Work-in-progress
Draft for comments
28 November, 2001

Measuring monetary policy in East Asia

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Abstract

In this paper, a VAR model is used to study monetary policy shocks in seven East Asian economies. The dynamic responses to a monetary shock are examined in light of the predictions of monetary theory. Given the openness of these economies, many central banks in the region also put a significant weight on the exchange rate in formulating monetary policy. In order to evaluate the importance of the exchange rate, a slightly different identification scheme is also considered. Instead of letting the model determine the weight on the exchange rate in the monetary policy measure, plausible weights are imposed to identify the model.

1 Introduction

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 after the Asian crisis in 1997. To maintain a nominal anchor, central banks in Indonesia, Korea and Thailand have also adopted the rate of inflation as the main target of monetary policy. More recently, the central bank in the Philippines announced that it would implement inflation targeting by January 2002, with the first official target set for 2003. Other central banks in the region that do not have an explicit inflation target also have sought price stability as one of their objectives of monetary policy. Thus, there is a tendency for central banks in the region to shift from focusing on exchange rate stability to price stability.

Why is there a need to have a measure of monetary policy? Having a quantitative measure of monetary policy is useful because such a measure helps the central bank to determine the proper course of monetary policy to keep inflation within a desirable range. In addition, a quantitative measure of monetary policy is important for the empirical study of the transmission of monetary policy through the economy. The study of the effects of monetary policy in Asia and the identification of any substantial differences in these effects is particularly important in the context of increasing monetary cooperation in the region.

A large part of the existing work related to measuring monetary policy is VAR-based, following the seminal work of Sims (1980). For the United States, Bernanke and Blinder (1992) and Sims (1992) consider the federal funds rate as an indicator of policy. Thus the innovations in the federal funds rate are interpreted as innovations to the Fed’s policy. Also using the VAR approach, Christiano and Eichenbaum (1992) suggest that the quantity of nonborrowed reserves is a good measure of monetary policy while Strongin (1995) proposes as a policy measure the portion of nonborrowed reserve growth that is orthogonal to total reserve growth. 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, thus suggesting M1-innovations could be interpreted as innovations to the central bank’s policy. Very limited amount of similar VAR work has been done on emerging Asian economies. Crosby and Otto (2001) use a VAR model to examine the speed of recovery of output following an interest rate shock in a number of Asia economies. A common feature among these studies is that a single variable is assumed a priori to be the best indicator of policy. Unfortunately, there is little agreement on which single variable most accurately captures monetary policy and there could be more than one variable that contain relevant information about monetary policy.

Bernanke and Mihov (1998) suggest a VAR methodology that can include all the policy variables previously proposed for the United States as particular specifications of a general model. This approach need not assume that a single variable is the best indicator of monetary 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 unobserved, can be measured by examining the behaviour of a set of observed variables, which we call policy variables or indicators. These policy variables are taken to be directly influenced by monetary policy within a period.

In this paper, we apply the Bernanke and Mihov methodology to seven East Asian economies, namely Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand. To obtain a measure of policy in these economies, we focus on only two policy variables in our study – the interest rate, and the exchange rate – for the following reasons. First, we consider a short-term interest rate to be the central bank's policy instrument since many recent studies have suggested that a short-term interest rate captures monetary policy well. Hence, we would like to see how well an interest rate performs in these Asian economies. Second, the exchange rate is added as a potential variable in the monetary policy measure, as in Fung and Yuan (2000), 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 tend to lead to an appreciation of the 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 is the exchange rate channel. In the case of Singapore, the exchange rate is also the acknowledged monetary policy instrument. Despite the important role of the exchange rate in the transmission mechanism, most of the existing work on measuring monetary policy does not pay much attention to the exchange rate. 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

		% of exports		
	Export share of GDP[1]	To US	To Japan	To Euro area
Indonesia	38.55	13.64	23.19	11.16
Korea	45.06	21.93	11.93	10.08
Malaysia	125.51	20.51	13.03	10.15
Philippines	56.10	29.80	14.66	13.72
Singapore	179.91	17.29	7.55	10.44
Taiwan	56.54	...	...	...
Thailand	67.03	22.51	15.70	12.28

[1] Exports of goods and services from line 90 of the *International Financial Statistics* of the IMF, on national accounts basis.

After estimating the model, we construct a measure of monetary policy, which includes both the endogenous and exogenous components of monetary policy. The measure of monetary policy is constructed from a linear combination of the interest rate and the exchange rate, and thus can be interpreted as a monetary conditions index (MCI). Impulse response functions of the orthogonalized innovations to the monetary policy measure trace out the dynamic responses of other variables in the VAR to monetary policy innovations. These impulse responses allow us to assess whether the shock identified can be interpreted as a monetary policy shock, by comparing the results to the following description of the predictions of monetary theory: following a contractionary policy shock, the interest rate rises, output, the price level and money decline, and the local currency appreciates. The results of the VAR studied here are found to be broadly consistent with these expected effects albeit with some notable exceptions. We also find only a very small weight on the exchange rate in the monetary policy measure except in the case of Thailand. In order to examine whether the model underestimate this weight and hence producing inconsistent impulse response functions, we consider an identification scheme that allows us to explicitly impose such a weight. Such an exercise, however, improves the results only marginally.

The rest of the paper is organized 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. Some sensitivity analyses are also carried out to examine the importance of the MCI weights on the impulse response functions of the monetary policy shocks. The last section offers the conclusion and some suggestions for future research.

2 The Model

2.1 Methodology

The methodology follows that described in Bernanke and Mihov (1998). Suppose that the “true” economic structure is the following unrestricted linear dynamic model:[1]

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

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

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 nonpolicy block (*Y*) and a policy block (*P*). The vector Y_t contains non-policy macroeconomic variables such as output and prices, whose responses to

[1] Capital letters are used to indicate vectors or matrices of variables or coefficients while lower case letters are for scalars.

monetary policy shocks we would like to examine. The vector P_t contains includes policy variables that are potentially useful as indicators of monetary policy, e.g. 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 may have a significant influence on these variables within the current period. Consider the exchange rate, for example: when the central bank implements monetary policy by setting the short-term interest rate, it takes into account the contemporaneous reaction of the exchange rate and its subsequent effects on the economy. 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.

If P_t has more than one element, one of the equations in the system of equations (2) can be interpreted as the policy reaction function. It is easiest to visualise this by considering the special case of *P* being a scalar, say *p* , instead of a vector. That is, there is a single variable which is assumed a priori to contain the relevant information about the stance of monetary policy. In this case, (2) can be written as

(3) $$p_t = \sum_{i=0}^{k} D_i Y_{t-i} + \sum_{i=0}^{k} g_i p_{t-i} + v_t^p .$$

The central bank sets policy after observing other variables, which are represented by the first two terms in (3). The term v_t^p is the orthogonalized innovation in p_t and represents the exogenous monetary policy shock, the monetary actions that are not predictable from the state of the economy and previous monetary policy moves . Thus the single indicator of monetary policy, *p*, consists of an endogenous component which describes the central bank's responses to the state of the economy and an exogenous component.

Next we make the timing assumption that innovations to variables in the policy block do not affect variables in the non-policy block within the period, or $C_0 = 0$ and write the system of equations (1) and (2) 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 which is orthogonal to U_t^y . Then equations (1) and (2) can be rewritten as the following reduced-form VAR for estimation:

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

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

We can estimate (4) and (5) by standard VAR estimating methods and then extract the component of the residual of (5) that is orthogonal to (4), denoted by U_t^p. Comparing equations (4) and (5) to (1) and (2), it can easily be shown that U_t^p is related to V_t^p by the following:[2]

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

Equation (6) can be rewritten, dropping subscripts and superscripts, as

(7) $$U = GU + AV \text{ or } (I - G)U = AV \,.$$

Equation (7) is a standard structural VAR system which relates observable VAR-based residuals U to unobserved structural shocks *V*. This system can be estimated and identified by conventional methods.

Given the parameter estimates, we can recover the structural shocks, V_t^p, including the exogenous monetary policy shock, v^s, by inverting (6)

(8) $$V_t^p = (A^p)^{-1}(I - G_0)U_t^p \,.$$

The dynamic responses of all variables to the policy shock can then be examined by the associated impulse response functions. Since our focus is on identifying monetary policy, this approach allows us to concentrate on the identification restrictions in the policy block by modeling equation (8). To identify the policy block, we rely on a model of the money market to impose parameter restrictions on the policy variables. To identify the non-policy block of equation (5), we impose a recursive casual ordering for the nonpolicy variables and restrict A^y to be diagonal. In other words, if output is ordered first in the nonpolicy block, it will not react contemporaneously to other variables in either the policy or the nonpolicy blocks.

Given the estimated coefficients of the VAR, we can also obtain the following vector of variables:

(9) $$(A^p)^{-1}(I - G_0)P$$

which are linear combinations of the policy indicators, P. The orthogonalized VAR innovations of the variables described by (9) correspond to the structural disturbances V_t^p in (8) and one of these variables has the property that its VAR innovations correspond to monetary policy shocks. This can most easily be seen by considering the case where *P* contains only one variable, say the overnight interest rate. In this case, the overnight rate is a measure of monetary policy and the orthogonalized innovations to the overnight rate correspond to exogenous monetary policy shocks. When *P* is a vector of policy variables, the estimated linear combination of policy variables included in *P* can be used to measure policy stance, including both the endogenous and exogenous portions of policy,

2. The reduced-form VAR residuals and the structural shocks are related by:

while the shock to this measure represents the exogenous monetary policy shock. In reporting our results in subsequent sections, we examine the impulse response functions of a shock to monetary policy so measured to examine whether it is consistent with what we expect the effects of a monetary policy shock to be.

2.2 Model identification

To focus is on the role of the interest rate and the exchange rate in monetary policy, we only include two equations in the policy block. First, we consider an equation for the exchange rate. Second, we include a short-term reaction function of the central bank. The variables included in the policy or monetary block are: a money market interest rate (R) and the exchange rate (X). The interest rate is considered to be the policy instrument of the central bank, except in the case of Singapore where we also consider the nominal effective exchange rate as the policy instrument (the set up is very similar and can be found in the appendix). These two variables potentially contain useful information about monetary policy and are influenced by monetary policy within the same period. The model, written in innovation form, is described by the following set of equations:

(10) Interest rate : $u_R = v^s + \phi^x v^x$

(11) Exchange rate : $\gamma_1 u_R + u_X = v^x$

Equation (10) describes how the central bank determines the interest rate. This equation implies that the central bank observes and responds to shocks to the exchange rate within a given period, with the extent of the responses given by the coefficients ϕ^x. The term v^s represents the exogenous monetary policy shock. Setting $\phi^x = 0$, for example, means that the central bank does not contemporaneously respond to the exchange-rate shock. The innovations in the interest rate are due purely to monetary policy shocks. Equation (11) is the exchange rate equation, which 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 we can write the relationship in (10) and (11) in matrix form as in equation (7):

(12) $$\begin{bmatrix} 1 & 0 \\ \gamma_1 & 1 \end{bmatrix} \begin{bmatrix} u_R \\ u_X \end{bmatrix} = \begin{bmatrix} 1 & \phi^x \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v^s \\ v^x \end{bmatrix}$$

We can then invert the relationship (12) to determine how the monetary policy shock, v^s, depends on the VAR residuals:

(13) $v^s = (1 - \phi^x \gamma_1) u_R - \phi^x u_x$

Equation (13) 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 (9). Thus monetary policy can be measured by a so-called monetary conditions index 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 (ϕ^x, γ_1, and the two shock variances) to be estimated from 2 residual variances and covariances. To identify the model, an additional identifying restriction is needed. To achieve just-identification, we impose the restriction that $\gamma_1 = 0$, which implies that the measure of the monetary policy shock is

(14) $$v^s = u_R - \phi^x u_x$$

This restriction implies that the innovation in the exchange rate does not respond to the interest rate contemporaneously and thus equal to the exogenous exchange rate shock. 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 apetitude as regards ot local equities, etc, than the interest rate in these economies. While this restriction allows us to identify the model, it is not possible to test the plausibility of this assumption. Therefore, we also consider several plausbile weights of the exchange rate to examine how sensitive the dynamic responses are to the MCI weights.

