However, the drops in the volatility rates are much more substantial. For the nominal exchange rate volatilities of the baht against the US dollar, the rate plummeted by about 40 percent in 1990s as compare to 1980s. As for the real exchange rate volatility against the US dollar, the drop was more moderate at about 25 percent.

In contrast, volumes of exports and imports of Thailand during the post-1989 period have risen by around two or three times the values of pre-1989 period (Figure 2A-2D). Next, we will conduct further investigations to examine whether the trends in the exchange rate volatilities of the baht has any implications on the trade performance of Thailand.

[6] To calculate the trends in both nominal and real exchange rate volatilities, we take the average of the different measures that we have. These results are available with the authors and can be made available upon request.

3. Working Model and Volatility Index

3.1. Working Model

There are two primary determinants of export and import demand (Dornbusch, 1988 and Hooper and Marquez, 1993). First, is the foreign income variable, measuring the economic activity and the purchasing power of the trading partner country. Second, is the relative price variable or the terms of trade (competitiveness factor)[7]. In addition, sharp gyrations in the foreign exchange markets in the last decade (Bird and Rajan, 2001) necessitate that we explicitly take into account exchange rate volatility as another explanatory variable in the export demand function. Incorporating all of the determinant factors, we can derive export- and import-demand working models:

$$x_t^{US/JP} = \alpha_{11} + \alpha_{21} y_t^{US/JP} + \alpha_{31} p_t^{US/JP} + \alpha_{41} V_t + \alpha_{51} Dummy_t + \varepsilon_{1t} \qquad (1)$$

$$m_t^{US/JP} = \alpha_{12} + \alpha_{22} y_t^{TH} + \alpha_{32} p_t^{US/JP} + \alpha_{42} V_t + \alpha_{52} Dummy_t + \varepsilon_{2t} \qquad (2)$$

where:

$x_t^{US/JP}$ $\Rightarrow$ the natural logarithm of Thailand's export volume to US or Japan.

$m_t^{US/JP}$ $\Rightarrow$ the natural logarithm of Thailand's import volume from US or Japan.

$y_t^{US/JP}$ $\Rightarrow$ the natural logarithm of real GDP of the US or Japan.

y_t^{TH} $\Rightarrow$ the natural logarithm of real GDP of Thailand.

$p_t^{US/JP}$ $\Rightarrow$ the natural logarithm of the ratio of the domestic export price to the export price of US or Japan (terms of trade).

[7] A recent study by Forbes (2001) has further shown that competitive effects and income effects are among the most important determinants explaining trade fluctuations between economies.

V_t ⇒ volatility of the nominal and real exchange rate.

$Dummy_t$ ⇒ dummy variable to capture the changes in the exchange rate regime. It equals to zero for the US-dollar pegged period (quarter 1, 1970 – quarter 4, 1984) and equals to one for the basket-pegged period (quarter 1, 1985 – quarter 1, 1997)

What theories say:

The volume of export (import) to foreign country (domestic economy) would be expected to increase as the real income of the foreign (domestic) economy increases, and vice versa (α_{21} and α_{22} are positive).

A rise (fall) in terms of trade will cause the domestic goods becoming less (more) competitive than foreign goods, therefore exports will fall (increase) and imports will rise (fall). Therefore, $\alpha_{31} < 0$ and $\alpha_{32} > 0$.

As discussed in the literature review, an increase in exchange rate volatility can increase or even decrease export and import (α_{41} and α_{42} can be positive or negative).

3.2 Volatility Index And Data Description

3.2.1 Volatility Index

Two important issues need to be highlighted when calculating the volatility index of exchange rate. First is the use of nominal versus real exchange rate. Second is the measurements used to calculate the volatility.

3.2.1.1 Nominal Versus Real Exchange Rate

IMF (1984) suggests that we should consider the time dimension of the economic decisions when measuring exchange rates volatility. In a relatively short observation period, fluctuations in the nominal exchange rate would have a significant effect on the traders' decision because all cost and prices are relatively rigid and therefore known. As for a relatively long observation period, prices as well nominal exchange rates are unknown.[8] For our purposes, we generate both the nominal and real exchange rate series of exchange rate volatilities.

The real exchange rate is calculated by multiplying nominal exchange rate by the relative price[9]:

$$RER_t^{US/JP} = NER_t^{US/JPN} \times \frac{WPI_t}{WPI_t^{US/JP}} \tag{3}$$

where WPI_t is the domestic wholesale price index and $WPI_t^{US/JP}$ is the US/Japan wholesale price index. An increase in $RER_t^{US/JP}$ (real exchange rate) or $NER_t^{US/JP}$ (nominal exchange rate) implies an appreciation in the Thailand baht against the two major currencies.

3.2.1.2 Volatility Measurements

Various measurements have been used to capture the exchange rate volatility (Table 2). While most studies only provide one measure of exchange-rate volatility, we

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8 However, after comparing results from nominal and real exchange rate volatility that are fitted by an ARCH model, McKenzie and Brooks (1997) come to a following conclusion:

> "… it would be irrelevant whether the volatility coefficients are estimated from real or nominal exchange rates as the volatility is sourced solely from the nominal exchange rate."

Their results show that use of nominal or real exchange rate volatility only creates insignificant differences in the coefficient estimates.

9 It has been argued by G.T. Management (1995) that when focusing on competitiveness, it is the wholesale price index, not the consumer price index that should be used. Furthermore, Hanke (1999) also argue that the consumer price index contain both traded and nontraded goods, while wholesale price index covers the tradable goods. So, to measure the competitiveness between two countries, it would be more appropriate to use wholesale price index.

construct two most commonly used measurements for each nominal and real exchange rate. Having more than one measurement of exchange-rate volatility allows us to verify the robustness of our regression results.

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Table 2

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The first measurement is a moving average standard deviation (MASD) of the growth rate of the exchange rate (ER) employed by Kenen and Rodrik (1986).

$$V_t = \left[\left(1/m \right) \sum_{i=1}^{m} \left(\ln ER_{t+i-1} - \ln ER_{t+i-2} \right)^2 \right]^{1/2} \quad (4)$$

Where *m* is the order of the moving average, and *ln* implies the log form of the series. Our estimations make use of *m* equals to 4 months[10]. This measurement has an advantage of capturing higher frequency movements of the exchange rate. Several authors have used a moving average transformation to smooth out the series[11].

For the second measurement of the exchange-rate volatilities, we employ different types of ARCH models. The GARCH specification that we consider takes the form:

$$\ln RER_t = a_0 + a_1 \ln RER_{t-1} + a_2 dummy_t + e_t \text{, where } e_t \sim N(0, h_t) \quad (5)$$

$$h_t = \alpha + \beta e_{t-1}^2 + \gamma h_{t-1} + \delta dummy_t + u_t . \quad (5b)$$

Where u_t is a white noise process with $E(u_t) = 0$ and $E(u_t u_\tau) = \begin{cases} \sigma_u^2 & for \quad t = \tau \\ 0 & otherwise \end{cases}$.

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[10] For our empirical tests, we also apply m=6 months and m=8 months. The results are in general consistent with m=4 months.

[11] Refer to Koray and Lastrapes (1989), Lastrapes and Koray (1990), Chowdhury (1993), and Daly (1998).

The conditional variance equation (Eq.5b) described above is a function of three terms: (1) the mean α; (2) news about volatility from the previous period, measured as the lag of the squared residual from the mean equation: e_{t-1}^2 (the ARCH term); and (3) the last periods forecast error variance, h_{t-1} (the GARCH term). In addition, we add the dummy variable to capture the shift in the exchange rate policy.

Many different types of ARCH models such as ARCH, GARCH and EGARCH models were estimated on the data. However, the ARCH(1) model is found to be superior in generating the volatility for the nominal and real exchange rates against US. On the other hand, ARCH(1) and GARCH(1,1) models are found to be superior in generating the volatility for the nominal and real exchange rates respectively against Japan. The ARCH(1) and GARCH(1,1) estimates are reported in Table 3 and Figure 2A – 2F. The role of exchange rate dummy variable (as introduced also in Equation 1) is found to be significant only for the nominal exchange rate volatility against the US dollar. As for the rest of the GARCH(1,1) test, the coefficient for dummy is insignificant and therefore the variable is excluded from the regressions.

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Table 3

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From the Figure 2A – 2F, it is interesting to note here that the results for the real and nominal exchange rate are consistent with each other. Both the real and nominal exchange rate volatilities against the US dollar indicate that with the exceptions of few hikes in mid-1970s and mid-1980s, the volatilities of the baht against the US dollar are relatively moderate otherwise. As for the nominal and real exchange rate volatilities against the Japanese yen, we find more persistent swings in general.

Mckenzie (1998) highlights the potential problems involved in ARCH based measures of exchange rate volatility. The study argues that the exchange rate volatility generated prior to the end of the sample period incorporates knowledge about the future as ARCH models are estimated over the entire sample period[12]. To overcome this problem, we need to re-estimate the ARCH model beginning of each quarter using information, which is known to the trader at the point in time. However, if the estimated ARCH/ GARCH coefficients are stable over time, one need not be concerned over the biasness of the volatility estimates.

