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ITO Takatoshi
RIETI

SASAKI N. Yuri
Meiji Gakuin University

SATO Kiyotaka
Yokohama National University

The Research Institute of Economy, Trade and Industry
http://www.rieti.go.jp/en/

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Takatoshi Ito[1], Yuri N. Sasaki[2] and Kiyotaka Sato[3]

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[1] Graduate School of Economics, the University of Tokyo and Faculty Fellow, RIETI.
[2] Department of Economics, Meiji Gakuin University.
[3] Faculty of Economics, Yokohama National University.

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Abstract

We examine the pass-through effects of exchange rate changes on the domestic prices among the East Asian countries using the conventional pass-through equation and a VAR analysis. First, dynamics of pass-through from the exchange rate to import prices and consumer prices is analyzed using the conventional model of pass-through based on the micro-foundations of the exporter's pricing behavior. Both the short-run and long-run elasticities of the exchange rate pass-through are estimated. Second, a vector autoregression (VAR) technique is applied to the pass-through analysis. A Choleski decomposition is used to identify structural shocks and to examine the pass-through of each shock to domestic price inflation by the impulse response function and variance decomposition analyses. Both the conventional analysis and VAR analysis show that while the degree of exchange rate pass-through to import prices is quite high in the crisis-hit countries, the pass-through to CPI is generally low, with a notable exception of Indonesia. The VAR analysis shows that the size of the pass-through of monetary shocks is even larger in Indonesia. Thus, it was Indonesia's accommodative monetary policy as well as the high degree of the CPI responsiveness to exchange rates that contributed to high domestic price inflation, resulting in the loss of its export competitiveness, even when the currency depreciated sharply in nominal terms in 1997-98.

Keywords: exchange rate pass-through, structural shocks, vector autoregression, East Asia

JEL Classification Codes: F12, F31, F41

1. Introduction

The objective of this paper is to examine pass-through effects of the exchange rate changes on the domestic prices among the East Asian countries. Whether the exchange rate changes have significant impact on the domestic prices immediately has several important implications to thinking of the role of the exchange rate in economic adjustment. If the degree of pass-through is high, the exchange rate changes will change the relative prices of tradables and non-tradables, so that the adjustment in trade balances will be prompt. For example, imported goods become expensive, if pass-through is high, so that imports will decline. Consumers purchase will shift to domestically-produced goods from imported goods. On the other hand, if the degree of pass-through is low, the exchange rate does not have much impact on the trade balance. Therefore, the exchange rate changes may have only a little impact on the macroeconomy.

If domestic prices do not change even when the exchange rate changes, then inflation acceleration (or deceleration) may not result from depreciation (appreciation) of the exchange rate. The degree of pass-through depends on several factors. In the short-run, the degree of pass-through depends on the choice of invoice currency, firms' expectation of the persistence of the change, price stickiness in general (including menu costs), and monopolistic power of products in the retail market. The pass-through also depends on macroeconomic conditions in general, especially output gap, and inflation expectation.

In the context of currency crisis, the degree of pass-through may influence the recovery process from a crisis. Suppose that two countries, say K and I, suffer large currency depreciations, and Country K did not suffer inflation after depreciation, while Country I suffers inflation after the depreciation. Country K has a low degree of

pass-through, Country I has a high degree of pass-through. Country K will enjoy, though temporary, strengthened price competitiveness in their exports, and economic recovery will be achieved relatively quickly. It is most likely that the currency of Country K will appreciate once the economy recovers sharply. The nominal exchange rate will appreciate to the level that is not the pre-crisis level, but a level that is slightly depreciated, and the crisis will be over. Country I will lose competitiveness through inflation, with sustained level of depreciated nominal exchange rate. Within a year or two, the real exchange rate of Country K and Country I will go back to a level that reflect its true competitiveness, but Country K achieves it by nominal appreciation while Country I achieves it by domestic inflation.

From the viewpoint of export competitiveness, the two paths may be equivalent, but from the financial system point of view, the two paths present sharply different result. Country I, with nominal depreciation and domestic inflation, tends to suffer from instability, if not a crisis, of the financial system, while Country K will not suffer from such instability in the medium run. The reason for financial instability in Country I is the deteriorated balance sheet of financial institutions. First, balance sheets of the financial institutions of developing countries tend to have currency mismatch—depreciation hurts the liability side more than asset side. This occurs when banks borrow in dollars from foreign institutions while lends in domestic currency to domestic firms. Second, in a financial crisis, domestic firms tend to fail as domestic consumers curtail spending and banks will find their lending turn nonperforming, as the firms develop financial difficulties and stop payments to banks. Third, they will develop liquidity shortage as depositors flee to foreign institutions (capital flight), when depreciation is fast and financial health of domestic institutions is questioned.

Hence, whether there is quick pass-through or not has significant implication

to the course of economic recovery. From this observation, we may tentatively conclude that it is important that domestic inflation should be kept minimal when the currency depreciates sharply, not a result of domestic inflation, but as a result of international capital flows, or a sudden change of investors' sentiment. This connection between the pass-through effect during the currency crisis and the economic recovery process is an innovative aspect of this paper.

In the literature of the financial crisis, another strand of analyzing the exchange rate and the inflation rate is more popular. If a developing country adopts the nominal exchange rate peg to the US dollar, then the country has to adopt monetary policy that is consistent with the exchange rate regime. The dollar peg requires that the country keeps the interest rate similar to the US interest rate (in order to avoid too much capital inflows or outflows), and keep the inflation rate similar to the US inflation rate (in order to avoid the loss of the export competitiveness). When the country fails to keep the inflation rate moderate (compared to the US), then the country risks its export competitiveness in the medium run. In order to make the exchange rate more flexible to avoid this problem, the exchange rate can be crawling peg, namely the exchange rate depreciate by the rate approximately equal to the inflation differential. Indeed, Mexico and Indonesia attempted this crawling peg, before their respective crisis. In the more flexible exchange rate regime, monetary policy can be independent, and a shock may occur in monetary policy, that causes inflation, and as a result, the exchange rate depreciation. The point is that the managed exchange rate regime during the peace time may produce a causality from the inflation rate to the exchange rate, precisely the opposite of the pass-through literature. This observation should be noted as a caution in the examination of pass-through.

In order to see whether causality runs from the exchange rate to the inflation

rate, or vice versa, the vector autoregression (VAR) analysis may be attempted. Other macroeconomic factors, such as output gap and inflation expectation may be added to the VAR system.

The rest of this paper is organized as follows. Section two describes the brief history of currency movements of the Asian currency crisis. Section 3 presents estimates of pass-through effects in the traditional pass-through equations. A VAR analysis is presented in Section 4. Section 5 concludes.

2. Experiences of the Asian Countries

After the Thai baht was floated in July 2, 1997, some Asian currencies immediately depreciated and others later depreciated. Although it is often characterized as a fast contagion across Asia starting from Thailand, that may not be a fair description as it took several months to bring currencies in the region to the trough in December 1997. The Asian currency crisis was not caused by a single shock to Thailand but multiple shocks to Thailand, Indonesia, and Korea with reinforcing spillover to each other.[4] Reasons for the downfall of the currencies seemed to be different in different countries.

As the reasons for a crisis being different, recoveries from the Asian currency crisis of 1997-98 have varied from one country to another. Especially, the crisis was most painful and the recovery was slowest in Indonesia. It has been well-known that Indonesia suffered most damages in the financial crisis of 1997-98. Indonesian rupiah depreciated to the level of one-sixth in the mid-January 1998, about 16,000 rupiah/dollar. The rupiah recovered somewhat in the spring, but again went to the 15,000 in May 1998 at the height of political crisis, that resulted in the resignation of

[4] See Ito and Hashimoto (2002).

president Suharto. Capital outflows continued and the recovery of nominal exchange rate from that trough was very much delayed.

Asian currencies except the Indonesian rupiah recovered from January to December of 1998, and then they were stabilized at around 30 to 40% depreciation compared to the pre-crisis level. The recovery of the Indonesian rupiah was much slower and never recovered to the level (relative to the pre-crisis level) of other Asian currencies.

*** Insert Figure 1. ***

The inflation rate of Indonesia was very high in 1998 and 1999 and remained higher than most Asian countries most of the time from 2000 to 2003. By 2004, the real exchange rate of Indonesia became similar to that of Thailand, the Philippines, and Malaysia. Namely, from the export competitiveness point of view, the advantage of Indonesia was offset by 2004.

*** Insert Figures 2 and 3. ***

So far, the arguments were the bilateral nominal and real exchange rate vis-à-vis the US dollar. However, export competitiveness is most accurately measured in the real effective exchange rate (the multilateral version of the real exchange rate). The weight of trading partners can be roughly equal to the trade weights.[5] The pass-through should be defined as the exchange rate changes of trading

[5] To be precise, price elasticities should be taken into account. See Ito, Ogawa, and Sasaki (1998).

partners and the impact should be measured as the weighted average of those exchange rates.

3. Estimation of Pass-Through Elasticities

As discussed in the previous section, after the currency crisis in 1997 and 1998, the crisis-hit countries showed different pattern of exchange rate movements in both nominal and real terms. As shown earlier, the bilateral nominal exchange rate of rupiah vis-à-vis the US dollar depreciated dramatically in 1998 and remained at the level where the degree of devaluation is far greater than that of other countries (Figure 1). In contrast, the real exchange rate of rupiah vis-à-vis the US dollar first depreciated sharply immediate after the crisis, but showed a reversal toward the pre-crisis level from around 1999 (Figure 2). Thus, the real exchange rate of rupiah moved back toward the pre-crisis level and, hence, the degree of devaluation in real terms turned out to be not very different from that of other countries by 2004.

Figure 3 compares domestic price levels of Asian countries. It shows that the inflation of Indonesia moved the price level of Indonesia far above any other price levels in Asia. The natural question is why such an increase in domestic price inflation followed a sharp depreciation of rupiah in Indonesia. To tackle this question, we employ an analytical framework of exchange rate pass-through to domestic prices, and compare the experiences of the Indonesia with others. In particular, we ask a question to what extent a change in the exchange rate induces the change in the export and/or import prices. In this section, we estimate pass-through elasticities of import prices and consumer prices in Asian countries by the ordinary method in order to compare the result of the pass-through elasticities in this paper with that in the pervious papers' analysis.

3.1. Overview of Previous Studies on Pass-Through

After the Plaza Accord of 1985, the yen appreciated dramatically against the US dollar, but the current account balances of the US and Japan did not change as expected, at least for the first year and half. The reasons for the slow response of trades to the exchange rate changes have been examined in many studies. Marston (1990), Knetter (1993), Goldberg and Knetter (1997), for example, have presented considerable empirical evidences of the pricing-to-market (PTM) behavior of Japanese exporters.

Feenstra and Kendall (1997) found that a significant portion of observed deviations in the law of one price are attributable to incomplete exchange rate pass-through that resulted from the PTM behavior. In the literature of new open macroeconomics, Obstfeld and Rogoff (1995) that have developed a sticky price model with dynamic maximization is a benchmark. Betts and Devereux (1996) extended the model of Obstfeld and Rogoff (1995) to allow for incomplete pass-through of exchange rates. They showed that the combination of PTM and sticky local-currency nominal prices amplifies the effect of money shocks on exchange rates.

Devereux and Engel (1998) directly examine how price-setting behavior affects choice of the optimal exchange rate regime. They show that when prices are set in consumers' currency, adopting floating exchange rate system would be better because the floating exchange rate insulates domestic consumption from foreign monetary shocks. Under floating exchange rates, the prices paid by home residents for imported goods are not affected by exchange rate fluctuations if producers set the price in the consumers' currency. When prices are set in the producers' currency, fixed exchange rate regime is better than the floating exchange rate system if the negative

effect of uncertainty of floating exchange rates on domestic consumption dominates the insulation effect of the float exchange regime. This reveals that when prices are set in the producers' currency, there is a tradeoff between floating and fixed exchange rates. Exchange rate adjustment under floating exchange rates yields a lower variance of consumption, but exchange rate volatility itself leads to a lower average level of consumption.

These local-currency pricing models assume that stickiness of local currency price is the reason why consumer prices do not respond much to exchange rates. But there are other possible interpretations of incomplete pass-through. For example, the optimal pricing behavior of exporters, taking into account competition with local producers, can be modeled as a basis for incomplete pass-through.

Campa and Goldberg (2004) provide empirical evidences on the exchange rate pass through into the import prices of twenty three OECD countries. Using quarterly data from 1975 through 2003, they estimate pass-through elasticities. They find that countries with less exchange rate and inflation variability are likely to have lower rates of pass-through of exchange rates into import prices. They also find that there has been a weak tendency of declining pass-through ratio of the exchange rate changes. The empirical analyses in this paper are similar to Campa and Goldberg (2004) but we focus on the Asian countries.[6]

3.2. Theoretical Model and Method of Estimation

A model of pass-through has been developed with micro foundation of optimal pricing behavior of exporters, to derive the dynamics of exchange rate

[6] While the existing studies have focused on developed countries' exchange rate pass-through, there are recent exceptions that analyze the exchange rate pass-through in Asian countries, such as Toh and Ho (2001), Parsons and Sato (2004) and Sasaki (2005).

pass-through to import prices[7]. The profit function of a monopolistic firm is assumed to be as follows.

$$\pi_t = S_t P^E{}_t f(P^E{}_t / P_t, Z_t) - C\{f(P^E{}_t / P_t, Z_t), P^W{}_t\} \qquad (1)$$

where

S_t : exchange rate (denominated in domestic currency),

$P^E{}_t$: export price in foreign currency terms,

$f(\cdot)$: demand functions in the foreign markets,

$C\{\cdot\}$: cost function,

Z_t : real income in the foreign countries,

$P^W{}_t$: wage in the domestic country.