3 Data and estimation

To estimate the model we need to specify the variables in the policy and non-policy blocks. In all VARs estimated in this paper, we use the following non-policy variables: the world commodity price index (PCOM) or oil price index (OPI), a measure of industrial production (Y), the CPI (P) and a measure of the monetary aggregate (M), M1 in most cases.[3] The commodity price index is used to capture the non-policy induced changes in inflation pressure that the central bank may react to when setting policy. Many U.S. 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. The four non-policy variables are ordered as follows: *PCOM, OUTPUT, P* and *M*. It is reasonable to order *PCOM* first since these Asian economies are small open economies with a relatively small influence on world commodity prices. We also include some U.S. variables, namely, CPI, industrial output and the federal funds rate, as exogenous variables in the estimation to capture

[3] In the case of Indonesia, only quarterly industrial production is available. Hence we convert quarterly GDP to a monthly frequency instead.

the close link between the U.S. economies and these Asian economies.[4] Policy variables include the interest rate, and the nominal effective exchange rate.[5]

Since the VAR models are identified by imposing contemporaneous restrictions, monthly data are more appropriate than quarterly data. It is more difficult to defend 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 national sources. The effective exchange rates calculated as in Turner and Van't dack (1993).

The choice of interest rates in these economies, which could have a significant effect on the results, deserves a brief discussion. It would be most desirable to use either a policy rate or a short-term rate that serves as the policy instrument of the central bank, such as the US federal funds rate. Unfortunately, in many Asian economies, such an interest rate is available only recently or has changed over time. In order to have a reasonably long sample, we also consider other short-term money market interest rate in the analysis. In Indonesia, the one-month SBI rate is only available from late 1996. Thus we use the 3-month deposit rate from the IFS, which is available since 1980. In Korea, the overnight call rate is the appropriate policy rate to use, especially after Korea adopted inflation targeting in 1998. This series is available from 1991. In Malaysia, we use the 3-month interbank rate, which is available since 1986. 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, we employ the 91-day T-bill rate as the interest rate measure. While the policy instrument in Singapore is the NEER, the relevant short-term rate to look at is the 3-month Singapore dollar interbank rate. The market rate that has good liquidity in Taiwan is the secondary market commercial paper rate with the maturity 91-180 days. This series begins in 1981. In Thailand, the relevant policy rate is the 14-day repurchase rate. While the series starts in 1989, the rate has been fixed at the official target rate since mid-2000. Thus, we use a 3-month money market rate from the IFS.

All variables are in log levels except the interest rates, which are in levels. Data availability is the main constraint for choosing the sample period and the interest rate used. The sample period and the interest rate used for each economy are reported in Table 2. The exchange rate regimes before and

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[4] The U.S. variables may be important because they helps to resolve the price puzzle found in previous work on monetary policy shocks. Including *PCOM* alone is not able to 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.

[5] We also try other measures of exchange rates such as a bilateral rate against the US dollar.

after the Asian crisis are reported in the third column of Table 2. With the exception of Malaysia, most economies have adopted a more flexible exchange rate regime after 1997. 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 full-sample estimation, 13 lags are used while for the post crisis sample, only 3 lags are used due to the short sample.

Table 2. Sample period and interest rate measure

	Full Sample	**Exchange rate regime**	**Interest rate**
Indonesia	1986:1-2001:6	Managed float/ floating	3-month deposit rate/3-month SBI
Korea	1991:1-20016	Managed float/floating	Overnight interest rate
Malaysia	1985:1-2001:6	Managed float /fixed	3-month interbank rate
Philippines	1986:1-2001:6	Managed float/ floating	Interbank call loan rate
Singapore	1980:1-2001:6	NEER targeting	3-month interbank rate
Taiwan	1981:1-2001:6	Managed float	91-180 days commercial paper rate
Thailand	1987:1-2001:6	Basket-peg / floating	3-month money market rate

4 Results

4.1 Impulse responses: interest rate as the policy instrument

Figures 1 to 7 show the impulse response functions of the variables included in the VAR (except the commodity price) to a monetary policy shock that results in a 25 basis points rise in the interest rate for the 7 economies studied here. The two dashed lines in each panel depict the 95% confidence bands. The first column of each figure reports the results for the full sample while the second and third columns depict those for the pre-crisis sample and the post-crisis sample, respectively. For the longer samples, the impulse responses are plotted over a 24-month horizon and for the shorter samples, only 12-month reporting horizon is used. We first proceed to discuss the results for each of the 7 economies and how the impulse responses vary across samples. Then we offer a summary of the results across these economies.

In the case of Indonesia (Figure 1), the results are broadly consistent with the conventional thinking of the effects of a monetary policy shock. Over the full sample reported in the first column, following a contractionary monetary policy shock, output declines and the response is significant about 3 months after impact. The initial price response is negligible but negative. Then prices rise rather than decline for the next 2 months before declining for the following 7 months or so. Prices rise again after the thirteen months and stay above trend for the remaining period. Although the price response is mostly insignificant, the initial rise in the price level is not consistent with the expected effects of a tightening policy shock. Following the shock, the interest rate rises and stays above the preshock level for the entire period but the response is only significant for the first 4 months. Money drops for the first 12 months before rising above trend, suggesting an initial decline in money demand in response to an interest rate hike. Following a rise in the interest rate, the effective exchange rate is expected to rise but it declines initially as shown in the last panel of column 1. The exchange rate rises in the second month before declining again after about 8 months. While the exchange rate response is insignificant, the initial depreciation poses an exchange rate puzzle.

The results differ somewhat when the subsamples are considered. Most notably, prices decline significantly as expected in the pre-crisis sample as shown in the second column of Figure 1. There is an output puzzle but the initial output response is rather small and insignificant. Output begins to fall 7 months after impact and the response is significant only from the 10^{th} to the 12^{th} month. Money decreases initially but then starts to rise 3 months after the shock. The responses of the interest rate and the exchange rate are fairly similar to those in the full sample. For the short sample of the post-crisis period, the results are quite similar to the full sample, except that output declines after the policy shock. There are, nevertheless, both the price puzzle and the exchange rate puzzle.

The impulse response functions for Korea are reported in Figure 2. Since the overnight call rate series begins in 1991, we consider a 10-year sample in the full-sample analysis. In general, the responses to a policy tightening are broadly consistent with the expected effects: the interest rate rises, output and prices drop while the exchange rate rises. The decline in output is very short-lived, lasting for only 2 months. As the interest rate begins to drop, output rises as well. The price response is not significant but is of the expected sign for the first 10 months. Following the contractionary shock, the interest rate rises only for the first two months and then declines significantly for the next 8 months. The response of the exchange rate is more persistent, with the appreciation lasting for more than 8 months. The response of money is inconsistent with intuition as it rises after an interest rate hike. If M1 has a large component that is interest bearing, a higher interest rate may result in an increase in demand for it. The responses are quite similar when other monetary aggregates such as M2 or M3 are considered.

There are few improvements in the results when the crisis period is excluded. For the sample ending before the crisis, the results show only slight difference as the response of the effective exchange rate is puzzling, i.e. the exchange rate decreases rather than increases after the shock. For the post-crisis sample, there are also perverse price responses and exchange rate responses. However, money declines after the shock, in contrast to the results in the other two samples.

For Malaysia (Figure 3), the responses to a contractionary shock are in general consistent with the expected effects, except for the response of prices. Prices rise initially rather than decline although the price response is significant for the first 3 months only. Output decreases significantly only for the first two months and stays below the preshock level for most of the reporting period. However, the output response is quite unstable. Money drops significantly for most of the reporting periods, indicating a decline in money demand in response to a rise in the interest rate. The interest rate response displays rather high persistence. After the initial 25 basis point jump, the interest rate remains significantly above the preshock level for the first 7 months. The rise in the exchange rate is not statistically significant and the exchange rate starts to fall after a year. The price puzzle does not appear for the sample that ends in mid-1997. The responses of other variables are quite similar to those in the full sample. The perverse price response reappears in the shorter post-crisis sample. In addition, money rises after the shock for the first 5 months, although the money response is insignificant.

For the Philippines (Figure 4) a tightening of policy leads to a decline in output 2 months after the shock and output remains significantly lower for more than a year. Prices, contrary to expectations, remain higher than the preshock level throughout the reporting horizon although the responses are not significant. Money falls below trend for most of the reporting period while the interest rate stays above trend for the first 5 months. The exchange rate rises briefly after impact but then quickly begins to decline 2 months after impact.

For the sample that ends in mid-1997, there is also a price puzzle although it lasts for only the first 6 months. After that, prices start to decline significantly. Output stays below the preshock level for the entire reporting period after the shock, with the response being significant only for the first few months. Money drops below trend for over a year but the money response is not significant. The interest rate response is not very persistent as it subsides 3 months after impact. The exchange rate appreciates significantly about 6 months after the shock and remains above trend for most of the reporting period. The responses to the tightening shock in the post-crisis sample are not very consistent with expectation. After the shock, output and prices rise, and the exchange rate depreciates.

Figure 5 displays the impulse responses to a contractionary monetary policy shock in Singapore when the interest rate is considered as the policy instrument as in other economies in this study. Although the nominal effective exchange rate is the monetary policy instrument according to the monetary authority, the responses reported in the first two samples in Figure 5 are quite consistent with the expected effects of a monetary policy shock. Over the full sample, the interest rate stays higher significantly for the first 6 months following the shock. The effective exchange rate initially depreciates for the first 2 months but then appreciates for the following 6 months, before depreciating again. While output, prices and money all fall after impact, the price response is not significant. Both the responses of output and money display high persistence, declining for almost the entire 24 months reported.

For the pre-crisis sample, the results are quite similar to the full sample, except that there is a significant appreciation of the NEER for over half a year. For the third sample that starts in 1998, the responses of all the variables are mostly insignificant but the responses of money and the exchange rate are also of the wrong signs.

The impulse responses in Taiwan reported in Figure 6 show mixed results. Output declines significantly following the shock except the brief and sharp spike in the second month. The output responses display a lot of volatility. The price response is very small and not signficant while the money response is significant and below the preshock level for most of the reporting horizon. The interest rate stays significantly above trend for the first 3 months and the exchange rate rises for the first 3 months after impact as well. Afterwards, the responses of the exchange rate and the interest rate are very small and insignificant, suggesting a close link between the interest rate and the exchange rate.

