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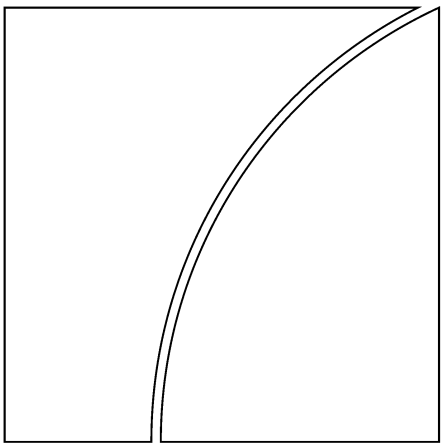

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A VAR analysis of the effects of monetary policy in East Asia

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Abstract

In this paper, a VAR model is used to study the effects of monetary policy shocks in seven East Asian economies. For each economy, the same identification scheme is imposed and the dynamic responses to a monetary shock are examined in the light of the predictions of monetary theory. The results suggest that the VAR model produces sensible impulse response functions for most of the economies, especially for the sample that ends before the 1997 Asian financial crisis. Given the openness of these economies, the exchange rate plays a significant role in the formulation of monetary policy. In order to capture explicitly the importance of the exchange rate in these economies, plausible weights are also imposed on the exchange rate to identify the model.

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Keywords: VAR, monetary policy shocks, East Asia

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1. Introduction[1]

Monetary policy in East Asia has undergone considerable changes in the last two decades. Most notably, many Asian economies have moved to a more flexible exchange rate regime since the Asian crisis in 1997. To maintain a nominal anchor, the central banks of Indonesia, Korea, the Philippines and Thailand have also adopted the rate of inflation as the main target of monetary policy. Other central banks in the region that do not have an explicit inflation target have also sought price stability as one of their objectives of monetary policy. In general, there is a tendency for central banks in the region to shift from focusing on exchange rate stability to price stability.

A better understanding of the monetary transmission mechanism is very important because it helps the central bank determine the proper course of monetary policy to keep inflation within a desirable range. However, there is still a great deal of uncertainty about the effects of monetary policy on economic activity and prices. Recent empirical and theoretic studies, mainly focusing on the United States, tend to come to the view that a contractionary monetary policy shock leads to an immediate rise in the interest rate, a temporary decline in output and money, and a gradual decrease in prices. The objective of this paper is to examine whether there are similar effects of monetary policy in East Asia. In addition, it would be useful to identify any major differences in these effects across the economies and over time. This kind of international comparison of the transmission mechanism is particularly important in the context of increasing monetary cooperation in the region.

A large part of the existing empirical work related to the study of the effects of monetary policy is VAR-based, following the seminal work of Sims (1980). Leeper et al (1998) and Christiano et al (2000) provide a good review of what one can learn from this extensive literature of VAR analysis of the monetary transmission mechanism. While most of the existing work focuses on the United States, this VAR approach has also been applied to many economies around the world. For example, Fung and Kasumovich (1998) find that M1 innovations in several industrialised countries produce impulse responses that are consistent with what one would expect from a monetary policy shock. Mojon and Peersman (2001) find consistent effects of monetary policy shocks in 10 countries of the euro area for the pre-EMU period, while Peersman and Smets (2001) find that a VAR approach generates sensible results using synthetic euro area data.

This paper examines whether a simple identified VAR can generate dynamic responses to a monetary policy shock that are consistent with the description above in seven East Asian economies, namely Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan, China (hereinafter Taiwan) and Thailand. To date, a very limited amount of similar work has been done on emerging Asian economies. Recently, Crosby and Otto (2001) have used a VAR model to examine the speed of recovery of output following an interest rate shock in a number of Asian economies. Several problems make it less straightforward to apply this kind of study in East Asia: data availability and quality, frequent structural breaks owing to rapid changes in these economies as well as changes in monetary policy such as operating procedures, policy instruments and policy objectives. Despite these potential problems, the VAR model developed in Bernanke and Mihov (1998) is applied to examine whether sensible results could be generated using data from the seven economies.[2] To identify the monetary policy shock, the interest rate and the exchange rate are considered as the policy variables for the following reasons. First, a short-term interest rate is often the central bank's policy instrument and many recent studies have suggested that a short-term interest rate is capable of capturing monetary policy. Hence, it would be of interest to see whether this is the case in these Asian economies. Second, the exchange rate is also included as a policy variable because these East Asian economies range from the open to the super-open (Table 1). The exchange rate channel is one of the key channels of monetary transmission. A contractionary monetary policy leads to an appreciation of the

[1] The author would like to thank Corrinne Ho, Guonan Ma, Robert McCauley, Mingwei Yuan and seminar participants at the Bank for International Settlements, the Hong Kong Institute of Monetary Research and the Monetary Authority of Singapore for their comments and suggestions.

[2] Bernanke and Mihov (1998) suggest a VAR methodology in which there is no need to assume a priori a single variable to be the best indicator of policy. This methodology has been applied to Germany (Bernanke and Mihov (1997)), Italy (De Arcangelis and Di Giorgio (1998)) and Canada (Fung and Yuan (2000)). Monetary policy, though not directly observed, can be measured by examining the behaviour of a set of observed variables, which are called policy variables or indicators. These policy variables are directly influenced by monetary policy within a period.

local currency, which in turn will reduce exports and exert downward pressure on inflation. The currency appreciation will also reduce domestic inflation through lower import prices. The more open the economy, the more important the exchange rate channel. In the case of Singapore, the exchange rate is also the acknowledged monetary policy instrument. Thus it is important and useful to include the exchange rate in studying the transmission mechanism and measuring monetary policy in East Asia.

Table 1

Openness of selected East Asian economies (as of June 2001)

	Export share of GDP[1]	Percentage of exports		
		to United States	to Japan	to euro area
Indonesia[2]	38.55	13.85	21.80	10.27
Korea	45.50	19.85	11.99	9.68
Malaysia[3]	128.23	20.16	13.85	10.50
Philippines	46.90	28.65	16.57	15.82
Singapore	179.91	15.51	8.36	10.37
Taiwan	53.39	...	...	...
Thailand	67.04	20.80	15.89	12.83

[1] Exports of goods and services from line 90, on a national accounts basis, as a percentage of GDP. [2] Data for 2000. [3] Data for 2000 Q4.

Source: *International Financial Statistics*, IMF.

After estimating the model, impulse response functions of the orthogonalised innovations to the monetary policy are generated to trace out the dynamic responses of other variables in the VAR to monetary policy innovations. These impulse responses allow the assessment of whether the shock identified can be interpreted as a monetary policy shock, by comparing the results to the consensus view of the transmission mechanism. The results of the VAR studied here are found to be broadly consistent with these expected effects: following a contractionary policy shock, the interest rate rises, output, the price level and money decline, and the local currency appreciates. There is also a substantial variation of these responses across economies and particularly across subsamples. The sample that excludes the Asian crisis period tends to produce results that are more consistent with the expected effects for most economies. Only a small weight on the exchange rate in the monetary policy measure in most economies studied is found, despite their high degree of openness. In order to examine whether the model underestimates this weight and hence produces some of the puzzling impulse response functions, the weight on the exchange rate is imposed as a way to identify the VAR model. Such an exercise helps correct some of the perverse results found in the earlier approach.

The rest of the paper is organised as follows. The next section offers a brief discussion of the VAR-based methodology and the identifying restrictions. The data and the estimation method are described in Section 3. The results are reported and discussed in Section 4. The importance of the exchange rate on the impulse response functions of the monetary policy shocks is also examined. The last section presents the conclusion and some suggestions for future research.

2. The VAR model and identification

2.1 Methodology

This section briefly describes the VAR model used to analyse the effects of monetary policy in the seven East Asian economies. As described in Bernanke and Mihov (1998), suppose that the "true" economic structure is the following unrestricted linear dynamic model:

$$Y_t = \sum_{i=0}^{k} B_i Y_{t-i} + \sum_{i=0}^{k} C_i P_{t-i} + A^y V_t^y \tag{1}$$

$$P_t = \sum_{i=0}^{k} D_i Y_{t-i} + \sum_{i=0}^{k} G_i P_{t-i} + A^p V_t^p \tag{2}$$

where B_i, C_i, A^y, D_i, G_i and A^p are square coefficient matrices. Equations (1) and (2) partition the variables under consideration into two groups: a non-policy block (Y) and a policy block (P). The vector Y_t contains non-policy macroeconomic variables such as output and prices, whose responses to monetary policy shocks are to be examined. The vector P_t includes policy or monetary variables that are potentially useful as indicators of monetary policy, eg a short-term interest rate. Note that the central bank may not have complete control over the policy variables because they are also influenced by other shocks. However, it has a significant influence on these variables within the current period. In this system, each variable is allowed to depend on current or lagged values (up to k lags) of any variables in the system. The vectors V^y and V^p are mutually uncorrelated "structural" or "primitive" disturbances.

Next with the timing assumption that innovations to variables in the policy block do not affect variables in the non-policy block within the period, or $C_o = 0$, the system of equations (1) and (2) can be written in standard reduced-form VAR format by collecting the contemporaneous terms Y_t and P_t on the left-hand side. Define U_t^y to be the VAR residuals corresponding to the Y block and U_t^p to be the component of the residuals corresponding to the P block that is orthogonal to U_t^y. Then equations (1) and (2) can be rewritten as the following reduced-form VAR for estimation:

$$Y_t = \sum_{i=1}^{k} H_i^y Y_{t-i} + \sum_{i=1}^{k} H_i^p P_{t-i} + U_t^y \tag{3}$$

$$P_t = \sum_{i=1}^{k} J_i^y Y_{t-i} + \sum_{i=1}^{k} J_i^p P_{t-i} + [(I - G_0)^{-1} D_0 U_t^y + U_t^p] \tag{4}$$

After estimating (3) and (4), the component of the residual of (4) that is orthogonal to (3), denoted by U_t^p, can be extracted. Comparing equations (3) and (4) to (1) and (2), it can easily be shown that U_t^p is related to V_t^p by the following:

$$U_t^p = (I - G_0)^{-1} A^p V_t^p \tag{5}$$

Given the parameter estimates, the structural shocks, V_t^p, including the exogenous monetary policy shock, v^s, can be obtained by inverting (5):

$$V_t^p = (A^p)^{-1} (I - G_0) U_t^p \tag{6}$$

The dynamic responses of all variables to the policy shock can then be examined via the associated impulse response functions. In order to generate impulse response functions, it is necessary to be able to identify monetary policy shocks first. In this approach, one can concentrate on the identification restrictions in the policy block by modelling equation (6). To identify the policy block, a model of the money market could be used to impose parameter restrictions on the policy variables. To identify the non-policy block of equation (5), one can impose a recursive causal ordering for the non-policy variables and restrict A^y to be diagonal. In other words, if output is ordered first in the non-policy block, it will not react contemporaneously to other variables in either the policy or the non-policy blocks.

