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Spillovers of Monetary Policy to the Asia from the US

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Abstract

This paper investigates how money-income causality in the Asia is influenced by the US interest rates and money supply policies, and which policy has stronger impacts on the Asian countries- Pakistan, India, Malaysia, Indonesia, Philippines and Korea-, by using an EGARCH model approximately during 1970:Q1-2002:Q4. This paper finds major results. The money-income causality regression should not be based on the OLS but the EGARCH model at statistics-adequacy. In economics sense, the spillover effect from the US interest rates or money supply unambiguously influences the money-income causality regression for each Asian country. This result suggests that the Asian monetary authorities have to monitor the US monetary policies carefully and to decide the domestic money supply by using the EGARCH model, in order to make the domestic money effects valid.

Keywords: OLS; EGARCH; Spillover effects; US monetary policy

1. Introduction

The evidence of monetary effects in a money-income causality regression depends mainly on the choice of controlling variables included in the regression and on the statistical methodology. [1]The statistical methodology for the model is developed from VAR(or OLS) to ARCH through ECM, by Stock and Watson (1988), Toda and Phillips(1993), Grier and Perry(1993) and Cheung and Fuji(2001).[2] In particular, Cheung and Fujii (2001) observed in a money-income causality regression that the volatility is conditional on the vast volatility, i.e., following autoregressive conditional heteroscedastic process. Then, the ARCH type model is more appropriate than the OLS model.

On the other hand, the choice of controlling variables implies the economics meaning for the model. Friedman and Kuttner (1993), Galbraith (1996) and Bernanke and Mihov (1998) included respectively the interest rates, the credit rationing and the monetary policy regimes as the set of controlling variables. Thus, the trial to include new controlling variables is country specific.

However, recent rapid financial deregulation in the Asian markets promotes a great deal of trading financial assets and attracts the international investors. Then, a large increase of portfolio and direct investment rushed from advanced countries to the Asian countries in 1980s-2000s. As a result, advanced countries have held a large amount of assets and hence their markets pressures have influenced the Asian markets greatly. In fact, Glick and Hutchison(1990), Chinn and Frankel(1994), Bekaert and Harvey (1997) and Miyakoshi(2003) show that the advanced stock markets and the Asian ones are deeply correlated. These findings suggest that the shocks of international monetary policy in advanced countries shake the Asian monetary markets and hence the effects of domestic monetary policy are disturbed and ineffective. Now, international monetary policy is a common controlling variable for the Asia, not country specific.

Therefore, by including the foreign monetary policy variables in money-income causality regression, we have to diagnose the efficacy of domestic monetary policy and then investigate how the foreign policy distributes the domestic policy. If so, the domestic monetary authority has to monitor the monetary policy of advanced country.

The purpose of this paper is to investigate how money-income causality in the Asia is influenced by the US interest rates and money supply policy, and which policy has stronger impacts on the Asian countries, by using an EGARCH model. We examine India, Pakistan, Malaysia, Indonesia, Philippines and Korea, using quarterly data approximately during 1970:Q1-2002:Q4. This investigation will provide useful information for the Asian monetary authority to make domestic policy be effective.

This paper finds a major result that the spillover effect from the US interest rate policy or money supply policy unambiguously exists in the money-income causality

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[1] The central bank policy of taking advantage of money-income causality is called an intermediate target policy. The final target is income, while the central bank controls the income target through the money supply target. As a matter of history, the policy has characterized Federal Reserve formulation for decades. See Friedman(1977) and Niehans(1978,pp.263-294) in detail.

[2] Christiano and Ljungqvist (1988) provide a positive support that the log level data leads to significant test results than difference data, though Hayo(1999) shows a negative one.

regression. These results suggest that the Asian monetary authorities have to monitor the US interest rate policy or money supply policy carefully, depending on their own country. The other result and suggestion are that the EGARCH is a better model than the OLS used in the previous money-income regression.

This paper is organized as follows. In Section 2 we present a univariate EGARCH model with money and income, including controlling variables of the US monetary policy. In Section 3 we describe the data set and explain the testable hypotheses. In Section 4 we first estimate money-income causality regression without the US monetary policy, by using an EGARCH and an OLS, and by checking the autocorrelation of volatility. Second, we re-estimate a money-income causality regression with each US monetary variable alone: interest rates and money supply. Third, we re-estimate the regression with both US monetary variables. Thus, we compare and discuss the results. Section 5 concludes.

