『国際開発研究フォーラム』25（2004. 2）
*Forum of International Development Studies,* 25（Feb. 2004）

# VAR Analysis of Monetary Policy Transmission Mechanisms:
## Empirical Study on Five Asian Countries after the Asian Crisis

Waranya ATCHARIYACHANVANICH*

## Abstract

This article employs VAR to analyze monetary policy transmission mechanisms of in Indonesia, Korea, Malaysia, the Philippines and Thailand (ASIA-5) after the Asian crisis. In order to resolve the "price puzzle" usually found in prior studies that applied the recursive Choleski decomposition, this article proposes to set the identifying restrictions on the coefficient matrix of innovations that are based on the empirical Granger causality and the cointegration relationships among variables in the systems. The results of this empirical study confirmed the superiority over the recursive scheme in terms of less puzzled signs of impulse responses of endogenous variables in the system to the interest rate disturbance. Despite the different economic structures among the ASIA-5, asset price relatively represents the most sensitive variable to the interest rate shock among all variables in the model; however, with a puzzle on its sign of the impulse response function. The second most sensitive variable is output, followed respectively by the real effective exchange rate, real bank credit and price. The findings indicate price stickiness. Moreover, foregone output and fluctuations in stock price indices as well as real effective exchange rates are the tradeoffs for price control.

Keywords: monetary policy transmission mechanism, VAR, identifying restrictions

## 1. Introduction

After the 1997 Asian Crisis (hereafter, the Crisis), the five most severely affected economies, namely, Indonesia, the Republic of Korea, Malaysia, the Philippines, and Thailand (hereafter, the ASIA-5) have changed their exchange rate regimes and implemented several measures for financial reforms. Consequently, the changes in monetary policy objectives and formulation required a solid understanding on the monetary policy transmission mechanisms (hereafter, transmission mechanisms) after the Crisis. In particular, as the reforms have caused both positive and negative impacts, the relative importance and characteristics of each channel of transmission mechanisms needed to be reexamined.

There have been some empirical studies that have tried to explain transmission mechanisms in the ASIA-5 after the Crisis by conducting Vector Autoregression (VAR) analysis, the approach that allows the analysis on the interrelation among different channels of monetary policy transmission

＊Doctoral Student, Graduate School of International Development, Nagoya University

mechanisms. However, most of these studies employed data that included the pre-crisis period or neglected the influence of exchange rate regimes and financial reforms on the existence or disappearance of some channels after the Crisis.[1] The main reason for including the pre-crisis data was because of insufficient quarterly data.[2] Among these studies that employed VAR analysis, Fung (2002) applies monthly data to semi-structural VAR models to analyze the effect of monetary policy in East Asian countries both before and after the Crisis. However, most of the impulse responses to interest rate shocks in the post-crisis period were found insignificant. Moreover, there were "puzzles," or impulse response functions of endogenous variables to policy shocks, of which signs are inconsistent with theoretical expectations. These "puzzles" reduced the reliability of the results.

This article aims to minimize "puzzles" on impulse response functions of VAR models before analyzing the transmission mechanisms. In order to obtain sufficient samples monthly data was utilized.

This article is organized as follows: Section 2 reviews the general concept and related studies of transmission mechanisms and VAR application; Section 3 explains a methodological framework pursued in this article; Section 4 discusses the variable selection; Section 5 is an empirical study on channels of transmission channels in the ASIA-5; and Section 6 contains conclusions and policy implications.

## 2. Literature Review on Transmission Mechanisms and VAR application

This section first reviews some related literature on transmission mechanisms. Second, it points out issues on the application of VAR in the study of transmission mechanisms.

### 2.1 Literature Review on Transmission Mechanisms

Following the explanation of Taylor (1995:11), monetary policy transmission mechanism refers to "the process through which monetary policy decisions are transmitted into changes in real GDP and inflation."[3] This definition implies a wider scope of analysis than some prior studies which have focused on only particular channels; for examples, the study by Mihaljeck and Klau (2001) emphasizes foreign exchange rate and import price channels; Meltzer (1995) takes a monetarist view and recognizes the importance of asset price channel in a closed economy; and, the study of Bernanke and Gertler (1995) focuses on the credit channel.

In open economies the role of the exchange rate has to be taken into consideration. The transmission of monetary policy is more directly complicated by an additional channel via the price of imports in addition to the aggregate-demand, credit, and asset price channels of a closed economy. According to Svensson (1998), apart from the direct exchange rate channel, the relative prices of foreign and domestic goods results in the real exchange rate affecting the aggregate-demand channel, the adjustment of expectation on exchange rate as an asset price represents wealth effects, and

foreign disturbances unavoidably affect the aggregate demand. The smaller the open economy, the higher the significance of these additional channels can be presumed.

Not only on openness and size of the economy, characteristics of transmission mechanisms also depend highly on the financial structure and macroeconomic environment. On one hand, deregulation, innovation and financial development can result in the diminishing importance of the credit channel, as claimed by Bernanke and Gertler (1995). On the other hand, an underdeveloped financial system is usually claimed as a reason for less effective monetary policy transmission. According to the study by Kamin, Turner, and Van 't dack (1998), a shallow and a volatile financial market is one reason for a weak influence of money policy on output. A survey of six developing countries in Schaechter, Stone, and Zelmer (2000, Table 5.1) indicates that weakening transmission mechanisms, particularly credit channel, were associated with weak financial sectors (for Czech Republic, Poland, and South Africa); and the exchange rate pass-through was recognized as a rapid and highly significant channel (for Brazil, Chile, and Israel).

### 2.2 VAR Application in the Study of Transmission Mechanism

As a complementary to the narrative approach, a quantitative approach enables the measurement of the impact of monetary policy.[4] The VAR technique is one of the most useful tools in illustrating a macro view of interrelation among all channels of transmission mechanism.[5] In particular, the effects of a shock to one of the variables on all the other variables of the system can be inferred from the impulse responses of the VAR model. However, as the innovations in the model are usually contemporaneously correlated, a transformation to derive a diagonal contemporaneous covariance matrix is necessary. Such identifying transformation is not unique, varying with the scheme to set up the coefficient matrix of the innovations.

Focusing on the scheme to set up the coefficient matrix of innovations, VAR can be classified into models of three types: unrestricted, structural, and semi-structural models. First, under an unrestricted VAR (UVAR) model, the recursive Choleski decomposition scheme is applied. The coefficient matrix of innovations is simply a lower triangular matrix without explicit economic theoretical basis. The contemporaneous effects of shocks are implied in the order of the variables in the UVAR. Therefore, with inappropriate order of variables, the recursive orthogonalization of the error terms for impulse response analysis can lead to "puzzles." Moreover, even though the order may be correct in terms of degree of exogenity, the assumption on complete causal order of endogenous variables is still unrealistic. Because of the different monetary structures, both the actual order of the variables and their causality may vary across countries.

Second, a structural VAR (SVAR) model is one in which the identifying restrictions for the structural components of the innovations are imposed to obtain non-recursive orthogonalization of the error terms. These structural restrictions are usually based on theoretical economic relationships. For

example, in the study of Martinez, Sanchez, and Werner (2001), the channels of transmission mechanisms in Mexico were analyzed by employing a SVAR system that contained three equations representing a Phillips curve, output-gap, and a real interest rate determination. No "puzzle" was found in the behavior of reaction of all variables in their study. The structural restrictions can also be set to reflect the perception towards true behaviors of variables in the model. For example, Odusola and Akinlo (2001) assumed innovations of nominal exchange rate in Nigeria to be due to only its "own shock" to reflect the fixed exchange rate regime. They investigated the interrelationships among output, inflation, and the exchange rate and found that behaviors of impulse responses of output and inflation to domestic currency depreciation in Nigeria were consistent with related empirical studies for some developing countries.