For this purpose, the ARCH model has been estimated systematically starting with full sample, and then subsequently re-estimated rolling back to the end date of the sample period by one quarter at each time for both nominal and real exchange rate volatilities. The model was estimated until we have the sufficient number of observations. The estimated ARCH/ GARCH coefficients become insignificant once the sample size dropped below 100. Figure 3 and 4 depict the estimated ARCH(1) coefficients and GARCH(1,1) coefficients (($\beta_1 + \gamma$) is smaller than 1) respectively for the real exchange rates starting with 100 observations to full samples for the real exchange rate[13]. From these figures, we can conclude that the ARCH(1) and GARCH(1,1) for US and Japan for

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[12] The ARCH based measures of exchange rate volatility incorporate a degree of foresight not known to the trader at the time decisions are made as the volatility estimate for a particular sample period is based on the ARCH model parameters generated using information which includes the following years of data.

[13] The same ARCH models has been estimated systematically by starting with the sub-sample of 100 from the first observation and then increase the sample by one quarter at each time until the end of the full sample is reached. The estimated ARCH / GARCH coefficients are found to be stable and significant for these cases as well. For the sake of brevity, we have not reported these results and can be made available from authors upon a request.

the real exchange rates respectively are stable over the time. Similar results are found for all four cases of nominal exchange rate[14]. These should be expected as the trends in both nominal and real exchange rate volatilities are, in general, comparable (Figure 2A-2F).

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Figure 3 and 4

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4. Data And Test Results

4.1 Data Descriptions

All data in quarterly frequencies are taken from the International Financial Statistics – IMF CD ROM, OECD Statistical Compendium - CD ROM and Bank of Thailand. The study covers the period from 1970s (depending on the availability of the data) until second quarter of 1997. The post-1997 crisis period is excluded to avoid any structural breaks in the data. For bilateral exports and imports, the most accessible data are in value rather than in quantity terms. However, early studies suggest that volume or quantity is the more appropriate measurement rather than value[15]. To get the export and import volume or quantity, we divide the value series by a measure of price. Note both value and price are in US$.

$$X_t^{US/JP} = \frac{XVAL_t^{US/JP}}{XP_t} \tag{6}$$

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[14] Stability test for the estimated ARCH(1) coefficients for the nominal exchanges rates against US and Japan can be made available from authors upon request.

[15] For instance, Learner and Stern (1970) suggest that the quantity (volume) of export is more appropriate to use than value of export.

$$M_t^{US/JP} = \frac{MVAL_t^{US/JP}}{XP_t^{US/JP}} \qquad (7)$$

$X_t^{US/JP}$ is the quantity of Thailand's export to US or Japan, and $M_t^{US/JP}$ is the quantity of Thailand's import from US or Japan. $XVAL_t^{US/JP}$ is the value of export to US or to Japan, and XP_t is Thailand's export price. $MVAL_t^{US/JP}$ is the value of Thailand's import from US or Japan, and $XP_t^{US/JP}$ is the US/Japan export price (proxy for Thailand's import price from US or Japan).

Quarterly real GDP of US, Japan and Thailand (y_t^{US}, y_t^{JP} and y_t^{TH}) are considered as a proxy for the US, Japan and Thailand's real income, respectively. The terms of trade variable is constructed as the ratio of Thailand's export price to the US/Japan export price. All of the GDP and price series are denominated in US$.

$$P_t^{US/JP} = \frac{XP_t}{XP_t^{US/JP}} \qquad (8)$$

$P_t^{US/JP}$ is the terms of trade with US/Japan, XP_t is Thailand's export price, and $XP_t^{US/JP}$ is the US/Japan export price.

The dummy variable is introduced to capture the structural change associate with a change in the exchange rate regime. We follow Bailey, Tavlas, and Ulan (1987). As indicated, the dummy variable equals to zero for the US-dollar pegged period (quarter 1, 1970 – quarter 4, 1984) and equals to one for the basket-pegged period (quarter 1, 1985 – quarter 1, 1997) (Figure 1)[16].

[16] A number of studies such as Koray and Lastrapes (1989) proceed to break the observation into two groups according to the exchange rate policies. We decide not to adopt this strategy due to our sample size.

4.2 Test Results

Table 4 presents the results for the commonly used ADF-unit root test. All variables are found to be stationary at first difference (I(1) variables), except the volatility index (all are I(0)). Given the unit-root properties of the variables, we next conduct the Johansen cointegration test procedures on Equation 1 and Equation 2.[17]

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Table 4

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4.2.1 Johansen Cointegration Test And Bootstrap

Test results for the number of co-integrating relationships among the variables $(x_t^{US/JP}, y_t^{US/JP}, p_t^{US/JP}, V_t)$ and $(m_t^{US/JP}, y_t^{US/JP}, p_t^{US/JP}, V_t)$ based on Johansen Procedure suggest that there exists only one co-integrating relationship among these variables at 5% level of significance (Table 5A-B). Let $(\beta_1, \beta_2, \beta_3, \beta_4)$ be the corresponding un-normalized co-integrating vector. The test results in Table 4 clearly indicate that the volatility measures are I(0) variables. It should be noted that for every stationary variable included, the co-integrating rank would increase accordingly. And thus, the "one" co-integrating vector found by Johansen procedure could be accounting for the stationary variables included in the model. It can be verified by testing the linear restriction (0,0,0,1) in the co-integrating vector. On the other hand, non-rejection of this hypothesis strongly supports the stationarity of the volatility index included in the model. For a given rank r, however, the LR principle leads to standard inference; that is, test statistic for linear

[17] Engle and Granger (2000, page 14) state that inclusion of stationary variable in the cointegrating relationship should not affect the remaining coefficients (assuming that it is not the dependent variable). It appears that it also should not affect the asymptotic critical values of the test statistics.

restrictions on β have asymptotic χ^2 distributions with 3 degrees of freedom (Johansen and Juselius (1992)).

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Table 5A – 5B

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Simulation studies by Gredenhoff and Jacobson (1998) indicate that there can be considerable size distortions when χ^2 tables are used for inference. Johansen (1999) derived a Bartlett-corrected likelihood ratio test for linear restrictions. On the other hand, Gredenhoff and Jacobson (2001) suggest a bootstrap-approach to avoid the drawbacks. In this paper, we use bootstrap-approach suggested by Gredenhoff and Jacobson (2001) to test for the linear restriction on the co-integrating vector. The bootstrap approach provides a feasible method for estimating the small-sample distribution of a statistic. This can be done by generating a larger number of resamples, based on the original sample, and by computing the statistics of interest in each resample.

We have used 5000 replications for this purpose and collected the bootstrap statistics, suitably ordered, which constitutes the required bootstrap distribution. Table 5C reports the LR test statistic and their corresponding probability of rejections. Based on the test statistics, we cannot reject the linear restriction (0,0,0,1) on the co-integrating vector at 5% level of significance. On the other hand, the test results strongly support that the volatility index are I(0) process and the "one" co-integrating vector obtained from the Johansen Procedure is purely due to the stationary volatility indices in all cases. Thus, we proceed to fit an Autoregressive Distributed Lags (ARDL) models by treating the volatility as an exogenous variable in the system.

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Table 5C

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4.2.2. Short-Run Dynamics

Next, we proceed to test the following Autoregressive Distributed Lags (ARDL) of the export and import demand functions.

$$\Delta x_t^{US/JP} = \alpha_{11} + \alpha_{21}\sum_{i=0}\Delta y_{t-i}^{US/JP} + \alpha_{31}\sum_{i=0}\Delta p_{t-i}^{US/JP} + \alpha_{41}\sum_{i=0}V_{t-i} + \alpha_{51}Dummy_t + \varepsilon_{1t} \quad (9)$$

$$\Delta m_t^{US/JP} = \alpha_{12} + \alpha_{22}\sum_{i=0}\Delta y_{t-i}^{TH} + \alpha_{32}\sum_{i=0}\Delta p_{t-i}^{US/JP} + \alpha_{42}\sum_{i=0}V_{t-i} + \alpha_{52}Dummy_t + \varepsilon_{2t} \quad (10)$$

All symbols and coefficients retain their prior meanings and expected signs as previously discussed for Equation 1 and 2. The error term (ε_t) is assumed to be a white noise stochastic process. Equation 9 and 10 are tested using the general-to-specific methodology of Hendry (1974, 1977). Six lags for the key explanatory variables (income, price and volatility) are included in the initial estimation, and then sequentially we exclude the statistically insignificant lags of the variables.[18]

The final regression results are posted in Table 6A-6D. The diagnostic statistics, including the R^2 statistics adjusted for degrees of freedom, the Durbin-Watson (DW), the F-statistics (and its probability), and the Engle's ARCH test for heteroscedasticity, are presented for each regression. In general, the test results indicate that the models perform respectably well insofar as the equations explain between 8 percent to 26 percent of the

[18] Six lags are chosen to ensure that we have enough degrees of freedom. Furthermore, the results also show that only up to six lags that we find significant t- statistics (at least 10% significant level).

variations in the dependent variables. The F-statistics indicate that the probability is at least 95 percent that one or more of the independent variables are non-zero. The Durbin-Watson statistics indicate that the serial correlations are not a problem in any of the regression results. In addition, the ARCH results conclude the absence of heteroscedasticity in general.

