CHAPTER 4

EMPIRICAL RESULTS AND DISCUSSION

In this chapter, we shall report all the results obtained and then attempt to account for the observations. We shall also discuss the possible implications of the findings. The computation of the mean returns and the standard deviations is meant as a preliminary study on the characteristics of each of the ASEAN-5 equity markets during the three periods. Their values will indicate an up or a down market and the prevalent volatility during any particular period. The dummy variable approach is used to test for significant structural changes in the returns of each market that are due to the three periods. In a way, the results from this least-squares regression method using dummy variables will help to justify the periods that we have defined in this study.

The daily closing stock index of each market is transformed to the logarithmic form and this series is referred to as the stock index in the level form. The return series, which is the first difference of the stock index in the level form, is computed based on the formula given in Equation (3.1). It is necessary to test the order of integration of the transformed series and return series before we perform the cointegration test. To ensure robustness, we use both the augmented Dickey-Fuller test and the Phillips-Perron test to ascertain statistically the presence of unit roots. The analysis of the correlation matrix will provide us with additional insights on the contemporaneous correlations between any two of the ASEAN-5 equity markets.

From the results of the Johansen's multivariate cointegration test, we will find out whether the five ASEAN stock markets share any long-run equilibrium relationships in each of the three periods. Subsequently, an error correction model or a vector autoregressive model, depending on the outcome of the cointegration test, will be estimated for each period. The Granger causality test for determination of temporal causal relationships is via the error correction model or the vector autoregressive model. Lastly, for each period, we use the simulated responses of the estimated VAR system to trace the dynamic responses of each of the five markets to innovations in a particular ASEAN-5 market.

4.1 Descriptive Statistics

A preliminary analysis on the mean and the standard deviation of the daily returns during the three identified periods reveals a certain obvious pattern. The results tabulated in Table 4.1 show a clear change in the signs of the mean daily returns across the periods. The mean returns are positive in the pre-crisis period, turn negative in the crisis period and then, with the exception of the Philippines, revert to positive in the post-crisis period. The results of the t-test show that these positive means in the pre-crisis are significant for Malaysia, Indonesia and the Philippines. The significantly negative mean returns for all the ASEAN markets in the crisis period support the common knowledge of a downturn market during this volatile period. After the financial crisis, the positive mean returns of the four markets, though not significantly different from zero, suggest that the markets are generally on the road of recovery.

Comparing the individual values across the three periods, the lowest mean return in the pre-crisis period is found in Thailand while the highest is in the Philippines. During the crisis period, Malaysia has the lowest mean return and Singapore, the highest. In the post-crisis period, the lowest and highest mean returns belong to the Philippines and Malaysia, respectively.

Table 4.1
Mean and Standard Deviation of Daily Returns (in percentage)

	Singapore	Malaysia	Indonesia	Thailand	Philippines
Panel A. Pre-crisis Period (January 1992 – January 1997, 1102 observations)					
Mean Return	0.0288	0.0718*	0.0935**	0.0092	0.0969*
S. D.	0.9544	1.2599	0.9437	1.5807	1.4099
Panel B. Crisis Period (February 1997 – September 1998, 364 observations)					
Mean Return	-0.1779*	-0.3244*	-0.2520*	-0.3112*	-0.2746*
S. D.	1.8329	3.6818	2.8823	2.9369	2.4825
Panel C. Post-crisis Period (October 1998 – 8 August 2002, 843 observations)					
Mean Return	0.0389	0.0783	0.0570	0.0415	-0.0168
S. D.	1.5067	1.5824	2.0031	2.0901	1.7419

S.D. denotes standard deviation.
* Significant at 5% level.
** Significant at 1% level.

The standard deviations give an indication of the volatility of the markets. For all the five markets, there is a general trend of an approximately two-fold increase in the standard deviations during the crisis period and then these standard deviations decrease during the post-crisis period, though remain higher than those corresponding values before the crisis period. This observation is in tandem with the expected increase in volatility during the crisis period. Gauging from the magnitude of the individual standard deviations, the highest volatility during the pre-crisis period is found in Thailand while the lowest is in Indonesia. During the crisis period, while Malaysia has the highest volatility, its closest neighbour, Singapore, records the lowest. After the financial crisis, Thailand again has the highest volatility while the volatility in Singapore remains the lowest.

4.2 Structural Changes and the Asian Financial Crisis

In this section, we shall examine the test of structural changes arising from the Asian financial crisis with the use of dummy variables. The regression results from the estimation of Equation (3.5) for all five ASEAN equity markets are presented in Table 4.2. The independent variables involve returns of lag one only. For each market, the model is fitted systematically up to three lags and it is found that the lag length of one gives the smallest SIC for all the markets.

The coefficients of D_{1t} are both negative and significant in all the five markets. This would suggest a decline in the average market returns during the crisis period and this observation is consistent with the significantly negative mean daily returns discussed above. Conversely, the non-significance of the coefficients of D_{2t} suggests that there is no significant difference between the average market returns of the pre-crisis period and the post-crisis period. The two cases of significant and negative coefficients of $D_{1t}R_{i,t-1}$ in Malaysia and Indonesia suggest that there is a decrease of lag dependence during the crisis period for these two countries when compared to the pre-crisis period. However, none of the coefficients of $D_{2t}R_{i,t-1}$ is significant. This suggests that there is no significant difference in lag dependence of the market returns between the pre-crisis and the post-crisis periods.

Table 4.2
Regression Results for Testing for Significance of Structural Changes due to the Asian Financial Crisis

Dependent	Independent Variables					
Variable R_{it}	Constant	D_{1t}	D_{2t}	$R_{i,t-1}$	$D_{1t}R_{i,t-1}$	$D_{2t}R_{i,t-1}$
Singapore	0.0003 (0.0004)	-0.0018* (0.0008)	0.0001 (0.0006)	0.0370 (0.0421)	0.0366 (0.0520)	0.1093 (0.0569)
Malaysia	0.0006 (0.0006)	-0.0039** (0.0012)	0.0001 (0.0009)	0.1709** (0.0465)	-0.1983** (0.0542)	-0.0674 (0.0629)
Indonesia	0.0006 (0.0005)	-0.0027* (0.0011)	-0.0002 (0.0008)	0.3308** (0.0560)	-0.1407* (0.0645)	-0.1675 (0.0636)
Thailand	0.0001 (0.0006)	-0.0030* (0.0012)	0.0003 (0.0009)	0.0861* (0.0388)	-0.0177 (0.0531)	0.0179 (0.0513)
Philippines	0.0008 (0.0005)	-0.0031** (0.0010)	-0.0009 (0.0008)	0.1796** (0.0368)	-0.0446 (0.0517)	-0.0426 (0.0501)

* Significant at 5% level.
** Significant at 1% level.
The figures in parentheses are the standard errors.
The optimal lag length of 1 is based on SIC.

We may, therefore, conclude that the financial crisis brought about a significant change in the intercept of the regression equation for all the five markets but the intercept in the post-crisis period seems to revert to that of the pre-crisis period. As for the slope of the regression equation, there are significant changes in the crisis period only in the case of Malaysia and Indonesia. The slope also seems to revert to that of the pre-crisis for each of the five markets after the financial crisis. The results of this analysis support the findings that there are structural changes in the behaviour of the market returns due to the Asian financial crisis.

4.3 Results of the Unit Root Tests

The augmented Dickey-Fuller (ADF) and the Phillips-Perron (P-P) tests are used here to test for the presence of unit root. The results of these two tests are presented in Table 4.3. It is evident that both the ADF and P-P test results show that the market indices in level form (that is, P_t) contain a unit root, and hence are not stationary, but the return series are stationary. The only exception is that of the Philippines during the post-crisis period.

