Granger Causality Among Pre-Crisis East Asian Exchange Rates

(Running Title: Granger Causality Among Pre-Crisis East Asian Exchange Rates)

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Abstract

We examine Granger causality among the exchange rates of eight East Asian economies prior to the Asian crisis. We adopt as our general model Engle and Gau's (1997) "official band" model, and use daily bilateral US dollar exchange rate data during January 1991-July 1997. Our findings provide some empirical support for the presence of systematic relationships that are consistent with the contagious nature of the Asian crisis.

Keywords: causality, exchange rate, East Asia, contagion, crisis

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1 Introduction

The 1997-1998 Asian currency crisis was marked by a sudden and sharp depreciation of many regional currencies. While there are a number of explanations for the crisis, including similar structural weaknesses, the propagation of the crisis from one country to another suggests that contagion effects may have played a role. In this connection, our paper investigates Granger causality among East Asia's bilateral exchange rates vis-à-vis the US dollar in the pre-crisis period. Such causality would lend some support to the presence of contagion effects. Our paper adds to the existing empirical literature on contagion effects and the Asian crisis by making use of Engle and Gau's (1997) "official band" model.

2 Data and Model Specification

Our study covers eight East Asian countries – Korea, Taiwan, Hong Kong, Singapore, Indonesia, Philippines, Thailand and Malaysia. The first four are newly industrialized economies while the latter four are collectively known as the ASEAN-4. We use daily bilateral US dollar exchange rate data from Datastream and our sample period is between 2 January 1991 and 1 July 1997.[1]

We use the causality tests developed by Cheung and Ng (1996) in order to examine the causality in variance, in the Granger (1969) sense, of two series using a two-step procedure. The first step requires the identification of the appropriate model for the univariate time series, and the second step utilizes a cross-correlation function (CCF) of the standardized squared residuals to check for causality in variance. The tests are robust to distributional assumptions. In this section, we identify the appropriate model for the exchange rates of all the eight countries.

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[1] Before 1991, the exchange rates of many East Asian countries were based on government-announced official rates rather than freely traded rates.

We adopt as our general model Engle and Gau's (1997) "official band" model. The model specification includes the impact of volatility on returns, and a location parameter that ensures consistency of non-Gaussian Quasi-Maximum-Likelihood Estimators (QMLE):

$$y_{i,t} = \alpha_{i,0} + \alpha_{i,1}h_{i,t} + \varepsilon_{i,t} + \alpha_{i,2}\varepsilon_{i,t-1} + \alpha_{i,3}\sqrt{h_{i,t}} \; ; \text{ and} \tag{1}$$
$$h_{i,t} = \beta_{i,0} + \beta_{i,1}h_{i,t-1} + \beta_{i,2}\varepsilon_{i,t-1}^2 + \beta_{i,3}x_{i,t-1}$$

where $y_{i,t}$ is exchange rate return given by $y_{i,t} = 100\log(S_{i,t}/S_{i,t-1})$, $S_{i,t}$ is the daily exchange rate of country i, $h_{i,t}$ is the conditional variance, $\varepsilon_{i,t}$ is the residual, and the term $x_{i,t}$ is equal to $\left|100\log(S_{i,t}/T_{i,t})\right|$, where $T_{i,t}$ is the "target" exchange rate.[2]

The specification of the univariate model employs the robust Wald test developed by Bollerslev and Wooldridge (1992). Table 1 below reports the results of the robust-Wald specification tests. The most parsimonious specification of each series determines the choice of univariate model. The no-GARCH(1,1) restriction against the GARCH(1,1) alternative cannot be rejected at the 5 percent significance level for Indonesia, the Philippines and Korea. Additional robust Wald tests for the remaining five cases indicate GARCH(1,1) to be the appropriate specification for the exchange rates of Malaysia and Singapore, while MA(1)-GARCH(1,1) characterize the exchange rates of Hong Kong and Taiwan. The GARCH(1,1)-with-band specification is suitable only for the Thai baht.

