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Exchange rates and stock prices interaction during good and bad times: evidence from the ASEAN4 countries

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Using bootstrap causality tests with leveraged adjustments, the link between exchange rates and stock prices in Malaysia, Indonesia, Philippines and Thailand is investigated for the periods immediately before and during the 1997 Asian crisis. Two variables are found to be significantly linked in the non-crisis period but not at all during the crisis period. The implications of this result in terms of hedging, market efficiency, market integration and policy intervention are explained in the paper.

1. Introduction

In this study, the relationship between exchange rates and stock prices is examined. In particular, it is investigated whether there is a causal relationship between the two variables and the direction of causality between them. This issue has theoretical, practical and policy importance. Theoretically, the relationship between asset prices is a crucial input to open macro-economy models as well as international portfolio diversification and hedging models. Practically, knowledge of the linkage between asset prices is necessary for investors in their search of diversification opportunities and for the hedging of their investments. Economic and financial policymakers and regulators would need to know the interaction between asset prices, such as those between exchange

rates and stock markets, if they are to formulate the appropriate policies.

The direction of causality between stock prices and exchange rates has been highly debated and continues to be so. It is claimed, on one hand, that exchange rates cause stock prices since a change in exchange rates affect firms' profits and therefore their stock prices (Aggarwal, 1981). On the other hand, it is also claimed that the relationship could be the other way around – that is, stock prices cause exchange rates because a change in stock prices affects domestic wealth which in turn affects the demand for money leading to a change in interest rates. This change in interest rates consequently impacts on capital flows, which then change exchange rates (Krueger, 1983).

A number of empirical studies have been conducted to verify this relationship with the use of

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different methodologies and data sets. Results of these studies have been mixed. Furthermore, these studies have been conducted under periods where the stock markets are operating under normal conditions. It would be important and interesting to consider situations where asset markets such as the foreign exchange and equity markets, are under stress given that such scenarios have in fact occurred a number of times in financial markets history (see Kindleberger, 1978). Having the proper understanding of the relationship between asset markets when they are in crisis conditions is even more important as this is the time when regulators are called to take immediate and decisive actions and decisions. During an economic crisis, exchange rates are often the easy target for policy intervention and therefore the significance of knowing how exchange rates will affect other asset markets would be crucial.

When asset markets are under stress, volatility will be higher and returns will be lower. It has been shown in the finance literature that in such conditions, correlations between markets tend to increase. This may therefore imply that the relationship between exchange rates and share prices would in fact become stronger during a crisis period. Caution, however, must be exercised in making this claim. The increase in correlation could be a statistical anomaly, as Forbes and Rigobon (2002) have pointed out.

On the other hand, it is possible that when markets are under too much strain, the relationships between them can completely break down as was the case between the futures and stock markets, at least in the USA during the stock market crash of 1987 (Roll, 1988). The same phenomenon can happen to the relationship between the foreign exchange and stock markets. When the stock market is under a severe crisis, participants may be just interested in the safety of their investments and may no longer pay attention to factors such as exchange rates, which they would usually do when times are normal. The normal channels by which share prices affect exchange rates may therefore not operate under crisis conditions.

In this study, an investigation is conducted based on the experience of the so-called ASEAN4 countries – Indonesia, Malaysia, Philippines and Thailand, before and during the Asian crisis. As is well known, the ASEAN countries were the most heavily affected by the crisis and among them, these four countries were the hardest hit. Before the crisis, these countries had booming asset markets, particularly the property and stock markets. Then, the crisis started as an exchange rate crisis, which is thought to have spilled over to the other asset markets within each country. Thus, the experience of these

ASEAN4 countries provides a good laboratory for the examination of the relationship between exchange rates and stock prices during normal and stressful conditions. The results of this investigation would have implications in terms of the following when markets are under stress:

- (a) Market efficiency – whether asset markets become efficient or not efficient in processing information generated from each other.
- (b) Financial market integration – whether asset markets such as the foreign exchange and stock markets become more or less integrated.
- (c) Financial contagion – whether the exchange rate crisis in fact spilled over to other asset markets such as the stock market.