2. An EGARCH model

We follow Cheung and Fujii (2001)'s suggestion that the ARCH type model is more appropriate than the OLS(VAR) model for a money-income causality regression, since the volatility is autoregressive conditional heteroscedastic process. We use a univerate EGARCH (1,1) model of the Nelson (1991)'s one. [3] A money-income causality regression is given by

$$Y_t = c + \mu \cdot t + \sum_{j=1}^{k} \alpha_j Y_{t-j} + \sum_{j=1}^{k} \beta_j M_{t-j} + \sum_{j=1}^{k} \gamma_j C1_{t-j} + \sum_{j=1}^{k} \phi_j C2_{t-j} + \varepsilon_t \qquad (1)$$

$$\varepsilon_t \mid (\varepsilon_{t-1}, \varepsilon_{t-2}, \ldots) \sim N(0, \sigma_t^2) \qquad (2)$$

$$\log\sigma_t^2 = \delta_0 + \delta_1 z_{t-1} + \delta_2(|z_{t-1}| - E(|z_{t-1}|)) + \delta_3 \log\sigma_{t-1}^2 \qquad (3)$$

$$\varepsilon_t \equiv \sigma_t z_t : \quad z_t \sim N(0,1) \qquad (4)$$

$t=1,2,\ldots,T$

The income Y and money M are represented by the industrial production in logs and by the money supply in logs, respectively. The t is a time trend and c is a constant term. The control variables include only the US'monetary policy instruments. Those are $C1_{t-j}$ or $C2_{t-j}$ which represent the quarterly call rate spreads (the US one minus the Asian one:%) or the money supply in logs, respectively. The ε_t represents an error term conditional on past information set. The σ^2_t is the variances for error term ε_t. The γ_j and ϕ_j measure the impact of a US monetary policy on income. The money effects on the income are represented by the coefficients β_j.

[3] The EGARCH model overcomes two drawbacks in GARCH for computation and simple effects of the past variance on the present one. See Nelson (1991) in detail.

In the EGARCH, the persistence of variance is measured by the magnitude of δ_3 : the more the magnitude approaches unity, the greater is the persistence of shocks to volatility. The positivity or negativity of unanticipated excess returns determines future variance, which is measured by δ_1 and δ_2: The δ_2 represents a magnitude effect. For $\delta_2 > 0$, the innovation in log σ^2 is then positive (negative) when the magnitude of Z_{t-1} is larger (smaller) than its expected value. The δ_1 represents a sign effect. For $\delta_1 < 0$, the innovation in conditional variance is positive (negative) when returns innovations are negative (positive).

We can write the log likelihood function logL and can determine the parameter $\theta(c, \mu, \alpha_j, \beta_j, \gamma_j, \phi_j, \delta_0, \delta_1, \delta_2, \delta_3)$ to maximize it :

$$Max \quad \log L(\theta) = -\frac{T}{2}\log 2\pi - \frac{1}{2}\sum_{t=1}^{T}\log\sigma_t^2 - \frac{1}{2}\sum_{t=1}^{T}\frac{\varepsilon_t^2}{\sigma_t^2} \qquad (5)$$

It should follow that the maximum likelihood estimate $\hat{\theta}$ for θ will be asymptotically normal and consistent with a covariance matrix equal to the inverse of Fisher's information matrix. As Nelson (1991) did, we assume this asymptotic normality and the consistency of estimate $\hat{\theta}$ and hence traditional inference procedures are available.

3. Data and testing hypotheses

All data are the quarterly data compiled from International Monetary Fund's International Financial Statistics(IFS) CD-ROM May 2003. The data run from 1970:Q1-2002:Q4 for Pakistan, India and Malaysia, 1978:Q1-2002:Q4 for Indonesia, 1981:Q1-2002:Q4 for Philippines and 1977:Q1-2002:Q4 for Korea, as shown in Table 1. [4] The starting date is different, depending on the data availability in each country.

In the database, the income Y is the industrial production indices (1990=100, line 66), and the money M is the seasonally adjusted money supply (line 34..BZ) divided by the wholesale prices indices p (1990=100,line 63). Thus, both variables are measured in a real term and in local currency. The industrial production indices for except for

[4] The series in IFS CD-ROM have several missing data and then we supplement these with the following. For Malaysia, the wholesale price has many missing data and then we used the consumer price (line 64) for it. For Indonesia, we use crude petroleum production indices (line 66AA) since there is no industrial production index, while we have still 11 missing values. We handle them as following: use 1999:Q2 value for 1999:Q3- 2001:Q1 and use 2001:Q4 value for 2002:Q1-2002:Q4. Also, we used the consumer price (line 64) for the wholesale price. We also handle the missing data for call rates: use 1985:Q4 for 1986Q1-1986:Q2. For Philippines, the production index during 1999:Q4-2002:Q4 are wrong and then are corrected by using Asian Development Bank's data (://www.aric.adb.org). For India, the industrial production indices have two missing values: use 1970:Q3 for 1970:Q4 and 2002:Q3 for 2002:Q4. Also, the call rate has the missing data during1998:Q2-2002:Q4, but we found the same kind of data in Reserve Bank of India during 1998:Q2-2001:Q3 and supplemented 2001:Q3 for missing values of 2001:Q4-2002:Q4.

