Did sterilization of capital inflows really increase domestic interest rates? : evidence from East Asia

Did Sterilization of Capital Inflows Really Increase Domestic Interest Rates?: Evidence from East Asia

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1. Introduction

The emerging market economies of East Asia had been the recipients of a large volume of capital inflows during the period of 1988 to 1996.[1] For example, in terms of GDP, the volume of cumulative capital inflows from 1988 to 1995 amounted to 51.5 percent in Thailand, 45.8 percent in Malaysia, 23.1 percent in the Philippines, 9.3 percent in Korea, and 8.3 percent in Indonesia. Of the two largest recipients, Malaysia received surges of massive capital inflows in 1992 and 1993, amounting to 15.3 and 23.2 percent of GDP, respectively, while Thailand received consistent flows averaging about 10 percent of GDP annually (Villanueva and Seng (1999)). At the end of 1996, the balance of claims held by foreign banks against these countries stood at $261.2 billion; of this total, $100 billion was accounted for by Korea, $69.4 billion by Thailand, $58.7 billion by Indonesia, $28.8 billion by Malaysia, and $14.1 billion by the Philippines. Except in Korea, more than a half of these claims were the obligations of the nonbank private sector (Radelet and Sachs (1998)).

Capital inflows have both benefits and costs. As benefits, they promote investment and economic growth in the recipient countries,

1 The beginning of the surge in capital inflows can be identified as 1988 for Thailand, 1989 for Malaysia and the Philippines, 1990 for Indonesia, and 1990-91 for Korea (Calvo, Leiderman and Reinhart (1996), Chuhan, Claessens and Mamingi (1998), Montiel (1998), and Villanueva and Seng (1999)).

allow intertemporal smoothing in consumption, and thus raise welfare across countries. At the same time, as costs, they may lead to a rapid expansion of money and credit, an excessive rise in domestic demand and inflationary pressures, an appreciation of the real exchange rate, and widening current account deficits. They may even increase the vulnerability of recipients to a sudden reversal in capital flows. For these reasons, and perhaps in the light of earlier international debt crisis, the surge in capital inflows was, almost from the inception, perceived by the recipient countries as posing a challenge for domestic macroeconomic management, and soon began to be referred to as the "capital inflow problem" in the literature on open economy macroeconomics (Isard (1995) and Montiel (1998)).

To avoid the costs of capital inflows, East Asian countries took various policies, including capital controls, trade liberalization, greater exchange rate flexibility, fiscal contraction, and a variety of monetary measures (Montiel (1998), Reinhart and Reinhart (1998), and Villanueva and Seng (1999)). To avoid a rapid monetary expansion, in particular, the monetary authorities of East Asia took various monetary measures, included the conventional form of sterilization intervention (designed to offset the effect of reserve inflows on the monetary base by open market sales of domestic securities, defined as sterilization in the narrow sense), increases in reserve requirement (designed to limit the impact of reserve inflows on the growth of monetary aggregates by reducing the monetary multiplier) and shifting of government deposits from commercial banks to the central bank, an increase in the discount rate or otherwise a greater limit on the discount window, moral suasion, and credit controls (these monetary measures are defined as sterilization in the broader sense).

However, only few empirical studies have so far been made to examine the effectiveness of sterilization (in the broader sense) in East Asia.[2] Takagi and Esaka (2001) test for the effectiveness of

2 Montiel and Reinhart (1999) directly test the effect of sterilization on the volume and composition of capital inflows.

sterilization by estimating the extent to which foreign assets in the monetary base explains or predicts monetary aggregates and suggest that the set of various sterilization measures pursued in East Asia were effective in limiting the growth of narrow and broad money. In this paper, we show an empirical analysis of the effects of sterilization of capital inflows on domestic interest rates in East Asia (i.e., Indonesia, Korea, Malaysia, the Philippines, and Thailand).[3] If sterilization of capital inflows actually raised East Asian interest rates, it induced domestic firms to borrow abroad and foreign investors to invest in domestic countries, promoting additional capital inflows in East Asia. For this reason, it is important to examine the relationship between sterilization and interest rates in East Asia.

Thus, this paper tests indirectly whether sterilization raised domestic interest rates (e.g., the money market rate, the deposit rate, and the lending rate) in East Asia by using time series approaches. We first use the Granger causality test based on Toda and Yamamoto's (1995) procedure to examine the extent to which foreign assets in the monetary base explains or predicts domestic interest rates. We then apply the impulse response functions of interest rates to innovations in foreign assets to examine the dynamic interaction between foreign assets and interest rates by estimating the vector error correction models.

The paper is organized as follows. Section 2 will review the policy responses, what is called, sterilization, taken by the East Asian monetary authorities to limit the expansionary impact of reserve inflows on the growth of monetary aggregates. Section 3 will show the data set and properties of data. Section 4 will examine the issue of whether sterilization raised domestic interest rates by using time series approaches. Finally, Section 5 will present a summary and

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3 It is thought that sterilization in narrowly and broadly senses may raise domestic interest rates (see Calvo, Leiderman and Reinhart (1996) and Reinhart and Reinhart (1998)). However, there has so far been no econometric studies which shows the evidence that sterilization of capital inflows significantly increased domestic interest rates.

concluding remarks.

2. An Overview of the Policy Responses to the Capital Inflows

During the period of 1988 to 1996, the volume of capital inflows exceeded the deficit in current account in all countries, hence resulting in increases in the foreign assets (FA) source component of the monetary base.[4] To avoid a rapid monetary expansion, the monetary authorities of East Asia then took various monetary measures, included the conventional form of sterilization intervention (designed to offset the effect of reserve inflows on the monetary base by open market sales of domestic securities), increases in reserve requirement (designed to limit the impact of reserve inflows on the growth of monetary aggregates by reducing the monetary multiplier) and shifting of government deposits from commercial banks to the central bank, an increase in the discount rate or otherwise a greater limit on the discount window, moral suasion, and credit controls.[5] Of these and other monetary measures, sterilized intervention and the tightening of reserve requirements were the most common and were employed by all of the central banks at one time or another.

At least initially, sterilized intervention through open market operations was done by the monetary authorities of East Asia in the most common and extensive. Often lacking the depth of markets in government securities, the central bank of East Asia supplemented operations in government securities, by issuing their own debt instruments (Villanueva and Seng (1999)). After the initial period, however, most of the central bank began to rely much less on conventional sterilized intervention, in part owing to the quasi-fiscal costs of such operation. The quasi-fiscal cost arises because, in sterilized intervention, the central bank typically exchanges high-yielding domestic assets for low-yielding foreign assets (Calvo (1991)

[4] For an increase in the foreign assets and the monetary aggregates, see Takagi and Esaka (2001).