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Table 6A-6D

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Turning now to examine the individual coefficients, we find all of the reported ones are having the correct signs. The income factor (Y^{TH}, Y^{JP}, Y^{US}) is the only explanatory found to be significant in each of the regression equations. Equally important to be underlined here is that the coefficient estimates for the income variable are found to be the largest in 12 out of 16 regression results posted in Table 6A-6D. Terms of trade variable is also found to be significant for all regressions of Thailand's exports to Japan and US, and Thailand's import from the US market. But interestingly, we find the price variable to be insignificant for Thailand's imports from Japan. Furthermore, in three cases of Thailand's imports from the US, we find the signs of the estimated coefficients for two different lags of the terms of trade variable are to be opposite. However the sum of the coefficients is positive, therefore consistent with the theory.[19]

As for the focus of our study that is to evaluate the role of exchange rate volatility on Thailand's exports and imports with the Japanese and the US markets, we find several interesting evidences. Based on the four estimated coefficients of the exchange rate

[19] With the main objective to understand the role of the exchange rate volatility on the trade performance, we opt to limit the discussion on the income and terms of trade variables.

volatility index, we find that the exchange rate volatility has significantly and adversely affected the Thailand's trades (exports and imports) with the Japanese market. All the volatility coefficients (and the sum of the coefficients for some cases) are found to be negative at 10 percent and 5 percent significance level (Table 6A-6B).

In contrast, we find no overall conclusive results from the Thailand's exports to the US market. Only one out of four coefficient estimates of the exchange rate volatility is found to be significant for the Thailand's exports to the US market (Table 6C). The total sum of the coefficient estimates of the MASD of the real exchange rate volatility is found to be negative with a very small coefficient size relative to both the income and terms of trade coefficient estimates.

For the Thailand's imports from the US market, we find the evidences to be more consistent with the Thailand's trades with the Japanese market. Three out of four regressions results indicate that exchange rate volatility has a significant and an adverse implication on the performance of imports from the US to Thailand (Table 6D).

In addition to the analysis presented above, it is also interesting to compare and contrast the test results for the nominal exchange rate and the real exchange rate volatility indices. Based on their t-statistics, the significance of the real and nominal exchange rate volatility indices are generally comparable for the cases of Thailand's trades with the Japanese market.

As for the Thailand's trade with the US market, we find only one case (out of four possibilities) where the nominal exchange rate volatility index has shown a significant impact on the trade performance of Thailand. That single case shows that the coefficient estimate of the ARCH(1) volatility index of the nominal exchange rate is found to be significant and negative in explaining the Thailand's imports from the US market (Table 6D). As for the real exchange rate volatility index, we find the coefficients to be significant in all of four possible cases. In all of them, we find the coefficients to be consistently negative.

4.3 Brief Policy Perspectives

In summary, our test results have conclusively shown that in 12 out of 16 regression tests, the volatility of exchange rate has been found to have a significant and an adverse implication on the trade performance of Thailand during the two decades prior to the break of the East Asian financial crisis in mid-1997. Few interesting and important policy analysis can be derived from these results.

Previous studies, such as Frankel and Wei (1994) and McKinnon (2001), have shown that in spite of the official claim that the Thailand baht has been managed under a peg regime to a currency basket, the nominal exchange rate of the baht has mostly been pegged to the US dollar since the early part of 1990s. Our volatility rates provide further supports to these previous studies. We find that from 1980 to 1996, the average of the GARCH(1,1) nominal exchange rate volatility of Thai baht against the Japanese yen to be around six times as the similar estimate for the Thai baht against the US dollar. As for the real exchange rate, we find the GARCH(1,1) estimate for the Thai baht against the yen to be in average at least twice as large as the average estimate for the Thai baht against the US dollar. [20]

Furthermore, when we closely analyse 1990s only, we find even more interesting and contrasting trends. Both the nominal and real exchange rate volatilities of the baht

[20] The means of the volatilities of nominal and real exchange rate indices are available with the authors and can be made available upon a request.

against the yen for quarter 1, 1995- quarter 1, 1997 were around 16% and 30% higher than their rates for quarter 1, 1990 – quarter 1, 1995, respectively. In contrast, the nominal exchange rate volatilities of the baht against the US dollar have moderated by about 7% in the last two years before the break of 1997 crisis relative to the levels in the early to mid-1990s. As for the average real exchange rate volatilities of baht against the US dollar, we find the rates for quarter 1, 1995 – quarter 1, 1997 have risen against the early years of 1990s, but the rise is a moderate one by around 5%.

Clearly from the magnitudes of the exchange rate volatilities, we can conclude that the policy of rigid peg against the US dollar has kept the domestic currency to be less volatile against the US dollar, however at the cost of much severe volatilities against other key currencies such as the Japanese yen. In turn, the much more volatile exchange rate has adversely impacted the trade performance of Thailand with the Japanese market. In contrast, we find a less conclusive role of exchange rate volatilities, especially the nominal exchange rate volatilities, in influencing the performance of Thailand's trade with the US market.

5. Conclusion

The objective of our paper is to investigate the impact of exchange-rate volatility on the volume of exports and imports of Thailand with the US and the Japanese markets. While most of early studies have only used one measurement of exchange-rate volatility (Table 1), we constructed four indices of volatility rates using the two commonly used measurements. This allows us to confirm the robustness of our findings.

Our empirical works have shown conclusively that the rise in exchange rate volatility had adverse consequences on both exports and imports of Thailand with the Japanese market, and the imports of Thailand from the US during the period of two decades before the break of the 1997 East Asian financial crisis. Less conclusive evidences were however found on the impact of exchange rate volatility for the performance of the Thailand's exports to the US market.

Recent estimates have shown that the real effective exchange rate volatilities of key Southeast Asian currencies, including baht, have increased dramatically during the first year of the 1997 financial crisis (Table 7). At the same time, we find both exports and imports in 1998 have gone down as compared to their 1996 levels. Obviously, one needs to consider various factors to explain the slowdowns in both exports and imports of Thailand in 1998. However, given the pre-crisis evidence, we can also argue that the rise in the volatilities is likely to have partly contributed to the declines in trade numbers.

Previous studies have suggested that the development of markets for various hedging instrument is indispensable to alleviate the adverse consequences of the rise in the volatilities (for instance Viaene and Vries (1992)). However, our results for Thailand have shown that hedging facilities may be a necessary but certainly not a sufficient condition. Despite the availability of forward instruments and other hedging instruments in Thailand (Wilson (1996)), the use of these instruments by domestic exporters and importers are limited. Calvo and Reinhart (2000a and 2000b) argue that most of the future markets in the emerging markets are illiquid. One explanation for the illiquid markets is high-risk premium associated with them, reflected by the persistently high domestic interest rate (Rajan, Siregar and Sugema (2001)). This high-risk premium, which is translated into a high cost of hedging, has been one of the key factors explaining the limited use of hedging instruments in Thailand and other main Southeast Asian countries. Consequently, the limited used of the forward market instruments failed to shield trade sectors in Thailand from experiencing the adverse impacts of the exchange-rate volatility.

As mentioned in the introduction, with the break of the worst financial crisis in the past decades in 1997, most of the Southeast Asian economies, including Thailand, are forced to abandon their rigid exchange rate regimes. The unprecedented swings and instabilities in the regional currencies have however regenerated efforts by these countries to readopt the rigid US-dollar pegged regime. McKinnon (2001) has shown that the weight that the US dollar has in explaining the fluctuations of the Southeast Asian currencies has returned to its pre-1997 crisis in early 1999.

Should Thailand be encouraged to go back to the US pegged system? Based on the results posted in Table 6A-6D, the answer is "no". Given the adverse consequences of high volatilities and the significant share of Thailand's trades with the Japanese market in the country's overall trade, the cost of the pegged US dollar system may not outweigh its benefits.[21] Rajan, Sen and Siregar (2000) have also shown the US pegged system has been largely responsible for the real exchange rate misalignments of the baht against the Japanese yen. In turn, the misaligned baht partly contributed to substantial trade deficits that Thailand had with Japan in 1990s. Consistent with our discussions, the recent IMF report on exchange rate regime has rightly cautioned that

> "There is an important danger, however, in slipping back into de facto pegging of exchange rates against the US dollar. While this may be sustainable for some considerable period, this may well eventually contribute to recreating the problems that led up to the Asian crisis". (Mussa et al. 2000, pg.59).

[21] In 1990s, Thailand's exports to Japan (the US market) have in average made up around 17% (18%) the country's total exports. Similarly, Thailand's imports from Japan (the US market) contributed around 28% (12.5%) of the country's total imports.