2.2 Model identification

The focus of the analysis is the role of the interest rate and the exchange rate in the study of the effects of monetary policy. Thus only a short-term interest rate (R) and the exchange rate (X) are included in the policy or monetary block. These two variables potentially contain useful information about monetary policy and are influenced by monetary policy within the same period. The short-run reduced-form model of monetary policy behaviour and the foreign exchange market is described by the following set of equations:

Interest rate: $$u_R = v^s + b_{12}v^x \tag{7}$$

Exchange rate: $$u_X = b_{21}v^s + v^x \tag{8}$$

Equation (7) describes the short-run reaction function of the monetary authority. The interest rate is considered to be the monetary policy instrument, except in the case of Singapore, where the nominal effective exchange rate is also considered as the policy instrument in a separate setup (see the Annex). The monetary authority sets the interest rate in response to shocks to the exchange rate v^x within a given period, with the extent of the response measured by the coefficients b_{12}. The term v^s represents the exogenous monetary policy shock. Setting $b_{12} = 0$, for example, means that the central bank does not contemporaneously respond to the exchange rate shock and the innovations in the interest rate are thus due purely to monetary policy shocks. Equation (8) relates the innovation in the exchange rate to the innovations in the other variables in the policy block. The equation says that the exchange rate innovations, u_x, can be decomposed into two parts: the responses to innovations in the interest rate plus an exogenous exchange rate shock.

Note that the relationship in (7) and (8) can be written in matrix form as in equation (6):

$$\begin{bmatrix} u_R \\ u_X \end{bmatrix} = \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} v^s \\ v^x \end{bmatrix} \tag{9}$$

The relationship (9) can then be inverted to determine how the monetary policy shock, v^s, depends on the VAR residuals:

$$v^s = (1 - b_{12}b_{21})^{-1}(u_R - b_{12}u_x) \tag{10}$$

Equation (10) shows that the monetary policy shock is a linear combination of the VAR residuals in the policy block with the weight on each variable equal to a combination of the model parameters. A measure of the monetary policy can be constructed using the same weights on the corresponding variables as in equation (10). Thus monetary policy can be related to the so-called monetary conditions index (MCI), which is a linear combination of the interest rate and the exchange rate, with the weights also determined by the model.

The model has four unknown parameters (b_{12}, b_{21}, and the two shock variances) to be estimated from three independent residual variances and covariances. To identify the model, an additional identifying restriction is needed. To achieve just-identification, two different ways of imposing this extra restriction are considered. First, the restriction that $b_{21} = 0$ is imposed, which implies that the measure of the monetary policy shock is

$$v^s = u_R - b_{12}u_x \tag{11}$$

This restriction implies that the innovation in the exchange rate does not respond to the interest rate contemporaneously.[3] This assumption may not be unreasonable given that the exchange rates in these Asian economies may have been more influenced by such factors as the yen/dollar exchange rate and international investors' risk appetite with regard to local equities, etc, than the interest rate in these economies. Second, several plausible weights of the exchange rate are considered to examine how sensitive the dynamic responses are to the weight on the exchange rate. In other words, values on the parameter b_{12} are imposed and then the estimation results of the model will determine the value of b_{21}.

[3] Note that the exchange rate responds contemporaneously to all variables in the non-policy block.

3. Data and estimation

To estimate the model, the variables in the policy and non-policy blocks need to be specified. Non-policy variables are relatively straightforward to specify. In all VARs estimated in this paper, the following non-policy variables are used: the world commodity price index (*PCOM*), a measure of industrial production (*Y*),[4] the CPI (*P*) and a measure of the monetary aggregate (*M*), for which M1 is used. The four non-policy variables are ordered as follows: *PCOM*, *Y*, *P* and *M*. *PCOM* is used in the models in order to capture the non-policy induced changes in inflation pressure that the central bank may react to when setting policy. Many US studies have found that including *PCOM* helps resolve the price puzzle (after an expansionary policy shock, prices decrease initially rather than increase) usually found in the VAR literature. Three US variables are also included, namely the CPI, industrial production and the federal funds rate, as exogenous variables in the estimation to capture the close link between the US economy and these Asian economies.[5] The specification of the policy variables, which include the interest rate and the nominal effective exchange rate, are important but less straightforward. Financial reforms and developments in these economies over the last few decades have led to substantial changes in the monetary policy regimes and settings. As such, a brief review of those developments that have major implications on the transmission of monetary policy would be helpful to understand the specification of the policy variables of the model.

Financial reforms such as interest rate deregulation that have occurred in East Asia since the 1970s have implications for the way central banks implement policy. Singapore was the first to introduce major financial reforms; for example, it liberalised interest rates in 1975. It was followed by Malaysia in the late 1970s. Other East Asian economies also gradually relaxed interest rate controls over the last few decades and, by the early 1990s, the interest rate was completely deregulated in these economies. Most central banks originally relied on direct credit control such as a credit ceiling to implement policy. But following interest rate liberalisation, most central banks lifted the credit ceiling and switched to using the interest rate, except for Singapore, which used the exchange rate. With the development of money and capital markets, many central banks have increased the use of open market and money market operations as well as standing facilities to implement monetary policy since the 1980s.

Several central banks have also used monetary aggregates as intermediate targets. But these central banks have targeted different monetary aggregates over time as a result of the unstable relationship between monetary aggregates and other macroeconomic variables. For example, Korea targeted M2 from 1979 to 1996 and then MCT (M2 plus CDs and money in trust) for a brief period in 1997. Since the end of 1997, The Bank of Korea has targeted M3, with the overnight call rate as the operating target after the introduction of inflation targeting in April 1999. Other central banks that have targeted a monetary aggregate faced similar problems. However, central banks have increasingly relied on a short-term interest rate to implement or signal monetary policy, as a result of moving towards market-based implementation of monetary policy. In recent years, most central banks in the region have followed the practice of other major central banks, such as the US Federal Reserve, of announcing a policy rate to signal the policy stance.

The regional central banks have different ways of choosing a policy rate. In Indonesia, owing to the unavailability of government debt securities when direct credit controls were removed in 1983, Bank Indonesia Certificates (SBI) have been the major tool of open market operation (OMO). Therefore, the one- and three-month SBI rates can be viewed as policy rates. Korea has followed the approach of Japan and the United States: the policy rate is the announced target level for the overnight rate. After the monthly meeting of the Monetary Policy Board, The Bank of Korea usually announces the level of the target overnight rate by issuing a press release. The three-month interbank rate has been considered as the rate that signals the direction of monetary policy in Malaysia. In early 1998, Bank Negara Malaysia began to designate a different policy rate - the three-month intervention rate. The

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[4] In the case of Indonesia, only quarterly industrial production is available. Hence quarterly GDP is converted to a monthly frequency by interpolation.

[5] The US variables may be important because they help to resolve the price puzzle found in previous work on monetary policy shocks. However, including *PCOM* and the US variables does not solve the price puzzle. Recent work on monetary policy shocks in Germany (Bernanke and Mihov (1997)) and Italy (De Arcangelis and Di Giorgio (1998)) also found the price puzzle even when *PCOM* is included in the VAR.

main channel of policy signalling became the central bank's daily tender operation and the intervention rate is used to reinforce the policy intention to the market. In the Philippines, open market operations with respect to T-bills involve repurchase and reverse repurchase agreements as well as outright transactions. Recently, the central bank has relied on reverse repurchase agreements in its liquidity management with the overnight reverse repo rate as the policy rate. The conduct of monetary policy in Singapore is mainly through managing its effective exchange rate. To complement its exchange rate policy, the Monetary Authority of Singapore also conducts money market operations to ensure that there is an appropriate level of liquidity in the banking system. In mid-1989, the Taiwanese Banking Law was revised to free both deposit and loan rates. The central bank has relied on the rediscount rate to signal monetary policy. After abandoning the use of direct control measures in late 1980s, the Bank of Thailand began to conduct its monetary policy through money market and credit operations, especially through the repurchase market for government bonds. Thailand has followed the Bank of England's practice of not using the overnight rate but rather the two-week repurchase rate as its key policy rate.

Given that the interest rate is used as a monetary policy instrument, it would be most desirable to use a policy rate as described above. However, in some Asian economies, only a short sample is available for such an interest rate. In order to have a reasonably long sample, other short-term money market interest rates are also considered in the analysis. In Indonesia, the call money rate, available from May 1986, is employed as the policy rate since the one-month SBI rate is availabe only from 1997. The overnight call rate in Korea is the appropriate policy rate to use and this series is available from 1977. In Malaysia, the three-month interbank rate, which is often considered as the policy rate and is available from 1986, is used. In the Philippines, the overnight reverse repo rate is the policy rate but the series starts only in 1997. This rate will be used in the sample that begins after the 1997 crisis. For a longer sample, the 91-day T-bill rate, which is also a relevant rate in signalling monetary policy, is employed as the policy rate measure. While the policy instrument in Singapore is the NEER, the relevant short-term rate to look at is the three-month Singapore dollar interbank rate. The market rate that has good liquidity in Taiwan is the secondary market commercial paper rate with the maturity of 91-180 days, which begins in 1981. In Thailand, the relevant policy rate is the 14-day repurchase rate, which starts in 1989. In short, the interest rates used are either the designated policy rates or close proxies to the relevant policy interest rates.