[5] Of course, as showed by the first section, East Asian countries took various policies to avoid the costs of capital inflows.

and Kletzer and Spiegel (1998)). In the consolidated government and central bank portfolio, the public sector ends up paying more on its liabilities than it receives on its assets, as more of government debt is held outside the central bank.

In addition to sterilized intervention, other measures were also used to control either the monetary base or the growth of monetary aggregate. Measures to control base money included central bank borrowing from commercial banks, and the shifting of government deposits from commercial banks to the central bank. The latter tool was frequently used in Malaysia, Thailand, and Indonesia. The most common tool of containing the growth of monetary aggregates (while accepting the increase in base money itself) was to effect a rise in reserve requirements. Malaysia frequently raised reserve requirements and expanded the coverage of institutions and deposits subject to the requirements. Indonesia and Thailand, although initially reluctant to raise reserve requirements, became more active users of this tool in later years.

In this paper, what we call sterilization included no only the conventional form of sterilized intervention (in which domestic and foreign securities are exchanged in an open market transaction), which may be termed "sterilization in the narrow sense", but also any form of transaction which is designed to limit the impact of reserve inflows on the growth of monetary aggregates, which may be termed "sterilization in the broader sense". Whether it is defined narrowly or broadly, sterilization tends to raise the level of domestic interest rates, provided that foreign and domestic assets are imperfect substitutes and hence sterilization is effective.

In the case of narrowly defined sterilization, domestic interest rates rise so as to induce the market participants to hold the greater amount of domestic assets willingly. In the case of broadly defined sterilization, domestic interest rates rise so as to clear the money market, given the restricted money supply.[6] In either case, a rise in

[6] Reinhart and Reinhart (1998) indicate that, because reserve requirements are a tax on the banking system, changes in reserve requirements have real effects. If it imposes a↗

foreign assets would be prevented from increasing the volume of monetary aggregates at least one to one, and the resulting rise in interest rate differentials favoring the domestic assets would promote additional capital inflows, given flexible but stable nominal exchange rates (Takagi (1999)). Of course, no additional capital inflows would results if the market participants correctly perceived that the higher interest rates only reflected the higher risk premium of domestic assets and the non-zero probability of currency depreciation.[7] Accordingly, in the following Section 4, we will make use of time series approaches to test whether sterilization of capital inflows really increased domestic interest rates, by estimating the extent to which foreign assets in the monetary base explains or predicts domestic interest rates.

3. The Data Set and Properties

3.1. The Data Set

We use quarterly data for the 10-year period from the first quarter of 1987 through the second quarter of 1997, immediately preceding the outbreak of the Thai crisis in July 1997. All data were obtained from the International Monetary Fund, *International Financial Statistics* (IFS), except for industrial production in Indonesia and Thailand (which were obtained from the Bank of Japan's economic database). Foreign assets (FA) were obtained from line 11. Narrow money (M1) and quasi-money were obtained from lines 34 and 35, respectively. Broad money (M2) is used as measures of monetary aggregates. M1 and quasi-money constitute M2. For Korea and the Philippines, real GDP is used for output (Y), whereas industrial production is used for the other three countries. Interest rates (i)

reserve tax on depositors, an increase reserve requirements lowers domestic deposit rate and if it imposes a reserve tax on borrowers, an increase reserve requirements increases domestic lending rate.

7 However, it is said that many market participants tried to exploit the interest rate differentials that existed between US dollar denominated and East Asian currency denominated assets by taking unhedged short-term positions for supposed financial gains, believing that the market were imperfect (Furman and Stiglitz (1998)).

were obtained from the money market rate (MMR)(line 60b), the Treasury bill rate (TBR) (line 60c) for the Philippines, the deposit rate (DER) (lines 60l), and the lending rate (LER)(line 60p).

3.2. Unit Root and Cointegration Tests

In order to acquire the time-series properties of the variables, we first employ the Augmented Dickey-Fuller (ADF) test. The test statistics are obtained from running a regression with a constant term and seasonal dummies or with a constant term and time trend. The ADF test overwhelmingly shows that the variables are non-stationary, that is, integrated of order one, i.e., I (1).[8] The only exceptions are LER in Malaysia and FA and Y in Thailand. Although not formally reported in the table, all the variables are found to become stationary when they are difference once.

Then, we test for the presence of cointegration between foreign assets and interest rates by using the Johansen's trace tests (Johansen (1988) and Johansen and Juselius (1990)).[9] In a bivariate system (all but i are expressed in natural logarithm), there are cointegaration relationships between FA and LER in Malaysia and FA and all interest rates in Thailand. In a multivariate system (consisting of M2, FA, Y and i, where all but i are expressed in natural logarithm), cointegration relationships are found for all interest rates in Indonesia, for LER in Malaysia, and for DER and LER in Thailand.

4. Time Series Approach

4.1. Granger Causality between Foreign Assets and Interest Rates

4.1.1. The Difference VAR System

We will test for the effects of sterilization of capital inflows on domestic interest rates, by estimating the extent to which foreign

8 For space constraints, the ADF test statistics were not reported in the table.

9 The Johansen's trace tests on a VAR system included a constant term and seasonal dummies. A maximum lag length was four in order to preserve a reasonable number of degrees of freedom and lag length was chosen by Schwarz's Bayesian information criterion (SBIC). For space constraints, the test statistics were not reported in the table.

assets (FA) in the monetary base explains or predicts domestic interest rates. First, we will test for Granger causality between foreign assets and interest rates. A stationary time-series x (e.g., FA) is said to Granger cause a stationary time-series y (e.g., MMR or DER or LER), if the hypothesis that the coefficients β_j are jointly zero can be rejected at a given level of significance,

$$y_t = \mu + \sum_{j=1}^{p} \alpha_j y_{t-j} + \sum_{j=1}^{p} \beta_j x_{t-j} + \gamma z + \varepsilon_t, \qquad (1)$$

where t is a time subscript, μ is a constant, α_j's are the coefficients of the lagged dependent variables, z is a vector of other variables, including seasonal dummies and, in a multivariate system, the lagged values of other variables, such as money and output, γ is a vector of coefficients associated with z, and u_t is an error term. Although both causality from FA to MMR or DER or LER and causality from MMR or DER or LER to FA are tested, only the first type of causality is discussed in the text below, because we are interested in the causality from foreign assets to interest rates.