For both tests, the null hypothesis of a unit root in the level form of the stock index is rejected. This would imply that the stock index of the Philippines is stationary in the level form. In these unit root tests, a deterministic trend was included in the equation (see Equations (3.9) and (3.10)). In fact, the underlying data generating process is not known. When the tests are repeated on the stock index of the Philippines for the post-crisis period without the deterministic trend, the ADF test and the P-P test produce a test-statistic of –0.9141 and -0.8074, respectively. The critical values for both tests are -3.4408, -2.8654 and -2.5688 at the 1%, 5% and 10% level, respectively. Thus, we do not reject the null hypothesis and conclude that the stock index is not stationary in the level form. When the tests are performed on the return series, the corresponding test-statistics are –19.8889 and –25.2937. Compared to the same set of critical values, we therefore do not reject the null hypothesis and conclude that the Philippines stock index is also integrated of order one.

Table 4.3
Unit Root Tests of ASEAN-5 Stock Market Indices

	Level			First difference		
		ADF	P-P		ADF	P-P
	Lag (p)	Test Statistic	Test Statistic	Lag (p)	Test Statistic	Test Statistic
Panel A. Pre-crisis Period						
Singapore	1	-1.4505	-1.4211	1	-23.5447**	-31.9255**
Malaysia	1	-2.0605	-1.8824	1	-21.8554**	-27.6490**
Indonesia	1	-1.9237	-1.6549	1	-18.8972**	-23.4721**
Thailand	1	-0.3337	-0.2369	1	-21.5051**	-30.4548**
Philippines	1	-1.6654	-1.5746	1	-20.3190**	-27.7083**
Critical values: 1%, -3.9714; 5%, -3.4163						
Panel B. Crisis Period						
Singapore	1	-3.0724	-2.8308	1	-11.8259**	-16.3919**
Malaysia	1	-2.815	-2.8576	3	-11.8305**	-19.5346**
Indonesia	1	-2.161	-1.8612	2	-12.1791**	-15.6997**
Thailand	1	-2.0223	-1.9480	1	-12.3737**	-17.7752**
Philippines	1	-2.0005	-1.8407	1	-12.9522**	-16.5835**
Critical values: 1%, -3.9871; 5%, -3.4238						
Panel C. Post-crisis Period						
Singapore	1	-3.1846	-3.2060	1	-19.4700**	-27.1394**
Malaysia	1	-3.1419	-3.1566	1	-18.6914**	-26.2671**
Indonesia	1	-3.1343	-3.1024	1	-19.2453**	-24.6639**
Thailand	1	-2.8367	-2.7651	1	-18.5845**	-26.1129**
Philippines	1	-3.9657*	-3.9810**	1	-20.0102**	-25.3931**
Critical values: 1%, -3.9738; 5%, -3.4174						

The Schwarz criterion is used in choosing the lag length for the ADF test regression.
The lag length of the P-P test follows that of the ADF test.
* Significant at 5% level.
** Significant at 1% level.

4.4 Contemporaneous Movements

A preliminary study on the contemporaneous movements between any two ASEAN markets is conducted by analyzing the correlation matrix of the returns. From the results presented in Table 4.4, it is clear that the correlations are the strongest during the crisis period. This reflects the much studied contagion effect in the financial crisis whereby movement of the returns in one market has great impact on the movement in another market. All the coefficients are significantly positive and this indicates that a rise or fall in the returns of a market would cause a movement in the same direction in another market in the same period.

Table 4.4
Correlation Matrix for the Returns of ASEAN-5 Stock Markets

	Singapore	Malaysia	Indonesia	Thailand	Philippines
Panel A. Pre-crisis Period					
Singapore	1.0000				
Malaysia	0.5773**	1.0000			
Indonesia	0.2895**	0.3161**	1.0000		
Thailand	0.3724**	0.4157**	0.2597**	1.0000	
Philippines	0.2227**	0.2264**	0.2982**	0.2260**	1.0000
Panel B. Crisis Period					
Singapore	1.0000				
Malaysia	0.5890**	1.0000			
Indonesia	0.4953**	0.4500**	1.0000		
Thailand	0.4538**	0.4857**	0.4490**	1.0000	
Philippines	0.5293**	0.3903**	0.4162**	0.4259**	1.0000
Panel C. Post-crisis Period					
Singapore	1.0000				
Malaysia	0.3177**	1.0000			
Indonesia	0.3559**	0.2094**	1.0000		
Thailand	0.4834**	0.2765**	0.3332**	1.0000	
Philippines	0.3326**	0.1943**	0.2846**	0.3240**	1.0000

** Significant at 1% level.

One interesting observation is that while the pair-wise correlations between the returns of Singapore, Indonesia, Thailand and the Philippines have strengthened during the post-crisis period as compared to the pre-crisis period, the pair-wise correlations of Malaysia and each of the other four countries have weakened considerably. In fact, the correlation coefficients between the returns of Malaysia and Singapore are the highest in both the pre-crisis and crisis periods, but this is no longer the case in the post-crisis period. The mutual economic interdependence between Malaysia and Singapore could account for these high correlations, but after the crisis, the implementation of capital controls in Malaysia could have insulated the Malaysian economy and hence substantially reduced the influence from the other ASEAN markets. In fact, due to such expectedly high interdependence between the Malaysian and Singaporean economies under normal market conditions, Jang and Sul (2002), who did a study on the co-movement of seven Asian countries, had deliberately included Singapore but left out Malaysia. They rationalized that due to high correlation between them, one market's movement would be similar to the other. The authors had also found a similar pattern of short-term inter-relationships in the three periods.

4.5 Results of the Johansen's Multivariate Cointegration Test

We next examine whether the ASEAN-5 stock markets are cointegrated, that is, they have a common long-run equilibrium relationship. For this purpose, the Johansen's multivariate cointegration test is used. This test can be sensitive to the order of the lag length used in the VAR. Before we select the optimal lag length based on SIC, the following procedure was carried out. For each period, the cointegration test was applied to the five stock indices in the level form, systematically increasing one lag at a time and up to eight lags. The maximum likelihood-ratio test indicates the following outcomes: In the pre-crisis period, there is one cointegrating equation for lag 1 and none for lags 2 to 8. There is no cointegrating equation for lag 1 to lag 8 in the crisis period. As for the post-crisis period, there are two cointegrating equations for lag 1 to lag 3 and only one for lag 4 to lag 8. For each period, we then estimated the unrestricted VAR models for those lag lengths that indicated no cointegrating equation and the ECMs for those that have one or more cointegrating equations. The SICs for the eight regression models of each period were noted. The optimal lag structure for the model was selected by minimizing SIC. Invariably, the lag length of one gave the lowest SIC for all the five markets in all three periods.

The results of the Johansen's multivariate cointegration test based on the model with the optimal lag length of one are tabulated in Table 4.5. The null hypothesis of no cointegrating equation is rejected for the pre- and post-crisis periods. In the post-crisis period, the null hypothesis of at most one cointegrating equation is also being rejected. The findings suggest one cointegrating equation in the pre-crisis period, none in the crisis period and two in the post-crisis period.

The implication of the cointegration test is that the ASEAN-5 market indices share at least one common long-run equilibrium relationship before and after the financial crisis but not during the crisis period. As shown in most studies on geographically linked group of markets, such long-run equilibrium relationships are to be expected under normal market conditions. However, given the uncertainties of the directions of the markets during the crisis period, the absence of a long-run linkage is not at all surprising. The high volatilities of the markets during the crisis period probably made it difficult for these markets to be integrated and to form a long-term common relationship.