With different numbers of endogenous variables in the system and assumptions regarding the structure of the economy, there are numerous possible ways to set up restrictions in SVAR models. Taylor (2000) reveals that there are at least eighteen different models of transmission mechanisms classified by the size of economy, the focus on price or volume of financial assets, the type of interest rate influencing demand, the existence of partial adjustment behaviors of variables in response to changes in interest rates, and the influence of exchange rate on aggregate demand. Since the impulse response functions are restriction-dependent, impossing unrealistic assumptions can also lead to " puzzles." The signs of impulse response functions derived from SVAR models, therefore, are not always more reliable or less "puzzled" than those from the unrestricted ones.

Third, as an alternative to UVAR and SVAR models, Bernanke and Mihov (1995) introduced a "semi-structural" VAR (semi-SVAR) model which imposes contemporaneous identifying restrictions only on a set of policy variables (which were variables relevant to the market for commercial bank reserve). They left relationships among non-policy variables (macroeconomic variables) unrestricted.

Fung (2002) applies semi-SVAR models to his empirical study on transmission mechanisms in seven East Asian countries, including the ASIA-5. His policy variables are short-term interest and exchange rates. The industrial production index, CPI, and monetary aggregate of the countries under consideration are main non-policy variables. His analysis covers both pre- and post-crisis periods. In the full-period sample, the world commodity price index (PCOM) and three US variables (CPI, industrial production index, and the federal fund rate) were introduced when "puzzles" were found. His first finding in the difference in the results of semi-SVAR models before and after the Crisis suggests a major shift in a regime or a change in the transmission mechanism. Secondly, he concludes that the exchange rate played a less powerful role in setting monetary policy rule in most ASIA-5 countries relative to that of the short-term interest rate. Moreover, it is inferable that the implicit weights of exchange rate in monetary policy declined after the Crisis for most of the ASIA-5 (Fung, 2002:11, Table 4).

Despite Fung's useful findings, there are "puzzles" found in his post-crisis sample. The impulse

responses of the endogenous variables to shocks on the policy rate for the period of January 1998 to June 2000, representing a post-crisis sample, are mostly insignificant as well as theoretically inconsistent. On one hand, it implies the inappropriateness of applying the VAR technique. However, it may also call for a new framework of analysis. Some adjustments in the type of non-policy variable, time frame, and identifying assumptions of restrictions in his post-crisis sample may be necessary.

## 3. Methodological Framework

This article aims to obtain impulse response functions that are more reliable and that conform to the theoretical expectations rather than through the Choleski decomposition scheme. First, a basic SVAR model in this study is defined in contrast to the UVAR model. Then, a framework for setting the identifying restrictions in the coefficient matrix of innovations is proposed.

### 3.1 Model Selection

The SVAR model selected follows Amisano and Giannini (1997) in explaining the interrelation among $n$ endogenous variables in a reduced form of VAR representation. First, assume that $\mathbf{y}_t$ is an ($n$ x 1) column vector of economic variables, and $\boldsymbol{\varepsilon}_t$, is an ($n$ x 1) vector of observed (reduced-form) residuals or innovations with the variance-covariance matrix of $E(\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}_t') = \boldsymbol{\Sigma}$. The finite order (p) autoregressive representation without the deterministic part that relates both vectors is:

$$\mathbf{A}(L)\mathbf{y}_t = \boldsymbol{\varepsilon}_t, \ \boldsymbol{\varepsilon}_t \sim (0, \boldsymbol{\Sigma}) \qquad (1)$$

$\mathbf{A}(L)$ is defined as $\mathbf{I} - \mathbf{A}_1 L - \ldots - \mathbf{A}_p L^p$, where $L$ is a lag operator, and $\mathbf{A}_i$ for i = 0,...,p are ($n$ x $n$) coefficient matrices. Since the innovations are usually correlated, the interpretation of the impulse response is not straightforward. The $\boldsymbol{\varepsilon}_t$ must be transformed into an ($n$ x 1) vector of (non-observed) structural disturbances or shocks, $\boldsymbol{\mu}_t$, that has mean of zero and a diagonal variance-covariance matrix.

Following the **K**-class of the SVAR model classified by Amisano and Giannini (1997:17), the vector of innovations, $\boldsymbol{\varepsilon}_t$, is transformed into the vector of shocks, $\boldsymbol{\mu}_t$, by pre-multiplying an ($n$ x $n$) invertible coefficient matrix, **K**, to the system (1) such that:

$$\mathbf{K}\mathbf{A}(L)\,\mathbf{y}_t = \mathbf{K}\,\boldsymbol{\varepsilon}_t, \ \boldsymbol{\varepsilon}_t \sim (0, \boldsymbol{\Sigma}) \qquad (2)$$

$$\mathbf{K}\,\boldsymbol{\varepsilon}_t = \mathbf{B}\,\boldsymbol{\mu}_t, \ \boldsymbol{\mu}_t \sim (0, \mathbf{I}) \qquad (3)$$

where an ($n$ x $n$) diagonal coefficient matrix, **B**, is introduced to the **K**-model in order to allow for the generation of impulse response functions in the empirical study.[6]

The assumption of orthonormal innovations, $\boldsymbol{\mu}_t$, imposes the following restriction on **K** and **B**:

$$\mathbf{K}\boldsymbol{\Sigma}\mathbf{K}' = \mathbf{B}\mathbf{B}' \qquad (4)$$

After identifying restrictions are imposed in **K** matrix, the remaining elements in **K** matrix and diagonal elements in **B** matrix are to be estimated by the maximum likelihood technique.

Under the UVAR model, $\boldsymbol{\varepsilon}_t$ is transformed into $\boldsymbol{\mu}_t$ by pre-multiplying the system (1) by the inverse

of the Choleski factor, such that:

$$\mathbf{A}^*(L)\,\mathbf{y}_t = \boldsymbol{\mu}_t,\ \boldsymbol{\mu}_t \sim (0, \mathbf{I}) \quad (5)$$

$\mathbf{A}^*(L)$ is defined as $\sum_{i=0}^{P} \mathbf{A}_i^*$ where $\mathbf{A}_0^* = \mathbf{P}^{-1}$, $\mathbf{A}_i^* = \mathbf{P}^{-1}\,\mathbf{A}_i$ and $\mathbf{P}$ is the Choleski factor of $\boldsymbol{\Sigma}$. $\mathbf{A}_0^*$ is a lower triangular with unit diagonal elements replicating recursive contemporaneous relationships among the endogenous variables.

### 3.2 Identifying Restrictions

There are two main problems in setting the structural identifying restrictions that best capture the interrelated behavior transmission mechanisms in each economy. First, so far the issue on assumptions regarding identifying restrictions has not been settled. Economic theory remains just a tool in setting the identifying restrictions, and it does not guarantee reliable results. Moreover, as the number of variables in the system increases, it becomes increasingly more difficult to explain theoretical relationships among variables. Second, causal directions of the relationships among variables in different economies are not identical due to the different context of their financial and economic development. Applying identical restrictions based on conventional theories seems to ignore the significance of this fact. For this empirical study, another problem faced was the relatively short time span for the period after the crisis. Despite the use of monthly data, it was ineffective to access cointegration property by the multivariate approach. The problem regarding the degree of freedom did not allow the analysis to be applied longer than four lags.