Since Section 3 gives the overwhelming evidence that all variables are I (1) and the general absence of cointegration, we will first estimate the following first difference VAR system without an error correction term,

$$\Delta i_t = \mu + \sum_{j=1}^{p} \alpha_j \Delta i_{t-j} + \sum_{j=1}^{p} \beta_j \Delta \ln FA_{t-j} + \gamma z + \varepsilon_t, \qquad (2)$$

where Δ is the first difference operator. The null hypothesis that the coefficients β_i are collectively zero can be tested by using the F statistic. If the null hypothesis can be rejected at the conventional significance level, we can find that FA Granger causes interest rate.

Table 1 shows the Granger causality between foreign assets and interest rates in a bivariate difference VAR system. From this table, FA is found to Granger cause interest rates in Malaysia when DER and LER are used and in the Philippines when DER is used, at the 5

percent level of significance, and in the Philippines when TBR and LER are used, both at the 1 percent level of significance. In a multivariate difference VAR system included FA, M2, Y and i, (all but i are expressed in natural logarithm), FA is found to Granger cause interest rates in Malaysia when LER are used, in the Philippines when DER is used and in Thailand when LER is used, at the 10 percent level of significance, in the Philippines when TBR is used, at the 1 percent level of significance and when LER is used, at the 5 percent level of significance (Table 2). These tables suggest that Granger causality was found from foreign assets to interest rates during 1987-97 for East Asian countries, except for Indonesia and Korea.[10]

Table 1. Granger Tests of Causality between Foreign Assets and Interest Rate, 1987-97 (Bivariate Difference VAR)

H_0:		FA does not Granger-cause i	i does not Granger-cause FA
FA and MMR (first row); FA and DER (second row); FA and LER (third row)			
Indonesia:	VAR (1)	F (1,34) 1.404 [0.244]	F (1,34) 2.217 [0.146]#
	VAR (1)	F (1,34) 0.004 [0.949]	F (1,34) 0.188 [0.667]
	VAR (1)	F (1,34) 1.862 [0.181]	F (1,34) 0.716 [0.403]
Korea:	VAR (1)	F (1,34) 0.173 [0.680]	F (1,34) 0.070 [0.793]
	VAR (1)	F (1,34) 0.005 [0.943]	F (1,34) 0.006 [0.936]
	VAR (1)	F (1,34) 0.462 [0.501]	F (1,34) 0.693 [0.411]
Malaysia:	VAR (1)	F (1,34) 2.433 [0.128]#	F (1,34) 0.164 [0.688]
	VAR (2)	F (2,31) 4.313 [0.022]**	F (2,31) 3.921 [0.030]**
	VAR (4)	F (4,25) 2.907 [0.042]**	F (4,25) 1.041 [0.406]
Philippines:	VAR (1)	F (1,34) 10.73 [0.002]***	F (1,34) 2.897 [0.098]*
	VAR (1)	F (1,34) 4.304 [0.046]**	F (1,34) 0.808 [0.375]
	VAR (1)	F (1,34) 7.428 [0.010]***	F (1,34) 0.422 [0.520]
Thailand:	VAR (1)	F (1,34) 0.352 [0.556]	F (1,34) 1.410 [0.243]
	VAR (1)	F (1,34) 0.788 [0.381]	F (1,34) 0.057 [0.812]
	VAR (3)	F (3,28) 1.183 [0.334]	F (3,28) 0.444 [0.723]

Notes : F-statistics in a bivariate difference VAR of foreign assets (FA) and interest rate (MMR or DER or LER) with a constant term and seasonal dummies. A maximum lag length is four in order to preserve a reasonable number of degrees of freedom and lag length (in parentheses) is chosen on the basis of SBIC. P-values are in brackets. ***, **, *, and # indicate that the statistic is significant at the 1, 5, 10, and 15 percent levels respectively.

[10] In six cases in bivariate systems and five cases in multivariate systems of fifteen tests, FA was found to Granger cause interest rates, at the 15 percent level of significance.

Table 2. Granger Tests of Causality between Foreign Assets and Interest Rate, 1987-97 (Multivariate Difference VAR)

H_0:		FA does not Granger-cause i	i does not Granger-cause FA
FA, M2, Y and MMR (first row); FA, M2, Y and DER (second row); FA, M2, Y and LER (third row)			
Indonesia:	VAR (1)	F (1,32) 1.104 [0.301]	F (1,32) 2.105 [0.156]
	VAR (1)	F (1,32) 0.027 [0.868]	F (1,32) 0.175 [0.678]
	VAR (2)	F (2,27) 1.161 [0.328]	F (2,27) 0.777 [0.469]
Korea:	VAR (1)	F (1,32) 0.153 [0.697]	F (1,32) 0.004 [0.949]
	VAR (1)	F (1,32) 0.015 [0.902]	F (1,32) 0.001 [0.978]
	VAR (1)	F (1,32) 0.707 [0.406]	F (1,32) 0.762 [0.388]
Malaysia:	VAR (1)	F (1,32) 1.279 [0.266]	F (1,32) 0.222 [0.640]
	VAR (1)	F (1,32) 0.918 [0.345]	F (1,32) 0.930 [0.342]
	VAR (3)	F (3,22) 2.492 [0.086]*	F (3,22) 1.590 [0.220]
Philippines:	VAR (1)	F (1,32) 11.10 [0.002]***	F (1,32) 2.863 [0.100]*
	VAR (1)	F (1,32) 2.996 [0.093]*	F (1,32) 0.826 [0.370]
	VAR (1)	F (1,32) 6.613 [0.015]**	F (1,32) 0.441 [0.512]
Thailand:	VAR (2)	F (2,29) 1.479 [0.244]	F (2,29) 0.426 [0.657]
	VAR (1)	F (1,32) 1.234 [0.274]	F (1,32) 0.048 [0.827]
	VAR (1)	F (1,32) 3.710 [0.062]*	F (1,32) 0.073 [0.787]

Notes : F-statistics in a multivariate difference VAR of foreign assets (FA), money (M2), output (Y), and interest rate (MMR or DER or LER) with a constant term and seasonal dummies. A maximum lag length is four in order to preserve a reasonable number of degrees of freedom and lag length (in parentheses) is chosen on the basis of SBIC. P-values are in brackets. ***, **, and * indicate that the statistic is significant at the 1, 5, and 10 percent levels respectively.