The responses for the pre-crisis sample reported in the second column are in general similar to those for the full sample. The key difference is the exchange rate response. While the interest rate response is mostly insignificant after the first 3 months, the exchange rate is significantly below the preshock level after rising above trend for the first 3 months. For the post-crisis sample, output, prices, and money all decline initially after the impact, but the responses are not persistent. While the interest rate stays above trend significantly for the first 6 months, the exchange rate only begins to rise after the second month.

The impulse responses of a contractionary monetary policy shock in Thailand displayed in Figure 7 vary quite a lot over the different samples. For the full sample reported in the first column, in response to the tightening shock, output declines significantly for the first few months. However, the responses display substantial instability throughout the reporting period. Prices rise for the first 9 months after impact, inconsistent with what one would expect prices to respond after a policy tightening. Prices decline briefly but rise above the preshock level again very quickly. Money declines and remains below trend for the entire reporting horizon. While the interest rate rises 25 basis points upon impact and remains above trend for the first 2 months, the response afterwards is mostly insignificant. The exchange rate decreases initially but the exchange rate response is not significant after a year.

When we end the sample in mid-1997, the output response mostly insignificant and does not display a clear pattern. Prices also display instability after the shock but prices go below the preshock level significantly 10 months after impact. Money and the interest rate respond as expected but the initial response of the exchange rate is to depreciate rather than appreciate. Only after 3 months that the local currency begins to appreciate. For the shorter post-crisis sample, the responses to a policy tightening fit well the expected effect of such a shock. However, prices decline only for the first month and the response is not significant.

Table 3. Impulse responses to a contractionary monetary policy shock

	ID	KR	MY	PH	SG	TW	T H	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	+	+	+	+	-	-	-	-
M	-	-	+	-	+	-	-	-
R	+	+	+	+	+	+	+	+
X	-	+	+	-	-	+	+	+

It is worthwhile at this point to briefly summarise the results for the 7 economies (also see Table 3) since the impulse responses display rather larger variations across economies. For the full sample, output initially declines in all economies as expected, in response to a contractionary monetary policy shock but the persistence of such a response varies a lot across economies. Output begins to rise in Korea, Malaysia and Taiwan 2 months after shock although the positive output responses are not significant and are only temporary in Malaysia and Taiwan. While output remains below the preshock level for almost the entire 24-month horizon reported in Malaysia, the Philippines and Singapore, the responses are significant up to 12 months only in the former two economies.

A price puzzle – prices decrease rather than increase after an expansionary shock – can be found in most cases except in Korea and Singapore. These perverse price responses are also rather persistent, especially in the case of the Philippines. Including the commodity price index or the oil price index does not seem to solve the problem. However, ending the sample in mid-1997 eliminates the price puzzle in Indonesia, Malaysia and to certain extent in the Philippines and Thailand. These results suggest that the break during the 1997 crisis has a substantial effect on the estimation. 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.

The response of money is in general consistent with the expectation that money demand drops in response to a policy tightening, except in Korea where money stays above the preshock level for almost a year before declining. In the post-crisis sample period, money in Korea decreases after the contractionary shock. The money responses tend to be quite stable across subsamples.

The interest rates in most cases remain above the pre-shock level for quite some time following an initial 25 basis-point hike. In Korea and the Philippines, the interest rate falls below trend a few months after the shock and remains significantly negative for a few months, suggesting a rather short-lived liquidity effect. In other cases, the interest rate response is mostly small and insignificant after about 6 months.

Following the interest rate drop, the currencies in Korea, Malaysia, the Philippines and Taiwan appreciate initially in effective terms as expected. However, the currency appreciation in the Philippines and Taiwan lasts for only 2 to 3 months. In other economies, there is a brief depreciation initially, followed by an appreciation afterwards. These results suggest that the exchange rate puzzle is a problem in 3 of the 7 economies studied.

Across subsamples, the sample that ends before the 1997 crisis tends to produce better results than those for the full sample. In particular, the price puzzle found in many economies in the full sample tends to be less a problem in this subsample, suggesting that the break in the crisis does matter for the analysis. In contrast, the post-crisis sample gives better results only in the case of Taiwan and Thailand, and to certain extent Singapore. In these 3 economies, in response to a tightening policy shock, output, prices and money decline while the local currency appreciates in effective terms.

Among the 7 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. As the interest rate rises, output, prices, and money all fall while the exchange rate appreciates. However, monetary policy in Singapore is mainly implemented through the management of its nominal effective exchange rate and thus the domestic interest rates are largely determined by external interest rates. In this case, the unexpected 25 basis-point 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 exert downward pressure on the economy, resulting in lower output, prices and money demand. If the rise in the local interest rate is less than that of the foreign interest rate, there will be some downward pressure on the exchange rate.

4.2 Impulse responses: exchange rate as the policy instrument

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. By buying Singapore dollar and selling foreign currency to pump up the effective exchange rate, there is 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 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 8 reports the results for Singapore in the case where the exchange rate is used as the policy instrument. Following a contractionary shock that results in an appreciation of the exchange rate by 1%, output and money respond to the shock immediately and significantly while prices are slow to respond and not significantly. The interest rate response reported in the first column is not significantly different from zero. The results are more or less the same across the subsamples, except that the interest rate rises significantly 2 months after impact in the post-crisis sample.

Overall, modelling the effective exchange rate as the monetary policy instrument produce results that are consistent with the conventional thinking about the monetary transmission mechanism. This result is quite interesting because unlike 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 will not 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 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 (ϕ_x) for the economies considered here vary substantially but in most cases tend to be smaller than one would expect (see Table 4), except in the case of Thailand, given the degree of openness of these economies. It also displays substantial variation across samples. The small weight on the exchange rate suggests that the exchange rate plays a relatively small role in the measure of monetary policy in most East Asian economies and that the short-term interest rate captures most of the information about monetary policy. However, this conclusion is reasonable only if the shock identified in the model resembles a monetary policy shock. The mixed results reported earlier for several economies cast some doubts on this interpretation.

Table 4. Sample period and estimated weights of the exchange rate (t-stats in parenthesis)

	Sample	Weight	Sample	Weight	Sample	Weight
Indonesia	86:1-2001:6	0.06 (3.56)	86:1-97:6	0.02 (1.11)	98:1-01:6	0.25 (1.17)
Korea	91:1-20016	0.16 (5.52)	91:1-97:6	0.12 (0.69)	98:1-01:6	0.05 (1.72)
Malaysia	85:1-2001:6	0.02 (1.27)	85:1-97:6	0.04 (0.98)	98:1-01:6	0.01 (0.28)
Philippines	86:1-2001:6	0.15 (1.34)	80:1-97:6	0.20 (1.13)	98:1-01:6	0.01 (0.17)
Singapore	80:1-2001:6	0.12 (2.81)	80:1-97:6	0.02 (0.45)	98:1-01:6	0.10 (1.83)
Taiwan	81:1-2001:6	0.10 (4.43)	81:1-97:6	0.09 (3.18)	98:1-01:6	0.01 (0.61)
Thailand	87:1-2001:6	0.27 (6.45)	87:1-97:6	0.4 (2.06)	98:1-01:6	0.07 (1.83)

In order to see whether the VAR model underestimate the role of the exchange rate, we try another identification scheme by imposing a weight on the exchange rate. Instead of imposing the restriction that $\gamma_1 = 0$ (which implies that the innovation in the exchange rate does not respond to the interest rate contemporaneously), we pick plausible values for the weights of the exchange rate in a measure of the MCI based on the openness of the economy. For example, we impose a weight of 0.3 in Thailand and 0.67 in Malaysia on the exchange rate to examine the sensitivity of the results to the relative weight of the exchange rate.[6]

The results for setting the weight to 0.67 in Malaysia are reported in Figure 9. Overall, while the responses of prices and the exchange rate improve substantially, the response of output becomes inconsistent with monetary theory. For the full sample in the first column, output rises for almost a year after the contractionary shock. In response to the shock, prices decline significantly for over a year. Money, however, declines only for the first 3 months and afterwards stays above the preshock level for almost a year. The interest rate response is quite volatile as it rises for the first 4 months and then dips below trend for the next 6 months, before rising above trend again. The local currency appreciates for the first 10 months and then depreciates afterwards. The results for the sample ending mid-1997 improve with a larger weight on the exchange rate, compared to that in Figure 3. In response to the tightening policy shock, output declines for the first 6 months, and prices and money decline significantly, while the interest rate and the exchange rate both rise significantly. The impulse responses for the post-crisis sample are quite similar to the one reported in Figure 3, displaying a price puzzle.

[6] Hataiseree (1998) estimated the weight of the exchange rate in Thailand to be 0.3 in the MCI and Razi (2001) found the weight in Malaysia to be 0.67.

The results for Thailand are reported in Figure 10. The impulse responses for the full sample are very similar to that depicted in Figure 7, displaying both the price and exchange rate puzzles. This result is not so surprising since the weights on the exchange rate in these two cases are rather similar (0.27 versus 0.3). For the pre-crisis subsample, the results are also quite similar despite a slightly larger difference in the weight. The improvement in the impulse response for the post-crisis sample is more substantial – a significant decline in the price level after the shock. This improvement is likely coming from a much larger weight compared to the one obtained from the estimation (0.3 compared to 0.07 estimated).

We also consider setting the weight equal to one of the following plausible values for the MCI weights, i.e. {0, 0.167, 0.33, 0.5, 0.67, 0.83}. When the weight is set to zero, it means the central bank is targeting the interest rate. Thus the higher the weight, the more attention the central bank pays to the exchange rate. The impulse responses for the different weights for each of the 7 economies are reported in Figure 10. The solid line depicts the responses for the case where the weight is zero and the long-dashed line for the weight to be 0.83. Results for other values of the weights are in between these two lines. Note that there are substantial variations in the impulse responses, both in terms of the direction and the magnitude. However, it is hard to conclude whether a higher weight on the exchange rate improves the results. For example, a larger weight tends to produce larger and more plausible responses of price as well as the exchange rate. In addition, the price puzzle is eliminated in Indonesia, Malaysia, the Philippines and Thailand with a large enough weight. The exchange rate appreciates in most economies, except Thailand, in response to a tightening policy shock when the weight is larger than zero. However, the output response poses a problem for most economies when the weight increases. The money responses also turn positive in Malaysia and Taiwan. Thus it is not very clear whether a better estimate of the weight will help to produce better impulse response functions.

There are several reasons for some of the perverse responses found in the VARs. 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 obviously 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 may have caused the price puzzle and the variable included in the VAR is not able to reflect that.

Second, some measures of the variables used in the analysis may not be suitable. The most likely candidate is the interest rate since some of these interest rates reflect not only central bank actions but other factors as well. If the variable included in the VAR is 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, many central banks in the region may not have used the interest rate as a policy instrument until quite recently. The measure of CPI could potentially be a problem given the relatively large rural sector in some Asian economies. A bad harvest could push up the CPI fairly quickly even if the central bank is in the midst of raising interest rates to cool down manufacturing.

Third, the poor results found in some economies could be due to the identification scheme used in the analysis. The two variables included in the policy block may not be adequate for identifying the policy shock. One potential candidate would be a measure of a monetary aggregate. Over the last two decades, some central banks had targeted some measures of monetary aggregates in implementing monetary policy.