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Table 1
Empirical Studies of Exchange Rate Volatility and Trade Flow

Author	Country / Sample Period	The effect of ER volatility to trade
Hooper and Kohlhagen (1978)	Germany, Japan, United Kingdom, United States, Canada, France (bilateral trade). 1965.1 – 1975.4	*X:* Significant negative relationship in 2 equation, significant positive relationship in 4 equation and insignificant in 26 equation.
Rana (1981)	South Korea, Philippines, Thailand, and Taiwan (multilateral trade). 1960.1 - 1976.4	*M:* Significant negative relationship in 4 equation and insignificant for 1 equation for the pegged period in Taiwan equation.
International Monetary Fund (1984)	United States, United Kingdom, France, Germany, Italy, Canada, and Japan (bilateral trade) 1965.1 – 1982.4	*X:* Significant negative relationship in 3 equation, significant positive relationship in 11 equation and insignificant in 28 equation.
Kenen & Rodrik (1986)	US, Canada, Japan, Belgium, France, Germany, Italy, Netherlands, Sweden, Switzerland, UK (multilateral trade) 1975.1 - 1984.2	*M:* Significant negative relationship in 4 equation and insignificant in 7 equation.
Bailey, Tavlas, & Ulan (1987)	Canada, France, Germany, Italy, Japan, UK, US, Australia, New Zealand, Netherlands, Switzerland (multilateral trade) 1962.2 - 1974.4 and 1975.1 - 1985.3	*X:* Significant negative relationship in 3 equation, significant positive relationship in 5 equation and insignificant in 34 equation.
Thursby and Thursby (1987)	Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Norway, South Africa, Sweden, Switzerland, United Kingdom, and United States. (bilateral trade); 1974 – 1982 (annually)	*X:* Significant negative relationship in 10 equation.
Cushman (1988)	US (bilateral trade) 1974 – 1983 (annually).	*X:* 2 of 6 equations have a significant negative effect and 1 has a significant positive effect. *M:* 5 of 6 equations have a significant negative effect.
Koray & Lastrapes (1989)	US with UK, France, Germany, Japan, & Canada (bilateral trade) 1959.01 - 1985.12	*M:* Significant negative relationship in 41 equation, significant positive relationship in 16 equation and insignificant in 39 equation.
Lastrapes & Koray (1990)	US (multilateral trade) 1973.03 - 1987.12	*X & M:* Significant negative relationship in 6 equation and insignificant in 42 equation.
Klein (1990)	US with Netherland, Canada, Japan, France, Italy, Germany. (sectoral analysis in bilateral trade) 1978.01 - 1986.12	*X:* Significant negative relationship in 4 equation, significant positive relationship in 7 equation and insignificant in 43 equation.
Asseery & Peel (1991)	Australia, Japan, UK, US, West Germany (multilateral trade) 1972.1 - 1987.4	*X:* Significant negative relationship in 1 equation, significant positive relationship in 2 equation and insignificant in 3 equation.

Table 1
Empirical Studies of Exchange Rate Volatility and Trade Flow *(continued)*

Author	Country / Sample Period	The effect of ER volatility to trade
Bini-Smaghi (1991)	Italy, France, Germany (multilateral trade of the manufacturing sector) 1976.1 – 1984.4	*X::* Significant negative relationship in 13 equation and insignificant in 11 equation.
Chowdhury (1993)	Canada, France, Germany, Italy, Japan, UK, US (multilateral trade) 1973.1 - 1990.4	*X:* Significant negative relationship in all 7 equation.
Kroner & Lastrapes (1993)	US, UK, France, Germany, Japan (multilateral trade) 1973.05 – 1990.11	*X:* Significant negative relationship in 3 equation, significant positive relationship in 1 equation and insignificant in 1 equation.
Caporale & Doroodian (1994)	US to Canada (bilateral trade) 1974.01 – 1992.10	*M:* Significant negative relationship.
Mckenzie & Brooks (1997)	German to US (bilateral trade) 1973.04 - 1992.09	*X:* 4 equation have a positive effect (but insignificant). *M:* 4 equation have a significant positive effect.
Mckenzie (1998)	Australia (multilateral, bilateral and sectoral trade) 1969.3 – 1995.4	*X:* Generally have a positive effect. *M:* 5 of 6 Generally have a negative effect.
Daly (1998)	Japan (bilateral trade) 1978.1 – 1992.2	*X:* 4 equation have a positive effect and 3 equation have a negative effect. *M:* 5 equation have a positive effect and 2 equation have a negative effect. (overall likely to have a positive correlation)
Wei (1998)	63 countries in the world (bilateral trade) 1975, 1980, 1985, & 1990	*X & M:* *Pooled equation* in 1975 & 1980 has significant negative effect. in 1985 has insignificant positive effect. in 1990 has significant positive effect. *Panel equation* significant positive effect.
Chou (2000)	China (multilateral and sectoral trade) 1981.1 – 1996.4	*X:* Negative effect on total export, export of manufacture goods & mineral fuels. Positive effect on export of industrial materials.
Aristotelous (2001)	UK to US (bilateral trade) 1889 – 1999	*X:* Neither exchange-rate volatility nor the different exchange rate regimes had an effect on export volume.

Notes : *X* refers to export model.
M refers to import model.

Table 2
Exchange Rate Volatility Measures

Measures of Exchange Rate Volatility	*Author*
The average (over thirteen weeks) absolute difference between the previous forward and the current spot rate.	Hooper Kohlhagen (1978)
Gini's mean difference (a non-parametric measure)	Rana (1981)
Standard deviation of the growth rate of the exchange rate (ER_t) with a moving average transformation (by several authors) : $$V_t = \left[\left(1/m \right) \sum_{i=1}^{m} \left(\ln ER_{t+i-1} - \ln ER_{t+i-2} \right)^2 \right]^{1/2}$$ where m is the order of the moving average.	IMF (1984) Kenen and Rodrik (1986), Bailey, Tavlas and Ulan (1987), Cushman (1988), Koray and Lastrapes (1989), Lastrapes and Koray (1990), Klein (1990), Bini-Smaghi (1991), Chowdhury (1993), Daly (1998), Wei (1998), Aristotelous (2001)
The variance of the spot exchange rate (ER_t) around its predicted trend that is estimated from: $$\ln ER_t = \phi_0 + \phi_1 t + \phi_2 t^2 + \varepsilon_t$$	Thursby and Thursby (1987),
Autoregressive Integrated Moving Average (ARIMA) model	Asseery and Peel (1991),
Autoregressive Conditional Heteroscedasticity (ARCH) models	Kroner and Lastrapes (1993), Caporale and Doroodian (1994), Mckenzie and Brooks (1997), Mckenzie (1998), Chou (2000)

Table 3
ARCH model summary: Quarterly real exchange rates against US dollars and Yen

$$h_t = \alpha + \beta e_{t-1}^2 + \gamma h_{t-1} + \delta dummy_t + u_t$$

Note: To generate best results, the GARCH volatility index has been generated based on observations from quarter 1, 1957 to quarter 2, 1997.

Nominal Exchange Rate:

	USA			JAPAN	
	β	γ	δ	β	γ
ARCH(1)	1.03 (0.33)		0.00051 (0.000039)	0.42 (0.18)	

Note: The values in the parentheses are standard errors. We find ARCH(1) for both nominal exchange rate volatilities against yen and U.S. dollar.

Real Exchange Rate:

	USA		JAPAN	
	β	γ	β	γ
ARCH(1)[a]	0.31 (0.16)			
GARCH(1,1)			0.11 (0.07)	0.82 (0.13)

Note: The values in the parentheses are standard errors.

[a]/ ARCH (1) is the best model for the real exchange rate of bath against the US dollar.
[b]/ GARCH(1,1) is the best model for the real exchange rate of bath against the yen.

Table 4
Augmented Dickey-Fuller Test Results

Country	Series		ADF statistics	Test type	Lag	Order of integration
Thailand	x^{US}	Level	-2.394	trend & drift	3	I(1)
		1st difference	-9.522 **	with drift	2	
	m^{US}	Level	-2.383	trend & drift	1	I(1)
		1st difference	-8.259 **	with drift	2	
	x^{JP}	Level	-1.835	trend & drift	5	I(1)
		1st difference	-4.301 **	with drift	6	
	m^{JP}	Level	-1.707	trend & drift	5	I(1)
		1st difference	-4.157 **	with drift	4	
	y^{TH}	Level	-2.590	trend & drift	1	I(1)
		1st difference	-4.729 **	with drift	2	
	p^{US}	Level	-2.103	with drift	1	I(1)
		1st difference	-5.924 **	no drift	1	
	p^{JP}	Level	-3.270	trend & drift	3	I(1)
		1st difference	-6.596 **	no drift	1	
	$V^{US\text{-}RMASD}$	Level	-6.558 **	with drift	1	I(0)
	$V^{US\text{-}RARCH}$	Level	-6.973 **	with drift	1	I(0)
	$V^{JP\text{-}RMASD}$	Level	-5.052 **	with drift	3	I(0)
	$V^{JP\text{-}RGARCH}$	Level	-2.826 *	with drift	1	I(0)
	$V^{US\text{-}NMASD}$	Level	-5.810**	with drift	1	I(0)
	$V^{US\text{-}NARCH}$	Level	-7.137**	with drift	1	I(0)
	$V^{JP\text{-}NMASD}$	Level	-5.605**	with drift	1	I(0)
	$V^{JP\text{-}NARCH}$	Level	-6.543**	with drift	1	I(0)
United States	y^{US}	Level	-2.309	trend & drift	1	I(1)
		1st difference	-5.215 **	with drift	1	
Japan	y^{JP}	Level	-2.076	with drift	1	I(1)
		1st difference	-3.808 **	with drift	1	

Note: * Significant at the 10 % level; ** Significant at the 5 % level. $V^{US\text{-}RMASD}$, $V^{US\text{-}RARCH}$, $V^{JP\text{-}RMASD}$ and $V^{JP\text{-}RGARCH}$ are capturing the moving average standard deviation and the GARCH/ARCH results for the real exchange rate volatilities. $V^{US\text{-}NMASD}$, $V^{US\text{-}NARCH}$, $V^{JP\text{-}NMASD}$ and $V^{JP\text{-}NARCH}$ are for the nominal exchange rate volatilities. Other variables are described in the main text.