4.1.2. New Type Granger Causality Test: Toda and Yamamoto's (1995) Procedure

Granger (1988) indicates that, when non-stationary time series share common trend, causality tests must take the cointegrating relationship into account. Because the traditional F-test in a regression for determining whether some parameters of the system are jointly zero is not valid when the variables are integrated or cointegrated, the test statistic does no have a standard distribution (see, for example, Hamilton (1994)). Moreover, although several tests for a unit root and cointegration in time series are performed before testing the Granger causality, it is well known that the power

of these tests are very low.[11] For these reasons, we will follow the new type method by proposed Toda and Yamamoto (1995).[12]

Toda and Yamamoto (1995) propose how to test the Granger causality in the VAR's formulated in levels, even if the time series processes may be integrated or cointegrated of an arbitrary order. The method involves the following steps. First, we will estimate a $(p+1)$ th-order VAR (in levels) which include time trend term, where p is an optimal lag.[13] Secondly, we will test the Granger causality from foreign assets to interest rates, by using the Wald statistic that is thought to asymptotic chi-square distribution with p degrees of freedom (the F-statistic with an asymptotic $\chi^2(p)/p$ distribution, that is, $pF=\chi^2(p)$). Then, we estimate the following equation,

$$i_t = \mu_0 + \mu_1 time + \eta SD_t + \sum_{j=1}^{p+1} \alpha_j i_{t-j} + \sum_{j=1}^{p+1} \beta_j \ln FA_{t-j} + u_t, \qquad (3)$$

where μ_0 is a constant, μ_1 is the coefficient of time trend $(time)$, η's are the coefficients of seasonal dummies (SD_t), and u_t is an error term. The null hypothesis that the coefficients β_j are collectively zero can be tested by using the Wald statistic.[14]

Table 3 reports the results of Toda and Yamamoto's (1995) Granger causality tests.[15] From this table, FA is found to Granger

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11 For example, in the ADF test, it is hard to reject the null hypothesis of non-stationary.

12 We can avoid the possible pretest biases and obtain a proper result of Granger causality between foreign assets and interest rates by using Toda and Yamamoto (1995).

13 In this test, a maximum lag length is four in order to preserve a reasonable number of degrees of freedom and lag length is chosen by Schwarz's Bayesian information criterion (SBIC). It is known that SBIC is strongly consistent lag order selection criterion suited for the analysis of finite lag order VAR systems and SBIC performs best in small samples.

14 Yamada and Toda (1998) compare the finite sample performance of new type Granger causality tests of Toda and Phillips (1993) and Toda and Yamamoto (1995) by using Monte Carlo simulation and find that the Toda and Yamamoto's (1995) procedure performs better than the Toda and Phillips's (1993) procedure in terms of size stability.

15 Toda and Yamamoto (1995) point out that, if a VAR system has many variables and the true lag length is one, then the inefficiency caused by adding even one extra lag might be relatively big. Accordingly, we did not employ Toda and Yamamoto's (1995) procedure in the case of multivariate VAR systems.

cause interest rates in Indonesia when LER is used and in Thailand when LER is used, also at the 10 percent level of significance, in Malaysia when all interest rates are used and in the Philippines when DER and LER are used, at the 5 percent level of significance, and in the Philippines when TBR is used, at the 1 percent level of significance. The results suggest that Granger causality was found from foreign assets to interest rates during 1987-97 for East Asian countries, except for Korea.[16] In particular, it is found that causality from FA to LER was stronger than that from FA to MMR or DER.

Table 3. Granger Tests of Causality between Foreign Assets and Interest Rate, 1987-97 (Bivariate Level VAR: Toda and Yamamoto's (1995) Procedure)

H_0:		FA does not Granger-cause i	i does not Granger-cause FA
FA and MMR (first row); FA and DER (second row); FA and LER (third row)			
Indonesia:	VAR (2)	$\chi^2(1)$ 2.104 [0.146]#	$\chi^2(1)$ 0.783 [0.376]
	VAR (2)	$\chi^2(1)$ 2.458 [0.116]#	$\chi^2(1)$ 0.361 [0.547]
	VAR (2)	$\chi^2(1)$ 3.576 [0.058]*	$\chi^2(1)$ 0.662 [0.415]
Korea:	VAR (2)	$\chi^2(1)$ 2.621 [0.155]	$\chi^2(1)$ 0.601 [0.438]
	VAR (2)	$\chi^2(1)$ 0.031 [0.860]	$\chi^2(1)$ 0.037 [0.846]
	VAR (2)	$\chi^2(1)$ 0.315 [0.574]	$\chi^2(1)$ 0.746 [0.387]
Malaysia:	VAR (3)	$\chi^2(2)$ 6.746 [0.034]**	$\chi^2(2)$ 10.07 [0.007]***
	VAR (2)	$\chi^2(1)$ 4.658 [0.030]**	$\chi^2(1)$ 4.620 [0.031]**
	VAR (2)	$\chi^2(1)$ 4.092 [0.043]**	$\chi^2(1)$ 2.227 [0.135]#
Philippines:	VAR (2)	$\chi^2(1)$ 8.044 [0.004]***	$\chi^2(1)$ 4.137 [0.042]**
	VAR (2)	$\chi^2(1)$ 5.396 [0.020]**	$\chi^2(1)$ 2.253 [0.112]#
	VAR (2)	$\chi^2(1)$ 5.945 [0.014]**	$\chi^2(1)$ 1.760 [0.185]
Thailand:	VAR (5)	$\chi^2(4)$ 6.988 [0.136]#	$\chi^2(4)$ 10.77 [0.029]**
	VAR (3)	$\chi^2(2)$ 1.211 [0.545]	$\chi^2(2)$ 0.936 [0.625]
	VAR (2)	$\chi^2(1)$ 2.909 [0.091]*	$\chi^2(1)$ 0.445 [0.504]

Note : Chi-square statistics in a bivariate level VAR of foreign assets (FA) and interest rate (MMR or DER or LER) with a constant term, time trend, and seasonal dummies. A maximum lag length is four in order to preserve a reasonable number of degrees of freedom and lag length (in parentheses) is chosen on the basis of SBIC. P-values are in brackets. ***, **, *, and # indicate that the statistic is significant at the 1, 5, 10, and 15 percent levels respectively.