Table 4.5
Johansen's Multivariate Cointegration Test of the ASEAN-5 Stock Market Indices

H_o	H_1	Eigenvalue	Likelihood ratio
Panel A. Pre-crisis Period			
$r = 0$	$r > 0$	0.0315	72.33*
$r \leq 1$	$r > 1$	0.0189	37.18
$r \leq 2$	$r > 2$	0.0102	16.24
$r \leq 3$	$r > 3$	0.0036	4.96
$r \leq 4$	$r = 5$	0.0009	0.94
Panel B. Crisis Period			
$r = 0$	$r > 0$	0.0598	50.79
$r \leq 1$	$r > 1$	0.0314	28.35
$r \leq 2$	$r > 2$	0.0281	16.73
$r \leq 3$	$r > 3$	0.0161	6.35
$r \leq 4$	$r = 5$	0.0012	0.43
Panel C. Post-crisis Period			
$r = 0$	$r > 0$	0.0644	107.42**
$r \leq 1$	$r > 1$	0.0337	51.27*
$r \leq 2$	$r > 2$	0.0169	22.34
$r \leq 3$	$r > 3$	0.0089	8.01
$r \leq 4$	$r = 5$	0.0005	0.46

r denotes the maximum number of cointegrating equations.
* Significant at 5% level.
**Significant at 1% level.

Critical values (Osterwald-Lenum, 1992)

H_o	5%	1%
$r = 0$	68.52	76.07
$r \leq 1$	47.21	54.46
$r \leq 2$	29.68	35.65
$r \leq 3$	15.41	20.04
$r \leq 4$	3.76	6.65

4.6 Analyses of the Vector Autoregressive Model and the Error Correction Model

We next proceed to estimate the error correction models of lag one for the pre- and the post-crisis periods and the vector autoregressive model, also of lag one, for the crisis period. The outputs of these regression results are given in Table 4.6.

The long-run relationship is implied through the significance of the coefficient of the lagged error correction term (ECT). The coefficient represents the proportion of the long-run imbalance in the dependent variable that is being corrected in each period. In the pre-crisis period, the cointegrating equation is normalized on the Philippines (EViews arbitrarily normalized on the first r variables) and there are only two significant coefficients of the ECTs (attested by the t-test), each in the regression equations of the Philippines and Indonesia. The implication is that if there were any deviation from the long-term equilibrium, the adjustment to clear the disequilibrium would be mainly through the Philippines and the Indonesian markets. For those markets where the coefficients are not significant, causal effects could still be present through some active short-run channels.

The necessity to include the error correction terms stems from the need to recapture the long-run information lost through differencing the variables that enter the VAR. Since there is no evidence of long-term linkages among the five ASEAN markets during the crisis period, a VAR model would sufficiently espouse

Table 4.6
The Vector Autoregressive Model / Error Correction Model of the Philippines, Thailand, Indonesia, Malaysia and Singapore

Independent variable	Dependent variable				
	ΔP_{1t} (Philippines)	ΔP_{2t} (Thailand)	ΔP_{3t} (Indonesia)	ΔP_{4t} (Malaysia)	ΔP_{5t} (Singapore)
Panel A. ECM(1) for the Pre-crisis Period					
Constant	0.0007	0.0000	0.0006*	0.0006	0.0002
	(0.0004)	(0.0005)	(0.0003)	(0.0004)	(0.0003)
$\Delta P_{1,t-1}$	0.1279**	0.0681	0.0351	0.0315	0.0325
	(0.0311)	(0.0359)	(0.0200)	(0.0284)	(0.0217)
$\Delta P_{2,t-1}$	0.0715*	0.0325	0.0483*	0.0391	0.0206
	(0.0296)	(0.0341)	(0.0190)	(0.0270)	(0.0206)
$\Delta P_{3,t-1}$	0.0171	0.0218	0.2474**	-0.0361	-0.0323
	(0.0479)	(0.0553)	(0.0307)	(0.0437)	(0.0334)
$\Delta P_{4,t-1}$	0.0632	0.0069	0.0557*	0.1337**	0.1040**
	(0.0421)	(0.0485)	(0.0270)	(0.0384)	(0.0293)
$\Delta P_{5,t-1}$	0.0497	0.1483*	0.0303	0.0566	-0.0582
	(0.0541)	(0.0624)	(0.0347)	(0.0494)	(0.0377)
z_{t-1}	-0.0117**	-0.0011	-0.0073**	0.0037	-0.0007
	(0.0029)	(0.0034)	(0.0019)	(0.0027)	(0.0020)

Cointegrating equation (normalized on the returns of the Philippines):

$z_{t-1} = P_{1,t-1} + 0.6015P_{2,t-1} + 1.3254P_{3,t-1} - 2.3523P_{4,t-1} - 1.4112P_{5,t-1} + 4.7521$

Independent variable	ΔP_{1t} (Philippines)	ΔP_{2t} (Thailand)	ΔP_{3t} (Indonesia)	ΔP_{4t} (Malaysia)	ΔP_{5t} (Singapore)
Panel B. VAR(1) for the Crisis Period					
Constant	-0.0020	-0.0029	-0.0021	-0.0030	-0.0013
	(0.0013)	(0.0016)	(0.0015)	(0.0019)	(0.0010)
$\Delta P_{1,t-1}$	0.0016	-0.0944	0.0744	0.1153	0.1002*
	(0.0626)	(0.0763)	(0.0735)	(0.0948)	(0.0468)
$\Delta P_{2,t-1}$	0.0032	0.0445	-0.0095	-0.0059	-0.0337
	(0.0528)	(0.0644)	(0.0621)	(0.0800)	(0.0395)
$\Delta P_{3,t-1}$	0.1591**	0.1202	0.2363**	0.2391**	0.0754
	(0.0538)	(0.0656)	(0.0633)	(0.0815)	(0.0402)
$\Delta P_{4,t-1}$	0.0796	0.0032	0.0199	-0.0659	0.0270
	(0.0450)	(0.0549)	(0.0530)	(0.0682)	(0.0337)
$\Delta P_{5,t-1}$	0.0219	0.0111	-0.2539*	-0.2518	0.0083
	(0.0960)	(0.1171)	(0.1129)	(0.1455)	(0.0718)

Table 4.6 (continued)

Independent variable	Dependent variable				
	ΔP_{1t} (Philippines)	ΔP_{2t} (Thailand)	ΔP_{3t} (Indonesia)	ΔP_{4t} (Malaysia)	ΔP_{5t} (Singapore)
Panel C. ECM(1) for the Post-crisis Period					
Constant	-0.0002	0.0004	0.0004	0.0007	0.0004
	(0.0006)	(0.0007)	(0.0007)	(0.0005)	(0.0005)
$\Delta P_{1,t-1}$	0.0572	0.0642	-0.0299	-0.0002	-0.0114
	(0.0367)	(0.0449)	(0.0418)	(0.0336)	(0.0326)
$\Delta P_{2,t-1}$	0.0864*	0.0270	0.0882*	0.0066	0.0703*
	(0.0336)	(0.0410)	(0.0382)	(0.0307)	(0.0298)
$\Delta P_{3,t-1}$	0.0056	0.0444	0.1197**	0.0159	-0.0154
	(0.0326)	(0.0399)	(0.0372)	(0.0298)	(0.0289)
$\Delta P_{4,t-1}$	-0.0462	-0.0441	0.0274	0.0836*	-0.0093
	(0.0394)	(0.0482)	(0.0449)	(0.0360)	(0.0350)
$\Delta P_{5,t-1}$	0.1086*	0.1513**	0.0103	-0.0176	0.0262
	(0.0472)	(0.0577)	(0.0538)	(0.0431)	(0.0419)
$z_{1,t-1}$	-0.0102**	-0.0029	-0.0151**	-0.0142**	-0.0050*
	(0.0028)	(0.0034)	(0.0032)	(0.0026)	(0.0025)
$z_{2,t-1}$	0.0249*	-0.0045	0.0525**	0.0154*	0.0034
	(0.0078)	(0.0095)	(0.0089)	(0.0071)	(0.0069)

Cointegrating equations (normalized on the returns of the Philippines and Thailand):

$z_{1,t-1} = P_{1,t-1} - 2.4108P_{3,t-1} + 3.7692P_{4,t-1} - 1.4369P_{5,t-1} - 8.3660$

$z_{2,t-1} = P_{2,t-1} - 1.8403P_{3,t-1} + 0.8305P_{4,t-1} + 0.4838P_{5,t-1} - 2.9661$

* denotes significance at 5% level.
** denotes significance at 1% level.
Standard errors are given in parentheses.

the dynamics during this volatile period. In this study, we use the F-test to determine short-term causal effects during this period. This will be discussed in the next section.