Table 5A

Cointegration Test Results

Measurement for Real Exchange Rate Volatility: ARCH/GARCH

Equation	Trace Statistics			
	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$
Thailand Exports to US	70.35**	21.88	8.08	0.16
Thailand Imports to US	59.24**	27.24	6.36	0.22
Thailand Exports to Japan	55.04*	27.79	15.39	5.76
Thailand Imports to Japan	66.54**	33.45	8.45	0.10

Equation	Max-Eigen Statistic			
	$r = 0$	$r = 1$	$r = 2$	$r = 3$
Thailand Exports to US	48.47**	13.80	7.92	0.16
Thailand Imports to US	32.01*	20.88	6.14	0.22
Thailand Exports to Japan	27.24*	12.41	9.63	5.76
Thailand Imports to Japan	33.09**	25.00	8.35	0.11

Measurement for Real Exchange Rate Volatility: Moving Average Standard Deviation (MASD) Method

Equation	Trace Statistics			
	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$
Thailand Exports to US	71.06**	22.59	7.95	0.14
Thailand Imports to US	63.32**	31.83	5.21	0.61
Thailand Exports to Japan	64.06**	26.06	8.72	1.00
Thailand Imports to Japan	71.13**	29.17	11.32	0.35

Equation	Max-Eigen Statistic			
	$r = 0$	$r = 1$	$r = 2$	$r = 3$
Thailand Exports to US	48.48**	14.64	7.81	0.14
Thailand Imports to US	31.49*	26.62*	4.59	0.61
Thailand Exports to Japan	38.00**	17.34	7.72	1.00
Thailand Imports to Japan	41.96**	17.85	10.97	0.35

Note: ** and * indicate the level of significance at 1% and 5% respectively.
r denotes the number of cointegrating vectors.

Table 5B

Cointegration Test Results

Measurement for Nominal Exchange Rate Volatility: ARCH/GARCH

Equation	Trace Statistics			
	$r = 0$	$r \le 1$	$r \le 2$	$r \le 3$
Thailand Exports to US	74.87*	20.80	7.93	0.27
Thailand Imports to US	58.85**	26.60	5.85	0.32
Thailand Exports to Japan	78.38**	26.06	9.06	1.00
Thailand Imports to Japan	60.87**	27.95	9.56	0.18

Equation	Max-Eigen Statistic			
	$r = 0$	$r = 1$	$r = 2$	$r = 3$
Thailand Exports to US	54.07**	12.87	7.66	0.27
Thailand Imports to US	32.25**	20.75	5.53	0.32
Thailand Exports to Japan	52.30**	17.01	8.05	1.00
Thailand Imports to Japan	32.91**	18.39	9.39	0.18

Measurement for Nominal Exchange Rate Volatility: Moving Average Standard Deviation (MASD) Method

Equation	Trace Statistics			
	$r = 0$	$r \le 1$	$r \le 2$	$r \le 3$
Thailand Exports to US	73.26**	22.22	7.96	0.16
Thailand Imports to US	63.36**	32.68	5.43	0.61
Thailand Exports to Japan	61.44**	26.17	8.68	1.19
Thailand Imports to Japan	65.75**	28.57	10.65	0.49

Equation	Max-Eigen Statistic			
	$r = 0$	$r = 1$	$r = 2$	$r = 3$
Thailand Exports to US	51.04**	14.26	7.80	0.16
Thailand Imports to US	30.69*	27.25*	4.82	0.61
Thailand Exports to Japan	35.27**	17.49	7.49	1.19
Thailand Imports to Japan	37.19**	17.91	10.16	0.49

Note: ** and * indicate the level of significance at 1% and 5% respectively.
r denotes the number of cointegrating vectors.

Table 5C
Linear Restriction on Co-integration equation Test results

	RER (ARCH/ GARCH)	RER MASD	NER (ARCH/ GARCH)	NER MASD
Thailand Exports to US	6.54 (0.12)	5.77 (0.16)	8.93 (0.07)	7.03 (0.11)
Thailand Imports to US	4.58 (0.28)	4.26 (0.30)	6.51 (0.17)	9.67 (0.06)
Thailand Exports to Japan	7.93 (0.12)	3.68 (0.36)	9.23 (0.06)	6.23 (0.16)
Thailand Imports to Japan	8.57 (0.11)	2.37 (0.88)	6.52 (0.11)	1.87 (0.75)

Note: Parenthesized values are rejection probabilities of null hypothesis obtained from Bootstrapping.

Table 6A

ARDL Results for Export to Japan & Observation Period: Quarter 1, 1975 – Quarter 2, 1997

1). $\Delta x_t^{JP} = f(\Delta y_t^{JP}, \Delta p_t^{JP}, V^{JP-RGARCH}{}_t, Dummy_t)$

$$\Delta x_t^{JP} = \underset{(0.011)^{**}}{0.712\Delta y_{t-2}^{JP}} + \underset{(0.0015)^{**}}{0.867\Delta y_{t-3}^{JP}} + \underset{(0.028)^{**}}{0.599\Delta y_{t-4}} - \underset{(0.001)^{**}}{7.553\Delta p_{t-2}^{JP}} - \underset{(0.0006)^{**}}{0.0012 V_{t-1}^{JP-RGARCH}} + \underset{(0.0006)^{*}}{0.0009 V_{t-2}^{JP-RGARCH}} + \underset{(0.039)^{**}}{0.039 Dummy_t}$$

R-squared= 0.26, DW=2.026; F-stat=4.669; Prob(F-stat) = 0.0004; ARCH (Prob) = 0.1058

2). $\Delta x_t^{JP} = f(\Delta y_t^{JP}, \Delta p_t^{JP}, V^{JP-RMASD}{}_t, Dummy_t)$

$$\Delta x_t^{JP} = \underset{(0.252)^{*}}{0.408\Delta y_{t-2}^{JP}} + \underset{(0.247)^{*}}{0.655\Delta y_{t-3}^{JP}} - \underset{(0.232)^{**}}{0.691\Delta p_{t-2}^{JP}} - \underset{(0.0001)^{*}}{0.0002 V_{t-3}^{JP-RMASD}} + \underset{(0.016)^{**}}{0.041 Dummy_t}$$

R-squared= 0.19, DW=2.152; F-stat=4.811; Prob(F-stat) = 0.0015; ARCH (Prob) = 0.4513

3). $\Delta x_t^{JP} = f(\Delta y_t^{JP}, \Delta p_t^{JP}, V_t^{JP-NMASD}\ Dummy_t)$

$$\Delta x_t^{JP} = \underset{(0.259)^{*}}{0.427\Delta y_t^{JP}} + \underset{(0.244)^{**}}{0.643\Delta y_{t-3}^{JP}} - \underset{(0.238)^{**}}{0.827\Delta p_{t-2}^{JP}} - \underset{(0.0001)^{*}}{0.0003 V_{t-1}^{JP-NMASD}} + \underset{(0.017)^{**}}{0.042 Dummy_t}$$

R-squared= 0.20, DW=2.218; F-stat= 5.158; Prob(F-stat) = 0.0009; ARCH (Prob) = 0.4894

4). $\Delta x_t^{JP} = f(\Delta y_t^{JP}, \Delta p_t^{JP}, V^{JP-NARCH}{}_t, Dummy_t)$

$$\Delta x_t^{JP} = \underset{(0.236)^{**}}{0.732\Delta y_{t-3}^{JP}} - \underset{(0.225)^{**}}{0.835\Delta p_{t-2}^{JP}} - \underset{(0.201)^{**}}{0.638\Delta p_{t-2}^{JP}} - \underset{(3.647)^{*}}{6.187 V_t^{JP-NARCH}} + \underset{(0.017)^{**}}{0.042 Dummy_t}$$

R-squared= 0.26, DW=2.287; F-stat=7.063; Prob(F-stat) = 0.00006; ARCH (Prob) = 0.114

* Significant at 10%, **Significant at 5%; DW= Durbin-Watson

Table 6B

Import from Japan & Observation Period: Quarter 1, 1975 – Quarter 2, 1997

1). $\Delta m_t^{JP} = f(\Delta y_t^{TH}, \Delta p_t^{JP}, V^{JP-RGARCH}{}_t, Dummy_t)$

$$\Delta m_t^{JP} = 2.055\Delta y_{t-1}^{TH} - 0.00097 V_{t-1}^{JP-RGARCH} + 0.00088 V_{t-4}^{JP-RGARCH}$$

(0.608)** (0.00034)** (0.00035)** Standard Errors

R-squared= 0.18, DW=2.026; F-stat= 9.627; Prob(F-stat) = 0.0002; ARCH (Prob) = 0.518

2). $\Delta m_t^{JP} = f(\Delta y_t^{TH}, \Delta p_t^{JP}, V^{JP-RMASD}{}_t, Dummy_t)$

$$\Delta x_t^{JP} = 2.379\Delta y_{t-1}^{TH} - 0.0002 V_{t-5}^{JP-RMASD}$$

(0.536)** (0.0001)* Standard Errors

R-squared= 0.14, DW=1.93; F-stat= 14.120; Prob(F-stat) = 0.0003; ARCH (Prob) = 0.7158