In terms of the exchange rate regime, many economies tended to maintain a stable relationship with the US dollar or gradually depreciate against the dollar until moving to a managed float system against a basket of currencies. After the Asian crisis, most central banks allowed greater flexibility of their currencies by following a floating rate system, except the Central Bank of Malaysia, which pegged the currency to the US dollar. As a result, the objective of monetary policy has become more focused on price stability than on exchange rate stability. Among these economies, Indonesia, Korea, the Philippines and Thailand also adopted numerical inflation targets subsequently.

Since contemporaneous restrictions are used to identify the VAR models, monthly data are more appropriate than quarterly data. It is more difficult to justify the identification assumption of no contemporaneous feedback from policy to the economy at the quarterly frequency. Data are mainly from the *International Financial Statistics* (IFS) published by the International Monetary Fund, supplemented by the CEIC database and national sources. The effective exchange rates used are calculated as in Turner and Van't dack (1993). [6] All variables are in log levels except the interest rates, which are in levels. Data availability, especially for the interest rate, and the date when the central bank moved to a market-based approach to implementing monetary policy are the main considerations in choosing the sample period. The sample period and the interest rate used for each economy are reported in Table 2. The exchange rate regimes before and after the Asian crisis are reported in the third column of Table 2. Subsamples are considered to examine the importance of structural breaks owing to the Asian crisis and the subsequent changes in targets and operating procedures of several central banks. The number of lags employed in the estimation varies according to the sample period. For most estimations, 12 lags are used, but for the post-crisis sample only 3 lags are used owing to the short sample.

[6] Other measures of exchange rates such as a bilateral rate against the US dollar are also tried and the results are qualitatively the same.

Table 2

Sample period and interest rate measure

	Full sample	Exchange rate regime	Interest rate
Indonesia	1986:5 - 2001:6	Managed float/floating	Call money rate/ 3-month SBI
Korea	1988:12 - 2001:6	Managed float/floating	Overnight interest rate
Malaysia	1985:1 - 2001:6	Managed float/fixed	3-month interbank rate
Philippines	1983:1 - 2001:6	Managed float/floating	3-month T-bill rate/ overnight RRP rate
Singapore	1980:1 - 2001:6	NEER targeting	3-month interbank rate
Taiwan	1989:7 - 2001:6	Managed float	91- to 180-day commercial paper rate
Thailand	1989:1 - 2001:6	Basket peg/floating	14-day repurchase rate

4. Results

4.1 Impulse responses: the interest rate as the policy instrument

Figure 1 shows the impulse response functions of the variables included in the VAR to a monetary policy shock that results in a one-standard deviation rise in the interest rate for the seven economies over the full sample. The two dashed lines in each panel depict the 95% confidence bands. The order of the impulse response functions in each economy is as follows: output, prices/CPI, money (*M*), the interest rate (*R*) and the exchange rate (*X*). The impulse responses are plotted over a 36-month horizon for the longer samples and over a shorter horizon for the shorter samples. Following a contractionary monetary policy shock, it is expected that output, prices and money demand will all fall while the interest rate and the exchange rate rise. Money and the exchange rate respond to the shock more immediately and prices tend to respond more slowly.

For non-policy variables, following a contractionary monetary policy shock, output falls immediately in all economies except Korea and Taiwan. This decline in output is also significant and rather persistent but the persistence varies a lot across economies. Output declines significantly for about a year in Indonesia, Malaysia and the Philippines. The output responses in Thailand and Singapore are more short-lived, falling significantly only for the first few months. Despite a tightening shock, prices decline initially only in Korea and Singapore, implying a price puzzle - prices increase rather than decrease after a contractionary shock - in all other economies. This perverse price response is also rather persistent in some of these economies, in particular Indonesia. Including the commodity price index or US variables in the VARs, however, does not resolve this price puzzle. As interest rates rise, money falls immediately in all economies but Korea. The money responses are also significant and persistent. The rise in money in Korea is counterintuitive, which suggests a positive short-run interest elasticity of money demand where money demand rises as the interest rate increases.

Among policy variables, interest rates in all economies rise immediately and significantly after the tightening policy shock. The interest rate increases are rather large in Indonesia and the Philippines, which both have high inflation experiences, jumping 200 and 125 basis points respectively. The rises in interest rates are more modest for the rest of the economies, ranging from 25 basis points in Malaysia to 75 basis points in Thailand. This may suggest that the monetary authorities in these economies tend to move the interest rate in smaller steps. The interest rate responses are very short-lived in Indonesia, Korea, Taiwan and Thailand, with interest rates rising significantly for less than three months after impact. For the other economies, interest rates rise significantly for no more than six months. These results are consistent with the view that the liquidity effect is relatively short-lived, ie the interest rate rises only for a short time after a tightening shock. Only the exchange rate responses

in Korea, Malaysia, Singapore and Thailand are as expected, appreciating after the shock. The exchange rates in the other three economies decline significantly and stay below trend for most of the reporting horizon. Previous VAR studies of open economies also find such an exchange rate puzzle.

In summary, there are some differences in the impulse response functions across the economies studied. In nearly all economies, the responses of output, money and the interest rate are consistent with monetary theory. The perverse price response and the exchange rate puzzle often found in other VAR studies are problems for most of the seven economies studied here. Among the economies examined, only in Singapore are the dynamic responses to a monetary policy shock in line with the expected effects.

While the relatively poor results may suggest that the monetary policy shocks are not properly identified, it is also plausible that the structural break as a result of the Asian financial crisis in 1997 may have distorted the results in the full sample. To investigate this proposition, two subsample periods of the VAR models for these economies are studied. The first sample ends in June 1997 and the second starts in January 1998. The resulting impulse response functions are reported in Figures 2 and 3 respectively. By looking at these two subsamples, it may also be possible to shed light on whether there has been a change in the monetary transmission mechanism since the 1997 Asian financial crisis.

By focusing on the subsample that ends in mid-1997, the results for most economies are more in line with the prediction of monetary theory. Output falls significantly after the tightening shock in all economies. The declines in output are also rather persistent in Indonesia, Singapore and Taiwan, suggesting that a contractionary shock has a longer-lasting effect on these economies. The output responses are generally more volatile in this subsample, possibly owing to a shorter sample. Prices decline in response to the shock in nearly all economies and the price responses are mostly significant and quite persistent. The price declines are also rather immediate, responding to the shock within the first few months. There is a common view that monetary policy affects prices with a long lag. However, the labour market is relatively less rigid and prices tend to be more flexible in East Asia, thus resulting in a shorter lag of the effect of monetary policy on prices. Following the tightening shock, money falls significantly in all economies and the declines in money are also quite persistent.

The responses of the policy variables are quite similar to those in the full sample. The rise in the interest rate is again very short-lived in most economies, lasting for only two to three months. Excluding the high interest rate episodes after the Asian financial crisis, the initial rise in the interest rate becomes more modest in Indonesia and the Philippines than in the full sample, up 125 and 100 basis points respectively. Immediately after the shock, the exchange rate increases significantly in Indonesia, Singapore, Taiwan and Thailand. These exchange rate responses are not very persistent, lasting for one to eight months. The initial responses of the exchange rate in Korea, Malaysia and the Philippines are a depreciation of the local currency, which is significant only in Malaysia. The perverse exchange rate response could be due to the identification restriction that the exchange rate does not respond to the monetary policy shock, which will be examined below in Section 4.3.

The overall results for the sample that ends before the Asian crisis show substantial improvement. The impulse responses in Indonesia, Singapore and Taiwan are consistent with the predictions of monetary theory. Other economies display either counterintuitive responses of prices or the exchange rate, but these perverse results tend to be short-lived and insignificant. Ending the sample in mid-1997 helps to eliminate the price puzzle found in many economies in the full sample. These results suggest that the 1997 crisis has a substantial effect on the analysis. During the crisis period, inflation rose sharply in the crisis-affected economies as the exchange rates in these economies collapsed while interest rates were raised substantially to defend the currency. The comovement of interest rates and prices in response to the huge external shock could result in the price puzzle observed here, absent a proper variable in the system that can account for this correlation.

Since the sample that begins in 1998 is very short, only four variables are included in the VAR and three lags are used in the estimation. The results, reported in Figure 3, show substantial variation across economies and are only weakly consistent with the predictions of monetary theory. Output falls in Indonesia, Korea, Malaysia, Taiwan and Thailand after the shock. The output responses are statistically significant in Korea and Malaysia only. Prices fall significantly in Malaysia and Singapore. A price puzzle could be found in the other economies. Interest rates increase significantly for about two to six months in all economies. Most exchange rate responses are insignificant except in the Philippines, where the peso depreciates in effective terms for more than three months after the shock.

This perverse exchange rate response is also observed in Indonesia, Singapore and Taiwan. Only the impulse response functions in Malaysia are consistent with the expected effects of a monetary shock.