The first-order conditions are written as,

$$S_t P^E{}_t = MC\{ f(P^E{}_t / P_t, Z_t), P^W{}_t \} N(P^E{}_t, Z_t) \qquad (2)$$

where

$MC\{\cdot\}$: marginal cost,

$N(\cdot)$: the markup of the foreign price over marginal cost.

Using lower case letter to reflect logarithms, (2) can be rewritten as follows.

$$p^E{}_t = a\ 1/s_t \ + \ b\ p_t \ + \ c\ p^W{}_t \ + \ d\ z_t \ + e_t \qquad (3)$$

In order to investigate how exchange rates changes affect export price levels, we

[7] This model is based on Sasaki (2002).

estimate the following equation.

$$\Delta p^{E}_{t} = \alpha \Delta\, 1/s_t \;+\; \beta \Delta\, p_t \;+\; \gamma \Delta\, p^{W}_{t} + \delta \;\Delta\, z_t \;+ \varepsilon\, e_t \qquad (4)$$

α in Equation (4), is pass-through elasticity. Recent papers on explaining exchange rate pass-through based on new open macro model show that when exporters set the price in their own currency, α will become 1. This case is called producer currency pricing. When exporters set the price in destination currency, α will become 0. This case is called local currency pricing. While, some previous studies which explain cross-sectional differences on exchange rate pass-through show that α depends on the structure of competition in the industry[8].

3.3. Exchange Rate Pass-Through

The variables to estimate equation (4) are specified as follows: p^{E}_{t} are local currency import prices, s_t is the exchange rate, z_t is real GDP. Instead of including Pt independently, the real exchange rate is used. The effects of the exchange rate changes on general import prices are examined as price-setting behavior of exporters in various trading partners. For the exchange rate, we use the effective exchange rate. p^{W}_{t} is exporter's production cost in the model. We omit this variable in estimation because such data are not available. For more detailed explanation on the data, see Appendix 1.

We add four lagged exchange rates to allow for gradual adjustment of import prices to changes in the exchange rates. The long run elasticity can be captured as a sum of four coefficients on the contemporaneous and lagged exchange rates. The ordinary least squares is used for estimation.

[8] Marston (1990), Knetter (1993), among others.

Since the exchange rate is expressed in local currency base, the elasticity is expected take a value between 0 and –1. The case of producer currency price is implied by the pass-through elasticity of –1, while the consumer currency pricing is implied by the elasticity of 0. In the latter case, the imported prices do not change when the exchange rate changes.

*** Insert Table 1 ***

The estimation results of short-run and long-run elasticities are reported in Table 1.[9] Short-run elasticities are estimated as negative and significant in 5 countries out of 7 countries: Hong Kong, Indonesia, Japan, Korea, and Thailand. These countries experienced, more or less, the producer currency pricing. Those countries, except Japan and Hong Kong, experienced severe currency crises in 1997. The large depreciation might soon raise their import prices. The short-run elasticity estimate of Singapore is puzzling, since the elasticity is estimated to be positive and significant, suggesting that exporters adjust prices of Singapore market in the direction of aggravating the exchange rate changes: if the Singaporean dollar depreciated, then export prices are raised so that the local prices would increase more than the exchange rate changes. This cannot be explained by a regular optimizing behavior of monopolistic firms.

The long-run elasticities are negative and significant in 4 out of 7 countries: Hong Kong, Indonesia, Japan, and Thailand. We interpret these elasticities as evidence of exporters to these countries adopting consumer pricing. Long-run elasticities are larger than short-run elasticities, that is, pass-through becomes larger as time passes (if

[9] The detailed results are reported in Appendix Table 1.

one-time exchange rate change was sustained). Exporters to Thailand may be over-doing the pricing, namely Thai imported prices become cheaper, instead of more expensive, than before if the currency depreciated—this is another puzzling result.

For Korea, short-run elasticity is close to –1 and significant, but the long-run elasticity is not significantly different from zero, suggesting that exporters to Korea adjust the consumer price according to the exchange rate (high pass-through), but export prices are adjusted in the long run so that Korean imported prices are not affected by the exchange rate changes in the long-run.

Both the short-run and long-run elasticities are statistically indistinguishable from zero for Taiwan, suggesting that Taiwan experienced consumer currency pricing both in the short run and the long run.

3.4. Pass-Through of Exchange Rates on CPI

In the last subsection, the responses of imported prices to the exchange rate changes were examined. In this section, we investigate how consumer price index (CPI) was affected by the exchange rate changes, namely the pass-through to CPI. Even when the imported prices are affected by the exchange rate changes (producer-currency pricing), the CPI may not be affected, if the losses or profits are absorbed in the distribution channels. If wholesalers and retailers are pricing according to maximize their profits, given the cost of imports, and if consumers price elasticiteis are very high, then wholesalers and retailers behave so that retail prices may not change much, when the costs of imports change.

Of course, influences of the exchange rate on CPI are much indirect and remote than those on the imported prices. First, CPI includes components of domestic value added in addition to imported inputs and final goods. The share of imports on

CPI is one important factor in evaluating the pass-through effects of exchange rate changes on CPI. Second, retails goods and services face more competitions and substitutable goods and services than imported goods. Third, CPI may fluctuate according to the macroeconomic business cycles. Fourth, whether CPI has high or low pass-through depends on the monetary policy regime. If monetary policy is accommodative, namely higher prices, due to imported prices as well as wage increases, the CPI pass-through may become higher. If monetary policy is conducted with strict inflation targeting, it may contain the CPI pass-through to be minimal.

*** Insert Table 2 around here. ***

Table 2 shows the short-run and long-run pass-through elasticities using CPI.[10] As before, full pass-through is implied by the coefficient of –1 and no pass-through is implied by the coefficient of 0.

The short-run elasticities are negative and significant in 3 countries out of 8 countries, and long-run elasticities are negative and significant in 4 countries. All of the short-run elasticity of the three countries, Indonesia, Korea and Singapore are about -0.1. The magnitude is much smaller than the case of import prices, as expected. For these countries, the exchange rate significantly affects the CPI. The results can be interpreted as evidence that import contents of the CPI may be higher in these countries, the retailers pass on the import cost increases to consumers more easily than other countries.

The long-run elasticities differ among the countries, the lowest is -0.57 of Indonesia; -0.13 of Korea, -0.15 of Philippines and -0.26 of Thailand. The

[10] The detailed results are reported in Appendix Table 2.

pass-through is expected to become larger as the exchange rate change persists. The magnitude of long-run elasticity is larger than that of short-run elasticity, as expected. The magnitude of the Indonesian CPI pass-through is much larger than other countries, and this is consistent with the general observation of high inflation following large depreciation in that country in 1998-2000, as shown in Section 2. It also suggests that the pass-through effects may be non-linear. If the exchange rate changes are small and gradual, exporters (or distributors in case of CPI) may be able to absorb the exchange rate changes by productivity increases or other ways. However, the exchange rate changes are large, the export prices are not changed (so that import prices have full pass-through). The menu cost argument, in terms of imported prices, may be applied to behaviors of the exporters (distributors).

As will be shown in Section 4, the result in this subsection is consistent with that of VAR analysis.

4. The VAR Analysis of Pass-Through of Exchange Rate and Macroeconomic Shocks

Recent studies, such as McCarthy (2000), Hahn (2003) and Faruqee (2004), use a VAR approach for an analysis of pass-through of several types of shocks to domestic inflation. More specifically, these studies take up six through eight endogenous variables in their VAR model and attempt to identify structural shocks by applying the Choleski decomposition. Then, they investigate the extent of the pass-through of each type of shocks on domestic price inflation by the impulse response function and variance decomposition analyses. Their empirical framework allows us to determine which type of shocks affects most domestic inflation in East Asian countries, especially the crisis-hit countries, from the mid-1990s to the present.

4.1. Analytical Framework

We set up a VAR model with the vector of five endogenous variables, $x_t = (\Delta oil_t, \Delta m_t, \Delta efexr_t, gap_t, \Delta p_t)'$, where oil_t denotes the natural log of oil prices, m_t that of money supply, $efexr_t$ that of nominal effective exchange rate, and p_t that of domestic prices. Δ represents the first difference operator. gap_t denotes the output gap that is constructed by taking the deviations of log of real outputs from a linear and quadratic trend.[11] As will be discussed below, we take the first-difference of all variables except for gap_t to ensure the stationarity of variables.

The endogenous variables in the VAR are selected on the basis of the following considerations. First, as a price variable, the consumer price index (CPI) is used to measure the domestic price inflation. Previous studies, such as McCarthy (2000) and Hahn (2003), attempt to incorporate three types of price variables (i.e., import prices, producer prices and consumer prices) in the VAR model to analyze the effects of shocks on prices at different stages of distribution, i.e., how external shocks are transmitted from one price stage to the next. Owing to the short sample period, however, we cannot include all three price variables in the VAR. Instead, we incorporate only one price variable, which results in a five-variable VAR model in contrast to the seven- or eight-variable VAR proposed by Hahn (2003) and McCarthy (2000). But, to investigate the difference in response to shocks between three price variables, we also attempt to include the producer price index (PPI) or the import price index in the VAR model instead of CPI and compare the results between them.

[11] We follow McCarthy (2000) to estimate the output gap. The industrial production index is employed to generate the output gap because we use the monthly series for an empirical analysis. Hence, the output gap is calculated as the residuals from a regression of the log of industrial production index on a constant plus linear and quadratic time trends.

Second, the nominal effective exchange rate is used in our VAR, although many studies have used the bilateral exchange rate vis-à-vis the US dollar. First, the effective exchange rate is the right concept to use when the total effect of the exchange rate changes is attempted to measure in a country with diversified trading partners. Second, most East Asian countries had (and, have, for some) adopted a *de facto* US dollar peg at least up to the currency crisis of 1997, the bilateral rate vis-à-vis the US dollar is an inappropriate variable to use for this study.

Third, money supply is used to allow for the effects of monetary policy on inflation. Whereas the call rate is typically used in the literature such as Clark (1999) and Hahn (2003), the rate shows the substantial fluctuation in the crisis-hit countries and, hence, the money supply growth rate appears more appropriate for the countries than the call rate.[12] Thus, we include not the call rate but the money supply growth rate in the VAR model.

Fourth, we attempt to allow for supply and demand shocks in our VAR estimation. Supply shocks are identified by the oil price inflation denominated not in the local currency but in US dollars. Although McCarthy (2000) and Hahn (2003) converted the US dollar-denominated oil prices into the local currency ones for their VAR estimation to identify supply shocks, the fluctuations of local currency oil prices for East Asian countries from the mid-1990s largely reflect not the oil price fluctuations per se but the variability of bilateral exchange rate vis-à-vis the US dollar. Hence, we chose the US dollar denominated oil prices for our analysis. To capture the demand side effect, the output gap variable is included for identification of demand shocks. In this paper, the industrial production index is employed as a proxy for real

[12] McCarthy (2000) includes both the call rate and the growth rate of the broad monetary aggregate in a VAR model.

outputs as we use the monthly series of variables.

The goal of this paper is to explore to what extent the exchange rate and other types of shocks affect domestic price inflation. To recover these structural shocks, we use a Choleski decomposition of the matrix Ω, a variance-covariance matrix of the reduced-form VAR residuals (u_t), to generate structural disturbances (ε_t). The relationship between the reduced-form VAR residuals and the structural disturbances can be written as follows:[13]

$$\begin{pmatrix} u_t^{oil} \\ u_t^{m} \\ u_t^{efexr} \\ u_t^{gap} \\ u_t^{p} \end{pmatrix} = \begin{pmatrix} S_{11} & 0 & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 & 0 \\ S_{31} & S_{32} & S_{33} & 0 & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} & 0 \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} \end{pmatrix} \begin{pmatrix} \varepsilon_t^{oil} \\ \varepsilon_t^{m} \\ \varepsilon_t^{efexr} \\ \varepsilon_t^{gap} \\ \varepsilon_t^{p} \end{pmatrix}. \qquad (5)$$

The structural model is identified because the $n(n-1)/2$ restrictions are imposed on the matrix *S* as zero restrictions where *n* denotes the number of endogenous variables. The resulting lower-triangular matrix *S* implies that some structural shocks have no contemporaneous effect on some endogenous variables given the ordering of endogenous variables.

