Exchange Rates, Price Levels, and Inflation Targeting: Evidence from Asian Countries

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Abstract

This study examines how the adoption of inflation-targeting influenced exchange rate pass-through and volatility in four Asian countries (Indonesia, Korea, the Philippines, and Thailand) over the sample period of January 1990 to June 2007. We find that reforming policy by adopting inflation targeting generally helped reduce pass-through in Korea and Thailand, while the results are less clear in Indonesia and the Philippines. Still, the findings indicate that inflation targeting has caused a decline in exchange rate volatility in all four countries. The important lesson from the experiences of these Asian countries is that the adoption of inflation targeting contributes to achieving the ultimate goal of inflation stability through reducing exchange rate pass-through or variability.

Keywords: Inflation targeting; Exchange rates; Pass-through; Exchange rate volatility
JEL classification: E31; E52; F31

1. Introduction

Exchange rates, which are among the most important variables used in modeling open economies, strongly influence monetary policy. Following the 1997 Asian financial crises, crisis-affected countries and many emerging economies, facing a world of highly volatile capital flows—notwithstanding the "fear of floating" that is often observed—have moved towards adopting a more flexible exchange rate regime (see, e.g., Calvo & Reinhart, 2002). With the more widespread adoption of a floating exchange rate regime, the adoption of inflation targeting is now at the center of monetary policy discussions. Many hope that it will prove to be an effective way to improve policy performance, as in developed countries, most of which adopted inflation targeting in the early 1990s.[1]

Asian countries are following this trend. To date, Indonesia, Korea, the Philippines, and Thailand have adopted a combination of a flexible exchange rate and inflation targeting. Such a structural reform seems to diminish the importance of managing exchange rates in policy debates in emerging countries. This does not, however, imply that exchange rates have vanished from policy discussions. Indeed, many questions related to exchange rates and inflation targeting figure prominently in such discussions. The fundamental question is whether or not inflation targeting contributes to price stability through external trade channels associated with exchange rate movements. This question is crucial for policymakers who oversee small open economies, like those in Asian countries, which rely heavily on external trade.

This paper considers how exchange rates, price levels, and inflation targeting in Asian countries are related by addressing two policy issues: First, how has the adoption of

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[1] For other studies on inflation targeting, see, e.g., Mishkin (2000), Mishkin & Schmidt-Hebbel (2001), Mishkin & Savastano (2001), Schmidt-Hebbel & Werner (2002), Parrado (2004), and Carare & Stone (2006).

inflation targeting affected the magnitude of pass-through from exchange rates to domestic prices? Second, how has inflation targeting affected the variability of exchange rates? In this study we direct these questions to Indonesia, Korea, the Philippines, and Thailand to examine empirically the impact of such a policy regime on price stabilization.

Many empirical studies analyze exchange rate pass-through to understand the inflationary transmission mechanism in various economic environments. Among them, Campa and Goldberg (2002), in their study on 25 OECD countries, suggest that pass-through tends to be lower for countries with low inflation as well as low exchange rate variability. Gagnon and Ihrig (2004), in their study on 20 industrial countries, assert that monetary policy in stabilizing inflation plays a vital role in reducing the pass-through. More recently, Choudri and Hakura (2006), covering 71 countries, find a positive relation between pass-through and the average inflation rate. These results could strengthen the argument of Taylor (2000) in the sense that a low inflationary environment leads to a decline in exchange rate pass-through.[2]

In addition to the pass-through issue, policymakers have also been concerned about exchange rate volatility since fluctuations in the exchange rate could pose a threat to the inflation target. Although it is generally believed that inflation targeting could function well under a floating exchange-rate regime, some argue that the combination of inflation targeting and a floating regime might cause exchange rate volatility to increase, so that such volatility is one of the costs of inflation targeting. Gali and Monacelli (2005) emphasize that inflation targeting would entail substantially higher exchange rate volatility. However, Chile's experience with inflation targeting, as mentioned in Schmidt-Hebbel and Tapia (2002),

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[2] Some studies attempt to explain this phenomenon by considering the prevalence of producer currency pricing over local currency pricing of imports and whether exchange rates are endogenous to a country's inflation performance. See Campa & Goldberg (2002) and Devereux & Engel (2003).

indicates that the volatility of nominal exchange rates has been no higher under inflation targeting than in other countries with floating exchange rate regimes. The recent study by Edwards (2006), covering seven countries with some extensions to Chile, shows that inflation targeting does not result in an increase in exchange rate volatility and emphasizes that inflation targeting helps reduce unexpected shocks by making monetary policy transparent and predictable.

In this regard, recent studies on the exchange-rate pass-through or volatility issues have focused on Asian countries. The empirical work of Ito and Sato (2006), covering the period of 1993 to 2005, seems to demonstrate that pass-through to the consumer price index (CPI) is relatively low compared with that to the producer price index (PPI) in Indonesia, Thailand, Malaysia, Singapore, and South Korea. Cortinhas (2007) also investigates pass-through in five ASEAN countries over the period of 1968 to 2001 and finds that exchange rates disconnect from pass-through in Singapore and Malaysia, while the Philippines and Thailand exhibit some evidence of pass-through.[3] In addition, extant empirical evidence concerning exchange rate volatility in Asian countries focuses mainly on its impact on trade (see, e.g., Rahmatsyah et al., 2002; Siregar & Rajan, 2004; Baak et al., 2007). To the best of our knowledge, few studies have taken into consideration the effect of inflation targeting on exchange rate pass-through and volatility in Asian countries, and this paper would therefore seem to be one of the first attempts to investigate how inflation targeting is related to exchange-rate pass-through and volatility for Asian countries.

Our results indicate that, with the adoption of inflation targeting, the degree of pass-through declined for either the PPI or the CPI in Korea and Thailand, although the

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[3] Moreover, Ghosh & Rajan (2009), in their empirical study covering the period of 1980 to 2006, find no evidence that pass-through has declined over time in Korea and Thailand, unlike in some other industrialized countries, but rather that it rose during the crisis.

evidence is less clear in Indonesia and the Philippines. The degree of inflationary inertia plays an important role in determining the magnitude of pass-through. There is, additionally, some evidence that the adoption of inflation targeting reduces exchange rate volatility in all countries, while reform in the direction of a floating regime has positively affected exchange rate variability. This is consistent with the results of various empirical studies, such as Edwards (2006) and Rose (2007), but it contrasts with Gali and Monacelli (2005). Interestingly, two very different effects on exchange rate volatility—one associated with a reform that involves a transition toward a floating regime and the other associated with a reform that involves inflation targeting under a floating regime—appear to cancel each other out. The most important implication of our results is that inflation targeting could be effective in stabilizing price levels and lowering inflation volatility through either of two channels: reduced exchange rate pass-through and exchange rate volatility. Portions of our results are consistent with evidence adduced by Edwards (2006).

The remainder of the paper is structured as follows. Section 2 presents the empirical analysis and evaluates how inflation targeting has influenced exchange-rate pass-through and exchange rate volatility in each country. Based on the estimated results, we discuss the role of inflation targeting as a monetary policy measure for the purpose of price stabilization. Section 3 offers concluding remarks.

2. Empirical Analysis

Any new direction in monetary policy should emphasize price stability. Since inflation targeting has been successfully adopted by several industrialized countries, it has become increasingly attractive as a policy measure in developing economies as well. Indeed, some

Asian countries have adopted inflation-targeting regimes (South Korea in 1998, Thailand in 2000, the Philippines in 2002, and Indonesia in 2005).[4]

To evaluate the impact of the introduction of inflation targeting on price stability in Asian countries, our empirical analysis is based on the following steps. First, we examine how the introduction of inflation targeting influences the impact of a change in exchange rates on domestic prices, that is, exchange-rate pass-through. Second, we study how the introduction of inflation targeting influences exchange rate variability. These two examinations yield some important implications of price fluctuations associated with exchange rate movements. If inflation targeting reduces pass-through or exchange rate volatility, it can help not only to stabilize price levels but also to mitigate the volatility of domestic prices. To verify this, we also examine the impact of inflation targeting on inflation (or price) variability.