3). $\Delta m_t^{JP} = f(\Delta y_t^{TH}, \Delta p_t^{JP}, V^{JP-NMASD}{}_t, Dummy_t)$

$$\Delta m_t^{JP} = 2.358\Delta y_{t-1}^{JP} - 0.0003 V_{t-5}^{JP-NMASD}$$

(0.536)* (0.0001)** Standard Errors

R-squared= 0.14, DW= 1.941; F-stat= 13.912; Prob(F-stat) = 0.00034; ARCH (Prob) = 0.7303

4). $\Delta m_t^{JP} = f(\Delta y_t^{TH}, \Delta p_t^{JP}, V^{JP-NARCH}{}_t, Dummy_t)$

$$\Delta m_t^{JP} = 2.156\Delta y_{t-1}^{JP} + 0.811\Delta y_{t-3}^{JP} - 7.063 V_t^{JP-NARCH}$$

(0.649)** (0.372)** (3.798)* Standard Errors

R-squared= 0.15, DW= 1.953; F-stat=7.344; Prob(F-stat) = 0.00115; ARCH (Prob) = 0.4245

* Significant at 10%, **Significant at 5%; DW= Durbin-Watson

Table 6C

Export to US & Observation Period: Quarter 1, 1970 – Quarter 2, 1997

1). $\Delta x_t^{US} = f(\Delta y_t^{US}, \Delta p_t^{US}, V^{US-RGARCH}{}_t, Dummy_t)$ $\Delta x_t^{US} = 3.658\Delta y_{t-1}^{US} - 0.837\Delta p_t^{US}$ (1.206)** (0.329)** Standard Errors R-squared= 0.08, DW=2.626; F-stat = 9.632 ; Prob(F-stat) = 0.0025; ARCH (Prob) = 0.1001
2). $\Delta x_t^{US} = f(\Delta y_t^{US}, \Delta p_t^{US}, V^{US-RMASD}{}_t, Dummy_t)$ $\Delta x_t^{US} = 3.122\Delta y_{t-1}^{US} - 0.591\Delta p_{t-4}^{US} - 0.000397V_{t-1}^{US-RMASD} + 0.000290V_{t-2}^{US-RMASD}$ (1.427)** (0.332)* (0.000161)** (0.000165)* Standard Errors R-squared= 0.10, DW=2.513; F-stat= 3.764; Prob(F-stat) = 0.013; ARCH (Prob) = 0.2313
3). $\Delta x_t^{US} = f(\Delta y_t^{US}, \Delta p_t^{US}, V^{US-NGARCH}{}_t, Dummy_t)$ $\Delta x_t^{US} = 3.658\Delta y_{t-1}^{US} - 0.837\Delta p_t^{US}$ (1.206)** (0.329)** Standard Errors R-squared= 0.08, DW=2.626; F-stat = 9.632 ; Prob(F-stat) = 0.0025; ARCH (Prob) = 0.1001
4). $\Delta x_t^{US} = f(\Delta y_t^{US}, \Delta p_t^{US}, V^{US-NMASD}{}_t, Dummy_t)$ $\Delta x_t^{US} = 3.658\Delta y_{t-1}^{US} - 0.837\Delta p_t^{US}$ (1.206)** (0.329)** Standard Errors R-squared= 0.08, DW=2.626; F-stat = 9.632 ; Prob(F-stat) = 0.0025; ARCH (Prob) = 0.1001

* Significant at 10%, **Significant at 5%; DW= Durbin-Watson

Table 6D

Import from US & Observation Period: Quarter 1, 1975 – Quarter 2, 1997

1). $\Delta m_t^{US} = f(\Delta y_t^{TH}, \Delta p_t^{US}, V^{US-RGARCH}{}_{t}, Dummy_t)$

$$\Delta m_t^{US} = 3.795\Delta y_{t-4}^{TH} - 1.092\Delta p_{t-3}^{US} + 2.176\Delta p_{t-6}^{US} - 0.00044V_{t-1}^{US-RGARCH}$$

(1.195)** (0.627)* (0.558)** (0.00020)** Standard Errors

R-squared= 0.22, DW=2.518; F-stat = 7.774; Prob(F-stat) = 0.00013; ARCH (Prob) = 0.3438

2). $\Delta m_t^{US} = f(\Delta y_t^{TH}, \Delta p_t^{US}, V^{US-RMASD}{}_{t}, Dummy_t)$

$$\Delta m_t^{US} = 2.992\,\Delta y_{t-4}^{TH} - 1.075\,\Delta p_{t-3}^{US} + 2.072\,\Delta p_{t-6}^{US} - 0.000385\,V_{t-2}^{US-RMASD}$$

(1.026)** (0.635)* (0.563)** (0.000224)* Standard Errors

R-squared= 0.21, DW=2.508; F-stat= 7.124; Prob(F-stat) = 0.0003; ARCH (Prob) = 0.6189

3). $\Delta m_t^{US} = f(\Delta y_t^{TH}, \Delta p_t^{US}, V^{US-NGARCH}{}_{t}, Dummy_t)$

$$\Delta m_t^{US} = 2.169\,\Delta y_{t-4}^{TH} + 1.799\,\Delta p_{t-6}^{US} - 9.143\,V^{US-NGSRCH}$$

(0.830)** (0.549)** (5.549)* Standard Errors

R-squared= 0.17, DW=2.471; F-stat = 8.562; Prob(F-stat) = 0.0042; ARCH (Prob) = 0.1993

4). $\Delta m_t^{US} = f(\Delta y_t^{TH}, \Delta p_t^{US}, V^{US-NMASD}{}_{t}, Dummy_t)$

$$\Delta m_t^{US} = 1.880\Delta y_{t-4}^{TH} - 1.189\Delta p_{t-3}^{US} + 2.100\Delta p_{t-6}^{US}$$

(0.805)** (0.639)* (0.569)** Standard Errors

R-squared= 0.18, DW=2.498; F-stat = 8.998; Prob(F-stat) = 0.0003; ARCH (Prob) = 0.1849

* Significant at 10%, **Significant at 5%; DW= Durbin-Watson

Table 7
Post-Crisis Experiences of Key Southeast Asian Economies

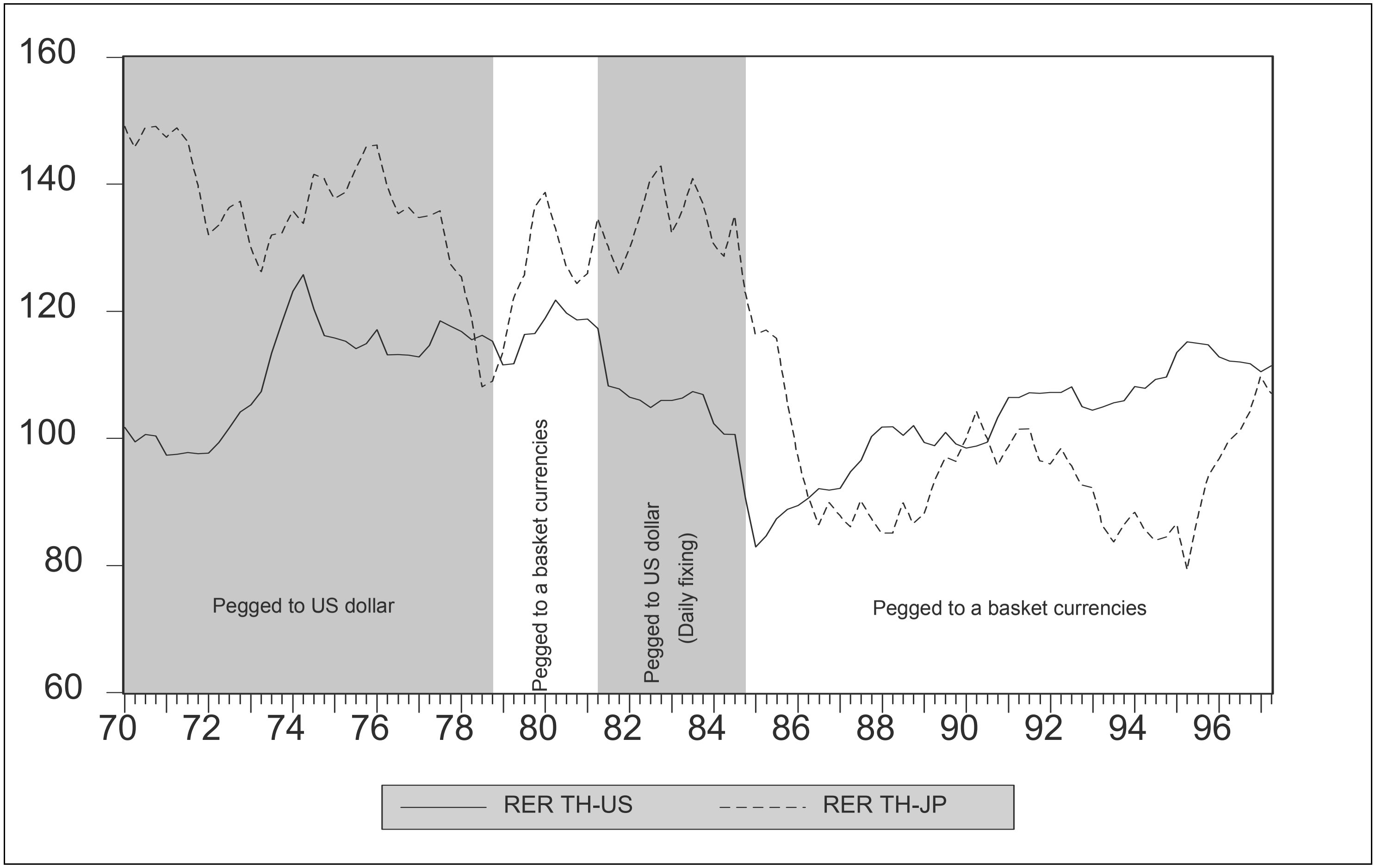
MULTILATERAL TRADE (in US$)

Country	Total Export Growth		Total Import Growth		REER Volatility*	
	1996	1998	1996	1998	1996	1998
Indonesia	9.68	-8.60	5.66	-34.43	100.00	1366.08
Malaysia	5.97	-6.90	0.94	-26.21	100.00	203.99
Singapore	5.70	-12.07	5.49	-20.93	100.00	201.41
Thailand	-1.27	-5.11	2.18	-31.63	100.00	567.55

Note: * Exchange rate volatility are in index (1996 = 100)

Note: REER (real effective exchange rate) volatility index is calculated using GARCH(1,1).