Considering the above problems, a new framework is introduced in setting the identifying restrictions to be imposed in the **K** matrix, assuming the structural disturbances (in $\boldsymbol{\mu}_t$) are independent. In order to set up the **K** matrix, instead of basing it on economic theoretical relationships among variables, this analysis focuses on cointegrating and causal pairwise relationships among variables based on empirical data. By applying pairwise Granger causality and cointegration tests, the relationships between two variables that have high potential of being truly spurious and non-causal relationships beyond four lags can be detected. This helps to decide which coefficients in the **K** matrix should be assigned a value of zero. Although the approach ignores the possible cointegrations among variables of the different order of integration, it can be presumed that the remaining unrestricted coefficients indicate significant, causal, cointegrated relationships between corresponding pair of variables.[7] Since the pairwise approach tends to result in a lesser number of significant relationships than in the case of the multivariate approach, it helps to ensure a sufficient number of identifying restrictions for factoralization.[8]

The framework comprises four stages. First, the stationary properties of each time-series are investigated to ensure that none of them are integrated at more than order one, I(1), to assure the effectiveness of the pairwise cointegration analysis. In the second stage, pairwise examinations are performed through coefficient t-test, cointegration and Granger causality tests. An F-test is applied on

the first test, while Dicky-Fuller (DF) and Augmented-Dicky-Fuller (ADF) tests up to eight lags are applied in the last two tests. The results of the examination are summarized into a single table. In the third stage, a tentative **K** matrix is constructed based on information from the second stage. In the **K** matrix, coefficients of corresponding pairs of variables having high potential of insignificant, non-Granger-causal and non-cointegrated relationships are set at a value of zero. Then, the remaining unrestricted coefficients of **K** and **B** matrices are estimated to satisfy the conditions in systems (2) to (4). A trial-and-error approach is employed to eliminate and include some remaining unrestricted coefficients to improve the value of log likelihood and to derive the final **K** matrix that results in the less "puzzled" impulse response functions. In the last stage, after the qualified SVAR models are derived, impulse response and variance decomposition analyses are conducted.

## 4. Variable Selection

This study describes the interrelationships among the five channels of transmission mechanisms: the aggregate demand, price, bank credit, asset price, and the exchange rate channels. The SVAR model for each country is comprised of six proxy variables: the industrial/manufacturing production index (Y), consumer price index (P), real bank credit (CREDIT), stock price index (STOCK), real effective exchange rate (REER), and interest rate (INT). All variables are in log levels, except for interest rates which are at levels. For model estimation, monthly data and four lags are employed.[9] The time-series from January 1999 to December 2002 monthly data represents the period of recovery from the Crisis.[10]

Regarding the proxy variable of output, the industrial/manufacturing production index is normally employed for a monthly-based analysis. Annual share of industrial/manufacturing product to GDP has exceeded that of agricultural product in all ASIA-5 countries since before the Crisis. By nature, the manufacturing sector is more capital intensive than the agricultural sector. It is supposed to be more sensitive to monetary policy shocks.

Since price stability is now recognized as one of (if not the only) monetary policy objectives in the ASIA-5, the price effect from transmission mechanism deserves analysis. The consumer price index (CPI) is chosen as a proxy of price. Although the use of the core CPI, which excludes high volatile items such as food and petroleum-related prices, is gaining its significant implication in inflation-targeting framework, limitation of monthly data deprives the application of the variable in this study.

Real commercial bank credit is chosen as a proxy variable in examining the effectiveness of the credit channel in each country to reflect the nature of bank-based financial structure of the ASIA-5. Since the relationships between monetary aggregates and economic variables in the ASIA-5 are claimed unstable, it becomes less interesting to review its effects in the transmission mechanism. On the other hand, the situation after the financial reforms deserves reexamining on the role of bank credits in the transmission mechanism.

Asset price channel has been the least discussed in previous literature. However, as real estate and stock booms can lead to a bubble economy, it is worth understanding to what extent monetary policy can influence the asset prices. Since the proxy variable for real estate is less standardized across countries and is not available on monthly basis, only the stock price index is utilized. Moreover, as stock markets in the ASIA-5 are more developed than bond markets, and their stock price indices are more sensitive to interest rate movement than that of bonds, then the variable is expected to be a better proxy.

The real effective exchange rate is included to reflect the nature of an open economy.[11] The variable is selected as a solution to limit the number of variables while accounting for foreign impacts. Neither PCOM nor the US variables are employed because they were not found useful in solving price "puzzles" in Fung (2002).

Following the suggestion given in Fung (2002), explicit policy interest rates or their closest substitutes are chosen to represent the monetary policy instruments of the ASIA-5. For Indonesia, the one-month SBI (Bank Indonesia Certificates) rate is employed. The overnight call rate is used for the case of Korea. In the case of Malaysia, although the three-month intervention rate is an official policy rate, its adjustments have been infrequent after the economy recovered from the Crisis. This reflects the role of being an intermediate target rather than a monetary policy instrument. Therefore, the three-month interbank rate is selected as it was more often adjusted to represent the Malaysian monetary policy instrument rate. In similar logic, it is accessory to choose an overnight reverse repurchase rate for the case of the Philippines. Its traditional instrument, the ninety-one-day Treasury bill rate is selected instead. In the case of Thailand, the fourteen-day repurchase rate is chosen.

## 5. Empirical Analysis

Shifting towards the floating exchange rate regime in Indonesia, Korea, the Philippines and Thailand theoretically strengthens the exchange rate channels and wealth effects, but weakens the real exchange rate effect and foreign disturbances. A reversal of outcomes is expected to occur in the case of Malaysia, which pursues an opposite exchange rate policy. Financial reforms in the ASIA-5 can be viewed as both sources that may strengthen and weaken other channels. For the credit channel, a closing down of financial institutions, particularly commercial banks, diminishes the degree of financial deepening. However, closer monitoring on bank loans and the declining trend of financial institutions in foreign borrowing represent a positive sign of a stronger linkage between the monetary policy and aggregate demand. Interest rate channels are affected by the decline in interest rate elasticity of investment due less pleasant investment environment after the Crisis. At the same time, the creation of new financial institutions such as bond markets, asset management corporations, and other financial reform measures have promoted the acceleration of settlements on non-performing loans and external debts. This creation provides a positive signal for a more efficient financial system, under which

interest rate channels can play a more important role. Complication also exists in asset price channels as a result of change in short-term interest rate that affect the present value of financial assets in the portfolio of household and corporate sectors.

This empirical study is divided into four parts: the first part follows the framework discussed in Section 3 to specify the identifying restrictions in **K** matrix; the second and third parts are impulse response and variance decomposition analyses; and in the last part a comparison on the channels of transmission mechanisms is summarized.

### 5.1 K matrix

First, the stationary properties of each variable were accessed by performing unit root tests. The results of DF and ADF tests for levels and first order of each corresponding variables suggested that all variables were either stationary at level or not more than at the first order of integration.

Next, in order to select which coefficients in the **K** matrix to be assigned a value of zero, bivariate cointegration regressions of all possible pairs of variables, i.e. $n^2 - n$ different equations were estimated. In addition to noticing the values of adjusted $R^2$, which are symmetrical, Granger causality and cointegration tests for each pair of variables up to eight lags were performed.[12] Table 1 represents the summary matrix of the adjusted $R^2$, which also reflects the results of F-tests as well as the Granger causality and cointegration tests. Independent variables in each pairwise cointegration regression are listed columnwise, while dependent variables are listed rowwise. Regarding the Granger causality tests, since the conclusions are lag dependent, it is more difficult to identify truly causal relationships than truly non-causal ones. A pair of variables can be regarded as having a non-Granger causal relationship when null hypotheses of non-causal relationship for all of the lags are not rejected even at 10% level of significance. In order to reflect the conclusion on non-Granger causality, it was denoted "NG." Similarly, any pair of variables of which null hypotheses of non-stationary residuals in DF and ADF-tests at all lags are not rejected even at 10 % level of significance was denoted "NC," implying the possession of truly non-cointegrated relationships. The remaining relationships with statistically significance, high adjusted $R^2$ without "NG" and "NC" notations were candidates of which corresponding coefficients in **K** matrix were to be left unrestricted.