With the exception of the Philippines, it is found that during the period before the Asian crisis, there was a significant causal relationship between exchange rates and stock prices in each of the four ASEAN countries where the causality ran from the former to the latter in the case of Indonesia and Thailand, but from the latter to the former in the case of Malaysia. However, during the Asian crisis period, this relationship between the two variables ceased in all the four ASEAN countries. This result could imply that the markets became more efficient in processing information during the crisis period or it could also mean that in fact during the Asian crisis period, the link between the two markets was snapped.

The rest of the paper is organized as follows. Section II gives a brief literature review and outlines the contributions of this paper. Section III explains the methodology followed by Section IV which describes the data. Section V presents the empirical results. Conclusions and policy implications are provided in the last section.

II. Brief Literature Review and Contributions of the Study

As stated earlier, a number of studies have empirically examined the relationship between stock prices and exchange rates using different methodologies, data sets and/or markets. Early investigations of this issue focused on the USA and reported divergent findings (see, for instance, Aggarwal, 1981; Soenen and Hennigar, 1988; Bahmani Oskooee and Sohrabian, 1992). Subsequent studies also failed to produce unanimous results. For instance, Abdalla and Murinde (1997) found that exchange rates drive stock prices in Korea, Pakistan and India but it is the reverse in the case of the Philippines. Ajayi *et al.*

(1998) found that exchange rates cause stock prices in the developed markets (Canada, Germany, France, Italy, Japan and UK) but uneven results for the case of developing countries. They reported bidirectional causality in Taiwan but a unidirectional one running from stock prices to exchange rates in Indonesia and the Philippines, vice versa in Korea but none in Hong Kong, Singapore, Thailand and Malaysia.

More recent studies also have not been able to settle this issue. Granger *et al.* (2000) reported that exchange rates influence stock prices in South Korea but it is the opposite in Hong Kong, Malaysia, Philippines, Singapore, Thailand and Taiwan. They also found no relationship between the two variables in Japan and Indonesia. Hatemi-J and Irandoust (2002) also examined this issue based on Sweden utilizing a causality test developed by Toda and Yamamoto (1995). Their results revealed that stock prices drive exchange rates rather than vice versa. Smyth and Nandha (2003) studied this issue with respect to the South Asian countries of Bangladesh, India, Pakistan and Sri Lanka using daily data covering the period 1995 to 2001. Applying cointegration and Granger-causality tests, they discovered no stable long-run relationship between exchange rates and stock prices in these four countries and that exchange rates Granger-cause stock prices in India and Sri Lanka. They did not, however, find any causality between the two variables in Pakistan and Bangladesh.

The present study contributes to the literature in the following ways. First, there is a dearth of literature on the relationship between exchange rates and stock prices during crisis periods. To the best of the authors' knowledge, there is only one study which has investigated this issue during the Asian financial crisis – that of Granger *et al.* (2000). Although their study covered the ASEAN4 countries that are included in this study, their study uses a different statistical methodology. Second, most of the studies cited above used asymptotic methods of statistical inference. It is well known that these methods result in bias when data are characterized by non-normalities and ARCH effects. Unfortunately, it is already well established that this is often the case for financial data particularly during periods when markets are under severe stress (see, for instance Chunchachinda *et al.* 1997, and Forbes and Rigobon, 2002). As demonstrated by Forbes and Rigobon (2002), correlations between markets can be overestimated when volatility increases. In terms of the present research, this situation can mean an overestimation of the strength of the relationship between exchange rates and share prices. In order

to overcome this problem, use is made of an econometric technique that is most appropriate to handle crisis periods. Causality tests are utilized based on leveraged bootstrap methods, which have been shown, by Hacker and Hatemi-J (2003) to provide robust and unbiased statistical results as these methods overcome problems of non-normalities and ARCH effects. Hence, this study can provide new evidence on this interesting and important issue pertaining to the link between the exchange rate and stock price during crisis periods.