Figure 1: Thailand’s Baht Real Exchange Rate against US Dollar and Japanese Yen



Source: International Financial Statistics, IMF (various series)

Figure 2A: Thailand's Export to US and Exchange Rate Volatility Index

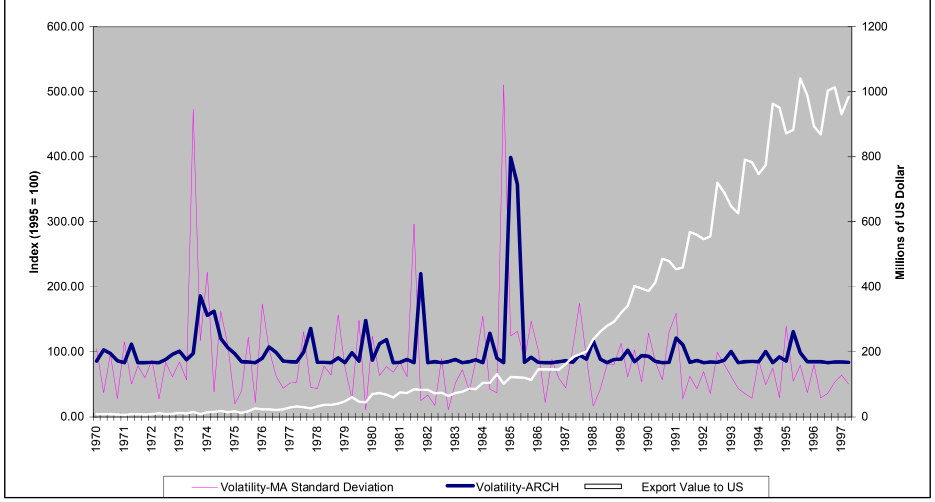


Figure 2B: Thailand's Import from US and Exchange Rate Volatility Index

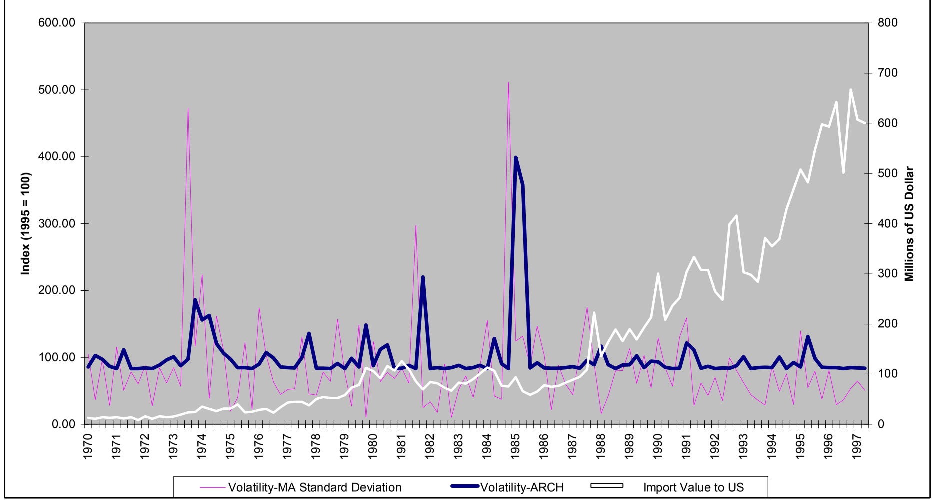


Figure 2C: Thailand's Export to Japan and Exchange Rate Volatility Index

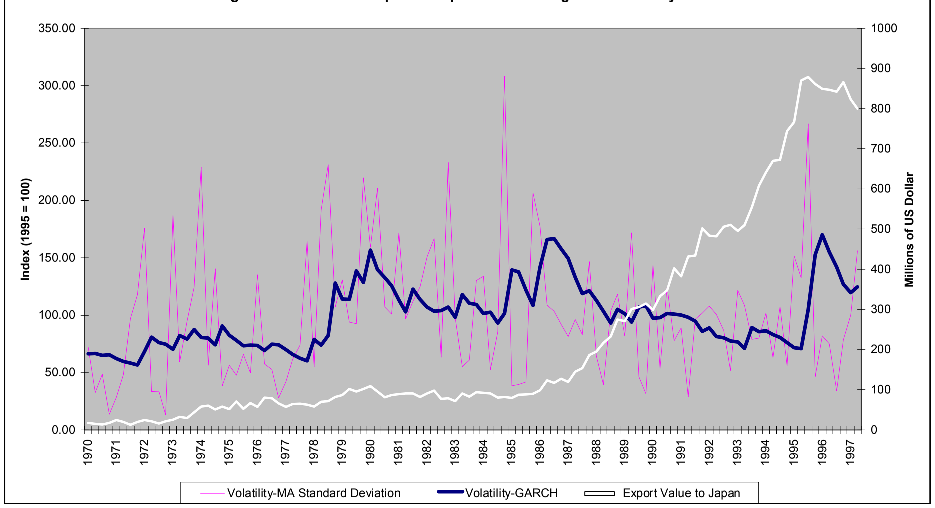


Figure 2D: Thailand's Import from Japan and Exchange Rate Volatility Index

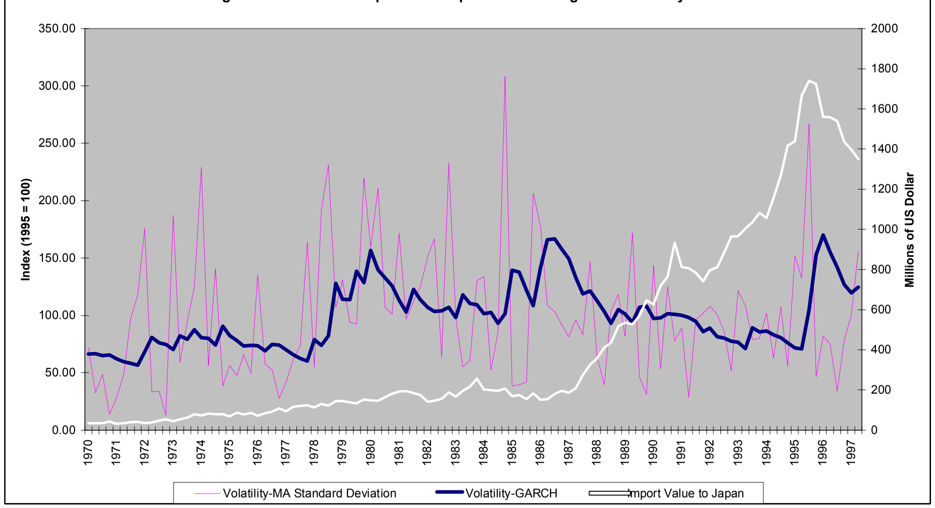


Figure 2E: Nominal Exchange Rate Volatility against the US dollar (1990:1 = 100)