[Insert Table 1 here]

3 Causality

We define the standardized squared residuals of the univariate models in section 2 as:

$$\overline{\varepsilon}_{i,t}^{2} = (y_{i,t} - \mu_{i,t})^2 / h_{i,t} \tag{2}$$

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[2] The term $x_{i,t}$ specifies the band in the conditional variance equation. For countries with undeclared bands, we use $x_{i,t-1} = \left|100\log(S_{i,t-1}/S_{i,t-2})\right|$ as the proxy for the band. The coefficient $\beta_{i,3}$ shows the impact of previous deviation of the exchange rate from its target rate on the magnitude of the volatility.

where $\mu_{i,t}$ is the mean of the exchange rate return for country i. The cross-correlation function (CCF) of the sample is given by:

$$\hat{\rho}_k(\bar{\varepsilon}_i^2, \bar{\varepsilon}_j^2) = \frac{\sum(\bar{\varepsilon}_{j,t}^2 - E(\bar{\varepsilon}_{j,t}^2))(\bar{\varepsilon}_{i,t-k}^2 - E(\bar{\varepsilon}_{i,t}^2))}{\sqrt{\sum(\bar{\varepsilon}_{j,t}^2 - E(\bar{\varepsilon}_{j,t}^2))^2 \sum(\bar{\varepsilon}_{i,t}^2 - E(\bar{\varepsilon}_{i,t}^2))^2}} \qquad (3)$$

where the subscripts j, i, and k refer to the first country, the second country, and the lead (k<0) or lag (k>0), respectively.

Cheung and Ng (1996) show that the square root of the number of observations multiplied by the sample cross-correlation has an asymptotic normal distribution. Therefore, the statistic ($\sqrt{T}\hat{\rho}_k(\bar{\varepsilon}_i^2, \bar{\varepsilon}_j^2)$) may be used to detect causality in variance. Given $\hat{\rho}_k(\bar{\varepsilon}_i^2, \bar{\varepsilon}_j^2) \neq 0$, if k>0, then the second series lags or "Granger causes" the first series, but if k<0, then the first series lags or "Granger causes" the second series. k equals zero indicates instantaneous causality. Bi-directional causality may exist if the statistics are significant for both k>0 and k<0. The maximum value of leads and lags is ten.

The cross-correlation of the standardized residuals also shows causality in mean. However, Cheung and Ng (1996) cautioned that for some model specifications, the presence of both the causality-in-variance and causality-in-mean may affect the CCF because of the violation of the independence assumption in either test. In a GARCH(1,1) model, the causality in mean may have a large effect on the size of the causality in variance test since the conditional variance is a function of squared errors, although the reverse may not be true.

Table 2 below shows the significant cross-correlation leads and lags of the standardized residuals and residual-squares of the bilateral rates versus the US dollar. The results indicate systematic relationships among the exchange rates, but mainly in mean rather than in variance. Since only the causality in mean exists in most cases, and the specified model is either no-GARCH or GARCH(1,1), then the CCF is not likely to be biased.

[Insert Table 2 here]

Within the ASEAN-4, bi-directional causality in mean exists between Thailand and the Philippines. There is also bi-directional causality in mean between Indonesia and both the Philippines and Thailand. The direction of causality in mean for Malaysia and the other ASEAN-4 countries is from Malaysia to Indonesia, the Philippines and Thailand, although causality in variance is bi-directional between Malaysia and Thailand.

Table 2 also indicates the spillover to Korea, which shows bi-directional causality in mean with Indonesia, Philippines and Thailand. There is also uni-directional causality in mean from Malaysia to Korea. For Hong Kong, Singapore and Taiwan, the causality is mainly from them to the ASEAN-4. Exceptions include bi-directional causality in both mean and variance between Malaysia and Singapore, and the unidirectional causality in mean from the Philippines to Taiwan.

For both mean and variance, there is also causality between Hong Kong and both Singapore and Taiwan. The causality is bi-directional for mean and variance between Singapore and Taiwan. Instantaneous causality in mean exists for most of the countries except South Korea and Taiwan on one hand and the other seven East Asian countries on the other. There is also no instantaneous causality in mean between Hong Kong and Indonesia. Instantaneous causality in variance is also present between Malaysia and both Thailand and Singapore, as well as between Singapore and Thailand.

Therefore, our results indicate the presence of systematic relationships among East Asian bilateral exchange rates vis-à-vis the US dollar in the pre-crisis period that are consistent with the contagious nature of the Asian currency crisis. Such systematic relationships can help explain how the currency crisis, which originated in Thailand, quickly spread to other Southeast Asian countries as well as Korea, resulting in a region-wide crisis.