III. Methodology

In this section the methodology that is applied to carry out the empirical analyses of the study is described. First, a robust test for unit roots introduced by Perron (1989) is described. Second, the Toda and Yamamoto (1995) test statistics for Granger (1969) causality between integrated variables are presented. Third, a new information criterion to choose optimal lag in the empirical model is defined. Finally, the leveraged bootstrap simulation method introduced by Hacker and Hatemi-J (2003) is presented that is used to create more precise critical values for tests of Granger causality.

It is well known in the econometric literature that it is important to check the time series properties of the data in order to make sure that the drawn inference is not spurious and misleading. It is also well established that standard tests for integration order have very low power if the effect of structural breaks that have occurred during the period of study is not explicitly taken into account. In this study, the effect of Asian crisis is taken into account by making use of the Perron (1989) test when tests for integration order are conducted. The Perron test is robust to a structural break in both the mean value and the deterministic trend of the variable that is tested for unit roots. This test for one unit root of variable z is based on the following regression:

$$z_t = c_1 + c_2 D_t + d_1 t + d_2 D_t t + g J_t + \gamma z_{t-1} + \sum_{i=1}^k b_i \Delta z_{t-i} + \omega_t \quad (1)$$

where t = the time period (the linear trend term), D_t is a dummy variable that takes value zero for the time period before break and one for the rest of the period, J_t is equal to one if the time period t is the first period after that of the structural break, and is zero otherwise. The first difference operator is denoted by Δ and ω_t represents a white noise error term. The null hypothesis of one unit root is $\gamma = 1$ and alternative

hypothesis is stationarity ($\gamma < 1$). The optimal number of lagged differences (k) is chosen by including more lags until the null hypothesis of no serial autocorrelation for ε_t is not rejected by the LM test at the 10% significance level.¹

The next step in this study is to investigate the causal relationship between the variables.² Consider the following vector autoregressive model of order p , VAR(p), to allow for dynamic interaction between variables of interest in a system perspective:

$$y_t = v + A_1 y_{t-1} + \dots + A_p y_{t-p} + \varepsilon_t \quad (2)$$

where y_t , v , and ε_t are n -dimensional vectors (n is the number of variables in the model, which is two in the present case) and A_r is an $n \times n$ matrix of parameters for lag r . A crucial issue in this regard is the choice of the optimal lag order (p) since all inference is based on the chosen lag order. To this end, the Hatemi-J (2003) information criterion is applied, which is described below:

$$HJC = \ln(|\Pi_j|) + j \times n^2 \left(\frac{\ln T + 2\ln(\ln T)}{2T} \right) \quad (3)$$

$$j = 0, \dots, p$$

Here $\ln$ signifies the natural logarithm, $|\Pi_j|$ is the determinant of the estimated variance-covariance matrix of the error terms in the VAR model for lag order j , n stands for the number of variables and T is the number of observations used to estimate the VAR model. Hatemi-J (2003) shows through Monte Carlo simulation experiments that this new information criterion performs well, particularly if variables are integrated. The optimal lag order is obtained by minimizing Equation 3.

It is well recognized in the literature that standard distributions are generally not valid if the variables in the model are integrated. Toda and Yamamoto (1995) suggest the following augmented VAR($p+d$) model to be used for tests of causality if the variables are integrated:

$$y_t = v + A_1 y_{t-1} + \dots + A_p y_{t-p} + \dots + A_{p+d} y_{t-p-d} + \varepsilon_t \quad (4)$$

where d is equal to the integration order of the variables. The j th element of y_t does not

Granger-cause the j th element of y_t if the following hypothesis is not rejected:

$$H_0: \text{the row } j, \text{ column } f \text{ element in } A_r \\ \text{equals zero for } r = 1, \dots, p_t \quad (5)$$