Determining the reasonable order of the endogenous variables is particularly important to identify structural shocks. The change in oil prices is ordered first because

[13] A unique lower-triangular matrix *S* can be derived given the positive definite symmetric matrix Ω. That is, the Choleski decomposition of Ω implies $\Omega = PP'$ where the Choleski factor, *P*, is a lower-triangular matrix. Since $\Omega = E(u_t u_t') = SE(\varepsilon_t \varepsilon_t')S' = SS'$ where structural disturbances are assumed to be orthonormal, i.e., $E(\varepsilon_t \varepsilon_t') = I$, the lower-triangular matrix *S* is equal to the Choleski factor *P*.

the reduced-form residuals of oil prices are unlikely affected contemporaneously by any other shocks except oil price shocks per se, while oil price shocks likely affect all variables in the system contemporaneously. Following Hahn (2003), the money supply, a representative of monetary policy, is ordered next because it seems more reasonable to assume that monetary shocks have a contemporaneous effect on the exchange rate than vice versa. In contrast, several studies such as McCarthy (2000) order the money supply last in their VAR model. Hence, the different ordering is also attempted to check the robustness and the result is reported in Appendix 3. We also assume the lagged availability of information on the real output gap, which results in no contemporaneous effect of demand (output gap) shocks on monetary policy. Furthermore, monetary policy does not react contemporaneously to price shocks, while monetary policy shocks affect the domestic price inflation contemporaneously.[14] Next, the nominal effective exchange rate is ordered prior to the output gap, which implies that the nominal effective exchange rate responds contemporaneously to oil price shocks and money supply shocks, not to demand (output gap) shocks. The exchange rate is also assumed not to respond to realized inflation. Finally, the price variable is ordered next to the output gap by assuming that the price variable is contemporaneously affected by the four shocks.

4.2. Data

The data for five East Asian countries, i.e., Indonesia, Korea, Thailand, Malaysia and Singapore, are used in this study. Taiwan, the Philippines and China are not studied because of the problem in data availability. The data are monthly from

[14] Hahn (2003) assumes that monetary policy reacts not to realized inflation but to expected inflation. The different ordering of the endogenous variables is investigated in Appendix 3.

1995M1 to 2004M8. All price series and the industrial production index (2000=100) are seasonally adjusted. As an exchange rate variable, we use the nominal effective exchange rate index (2000=100) that indicates that an increase in index means depreciation. As the money supply variable, the seasonally adjusted M2 monetary aggregate is used. The output gap is derived as the residuals from a regression of the natural log of the industrial production index on a constant plus linear and quadratic time trends.[15] The data sources are IMF, *International Financial Statistics*, online version, the CEIC Asia Database and the Datastream. The details are described in Appendix 2.

*** Insert Table 3 around here. ***

The time series properties of variables are tested by the Phillips-Perron (PP) test. The result is reported in Table 3 that shows that the oil price, three types of domestic prices, the money supply and the nominal effective exchange rate appear to be non-stationary in level but stationary in first-differences for all countries. We apply the Kwiatowski, et al. (KPSS) test as well as the PP test to the output gap variable, but it is less clear whether the output gap is an I(0) or I(1) process. Bearing in mind the well-known problems associated with unit root tests, we assume that the output gap variable is stationary in level. Thus, the five endogenous variables in the VAR model are assumed to be stationary and we proceed to the VAR estimation. The lag order of the VAR model is selected based on the likelihood Ratio (LR) test.

[15] The regression is performed with the sample of 1980M1-2004M8 for Korea and Malaysia. Owing to the data availability, the sample starts from 1993M1 for Indonesia, from 1989M1 for Singapore, and from 1987M1 for Thailand.

4.3. Empirical Results

This sub-section reports the result of the impulse response function analysis to reveal the degree of pass-through of each shock to domestic price inflation. The result of variance decompositions is also presented to investigate the relative importance of respective shocks for fluctuations in domestic prices.

4.3a. Impulse Response Function Analysis

We first estimate the VAR model including CPI as a price variable and perform the impulse response function analysis. The accumulated impulse responses are presented over a twenty-four months time horizon for five East Asian countries. All shocks are standardized to one-percent shocks and, hence, the vertical axis in Figures reports the approximate percentage change in domestic prices in response to a one percent shock.

*** Insert Figure 4 around here. ***

As for a response of CPI to exchange rate shocks, Indonesia shows a very different pattern of the CPI response from other countries (Figure 4). In Indonesia, a one percent depreciation (increase) in nominal effective exchange rates amounts to the one percent increase in CPI after four months and then to about four percent after one year. The Korea's CPI response to exchange rate shocks accumulates to 0.5 percent in four months, but starts to decline after then. Thailand, Malaysia and Singapore exhibit far smaller, and even negative, response of CPI to exchange rate shocks.

As regards a response of CPI to monetary shocks, Indonesia again shows the large response, accumulating to more than two percent after seven months. In contrast,

the CPI response to monetary shocks is much smaller in other countries. Regarding a CPI response to other types of shocks (oil price shocks and demand shocks), the Indonesia's response is far larger than others.

Overall, the response of CPI to various shocks is greater in Indonesia than in other countries, implying a high degree of the pass-through of various shocks, especially the exchange rate and monetary shocks, on CPI in Indonesia. The response of CPI is much faster to exchange rate and monetary shocks in Indonesia than to demand and oil price shocks.

*** Insert Figure 5 around here. ***

Turning to the response of PPI, Figure 5 shows that the response of PPI to nominal effective exchange rate shocks is quite different from that of CPI. In Indonesia, the initial response of PPI to exchange rate shocks is higher and reaches the peak of the accumulated response (about four percent) much faster than that of CPI. Thailand and Malaysia show the larger response of PPI to exchange rate shocks, amounting to about one percent increase after three months. In contrast, the PPI response of Korea and Singapore is not very different from the case of the CPI response. Again, the PPI response to other shocks is larger and faster in Indonesia than in other countries.

*** Insert Figure 6 around here. ***

Figure 6 reports the response of import prices to various shocks in four

countries,[16] which indicates that import prices are generally far responsive to various shocks than the case of CPI and PPI. The initial response of import prices to exchange rate shocks is between one to two percent in Korea and Thailand and about four percent in Indonesia. The response of import prices to other shocks, especially oil price shocks, is much larger in the crisis-hit countries than that of PPI and CPI.

The above results conform to the findings of the previous studies that show that the size of the exchange rate pass-through for developed countries decreases across the different price stages, i.e., the pass-through of exchange rate shocks is the largest on import prices, the second on PPI, and the smallest on CPI.[17] In addition, our result reveals that the response of exchange rate shocks is far greater in Indonesia, implying a high degree of exchange rate pass-through. Moreover, the response of CPI to monetary shocks is quite large in Indonesia, which contrasts markedly with other East Asian countries.

4.3b. Variance Decomposition Analysis

For a further analysis of the effect of various shocks on domestic prices, we conduct the variance decomposition analysis as well, which provides the information on the percentage contribution of various shocks to the variance of the *k*-step ahead forecast errors of respective variables. Figure 7 reports the result of variance decomposition of CPI, PPI and import prices over a forecast horizon of twenty-four months in order to check the relative importance of each shock in explaining the variation of the above three prices.[18]

[16] Due to the data availability problem, the result for Malaysia is not reported in Figure 6.
[17] See McCarthy (2000) and Hahn (2003).
[18] The contribution of own price shocks is not reported in Figure 7 for the sake of clearness.

*** Insert Figure 7 around here. ***

As for the variance of CPI, exchange rate shocks are an important determinant in Indonesia and Korea, where about 40 percent of variation are accounted for by the exchange rate shocks. Interestingly, monetary shocks are the most important determinant for the first ten months in Indonesia, implying that the initial response of CPI is largely affected by the monetary policy in Indonesia. In Thailand, Malaysia and Singapore, exchange rate and other three shocks, respectively, account for less than twenty percent in variance of CPI,[19] which indicates that the own price (CPI) shocks are the most important in explaining its variation.

Regarding the variance of PPI, exchange rate shocks appear to be more important determinant and account for twenty percent or more in the four crisis-hit countries. Again, monetary shocks are the most important determinant in Indonesia, and the PPI variation in Singapore is largely explained by oil price shocks. In the case of import prices, the result is quite similar to the case of PPI, where exchange rate shocks are far more important in Korea but less important in Indonesia and Thailand than the case of PPI.

4.3c. Discussion

It is revealed that the degree of the exchange rate pass-through is different between CPI, PPI and import prices in East Asian countries. It is shown that import prices are the most responsive to exchange rate shocks, PPI is the second and CPI is the least responsive, which conforms to the previous studies such as McCarthy (2000)

[19] The exception is Singapore where oil price shocks account for more than twenty percent in explaining the CPI variation.

and Hahn (2003) that investigate the pass-through effects for developed countries. The result makes sense as the downstream prices contain less trade-related goods and services. In addition, the high response of import prices to exchange rate shocks is consistent with that of the conventional analysis of exchange rate pass-through discussed in Section 3.

It must be noted that Indonesia shows a high degree of pass-through of exchange rate shocks to CPI, which contrasts markedly with other countries. Such a large response of CPI in Indonesia has important implications for an appropriate exchange rate policy of Indonesia. We must note, however, that the size of the pass-through of monetary shocks is also large in Indonesia, and the initial response to monetary shocks is much larger than that to the exchange rate shocks. McLeod (2003) argues that Indonesia's inflation after the crisis is primarily caused by the money growth that reflects the Bank Indonesia's monetary policy. Indeed, the result of variance decompositions also indicates that monetary shocks have the largest impact on the variance of CPI in Indonesia for the first ten months and, hence, it seems plausible to state that the money growth by the Bank Indonesia mainly caused domestic inflation in Indonesia. However, the result of variance decompositions also reports the gradual increase in the percentage share of exchange rate shocks in the CPI variation in Indonesia, which may reflect that the Indonesia's CPI is affected by the second-round effects of the exchange rate depreciation from import prices through CPI. Hence, a further investigation will be called for regarding the transmission of exchange rate effects across different price stages.[20]

[20] de Brouwer (2003) argues that the McLeod's (2003) monetarist explanation that inflation was caused by excessive base money growth is not consistent with the evidence that traded good prices rose before non-traded goods prices in Indonesia during the crisis period and a rise in prices is much larger in the former prices than in the latter ones.

5. Concluding Remarks

In this paper, we have investigated the pass-through effects from the exchange rate changes to imported prices, producer (wholesale) prices, and consumer prices for East Asian countries. The study is motivated by the varying performances of inflation after currency crisis of 1997-98. Both a conventional pass-through equation and a VAR framework are used to characterize the price behavior in response to the exchange rate changes. Several new findings have been obtained. First, crisis countries, like Indonesia, Korea, and Thailand experienced large pass-through from the exchange rate to the domestic prices. Second, pass-though effects of Indonesia are large, both short-run and long-run, measured in both the conventional form and a VAR form. Third, for Indonesia, the VAR analysis reveals that not only the pass-through but also the monetary policy contributed to large increase in CPI in the aftermath of the currency crisis of 1997-98.

The pass-through examination, especially a VAR analysis, provides an important insight into a crisis propagation mechanism in emerging market economies. When depreciation results in domestic inflation, that makes the resolution of a crisis much harder. The estimated coefficients show that one of the reasons for the Indonesian crisis was high pass through of exchange rate to CPI and large monetary policy impact to CPI. Domestic inflation of Indonesia had eliminated price competitiveness, relative to neighboring countries, due to a large depreciation by 2004.

Several tasks are left for future research. Refinement of a VAR analysis is desirable. More structural investigations for demand and supply factors to CPI are needed to differentiate the role of the exchange rate and other factors in the inflation process. Second, the sample can be expanded to other countries, if some data are obtained.

Appendix 1: Data Description for Section 3

Import price: We use unit value of import if available and otherwise use import price index. We could get unit value of import data of Hong Kong, Japan, Korea and Thailand, and we could get only import price index for the other countries, Indonesia, Singapore and Taiwan. We quote the Indonesia data from Economic Indicators (Indikator Economi) published by BPS statistics Indonesia, and Taiwan data from web page by National Statistics, Republic of Chine. The other data are from International Financial Statistics, IMF.

Exchange rates: We use real effective rates for all the countries but Hong Kong. For Hong Kong we use nominal effective rate. Real effective rates offered by JP Morgan are used for Korea Indonesia Thailand. The other data are from International Financial Statistics, IMF.

Real GDP: All the data are from International Financial Statistics, IMF.

Appendix 2: Data Description for Section 4

A. Common Variable

Oil price: The US dollar-basis oil price index (2000=100, monthly series) is taken from IMF, *International Financial Statistics (IFS)*, online version.

B. Country-Specific Variables

B1. Indonesia

Money supply: The monthly series of money supply, M2, is used from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

Nominal effective exchange rate: The monthly series of the nominal effective exchange rate index (2000=100) is constructed by the weighted average of forty-five trading partner countries. The bilateral exchange rate and the trade share are, respectively, obtained from IFS and IMF, *Direction of Trade Statistics*, CD-ROM.