Fourthly, seasonality could be a potential problem in some of the Asian economies. For example, in economies which have a large Chinese community, say Taiwan and Singapore, the slowdown in production due to factory closure and a jump in the demand for currency during the Chinese New Year holidays could generate substantially seasonality.

5 Appendix

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

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

(15) Exchange rate : $u_X = v^s + \phi^b v^b$

(16) Interest rate : $\gamma_1 u_X + u_R = v^b$

Equation (15) describes how the central bank sets the exchange rate. This equation implies that the central bank observes and responds to shocks to the interest rate within a given period, with the extent of the responses given by the coefficients ϕ^b. Setting $\phi^b = 0$, for example, means that the central bank does not respond to the interest-rate shock. The term v^b represents the exogenous monetary policy shock. Equation (16) 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.

Note that we can write the relationship in (10) and (11) as (see equation (7)):

(17) $$\begin{bmatrix} 1 & 0 \\ \gamma_1 & 1 \end{bmatrix} \begin{bmatrix} u_X \\ u_R \end{bmatrix} = \begin{bmatrix} 1 & \phi^b \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v^s \\ v^x \end{bmatrix}.$$

We can then invert the relationship (17) to determine how the monetary policy shock, v^s, depends on the VAR residuals:

(18) $v^s = (1 - \phi^b \gamma_1) u_X - \phi^b u_R$.

Equation (18) 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, we impose the restriction that $\phi^b = 0$, thus allowing the derivation of a measure of monetary policy stance as follows:

(19) $v^s = u_x$.

This restriction implies that the innovation in the exchange rate represents the monetary policy shock.

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Figure 1. Impulse response for Indonesia

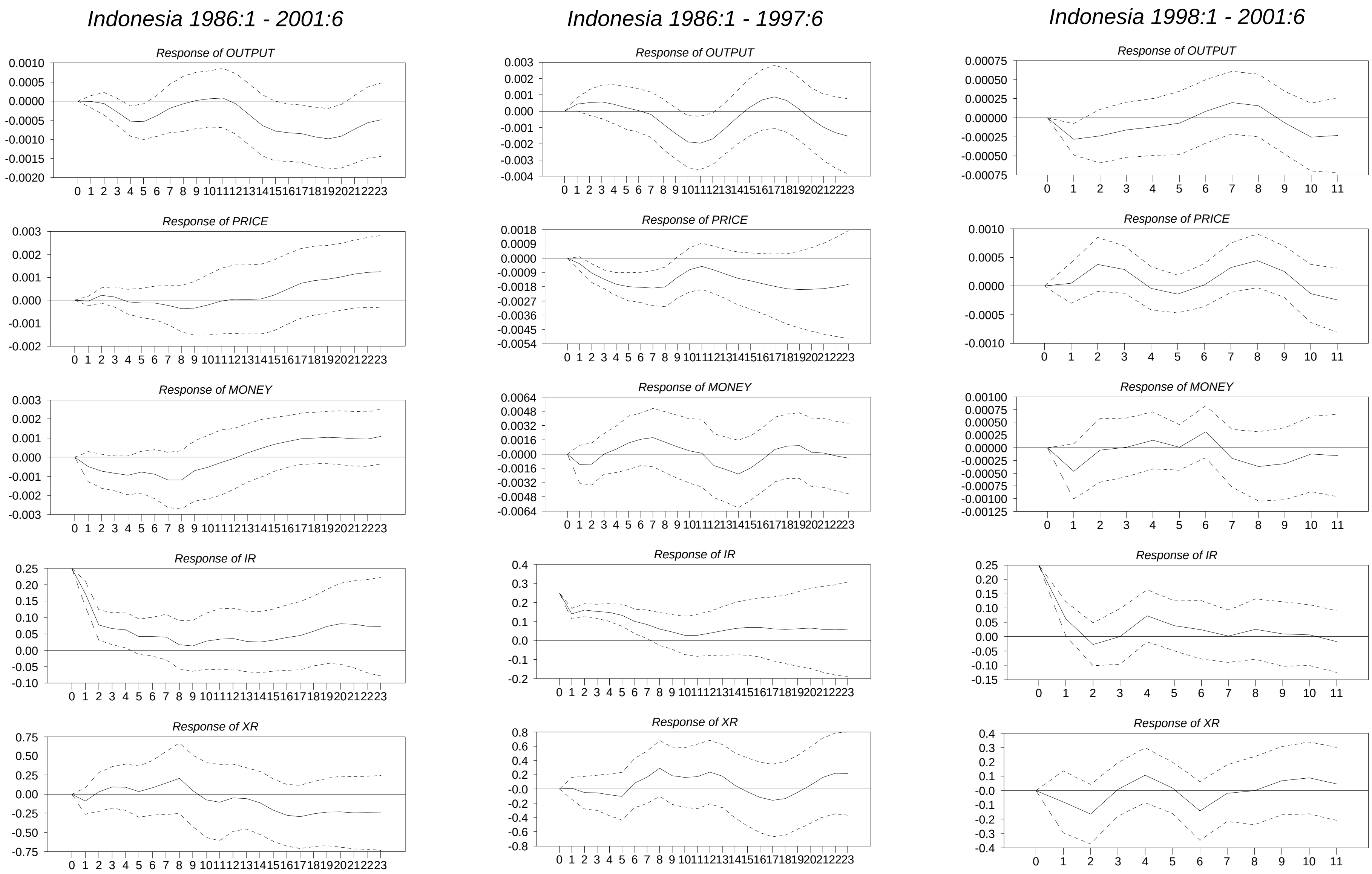


Figure 2. Impulse responses for Korea

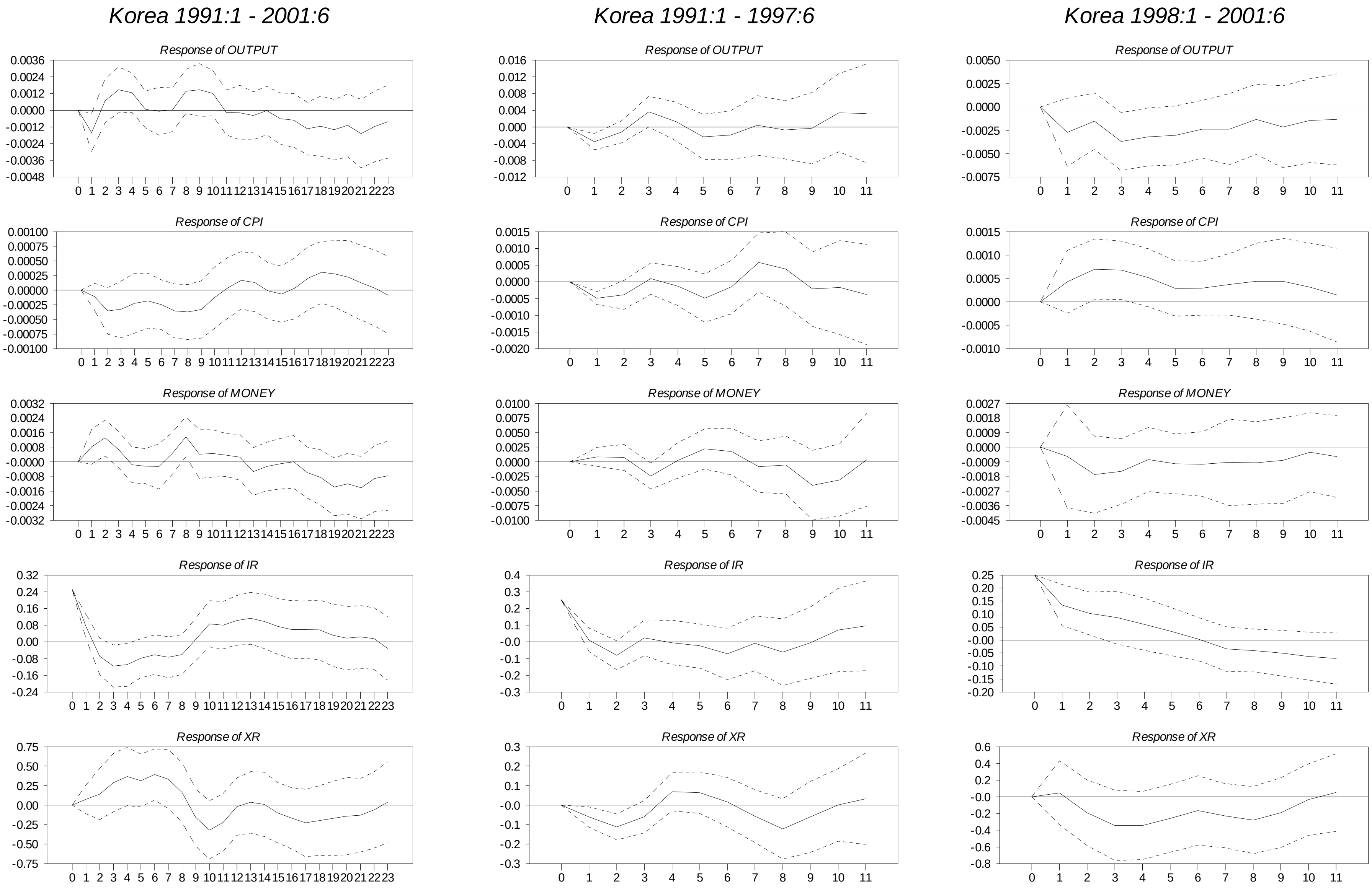


Figure 3. Impulse responses for Malaysia

Malaysia 1985:1 - 2001:6 | *Malaysia 1985:1 - 1997:6* | *Malaysia 1998:9 - 2001:6*