Korea are not seasonally adjusted and then were adjusted by SAMA in the statistical package TSP4.4. Moreover, we introduce two monetary policy instruments. One of them is the seasonally adjusted money supply (line 34..BZ) of the US in the US dollars. The other is a quarterly call rate spreads R_{US} which are defined as follows:

$$R_{US} = r_{US} - r_{AS} : \quad r_j = i_j - \pi_j , \qquad \pi_j = (\log P_{j,t} - \log P_{j,t-1}) \times 100 \quad (6)$$

j=US,AS; AS= Asian countries

where r_{US} and r_{AS} are also real call rates (a nominal rate i_j minus an inflation rate π_j) for US and Asian countries which are measured in local currency.[5] The call rate is in line 60B and the price is a wholesale price in line 63. Then, the call rate spreads R_{US} delete the price effects by the inflation rate and the exchange rate depreciation effects by expression in local currency.

The number of observations is approximately 130 for each country. The data for the whole period are illustrated in the Appendix. We check the statistical requirements to judge whether or not we use adequately an EGARCH (or OLS) model. The first step is to implement the augmented Dickey-Fuller unit root test for every series. The second is to perform the cointegration test among non-stationary series. However, the properties of non-stationary series in the ARCH-type model are not analyzed yet, as opposed to the properties in VAR studied by Toda and Phillips(1993) and others. Moreover, the visual inspection for the income and money in log and the call rates spreads allow us to consider it to be a trend stationary. Then, we assume that all data are a trend stationary.

We investigate the Granger causality from domestic money and the US monetary policy to income by testing the following hypotheses on equation (1):

$$H_1 : \beta_j = 0 \;\; for \;\; all \;\; j = 1, \ldots, k \qquad (7)$$

$$H_2 : \gamma_j = 0 \;\; for \;\; all \;\; j = 1, \ldots, k \qquad (8)$$

$$H_3 : \phi_j = 0 \;\; for \;\; all \;\; j = 1, \ldots, k \qquad (9)$$

The null hypothesis of H_1 means that effects of lagged money are jointly insignificant. Then, if H_1 (and /or H_2, H_3) is rejected, the Granger causality from money (and /or from monetary policies of the US) to income exists.

4. Results of tests and discussions

We use the SBIC to determine the optimal lag length out of eight lags for OLS used in the previous regressions.[6] Table 1 show that both the optimal lag for all OLS

[5] We measure the market returns in local currency just as Karolyi (1995) and others do in their studies. Note that when market returns are denominated in US dollars, international investors are assumed to be unhedged against foreign exchange risk. Then, we now assume that the investors are hedged against it. See Miyakoshi (2003) in detail.

[6] All computations in this paper were carried out by the statistical package WINRATS-32 Version 4.30. The BHHH algorithm for the Maximum Likelihood is sensitive to the choice of initial estimates. The combination of SIMPLEX and BHHH works better than BHHH alone. We

excluding or including any US monetary policy are four for Pakistan and one for India and Malaysia. For the remained countries, the optimal lag lengths are one or two, depending on which the US monetary policies are included. We apply the same lag lengths to EGARCH as those to OLS for each country.

[INSERT Table 1 and Table 2]

Table 2 presents the results of the Granger–causality test by using the OLS with the optimal lag length chosen in Table 1 and by using the EGARCH with the same lag length as the OLS, excluding both the spillover effects to the Asia from the US monetary policies. In the first row of Pakistan, the OLS estimation finds that the sum of coefficient for lagged money variables is 0.13. However, as similar to Owoye (1997), the F-statistic fails to reject the null hypothesis H_1 in (7), since P-value is 0.17. The Ljung-Box Q^2-statistics for estimated squared residuals range from 7.64 to 24.36 and suggest the ARCH effects (serial correlation of volatility). In the second row, the results based on EGARCH show that the parameter δ_2 in the third column which presents a magnitude effect is highly significant, as well as δ_1. As the fourth column indicates, the EGARCH specification statistics-adequately describes the conditional heteroskedasticity in (1). On the domestic money effects, the test on the EGARCH in the second column rejects mostly the null hypothesis of H_2 that the lagged money has no effects on income.

Thus, we analyze statistics-adequately the money-income causality regression by taking account for the ARCH effect and provides a positive support with Cheung and Fuji(2001,pp.255)'s suggestion. As a result, the money income-causality appears to be significant and the sum of lagged money coefficients is positive for except for Philippines and Korea, which shows opposite results to those of Owoye (1997) by using ECM (OLS-type).