Industrial production index: The monthly series of the manufacturing industrial production index (2000=100) is taken from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

CPI: The monthly series of CPI (2000=100) is taken from IFS. Seasonality is adjusted using the Census X12 program.

PPI: The monthly series of wholesale price index (including petroleum; 2000=100) is taken from IFS. Seasonality is adjusted using the Census X12 program.

Import prices: The monthly series of the import unit value index (2000=100) is constructed by dividing the total import value by the total import volume. The US dollar based total import values are converted into local currency values by suing an index of bilateral nominal exchange rate of rupiah vis-à-vis the US dollar (2000=1.00). The data for the total import value and volume are obtained from the CEIC Asia

Database. Seasonality is adjusted using the Census X12 program.

B2. Korea

Money supply: The monthly series of money supply, M2, is used from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

Nominal effective exchange rate: The monthly series of the nominal effective exchange rate index (2000=100) is obtained from the Datastream.

Industrial production index: The monthly series of the industrial production index (2000=100) is taken from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

CPI: The monthly series of CPI (2000=100) is taken from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

PPI: The monthly series of producer price index (including all commodities and services; 2000=100) is taken from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

Import prices: The monthly series of the import price index (the Korean won basis; 2000=100) is obtained from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

B3. Malaysia

Money supply: The monthly series of money supply, M2, is used from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program

Nominal effective exchange rate: The monthly series of the nominal effective exchange rate index (2000=100) is obtained from IFS.

Industrial production index: The monthly series of the industrial production

index (2000=100) is taken from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

CPI: The monthly series of CPI (2000=100) is taken from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

PPI: The monthly series of producer price index (for goods in the domestic economy; 2000=100) is taken from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

B4. Singapore

Money supply: The monthly series of money supply, M2, is used from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

Nominal effective exchange rate: The monthly series of the nominal effective exchange rate index (2000=100) is obtained from IFS.

Industrial production index: The monthly series of the industrial production index (2000=100) is taken from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

CPI: The monthly series of CPI (2000=100) is taken from IFS. Seasonality is adjusted using the Census X12 program.

PPI: The monthly series of wholesale price index (2000=100) is taken from IFS. Seasonality is adjusted using the Census X12 program.

Import prices: The monthly series of the import price index (2000=100) is obtained from IFS. Seasonality is adjusted using the Census X12 program.

B5. Thailand

Money supply: The monthly series of money supply, M2, is used from the

CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

Nominal effective exchange rate: The monthly series of the nominal effective exchange rate index (2000=100) is obtained from the CEIC Asia Database.

Industrial production index: The monthly series of the manufacturing production index (2000=100) is taken from the CEIC Asia Database. Seasonality is adjusted using the Census X12 program.

CPI: The monthly series of CPI (2000=100) is taken from IFS. Seasonality is adjusted using the Census X12 program.

PPI: The monthly series of producer price index (2000=100) is taken from IFS. Seasonality is adjusted using the Census X12 program.

Import prices: The monthly series of the import value index (the Thai Baht basis; 2000=100) is obtained from the CEIC Asia Database. The data is available from January 1996. Seasonality is adjusted using the Census X12 program.

Appendix 3. Robustness Across VAR Reorderings

We have analyzed the degree of pass-through of exchange rate and other types of shocks by the 5-variable VAR model with $x_t = (\Delta oil_t, \Delta m_t, \Delta efexr_t, gap_t, \Delta p_t)'$. However, the different ordering of variables in a VAR model is applied in the previous studies and, hence, the robustness of the above empirical results needs to be checked by performing a VAR estimation and a Choleski decomposition with alternative plausible orderings of the endogenous variables.

We propose the three different and plausible orderings of endogenous variables by modifying the baseline model, $x_t = (\Delta oil_t, \Delta m_t, \Delta efexr_t, gap_t, \Delta p_t)'$. First, the nominal effective exchange rate may be ordered prior to the money supply variable by assuming that exchange rate shocks at monthly frequency are driven by exogenous asset market disturbances and, hence, domestic monetary disturbances are unlikely to affect the nominal effective exchange rate contemporaneously. Thus, the first alternative model is just to change the order of the nominal effective exchange rate and the money supply, i.e., $x_t = (\Delta oil_t, \Delta efexr_t, \Delta m_t, gap_t, \Delta p_t)'$. Second, the output gap can be ordered prior to the nominal effective exchange rate but next to the money supply variable. This ordering corresponds to that of Hahn (2003) and implies that exchange rate shocks respond contemporaneously to demand shocks but also that demand shocks is not affected contemporaneously by exchange rate shocks. Accordingly, the second alternative model is $x_t = (\Delta oil_t, \Delta m_t, gap_t, \Delta efexr_t, \Delta p_t)'$. Finally, Clark (1999) and McCarthy (2000) order the money supply variable last so that the central bank reacts contemporaneously to all shocks, while the monetary policy has no contemporaneous impact on other endogenous variables. In addition, the output gap is ordered prior to the nominal effective exchange rate so that exchange rate fluctuations are contemporaneously affected by supply and demand shocks. Hence, the

third alternative model is $x_t = (\Delta oil_t, gap_t, \Delta efexr_t, \Delta p_t, \Delta m_t)'$, which conforms to the McCarthy (2000) model.

We report the result of responses of CPI to exchange rate shocks only under the different order of endogenous variables in the VAR. Appendix Figure 1 shows that the impulse responses are very similar across the different orderings in all countries except Indonesia. In Indonesia, the response for the first ten months is larger if exchange rate variable is ordered prior to the money supply variable. However, the size and the speed of response in Indonesia are not very different across alternative orderings.

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Table 1. The Pass-Through elasticities of Exchange Rates on Import Prices

	Short-run	T stat. Null = 0	T stat. Null = -1	Long-run	T stat. Null = 0	T stat. Null = -1	Degrees of Freedom	Specification of import prices	Sample Periods
Hong Kong	-0.23*+	-6.31	21.00	-0.49*+	-8.61	-8.92	65	UV	From 1986:Q1 to 2004:Q2
Indonesia	-0.53*+	-11.18	9.87	-1.04*	-10.69	0.41	39	MP	From 1990:Q1 to 2002:Q3
Japan	-0.84*	-9.76	1.92	-0.99*	-6.75	-0.1	83	UV	From 1980:1 to 2004:2
Korea	-1.05*	-10.81	-0.49	-0.17+	-0.74	-3.59	46	UV	From 1990:1 to 2004:2
Singapore	0.59*+	2.80	7.53	-0.01+	-0.03	-3.68	69	MP	From 1984:Q3 to 2001:Q1, From 2001:Q4 to 2004:Q2
Thailand	-1.27*+	-9.88	-2.08	-1.66*+	-6.03	2.4	38	UV	From 1993:1 to 2004:2
Taiwan	0.09+	0.35	4.35	0.3+	0.63	-2.72	46	MP	From 1990:1 to 2004:2

Notes: * denotes that elasticity is significantly different from zero at a 1 percent level.

+ denotes that elasticity is significantly different from -1 at a 1 percent level.

UV denotes unit value of import. MP is import price index.

Table 2. The Pass-Through of Exchange Rates on CPI

	Short-run	T stat. Null = 0	T stat. Null = -1	Long-run	T stat. Null = 0	T stat. Null = -1	Degrees of Freedom	Sample Periods
Hong Kong	0.09+	0.99	12.27	0.07+	0.51	-7.72	66	From 1986:Q1 to 2004:Q2
Indonesia	-0.11*+	-4.45	34.79	-0.57*+	-11.02	-8.15	39	From 1990:Q1 to 2002:Q3
Japan	0.03+	1.63	64.7	-0.01+	-0.27	-36.51	86	From 1980:1 to 2004:2
Korea	-0.08*+	-4.42	47.76	-0.13*+	-2.74	-19.12	46	From 1990:1 to 2004:2
Malaysia	0.01+	0.88	60.95	-0.03+	-0.9	-31.79	58	From 1990:1 to 2004:2
Philippines	0.02+	0.74	43.78	-0.15*+	-3.51	-19.39	46	From 1988:1 to 2004:2
Singapore	0.1*+	3.88	41.37	0.2*+	5.82	-35.25	69	From 1984:Q3 to 2001:Q1, From 2001:Q4 to 2004:Q2
Thailand	-0.08*+	-2.7	32.96	-0.26*+	-4.36	-12.25	38	From 1993:1 to 2004:2
Taiwan	-0.1+	-1.22	11.48	0.17+	1.12	-7.78	46	From 1990:1 to 2004:2

Notes: * denotes that elasticity is significantly different from zero at a 1 percent level.

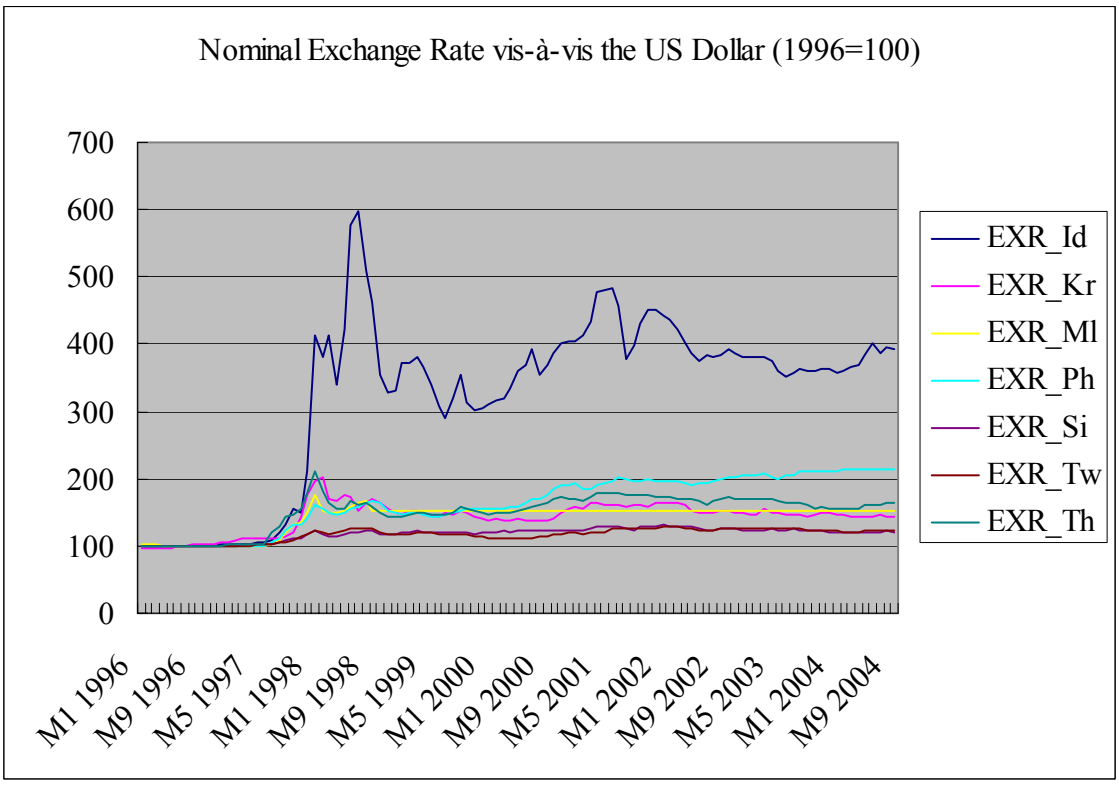
+ denotes that elasticity is significantly different from -1 at a 1 percent level.