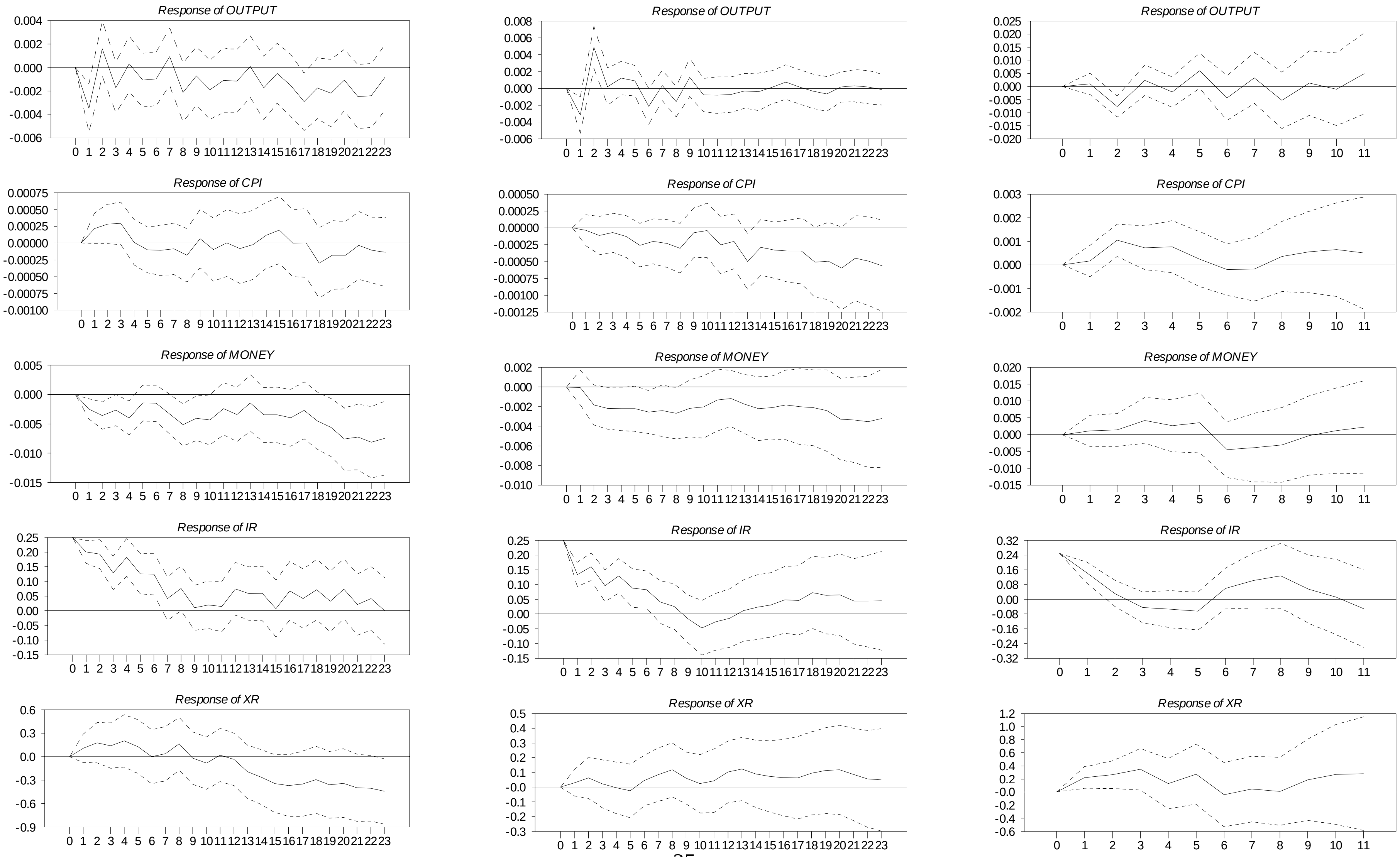


Figure 4. Impulse responses for the Philippines

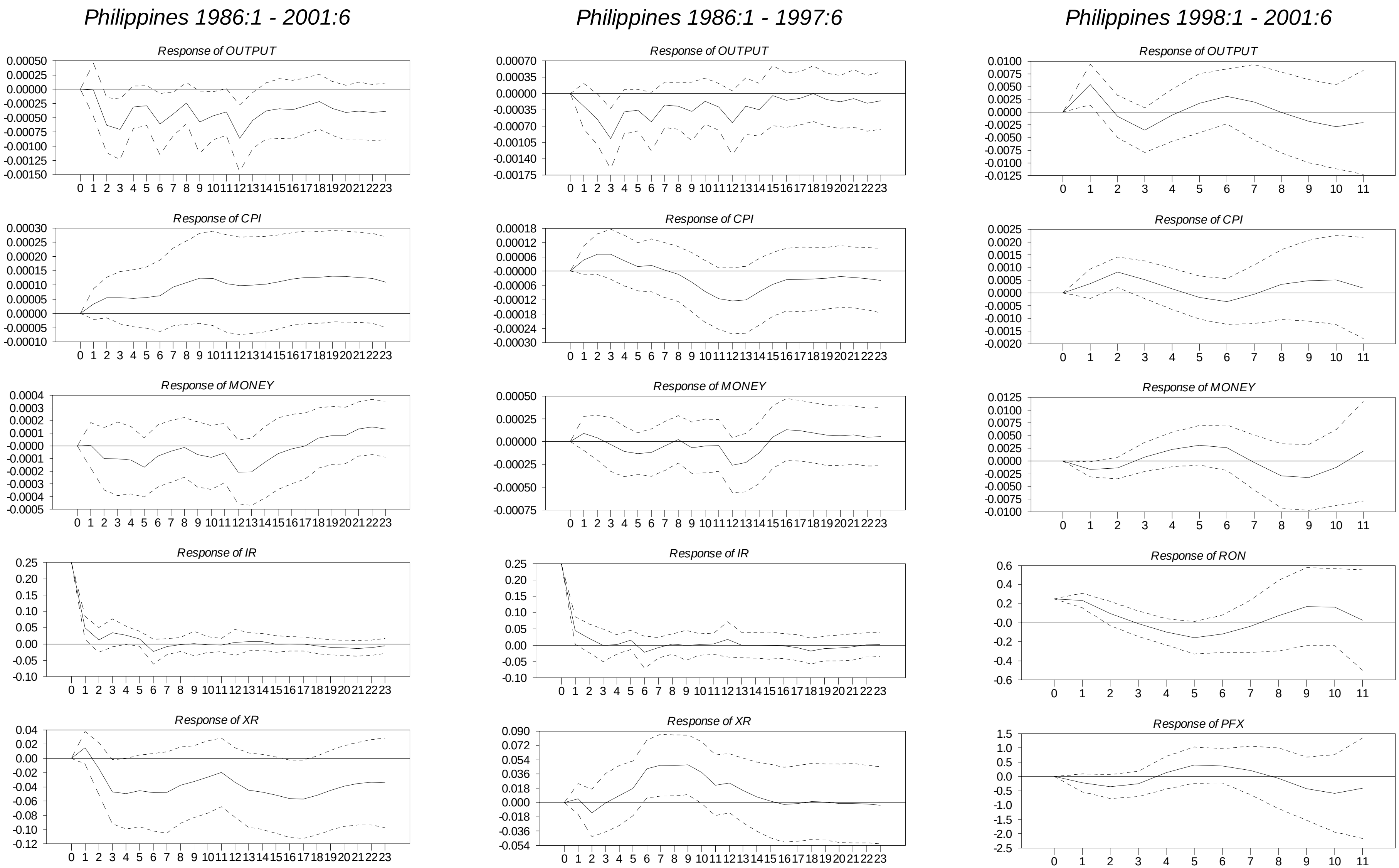


Figure 5. Impulse responses for Singapore

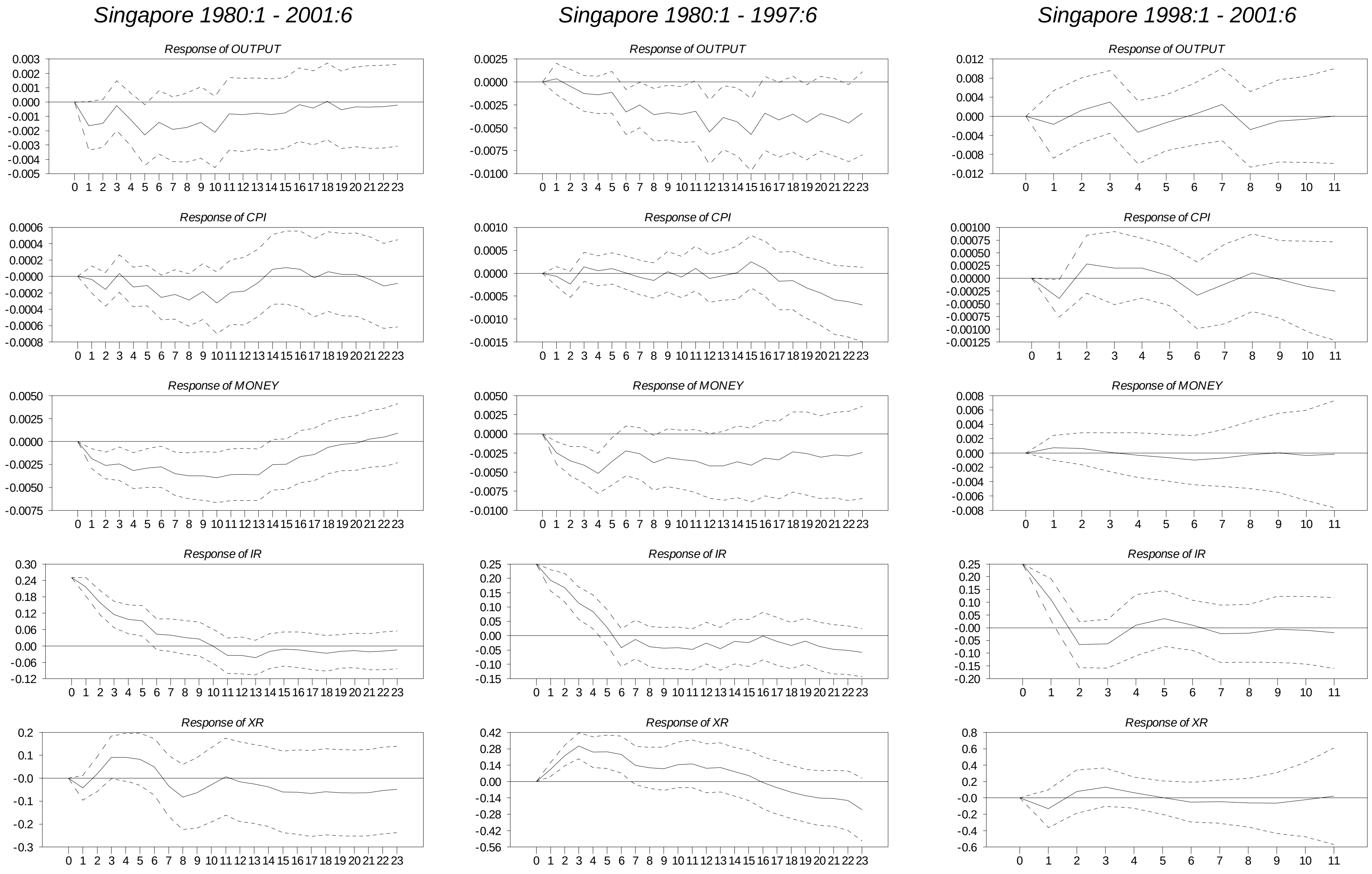


Figure 6. Impulse responses for Taiwan

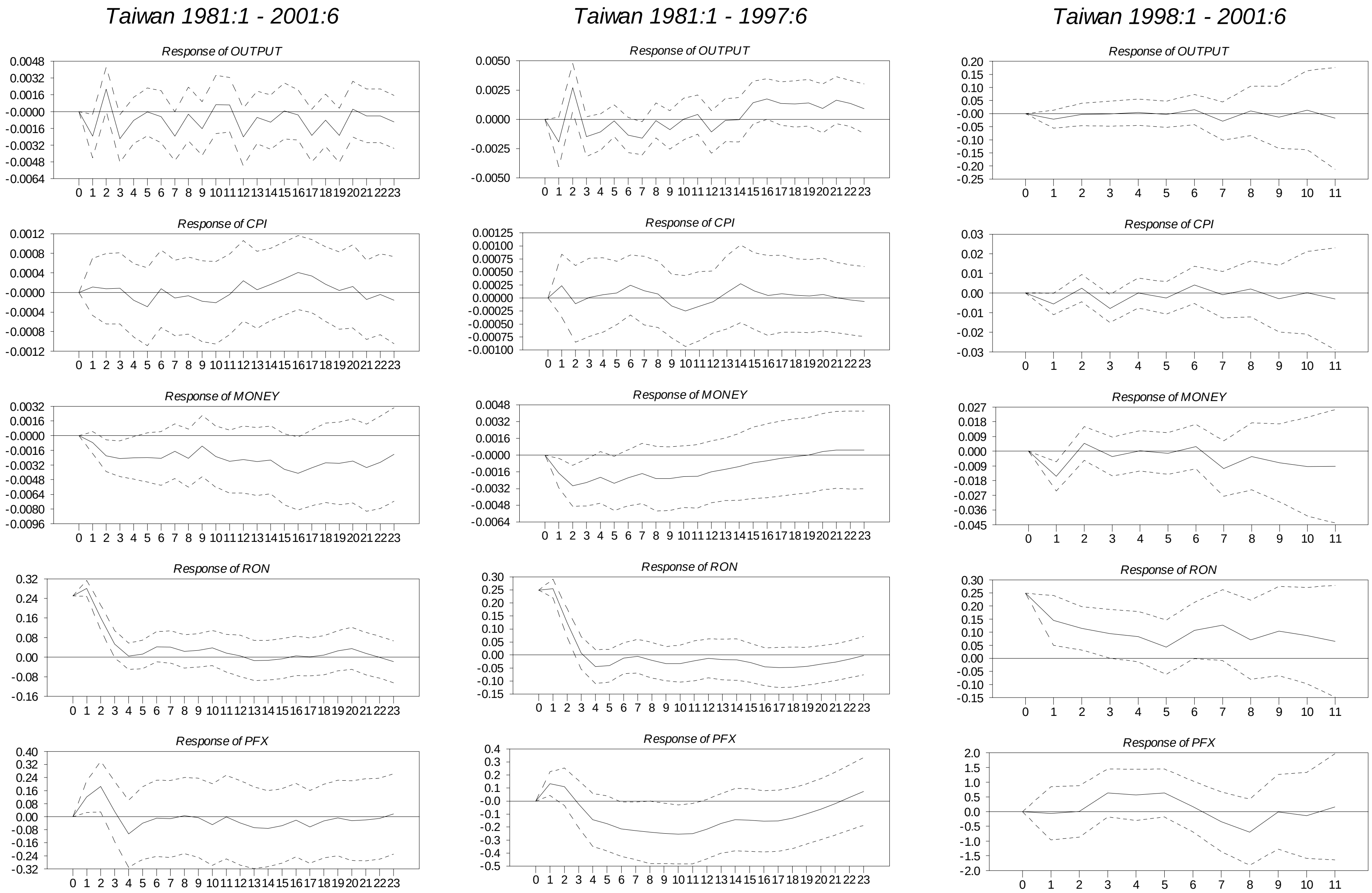