Table 3

Impulse responses to a contractionary monetary policy shock

	ID	KR	MY	PH	SG	TW	TH	Expected
(I)	**Full sample**							
Y	–	+	–	–	–	+	–	–
P	+	–	+	+	–	+	+	–
M	–	+	–	–	–	–	–	–
R	+	+	+	+	+	+	+	+
X	–	+	+	–	+	–	+	+
(II)	**First subsample: before July 1997**							
Y	–	–	–	–	–	–	+	–
P	–	–	–	+	–	–	+	–
M	–	–	–	–	–	–	–	–
R	+	+	+	+	+	+	+	+
X	+	–	–	–	+	+	–	+
(III)	**Second subsample: after 1998**							
Y	–	–	–	+	+	–	–	–
P	–	+	–	+	–	+	+	–
R	+	+	+	+	+	+	+	+
X	–	+	+	–	–	–	+	+

Table 3 summarises the impulse responses for the seven economies and the results display rather large variations across economies. Among the seven economies examined, it is interesting to find that the impulse responses in Singapore are most consistent with what one would expect about the effects of a monetary policy shock, particularly in the sample that ends in 1997. Output falls significantly about six months after the tightening shock; prices and money fall immediately after impact and persistently; the interest rate rises for about five months and then falls below trend, displaying a relatively short-lived liquidity effect; the exchange rate increases immediately for about six months. However, monetary policy in Singapore is mainly implemented through the management of the nominal effective exchange rate and thus the domestic interest rates are largely determined by external interest rates. In this case, the unexpected rise in the interest rate in Singapore could be due to an external interest rate shock. A rise in the interest rate of its major trading partners reduces the demand for exports from Singapore and thus exerts downward pressure on the economy, resulting in lower output, prices and money demand. If the rise in the local interest rate is more than that of the foreign interest rate, there will be some upward pressure on the exchange rate.

Overall, the results show substantial differences before and after mid-1997. For the pre-crisis sample, the results tend to suggest that the VAR model can generate sensible results for most East Asian economies. However, the results for the post-crisis sample are mostly insignificant and in several cases not consistent with monetary theory. The results for Singapore, which was less affected by the crisis, are qualitatively the same for the two subsamples. In contrast, the crisis-affected economies tend to have more notable differences in the results. This could suggest that there has been a major shift in regime or a change in the transmission mechanism. In other words, the model that generates plausible results before 1997 may not be suitable for the analysis after 1997. However, the short sample used in the second subsample makes it difficult to come to a sound conclusion.

While ending the sample before the 1997 financial crisis generates results that are quite consistent with the consensus view, there are still some perverse responses found in the VARs such as the price

puzzle and the exchange rate puzzle owing to the following possible reasons. First, the price puzzle found in most economies could be due to a missing variable that captures the underlying inflation that the central bank is responding to. The commodity price index does not capture this relationship as in studies using US data and neither does the oil price index. Since the price puzzle found in some economies is corrected by ending the sample before the Asian crisis, it is likely that the break during the crisis caused the price puzzle and that the variables included in the VAR do not characterise the crisis. Second, the policy variables used in the analysis, for example the interest rates, may not reflect only central bank actions but other factors as well. If the variables included in the VAR are not able to disentangle the monetary policy shock from non-policy shocks, the effects of the shock identified in the VAR may not resemble a monetary policy shock. In addition, given the changes in implementing monetary policy over the years, some central banks in the region may not have used the interest rate as a policy instrument until quite recently. Third, the identification restrictions used in the analysis may not be suitable for identifying the monetary policy shocks in some economies, especially those that have experienced considerable exchange rate fluctuations. Thus an alternative identification that imposes a larger role of the exchange rate is considered in Section 4.3.

4.2 Impulse responses: the exchange rate as the policy instrument

In this section, the results for Singapore in the case where the effective exchange rate is used as the monetary policy instrument are reported. Following a monetary policy shock that results in an appreciation of the effective exchange rate, output, prices, money and the interest rate are expected to fall. Buying Singapore dollars and selling foreign currencies to raise the effective exchange rate leads to a shortage of local currency that will drive up the interest rate. However, with effective sterilisation, the impact on the interest rate should be neutralised. In fact, if the intended trend appreciation is credible, the interest rate parity condition between Singapore and its major trading partners should favour a decline in the local interest rate.

Figure 4 reports the results for Singapore over the three sample periods. As discussed in the Annex, the additional restriction imposed is that the monetary authority does not respond to the interest rate within the same period when setting the exchange rate. The first column shows the impulse responses to a contractionary shock in the full sample, represented by a one-standard-deviation appreciation of the exchange rate. After the shock, output and money respond immediately and significantly. These responses are also very persistent, lasting for almost two years. Prices are more sluggish and start to fall significantly below the pre-shock level over a year after impact. The exchange rate remains above trend significantly for almost a year, suggesting a persistent deviation of the exchange rate from its trend. The interest rate declines significantly after impact for about four months.

The second and third columns report the results for the pre-crisis and the post-crisis subsamples respectively. The impulse responses of output, money and the exchange rate are more or less the same as those in the full sample. One key difference of these responses is that they are less persistent in the shorter post-crisis sample. The responses of prices and the interest rate show more variations across samples. In the subsample that ends in mid-1997, prices rise for the first four months but the response is not significant. Prices begin to fall significantly after about eight months, faster than the price response in the full sample. The interest rate declines initially but the interest rate response is mostly insignificant. In the post-crisis period, prices fall significantly for the first two months but the response is insignificant after that. The interest rate rises significantly only in the first three months and stays above trend for most of the reporting period.

Overall, modelling the effective exchange rate as the monetary policy instrument produces results that are consistent with the conventional thinking about the monetary transmission mechanism. This result is quite interesting because, unlike in the case using the interest rate as the instrument, there are other factors affecting the exchange rate that may not be captured by the variables included in the VAR. For example, capital flows due to major mergers and acquisitions could move the exchange rate but are unlikely to be accounted for by the macroeconomic variables included. However, this exogenous exchange rate movement may be interpreted as a monetary policy shock in the VAR. Nevertheless, the results suggest that the VAR model is capable of identifying the exogenous monetary policy shock that results in an appreciation of the nominal effective exchange rate.

4.3 Relative weights of the exchange rate and the interest rate

The estimated weights on the exchange rate (b_{12}) for the economies considered here vary substantially across economies and across samples (see Table 4). As discussed in Section 2.2, the weight can be related to an MCI for each of the economies considered.[7] In Thailand, the weight of 0.34 obtained for the full sample is very close to that estimated by Hataiseree (1998) over the period January 1990 to July 1998. However, the weights estimated for other economies, especially for those that are more open than Thailand, such as Malaysia and Singapore, tend to be smaller than one would expect. The small weight on the exchange rate suggests that the central bank does not pay much attention to the exchange rate in setting monetary policy by adjusting its interest rate. Another interpretation is that the central bank attempts to offset the exchange rate fluctuation within the period so as to keep the interest rate stable. In any event, it appears that the exchange rate plays a relatively small role in the setting of monetary policy in most East Asian economies and that the short-term interest rate captures most of the information about monetary policy. However, extra caution must be exercised in drawing conclusions from these estimates, given the mixed results for the impulse response functions reported earlier for some economies.

Table 4

Sample period and estimated weights on the exchange rate (t-stats in parentheses)

	Sample	Weight	Sample	Weight	Sample	Weight
Indonesia	86:5-01:6	0.20 (2.93)	86:5-97:6	0.22 (1.69)	98:1-01:6	0.20 (4.11)
Korea	88:12-01:6	0.12 (4.77)	88:12-97:6	0.19 (2.04)	98:1-01:6	0.05 (1.19)
Malaysia	85:1-01:6	0.02 (1.33)	85:1-97:6	0.02 (0.49)	98:1-01:6	0.01 (0.50)
Philippines	83:1-01:6	0.20 (5.34)	83:1-97:6	0.24 (4.74)	98:1-01:6	0.01 (0.17)
Singapore	80:1-01:6	0.11 (2.63)	80:1-97:6	0.01 (0.18)	98:1-01:6	0.10 (1.83)
Taiwan	89:7-01:6	0.01 (0.35)	89:7-97:6	0.13 (2.53)	98:1-01:6	0.01 (0.61)
Thailand	89:1-01:6	0.34 (9.73)	89:1-97:6	0.06 (0.43)	98:1-01:6	0.05 (3.50)

In order to see whether the VAR models underestimate the role of the exchange rate and thus result in some of the puzzles observed, another identification scheme is considered. Instead of imposing the restriction that $b_{21} = 0$ (which implies that the innovation in the exchange rate does not respond to the interest rate contemporaneously), plausible values are chosen for the weights of the exchange rate based on the openness of the economy.

The results for the seven economies over the pre-crisis period are reported in Figure 5, with the imposed weights displayed at the top of each column. This alternative identification generates results that show some improvement over those reported in Figure 2, especially for the exchange rate responses. Allowing the exchange rate to respond to the interest rate within the same period, it appreciates significantly after the tightening shock in all economies except Thailand, where the immediate response is very small. The perverse price responses found in the Philippines and Thailand before are also less of a concern here, lasting only very temporarily. Using this alternative identification tends to produce impulse responses that are quite consistent with those expected for a monetary policy shock.

[7] The MCI can be interpreted as a measure of the ease or tightness of monetary conditions relative to a base period. It captures the effect monetary policy has on the economy through both the interest rate and the exchange rate. An estimated weight of 0.3 implies that the effect of a change in the exchange rate is about 3/10 of that of the interest rate.

5. Concluding remarks

While the findings in this paper are promising and encouraging, it remains a challenge to apply such a VAR analysis to the study of the monetary transmission mechanism in the region. Many academic and central bank researchers have applied this technique to a large number of economies. Thus it is of interest and of importance to extend the analysis to economies in the region. This paper sets out to study and compare the effects of monetary policy in several Asian economies using a simple VAR model that also estimates the relative weights of the interest rate and the exchange rate. The impulse response functions are in general consistent with the expected effects of monetary policy as found in other VAR studies, especially in the sample that ends before the 1997 Asian crisis. However, perverse responses of prices and the exchange rate are also found in some of the economies studied. Previous VAR studies of industrialised countries find similar puzzles as well. While much work has been done and some progress has been made in resolving these puzzles in developed countries, these measures do not seem to help rectify the problems in emerging market economies. Despite the important role played by the exchange rate in these economies, only a relatively small weight on the exchange rate for some of the economies is found. The mixed results of this study point to the difficulty of applying existing techniques to emerging Asia.

This paper could be viewed as a first step in the attempt to identify and study monetary policy shocks in East Asia in order to facilitate the study of the monetary transmission mechanism. Since more Asian central banks are using market-based measures to implement monetary policy, a better understanding of how monetary policy impulses are transmitted in the economy is increasingly important. However, much work needs to be done to deal with the issues regarding this type of study raised earlier in the paper.