Table 3. Unit Root Tests

	Phillips-Perron (PP) Test				
Variable	Indonesia	Korea	Malaysia	Singapore	Thailand
m	-0.54	-1.23	-2.97	-1.22	-2.50
Δm	-11.03 **	-4.88 **	-10.14 **	-10.39 **	-9.65 **
Order in level	I(1)	I(1)	I(1)	I(1)	I(1)
efexr	-1.67	-2.16	-1.90	-2.13	-2.32
Δefexr	-10.00 **	-5.60 **	-9.23 **	-8.99 **	-7.30 **
Order in level	I(1)	I(1)	I(1)	I(1)	I(1)
cpi	-1.53	-2.02	-0.85	-2.36	-2.11
Δcpi	-4.11 **	-7.72 **	-10.42 **	-9.48 **	-7.78 **
Order in level	I(1)	I(1)	I(1)	I(1)	I(1)
ppi	-1.32	-1.89	-1.86	-1.35	-2.55
Δppi	-6.23 **	-5.80 **	-7.43 **	-7.50 **	-6.80 **
Order in level	I(1)	I(1)	I(1)	I(1)	I(1)
imp	-2.29	-2.52	-	-1.75	-3.00
Δimp	-12.24 **	-5.62 **	-	-8.30 **	-18.61 **
Order in level	I(1)	I(1)	-	I(1)	I(1)
gap					
(PP Test)	-7.66 **	-3.20 #	-2.51	-5.79 **	-1.18
(KPSS Test)	0.16 *	0.11	0.07	0.06	0.26 **
Order in level	I(0) or I(1)	I(0)	I(0) or I(1)	I(0)	I(1)
oil	-1.92				
Δoil	-9.75 **				
Order in level	I(1)				

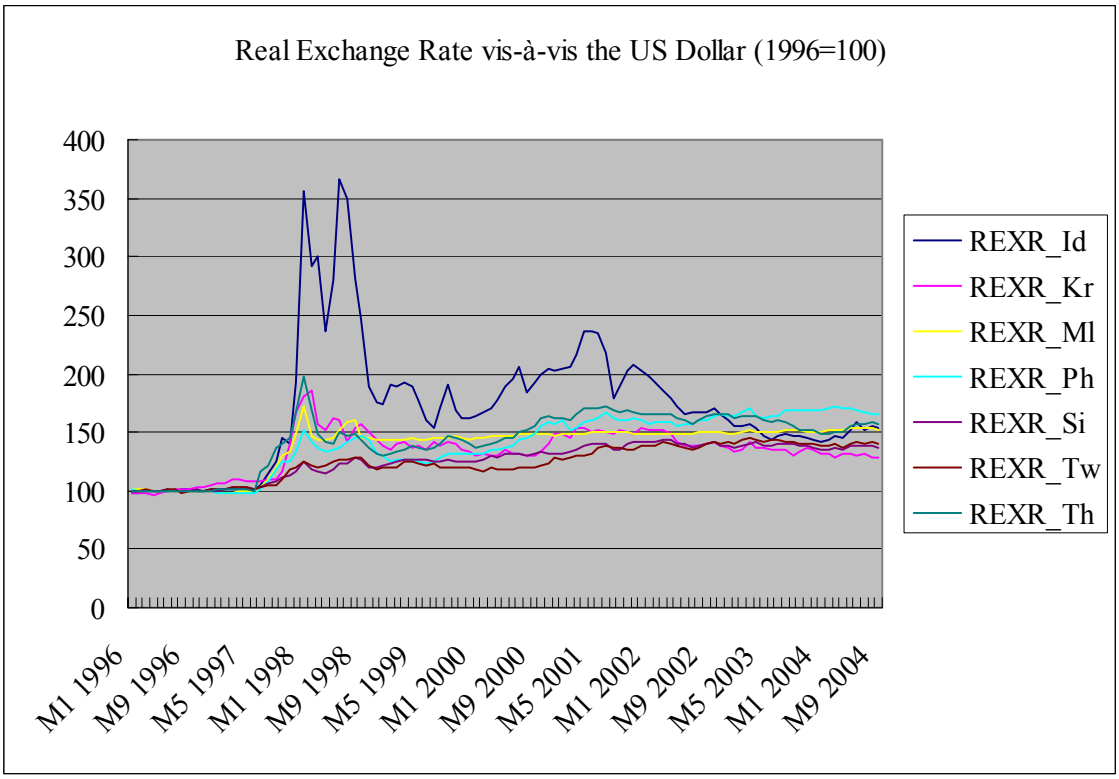
Notes: Double asterisks (**), a single asterisk (*) and a sharp (#), respectively, denote the significance at the one percent, five percent and ten percent level. Sample period: 1995M1-2004M8. The null hypothesis of the PP test is that the variable is nonstationary. The null hypothesis of the Kwiatowski, et al. (KPSS) test is that the variable is stationary. For the level of variables, constant and time trend are included. For the first-difference of variables, only constant is included.

Figure 1. Nominal Exchange Rate vis-à-vis the US Dollar (1996=100)



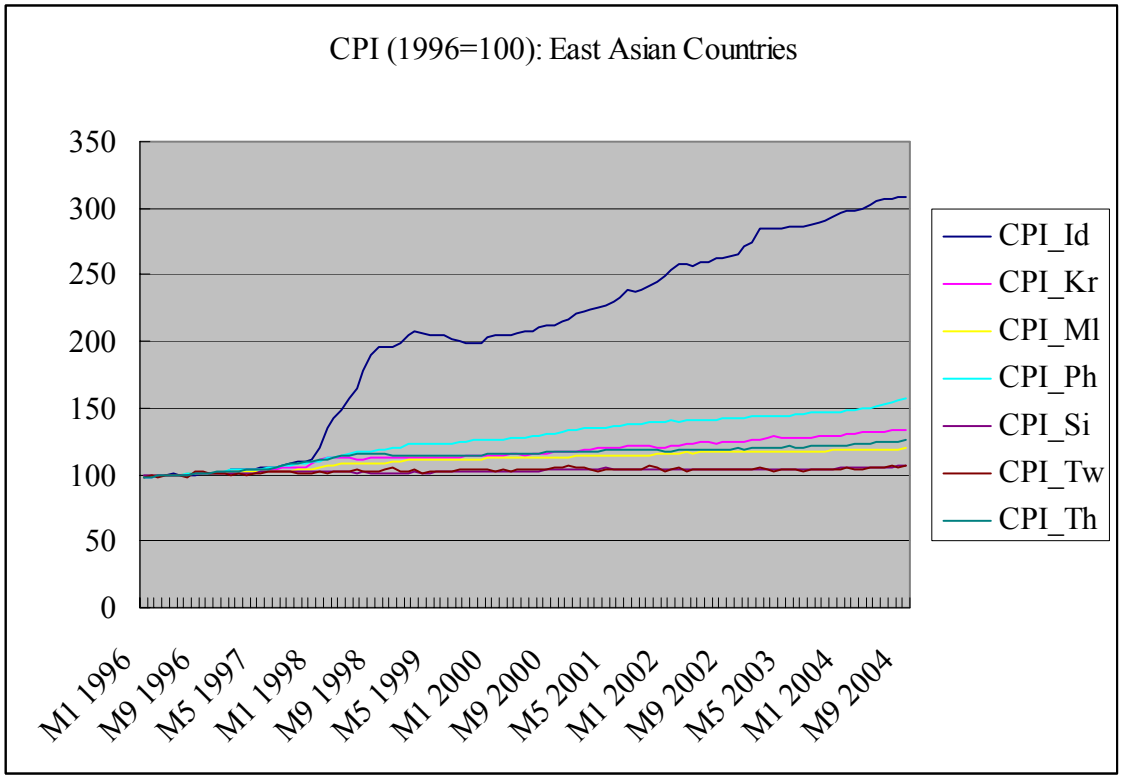
Sources: IMF, *International Financial Statistics*, online version; The CEIC Asia Database; and Taiwan Economic Data Center.

Figure 2. Real Exchange Rate vis-à-vis the US Dollar (1996=100)



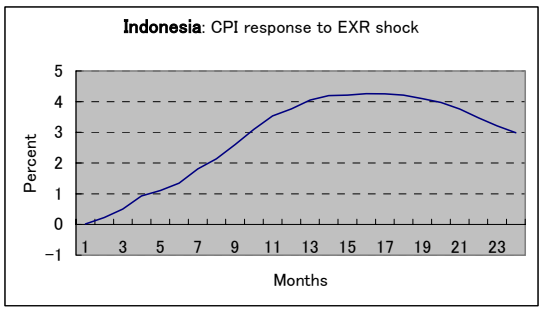
Sources: IMF, *International Financial Statistics*, online version; The CEIC Asia Database; Datastream; and authors' calculation.

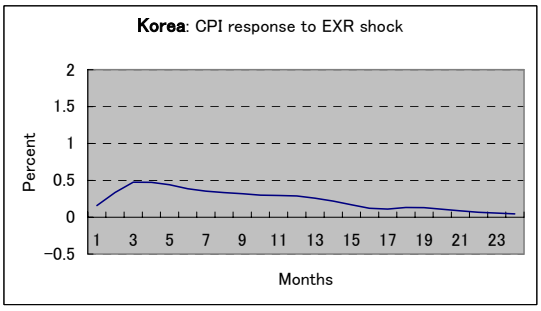
Figure 3. CPI (1996=100): East Asian Countries

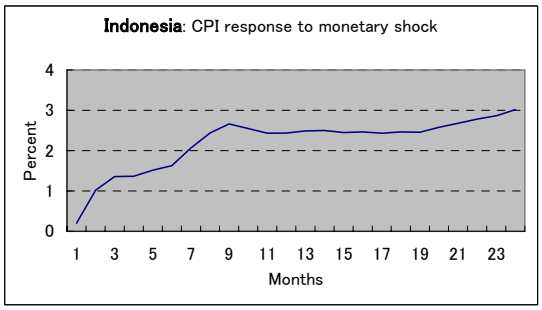


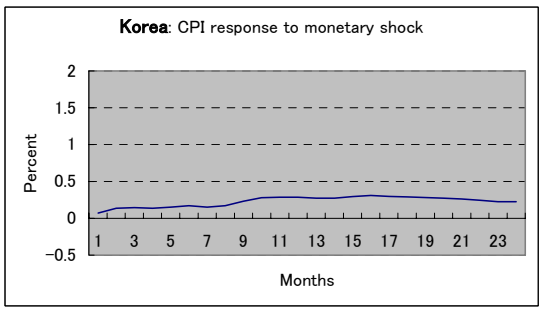
Sources: IMF, *International Financial Statistics*, online version; The CEIC Asia Database; and Taiwan Economic Data Center.

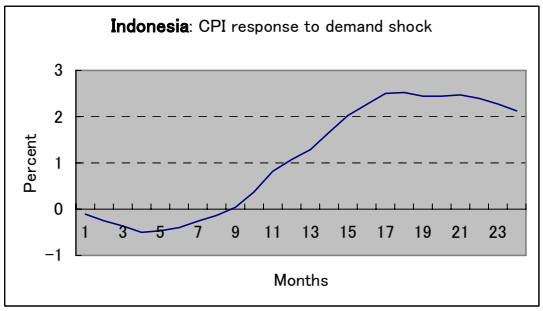
Figure 4. Impulse Response of CPI

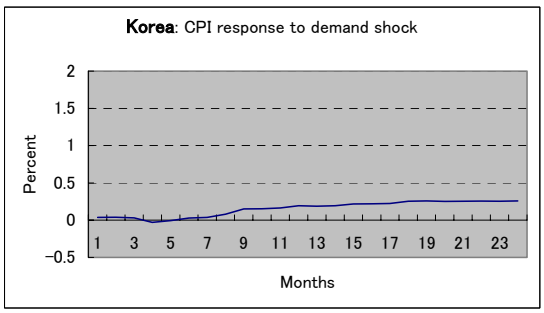


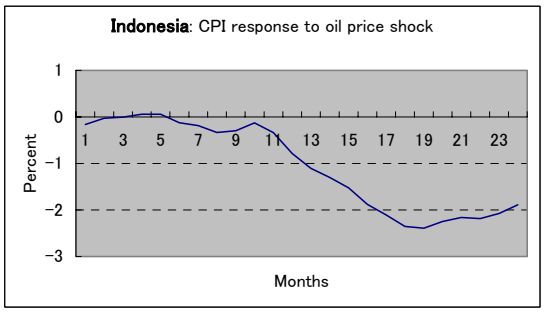












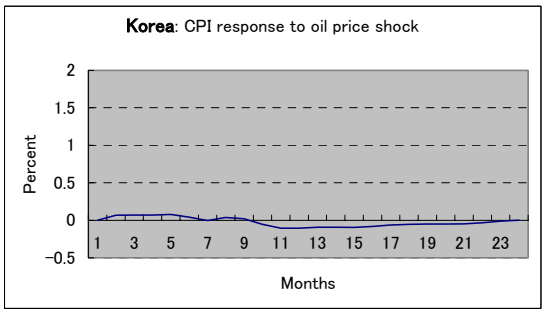
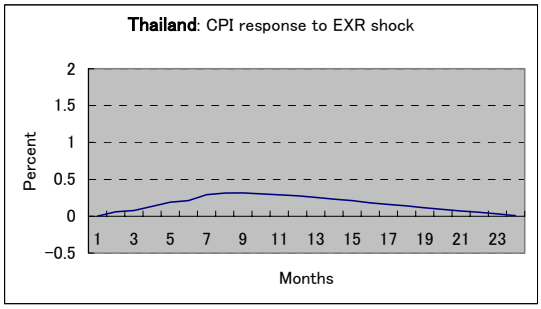
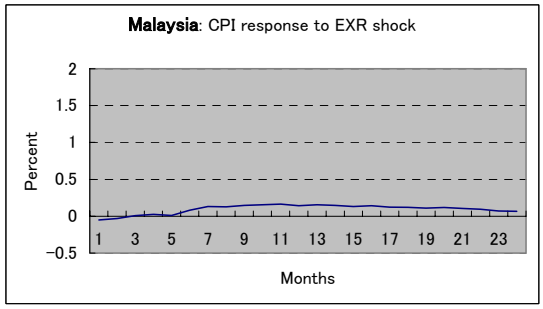
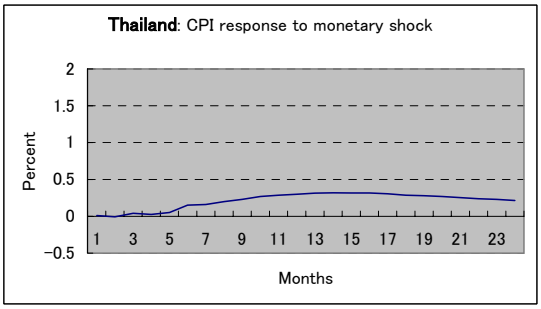
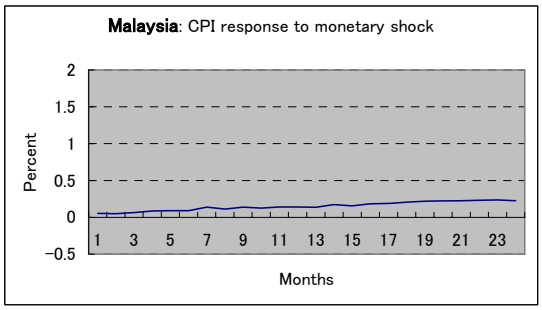