2.1 Exchange Rate Pass-Through

Exchange rate pass-through indicates how changes in nominal exchange rates affect domestic prices. The question is whether the adoption of inflation targeting leads to a corresponding reduction in exchange rate pass-through. Following the studies by Campa and Goldberg (2002), Gagnon and Ihrig (2004), and Edwards (2006), we estimate the following model for each country:

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\begin{aligned}
\Delta \ln P_t = {} & \beta_0 + \beta_1 \Delta \ln E_t + \beta_2 \Delta \ln P_t^* + \beta_3 \Delta \ln P_{t-1} + \beta_4 \Delta \ln E_t \times FLT + \beta_5 \Delta \ln P_{t-1} \times FLT \\
& + \beta_6 \Delta \ln E_t \times DIT + \beta_7 \Delta \ln P_{t-1} \times DIT + \sum \beta_{8i} x_i + \varepsilon_t
\end{aligned}
\tag{1}
$$

where P_t, E_t and P_t^* are the monthly price index (consumer or producer price index), the nominal effective exchange rate, and the index of foreign prices, respectively, and ln

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[4] Although Bank Indonesia started to announce its annual inflation target at the beginning of 2000, the adoption of the full-fledged inflation targeting framework started in 2005.

represents a natural log. x_i's are other control variables expected to capture a change in price levels and ε_t is a disturbance term with standard characteristics. To capture the floating exchange rate and inflation-targeting regimes, we incorporate two dummy variables into the equation. The first dummy variable is *FLT*, which takes the value of 1 if the country has adopted a floating exchange rate regime; the second dummy variable is *DIT*, which takes the value of 1 if the country has adopted inflation targeting.[5] In our case, the *FLT* period is divided into a pre-*DIT* period and a *DIT* period. Thus, the *DIT* dummy captures the *DIT* effect under the floating exchange rate regime, that is, it is a conditional effect. Notice that the *FLT* variable is not included for the Philippines because a floating exchange rate regime was adopted in the Philippines in 1970. Equation (1) is specified as the first-differenced form as price and the exchange rate have unit roots at the level of the series (see Table 1).

The coefficients of exchange rate represent pass-through elasticity.[6] Short-run pass-through before the floating exchange rate regime is β_1 while long-run pass-through is $\beta_1/(1-\beta_3)$. Under the floating exchange rate regime without inflation targeting, short-run pass-through becomes $\beta_1+\beta_4$ and long-run pass-through is $(\beta_1+\beta_4)/(1-\beta_3-\beta_5)$. Furthermore, when the effect of inflation targeting is taken into consideration, short-run pass-through during the post-inflation targeting period becomes $\beta_1+\beta_4+\beta_6$ and long-run pass-through in the post-inflation targeting period is $(\beta_1+\beta_4+\beta_6)/(1-\beta_3-\beta_5-\beta_7)$. It should be noted that there are two implications of incorporating the coefficients of $\Delta\ln P_{t-1}$. First, doing so enables us to assess whether a stronger anti-inflationary policy decreases inflationary inertia (Taylor,

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[5] Floating exchange rate regimes were adopted in August 1999, December 1997, and July 1997 in Indonesia, Korea, and Thailand, respectively. The Philippines adopted such a regime in the 1970s. An inflation targeting framework was adopted in July 2005, April 1998, January 2002, May 2000 in Indonesia, Korea, the Philippines, and Thailand, respectively.

[6] In contrast to certain other studies, the present study does not impose the condition of the law of one price, i. e., $\beta_1=\beta_2$.

2000) and it also furnishes another channel through which inflation targeting may lower long-run pass-through (Edwards, 2006).

To estimate the model, this study applies ordinary least squares (OLS) and seemingly unrelated regression (SUR), the latter of which allows for the correlation of error terms across equations, following several previous studies (e.g., Campa & Goldberg, 2002; Gagnon & Ihrig, 2004; Edwards, 2006).[7] The exchange rate pass-through to the CPI and the PPI are respectively estimated for Indonesia, Korea, the Philippines, and Thailand over the sample period spanning January 1990 to June 2007. The CPI and the PPI can be considered as proxies for the domestic price of nontradables and the domestic price of tradables, respectively (Figures 1 and 2). The exchange rate is the nominal effective exchange rate (NEER), which represents the domestic price of a basket of currency (Figure 3). An increase in the index means a nominal depreciation. The US PPI is used as a proxy for world inflation. We take the output gap and average world oil price index to control for various external shocks such as supply and domestic demand pressures. The data reflecting all price indices, which are seasonally adjusted, are taken from *International Financial Statistics* (IFS). The output gap is derived from the difference between actual and potential outputs. Potential output is estimated by the Hodrick-Prescott (HP) filter to the manufacturing production index. The NEER and the manufacturing production index are taken from IFS or central banks.

Table 1 shows the results of the unit root tests (the Augmented Dickey-Fuller test, and the Phillips-Perron test), which suggest that the output gap is stationary at the level,

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[7] There may be a potential endogeneity problem with the estimated equation. As emphasized in various studies such as Meese & Kenneth (1983) and Edwards (2006), there may be no particular technique that is appropriate to deal with this problem. One possible approach is to apply simultaneous equation methods, such as two-stage least-squares (TSLS) and generalized methods of moments (GMM). It is, however, generally difficult to find reliable instrumental variables.

while other variables are stationary not at the level but at the first difference. Tables 2 and 3 report the empirical results of exchange rate pass-through for the OLS and the SUR. These methods yield similar estimates, suggesting that the analysis based on the OLS may not lose generality. Table 4 provides a summary of the pass-through coefficients, which notably capture short-run and long-run pass-through to the CPI and the PPI during the periods of the pre-floating exchange rate regime, the floating exchange rate regime without inflation targeting, and the floating exchange rate regime with inflation targeting.[8]

We first find that the short-run and long-run pass-throughs to the PPI are greater than either is to the CPI for all countries during each of the three sub-periods. This suggests that exchange rate fluctuations are transmitted more easily to producer prices than to consumer prices. Since services account for a large proportion of the CPI, a less-pronounced pass-through to the CPI is not surprising. The relatively large pass-through to the PPI may come about partly because the PPI consists largely of tradable goods, such as agricultural products. A simple implication is that the pass-through rate declines as one moves down along the distribution channel. This is consistent with the results of previous studies (see, e.g., McCarthy, 2000; Hahn, 2003; Faruqee, 2004; Edwards, 2006; Ito & Sato, 2006).

Our results also suggest that long-run pass-through depends not only on the coefficients of $\Delta \ln E_t$ but also on inflation inertia, which can be captured by the coefficients of $\Delta \ln P_{t-1}$. The estimated coefficients of $\Delta \ln P_{t-1}$ in Table 2 shows that, except for the PPI in the

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[8] The method of calculation is the same as that used in Edwards (2006). The short-run pass-through during the period of the pre-floating regime is the coefficient on $\Delta \ln E_t$. The long-run pass-through during the period of the pre-floating regime is equal to the short-run pass-through if the coefficient of $\Delta \ln P_{t-1}$ is insignificant, and it is equal to the short-run pass-through divided by one minus the coefficient of $\Delta \ln P_{t-1}$ if the coefficient of $\Delta \ln P_{t-1}$ is significant. The short-run pass-through during the period of the floating regime without inflation targeting is the coefficient of $\Delta \ln E_t$ if the coefficient of FLT*$\Delta \ln E_t$ is insignificant, and it is the sum of the coefficients of $\Delta \ln E_t$ and FLT*$\Delta \ln E_t$ if the coefficient of FLT*$\Delta \ln E_t$ is significant. The other short-run pass-through and long-run pass-through are also calculated in the same manner.

Philippines, inflation is characterized by a marked degree of inflationary inertia, in virtue of which current inflation is significantly influenced by lagged inflation. This result implies that, due to the existence of inflation inertia, long-run pass-through is generally greater than short-run pass-through in all countries. Moreover, the relatively large coefficients of $\Delta \ln P_{t-1}$ for the CPI compared with those for the PPI indicates that the degree of inflation inertia is generally greater for the CPI than for the PPI (see, e.g., Edward, 2006).

We also demonstrate that the adoption of the floating exchange rate regime does not have a clear effect on pass-through to the CPI and PPI in Thailand, given that the estimated coefficients of $\Delta \ln E_t \times FLT$ and $\Delta \ln P_{t-1} \times FLT$ are not significant in Table 2. On the other hand, the adoption of the floating regime has a significant impact on pass-through to the PPI in Indonesia and to both the PPI and the CPI in Korea. Interestingly, the adoption has the opposite impact on pass-through in these countries. The significantly negative coefficients of $\Delta \ln E_t \times FLT$ and $\Delta \ln P_{t-1} \times FLT$ for Indonesia show the declines in short-run and long-run pass-through to the PPI, while the significantly positive coefficients in Korea imply the rise in short-run and long-run pass-through to the CPI and the PPI.