Annex

In this appendix, the model for the case that the exchange rate is used as the policy instrument in Singapore is described.

The model, written in innovation form, is described by the following set of equations:

Exchange rate: $u_X = v^s + b_{12} v^b$ (12)

Interest rate: $u_R = v^b + b_{21} v^s$ (13)

Equation (12) describes how the monetary authority sets the exchange rate. This equation implies that the monetary authority observes and responds to shocks to the interest rate within a given period, with the extent of the responses given by the coefficients b_{12}. Setting $b_{12} = 0$, for example, means that the monetary authority does not respond to the interest rate shock. The term v^s represents the exogenous monetary policy shock. Equation (13) is the interest rate equation, which relates the innovation in the interest rate to the innovations in the other variables in the policy block. The equation says that the interest rate innovations can be decomposed into two parts: the responses to innovations in the exchange rate plus an exogenous interest rate shock.

Combining equations (12) and (13) gives:

$$v^s = (1 - b_{12} b_{21})^{-1} (u_X - b_{12} u_R) \quad (14)$$

Equation (14) shows that the monetary policy shock is a linear combination of the VAR residuals in the policy block with the weight on each variable equal to a combination of the model parameters.

To achieve just-identification, the restriction that $b_{12} = 0$ is imposed, thus allowing the derivation of a measure of monetary policy stance as follows:

$$v^s = u_x \quad (15)$$

This restriction implies that the innovation in the exchange rate represents the monetary policy shock. In other words, the model could be identified by imposing a simple Choleski decomposition.

Figure 1

Impulse response functions – full sample

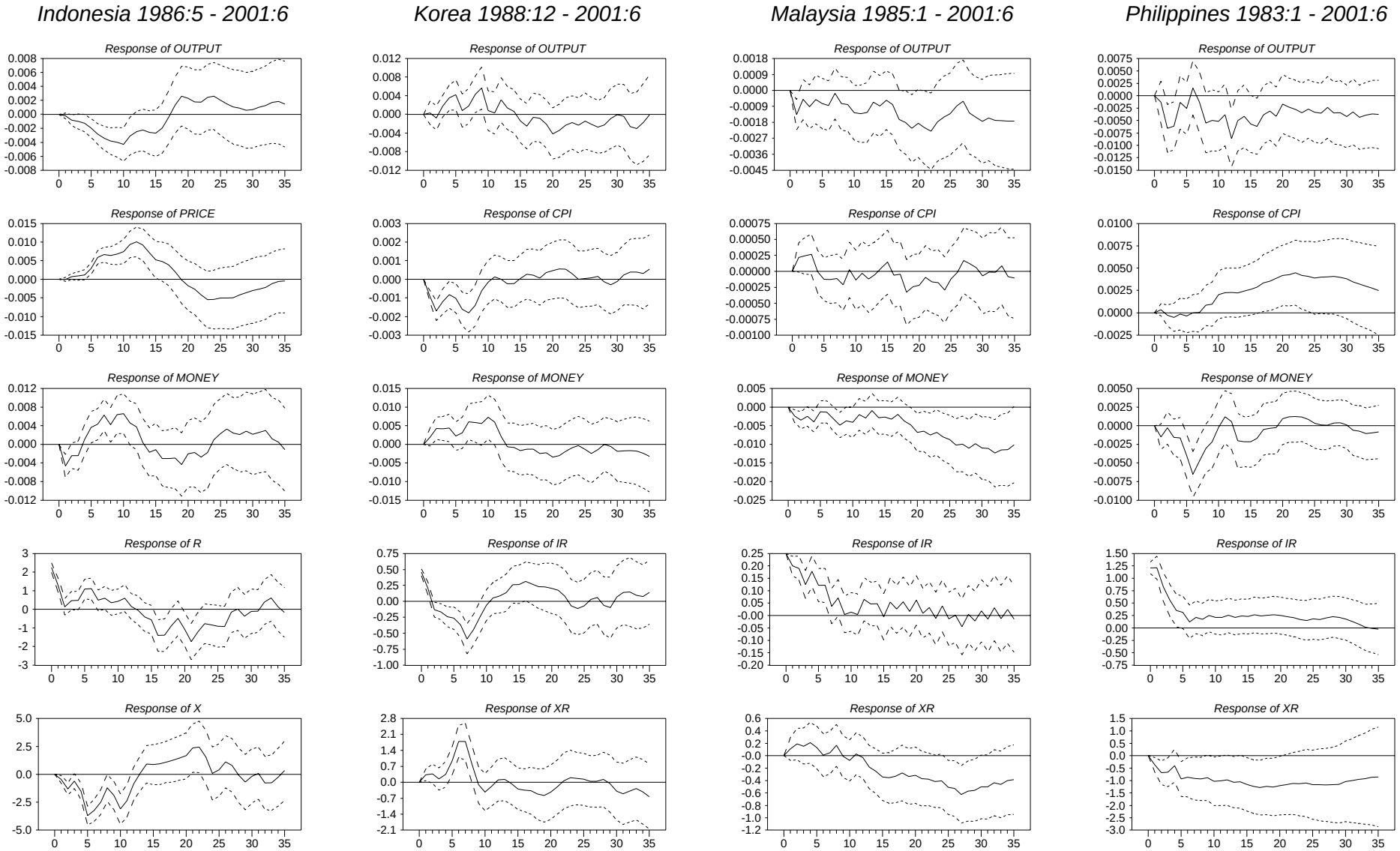


Figure 1 (continued)