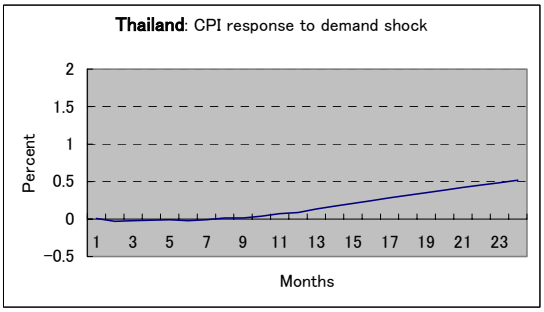
Figure 4. Impulse Response of CPI (cont'd)

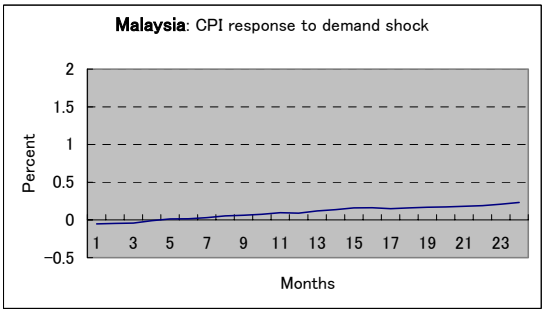


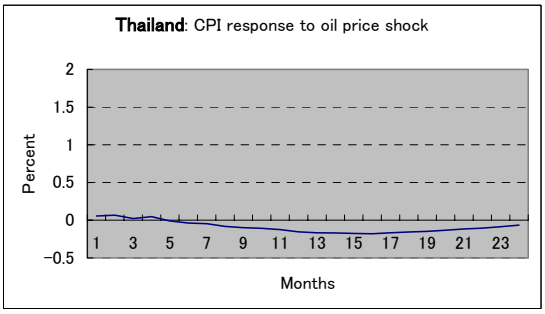












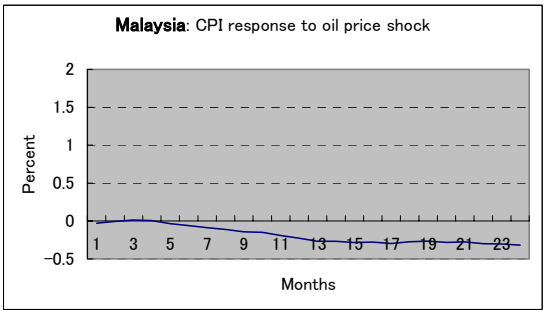
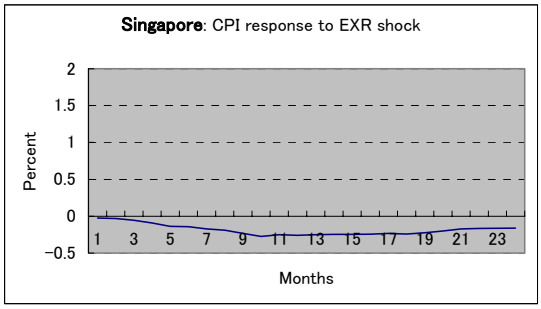
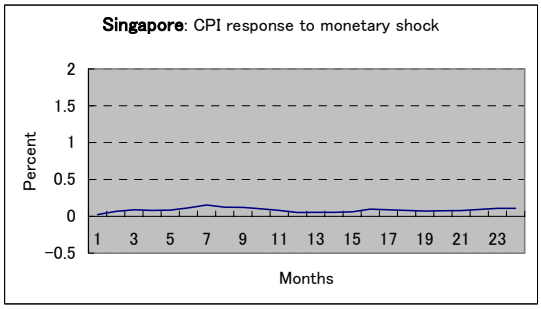
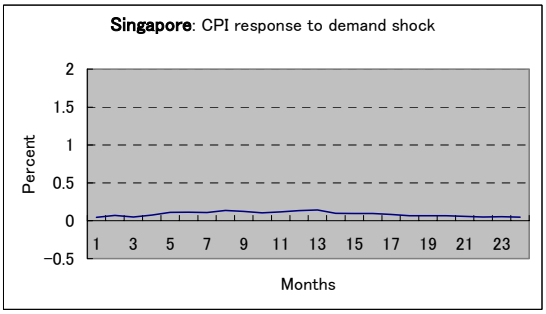


Figure 4. Impulse Response of CPI (cont'd)







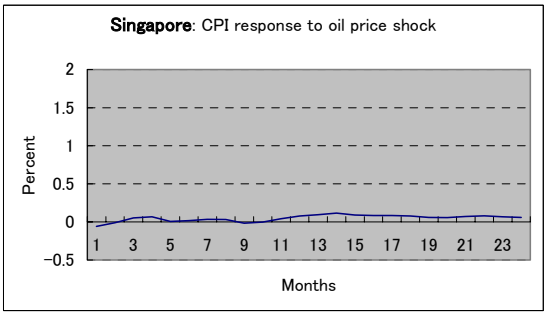
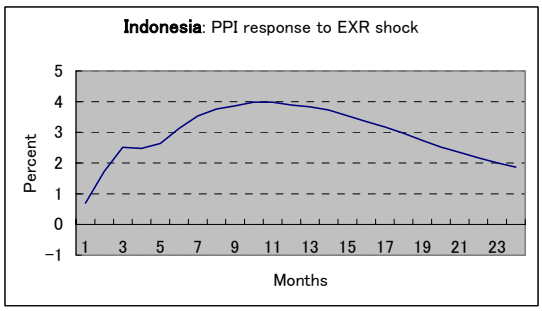
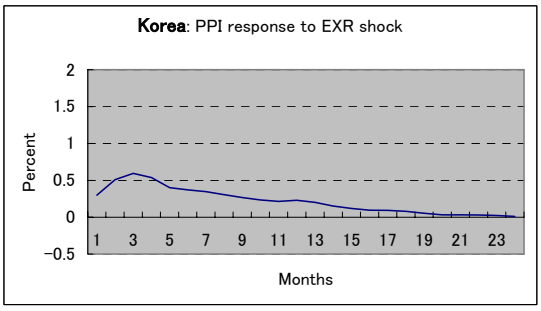
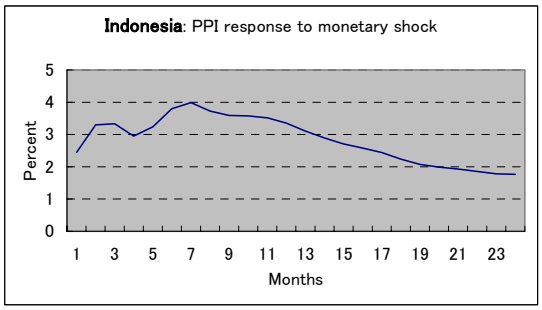
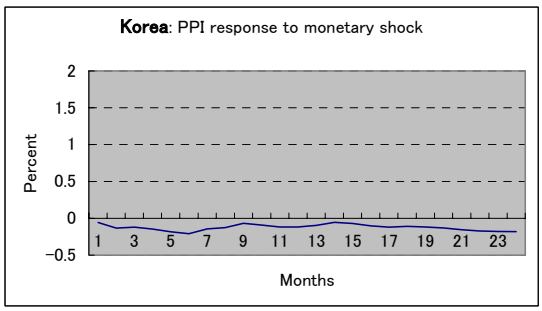


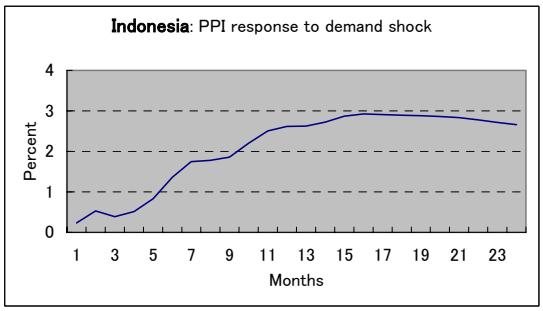
Figure 5. Impulse Response of PPI

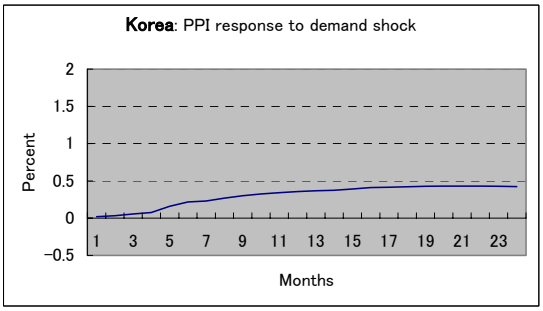


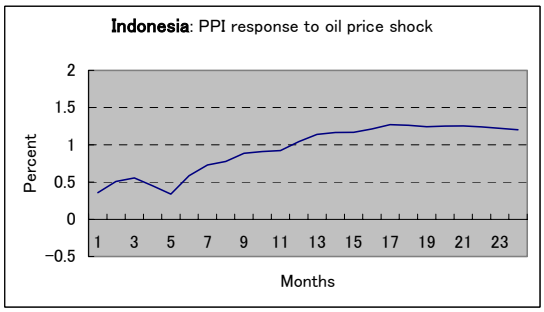












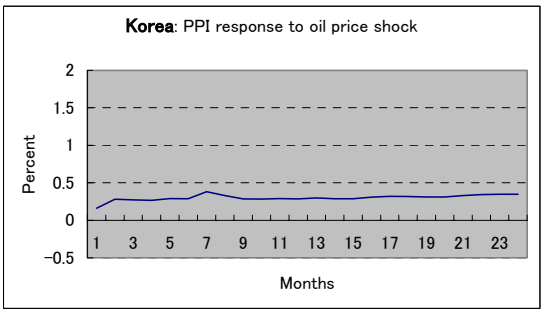
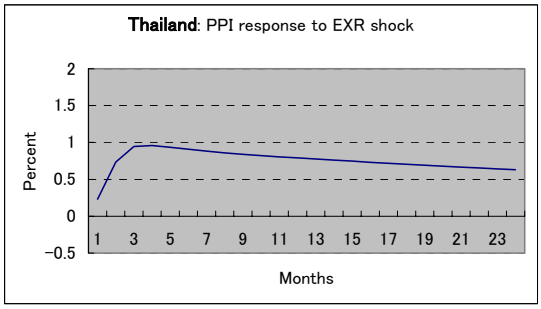
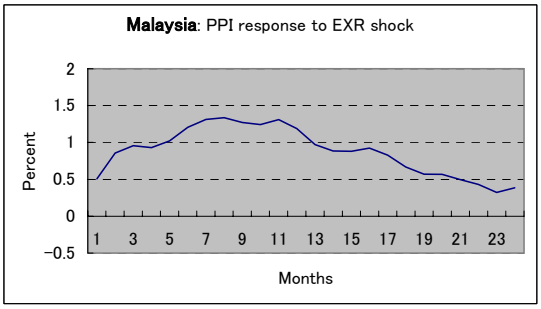
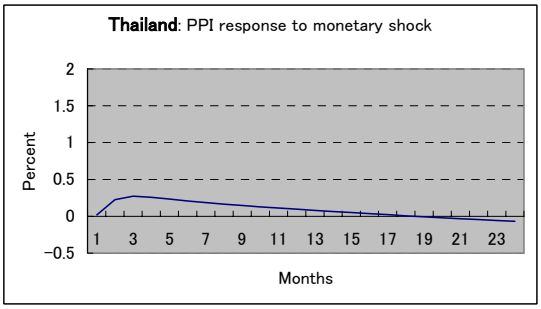
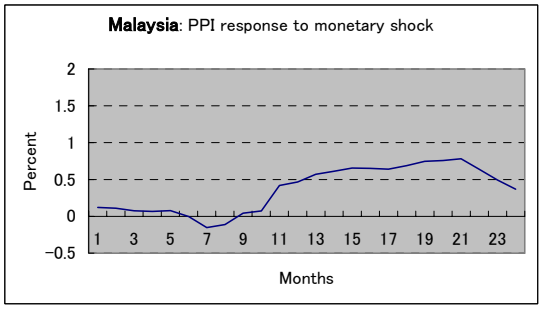