In the post-crisis period, the two cointegrating relations are normalized on the Philippines and Thailand. With two cointegrating relationships, each regression equation of the ECM would have two ECTs. The t-test indicated that both the coefficients of the ECTs are significant in the regression equations of the Philippines, Indonesia and Malaysia. Only one is significant in Singapore and none in Thailand. These findings imply that when there is a deviation from the long-run relationship, all the markets, with the exception of Thailand, would make adjustment to return to the long-run equilibrium. Obviously, compared to the pre-crisis period, there are more of significant coefficients of the ECTs, which mean more markets are more likely to be involved in the adjustment towards any disequilibrium from the long-run relationships.

4.7 Granger Causal Relationships

We now examine the Granger-causal relationships among the ASEAN-5 equity markets during the three periods. This is done through the multivariate regression equations of the error correction model and the vector autoregressive model. The joint F-test is used to test the null hypothesis of an ASEAN market not Granger-causing another ASEAN market.

The ordering of the markets that enter the error correction model or the vector autoregressive model does not affect the magnitude as well as the statistical significance of the coefficients of the $R_{i,t-1}$ in the regression equations (see Equations (3.14) and (3.16)). However, EViews automatically normalized the error correction terms on the first r markets that enter the model if there are *r* cointegrating relations. This means that changing the first *r* markets in the model would alter the normalized cointegrating coefficients.

With regard to the multivariate Granger-causality test in this study, a rather interesting discovery arose when several different orderings of the markets were used in the estimation of the error correction models for the pre- and post-crisis periods and the vector autoregressive model for the crisis period. The results of the F-test are consistently the same for the pre-crisis period and the crisis period, regardless of the ordering of the markets entered. However, this is not true for results pertaining to the post-crisis period. There are two cointegrating relations in the post-crisis period and we found that changing the first two markets resulted in different sets of F-statistics. The significance of the F-statistics changed, although not drastically. This would mean that the results of the Granger-causality test are not unique for this period if arbitrary choice of normalization of variables is used.

This is due to the changing of the two ECTs each time when the two cointegrating equations are normalized on different markets. Specifically, in this study where the first two markets entered are those of the Philippines and Thailand, the first normalized cointegrating equation (see Table 4.6, Panel C) does not include the lagged returns of Thailand as one of its explanatory variables while the second equation does not include that of the Philippines. A change in the first two markets entered would change the composition of the variables in the two normalized cointegrating equations and this would mean a change in the coefficients of the ECTs being tested in the null hypothesis. In contrast, there is only one cointegrating equation in the pre-crisis period. No matter which market is chosen to be normalized on, the lagged returns of all the five markets are included in this equation. Thus, the coefficient of the ECT is associated with all the five markets. This means in the F-test, the joint null hypothesis will consistently include a testing of the coefficient of the ECT being equal to zero.

In order to circumvent the problem when there is more than one cointegrating equation, we use the unnormalised cointegrating coefficients to regenerate another set of two ECTs. This set of ECTs is then used to re-estimate the regression equations of the error correction model in the post-crisis period. The two cointegrating equations now involve the lagged indices of all the five markets and this renders the F-statistics independent of the choice of normalization. The Granger-causality test results are now unique. The F-statistics for the three periods are reported in Table 4.7.

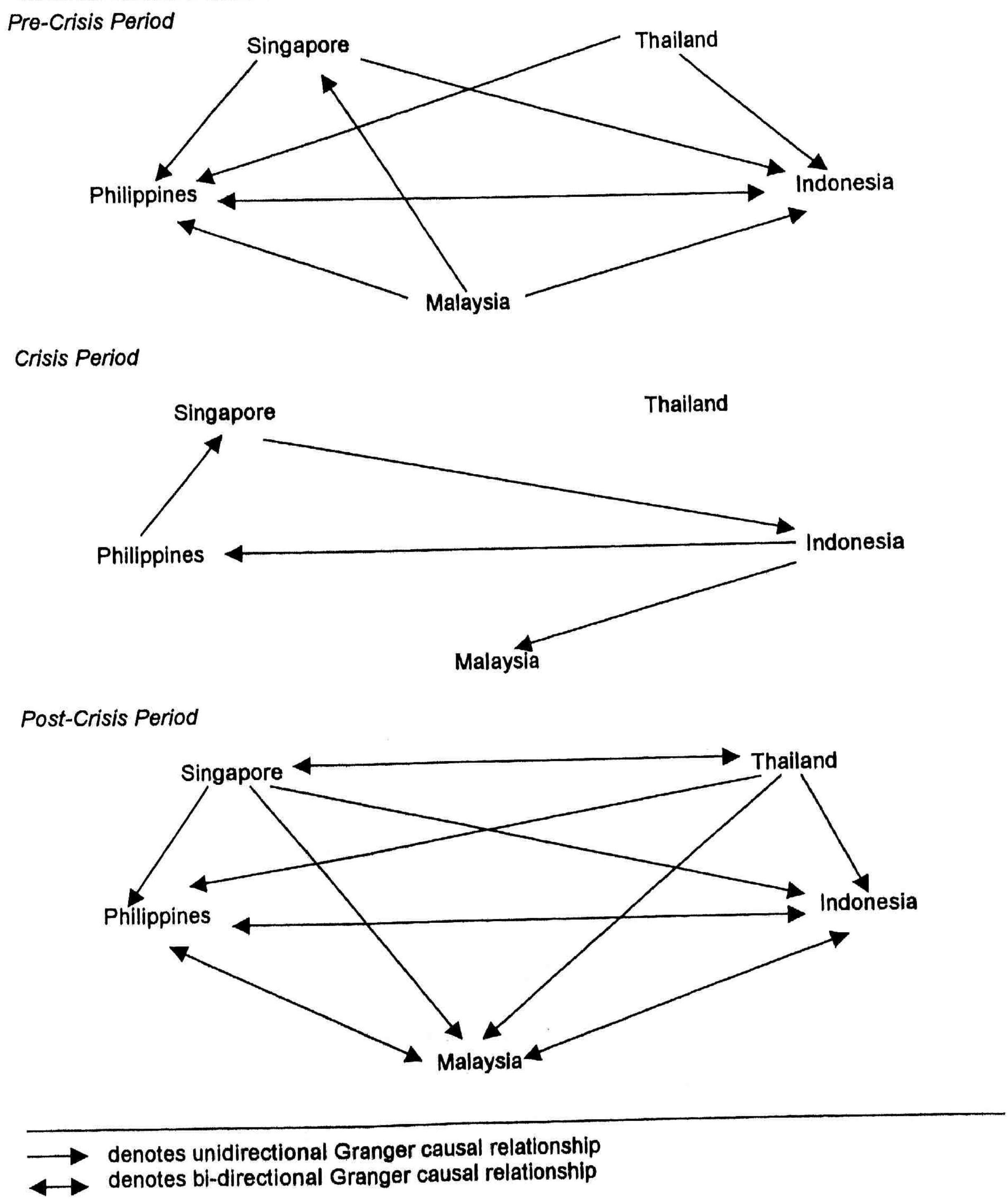
Table 4.7
F-statistics of the Granger Causality Test among the Five ASEAN Equity Markets