Impulse response functions – full sample

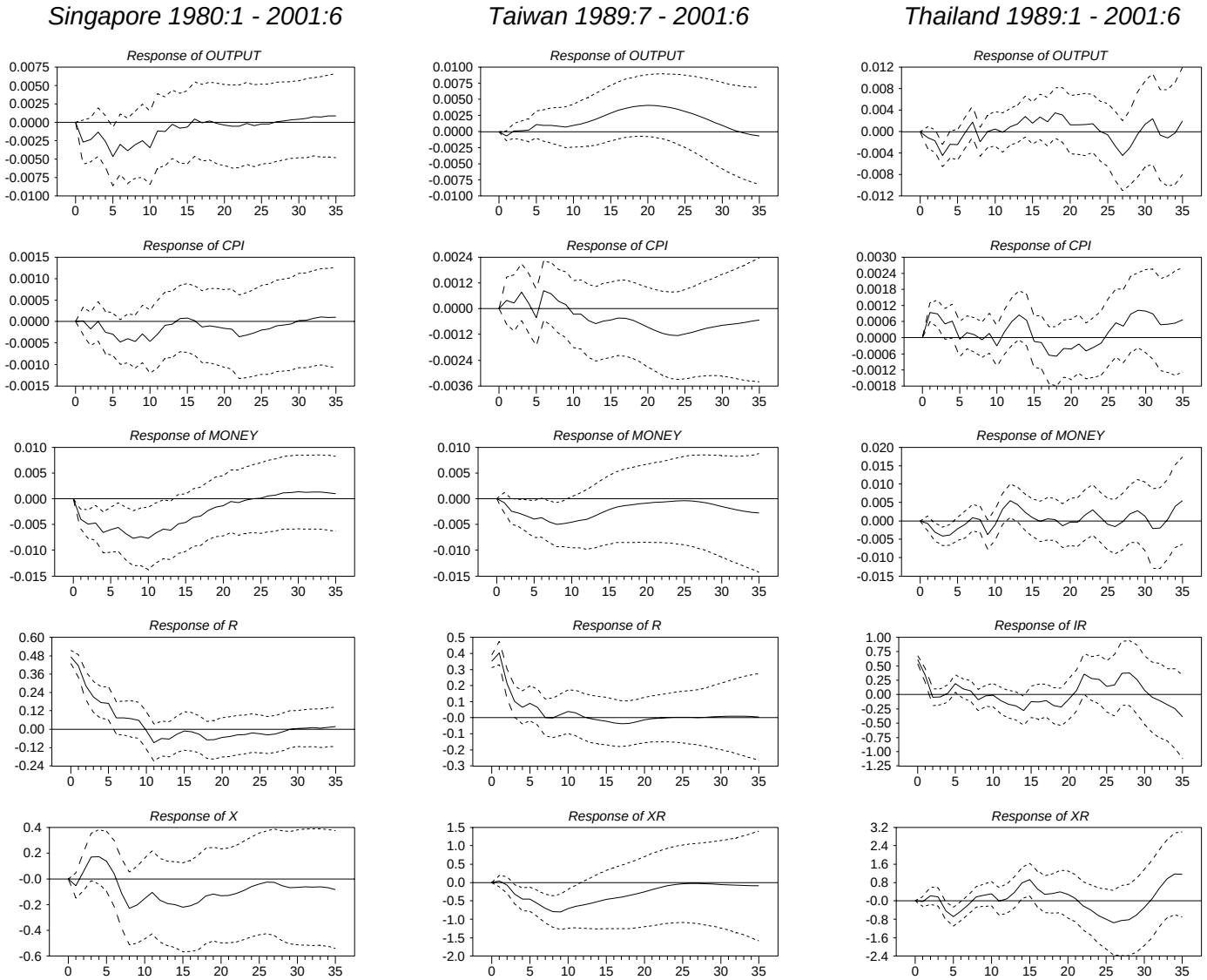


Figure 2

Impulse response functions – pre-crisis

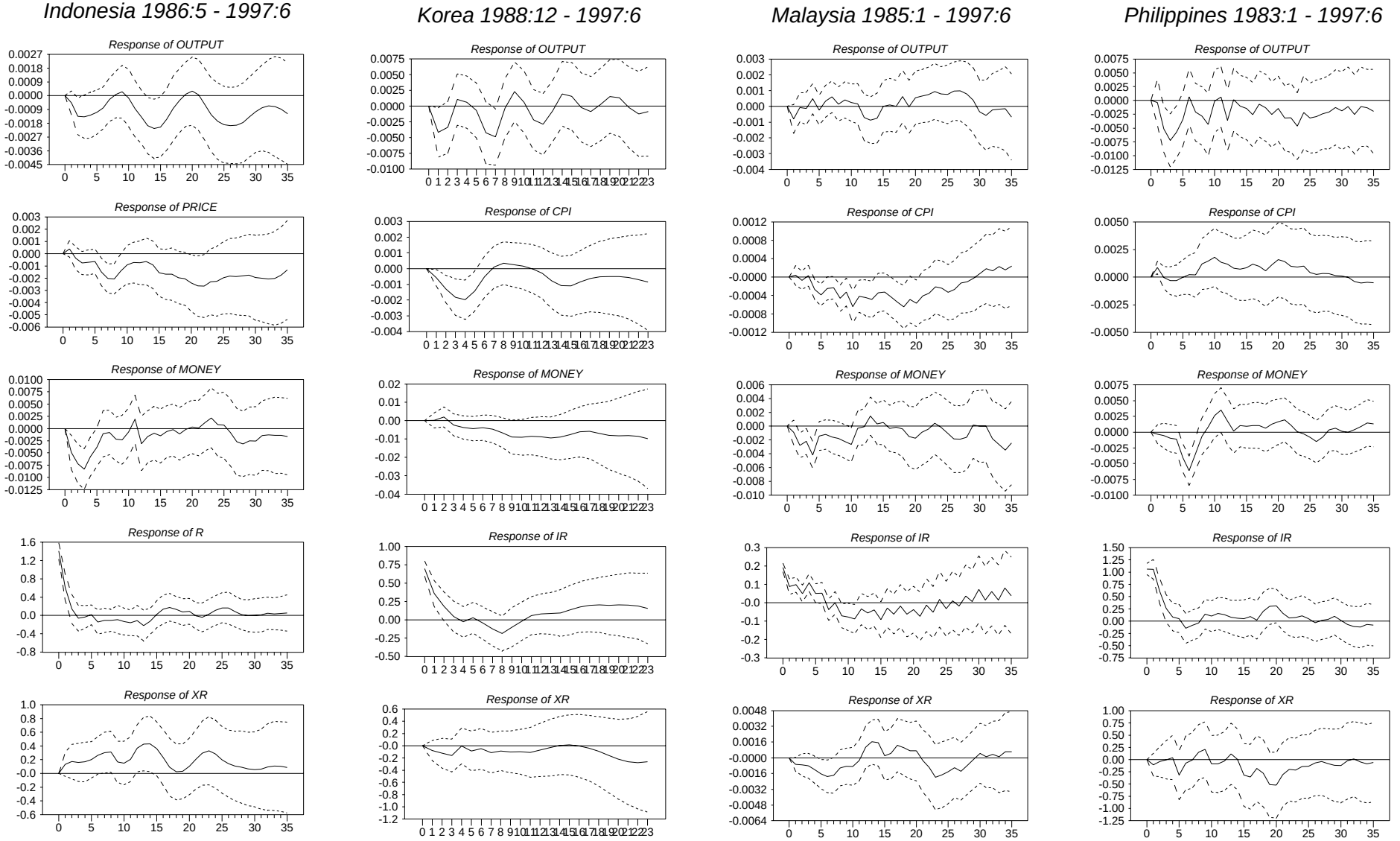


Figure 2 (continued)

Impulse response functions – pre-crisis

Singapore 1980:1 - 1997:6 | *Taiwan 1989:7 - 1997:6* | *Thailand 1989:1 - 1997:6*

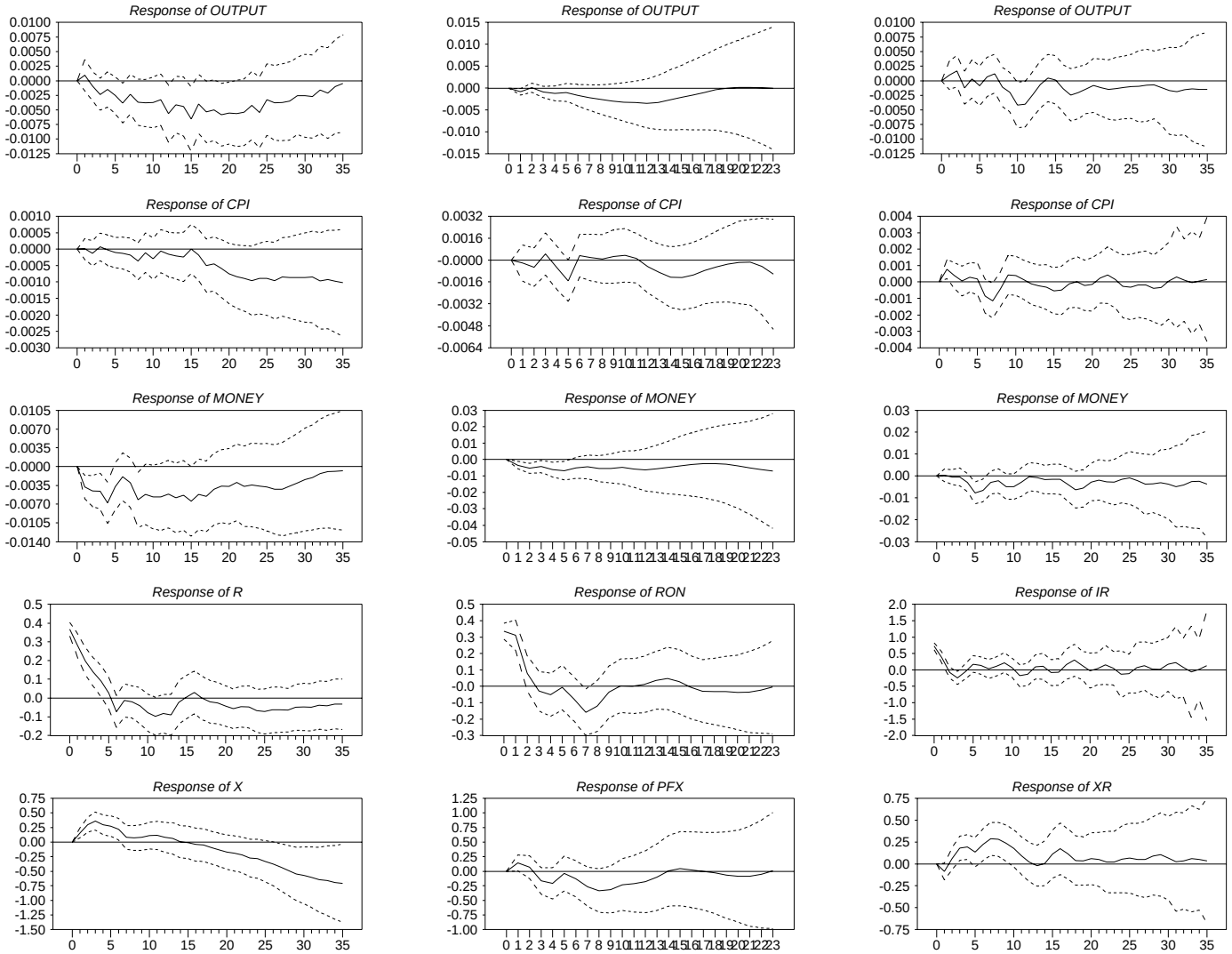
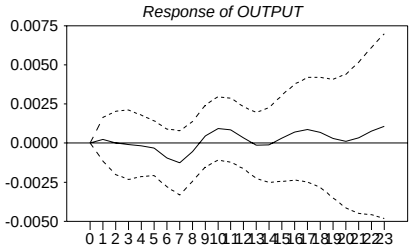
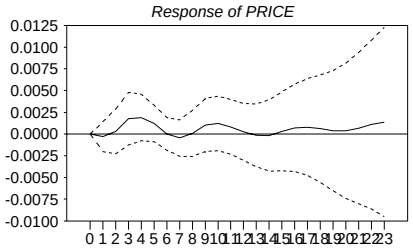


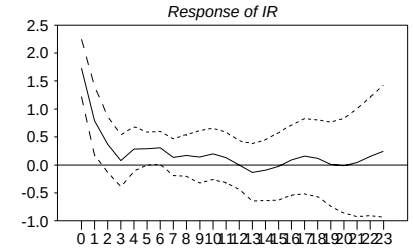
Figure 3

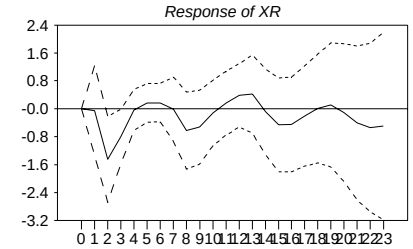
Impulse response functions – post-crisis