More importantly, our estimated results suggest that the adoption of inflation targeting under the floating exchange rate regime induced the decline in pass-through in Korea and Thailand, although there is no clear evidence with respect to Indonesia and the Philippines (Table 2). In Korea, the significantly negative coefficients of $\Delta \ln P_{t-1} \times DIT$ in the CPI equation and $\Delta \ln E_t \times DIT$ and $\Delta \ln P_{t-1} \times DIT$ in the PPI equation imply the decline in long-run pass-through to the CPI and in short-run and long-run pass-through to the PPI. In Thailand, the negative coefficient of $\Delta \ln P_{t-1} \times DIT$ in the PPI equation indicates the decline in long-run pass-through to the PPI. The decline in the degree of inflation inertia

associated with inflation targeting plays an important role in decreasing long-run pass-through in these countries. In fact, our results with respect to Korea and Thailand are consistent with those in Edwards (2006) on some emerging economies such as Chile and Mexico.

2.2 Alternative Approach for Exchange Rate Pass-Through

Our empirical analysis in the previous section provides evidence that inflation targeting reduces pass-through in Korea and Thailand, even though the results are not significant when applied to Indonesia and the Philippines. We now estimate a VAR model to assess the robustness of these results. Since exchange rates and inflation rates are endogenously determined, the estimation of their relationship in the VAR framework may be a more appropriate method of analysis (Ito & Sato, 2006). In addition, VAR analysis may provide an advantage over single-equation analysis in that it allows us to examine the effects of structural shocks.

We attempt to investigate how the CPI and PPI respond to exchange rate shocks using the impulse response functions (IRFs) derived from the VAR model. The VAR estimation is separately conducted for the pre-inflation-targeting periods (January 1990 to June 2005 in Indonesia, January 1990 to March 1998 in Korea, January 1990 to December 2001 in the Philippines, and January 1990 to April 2000 in Thailand) and for the post-inflation-targeting periods (July 2005 to June 2007 in Indonesia, April 1998 to June 2007 in Korea, January 2002 to June 2007 in the Philippines, and May 2000 to June 2007 in Thailand). The sub-sample examinations aim at identifying how pass-through to the CPI and the PPI has changed after the adoption of inflation targeting in each country.

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For these purposes, we follow Ito and Sato (2006) in their empirical analysis of Asian economies, and estimate the 5-variable VAR model with $\Delta usppi_t$, gap_t, Δm_t, $\Delta neer_t$, and Δp_t, where $usppi_t$ is the log of the US PPI, gap_t is the output gap, m_t is the log of the money supply (narrow money or M2), $neer_t$ is the log of the nominal effective exchange rate, and p_t is the log of the domestic CPI or PPI. All variables, except for gap_t, are employed in terms of the first difference to assure the stationarity of variables (Table 1). The same dataset of prices, output gap, and NEER from the previous subsection is used and the money supply data is taken from IFS. The number of lags is set according to Akaike and Schwarze information criteria.

The endogenous variables are included in the model in the following order— $\Delta usppi_t$, gap_t, Δm_t, $\Delta neer_t$, and Δp_t—under the assumption that some endogenous variables do not respond contemporaneously to other structural shocks. In other words, the variables that appear first in the ordering are assumed to have no contemporaneous response to shocks generated by the variables that follow. The order of the endogenous variables should be justified by appropriate economic intuitions. For example, the price variable is placed last in the order on the assumption that it responds contemporaneously to shocks from the US PPI, the output gap, the money supply, and the nominal effective exchange rate, while these other variables are not contemporaneously influenced by price shocks.[9] Figure 4 represents the estimated impulse response functions for the pre-inflation-targeting and the post-inflation-targeting periods.

First, we find that the accumulative CPI responses to exchange rate shocks in the Philippines and Thailand over both the pre- and the post-inflation-targeting periods are

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[9] For the robustness check, we have examined the VAR models with other possible orderings. For example, we place the output gap below changes in money supply since it may be considered that money supply as a policy measure is supposed to be more exogenous than output variables. However, the changes in the ordering do not change our results.

not significantly different from 0, as the 0-line lies within the two-standard-error confidence bands. In contrast, the CPI responses to exchange rate shocks in Indonesia and Korea over the pre-inflation-targeting period are significant, while over the post-inflation-targeting period they are insignificant. These results imply that pass-through to the CPI diminished after the introduction of inflation targeting in Indonesia and Korea. Second, the PPI responses to exchange rate shocks in all four countries over the pre-inflation-targeting period are significantly positive. However, the responses over the post-inflation-targeting period are generally not significant, although the response in Thailand is still significantly positive for the first few months. These results again suggest that exchange rate pass-through to the PPI becomes less significant after the adoption of inflation targeting.

The results from the VAR analysis support the evidence associated with the single-equation approach in the previous section in the sense that pass-through to the PPI in all four countries is more significant than is pass-through to the CPI. Moreover, our results provide an important insight into the relationship between pass-through and inflation targeting. Our VAR analysis partly confirms the results of the single-equation approach that the adoption of inflation targeting would help reduce (short-run or long-run) pass-through to the CPI or the PPI.

2.3 Exchange Rate Volatility

Inflation-targeting regimes have provoked considerable controversy over 'fear of floating.' Many believe that the adoption of inflation targeting incurs some economic costs associated with rising exchange rate volatility since, it is argued, it necessarily requires a floating exchange rate regime (see, e.g., Mishkin & Savastano, 2001, for a discussion of

monetary policy including inflation targeting in Latin America). Several approaches to resolving this issue have emerged. Some studies compare the magnitude of exchange rate volatility under a pegged or managed exchange rate regime with its magnitude under an inflation-targeting regime. In a critique of such a comparison, Edwards (2006) emphasizes that the correct approach is to evaluate the impact of the adoption of inflation targeting on exchange rate volatility with a control for the exchange rate regime.

Following Edwards (2006), we attempt to examine the impact of the adoption of inflation targeting on conditional exchange rate volatility for each country under study using the generalized autoregressive conditional heteroskedasticity (GARCH) model. The GARCH specification is described as:

$$\Delta \ln E_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta \ln E_{t-i} + \sum_{j=1}^{n} \phi_j x_{j,t} + \varepsilon_t, \tag{2}$$

$$\sigma_t^2 = \delta_0 + \sum_{i=1}^{p} \delta_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \gamma_j \sigma_{t-j}^2 + \sum_{k=1}^{s} \theta_k y_{k,t}, \tag{3}$$

where E_t is the nominal effective exchange rate as before; the x_j's represent other explanatory variables that might explain changes in the nominal effective exchange rate; the ε_t is a disturbance with the properties of zero mean and conditional variance σ_t^2; and the y_k's are the other control variables that affect exchange rate volatility.

As in Edwards (2006), we incorporate two dummy variables, *DIT* and *FLT,* into the conditional variance equation to capture the floating exchange rate and inflation-targeting regimes, as in the single-equation analysis we have already examined. Recall that the *DIT* dummy captures the *DIT* effect under *FLT*. In addition, we include the differential between the domestic and foreign price levels as well as interest rate differentials in the mean equation based on the flexible-price monetary model (see Taylor, 1995). We also

include a dummy variable in the mean equation to control for the impact of the Asian financial crisis during 1997–1998.

As in the previous estimation, we take monthly data over the period of January 1990 to June 2007 to estimate the GARCH model for each of the four countries. We use the same dataset as in the previous subsections and take the interest rate date from IFS.[10] We order the GARCH model as follows: GARCH (2,2), GARCH (1,2), GARCH (2,1), and GARCH (2,0) apply to Indonesia, Korea, the Philippines, and Thailand, respectively, according to the Akaike information criterion (AIC).

Our main concern in this model is whether or not inflation targeting under a floating exchange rate regime causes nominal effective exchange rates to be more volatile. Since a policy reform that involves a transition toward a floating exchange rate regime increases exchange rate volatility, the estimated coefficient of *FLT* is expected to be positive. The impact of the adoption of inflation targeting under a floating exchange rate regime can be evaluated through the sign of the estimated coefficient of *DIT*. A positive coefficient means that increased exchange rate volatility is associated with the adoption of inflation targeting (Mishkin & Savastano, 2001; Gali & Monacelli, 2005), while a negative coefficient implies that inflation targeting helps reduce exchange rate volatility. If the latter is the case, we may conclude that inflation targeting is effective in reducing the social cost associated with exchange rate variability.