Dependent variable	Independent variable				
	Singapore	Malaysia	Indonesia	Thailand	Philippines
Panel A. Pre-crisis Period					
Singapore	-	6.5206** (0.002)	0.5094 (0.601)	0.5441 (0.581)	1.1971 (0.302)
Malaysia	1.5027 (0.223)	-	1.3895 (0.250)	2.1410 (0.118)	1.5405 (0.215)
Indonesia	8.3625** (0.000)	10.6007** (0.000)	-	10.3395** (0.000)	9.3837** (0.000)
Thailand	2.9554 (0.052)	0.0680 (0.934)	0.1398 (0.870)	-	1.8701 (0.155)
Philippines	8.7291** (0.000)	9.7043** (0.000)	8.1516** (0.000)	10.3515* (0.000)	-
Panel B. Crisis Period					
Singapore	-	0.6414 (0.424)	3.5081 (0.062)	0.7275 (0.394)	4.5896* (0.033)
Malaysia	2.9956 (0.084)	-	8.6007** (0.004)	0.0054 (0.942)	1.4804 (0.225)
Indonesia	5.0601* (0.025)	0.1407 (0.708)	-	0.0236 (0.878)	1.0246 (0.312)
Thailand	0.0090 (0.924)	0.0033 (0.954)	3.3531 (0.068)	-	1.5315 (0.217)
Philippines	0.0518 (0.820)	3.1255 (0.078)	8.7400** (0.003)	0.0036 (0.952)	-
Panel C. Post-crisis Period					
Singapore	-	2.0167 (0.110)	2.0096 (0.111)	4.0621** (0.007)	2.0269 (0.109)
Malaysia	12.5790** (0.000)	-	13.0546** (0.000)	12.6960** (0.000)	12.5734** (0.000)
Indonesia	12.0094** (0.000)	12.0013** (0.000)	-	15.3844** (0.000)	11.8328** (0.000)
Thailand	3.5045* (0.015)	1.3494 (0.257)	1.7192 (0.161)	-	1.7022 (0.165)
Philippines	7.1312** (0.000)	5.0247** (0.002)	4.6378** (0.003)	7.8893** (0.000)	-

* denotes 5% significance level.
** denotes 1% significance level.
The p values are given in parentheses.

The Granger causality results are also graphically depicted in Figure 4.1. An arrow represents a significant causal relationship.

Figure 4.1
Granger Causal Relationships among the ASEAN-5 Equity Markets in the Pre-crisis, Crisis and Post-crisis Periods



In the pre-crisis period, Malaysia leads all the ASEAN markets except the Thai market. The Singapore leads the Indonesian and the Philippine markets. Similarly, the Thai market also leads these two markets. The Philippine and the Indonesian markets do not Granger-cause the returns in any other markets, except for the feedback between them. This could be due to their much lower market capitalization (see Appendix 2). The Singapore market is led only by the bigger Malaysian market. Based on the highly significant F-statistics, the Malaysian market seems to be a dominant leader.

The crisis period shows up fewer causal relationships. The Malaysian market has lost its leading position. A feedback between the Philippines and Indonesia is now changed to a unidirectional relationship from Indonesia to the Philippines. The directions of causality between Singapore and Philippines and between Indonesia and Malaysia are now reversed. No causal relationship is found between the Thai market and the other ASEAN markets. During this period of high volatility, the common perception of a bigger market leading a smaller one is probably no longer applicable. The conventional explanations that are used to account for movements during the time of tranquil market conditions do not seem to hold true here. Each market appears to 'run' independently of the others with no particular regard to the size of the markets.

In the post-crisis period, there is a substantial increase in the number of unidirectional and bi-directional causal relationships. The Singapore and the Thai markets seem to have taken over the dominant role. Besides a feedback between them, they each Granger-cause the other three markets. These three markets of Malaysia, Indonesia and the Philippines, in turn, have feedbacks between any two of them. The imposition of capital controls in an attempt to buffer the aftermath of the Asian financial crisis could be the reason for the lost dominant role of the Malaysian market. Rather surprisingly, the results reveal that the Malaysian market has assumed the role of a 'follower' in the post-crisis period.

The results in Table 4.7 show that most of the F-statistics are highly significant. This means that most of the causal relationships reported above for the three periods are very strong. Superficially, there seems to be a link between the number of causal relationships and the presence of long-term cointegrating relation(s) in a particular period. Comparing the pre- and the post-crisis periods, there are more causal relationships in the post-crisis period, a period whereby the markets are sharing two cointegrating equations as compared to only one in the pre-crisis period. The absence of long-run equilibrium relationship during the crisis period is coincidentally associated with few causal relationships.

The findings of this study are similar to those of Jang and Sul (2002) in that co-movements among the seven Asian stock markets of Korea, Japan, Hong Kong, Taiwan, Thailand, Indonesia and Singapore have increased remarkably after the financial crisis. A contradictory result is, however, found in the crisis period. Jang and Sul (2002) showed that there is an increase in co-movement as opposed to a decrease in this study. This could be attributed to the different set of markets studied and the different duration of the crisis period defined by them.

4.8 Findings of the Variance Decomposition and Impulse Response Analyses

As mentioned earlier, the study on the mechanism of international transmission of stock market movements can be espoused through the variance decomposition and impulse response analyses. The forecast error variance of each ASEAN equity market is allocated to sources via orthogonalized innovations. With this technique, we can trace out the dynamic responses of each of the five markets to innovations in a particular market by using the simulated responses of the estimated VAR system. In this study, we rank the markets in a decreasing order based on their average end-of-year total market capitalization for the years 1992 to 2002 (see Appendix I). Thus, the orthogonalization is ordered as Malaysia, Singapore, Thailand, the Philippines and Indonesia.

Table 4.8 reports the decomposition of 1-day, 3-day and 5-day ahead forecast error variance of stock returns of each ASEAN-5 market into fractions (in terms of percentages) that are accounted for by innovations in the market itself and each of the other ASEAN-4 markets. The stock movements of a dominant equity market should affect the subsequent stock movements in other markets, but conversely, the movements of the other markets would have very little effect on it, particularly at the initial periods after the shock. In other words, the forecast errors of future returns of this dominant market should be accounted for mostly by its own innovations and not be explained by the innovations of the other markets.

By putting the Malaysian stock market first in the ordering of the orthogonalization procedure has actually a priori set the Malaysian stock market as the most dominant market within each of the three periods. Therefore, not surprisingly, the percentages of variance attributed to the Malaysian market itself are more than 99% in the pre-crisis and post-crisis periods. Even during the crisis period, it is more than 96%. The point to stress here is that any inference based on the absolute values of the percentages would not be accurate as the process of orthogonalization has an implied direction of causation, particularly when the markets are strongly correlated contemporaneously. This suggests that the results here are not suitable for studying the causal relationships. Nonetheless, the variance decomposition analysis is still useful for comparing relative changes across the three periods by keeping the same ordering.

Generally, the percentage of forecast variance in any market due to innovations in itself or any other market decreases as the horizon (in days) lengthens. These percentages converge at the five-day horizon. The most striking observation shows up in the forecast variance of Singapore. The percentage of forecast variance that is explained by one standard deviation of shock in Malaysia varies from a relatively high 33% in the pre-crisis period to about 35% in the crisis period, and then drops drastically to about 10% in the post-crisis period. The high percentages in the first two periods could be attributed to the fact that the Singapore and Malaysian stock markets were closely linked through CLOB, an over-the-counter market in Singapore that dealt mainly in Malaysian securities. The closure of CLOB in Singapore and the imposition of capital controls in Malaysia at the beginning of the post-crisis period lessened considerably the link between these markets. The decrease in the impact of the Malaysian market on the Singapore market in the post-crisis period is also consistent with the findings from the Granger causality test that the Singaporean market has assumed a more dominant role after the financial crisis, as compared to the Malaysian market. As for each of the other three equity markets, the percentage of forecast variance due to a shock in the Malaysian market also exhibits this general pattern of increase during the crisis period and then a pattern of substantial decrease in the post-crisis period. The findings here complement the earlier results that show lower contemporaneous correlations between the Malaysian market and the other four markets in the post-crisis period.