Indonesia 1998:1 - 2001:6

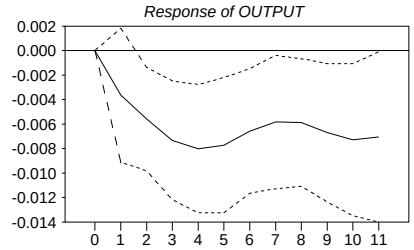


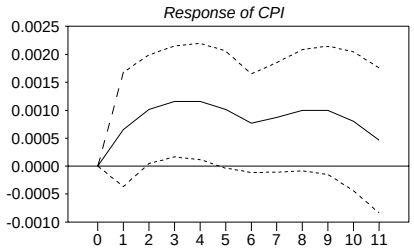


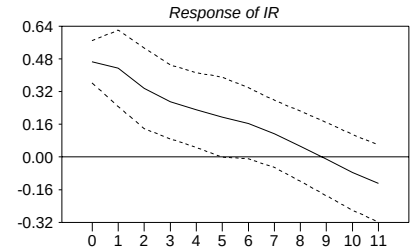


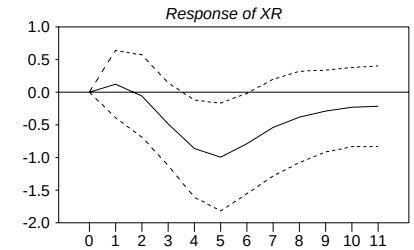


Korea 1998:1 - 2001:6

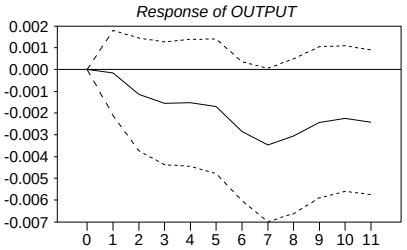


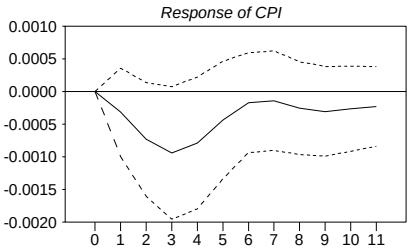


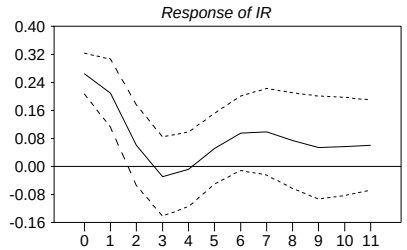


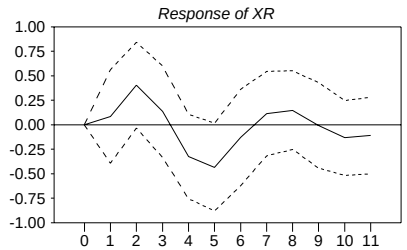


Malaysia 1998:1 - 2001:6

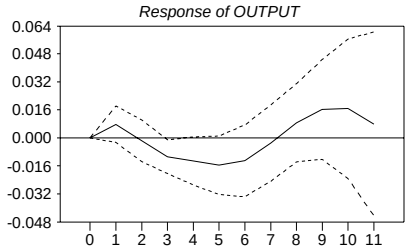


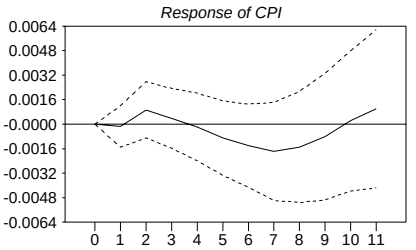


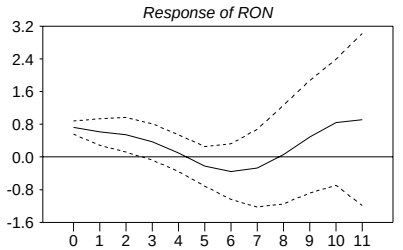




Philippines 1998:1 - 2001:6







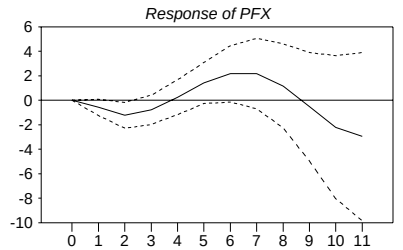
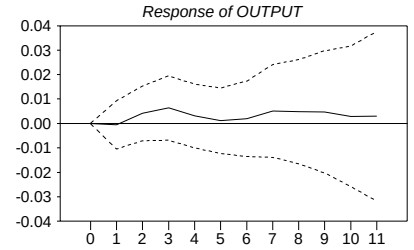
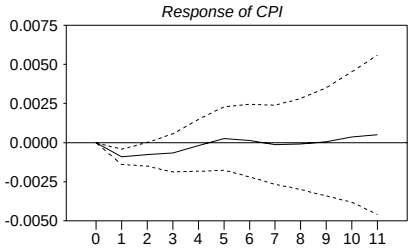


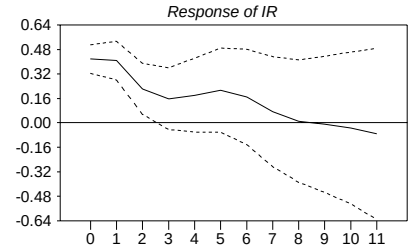
Figure 3 (continued)

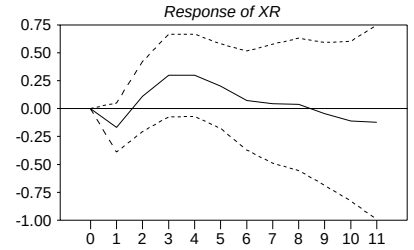
Impulse response functions – post-crisis

Singapore 1998:1 - 2001:6

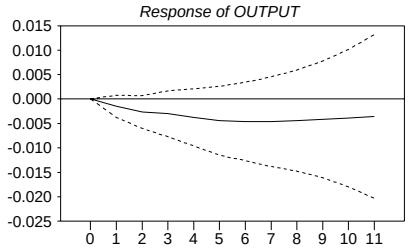


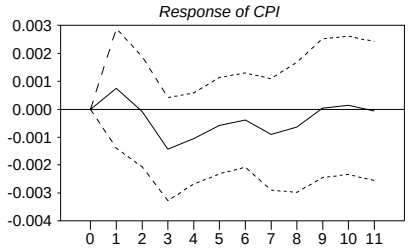


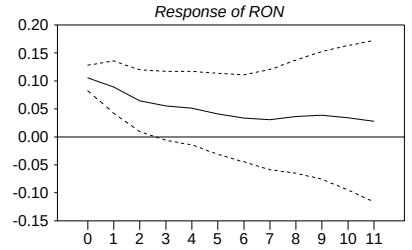


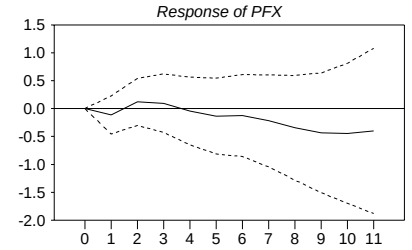


Taiwan 1998:1 - 2001:6

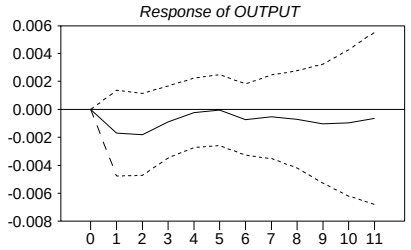


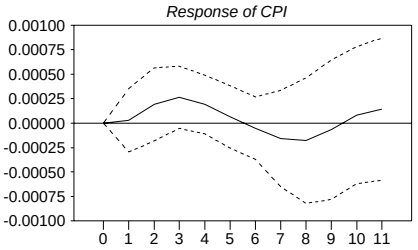


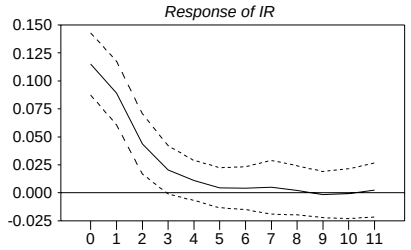




Thailand 1998:7 - 2001:6







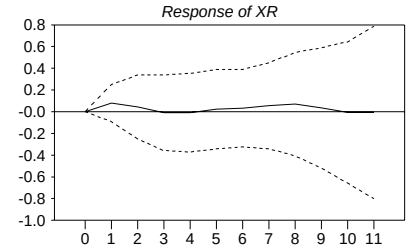


Figure 4

Impulse responses for Singapore (the exchange rate as instrument)

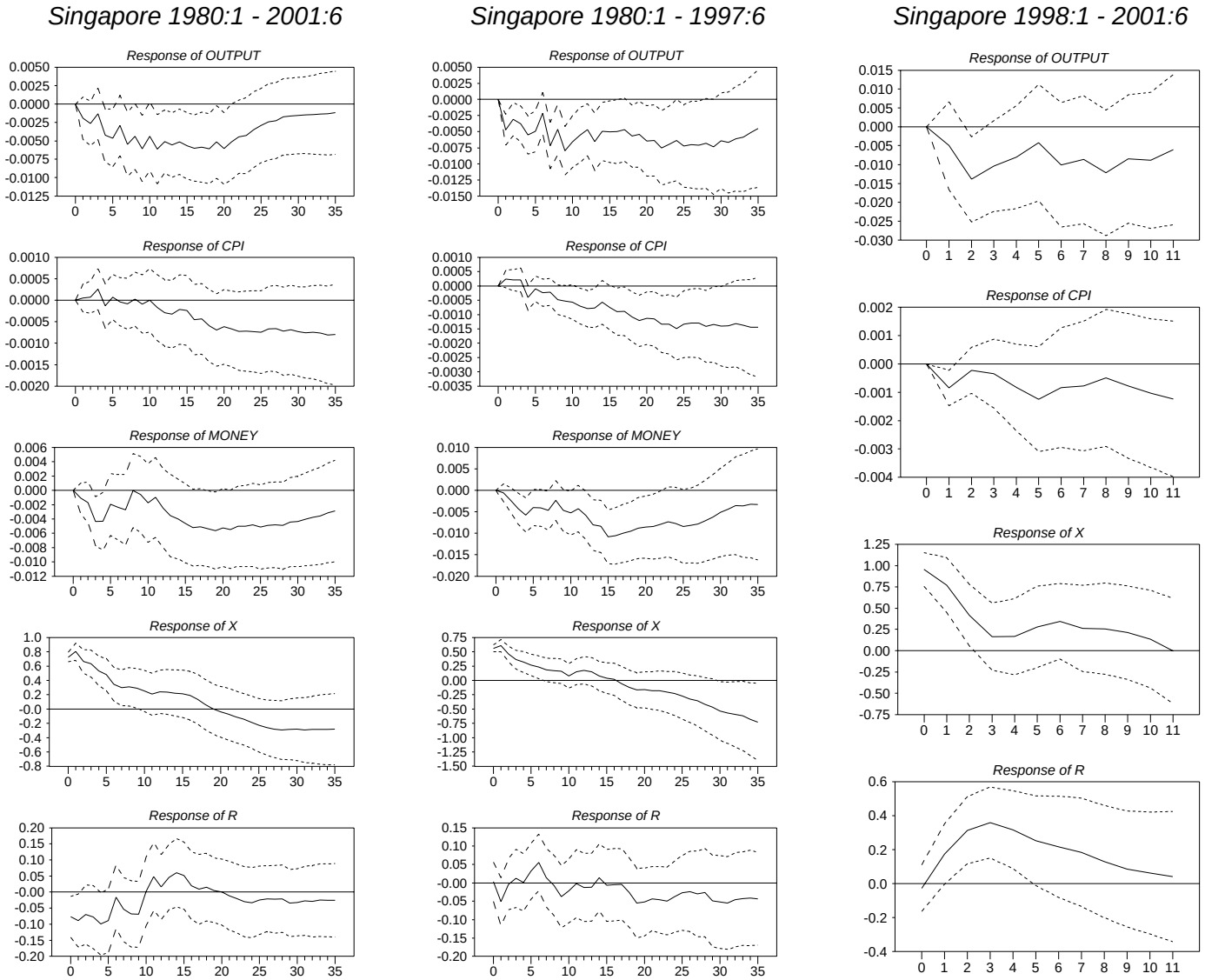


Figure 5

Impulse responses with weight on the exchange rate imposed (pre-crisis sample)