Table 5 shows the main results, which include the estimated coefficients of *FLT* and *DIT*. First, the coefficient of *FLT* is significantly positive for Indonesia, Korea, and Thailand. This confirms the conventional argument in favor of increased fluctuation under a

[10] The differential between domestic and foreign prices is based on the log of PPI for the domestic country and the US. The interest rate differentials consist of the difference between the US federal funds rate and the domestic short-term interest rate in each country. For the short-term interest rates we use the money market rate for Indonesia and Korea and the discount rate for the Philippines and Thailand. All data is taken from IFS.

floating exchange rate regime. Recall that the *FLT* variable is not included for the Philippines because a floating exchange rate regime was adopted in 1970. Second, the coefficients on *DIT* are negative and significant for all countries. Thus, adopting inflation targeting tends to decrease conditional exchange rate volatility under a floating exchange rate regime. Third, the increment in conditional volatility derived from the floating exchange rate regime is almost canceled out by a reduction in conditional volatility as a result of adopting inflation targeting in Indonesia, Korea, and Thailand. These results are generally consistent with those that pertain to Chile and Brazil in Edwards (2006) and Rose (2007).

One possible explanation for the reduction in exchange rate volatility during the post-inflation-targeting period is that inflation targeting makes monetary policies more transparent and predictable, which could help reduce unexpected external shocks. Another explanation may be that some intervention remains essential for central banks even under a floating rate regime in order to smooth excessive variability of exchange rates in relatively small foreign exchange markets.[11] As emphasized by Ho and McCauley (2003), market intervention and capital control are required to achieve an inflation target for emerging economies, which tend to be more exposed to exchange rate movements. Although a central bank while adopting inflation targeting pays attention primarily to price stability by formally committing to an explicit inflation target, the stability of exchange rates is a major concern as well (see, e.g., Sarno & Taylor, 2001). Inflation targeting implies neither 'benign neglect' of the exchange rate nor avoidance of foreign exchange rate market intervention (see Mishkin 2004). The central bank is required to

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[11] Since the exchange rate matters due to its impact on inflation as well as on the functioning of markets, it is often claimed that exchange rate management is particularly essential for emerging countries to assure the tradable sector's competitiveness as well as financial stability. Mohanty & Klau (2004) discuss how central banks in emerging countries react to exchange rate variability. Several emerging economies have intervened— often on a large scale—to stabilize the exchange rate by adjusting interest rates.

make it clear to the public that the primary goal is still inflation control; meanwhile, such an intervention aims to smooth excessive exchange rate volatility, but not to distort its market-determined level in the long-run.

2.4 Inflation Volatility

The foregoing discussions illustrate the proposition that price stability can be achieved by the adoption of inflation targeting through reduced exchange rate pass-through and volatility. As exchange rate pass-through and exchange rate volatility are prominent sources of inflation variability, we expect that inflation targeting also contributes to reduced inflation volatility. To verify this argument, this section directly examines the effect of inflation targeting on inflation volatility for each country under study, using the framework of the GARCH model. The GARCH specification is described as:

$$\Delta \ln P_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta \ln P_{t-i} + \sum_{j=1}^{n} \phi_j x_{j,t} + \varepsilon_t, \qquad (4)$$

$$\sigma_t^2 = \delta_0 + \sum_{i=1}^{p} \delta_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \gamma_j \sigma_{t-j}^2 + \sum_{k=1}^{s} \theta_k y_{k,t}, \qquad (5)$$

where P_t is the domestic price (PPI); the x_j's and y_k's represent other explanatory variables in the mean and variance equations, respectively; and the ε_t is a disturbance with the properties of zero mean and conditional variance σ_t^2. As in the previous section, we incorporate *DIT* and *FLT* into the variance equation to capture the effects of the floating exchange rate and inflation-targeting regimes. In addition, we include the log of NEER, the log of the US PPI, interest rate differentials, and a dummy variable for the Asian crisis in the mean equation. We order the GARCH model as follows: GARCH (2,2), GARCH (3,1), GARCH

(2,1), and GARCH (2,0) for Indonesia, Korea, the Philippines, and Thailand, respectively, according to the AIC.

Table 6 shows the estimated results of the GARCH model for each of the four countries over the sample period of January 1990 to June 2007. The estimated coefficients of *DIT* are significantly negative for Korea, the Philippines, and Thailand, while the corresponding coefficient is insignificant for Indonesia. Therefore, inflation volatility tends to shrink during inflation targeting periods even though floating increases the volatility. Our results thus vindicate the supposition that inflation targeting can contribute to inflation stability without causing a rise in inflation volatility through reduced exchange rate pass-through and exchange rate volatility.

3 Conclusion

In this paper, we verify the position that the adoption of inflation targeting can have an important effect on exchange rate pass-through and exchange rate volatility, using data from four crisis-afflicted Asian countries: Indonesia, Korea, the Philippines, and Thailand. One important lesson we can draw from the experiences of these countries is that inflation targeting has helped achieve its primary objective of price stability through a decline in exchange-rate pass-through or exchange rate volatility, a possible complement to a expected reduction in inflation. Another important result is that there is no evidence that adopting inflation targeting increases nominal exchange rate volatility, whereas monetary reform in the direction of a floating regime raises exchange rate volatility. Indeed, we have shown that the adoption of inflation targeting would tend to offset any increase in exchange rate volatility associated with the adoption of a floating regime.

Our results suggest that central banks' commitment to low inflation is an important factor in determining exchange rate pass-through and volatility. To preserve the credibility of an inflation-targeting regime, inflation targeting central banks should make their monetary policies more accountable and transparent. Moreover, they may also have to resort to foreign exchange intervention and capital control in response to exchange rate shocks in order to mitigate the impact of pass-through effects on inflation as well as to reduce exchange rate volatility.

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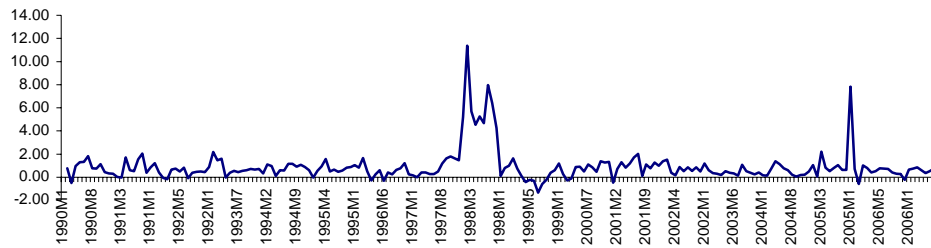
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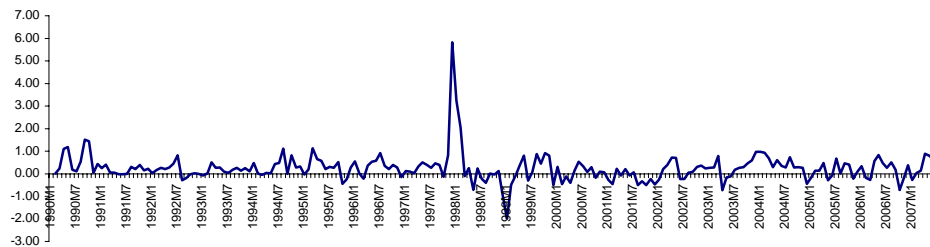Siregar, R., and R.S. Rajan (2004): "Impact of Exchange Rate Volatility on Indonesia's