The most interest of this paper is in the spillover effects to the Asia from the US monetary policy, which is not studied yet. This aspect comes from analyzing economics-adequately the money-income causality regression. We incorporate the spillover effects in the OLS and the EGARCH. The test results by using these models are summarized in Table 3. As indicated by the diagnostics on the serial correlation of variance, the EGARCH specification adequately describes the money-income causality regression in (1), compared with the OLS. Then, we rely on the results by the EGARCH in the second row.

[INSERT Table 3]

When we compare the reliable results by the EGARCH between excluding (at the second row in Table 2) and including spillover effects of the US interest rates policy (testing H_2: γ_j=0), we can provide three evidences. First, there exists obviously the causality from the US interest rate to income for India and Indonesia (i.e., the spillover effects from the US interest rate policy). Second, considering the spillover effects, the domestic money effect (sum of coefficients for domestic lagged money) is reduced: eg,

set 25 more than parameter plus one as the iteration number in SIMPLEX for all countries for the sake of simplicity. The results are not greatly changed by this iteration number, compared with the number of parameter plus one.

for Inoonesia, 55%=(0.207-0.094)/0.207, comparing with the second row in Table 2. Third, the domestic money effects still exist except for India and Philippines(based on 0.05 p-value).

On the other hand, when we compare the results by the EGARCH between excluding (at the second row in Table 2) and including spillover effects of the US money supply policy (testing H_3: $\phi_j=0$ at the first row in Table 4), we can provide symmetrical results to those of interest rate.[7] First, there exists obviously the causality from the US money supply to income except for India (i.e., the spillover effects from the US money supply policy). Second, considering the spillover effects, the domestic money effect (sum of coefficients for domestic lagged money) is reduced except for Malaysia and Philippines, comparing with the second row in Table 2. Third, the domestic money effects still exist except for Pakistan, India and Philippines.

These evidences are still strong even when we add both the US interest rate and money supply policy as seen at the second row in Table 4. For Malaysia, Indonesia and Korea, the domestic money causality still exists, while the US interest rate policy effects also exists for Indonesia and the US money supply effects also exists for Malaysia and Korea. For India and Philippines, the domestic money causality never exists, while the US interest rate policy effects exists for India and the US money supply policy effects exists for Philippines. For Pakistan, any causality to income does not exist.

[INSERT Table 4]

The results suggest that the intermediate target policy (money-income causality) of a central bank is statistics-adequately not based on the OLS but on the EGARCH models, and that the Asian monetary authorities have to monitor the US interest rate or money supply policy carefully, because the US interest rate or money supply causes the industrial production index. For instance, the Malaysian industrial production 0.062% increase is caused by the domestic money supply 1% increase and 0.063% increase by the US money supply 1% increase. Then, when the monetary authority stabilizes the production growth, it decreases the same magnitude of domestic money supply growth as the US money supply increases. Also, the Indonesia authority has to monitor the US interest rate policy in order to make domestic money supply effect valid. On the other hand, the Philippines authority have no effective intermediate target policy and then have to only monitor the US money supply.

Finally, we have to interpret the results, which are closely related to the transmission mechanism. However, the kernel of the intermediate target policy abandons the analysis for the transmission mechanism from money to income, since the rigorous analysis is complicated. Then, only the quantitative relation between the intermediate target of money and the final target of income is analyzed by the money-income causality regression. Therefore, we do not provide the interpretation for the results, which will be a future task if we have to do so.

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[7] We have to give a note that the US money supply is measured in US dollars, while the Asian money is measured in local currency. However, we analyzed both money variables in the same regression as well as Baks and Kramer(1999) did. They used the sum of the money growth rate measured in local currency. One reason for this is that the US money is invested in the Asia, where the investors are assumed to be hedged against it.

5. Concluding Remarks

This paper investigates how money-income causality in the Asia is influenced by the US interest rates and money supply policy, and which policy has stronger impacts on the Asian countries, by using an EGARCH model. We examine India, Pakistan, Malaysia, Indonesia, Philippines and Korea, using quarterly data approximately during 1970:Q1-2002:Q4.

This paper finds major results in statistics and economics sense. The money-income causality regression is statistics-adequately not based on the OLS but on EGARCH models, as Cheung and Fujii (2001) pointed out by using the US money-income causality regression. In economics sense, the spillover effect from the US interest rates or the US money supply unambiguously exists in the money-income causality regression for each Asian country and the effect of domestic money exists for some country but do not for other country.

This result suggests that the Asian monetary authorities have to monitor the US monetary policy carefully and to decide the domestic money supply by using the EGARCH model. This monitor is to make the domestic money supply effective for the country where the effect of domestic money exists, while the monitor is to capture the information in advance for the country with no domestic money effects.