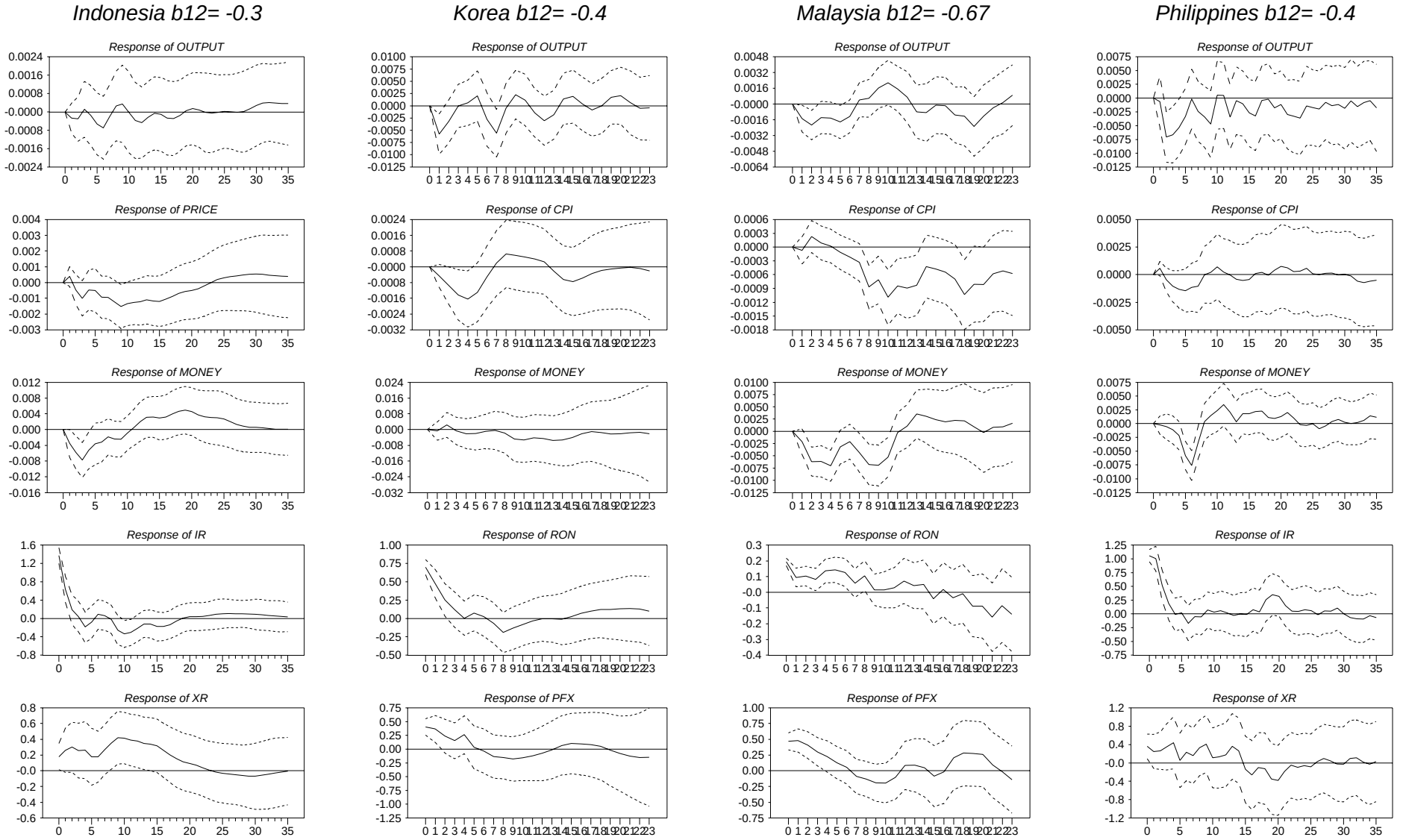
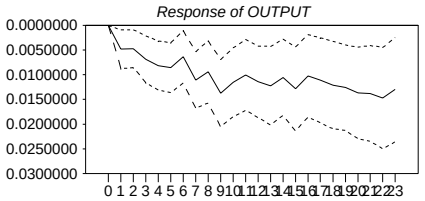
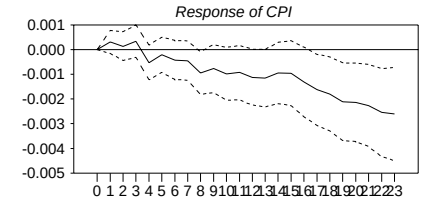


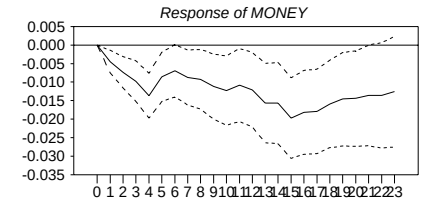
Figure 5 (continued)

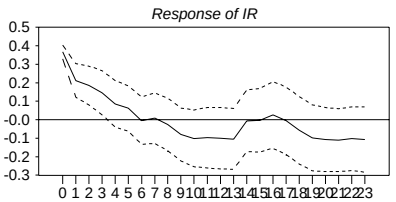
Impulse responses with weight on the exchange rate imposed (pre-crisis sample)

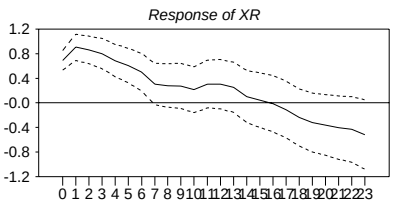
Singapore b12= -0.8











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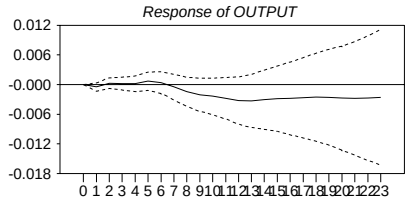
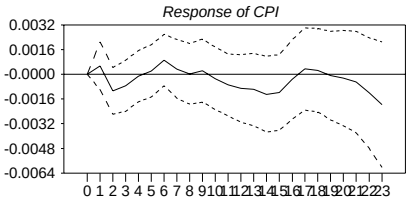
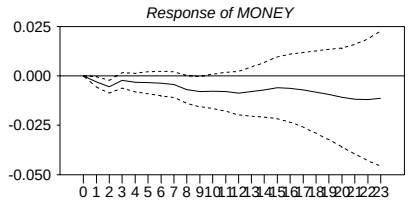
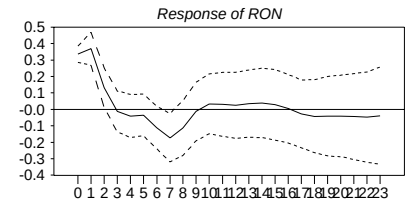
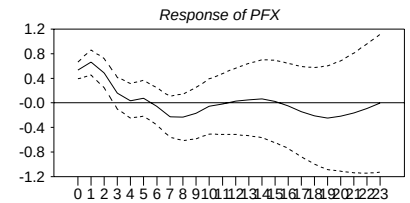


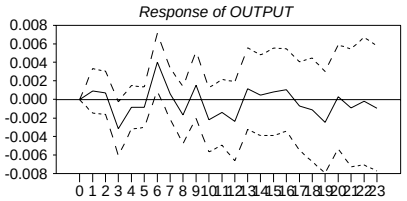


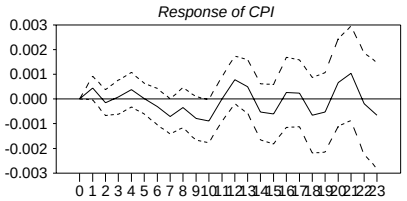


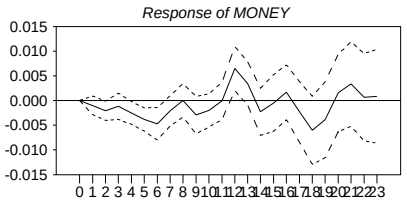


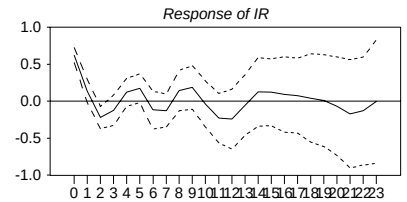


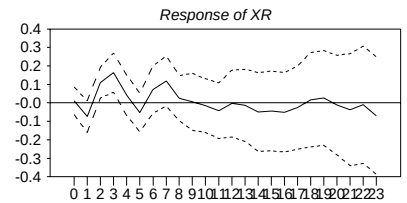
Thailand b12= -0.4











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