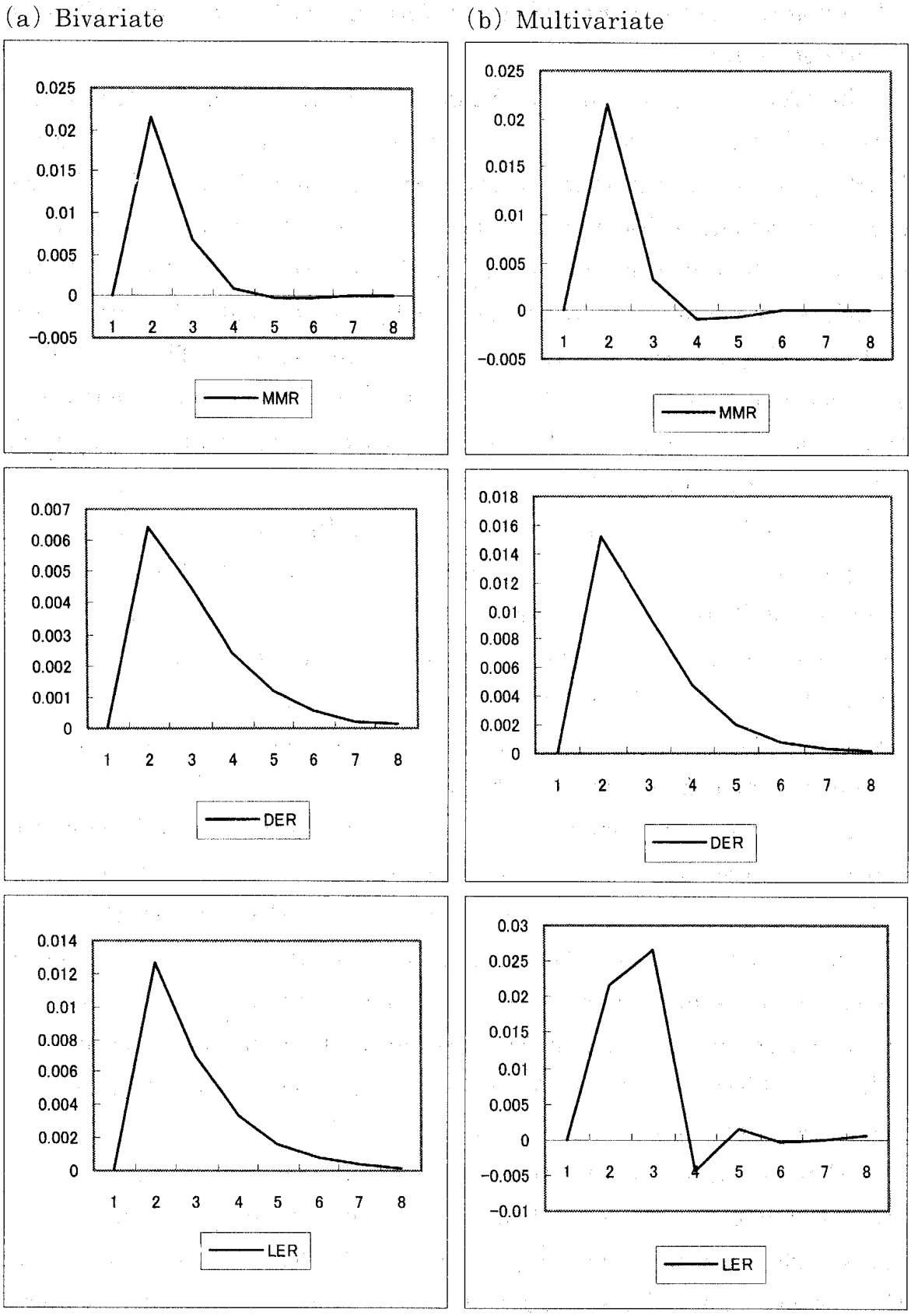
[16] In eleven of the fifteen tests, FA was found to Granger cause interest rates, at the 15 percent level of significance.

4.2. Impulse Response Functions of Interest Rates to Innovations in Foreign Assets

In order to gain further insights into the dynamic interaction between foreign assets and interest rates, we estimate the difference VAR systems and the vector error correction models (VECM) in the cases of Indonesia for multivariate systems, Malaysia for bivariate and multivariate systems when LER is used and Thailand for bivariate and multivariate systems when DER and LER are used, because of the possible presence of cointegration. The estimated systems can be transformed to a vector moving average representations and then we apply the impulse response functions of interest rates to innovations in foreign assets.

Figures 1-5 present the impulse response functions of interest rates changes to a one standard deviation innovation in foreign assets changes for East Asian countries. We find that foreign assets shock raise the level of interest rates for any of countries, except for Korea when MMR and DER are used. This result is consistent with the results of the Granger causality tests. From these figures, both the magnitude and dynamics of the response of interest rates varied across countries and kinds of interest rates. Our interest is how the effects of these foreign assets innovations on interest rates are. The effects range from 0 percent in Korea for MMR and DER to 4.0 percent changes in the Philippines, in response to a one standard deviation shock in foreign assets. For East Asian countries, in general, the responses of the lending rate are larger than those of the deposit rate (i.e., LED> DER). In Malaysia, the response of the lending rate continues over 8 terms (32 quarters).

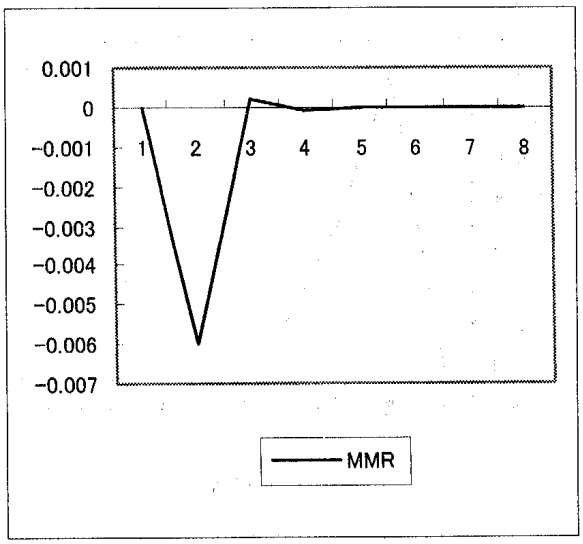
These results indicate that the set of various sterilization did increase domestic interest rates, or kept the level of domestic interest rates high. In particular, they increased the lending rate more than the deposit rate. These suggest that sterilization may have induced domestic firms to borrow abroad and foreign investors to invest in domestic countries, promoting additional capital inflows.