Figure 7. Impulse responses for Thailand

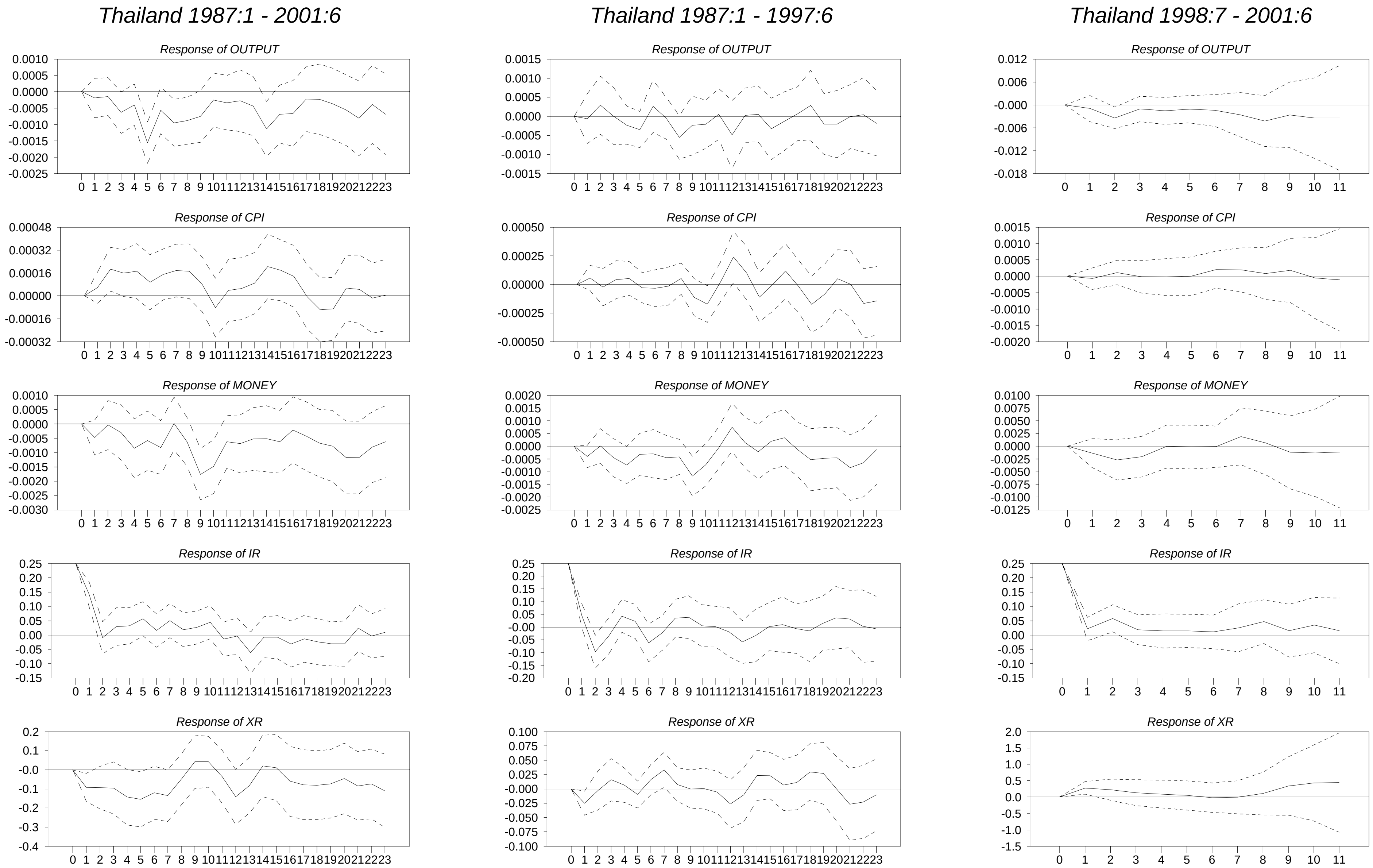


Figure 8. Impulse responses for Singapore (the exchange rate as instrument)

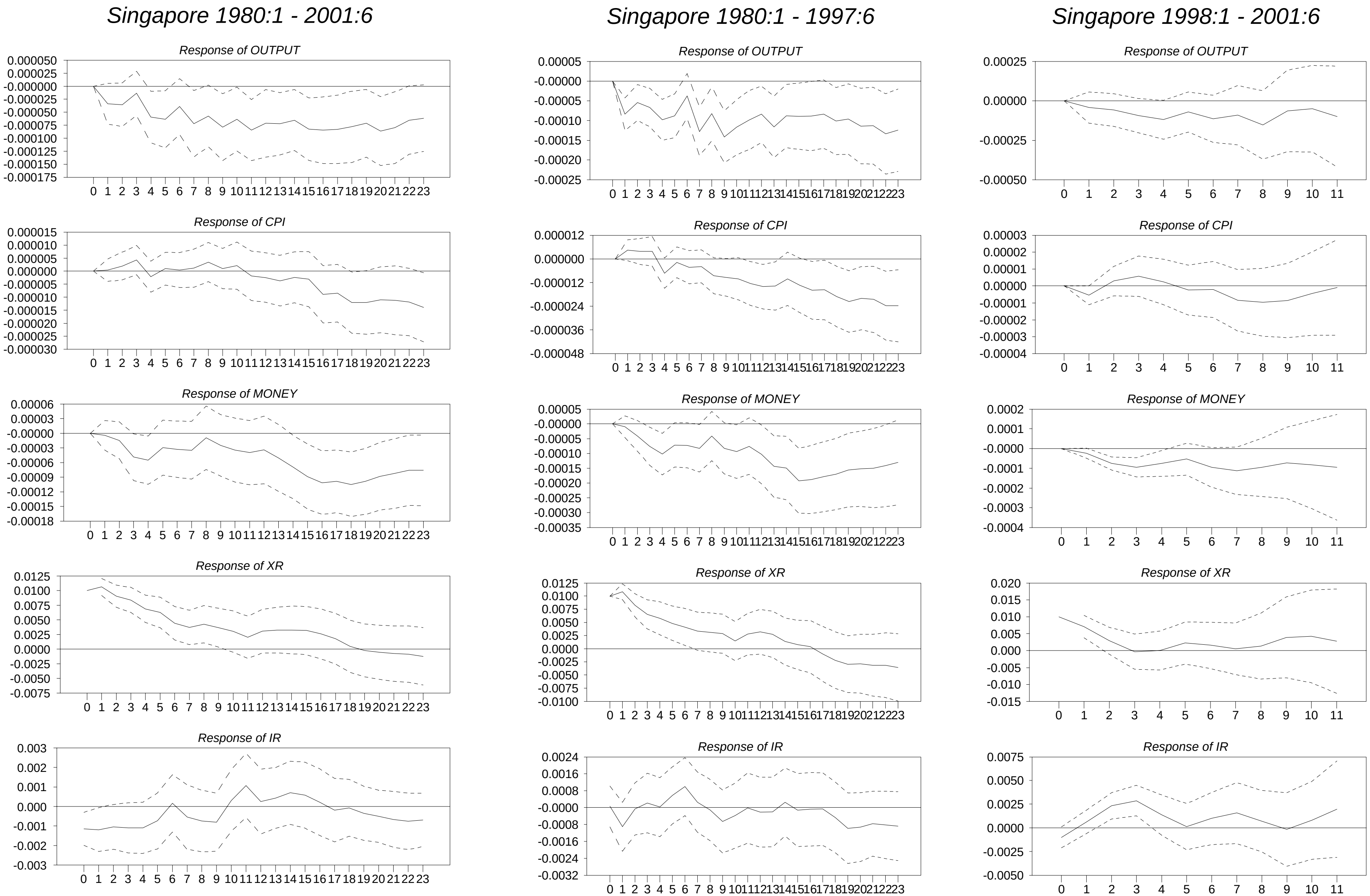


Figure 9. Impulse responses for Malaysia, with weight on the exchange rate set = 0.67