However, the percentages of forecast variance due to a shock in Singapore display a less consistent pattern. At the 5-day horizon, the forecast variance in Thailand increases mildly from 3.54% in the pre-crisis period to 4.35% in the crisis period and then sharply to 18.99% in the post-crisis period. As for Indonesia, a similar pattern is found, though the magnitude of increase in the post-crisis period is only about 2%. The Philippine market, however, records a sharp increase from 1.69% in the pre-crisis period to 11.32% in the crisis period and then a slight decrease to 10.44% in the post-crisis period.

In the last column of Table 4.8, we report the percentage of forecast error variance of each ASEAN market in the first column explained collectively by the other four ASEAN markets. These figures indicate the total 'foreign' influence on each market. Comparing across the three periods, the proportion of the forecast error variance of each ASEAN stock market that is attributable to shocks from the other four ASEAN markets is the highest during the crisis period. For instance, at the 5-day horizon, the collective percentages of the Philippines are 10.04%, 35.55% and 17.62% for the pre-crisis, crisis and post-crisis periods, respectively.

Table 4.8
Variance Decomposition at 1-day, 3-day and 5-day Horizons

		% of forecast variance explained by one S.D. of innovations in					
Relative variance in	Horizon (day)	Malaysia	Singapore	Thailand	Philippines	Indonesia	Foreign
Panel A. Pre-crisis Period							
Malaysia	1	100.00	0.00	0.00	0.00	0.00	0.00
	3	99.45	0.16	0.23	0.08	0.08	0.55
	5	99.45	0.16	0.23	0.08	0.08	0.55
Singapore	1	32.53	67.47	0.00	0.00	0.00	32.53
	3	33.33	66.32	0.11	0.17	0.08	33.68
	5	33.33	66.32	0.11	0.17	0.08	33.68
Thailand	1	16.40	2.83	80.77	0.00	0.00	19.23
	3	16.87	3.54	79.20	0.37	0.01	20.80
	5	16.87	3.54	79.20	0.37	0.01	20.80
Philippines	1	3.94	1.27	1.32	93.45	0.00	6.55
	3	6.35	1.69	1.94	89.98	0.03	10.02
	5	6.37	1.69	1.95	89.96	0.03	10.04
Indonesia	1	8.84	2.04	1.06	2.95	85.11	14.89
	3	13.29	2.62	1.98	3.56	78.56	21.44
	5	13.37	2.63	1.99	3.57	78.44	21.56
Panel B. Crisis Period							
Malaysia	1	100.00	0.00	0.00	0.00	0.00	0.00
	3	96.71	0.06	0.23	0.69	2.31	3.29
	5	96.70	0.06	0.23	0.69	2.31	3.30
Singapore	1	35.28	64.72	0.00	0.00	0.00	35.28
	3	35.36	61.98	0.01	1.53	1.12	38.02
	5	35.35	61.97	0.02	1.53	1.14	38.03
Thailand	1	23.78	4.37	71.85	0.00	0.00	28.15
	3	23.61	4.35	70.85	0.26	0.92	29.15
	5	23.61	4.35	70.85	0.26	0.92	29.15
Philippines	1	15.37	11.76	3.35	69.53	0.00	30.47
	3	18.45	11.32	3.29	64.46	2.49	35.54
	5	18.44	11.32	3.29	64.45	2.51	35.55
Indonesia	1	18.52	8.24	4.29	1.27	67.67	32.33
	3	17.83	8.03	4.35	1.81	67.99	32.01
	5	17.83	8.03	4.35	1.81	67.98	32.02

Table 4.8 (continued)

Relative variance in	Horizon (day)	Malaysia	Singapore	Thailand	Philippines	Indonesia	Foreign
		% of forecast variance explained by one S.D. of innovations in					
Panel C. Post-crisis Period							
Malaysia	1	100.00	0.00	0.00	0.00	0.00	0.00
	3	99.61	0.12	0.09	0.01	0.17	0.39
	5	99.61	0.12	0.09	0.01	0.17	0.39
Singapore	1	9.92	90.08	0.00	0.00	0.00	9.92
	5	9.86	89.42	0.70	0.02	0.01	10.58
	10	9.86	89.42	0.70	0.02	0.01	10.58
Thailand	1	7.34	17.33	75.34	0.00	0.00	24.66
	3	7.20	18.99	73.29	0.29	0.23	26.71
	5	7.20	18.99	73.29	0.29	0.23	26.71
Philippines	1	3.44	7.61	2.42	86.52	0.00	13.38
	3	3.45	10.44	3.72	82.39	0.01	17.61
	5	3.45	10.44	3.72	82.38	0.01	17.62
Indonesia	1	3.78	9.02	2.54	1.47	83.19	16.81
	3	4.43	9.93	4.03	1.41	80.20	19.80
	5	4.43	9.93	4.03	1.41	80.19	19.81

S.D denotes standard deviation.
Each entry in the last column of the table denotes the percentage of forecast error variance of the market in the column explained collectively by the other four 'foreign' markets in the row.
The percentage of forecast variance explained by one standard deviation of innovations in each market converges by day 5.
Ordering: Malaysia, Singapore, Thailand, Philippines, Indonesia

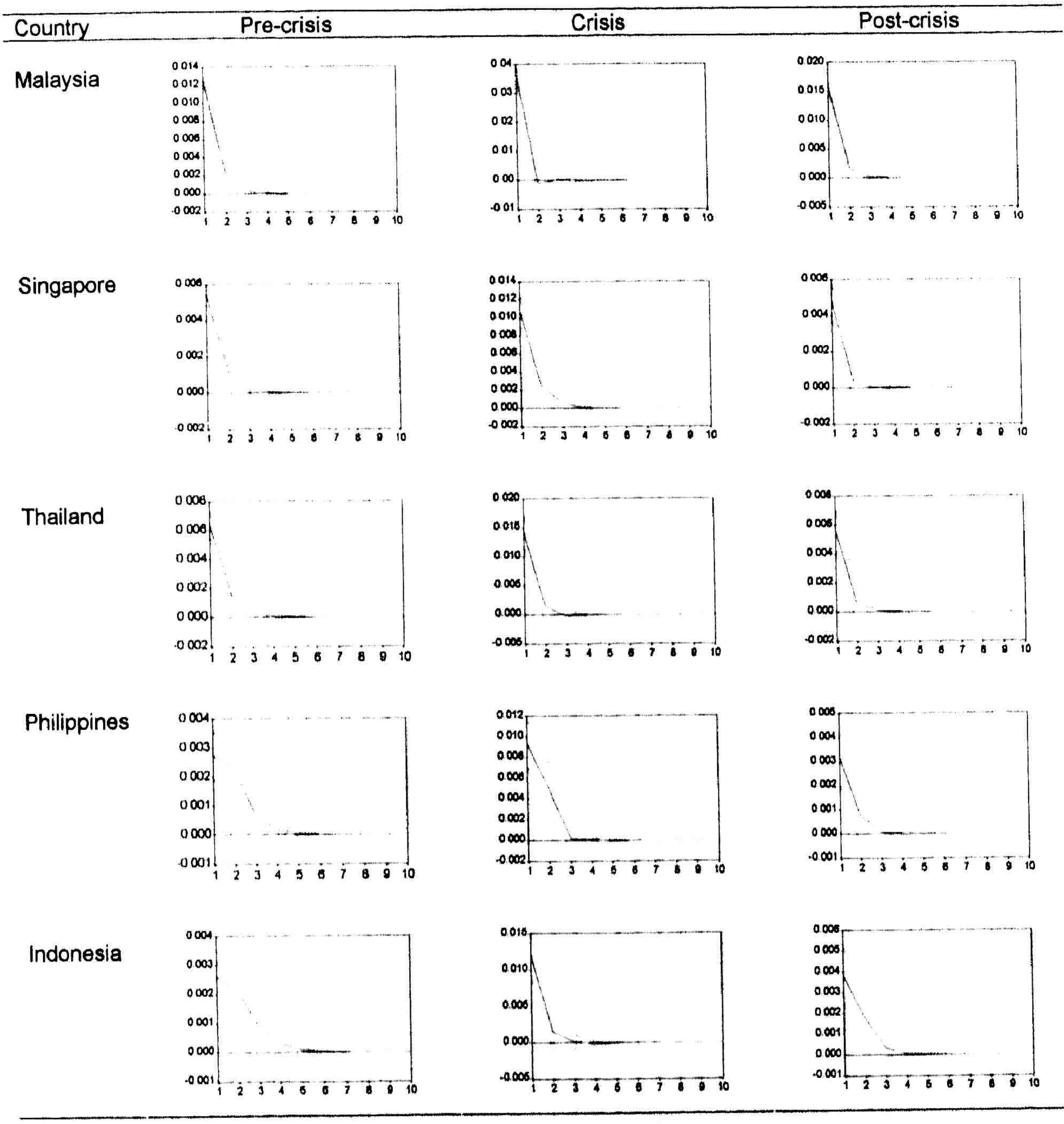
Given the increasing dominant role of the Singapore market in the post-crisis period, it is seen that the foreign influence on this market has reduced significantly.