It should be clarified that the parameters for the extra lag(s), i.e., d , are unrestricted in testing for Granger causality. According to Toda and Yamamoto (1995), these unrestricted parameters ensure that the asymptotical chi-square distribution can be used if the residuals in the VAR model are normally distributed. In order to describe the Toda-Yamamoto test statistic in a compact way, define the following denotations for a sample size T :

$$Y := (y_1, \dots, y_T) \quad (n \times T) \text{ matrix}$$

$$B := (v, A_1, \dots, A_p, \dots, A_{p+d}) \\ (n \times (1 + n(p+d))) \text{ matrix}$$

$$Z_t := \begin{bmatrix} 1 \\ y_t \\ y_{t-1} \\ \vdots \\ y_{t-p-d+1} \end{bmatrix} \quad ((1 + n(p+d)) \times 1) \text{ matrix,} \\ \text{for } t = 1, \dots, T$$

$$Z := (Z_0, \dots, Z_{T-1}) \quad ((1 + n(p+d)) \times T) \text{ matrix}$$

$$\delta := (\varepsilon_1, \dots, \varepsilon_T) \quad (n \times T) \text{ matrix}$$

By means of this notation, the estimated VAR($p+d$) model is written compactly as:

$$Y = \hat{B}Z + \hat{\delta} \quad (6)$$

The analysis continues by estimating $\hat{\delta}_U$, the $(n \times T)$ matrix of estimated residuals from the regression Equation 6 without imposing the null hypothesis of none causality. Then the variance-covariance matrix of these residuals is computed as $S_U = \hat{\delta}_U' \hat{\delta}_U / T$. $\hat{\beta} = \text{vec}(\hat{B})$ is now defined, where vec signifies the column-stacking operator. The modified Wald (MWALD) test statistic, introduced by Toda-Yamamoto, for testing the null hypothesis of non-Granger causality is then written as

$$MWALD = (C\hat{\beta})' \left[C \left((Z'Z)^{-1} \otimes S_U \right) C' \right]^{-1} (C\hat{\beta}) \sim \chi_p^2 \quad (7)$$

where the notation $\otimes$ is the Kronecker product (element by all element matrix multiplication), and C is a $p \times n(1 + n(p+d))$ indicator matrix, which is used to

¹The LM test is used for testing for autocorrelation since this test has better size properties compared to other alternative tests (see Hatemi-J, 2004).

²By causality is meant causality in the Granger sense. That is, the interested is to find out whether the past history of one variable has significant impact on the forecast of another variable or not.

define the parameters that should take value zero. Via these notations, the null hypothesis of no Granger causality is defined as the following:

$$H_0: C\beta = 0$$

The asymptotic distribution of MWALD is χ^2 with the number of degrees of freedom equal to the number of restrictions to be tested under the null (equal to p in this case). However, the simulation experiments conducted by Hacker and Hatemi-J (2003) demonstrate that the MWALD test statistic overrejects the null hypothesis if it is based on asymptotical distributions. The authors introduce a bootstrap with leveraged adjustments method to remedy the poor performance of causality test. Their paper shows that the inference based on leveraged bootstrap distributions is much more precise, especially when non-normality or ARCH effects exist. On these grounds, use of this bootstrap method will be made to improve the correctness of the inference. Another advantage of the mentioned bootstrap method is that it is based on the empirical distribution of the underlying data set and it is not sensitive to normal distribution. Since the probability of extreme events in the financial markets is usually much higher compared to the normal distribution, the application of the bootstrap method is justified.