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Table 1. An optimal lag length for OLS and sample periods for each country

	Pakistan	India	Malaysia	Indonesia	Philippines	Korea
An optimal lag length by SBIC						
Excluding both US monetary policies:	4	1	1	1	1	2
Including the US interest rate alone:	4	1	1	2	1	1
Including US money supply alone:	4	1	1	1	2	2
Including US money supply alone:	4	1	1	1	1	1
Sample periods	70:Q1-02:Q4	70:Q1-02:Q4	70:Q1-02:Q4	78:Q1-02:Q4	81:Q1-02:Q4	77:Q1-02:Q4

Notes: The same lag length is applied to the EGARCH model.

Table 2. Money-income causality excluding the spillover effects from both the US monetary policies

Country	Causality Test H_1: β_j=0 M➡Y	EGARCH Parameters δ_1	δ_2	δ_3	The first k autocorrelation $Q^2(1)$	$Q^2(2)$	$Q^2(3)$	$Q^2(4)$
Pakistan								
OLS	0.130(0.17)				7.64(0.01)	10.66(0.01)	15.04(0.00)	24.36(0.00)
EGARCH	0.236(0.00)	-0.086(0.59)	0.978(0.00)	0.297(0.23)	3.40(0.07)	3.89(0.14)	4.34(0.23)	6.86(0.14)
India								
OLS	0.113(0.00)				3.63(0.06)	5.64(0.06)	5.93(0.12)	26.39(0.00)
EGARCH	0.083(0.01)	0.340(0.03)	-0.087(0.64)	-0.104(0.85)	0.04(0.84)	0.24(0.89)	0.81(0.85)	8.27(0.08)
Malaysia								
OLS	0.052(0.06)				4.18(0.04)	4.22(0.12)	4.30(0.23)	17.67(0.00)
EGARCH	0.052(0.05)	-0.345(0.03)	0.592(0.02)	0.228(0.37)	1.49(0.22)	2.46(0.29)	2.64(0.45)	3.56(0.47)
Indonesia								
OLS	0.155(0.02)				4.17(0.04)	4.22(0.12)	4.22(0.24)	4.26(0.37)
EGARCH	0.207(0.00)	0.031(0.840)	0.437(0.08)	0.672(0.02)	0.14(0.71)	0.31(0.86)	0.38(0.94)	0.40(0.98)
Philippines								
OLS	-0.017(0.64)				8.17(0.00)	8.17(0.02)	8.64(0.04)	8.72(0.07)
EGARCH	0.006(0.89)	0.355(0.04)	0.074(0.80)	-0.169(0.73)	0.28(0.60)	0.36(0.84)	0.40(0.94)	0.94(0.92)
Korea								
OLS	0.007(0.03)				1.51(0.22)	1.76(0.42)	1.77(0.62)	2.13(0.71)
EGARCH	-0.016(0.19)	-0.549(0.01)	1.543(0.00)	-0.002(0.99)	2.10(0.15)	2.23(0.33)	2.98(0.40)	3.24 (0.52)

Notes: The first row is the result for OLS and the second row for EGARCH. The entry in the column of Causality Test represents the sum of the coefficient of lagged money and the entry in parentheses represents the p-values for the null hypothesis of non-causality: H_1: β_j=0. The other entities in the other column are the estimated parameters for the δ_j and the Ljung-Box Q^2-statistics for estimated squared-error terms. The other entities in parentheses are the p-values for the null hypotheses for zero and no autocorrelation, respectively. The M➡Y is a logotype for money-cause-income.

Table 3. Money-income causality including the spillover effects from the US interest rates policy alone