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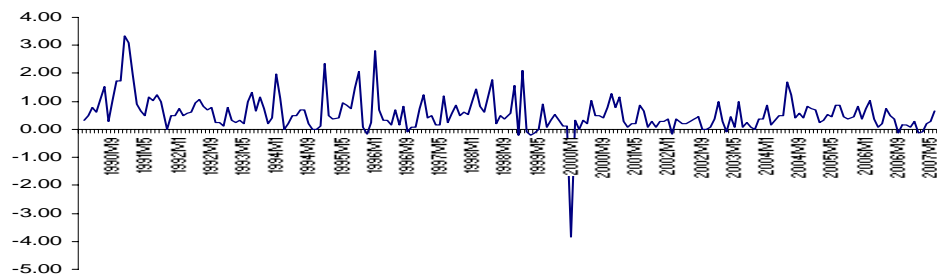# Figure 1: Monthly Percentage Change in Consumer Price Index
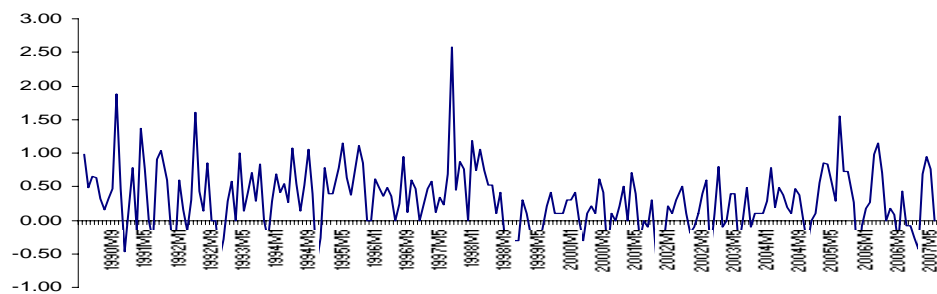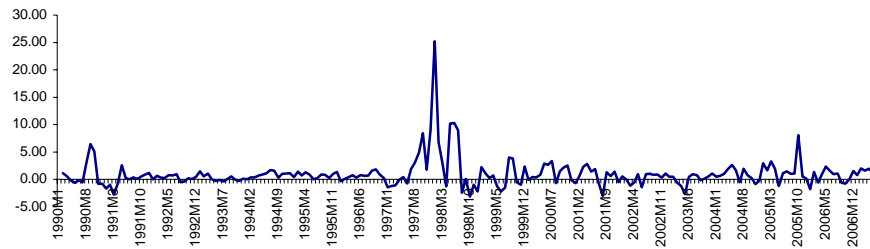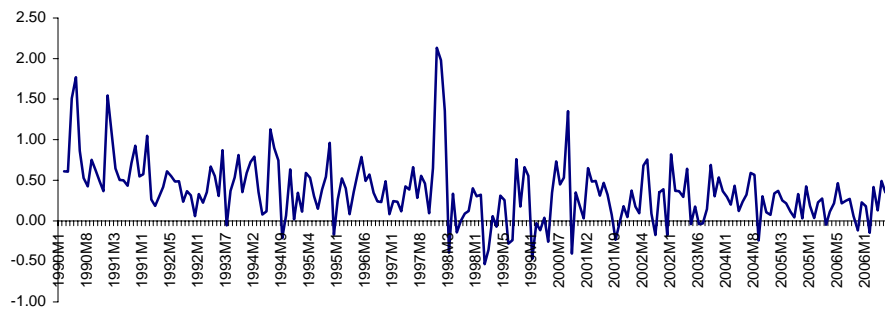
Indonesia

Korea

Philippines

Thailand

22

Figure 2: Monthly Percentage Change in Producer Price Index

Indonesia
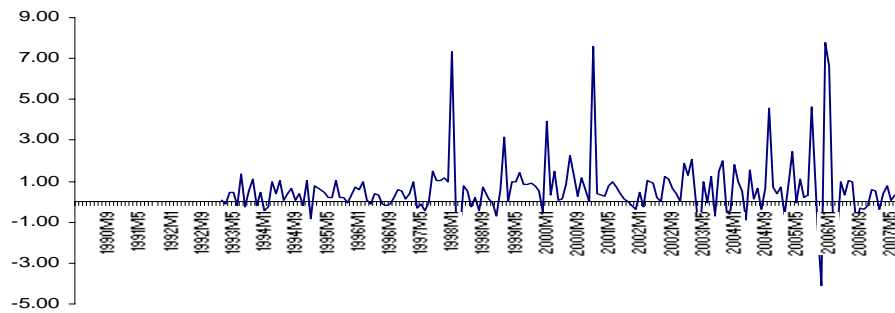
Korea

Philippines
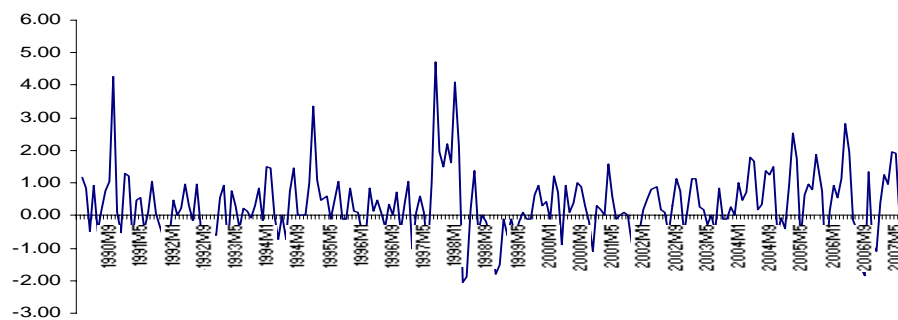
Thailand

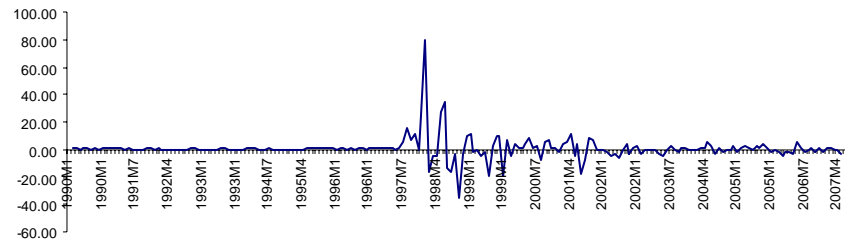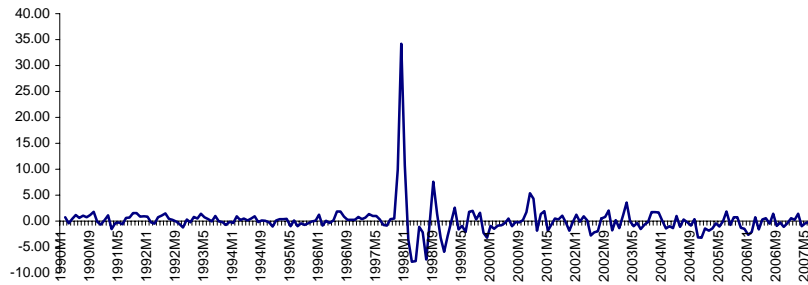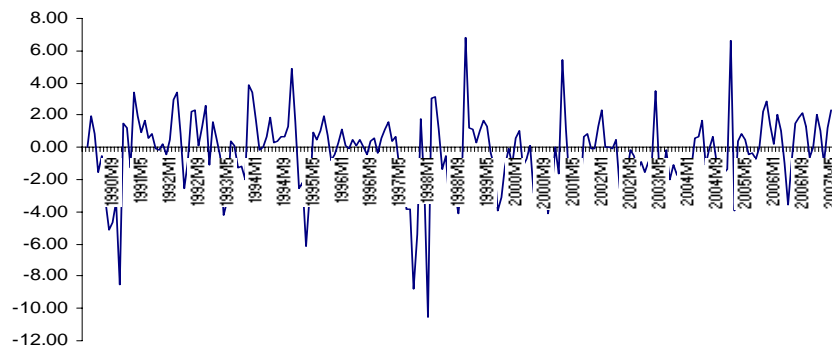# Figure 3: Monthly Percentage Change in Nominal Effective Exchange Rate
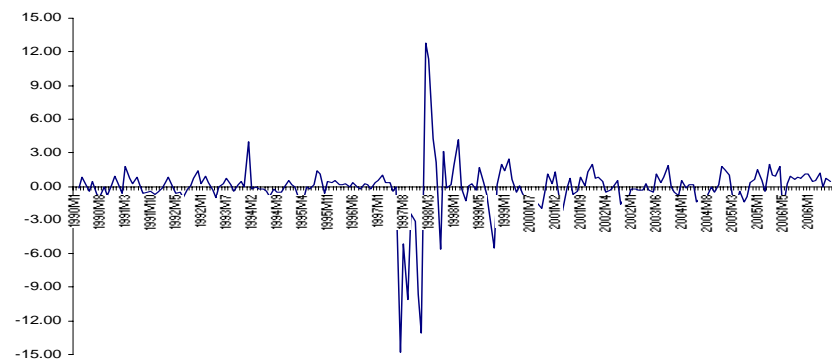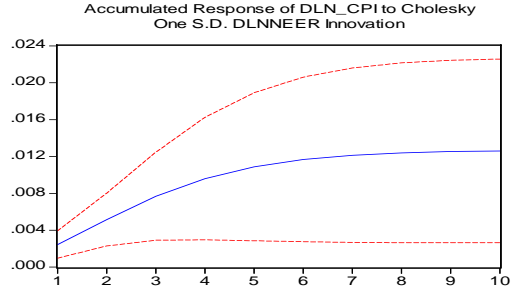
Indonesia