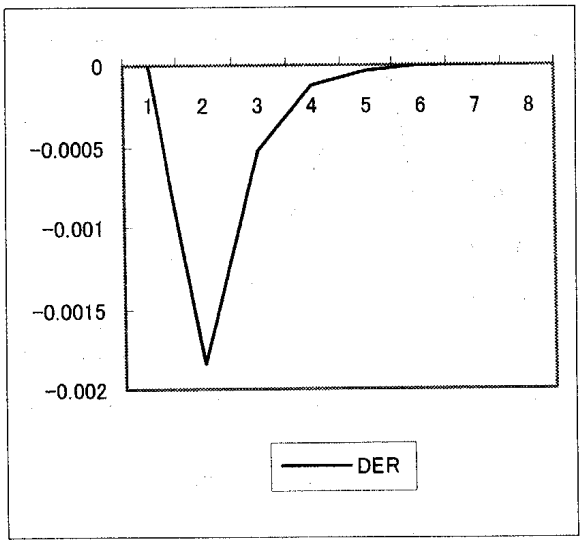


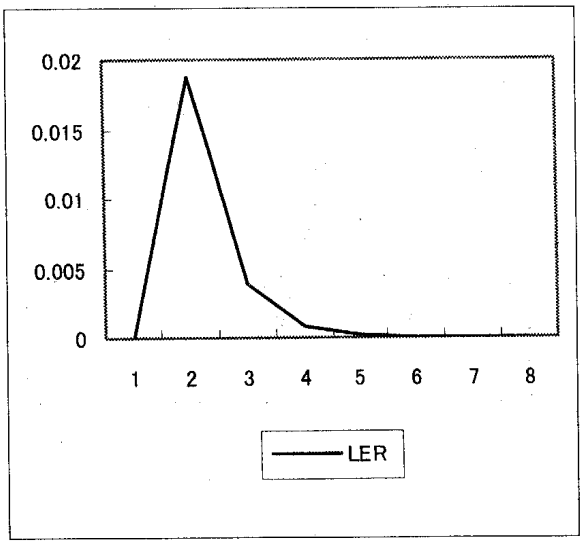
Note: See Figure 5.

Figure 1. Indonesia: The Responses of Interest Rates to an Innovations in Foreign Assets