In order to set up a **K** matrix for each country, it was assumed that the contemporaneous relationships among innovations conform to the results of pairwise relationships. Based on Table 1, by excluding the relationships which have a high potential of possessing non-Granger causality and non-cointegration, the relationships among variables could be summarized in terms of functions. For instance, the functions derived from Table 1 for Indonesia can be written as:

**Table 1 Adjusted $R^2$ Matrix of Variables in Structural VAR models of the ASIA-5**

| | Y | P | CREDIT | STOCK | REER | INT |
|---|---|---|---|---|---|---|
| **Indonesia** | | | | | | |
| Y | 1 | 0.003 | 0.076** | -0.023 NG | 0.036 NG | 0.081** NG |
| P | 0.003 NCa | 1 | 0.033 NCa | 0.255*** NCa | 0.256*** NCc | 0.009 NCa |
| CREDIT | 0.076** NG | 0.033 NG | 1 | 0.078** NCa | 0.055* | 0.741*** |
| STOCK | -0.023 NG, NCc | 0.255*** | 0.078** NCc | 1 | 0.063** NG, NCc | 0.039* NCc |
| REER | 0.036 NG | 0.256*** | 0.055* NCa | 0.063** NCa | 1 | 0.012 NCa |
| INT | 0.081** NG | 0.009 NG | 0.741*** | 0.039* | 0.012 | 1 |
| **Korea** | | | | | | |
| | Y | P | CREDIT | STOCK | REER | INT |
| Y | 1 | 0.581*** | 0.729*** | -0.017 NG | 0.250***NG | 0.312*** |
| P | 0.581*** NG | 1 | 0.921*** | 0.021 NG, NCc | 0.355***NG, NCc | 0.416*** NCc |
| CREDIT | 0.729*** NG | 0.921*** NG | 1 | -0.016 NCa | 0.436***NG | 0.410*** |
| STOCK | -0.017 NG | 0.021 | -0.016 NG | 1 | -0.005 | 0.064** |
| REER | 0.250*** | 0.355*** | 0.436*** | -0.005 NG, NCc | 1 | 0.161*** NCc |
| INT | 0.312*** | 0.416*** | 0.410*** NG | 0.064** NCb | 0.161***NG | 1 |
| **Malaysia** | | | | | | |
| | Y | P | CREDIT | STOCK | REER | INT |
| Y | 1 | 0.396*** NG | 0.379*** NG | 0.053* | -0.003 NG | 0.489*** |
| P | 0.396*** NG, NCa | 1 | 0.879*** | -0.005 NG, NCa | 0.539***NG, NCc | 0.219***NG, NCa |
| CREDIT | 0.379*** NG, NCa | 0.879*** | 1 | 0.017 NCa | 0.469***NG, NCc | 0.164*** NCa |
| STOCK | 0.053* | -0.005 | 0.017 | 1 | 0.176***NG | 0.143*** |
| REER | -0.003 NCa | 0.539*** NCc | 0.469*** | 0.176*** | 1 | -0.006 NCc |
| INT | 0.489*** NG | 0.219*** | 0.164*** NG | 0.143*** NG | -0.006 | 1 |
| **Philippines** | | | | | | |
| | Y | P | CREDIT | STOCK | REER | INT |
| Y | 1 | 0.217*** | 0.465*** | 0.056* NG | -0.021 | 0.271*** |
| P | 0.217*** NCb | 1 | 0.718*** | 0.827*** | 0.524*** NCa | 0.275***NG, NCa |
| CREDIT | 0.465*** NG | 0.718*** | 1 | 0.465*** NG | 0.075** NG, NCa | 0.485***NG |
| STOCK | 0.056* NG, NCc | 0.827*** | 0.465*** | 1 | 0.632***NG, NCc | 0.161*** NCc |
| REER | -0.021 NG, NCc | 0.524*** NG, NCc | 0.075** NG, NCc | 0.632*** | 1 | -0.011 NCc |
| INT | 0.271*** | 0.275*** NG | 0.485*** | 0.161*** | -0.011 | 1 |
| **Thailand** | | | | | | |
| | Y | P | CREDIT | STOCK | REER | INT |
| Y | 1 | 0.371*** | 0.324*** | -0.007 NG | 0.022 NG | 0.004 NG, NCb |
| P | 0.371*** NG | 1 | 0.862*** NCc | 0.260*** NG, NCa | 0.220***NG, NCa | -0.012 NCa |
| CREDIT | 0.324*** NCb | 0.862*** NG | 1 | 0.362*** | 0.257*** NCa | -0.020 NCc |
| STOCK | -0.007 NCc | 0.260*** NG, NCc | 0.362*** | 1 | 0.480*** | -0.007 |
| REER | 0.022 | 0.220*** | 0.257*** NG | 0.480*** | 1 | 0.120*** |
| INT | 0.004 | -0.012 | -0.020 | -0.007 NG | 0.120*** | 1 |

Notes: The value in each cell represents adjusted $R^2$ in bivariate cointegration regression of $Y_t = \beta_o + \beta_1 X_t + \varepsilon_t$ where is $Y_t$ is a dependent variable (listed rowwise) and $X_t$ is independent variable (listed columnwise). ***,** and * indicate rejection of the null hypothesis of coefficient $\beta_1 = 0$ at 1%, 5% and 10% levels of significance, respectively. "NG" indicates acceptance of the null hypothesis of $X_t$ does not Granger cause $Y_t$, at any levels of significance at all legs up to eight lags. "NC" indicates acceptance of null-hypothesis of non-stationary residual value, $\varepsilon_t$, at any levels of significance in both Dicky-Fuller (DF) and Augmented Dicky-Fuller (ADF) tests at all lags up to eight legs. The subscriptions a, b and c refer to acceptance of the null hypotheses regardless of types of tests and the number of lags imposed; rejection of the null-hypothesis only under DF-test; and rejection of the null hypotheses only under ADF test at just particular lags, respectively.

a. **Indonesia**

$$\varepsilon_P = f(\varepsilon_{REER}^*, \mu_P) \quad (6)$$
$$\varepsilon_{REER} = f(\varepsilon_P, \mu_{REER})$$
$$\varepsilon_{STOCK} = f(\varepsilon_P, \varepsilon_{CREDIT}^*, \varepsilon_{INT}^*, \mu_{STOCK})$$
$$\varepsilon_Y = f(\varepsilon_{CREDIT}^*, \mu_Y)$$
$$\varepsilon_{CREDIT} = f(\varepsilon_{REER}^*, \varepsilon_{INT}, \mu_{CREDIT})$$
$$\varepsilon_{INT} = f(\varepsilon_{STOCK}^*, \varepsilon_{CREDIT}, \varepsilon_{INT})$$

An asterisk is placed on any coefficient if its corresponding relationship in the cointegration test is marked "NCb" and "NCc," or the one of which the value adjusted $R^2$ is less than 0.10 (although it is statistically significant). It is also worth noting that the order of relationships for each country is different. The purpose of such an arrangement is to indicate the degree of exogenity based on empirical data. However, in ordering the functions, the variables with * were ignored. The order can be useful in estimating UVAR.