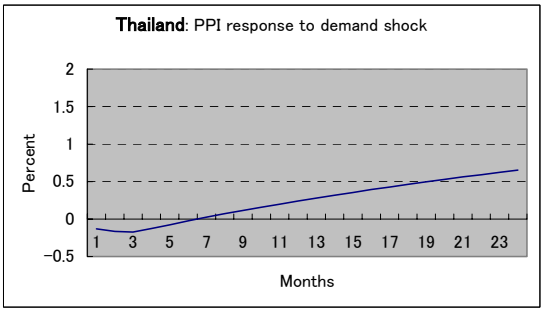
Figure 5. Impulse Response of PPI (cont'd)

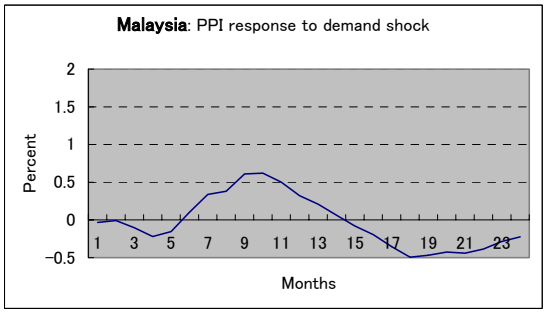


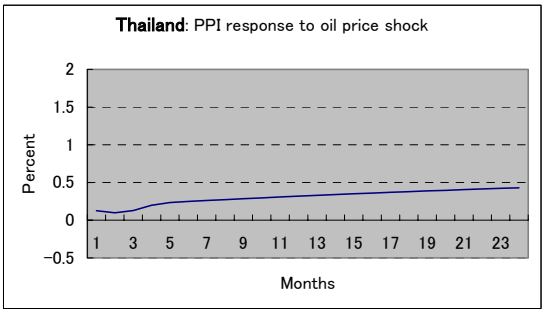












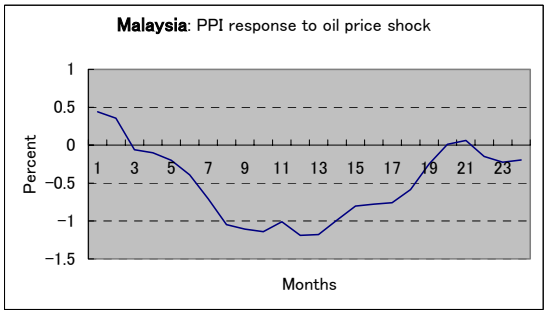
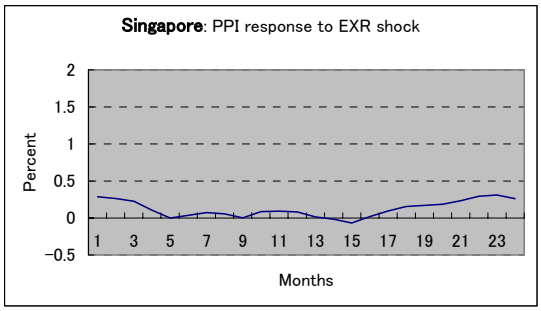
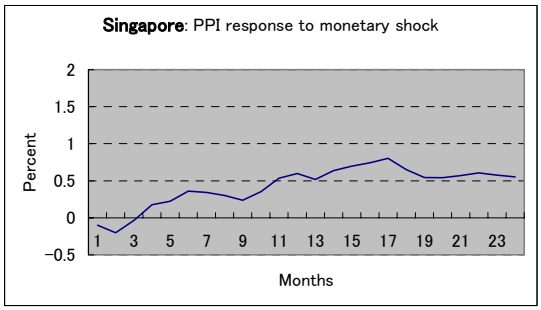
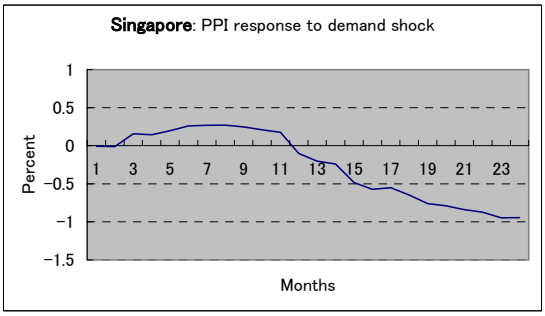


Figure 5. Impulse Response of PPI (cont'd)







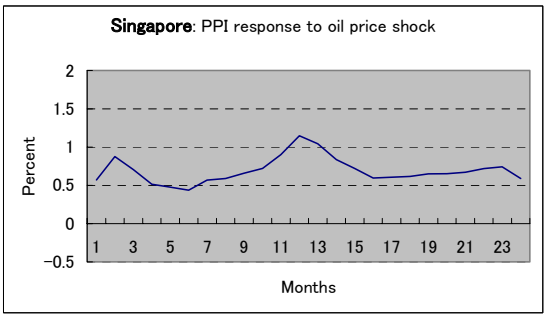
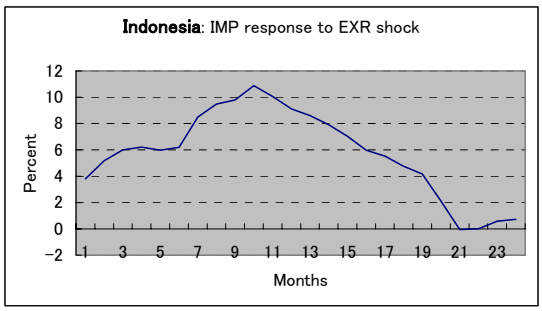
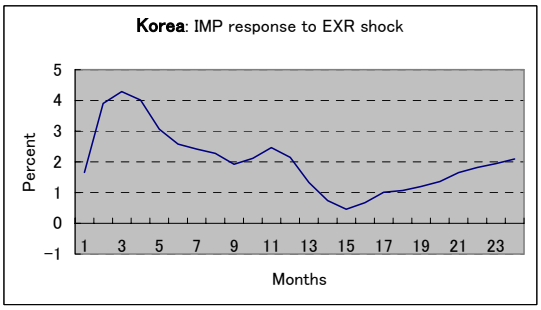
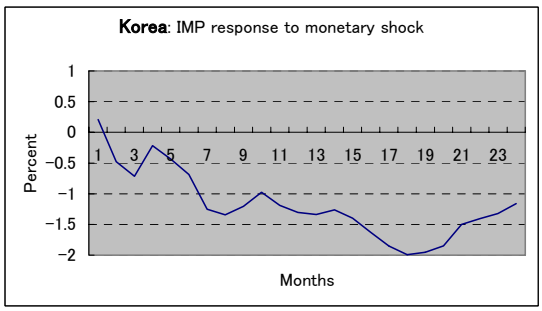
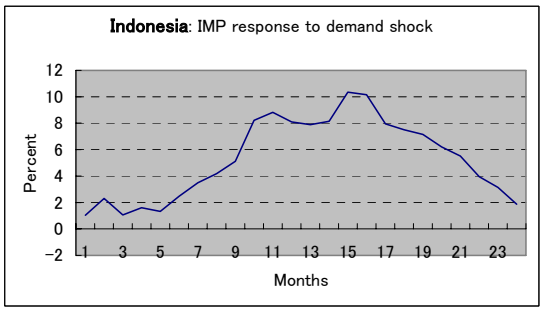


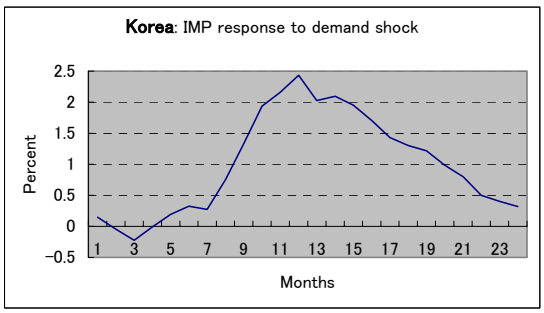
Figure 6. Impulse Response of Import Prices

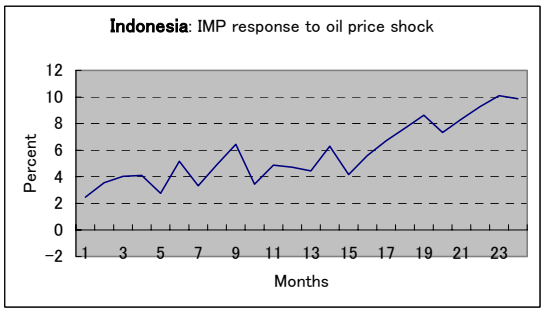












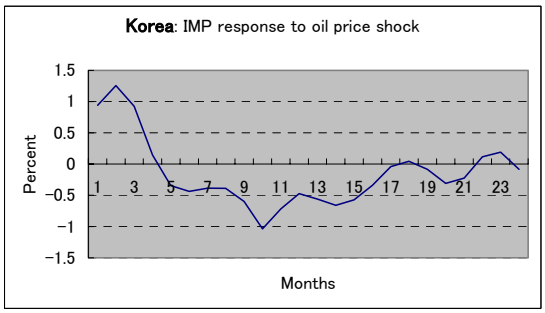
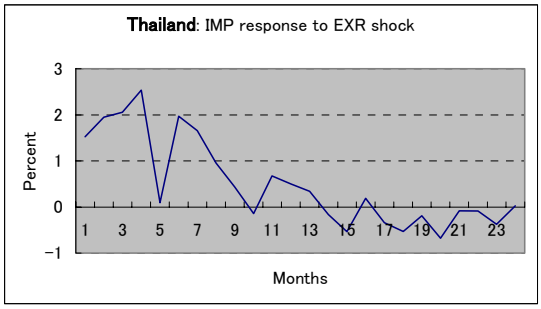
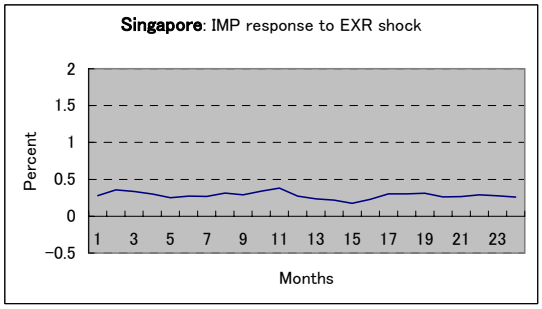
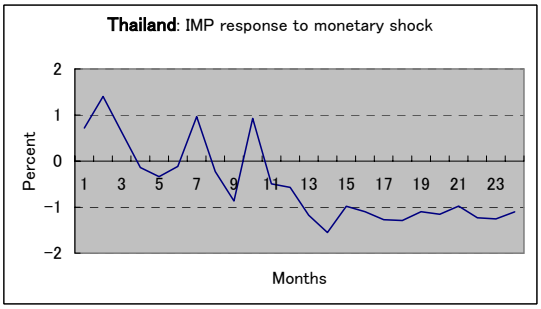
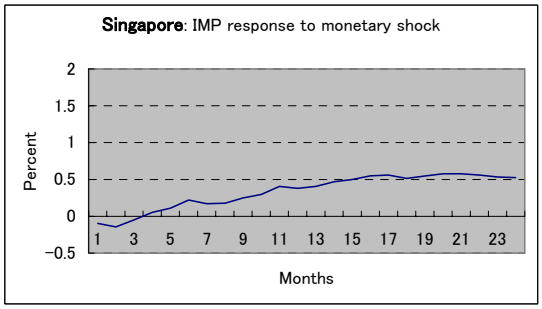


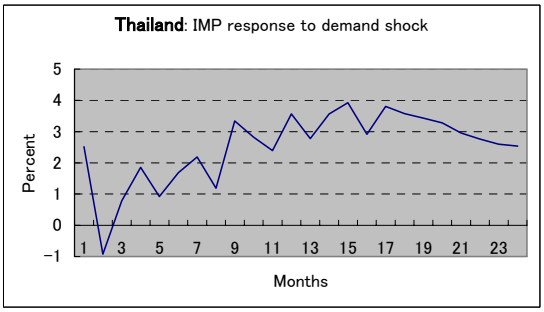
Figure 6. Impulse Response of Import Prices (cont'd)