References

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Table 1
Robust Wald Tests [a] for Models of Bilateral Rates Versus US Dollars

$$y_{i,t} = 100 \log(S_{i,t}/S_{i,t-1}) \; ; \; y_{i,t} = \alpha_{i,0} + \alpha_{i,1}h_{i,t} + \varepsilon_{i,t} + \alpha_{i,2}\varepsilon_{i,t-1} + \alpha_{i,3}\sqrt{h_t} \; ; h_{i,t} = \beta_{i,0} + \beta_{i,1}h_{i,t-1} + \beta_{i,2}\varepsilon_{i,t-1}^2 + \beta_{i,3}x_{i,t-1} \; ; \; x_{i,t} = \left|100 \log(S_{i,t}/T_{i,t})\right|$$

Null Hypothesis	Indonesia[c]	Malaysia[d]	Philippines[c]	Thailand[f]	Hong Kong[e]	S. Korea[c]	Singapore[d]	Taiwan[e]
$\beta_1=\beta_2=0$ [b]	0.188	94.767**	0.108	7.027*	156.123**	0.429	120.890**	167.527**
$\alpha_1=\alpha_2=\beta_3=0$	-	0.281	-	7.128+	16.100**	-	2.110	290.528**
$\alpha_1=\alpha_2=0$	-	0.021	-	0.008	15.676**	-	0.992	290.059**
$\alpha_1=\beta_3=0$	-	0.277	-	7.111*	0.086	-	2.110	0.722
$\alpha_2=\beta_3=0$	-	0.276	-	7.119*	16.046**	-	1.101	288.795**
$\alpha_1=0$	-	0.000	-	0.001	0.071	-	0.933	0.301
$\alpha_2=0$	-	0.021	-	0.007	15.652**	-	0.046	288.388**
$\beta_3=0$	-	0.271	-	7.105*	0.024	-	1.100	0.444

[a] The misspecification test initially considers the no-GARCH as the null hypothesis against the alternative of GARCH(1,1). If GARCH(1,1) is not rejected, then additional misspecification tests under various null hypotheses are conducted against the general model (MA(1)-GARCH(1,1)-M-with-a-band) as the alternative. The most parsimonious specification is chosen for each series. The computer programs are in RATS 4.3.

[b] To test for no-GARCH(1,1), the robust Wald test has a null hypothesis of no GARCH(1,1) against GARCH(1,1) as an alternative. (**), (*) and (+) indicate 1%, 5% and 10% levels of significance respectively.

[c] Indonesia, the Philippines and Korea exchange rates do not reject the no-GARCH(1,1) specification against the alternative of GARCH(1,1) at the 5% level of significance.

[d] Additional robust Wald tests indicate the nonrejection of the null against the general model for Malaysia and Singapore, therefore the GARCH(1,1) model is chosen.

[e] The rejection of the null $\alpha_1=\alpha_2=\beta_3=0$, $\alpha_1=\alpha_2=0$, $\alpha_2=\beta_3=0$, $\alpha_2=0$ but the nonrejection of $\alpha_1=\beta_3=0$, $\alpha_1=0$, $\beta_3=0$ at the 5% level of significance for Hong Kong and Taiwan denote an MA(1)-GARCH(1,1) model.

[f] The rejection of the null $\alpha_1=\alpha_2=0$, $\alpha_1=\beta_3=0$, and $\beta_3=0$ at the 5% level and $\alpha_1=\alpha_2=\beta_3=0$ at the 10 % level of significance and the nonrejection of $\alpha_1=\alpha_2=0$, $\alpha_1=0$, $\alpha_2=0$ at the 10 percent and higher level of significance denote a GARCH(1,1)-with-a-band model.

Table 2
Significant Cross-Correlation Leads and Lags of Standardized Residuals in
Levels (Upper Diagonal) and Squares (Lower Diagonal)
(Bilateral Rates versus US dollar)

Second Variable	First Variable							
	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	S. Korea	Singapore	Taiwan
Indonesia		-5, 0	-5, 0, 2, 3, 5	-5, 0, 5	-5, -2, 5	-5, 0, 5	-5, 0	-2
Malaysia	-		0, 3	0, 5	-5, 0	0, 1, 4,5	-1, 0, 1	-
Philippines	-	-		-5, -4, -3, -2, 0, 1, 2, 3, 5	-	-5, 0, 1	-5, -3, 0	2, 4, 5
Thailand	-	-4, 0 1	-		-	-5, 0, 5	-5, 0	-4
Hong Kong	-	5	-	-4		1, 4	-1, 0, 2, 5	-4, -2
S. Korea	-	-	-	-	-		-3, 0	-
Singapore	-	-1, 0, 1	-	0	-5	-		-2, -1, 5
Taiwan	-	-	-	-	-3,	-	-5, 1, 2	

Notes: "Significant" refers to significance level of 5% or higher. The cross-correlation leads and lags of standardized residuals (causality in mean) are shown on the upper diagonal while lower diagonal show the significant lead or lags of the standardized residual squares (causality in variance). A positive value means that the second variable lags the first variable while a negative value connotes the first variable lags the second variable. Zero indicates significant instantaneous correlation. The computer programs are written in RATS 4.3.