The bootstrap simulation is conducted in the following manner. First regression Equation 6 is run with the null hypothesis of no Granger causality imposed. For each bootstrap simulation the simulated data, y_t^* , is generated based on the coefficient estimates from this regression, $\hat{\nu}, \hat{A}_1, \dots, \hat{A}_p$; the original $y_{t-1}, \dots, y_{t-p}$ data; and ε_t^* (the bootstrapped residuals). These residuals are based on T random draws with replacement from the regression's modified residuals, each with equal probability of $1/T$. The bootstrap residuals are mean adjusted to have the expected value of zero. The bootstrap residuals are also modified to have constant variance, through the use of *leverages*.³

The empirical distribution for the MWALD is generated based on conducting the bootstrap simulation 10000 times and then producing the MWALD test statistic each time. Then the (α) th upper quantile of the distribution of bootstrapped MWALD statistics is obtained, which is the α -level 'bootstrap critical values' (c_α^*). The bootstrap critical values are produced for 1%, 5% and 10% significance levels. The next step is to calculate the MWALD statistic using

the original data (not the bootstrapped simulated data). Then, the null hypothesis of no Granger causality is rejected based on bootstrap method if the actual MWALD is higher than c_α^* . The simulations are conducted by using a program procedure written in GAUSS, which is available from the authors on request.

IV. Data

The causal link between exchange rates and stock prices is investigated during the periods before and during the Asian financial crisis of 1997 with respect to ASEAN4 countries – Malaysia, Indonesia, Philippines and Thailand. Daily data is made use of for nominal exchange rates and the MSCI price indices for stock prices from 1 January to 31 December 1997. The sample period is divided into two subperiods – with period 1, from 1 January to 1 July 1997 representing the period before the crisis or normal situation, and period 2, from 2 July to 31 December 1997 representing the crisis period.

Descriptive statistics pertaining to exchange rates and stock prices are calculated for the different markets and for the two subperiods. The null hypothesis of normality is rejected for each variable in each period. It seems that kurtosis is the main reason for non-normality. Multivariate normality is tested for using Doornik and Hansen (1994) and ARCH effects by using Hacker and Hatemi-J (2004) test. The results of the multivariate test for ARCH effects and non-normality are presented in Table 1. The null hypothesis of no multivariate ARCH effects in the VAR model is rejected for each case except for the Philippines in the first subperiod and the null hypothesis of multivariate normality is also rejected strongly for each country in each subperiod. This justifies the usage of the leveraged bootstrap test, which is robust to both ARCH effects and non-normality.

V. Empirical Results

Prior to causality analysis, the Perron (1989) test for unit roots was conducted on the data. Results from these tests are presented in Table 2. For the null hypotheses of $I(1)$, i.e. integration of the first order, the estimated test statistics in absolute terms are found to be less than the critical values at any

³For more details on leverage adjustment, see Davison and Hinkley (1999) and Hacker and Hatemi-J (2003). The latter authors introduce this adjustment for multivariate equation cases.

Table 1. *P*-values of the tests for multivariate ARCH and multivariate normality in the VAR model

Test	Indonesia	Malaysia	Philippines	Thailand
Period 1				
ARCH	0.0020	0.0365	0.8460	0.0353
Normality	0.0000	0.0000	0.0000	0.0000
Period 2				
ARCH	0.0003	0.0000	0.0024	0.0000
Normality	0.0000	0.0000	0.0000	0.0000

Table 2. Test for unit roots using the Perron test

	H ₀ : I(1), H ₁ : I(0)	Test value	H ₀ : I(2), H ₁ : I(1)	Test value
Indonesia	SP	-1.416 (0)	SP	-13.880 (0) ***
	EX	-2.270 (0)	EX	-13.610 (0) ***
Malaysia	SP	-3.289 (11)	SP	-7.263 (10)
	EX	-3.402 (9)	EX	-6.914 (8) ***
Philippines	SP	-2.054 (8)	SP	-7.697 (7) ***
	EX	-3.560 (4)	EX	-10.180 (3) ***
Thailand	SP	-3.718 (0)	SP	-13.490 (0) ***
	EX	-1.53 (1)	EX	-12.270 (0) ***