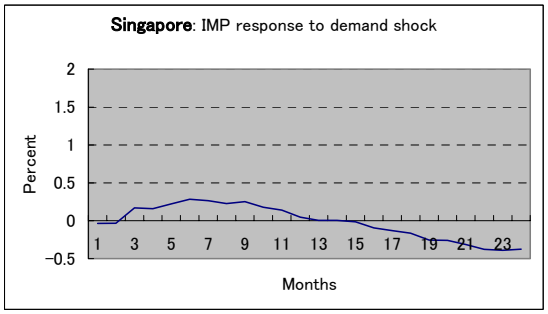


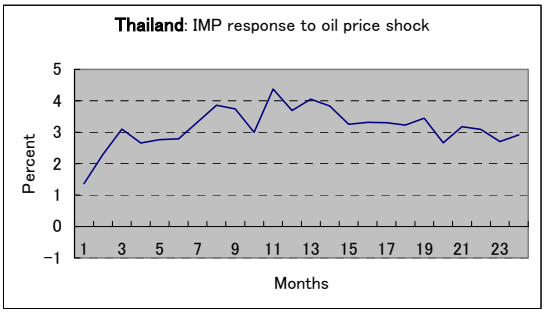












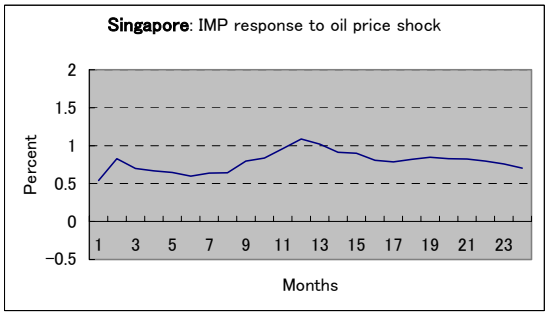
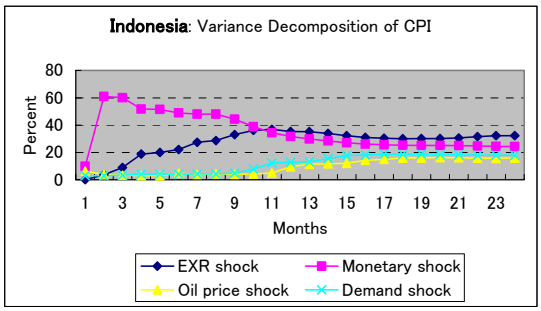
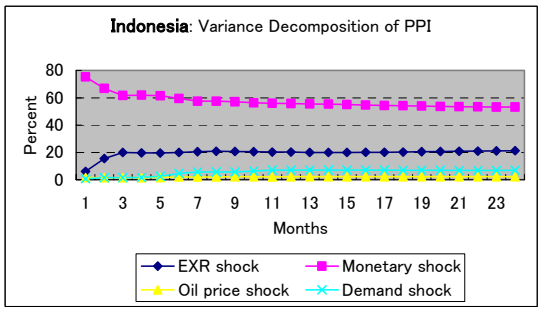
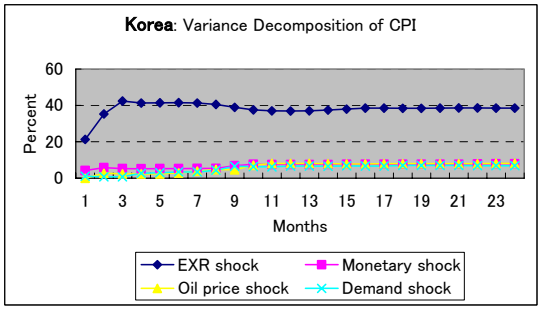
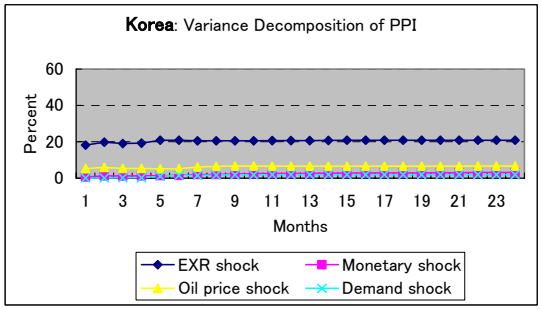


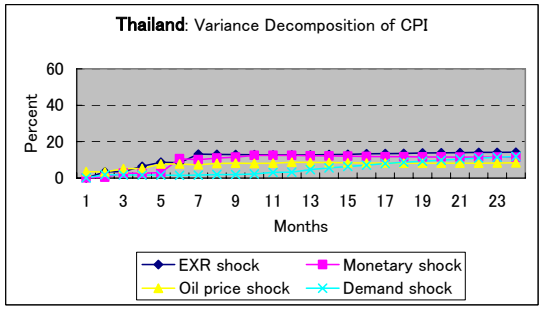
Figure 7. Variance Decompositions

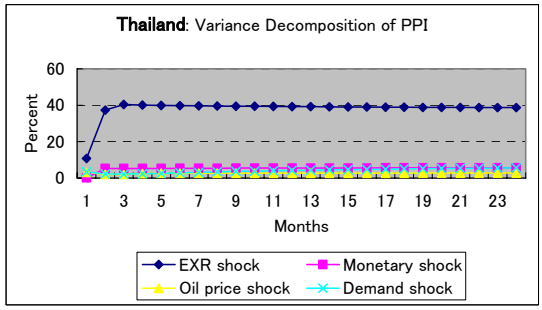


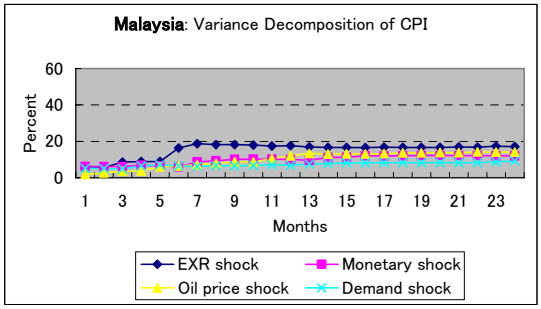


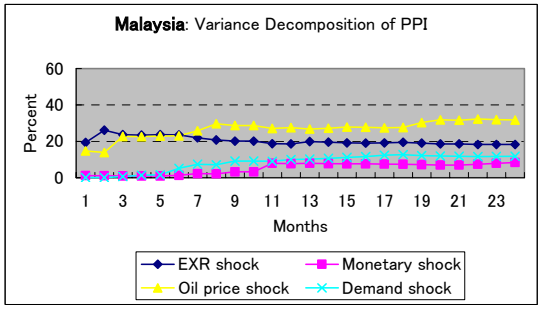


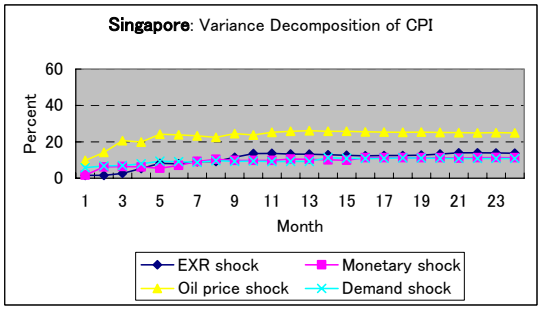












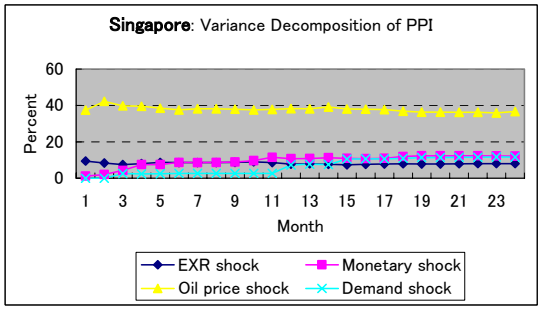
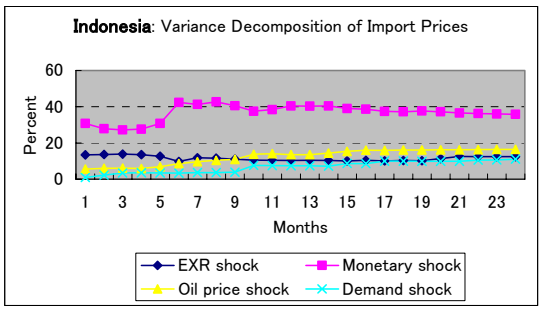
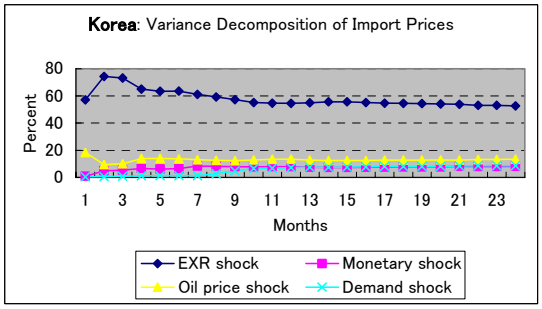
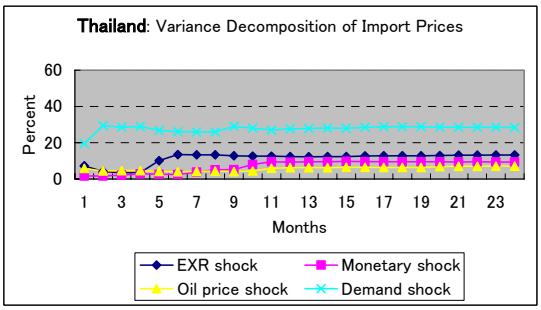
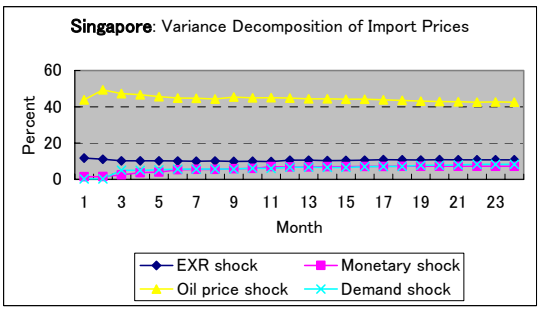


Figure 7. Variance Decompositions (cont'd)









Appendix Table 1

	DHKMU		DINMP		DJPMU		DKRMU		DSPMP		DTHMU		DTWMP	
Degree of Freedom	65		39		83		46		69		38		46	
R bar Square	0.65		0.81		0.58		0.78		0.21		0.79		-0.04	
Constant	0	-2.98	0.02	3.86	-0.01	-1.42	0.01	1.57	0	0.39	0.01	2.23	0	0.84
REER	-0.23	-6.31	-0.53	-11.18	-0.84	-9.76	-1.05	-10.81	0.59	2.8	-1.27	-9.88	0.09	0.35
REER(-1)	-0.16	-4.49	-0.2	-4.09	-0.18	-2.06	0.17	1.83	0.1	0.46	-0.24	-1.81	0.15	0.7
REER(-2)	0.01	0.41	-0.09	-2.05	-0.03	-0.38	0.21	2.05	0.31	1.4	-0.35	-2.81	0.23	1.03
REER(-3)	-0.09	-2.52	-0.14	-2.83	0.04	0.44	0.23	2.42	-0.16	-0.73	0.03	0.2	0.01	0.07
REER(-4)	-0.02	-0.66	-0.08	-1.66	0.03	0.32	0.27	2.78	-0.85	-3.98	0.16	1.22	-0.18	-0.79
GD	0.02	2.07	0	-0.08	0.15	0.35	-0.06	-1.17	0.04	0.79	0.14	1.08	0.03	0.19
CP	0.33	6.59												
ΣREER	-0.49	-8.61	-1.04	-10.69	-0.99	-6.75	-0.17	-0.74	-0.01	-0.03	-1.66	-6.03	0.3	0.63

Appendix Table 2

	DHKCP		DINCP		DJPCP		DKRCP		DMLCP		DPHCP	
Degree of Freedom	66		39		86		46		58		46	
R bar Square	−0.06		0.76		0.01		0.47		0.29		0.3	
Constant	0.01	6.13	0.03	8.62	0	3.65	0.01	11.09	0.01	12.9	0.02	15.98
REER	0.09	0.99	−0.11	−4.45	0.03	1.63	−0.08	−4.42	0.01	0.88	0.02	0.74
REER(-1)	0.04	0.44	−0.12	−4.64	−0.03	−1.91	−0.04	−2.18	−0.03	−1.38	−0.07	−2.85
REER(-2)	−0.02	−0.25	−0.15	−6.07	0.01	0.53	0	0.18	−0.02	−1.05	−0.02	−0.96
REER(-3)	0.03	0.29	−0.11	−4.19	−0.02	−1.38	−0.01	−0.6	−0.01	−0.33	−0.04	−1.72
REER(-4)	−0.06	−0.68	−0.08	−3.19	0.01	0.8	0.01	0.41	0.01	0.54	−0.04	−1.53
GD	0	−0.12	0.03	1.71	−0.07	−0.96	−0.03	−3.34	−0.06	−4.13	−0.03	−2.33
ΣREER	0.07	0.51	−0.57	−11.02	−0.01	−0.27	−0.13	−2.74	−0.03	−0.9	−0.15	−3.51

	DSPCP		DTHCP		DTWCP	
Degree of Freedom	69		38		46	
R bar Square	0.34		0.36		0.06	
Constant	0	8.4	0.01	7.87	0	3.38
REER	0.1	3.88	−0.08	−2.7	−0.1	−1.22
REER(-1)	0.05	1.87	−0.06	−2.15	0.17	2.46
REER(-2)	0.03	1.07	−0.05	−1.82	0.06	0.87
REER(-3)	0.03	1.17	−0.04	−1.23	−0.02	−0.28
REER(-4)	−0.02	−0.79	−0.04	−1.31	0.05	0.77
GD	0	0.25	−0.05	−1.6	0.04	0.89
ΣREER	0.2	5.82	−0.26	−4.36	0.17	1.12

Appendix Figure 1. Impulse Responses of CPI to Exchange Rate Shocks Across Different Orderings