From the functions in systems (6), let $\boldsymbol{\varepsilon}_{t\text{Indonesia}}$ is a (6 x 1) vector of innovations $[\varepsilon_P, \varepsilon_{REER}, \varepsilon_{STOCK}, \varepsilon_Y, \varepsilon_{CREDIT}, \varepsilon_{INT}]'$. The order of variables in the vector follows the order of functions in the above system. A tentative **K** matrix can be written as:

$$\begin{bmatrix} 1 & \alpha_{12}^* & 0 & 0 & 0 & 0 \\ \alpha_{21} & 1 & 0 & 0 & 0 & 0 \\ \alpha_{31} & 0 & 1 & 0 & \alpha_{35}^* & \alpha_{36}^* \\ 0 & 0 & 0 & 1 & \alpha_{45}^* & 0 \\ 0 & \alpha_{52}^* & 0 & 0 & 1 & \alpha_{56}^* \\ 0 & 0 & \alpha_{63}^* & 0 & \alpha_{65} & 1 \end{bmatrix} \quad (7)$$

The trial-and-error process started from setting value zero on inconclusive coefficients with asterisk marks then estimated the remaining unrestricted coefficients in **K** matrix and diagonal elements in **B** matrix by the maximum likelihood technique. The method of scoring was employed in maximizing the log likelihood. In the optimization process, the maximum number of iterations of 500 was imposed.[13] Before adding and eliminating unrestricted coefficients in the **K** matrix, the value of log likelihood and signs of impulse response functions against one standard deviation change in interest rate were observed. For Indonesia, $\alpha_{12}$, $\alpha_{52}$, and $\alpha_{63}$ were eliminated from the tentative **K** matrix. Therefore, the final **K** matrix for Indonesia replicates the following relationships:

$$\varepsilon_P = f(\mu_P) \quad (8)$$
$$\varepsilon_{REER} = f(\varepsilon_P, \mu_{REER})$$
$$\varepsilon_{STOCK} = f(\varepsilon_P, \varepsilon_{CREDIT}^*, \varepsilon_{INT}^*, \mu_{STOCK})$$
$$\varepsilon_Y = f(\varepsilon_{CREDIT}^*, \mu_Y)$$
$$\varepsilon_{CREDIT} = f(\varepsilon_{INT}, \mu_{CREDIT})$$
$$\varepsilon_{INT} = f(\varepsilon_{CREDIT}, \mu_{INT})$$

LR = 387.3511 Chi-square (9) = 65.246 Prob. = 0.0000

The value of log likelihood (LR) of the derived structural VAR is 387.3511, and its likelihood ratio test statistics of Chi-square with nine degrees of freedom is 65.24, which is equivalent to 0% probability (Prob.) to reject the null hypothesis of over-identification.

Similar steps were repeated to the remaining countries and present only final relationships from which the **K** matrix was set.

b. **Korea**

For Korea, after the trial-and-error process, $\alpha_{34}$, $\alpha_{45}$, $\alpha_{62}$, $\alpha_{63}$ and $\alpha_{64}$ were eliminated from the tentative **K** matrix. The final **K** matrix for Korea replicates the following relationships:

$$\begin{aligned}
\varepsilon_{STOCK} &= f(\varepsilon_{INT}^{*}, \mu_{STOCK}) \\
\varepsilon_{Y} &= f(\varepsilon_{P}, \varepsilon_{CREDIT}, \varepsilon_{INT}, \mu_{Y}) \\
\varepsilon_{P} &= f(\varepsilon_{INT}^{*}, \mu_{P}) \qquad (9) \\
\varepsilon_{CREDIT} &= f(\mu_{CREDIT}) \\
\varepsilon_{INT} &= f(\varepsilon_{STOCK}^{*}, \varepsilon_{Y}, \varepsilon_{P}, \mu_{INT}) \\
\varepsilon_{REER} &= f(\varepsilon_{INT}^{*}, \mu_{REER})
\end{aligned}$$

LR = 640.197 Chi-square (7) = 15.596 Prob. = 0.0291

c. **Malaysia**

For Malaysia, after the trial-and-error process, only $\alpha_{12}$ was eliminated from the tentative **K** matrix. The final **K** matrix for Malaysia replicates the following relationships:

$$\begin{aligned}
\varepsilon_{P} &= f(\mu_{P}) \qquad (10) \\
\varepsilon_{CREDIT} &= f(\varepsilon_{P}, \mu_{CREDIT}) \\
\varepsilon_{INT} &= f(\varepsilon_{P}, \varepsilon_{INT}) \\
\varepsilon_{REER} &= f(\varepsilon_{P}^{*}, \varepsilon_{CREDIT}, \varepsilon_{STOCK}, \mu_{REER}) \\
\varepsilon_{STOCK} &= f(\varepsilon_{INT}, \varepsilon_{Y}^{*}, \mu_{STOCK}) \\
\varepsilon_{Y} &= f(\varepsilon_{INT}, \varepsilon_{STOCK}^{*}, \mu_{Y})
\end{aligned}$$

LR = 662.511 Chi-square (8) = 33.237 Prob. = 0.0001

d. **Philippines**

For the Philippines, after the trial-and-error process, only, $\alpha_{12}$, $\alpha_{21}$, $\alpha_{23}$, $\alpha_{24}$ and $\alpha_{63}$ were eliminated from the tentative **K** matrix. The final **K** matrix for the Philippines replicates the following relationships:

$$\begin{aligned}
\varepsilon_{CREDIT} &= f(\mu_{CREDIT}) \\
\varepsilon_{P} &= f(\mu_{P}) \qquad (11) \\
\varepsilon_{Y} &= f(\varepsilon_{CREDIT}, \varepsilon_{P}, \varepsilon_{INT}, \mu_{Y}) \\
\varepsilon_{STOCK} &= f(\varepsilon_{CREDIT}, \varepsilon_{P}, \varepsilon_{INT}^{*}, \mu_{STOCK}) \\
\varepsilon_{REER} &= f(\varepsilon_{STOCK}, \mu_{REER}) \\
\varepsilon_{INT} &= f(\varepsilon_{CREDIT}, \varepsilon_{STOCK}, \mu_{INT})
\end{aligned}$$

LR = 511.030 Chi-square (6) = 60.628 Prob. = 0.0000

e. **Thailand**

For Thailand, after the trial-and-error process, only $\alpha_{26}, \alpha_{34}, \alpha_{43}$ and $\alpha_{62}$ were eliminated from the tentative **K** matrix. The final **K** matrix for Thailand replicates the following relationships:

$$\varepsilon_P = f(\varepsilon_{CREDIT}^{*}, \mu_P) \quad (12)$$

$$\varepsilon_{INT} = f(\mu_{INT})$$

$$\varepsilon_{CREDIT} = f(\varepsilon_{STOCK}, \mu_{CREDIT})$$

$$\varepsilon_Y = f(\varepsilon_P, \mu_Y)$$

$$\varepsilon_{STOCK} = f(\varepsilon_{CREDIT}, \varepsilon_{REER}, \mu_{STOCK})$$

$$\varepsilon_{REER} = f(\varepsilon_P, \varepsilon_{STOCK}, \mu_{REER})$$

LR = 601.869 Chi-square (8) = 24.820 Prob. = 0.0017

## 5.2 Impulse Response Analysis

Table 2 summarizes the signs of impulse response functions following a one-time shock to interest rate innovation. Expected signs of each impulse response for the initial period are listed in the first row. The results from Fung (2002) are summarized in the second row. The third row presents the results after constructing UVAR models based on the order of the variables in 5.1. The results from the proposed SVAR models are presented in the last row.