Country	Causality Test $H_1: \beta_j=0$ M➡Y	$H_2: \gamma_j=0$ IUS ➡Y	EGARCH Parameters δ_1	δ_2	δ_3	The first k autocorrelation $Q^2(1)$	$Q^2(2)$	$Q^2(3)$	$Q^2(4)$
Pakistan									
OLS	0.104(0.24)	0.006(0.01)				6.31(0.01)	6.55(0.04)	7.83(0.05)	12.49(0.01)
EGARCH	0.196(0.00)	0.005(0.07)	0.030(0.86)	0.857(0.01)	0.315(0.32)	2.88(0.09)	3.77(0.15)	4.14(0.25)	5.31(0.26)
India									
OLS	0.092(0.01)	-0.001(0.04)				5.05(0.03)	5.83(0.05)	6.12(0.11)	22.24(0.00)
EGARCH	0.067(0.06)	-0.001(0.02)	0.253(0.07)	0.10(0.58)	-0.049(0.93)	0.52(0.47)	1.40(0.50)	1.76(0.62)	8.05(0.09)
Malaysia									
OLS	0.057(0.04)	-0.001(0.43)				4.61(0.03)	4.62(0.10)	4.66(0.20)	19.48(0.00)
EGARCH	0.065(0.02)	0.000(0.91)	-0.344(0.03)	0.576(0.02)	0.281(0.29)	1.34(0.25)	2.38(0.30)	2.49(0.48)	3.36(0.50)
Indonesia									
OLS	0.090(0.16)	0.002(0.01)				7.44(0.01)	7.64(0.02)	7.67(0.05)	7.85(0.10)
EGARCH	0.094(0.00)	0.002(0.00)	0.104(0.62)	1.942(0.00)	-0.034(0.83)	1.48(0.22)	4.21(0.12)	4.51(0.21)	4.70(0.32)
Philippines									
OLS	-0.042(0.30)	0.003(0.12)				9.53(0.00)	9.55 (0.01)	9.95(0.02)	9.99(0.04)
EGARCH	-0.032(0.48)	0.003(0.17)	0.301(0. 03)	-0.011(0.95)	-0.770(0.00)	0.00(0.97)	1.03(0.60)	1.44(0.70)	1.47(0.83)
Korea									
OLS	0.024(0.35)	0.000(0.78)				2.63(0.11)	2.70(0.26)	4.89(0.18)	4.95(0.29)
EGARCH	-0.035(0.01)	-0.001(0.12)	-0.392(0.08)	1.453(0.00)	0.409(0.05)	2.08(0.15)	3.86(0.15)	4.07(0.25)	4.19 (0.38)

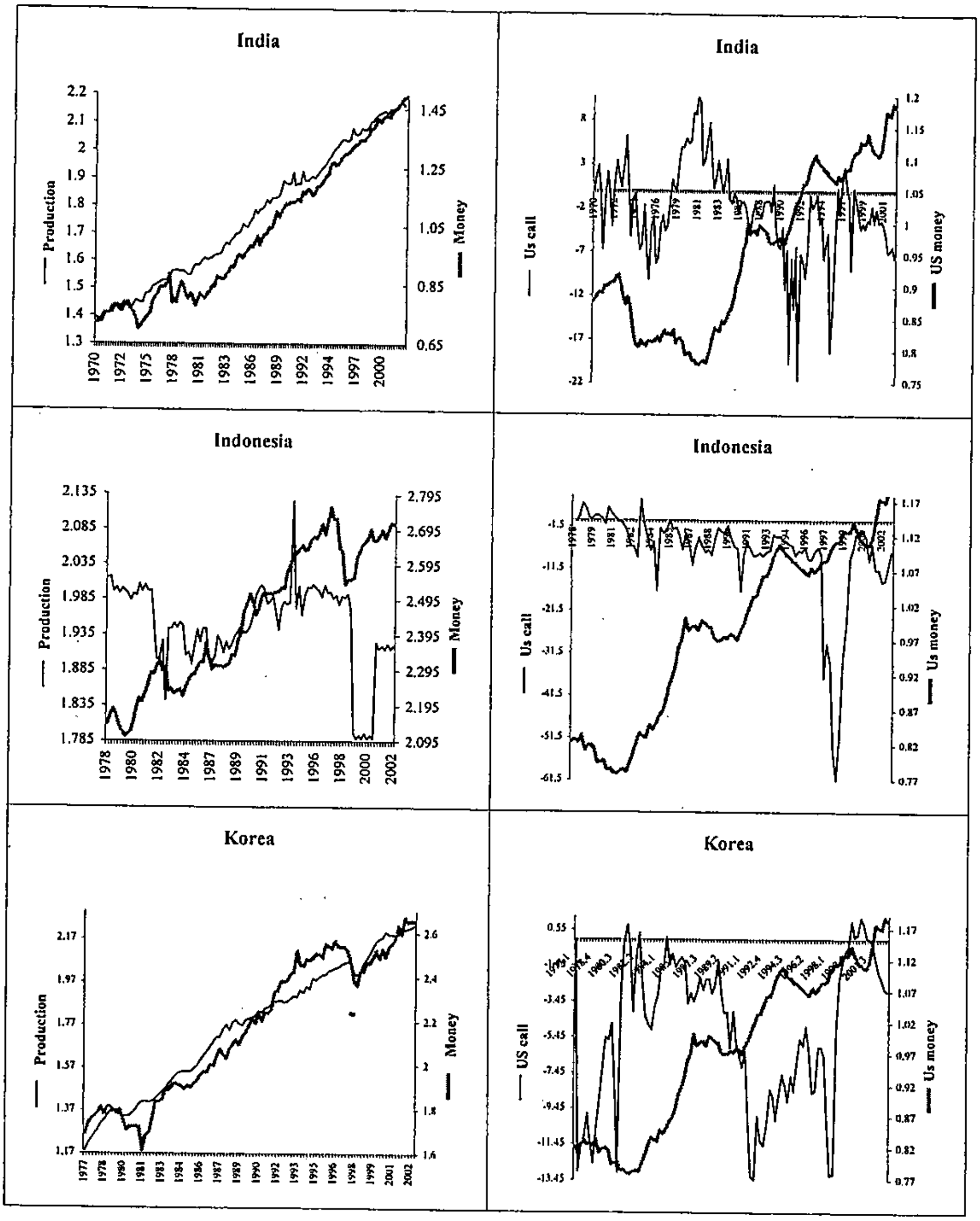
Notes: See notes in Table 2. The entry for H_2 $\gamma_j=0$ (IUS ➡Y) in the column of Causality Test represents the sum of the coefficient of the lagged US interest rates and the entry in parentheses represents the p-values for the null hypothesis of non-causality: H_2 $\gamma_j=0$. The IUS➡Y is a logotype for the US interest rates-cause-income.