Through the impulse response analysis, we can examine the time span in which one standard deviation of shock in one market would take to exert an impact on the other markets. Figures 4.2 to 4.6 show the time paths of impulse responses to one standard deviation of innovations in each of the five ASEAN markets of Malaysia, Singapore, Thailand, the Philippines and Indonesia, respectively. There seems to be an overall increase in the magnitude of responses of all the markets to shocks during the crisis period and this shows a greater sensitivity of each market to movements in the other markets. Moreover, this complements the earlier findings of stronger contemporaneous movements between the markets during the crisis period.

The responses also tend to be mostly short-lived during the crisis period (generally a duration of three days). The short-term nature of the responses supports the results of the cointegration test that there is no long-term equilibrium relationship in the crisis period. As for the other two periods, the time span for the response to fade completely is slightly longer, about five days. Such generally short time spans are to be expected. Considering the close geographical proximity and strong trade ties, we would expect rapid and efficient propagation of information or news from one country to another. Thus, the impact takes effect rather quickly and the response is not sluggish.

A close examination of the diagrams in Figures 4.2 to 4.6 also reveals the following pattern. For all the three periods, all the markets respond immediately to a shock in Malaysia. Nevertheless, a shock in Singapore would only elicit a response from Malaysia on the second day. Similarly, Malaysia and Singapore respond to Thailand only on the second day. For the Philippines, all the three bigger markets of Malaysia, Singapore and Thailand do not respond to it immediately on the first day. In a similar fashion, a shock in the smallest market of Indonesia would draw a response from the other four markets only on the second day. The responses of the Philippines and Indonesia to a shock in Thailand take about five days to fade completely in all three periods.

Figure 4.2
Time Paths of Impulse Responses of ASEAN Markets to One Standard Deviation of Innovations in Malaysia

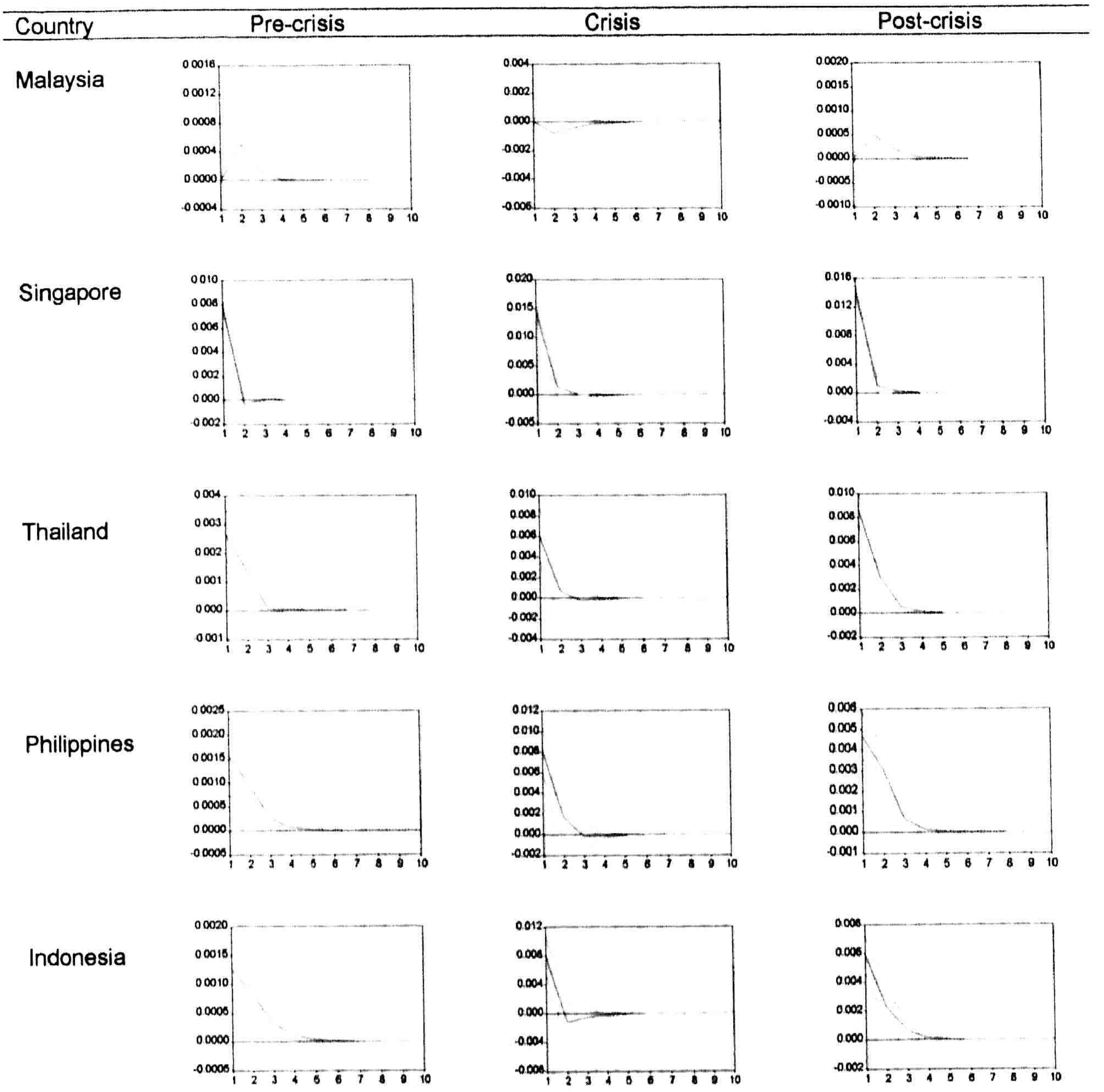


Ordering: Malaysia, Singapore, Thailand, Philippines, Indonesia

The blue line represents the time path of the impulse response.

The red dotted lines represent the 95% confidence band based on the asymptotic standard error.