**Table 2 Impulse Responses to One Standard Deviation of Interest Rate Shock**

| **Indonesia** | P | REER | STOCK | Y | CREDIT | INT |
|---|---|---|---|---|---|---|
| Expected | — | + | — | — | — | + |
| Fung (2002) | — | — | NA | — | NA | + |
| UVAR | — | + | + | — | — | + |
| SVAR | — | + | —* | — | — | + |
| **Korea** | STOCK | Y | P | CREDIT | INT | REER |
| Expected | — | — | — | — | + | + |
| Fung (2002) | NA | — | + | NA | + | + |
| UVAR | + | — | + | — | + | — |
| SVAR | + | — | — | — | + | + |
| **Malaysia** | P | CREDIT | INT | REER | STOCK | Y |
| Expected | — | — | + | + | — | — |
| Fung (2002) | — | NA | + | + | NA | — |
| UVAR | — | + | + | — | + | + |
| SVAR | — | — | + | — | + | — |
| **Philippines** | CREDIT | P | Y | STOCK | REER | INT |
| Expected | — | — | — | — | + | + |
| Fung (2002) | NA | + | + | NA | — | + |
| UVAR | + | — | + | — | + | + |
| SVAR | — | — | +* | + | + | + |
| **Thailand** | P | INT | CREDIT | Y | STOCK | REER |
| Expected | — | + | — | — | — | + |
| Fung (2002) | + | + | NA | — | NA | + |
| UVAR | — | + | + | — | + | + |
| SVAR | — | + | — | — | + | + |

Notes: * remarks the impulse response function of which value of the first period is less than absolute one basis point and the value in next following period has opposite sign. Ordering of variables follows conclusion on the degree of exogenity in 5.1.

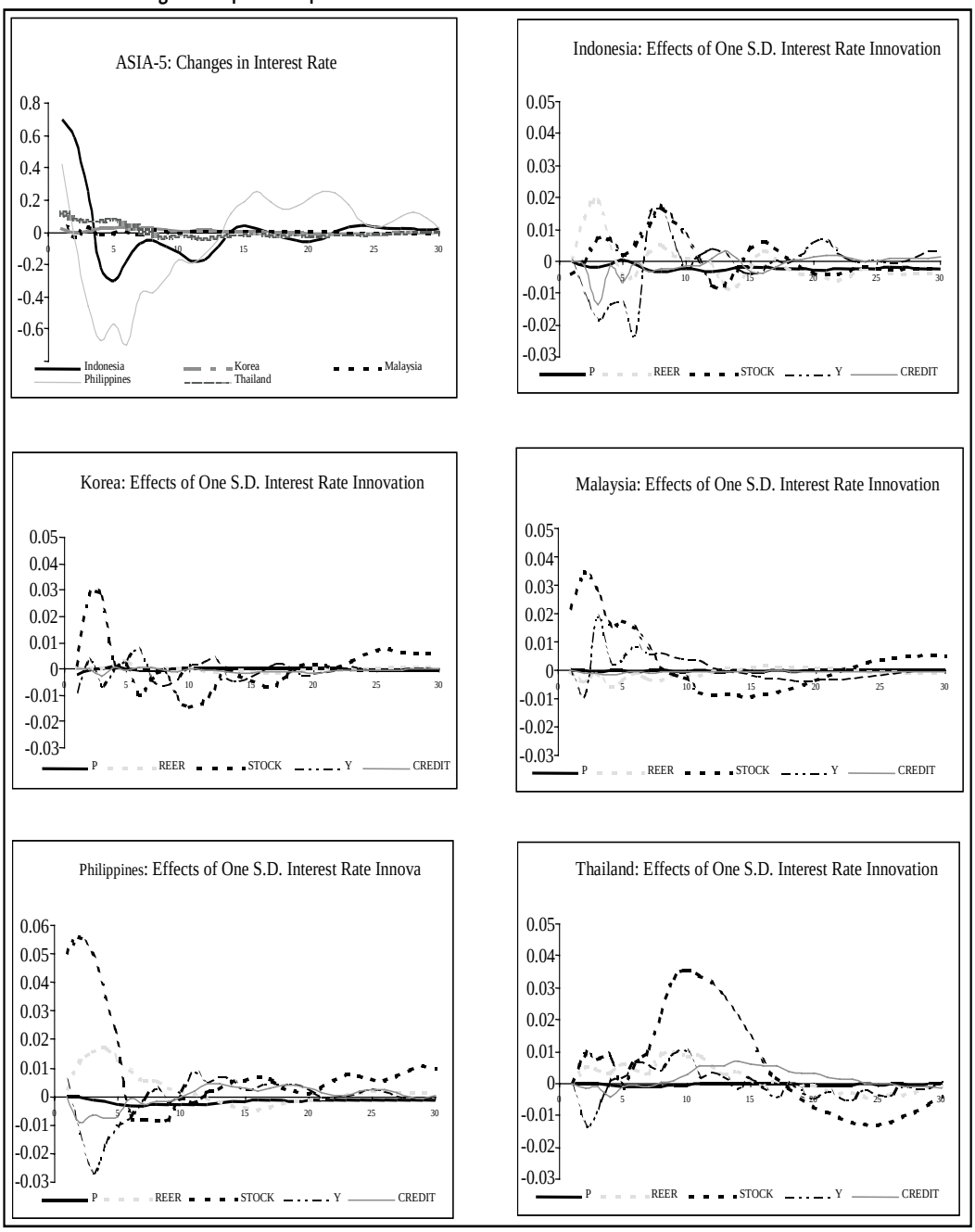
Compared with the results in Fung (2002), the UVAR models based on the empirical order of exogenity could resolve "price puzzles" in the Philippines and Thailand, but not in Korea. However, they also led to new STOCK puzzles to the ASIA-5, except for the Philippines; Y puzzles to Malaysia and the Philippines; CREDIT puzzles to Malaysia, the Philippines, and Thailand; and, REER puzzles to Korea and Malaysia. After imposing structural identifying restrictions according to the proposed scheme, nearly all puzzles in all ASIA-5 countries could be resolved, except for the STOCK puzzle in all countries, and the REER puzzle in Malaysia. This reduction in the number of puzzles strongly illustrates that the proposed structural identifying scheme is superior to the Choleski decomposition scheme in attaining expected signs of impulse response functions of interest rate disturbance. The "puzzles" found on STOCK, on one hand, may be due to model misspecification problem. On the other hand, it may be related with the well-claimed nature of the inefficient stock markets in the developing countries, not except for the ASIA-5.

The first graph in Figure 1 shows that interest rates in all ASIA-5 countries rose immediately after tightening in the monetary policy which results in one standard deviation rise in INT. Similar to the findings of Fung (2002), relatively large increases in interest rates were found in Indonesia and the Philippines. The rates were below 20% in the remaining countries. Looking at the lengths of the interest rate rise in each country, the impacts after the shock were equally very short-lived in Korea, Malaysia, and the Philippines (about one month), followed by Indonesia (three months). In Thailand, although the rise in the interest rate was not relatively high, the impact lasted for about seven months. In ranking, the magnitude of INT response, the Philippines and Indonesia had the highest fluctuations, followed by Thailand. In both Korea and Malaysia, the ranged of variations were relatively very low.

In Indonesia, the monetary shock was equivalent to an increase in INT around 70.16%. It led to a substantial decline in Y which bottomed out in six months at around 2.26% below the baseline. In contrast, the P response was very small but remained below the baseline through out thirty months, at the range of 0.08 to 0.35%. REER responded positively to the INT shock as would be expected. It stayed above baseline for four months at the peak of 1.90% in the third month. STOCK declined by 0.42% immediately after the INT shock. However, after a month, the trend was reversed for ten months, reaching its peak in the eighth month at 1.65%, before returning below the baseline again. The CREDIT slowly declined in first two months and reached bottom in the third month at -1.37%.