Korea

Philippines

Thailand

24

Figure 4: Impulse Response to Exchange Rate Shock
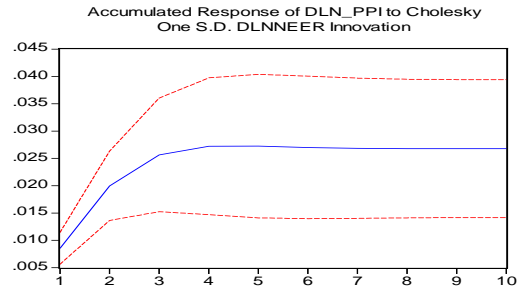
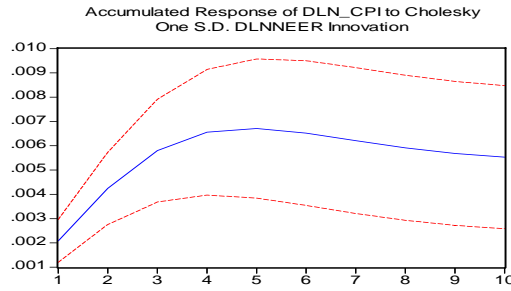## Before Adoption of Inflation Targeting Regime
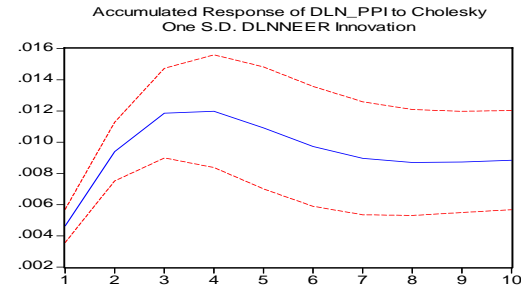
(1) Response of CPI

(i) Indonesia

Accumulated Response of DLN_CPI to Cholesky
One S.D. DLNNEER Innovation

(ii) Korea

Accumulated Response of DLN_CPI to Cholesky
One S.D. DLNNEER Innovation

(iii) Philippines

Accumulated Response of DLN_CPI to Cholesky
One S.D. DLNNEER Innovation

(iv) Thailand

Accumulated Response of DLN_CPI to Cholesky
One S.D. DLNNEER Innovation

(2) Response of PPI

(i) Indonesia

Accumulated Response of DLN_PPI to Cholesky
One S.D. DLNNEER Innovation

(ii) Korea

Accumulated Response of DLN_PPI to Cholesky
One S.D. DLNNEER Innovation

(iii) Philippines

Accumulated Response of DLN_PPI to Cholesky
One S.D. DLNNEER Innovation

(iv) Thailand

Accumulated Response of DLN_PPI to Cholesky
One S.D. DLNNEER Innovation

25

Figure 4: Impulse Response to Exchange Rate Shock (Cont.)

After Adoption of Inflation Targeting Regime

(1) Response of CPI
(i) Indonesia

Accumulated Response of DLN_CPI to Cholesky
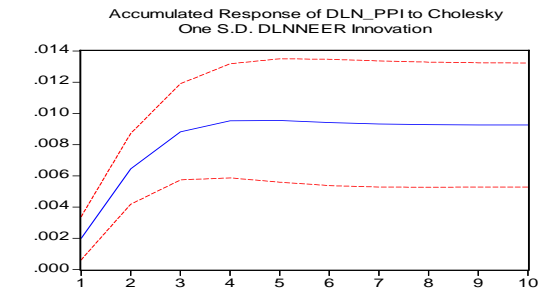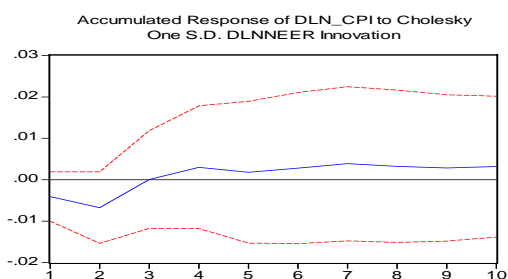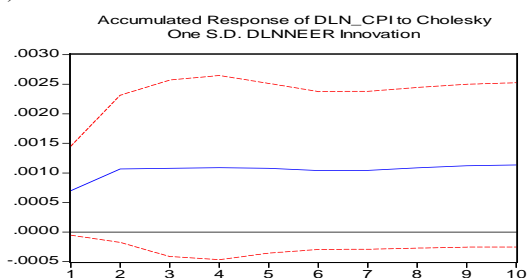One S.D. DLNNEER Innovation

(2) Response of PPI
(i) Indonesia

Accumulated Response of DLN_PPI to Cholesky
One S.D. DLNNEER Innovation

(ii) Korea

Accumulated Response of DLN_CPI to Cholesky
One S.D. DLNNEER Innovation

(ii) Korea

Accumulated Response of DLN_PPI to Cholesky
One S.D. DLNNEER Innovation

(iii) Philippines

Accumulated Response of DLN_CPI to Cholesky
One S.D. DLNNEER Innovation

(iii) Philippines

Accumulated Response of DLN_PPI to Cholesky
One S.D. DLNNEER Innovation

(iv) Thailand

Accumulated Response of DLN_CPI to Cholesky
One S.D. DLNNEER Innovation

(iv) Thailand

Accumulated Response of DLN_PPI to Cholesky
One S.D. DLNNEER Innovation

Notes: 1) The accumulated impulse responses of CPI and PPI are shown.
2) All shocks are standardized to a 1% shock.
3) The vertical axis represents the approximate percentage change in response to a 1% exchange rate shock, while the horizontal axis demonstrates the time horizon (1 through 10 months).
4) The dotted line denotes a two-standard-error confidence band around the estimate.

Figure 5: Conditional Effective Exchange Rate Volatility

Indonesia
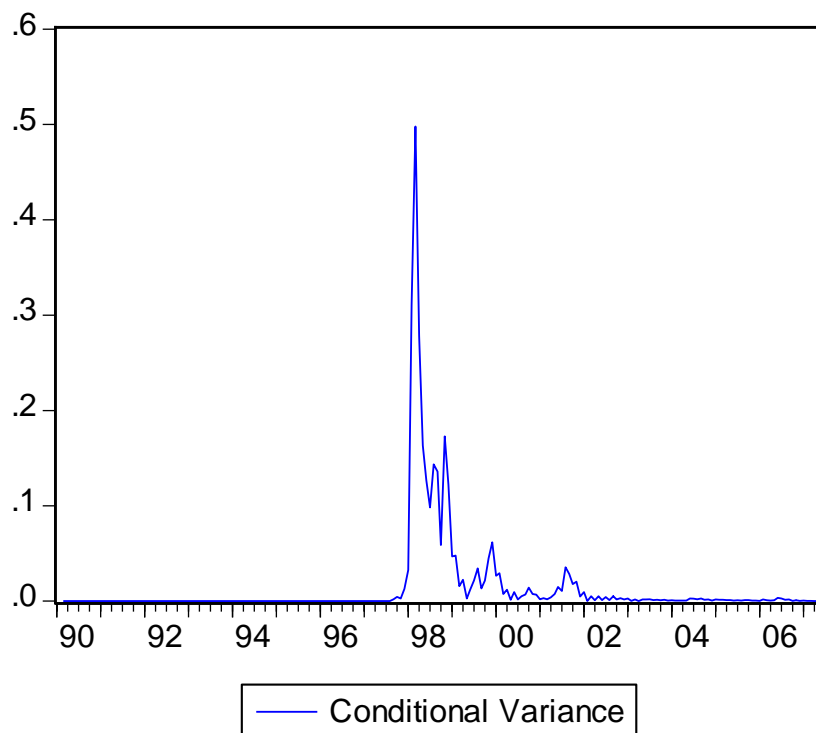
Korea

Figure 5: Conditional Effective Exchange Rate Volatility (continued)