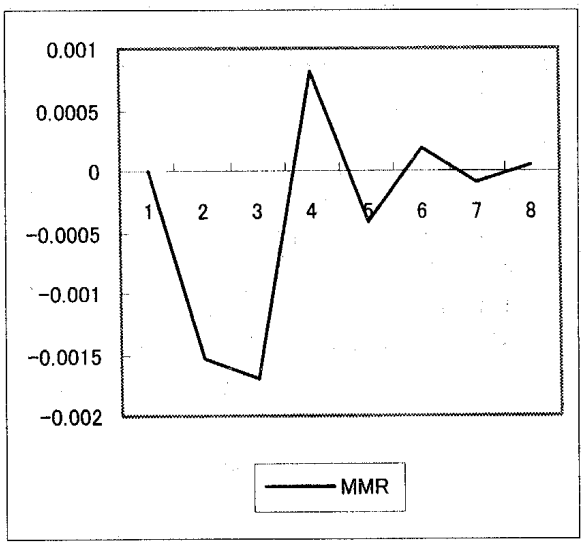
(a) Bivariate

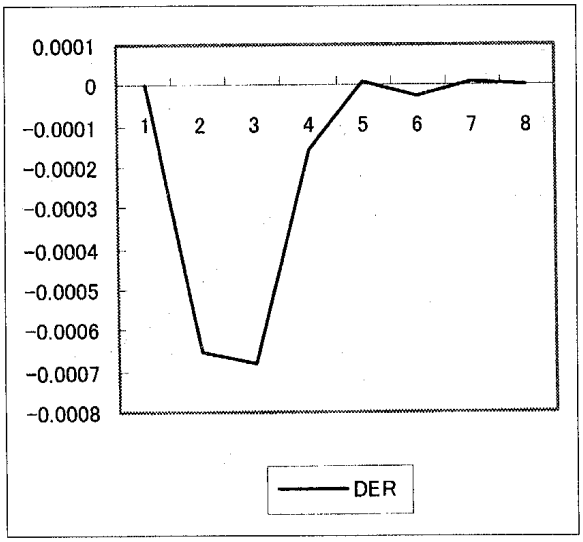


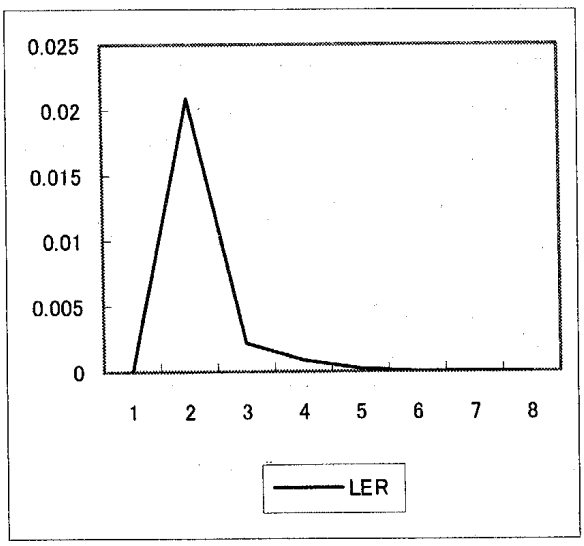




(b) Multivariate

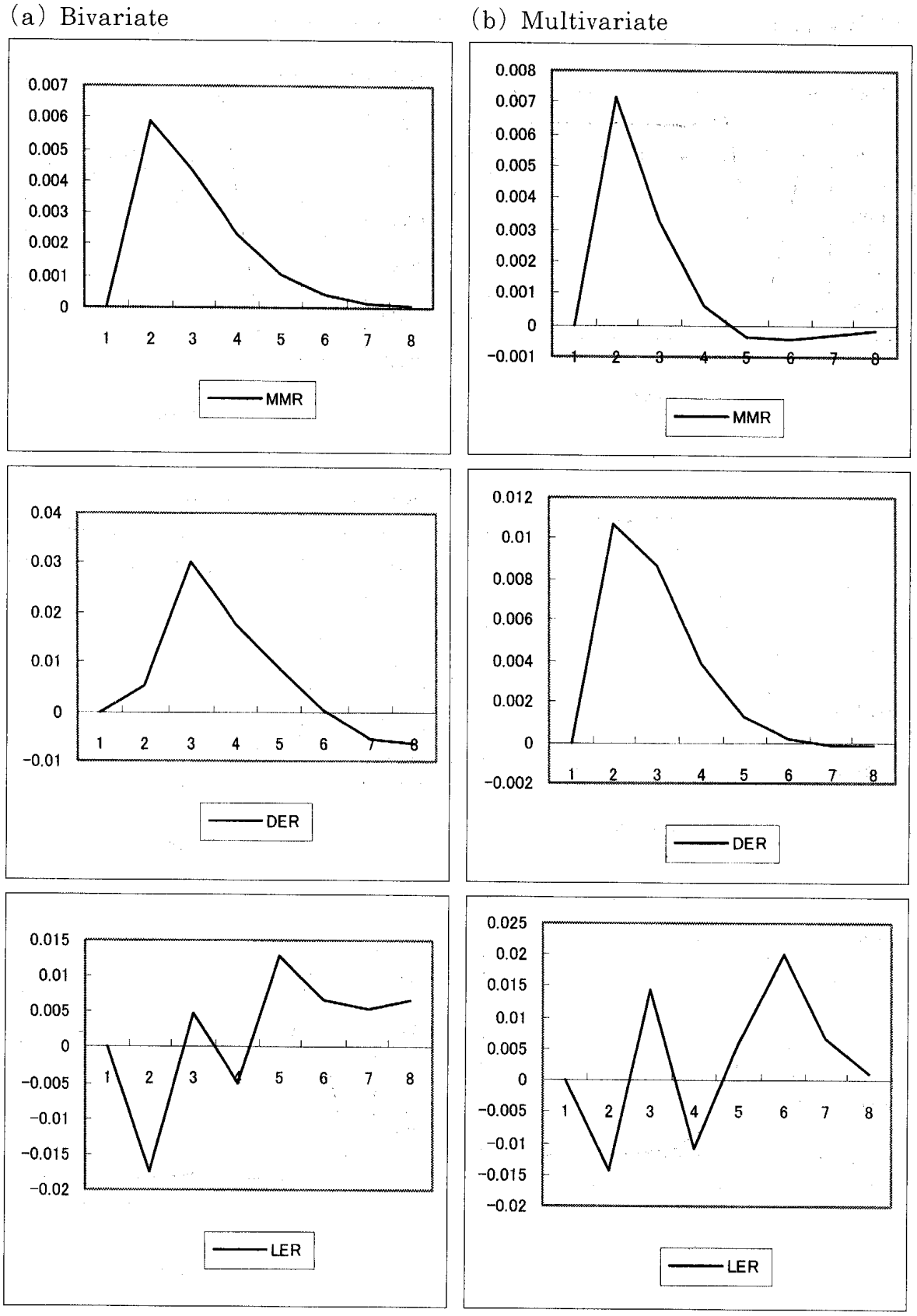






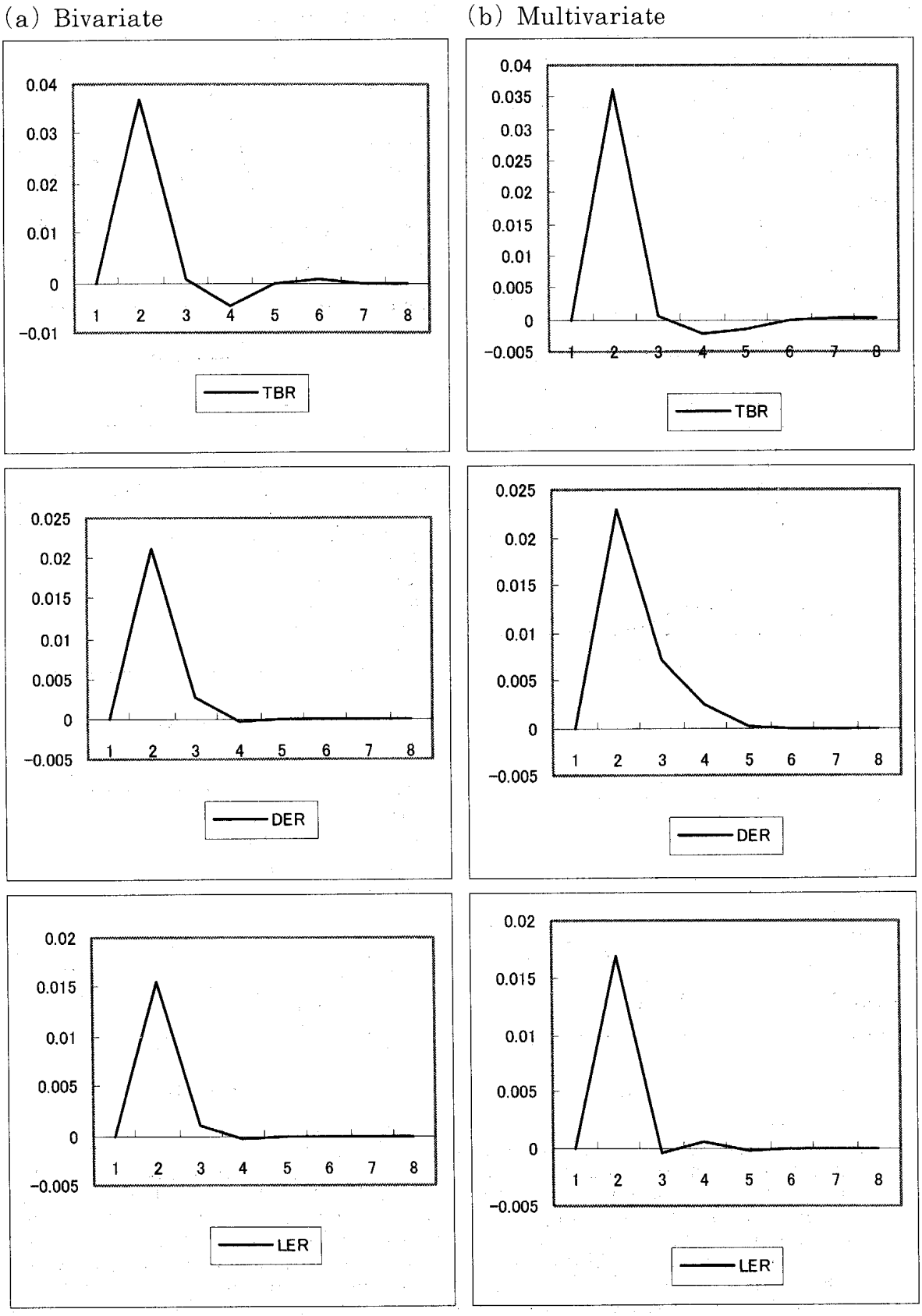
Note: See Figure 5.