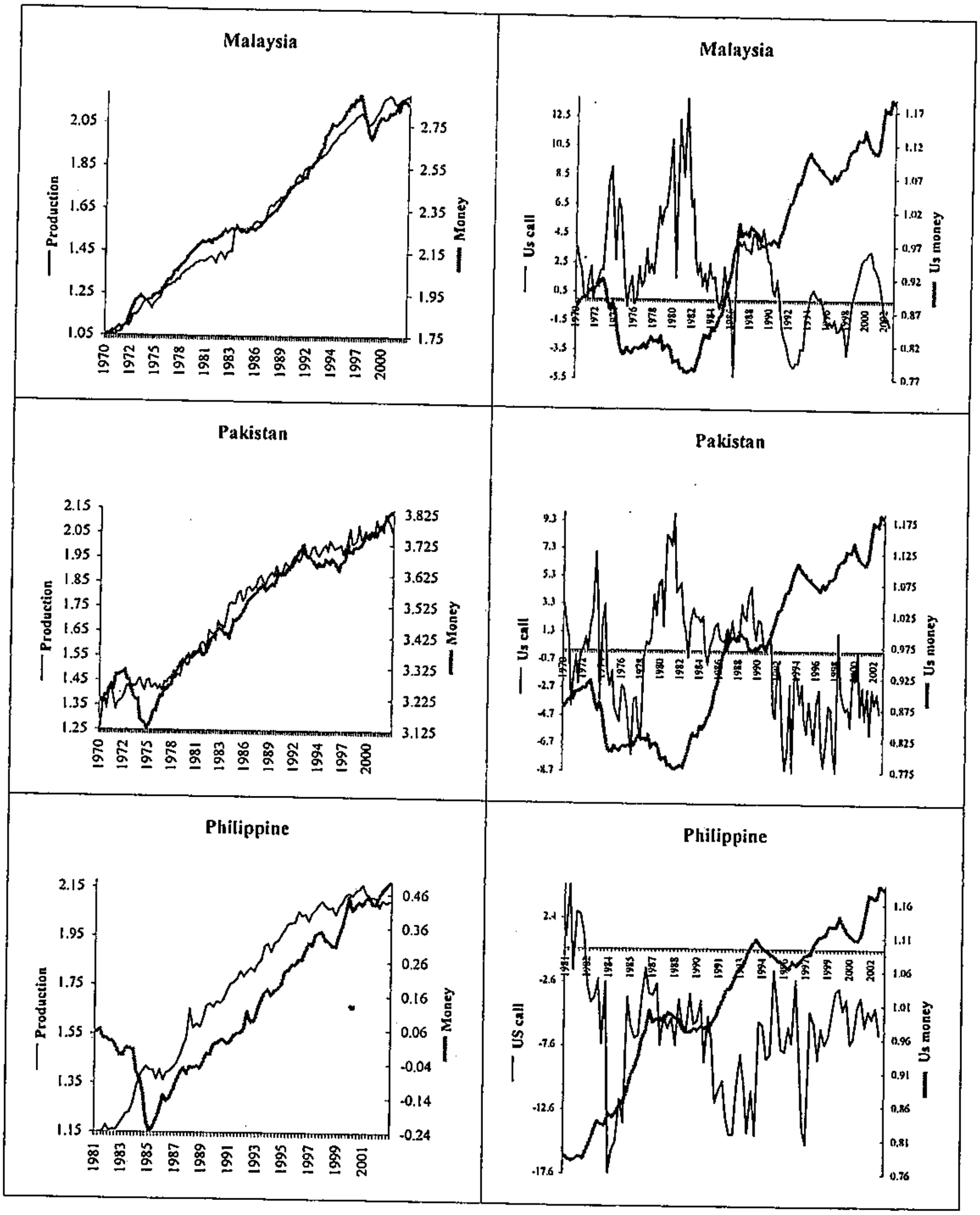
Table 4. Money-income causality including the spillover effects from the US money supply alone and from both the US interest rates and money supply in EGARCH