Philippines

Conditional Variance

Thailand

Conditional Variance

Table 1: Unit Root Tests

Augmented Dickey-Fuller (ADF) Test

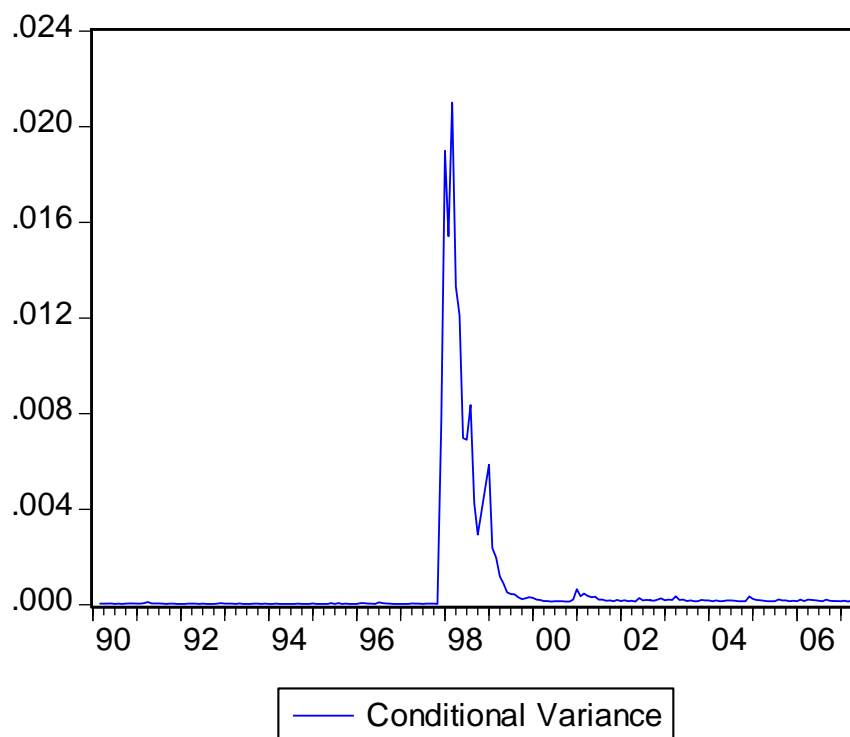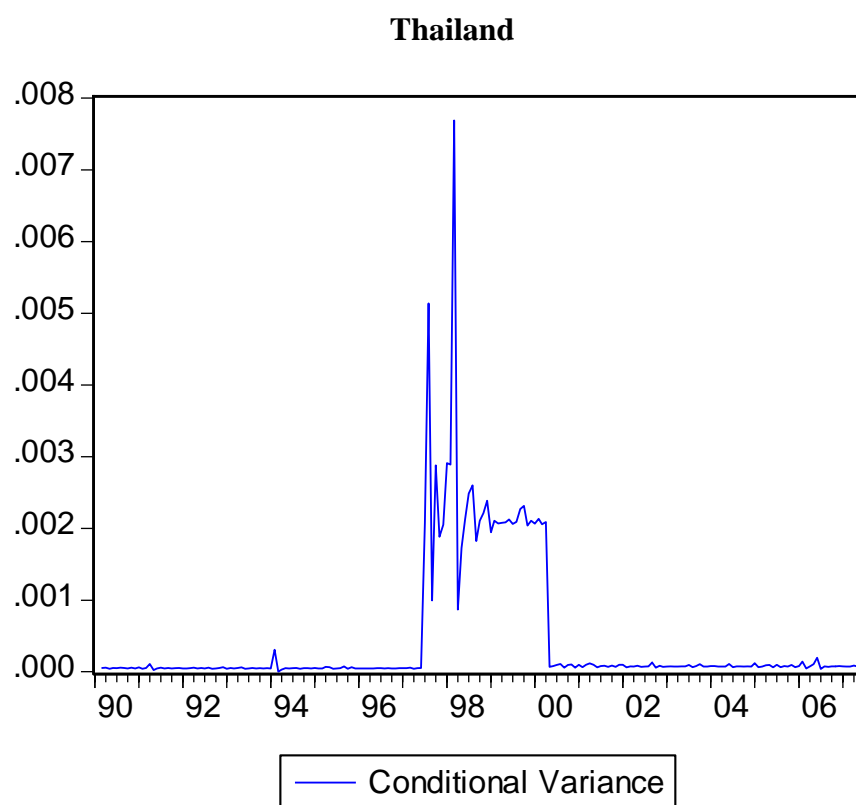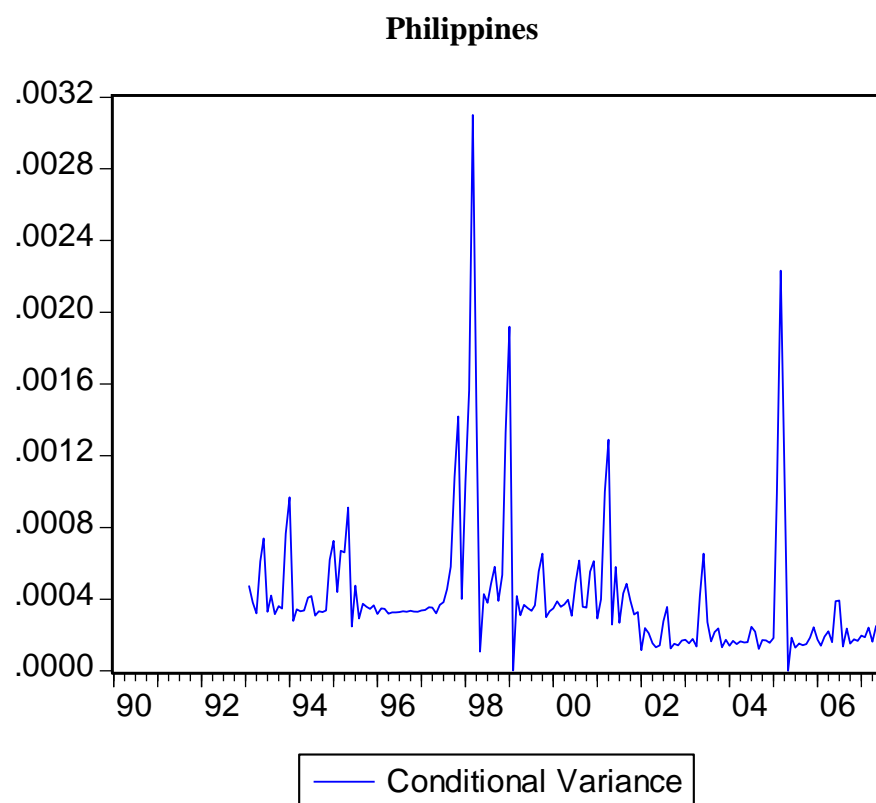|	Indonesia	Korea	Philippines	Thailand
ln(oil)	-2.467			
Δln(oil)	-11.183*			
ln(usppi)	-0.662			
Δln(usppi)	-3.855*			
gap (in level)	-3.619*	-3.031*	-3.953*	-5.566*
ln(m)	-1.941	-2.266	-1.773	-1.629
Δm	-3.903*	-20.097*	-4.708*	-2.171
ln(neer)	-1.689	-1.780	-1.705	-2.009
Δln(neer)	-3.810*	-10.354	-10.096*	-4.701*
ln(ppi)	-2.285	-2.955	-2.307	-2.767
Δln(ppi)	-5.023*	-8.249*	-12.634*	-6.145*
ln(cpi)	-2.076	-2.607	-2.956	-1.485
Δln(cpi)	-4.626*	-9.432*	-10.262*	-5.650*

Phillips-Perron (PP) Test

	Indonesia	Korea	Philippines	Thailand
ln(oil)	-2.150			
Δln(oil)	-10.828*			
ln(usppi)	-0.520			
Δln(usppi)	-11.873*			
gap (in level)	-5.579*	-4.015*	-9.328*	-8.312*
ln(m)	-1.631	-2.362	-2.217	-2.245
Δm	-11.788*	-20.811*	-16.578*	-12.888*
ln(neer)	-1.638	-1.523	-1.609	-2.292
Δln(neer)	-12.591*	-7.593*	-10.087*	-9.927*
ln(ppi)	-1.966	-2.294	-2.544	-2.141
Δln(ppi)	-8.989*	-7.688*	-13.261*	-9.985*
ln(cpi)	-1.938	-3.260	-2.705	-1.408
Δln(cpi)	-6.946*	-8.830*	-10.398*	-11.367*

Notes: 1) A single asterisk (*) denotes significance at the 5% level.
    2) The null hypothesis of the ADF and PP tests is that the variable is non-stationary.
    3) For the log level of variables, the intercept and time trend are included, whereas only the intercept is included for the first difference of variables.