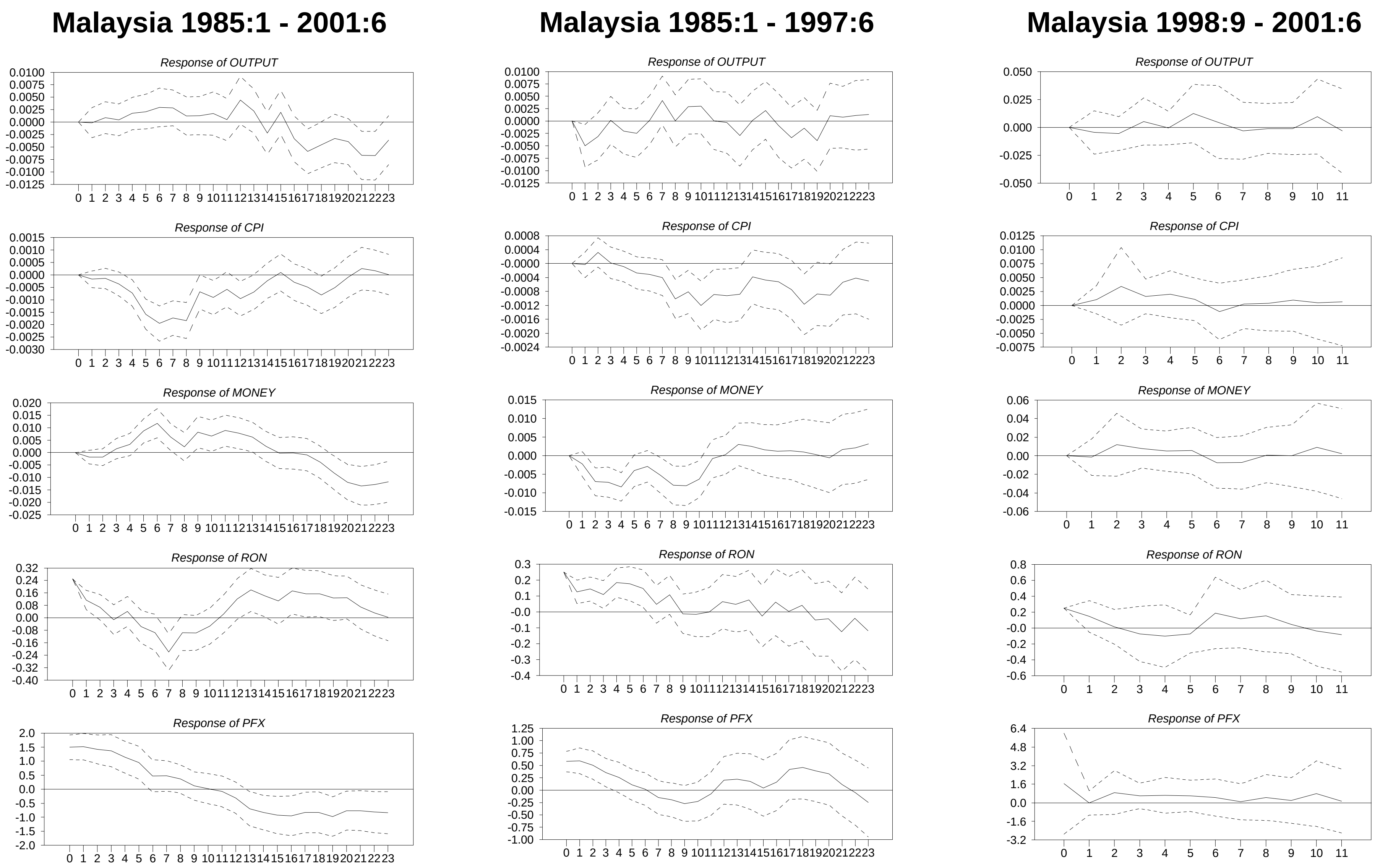


Figure 10. Impulse responses for Thailand, with weight on the exchange rate set = 0.3

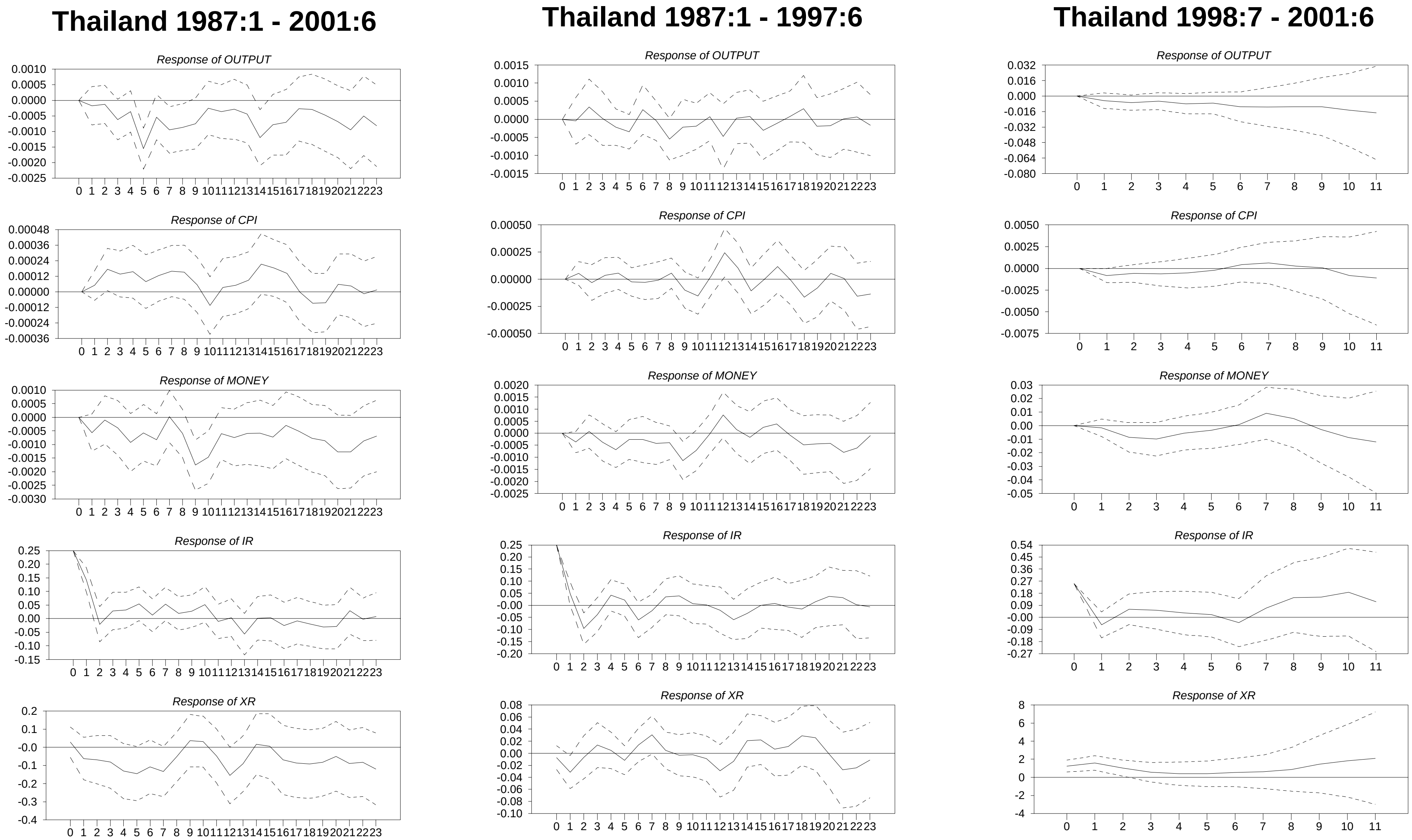
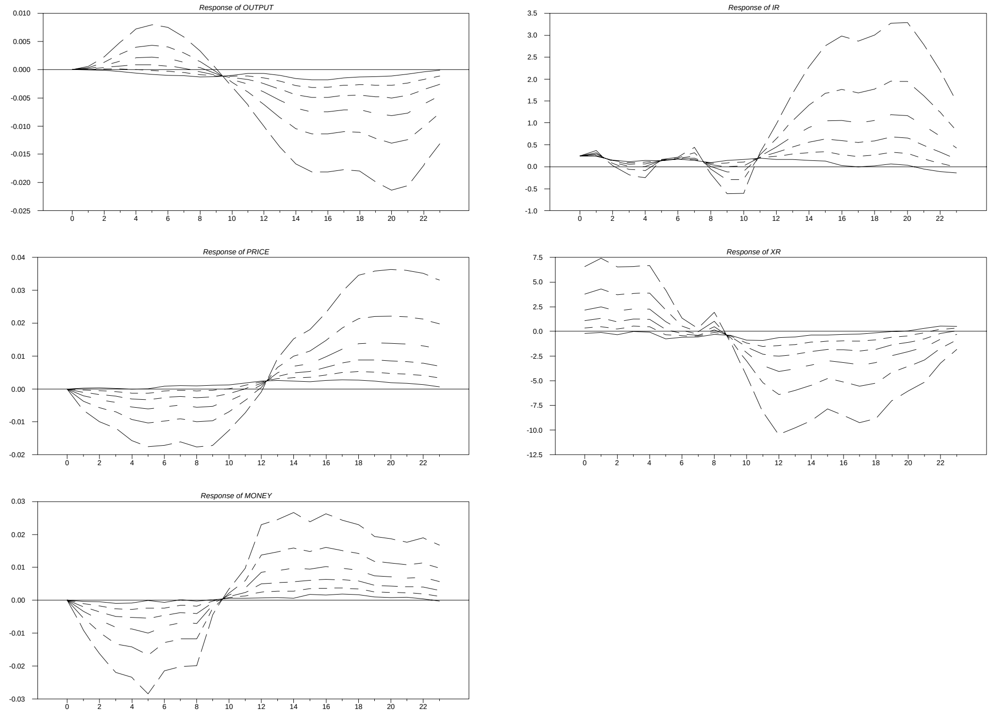