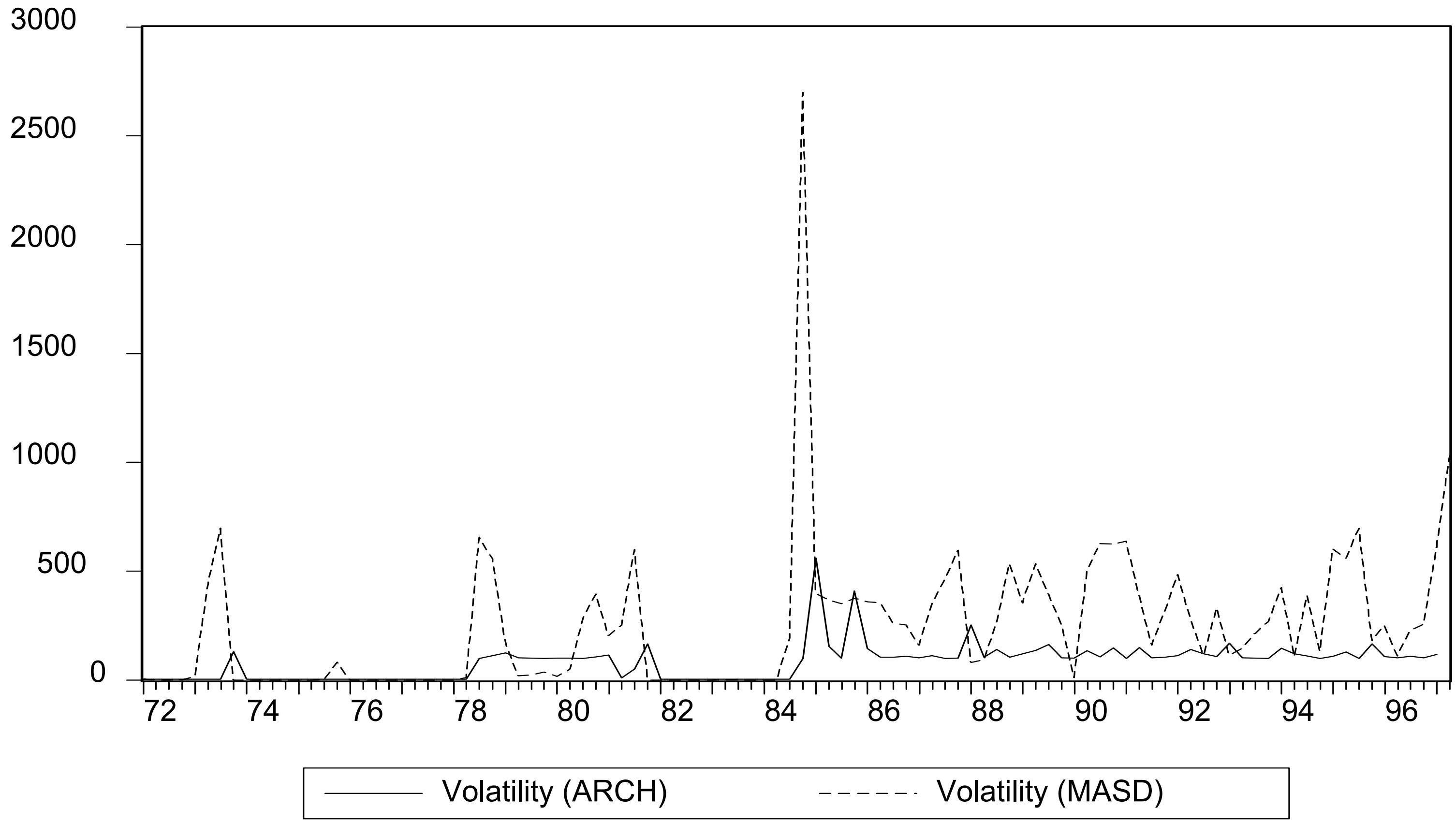


Figure 2F: Nominal Exchange Rate Volatility against the Japanese Yen (1990:1 = 100)

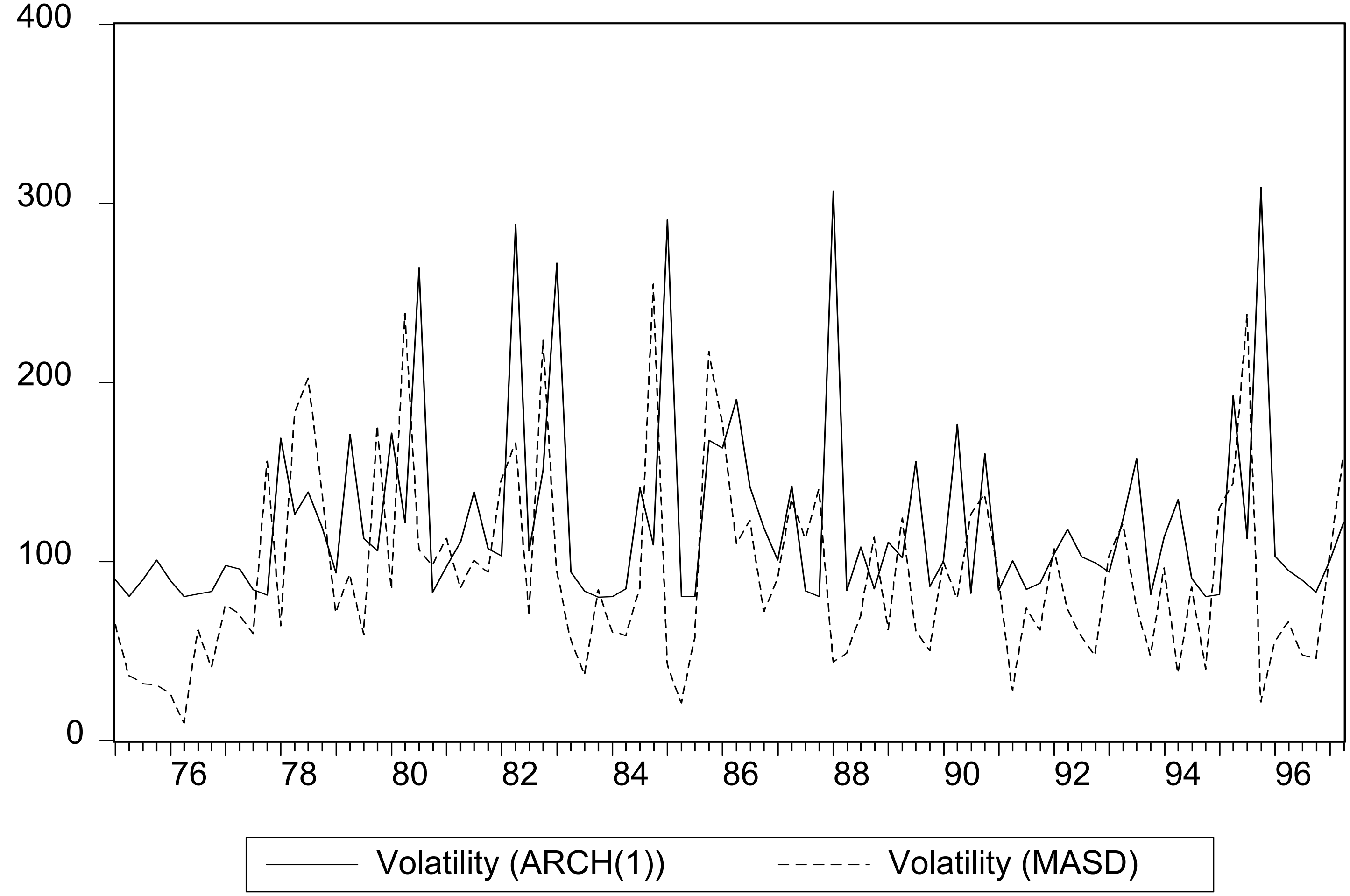


Figure 3: Stability of ARCH(1)

(Volatility of Baht against the US dollar)

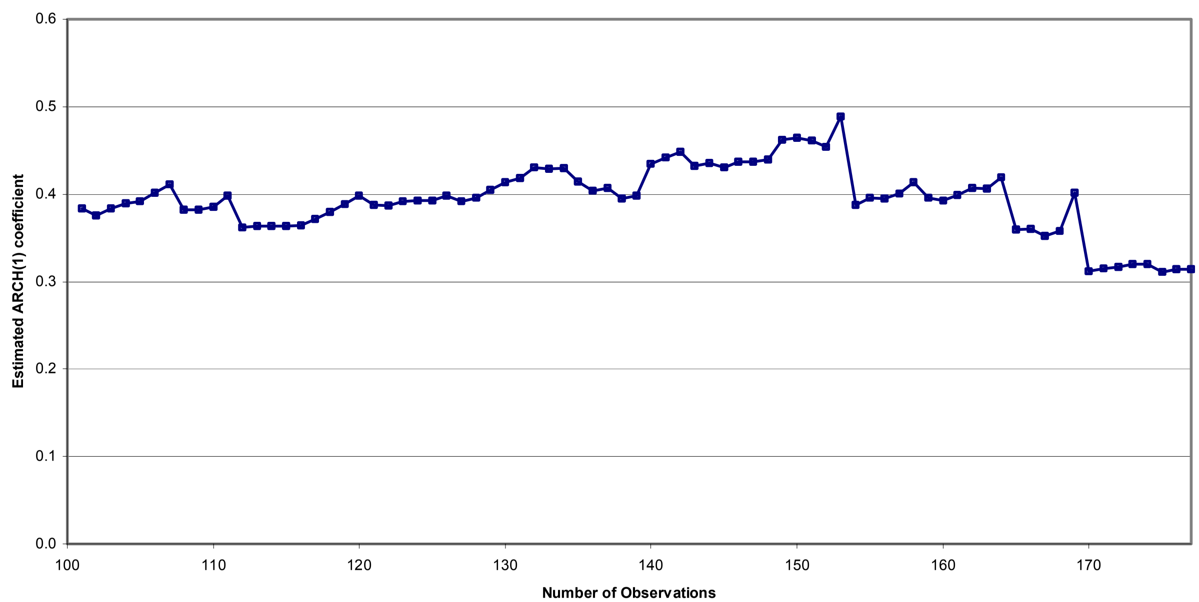


Figure 4: Stability of GARCH(1,1)

(Volatility of Baht against the Japanese Yen)