Notes:

- (a) The critical value is -4.78 and -4.24 at the 1% and 5% significance level, respectively.
 (b) The notation *** implies significance at the one percent significance level.
 (c) The numbers in the parentheses indicate the number of lags required to remove potential autocorrelation in the Perron regression (Equation 1) at the 10% significance level using the LM test.

conventional significance level. Thus, the null hypothesis that each variable is $I(1)$ cannot be rejected. However, the null hypothesis that each variable is $I(2)$ is rejected at the 1% significance level. Hence, the evidence shows that each variable contains one unit root. Thus, the integration properties of the data must be taken into account in order to avoid spurious and invalid inference.

The results of the Granger causality tests based on leveraged bootstrap method for the two subperiods are presented in Table 3. It can be seen from this table that during the period before the crisis, except for the Philippines, exchange rates and stock prices are significantly related. This could mean that the transmission of information between the two asset markets – foreign exchange and stock, was inefficient. However, this could also be interpreted that the two asset markets were integrated. The direction of causality is from the former to the latter in the case of Indonesia and Thailand but it is from the latter to the former in the case of Malaysia. Thus, in Malaysia, during this period, foreign exchange could be used to hedge investments in the stock market since any

Table 3. Results of causality test based on bootstrap simulation techniques

The null hypothesis	The estimated test value (<i>MWALD</i>)	1% Bootstrap critical value	5% Bootstrap critical value	10% Bootstrap critical value
First subperiod (day ending on 1 Jan. 1997 to day ending on 31 Jun. 1997)				
Indonesia				
EX $\neq$ > SP	1.815*	26.161	4.454	1.602
SP $\neq$ > EX	0.925	4.032	2.032	1.958
Malaysia				
EX $\neq$ > SP	0.597	6.469	2.968	2.093
SP $\neq$ > EX	1.842*	18.741	2.445	1.820
Philippines				
EX $\neq$ > SP	0.310	6.336	3.210	1.931
SP $\neq$ > EX	0.242	5.849	4.116	2.864
Thailand				
EX $\neq$ > SP	2.994*	20.332	4.124	1.968
SP $\neq$ > EX	0.751	6.746	2.901	1.989
Second subperiod (day ending on 2 July 1997 to day ending on Dec. 1997)				
Indonesia				
EX $\neq$ > SP	1.208	7.089	4.374	3.014
SP $\neq$ > EX	1.459	5.616	2.573	2.089
Malaysia				
EX $\neq$ > SP	1.547	7.586	3.863	3.217
SP $\neq$ > EX	0.272	7.419	3.288	2.498
Philippines				
EX $\neq$ > SP	0.982	10.083	5.172	2.535
SP $\neq$ > EX	0.390	10.128	3.876	2.504
Thailand				
EX $\neq$ > SP	0.002	8.029	5.232	2.555
SP $\neq$ > EX	0.301	7.348	4.347	3.158

Notes:

- (a) The notation $\neq$ > implies non-Granger causality.
 (b) *MWALD* represents the modified Wald test statistic as described in Equation 7.
 (c) The lag order of the VAR model, p , was set to one for the first subperiod and two for the second subperiod. Also the augmentation lag, d , was set to one in each subperiod since each variable contains one unit root.
 (d) *implies that the null hypothesis can be rejected at the 10% significance level.

movement in stock prices Granger-causes exchange rates. In the case of Indonesia and Thailand, it is the other way around – i.e. stocks being used as a hedge for foreign exchange investment. During the crisis period, however, this significant relationship between the two variables ceased to exist in each country. Thus, this may indicate that the foreign exchange and asset markets became more efficient during the crisis period or that they ceased to be integrated. This seems to be obvious from Fig. 1, which shows the behaviour of each variable in each country. The two series seems to be diverging away from each other, instead of converging. Thus, during the crisis period, it would not be possible to use the