Figure 11. Impulse responses for different weights on the exchange rate

Indonesia 1986:1 - 2001:6



Korea 1991:1 - 2001:6

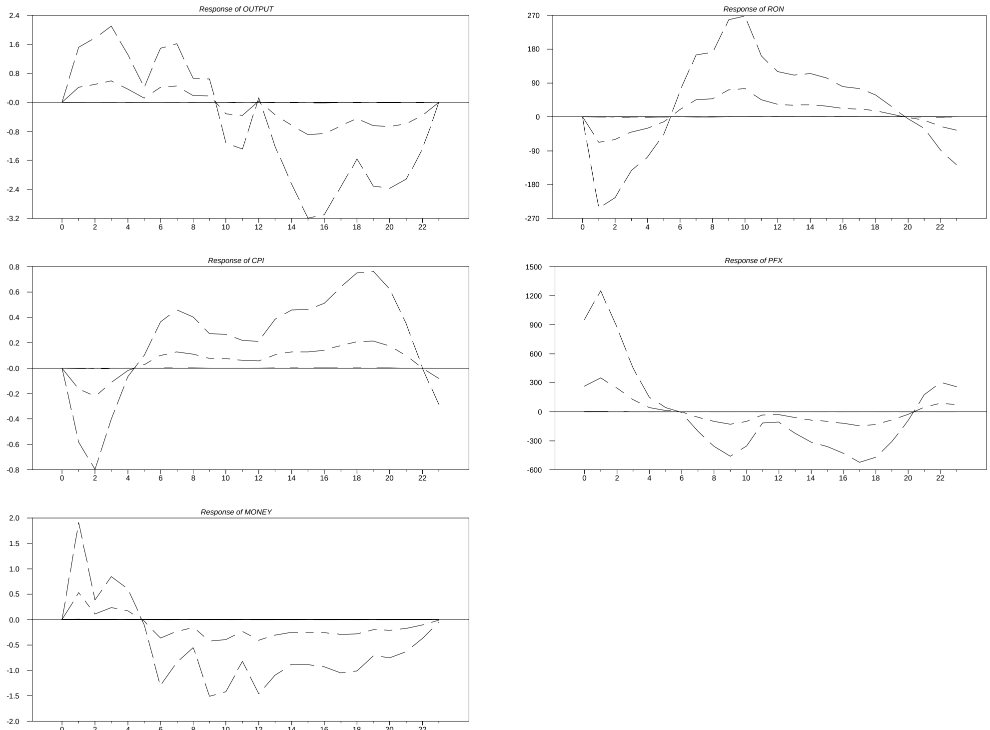
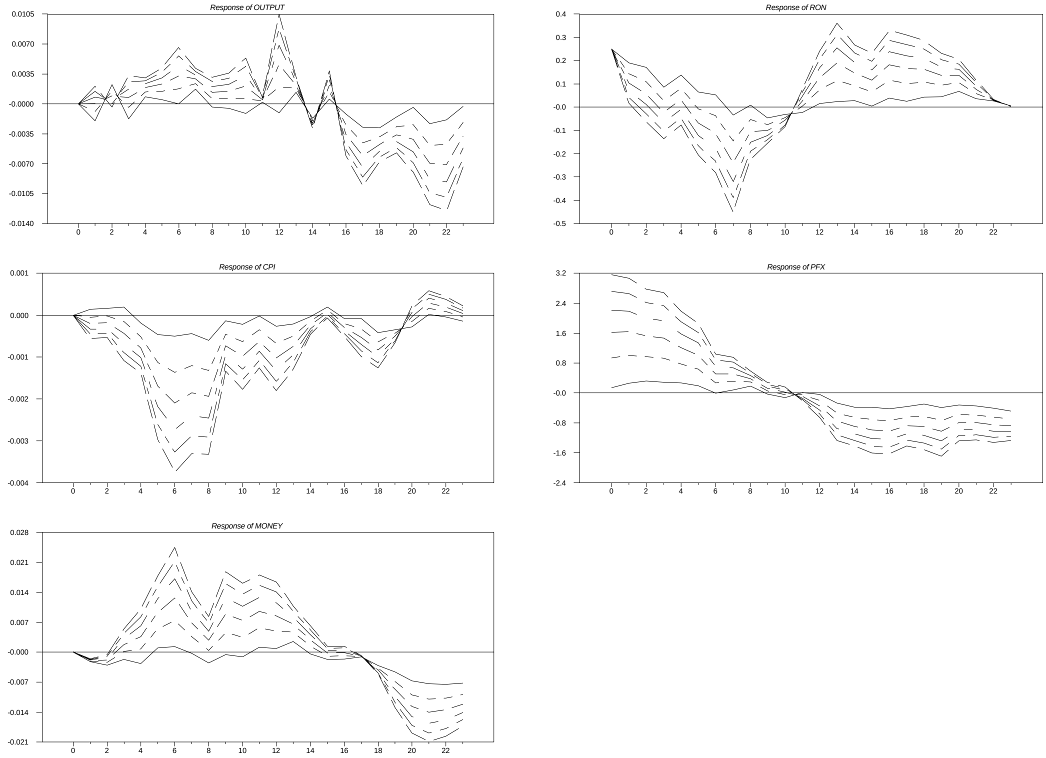


Figure 11 (cont) Impulse responses for different weights on the exchange rate

Malaysia 1985:1 - 2001:6



Philippines 1986:1 - 2001:3

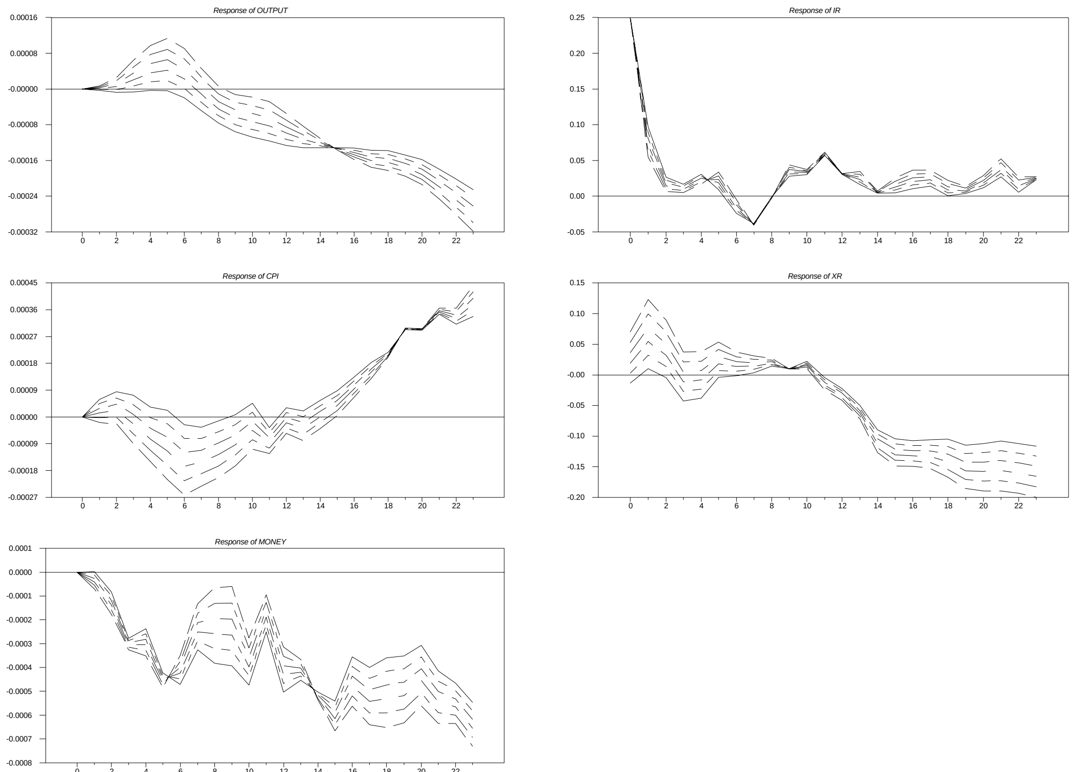
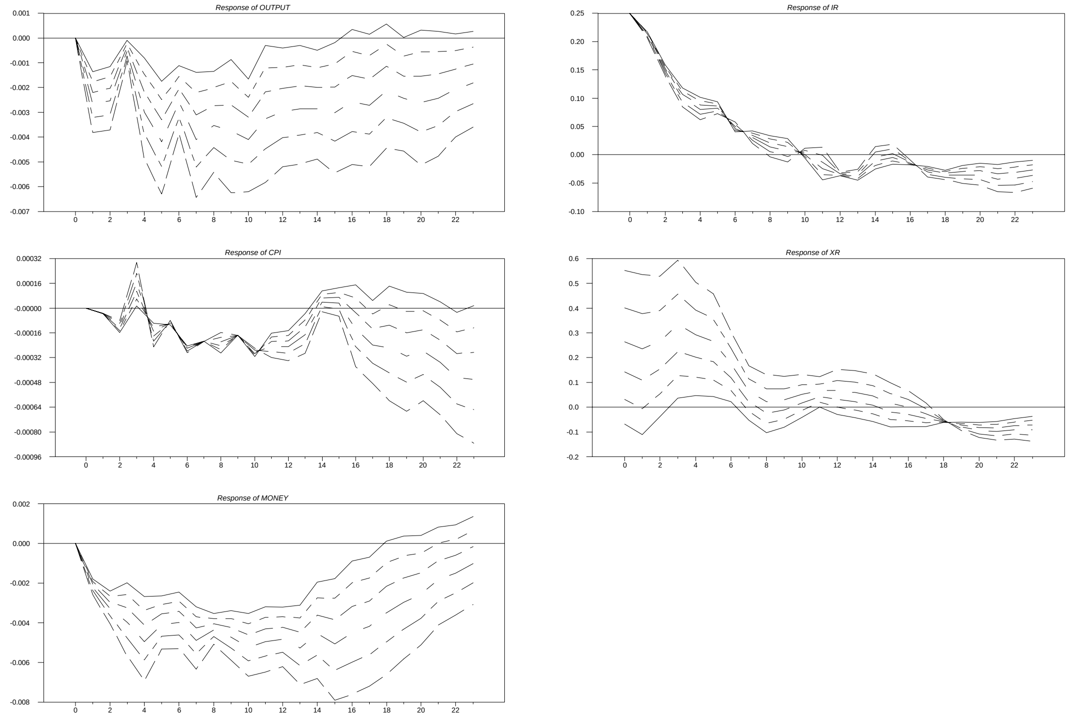


Figure 11 (cont) Impulse responses for different weights on the exchange rate

Singapore 1980:1 - 2001:6



Taiwan 1981:1 - 2001:6

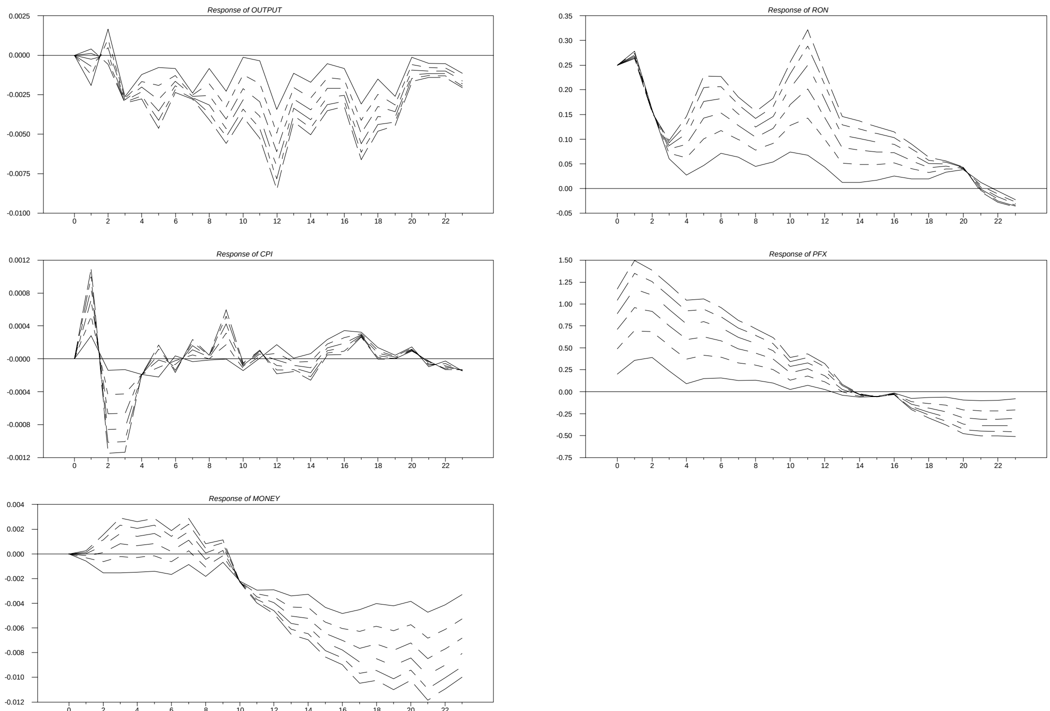


Figure 11 (cont) Impulse responses for different weights on the exchange rate

Thailand 1987:1 - 2001:6