	Causality Test			EGARCH Parameters			The first k autocorrelation			
	H_1: β_j=0 M➡Y	H_2: γ_j=0 IUS ➡Y	H_3: φ_j=0 MUS ➡Y	δ_1	δ_2	δ_3	$Q^2(1)$	$Q^2(2)$	$Q^2(3)$	$Q^2(4)$
Pakistan										
MUS	0.163(0.06)		-0.166(0.00)	-0.093(0.16)	-0.038(0.16)	0.978(0.00)	1.21(0.27)	2.29(0.32)	2.82(0.42)	4.99(0.29)
IUS&MUS	0.143(0.50)	0.004(0.21)	-0.109(0.13)	-0.059(0.59)	-0.056(0.46)	1.015(0.00)	0.00(0.95)	0.04(0.98)	0.26(0.97)	3.74(0.44)
India										
MUS	0.047(0.27)		0.040(0.27)	0.373(0.01)	-0.116(0.53)	-0.075(0.88)	0.02(0.89)	0.73(0.70)	0.85(0.84)	9.35(0.05)
IUS&MUS	0.040(0.39)	-0.001(0.03)	0.034(0.37)	0.260(0.05)	0.086(0.62)	-0.062(0.91)	0.37(0.54)	1.25(0.54)	1.36(0.72)	9.80(0.04)
Malaysia										
MUS	0.062(0.02)		0.057(0.01)	-0.342(0.04)	0.669(0.01)	0.207(0.39)	1.84(0.18)	2.32(0.31)	2.68(0.44)	3.16(0.53)
IUS&MUS	0.062(0.02)	0.001(0.64)	0.063(0.01)	-0.347(0.04)	0.671(0.01)	0.199(0.43)	1.81(0.18)	2.20(0.33)	2.73(0.44)	3.19(0.53)
Indonesia										
MUS	0.158(0.00)		0.104(0.04)	-0.008(0.96)	1.164(0.00)	-0.435(0.02)	2.96(0.09)	5.38(0.07)	7.01(0.07)	7.02(0.14)
IUS&MUS	0.081(0.00)	0.002(0.01)	-0.031(0.72)	0.028(0.85)	1.432(0.00)	-0.094(0.62)	1.88(0.17)	4.12(0.13)	4.19(0.24)	4.85(0.30)
Philippines										
MUS	0.064(0.10)		0.246(0.01)	0.505(0.00)	-0.186(0.36)	0.068(0.87)	2.32(0.13)	4.36(0.11)	4.57(0.21)	4.64(0.33)
IUS&MUS	0.035(0.43)	0.002(0.21)	0.217(0.02)	0.461(0.01)	-0.126(0.51)	0.098(0.83)	1.34(0.25)	3.18(0.20)	3.26(0.35)	3.27(0.51)
Korea										
MUS	-0.026(0.03)		0.075(0.04)	-0.361(0.18)	1.423(0.00)	0.356(0.06)	2.26(0.13)	3.90(0.14)	3.91(0.27)	10.94(0.03)
IUS&MUS	-0.040(0.01)	-0.001(0.23)	0.068(0.04)	-0.350(0.18)	1.408(0.00)	0.442(0.03)	1.87(0.17)	3.76(0.15)	4.22(0.24)	6.46(0.17)

Notes: See notes in Table 3. The first row MUS is the result for EGARCH including the US money supply and the second row IUS&MUS for EGARCH including both the US interest rate and money supply. The entry for H_3: φ_j=0 (MUS ➡Y) in the column of Causality Test represents the sum of the coefficient of the lagged US money supply and the entry in parentheses represents the p-values for the null hypothesis of non-causality: H_3: φ_j=0. The MUS➡Y is a logotype for the US money supply-cause-income. The serial correlation of only $Q^2(1)$ at MUS for India exists obviously, while there are many serial correlation for OLS with including the US money supply policy.

Apendix :Graph of the Observed Data Series.





Notes: For the left-side graphs, the left and right axes are respectively production index in logs(depicted in fine) and money supply in logs(depicted in bold);
For the right-side graphs, the left and right axes are espectively the US call spread (%, depicted in fine) and the US money supply in logs(depicted in bold);
The money supply is measured in billions in national currency fro US and Asian countries. Exception are Malaysia and Pakistan for which money supply is measured in millions in national currency.