The INT shock caused only a rise in INT of 1.88% in Korea. This led to less pervasive impacts. All responses, except for that of STOCK, fluctuated within small ranges not exceeding -0.1 to 0.1%. However, the negative responses of P and Y were rapid and short-lived compared with the case of Indonesia. The STOCK response stayed positive for five months, with a rather high peak of 2.84% in the second month, before declining below the baseline of thirteen months. The CREDIT response could also be observed from the second month. The negative response was obvious for two months

**Figure 1 Impulse Response Functions to One S.D. Interest Rate Innoration in the ASIA-5**




before a fluctuation in the narrow range between -0.02 to 0.06%.

In Malaysia, the INT shock resulted in immediate but short-lived INT response of 11.48%. The STOCK response appeared the most sensitive to the shock, with the immediate positive response of 2.16% and the peak of 3.41% in the following month. It stayed above the baseline for eight months before the response becomes negative. Responses of P and Y could be observed from the second

month. However, the latter was shorter-lived and more fluctuating than the former. After five months, the P response remained mildly negative at below -0.01% throughout the remaining twenty-five months. Negative CREDIT response could be observed from the second month. The response, although represented low sensitivity to the INT shock, was persistently below the baseline throughout the remaining twenty-nine months.

The INT response in the Philippines was sensitive but short-lived to the INT shock. After an immediate rise of 41.67%, the INT response suddenly fell and stayed below the baseline for around twelve months. The INT shock also led to immediate positive responses on REER, STOCK, and Y; however, the last response turned negatively from the second month and stayed for six months at the bottom of -2.67% in the third month. Negative CREDIT response could be observed from the second month and remained below the baseline for nine months. The P response remained persistently mildly negative at below -0.01% throughout the remaining twenty-nine months.

In Thailand, the INT shock resulted in an INT rise of 13.53%. Other effects could be observed only from the second month, except for the P response which was clear from the fourth month. The STOCK response stood out as the most obvious because of its relatively high and long period above the baseline for seventeen months with a peak in the eleventh month at 3.37%. The REER response showed a parallel movement, at a lower magnitude, with STOCK response, noticeable from the change in signs of the response during thirty months. The Y response was moderately short-lived, compared with that of the other ASIA-5 countries. It remained below the baseline just for three months, with a bottom of -1.31% at the second month. Fluctuations could be observed throughout thirty months.

### 5.3 Variance Decomposition

A variance decomposition analysis to compare the relative importance of each structural innovation was conducted. The results, summarized in terms of average percentage of variation attributed to each innovation over thirty months, are presented in Table 3. For each endogenous variable, the values of the fraction of the forecast error variance corresponding to each shock are listed rowwise to attend to the summation of 100 %.

From Table 3, “own shock” was mostly the main source of variation in all variables, except for: REER in Indonesia; INT in Korea; P, STOCK and INT in the Philippines; and, STOCK and CREDIT in Thailand. Innovation in P was the main source of variation in INT for Korea, and in REER for Malaysia. On the other hand, innovation in REER was the main source of variation in CREDIT for the Philippines. The opposite direction could be observed in Indonesia. As for Thailand, the innovation in CREDIT was the main source explaining the variation in STOCK, while the innovation in STOCK was also the main source of variation in CREDIT.

Narrowing down the discussion, a special emphasis was placed on the variation in P that is related

**Table 3 Average Variance Decomposition over 30 Months in the ASIA-5**

| **Indonesia** | P | REER | STOCK | Y | CREDIT | INT |
|---|---|---|---|---|---|---|
| P | 50.84 | 10.56 | 17.49 | 1.67 | 6.35 | 13.08 |
| REER | 4.97 | 28.74 | 19.02 | 3.54 | 35.50 | 8.23 |
| STOCK | 3.26 | 18.82 | 44.01 | 2.78 | 27.77 | 3.36 |
| Y | 9.53 | 14.95 | 12.64 | 34.05 | 19.57 | 9.26 |
| CREDIT | 2.67 | 7.58 | 11.71 | 3.71 | 69.32 | 5.01 |
| INT | 3.20 | 10.38 | 17.41 | 1.80 | 30.60 | 36.61 |
| **Korea** | STOCK | Y | P | CREDIT | INT | REER |
| STOCK | 53.50 | 8.91 | 17.85 | 7.23 | 8.31 | 4.20 |
| Y | 18.19 | 34.92 | 3.70 | 29.98 | 7.60 | 5.60 |
| P | 22.11 | 13.65 | 23.61 | 18.87 | 12.64 | 9.12 |
| CREDIT | 9.90 | 14.47 | 3.82 | 65.19 | 1.91 | 4.70 |
| INT | 10.47 | 18.99 | 46.04 | 13.12 | 5.82 | 5.57 |
| REER | 16.49 | 9.12 | 12.00 | 17.18 | 1.96 | 43.25 |
| **Malaysia** | P | CREDIT | INT | REER | STOCK | Y |
| P | 54.76 | 20.65 | 2.13 | 15.27 | 3.76 | 3.42 |
| CREDIT | 23.15 | 42.19 | 4.17 | 14.62 | 1.77 | 14.10 |
| INT | 27.03 | 3.17 | 36.00 | 13.60 | 3.88 | 16.32 |
| REER | 34.34 | 6.41 | 8.42 | 32.62 | 5.89 | 12.33 |
| STOCK | 22.16 | 14.84 | 19.65 | 0.70 | 32.37 | 10.28 |
| Y | 14.85 | 6.10 | 17.49 | 1.10 | 19.27 | 41.20 |
| **Philippines** | CREDIT | P | Y | STOCK | REER | INT |
| CREDIT | 16.59 | 24.34 | 7.66 | 4.22 | 30.94 | 16.25 |
| P | 14.29 | 26.99 | 2.40 | 0.71 | 27.37 | 28.23 |
| Y | 3.79 | 9.39 | 35.36 | 8.95 | 26.22 | 16.30 |
| STOCK | 10.95 | 8.27 | 5.67 | 15.07 | 7.76 | 52.29 |
| REER | 11.95 | 1.22 | 4.55 | 3.88 | 50.31 | 28.09 |
| INT | 13.55 | 9.23 | 7.86 | 18.15 | 25.83 | 25.40 |
| **Thailand** | P | INT | CREDIT | Y | STOCK | REER |
| P | 42.32 | 6.62 | 1.47 | 10.85 | 35.08 | 3.67 |
| INT | 35.43 | 37.13 | 2.20 | 14.01 | 9.18 | 2.04 |
| CREDIT | 6.39 | 9.32 | 15.28 | 8.00 | 52.59 | 8.42 |
| Y | 14.77 | 10.64 | 12.82 | 39.52 | 13.80 | 8.45 |
| STOCK | 7.60 | 13.50 | 47.13 | 13.88 | 13.94 | 3.94 |
| REER | 8.54 | 15.99 | 21.81 | 14.52 | 11.34 | 27.80 |

Note: The ordering of variables follows Table 2.

with the price stability, the most important (if not the only) monetary policy objective in most countries. In Indonesia, the forecast variance errors in P were mainly due to "own shock," followed by STOCK and INT (50.84, 17.49 and 13.08%, respectively). Innovations in CREDIT, followed by INT, were the next important sources after "own shock" for the case of Korea. Innovations in INT and REER were more important than "own shock" in the case of the Philippines. In Thailand, next to "own shock," innovations in STOCK and Y were more important than that in INT. On the other hand, in Malaysia, innovation in INT was not at all as significant as those in CREDIT and REER in explaining the variation in P. This conforms to the theoretical expectation that under the fixed exchange rate regime the influence of monetary policy on price is less powerful than under the flexible exchange rate regime.

### 5.4 Channels of Transmission Mechanisms

This subsection begins with showing the effects on aggregate demand and price, and then

describes the other three channels of transmission mechanisms.