Table 2: Exchange-Rate Pass-Through: OLS

	Indonesia		Korea		Philippines		Thailand	
	CPI	PPI	CPI	PPI	CPI	PPI	CPI	PPI
dlog E_t	0.030*	0.266*	0.008	0.068*	0.010	0.167*	0.089	0.143
	(2.81)	(19.07)	(0.21)	(1.97)	(0.47)	(2.98)	(1.57)	(1.19)
dlog P_t*	0.159	0.445*	0.056	0.214*	0.054	0.372*	0.077*	0.219*
	(1.45)	(3.04)	(1.32)	(5.40)	(0.86)	(2.54)	(2.10)	(2.67)
dlog P_{t-1}	0.585*	0.424*	0.492*	0.324*	0.311*	0.027	0.282*	0.218*
	(8.23)	(9.98)	(6.33)	(3.52)	(4.47)	(0.25)	(3.25)	(2.05)
FLT*dlog E_t	-0.038	-0.099*	0.068**	0.103*	-	-	-0.083	-0.037
	(-1.37)	(-2.66)	(1.80)	(2.94)			(-1.43)	(-0.30)
FLT*dlog P_{t-1}	-0.166	-0.208**	0.137	0.196**	-	-	0.020	0.223
	(-1.01)	(-1.95)	(0.92)	(1.80)			(0.12)	(1.55)
DIT*dlog E_t	-0.161	-0.120	-0.038	-0.130*	-0.025	-0.086	0.025	0.022
	(-1.51)	(-0.84)	(-1.54)	(-5.67)	(-0.51)	(-0.75)	(0.61)	(0.26)
DIT*dlog P_{t-1}	-0.234	0.053	-0.473*	-0.198*	-0.143	-0.042	-0.257	-0.322*
	(-1.21)	(0.31)	(-3.05)	(-1.99)	(-0.86)	(-0.29)	(-1.41)	(-2.12)
Constant	0.003*	0.003*	0.002*	0.001*	0.004*	0.005*	0.002*	0.002*
	(3.29)	(2.35)	(5.25)	(2.61)	(6.35)	(3.80)	(6.11)	(3.32)
R^2	0.491	0.754	0.370	0.707	0.126	0.125	0.151	0.290

Notes: 1) The values of t-statistics are reported in parentheses.
2) E_t is the multilateral effective exchange rate, P_t* is the US producer price index, P_{t-1} is a lag of the domestic consumer or producer price index, FLT is a dummy for periods with a floating exchange rate regime, and DIT is a dummy for periods with inflation targeting.
3) The single asterisk (*) and double asterisks (**) denote significance at the 5% and 10% levels, respectively.

Table 3: Exchange-Rate Pass-Through: SUR

	Indonesia		Korea		Philippines		Thailand	
	CPI	PPI	CPI	PPI	CPI	PPI	CPI	PPI
dlog E_t	0.029*	0.264*	0.009	0.067*	-0.003	0.169*	0.090**	0.151
	(2.77)	(19.42)	(0.24)	(2.01)	(-0.13)	(3.08)	(1.64)	(1.29)
dlog P_t^*	0.155	0.460*	0.055	0.214*	0.037	0.373*	0.080*	0.233*
	(1.46)	(3.23)	(1.35)	(5.58)	(0.60)	(2.62)	(2.27)	(2.96)
dlog P_{t-1}	0.550*	0.321*	0.449*	0.313*	0.119	0.045	0.309*	0.106
	(8.55)	(8.34)	(6.65)	(3.92)	(1.49)	(0.42)	(3.96)	(1.12)
FLT*dlog E_t	-0.036	-0.098*	0.066	0.104*	-	-	-0.084	-0.044
	(-1.33)	(-2.71)	(1.82)	(3.06)			(-1.49)	(-0.36)
FLT*dlog P_{t-1}	-0.082	-0.106	0.129	0.191*	-	-	-0.022	0.318*
	(-0.56)	(-1.09)	(0.92)	(1.96)			(-0.14)	(2.43)
DIT*dlog E_t	-0.161	-0.118	-0.035	-0.129*	-0.013	-0.088	0.025	0.025
	(-1.54)	(-0.84)	(-1.46)	(-5.82)	(-0.26)	(-0.79)	(0.63)	(0.30)
DIT*dlog P_{t-1}	-0.267	0.011	-0.457*	-0.193*	0.054	-0.051	-0.274**	-0.348*
	(-1.49)	(0.07)	(-3.17)	(-2.17)	(0.32)	(-0.37)	(-1.64)	(-2.51)
Constant	0.003*	0.003*	-0.002**	0.001*	0.004*	0.005*	0.002*	0.002*
	(3.43)	(2.69)	(6.00)	(2.80)	(6.16)	(3.84)	(6.37)	(3.78)
R^2	0.490	0.746	0.368	0.707	0.042	0.125	0.150	0.286

Notes: 1) The values of t-statistics are reported in parentheses.
2) E_t is the multilateral effective exchange rate, P_t^* is the US producer price index, P_{t-1} is a lag of the domestic consumer or producer price index, FLT is a dummy for periods with a floating exchange rate regime, and DIT is a dummy for periods with inflation targeting.
3) The single asterisk (*) and double asterisks (**) denote significance at the 5% and 10% levels, respectively.

Table 4: Short-Run and Long-Run Exchange-Rate Pass-Through

			Pre-floating Exchange Regime	Floating Regime without Inflation Targeting	Floating Regime with Inflation Targeting
Indonesia	Short-run	CPI	0.030	0.030	0.030
		PPI	0.266	0.167	0.167
	Long-run	CPI	0.072	0.072	0.072
		PPI	0.462	0.213	0.213
Korea	Short-run	CPI	0.008	0.076	0.076
		PPI	0.068	0.171	0.041
	Long-run	CPI	0.016	0.150	0.076
		PPI	0.101	0.356	0.060
Philippines	Short-run	CPI	-	0.010	0.010
		PPI	-	0.167	0.167
	Long-run	CPI	-	0.015	0.015
		PPI	-	0.167	0.167
Thailand	Short-run	CPI	0.089	0.089	0.089
		PPI	0.143	0.143	0.143
	Long-run	CPI	0.124	0.124	0.124
		PPI	0.183	0.183	0.130

Note: Elaboration based on OLS estimations shown in Table 2.

**Table 5: GARCH Estimates: Inflation Targeting, Exchange Rate Regime and
Nominal Effective Exchange Rate Volatility**

Country	FLT	DIT
Indonesia	0.000455*	-0.000444**
GARCH(2,2)	(2.12)	(-1.89)
Korea	0.007596*	-0.007541*
GARCH(1,2)	(3.79)	(-3.77)
Philippines	-	-0.000236*
GARCH(2,1)	-	(-3.90)
Thailand	0.002029*	-0.002004*
GARCH(2,0)	(4.96)	(-4.94)

Notes: 1) The values of z-statistics are reported in parentheses.
2) The asterisks (*,**) indicate significance at the 5% and 10% levels, respectively.
3) DIT is a dummy for periods with inflation targeting, while FLT is a dummy for periods with floating exchange rates.
4) The Philippines embarked on its floating exchange rate regime in 1970.
5) The lags of GARCH models are decided according to the AIC.

Table 6: GARCH Estimates: Inflation Targeting, Exchange Rate Regime and Inflation Volatility

Country	FLT	DIT
Indonesia	0.000086**	0.000005
GARCH(2,2)	(1.92)	(0.05)
Korea	0.000307*	-0.000308*
GARCH(3,1)	(4.91)	(-4.90)
Philippines	-	-0.000130*
GARCH(2,1)	-	(-4.89)
Thailand	0.000063**	-0.000077**
GARCH(2,0)	(1.65)	(-1.95)

Notes: 1) The values of z-statistics are reported in parentheses.
2) The asterisks (*,**) indicate significance at the 5%and 10% levels, respectively.
3) DIT is a dummy for periods with inflation targeting, while FLT is a dummy for periods with floating exchange rates.
4) The Philippines embarked on its floating exchange rate regime in 1970.
5) The lags of GARCH models are decided according to the AIC.