Figure 2. Korea: The Responses of Interest Rates to an Innovations in Foreign Assets



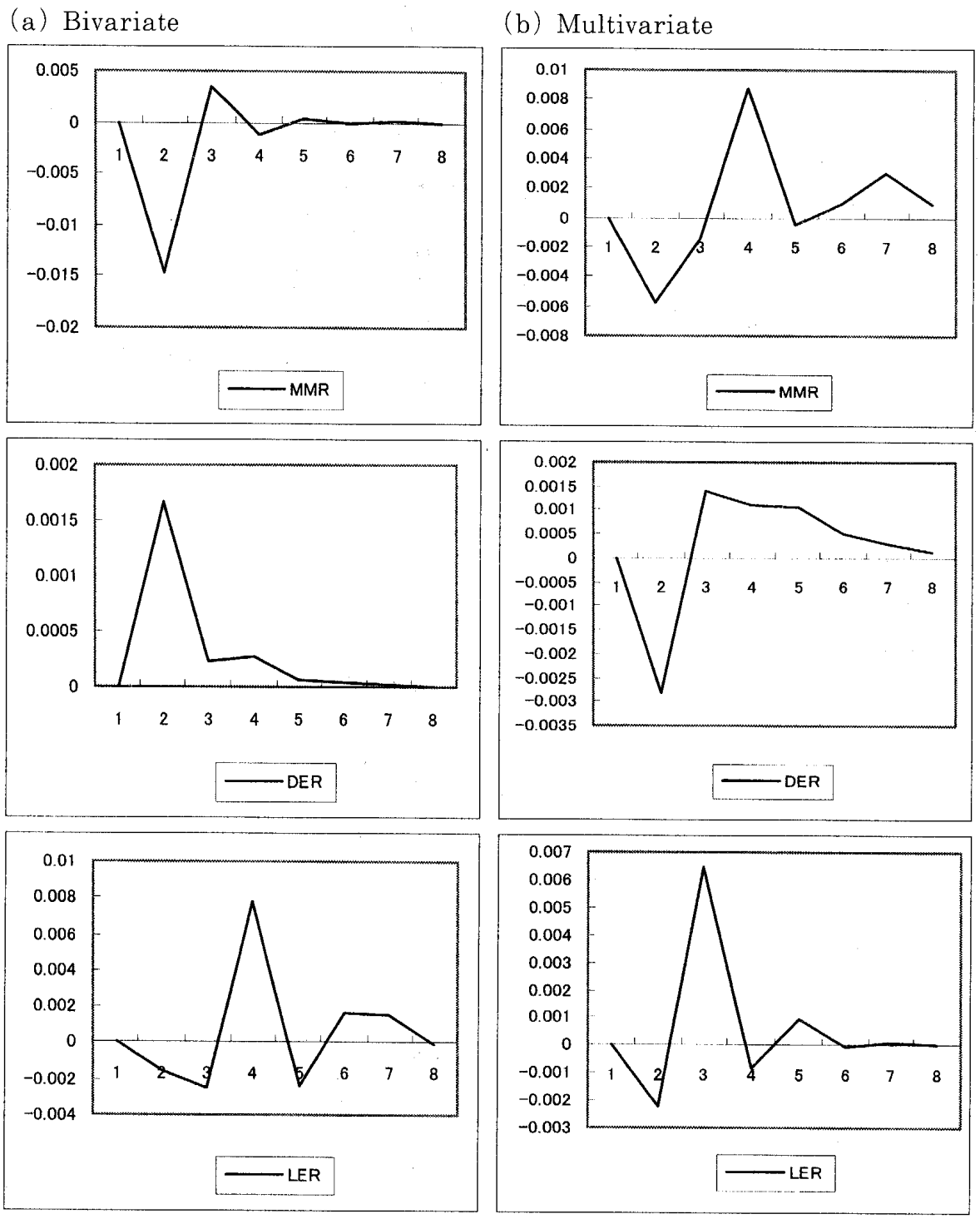
Note: See Figure 5.

Figure 3. Malaysia: The Responses of Interest Rates to an Innovations in Foreign Assets



Note: See Figure 5.

Figure 4. The Philippines: The Responses of Interest Rates to an Innovations in Foreign Assets



Note: The impulse responses of interest rates (MMR or DER or LER) to a one standard deviation innovation in foreign assets (FA) in a bivariate VAR systems (a) consisting of FA and MMR or DER or LER, and multivariate VAR systems (b) consisting of M2, FA, Y, and MMR or DER or LER, with a constant term and seasonal dummies. In the cases of Indonesia for multivariate systems, Malaysia for bivariate and multivariate systems when LER was used, and Thailand for bivariate systems and multivariate systems when DER and LER were used, a vector error correction model (VECM) was applied, given the possible presence of cointegration.

Figure 5. Thailand: The Responses of Interest Rates to an Innovations in Foreign Assets

5. Summary and Concluding Remarks

The East Asian countries of Indonesia, Korea, Malaysia, the Philippines, and Thailand received large volumes of capital inflows from the end of the 1980s through early 1997. Against the surge in capital inflows, the monetary authorities of East Asia took various measures to sterilize the expansionary effect of reserve inflows on the growth of monetary aggregate. In this paper, we have presented an empirical analysis of the effectiveness of sterilization during the 10-year period from the first quarter of 1987 through the second quarter of 1997, immediately preceding the outbreak of the Thai crisis in July 1997.

We have indirectly examined for the effects of sterilization of capital inflows on domestic interest rates in East Asia by estimating the extent to which foreign assets in the monetary base explains or predicts domestic interest rates, by using time series approaches. It was shown that the set of various sterilization did increase domestic interest rates (in particular, the lending rate), because Granger causality was found from foreign assets to interest rates during 1987-97 for East Asian countries, except for Korea and foreign assets shock raise the level of interest rates for any of countries, except for Korea in an impulse response analysis.

These results suggest that sterilization may have induced domestic firms to borrow abroad and foreign investors to invest in domestic countries, promoting additional capital inflows. Takagi and Esaka (2001) presented that the set of various sterilization measures pursued were effective in limiting the growth of narrow and broad money. They also pointed out that sterilization may have caused disintermediation and expanded the volume of assets in the poor supervised nonbank financial sector. Hence, we conclude that the potential risk of capital inflows in East Asia was likely magnified by the active policy of sterilization.

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