Regarding the aggregate demand effect, Y declined after an interest rate rise in the Philippines and tended to last the longest, at least eight months, before it turned positive. It took six months for Indonesia, three months for Thailand, two months for Malaysia, and one month for Korea. However, it is worth keeping in mind that the proxy employed to indicate output is the log of industrial/ manufacturing production index.[14] The results are quite dependent on the nature of samples of industries/manufactures from which the indices are calculated.

A "price puzzle" - increase in P after a rise in INT - was not found in any country. The price was found relatively the most insensitive among all variables in the ASIA-5. A small sudden decline in P was found only in Korea, while it was gradual in the remaining countries. Despite minimal changes observable on P, the signs of the effect for all ASIA-5 countries remained mildly negative though thirty months. This confirms the nature of price stickiness in these countries. The immediate price response in Korea reflected high sensitivity of public expectation against the change in monetary policy. This may be a fruit from the successfulness in adopting an explicit monetary policy objective of price stability and the increase in monetary policy credibility.

The bank credit channel in terms of the response of real bank credit, CREDIT, in all ASIA-5 countries was negative to the rise in interest rate as expected, although at a different degree of sensitivity. The bank credit channel was relatively the most significant in Indonesia and the Philippines where it took eleven and ten months for the real bank credit to start rising again. The variable was found relatively insensitive in Malaysia (one month) and Korea (three months), as the responses were very short-lived. In the most intermediate case, Thailand, took about seven months. The order exactly followed that of magnitude of variation in INT. This confirms the general perception of the negative relationship between interest rate and demand for credit.

For asset price channel, the rises in stock price indices, STOCK, were found in the ASIA-5 after the interest shock. Particularly, in Malaysia and the Philippines, the only two countries where average ratio of stock capitalization to GDP from 1998 to 1999 was higher than that of bank credits, the indices even jumped immediately after an interest rate rise and further rose for a month before declining. The phenomenon, at first glance, replicates a "puzzle" contradictory to the traditional Tobin's Q theory on portfolio reallocation, implying that the interest rate rise should lead to a decline in stock price as its rate of returns becomes less attractive. However, when applying this theory to an international perspective, the increase in interest rate differential can also lead to an international readjustment of capital portfolios, including stocks. At the initial stage, the effect of capital inflows via the stock markets might have been stronger and more rapid than the domestic portfolio reallocation effect to the extent that the net adjustment of STOCK showed a positive sign. In Malaysia, the undervalued exchange rate possibly promoted the capital inflows. STOCK and REER move nearly perfectly in the opposite direction, although the latter is less fluctuating.

For the real effective exchange rate channel, REER in the ASIA-5, except for Malaysia, appreciated after the interest rate rise. For the first five months, REER appreciated relatively high (above one basis point) in Indonesia and the Philippines, the countries where changes in interest rates were recognized as the largest. The appreciation was observable from the third month for Korea. The exchange rate "puzzle" found in the case of Malaysia might be related with the fixed exchange rate regime that resulted in the undervalue of its domestic currency in response to interest rise. When CPI remains sticky if there is a surge in capital inflows as interest rate differential arise, the trade deficit against the host countries of capital inflows help to explain a possible decline in REER.

## 6. Conclusions and Policy Implications

This article recognized the "price puzzle" arising from the use of a recursive unrestricted VAR in the study of monetary policy transmission mechanisms. An alternative scheme for setting in identifying restrictions in coefficient matrix of innovations was proposed to resolve two main problems that true structural relationships among variables were not known, and the time-series was not wide enough to allow multivariate analysis. The scheme was based on the empirical characteristics of Granger causality and cointegration of pairwise relationships. Despite its lengthy process, it provided more meaningful results in terms of the correct signs of impulse response functions to the interest rate shock rather than what was provided by the recursive scheme.

The results of impulse response from the structural VAR models, based on the proposed identification scheme, suggest that the monetary policy shock caused an immediate response to interest rates in the ASIA-5. The immediate interest effect was the highest in Indonesia, followed by the Philippines, Thailand, Malaysia and Korea, respectively. The order was also the same for the relative magnitude of fluctuation.

From the variance decomposition analysis, the first interesting finding was that innovation in interest rate played relatively the least significant role in explaining the price variation in Malaysia, the only country that has adopted fixed exchange rate regime. This finding conforms well to the theoretical expectation. The ranking of countries where by the fraction of interest rate innovation was found significant in explaining the price variation was the Philippines, Indonesia, Korea, Thailand, and Malaysia. The finding implies that interest rate policy was less effective in affecting the price in Thailand and Malaysia, but rather had more influence on the stock price index and output for Malaysia, and on real effective exchange rate and stock price index for Thailand. The interest rate innovation had a significant influence not only on the variation in price, but also on those of the stock price index and the real effective exchange rate.

Differences in transmission mechanisms among the ASIA-5 tended to be related with differences in economic structure, monetary policy credibility, and exchange rate regime. As for the structural factor, the degree of industrialization and bank credit domination in domestic financing could help to

explain responsiveness of the aggregate demand effect and stock price response. In addition to the structural factor, the monetary policy credibility in attaining a price stability objective might influence the responsiveness of price adjustment. Differences between nominal and real exchange rates due to non-flexible exchange rate regime, on other hand, might have an implication on the direction of real effective exchange rates.

Despite the different economic structures among the ASIA-5, some common characteristics of their transmission mechanisms can be drawn. The stock price index represented the most relatively sensitive variable to interest rate shock among all variables in the model, with a "puzzle" on its sign of impulse response function. The rankings for the remaining variables from the second most sensitive were output, the real effective exchange rate, real bank credit and price, respectively. The finding implies that trying to adjust the price level via the interest rate instrument may not be appropriate due to price stickiness. Moreover, the foregone output and fluctuations in stock price indices as well as real effective exchange rate, were the tradeoffs in exchange for price control.

## Notes

1. Examples of the studies are Mohanty and Klau (2001), Mihaljeck and Klau (2001), Waiquamdee (2001).
2. Particularly, the GDP or GNP that proxies real sector.
3. This definition is shared by McCallum (1999).
4. An example of a narrative analysis on transmission mechanism is Mishkin (1996).
5. For a micro view, a corporate flow of fund data is necessary. However, the focus of this article is on a macro perspective.
6. The original form of a **K**-model in Amisano and Giannini (1997) implies that **B** matrix is a unit matrix.
7. In order to analyze the possible number of cointegration among variables, Johansen cointegration test can be applied. However, the problem of degree of freedom limits its application in this study.
8. The less number of signification relationships can be explained by the existence of multicollinearity.
9. Although Akika, Schwarz, and Hannan-Quinn information criteria are frequently used in selecting the optimal lag length, the author has employed four lags for the purpose of compatibility with quaterly-based studies that usually employ at least one lag.
10. Almost all time-series used in this analysis are available in http://aric.adb.org/user_defined_indicators.asp. Names of sources follow those presented in the website.
11. The calculation was performed by Asian Recovery Information Center, Asian Development Bank. See details in http://aric.adb.org/technicalnotes.asp
12. The results of unit root tests, Granger causality tests and Cointegration tests can be presented upon request.
13. The computer software used was EViews 4.0.
14. The author performed Granger causality and cointegration tests on the relationships between log real GDP (RGDP) and log industrial/production index (IND) and found that the causal relationships, on quarterly basis

from 1992q2 to 2002q4, differed across countries. In Korea, both variables were highly correlated with bilateral relationships. On the other hand, the relationships were found insignificant in Indonesia and the Philippines. For Malaysia, the value of adjusted $R^2$ was very high without the evidence of causal relation. One-way direction, which was from Y-RGDP to Y-IND, was found in the case of Thailand.

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