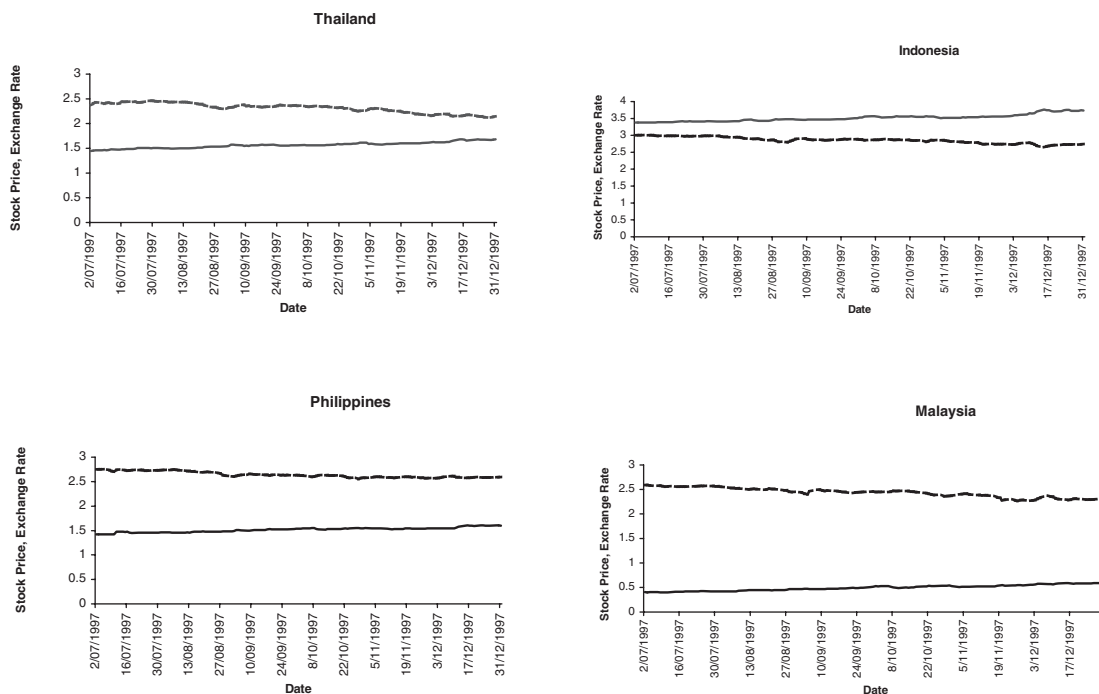


Fig. 1. Exchange rates (—) and stock prices (---) – Thailand, Indonesia, Philippines and Malaysia during the Asian crisis period

foreign exchange market as a hedge for investments in the stock market and vice versa. One market cannot also serve as a base for policy intervention for stabilizing the other market – that is, the foreign exchange market cannot serve as venue for intervention for the purpose of stabilizing the stock market and vice versa.

VI. Conclusion

The causal relationship between exchange rates and equity market prices has been examined focusing on the periods immediately prior to and during the Asian financial crisis using bootstrap causality tests with leveraged adjustments as introduced by Hacker and Hatemi-J (2003). This technique overcomes problems associated with non-normalities and ARCH effects in the data. It was found that during the period before the Asian crisis, with the exception of the Philippines, exchange rates and stock prices were significantly related, with the direction of causality running from the former to the latter in the case of Indonesia and Thailand, and from the latter to the former in the case of Malaysia. However, during the crisis period, this relationship ceased to exist in any of the countries. This could mean that the foreign exchange and stock markets became segmented or the transmission of information between the two markets became efficient during the crisis. This

would have important implications in terms of policy and in terms of hedging of portfolios. For investors in the stock markets, it would imply that they cannot use the foreign exchange markets as effective hedge for their investment and vice versa during crisis periods. For policymakers, it means that manipulating exchange rates to pop up the stock market during a crisis period would not also be an option.

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