Figure 4.3
Time Paths of Impulse Responses of ASEAN Markets to One Standard Deviation of Innovations in Singapore

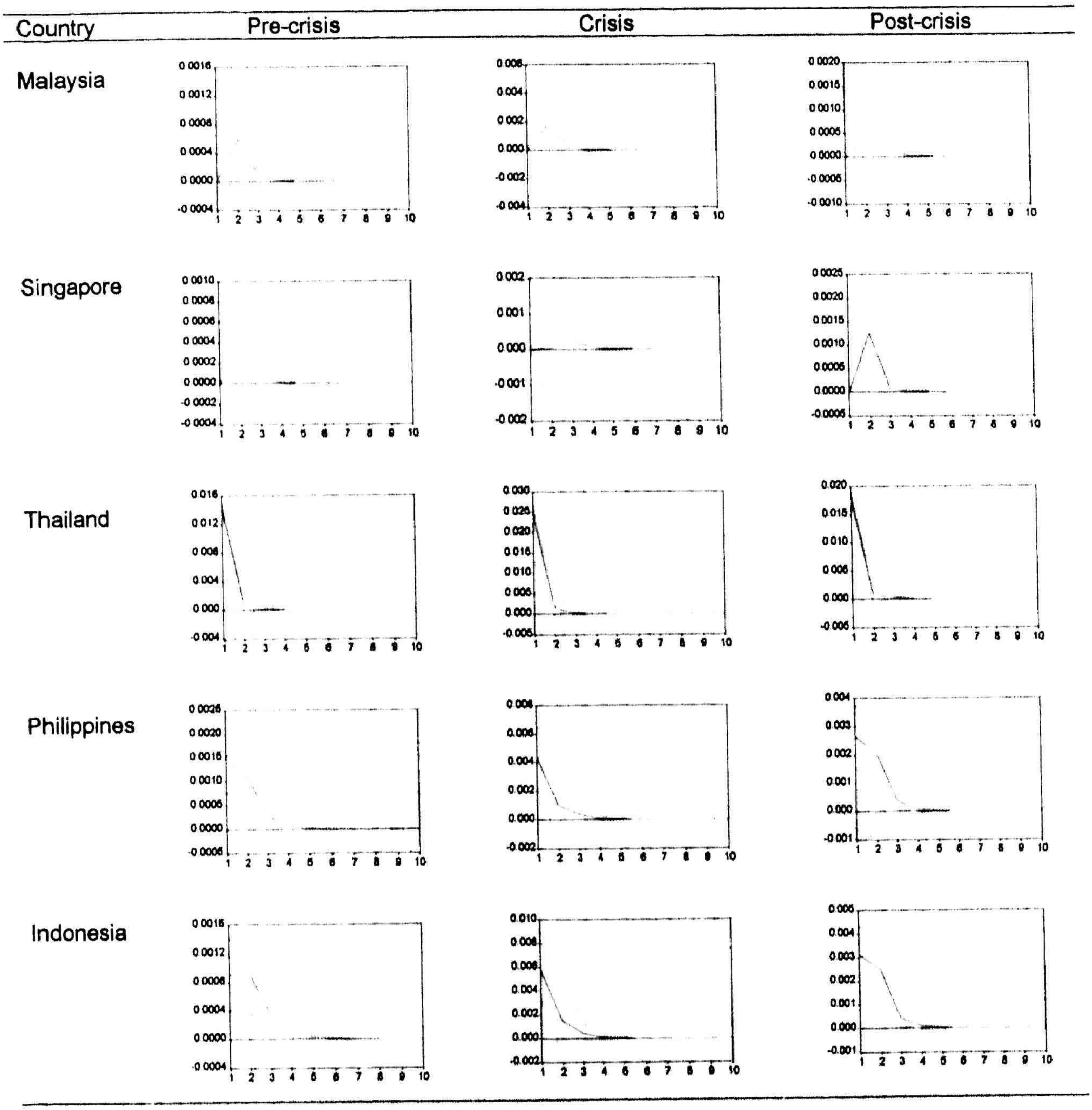


Ordering: Malaysia, Singapore, Thailand, Philippines, Indonesia

The blue line represents the time path of the impulse response.

The red dotted lines represent the 95% confidence band based on the asymptotic standard error.

Figure 4.4
Time Paths of Impulse Responses of ASEAN Markets to One Standard Deviation of Innovations in Thailand

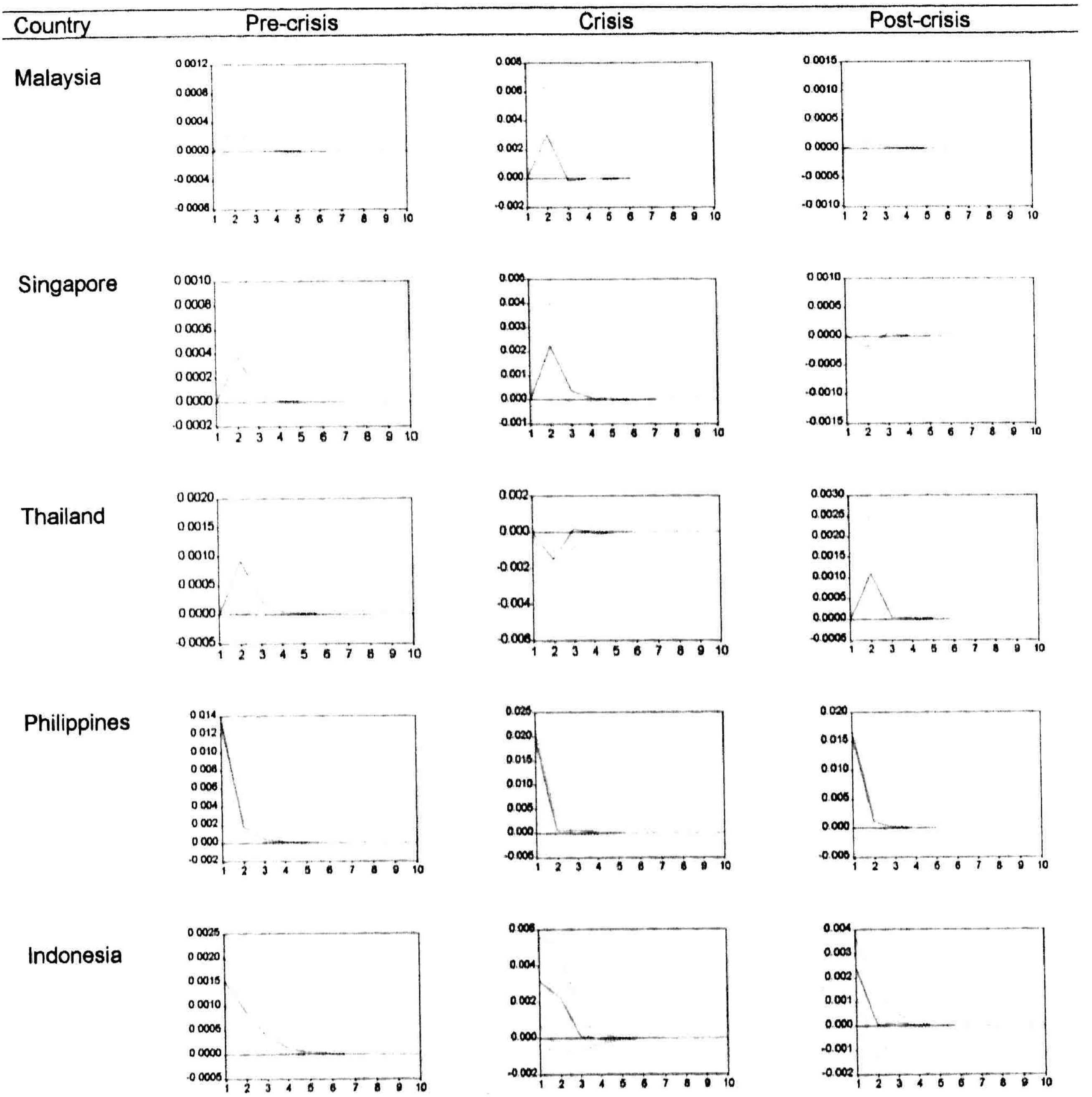


Ordering: Malaysia, Singapore, Thailand, Philippines, Indonesia

The blue line represents the time path of the impulse response.

The red dotted lines represent the 95% confidence band based on the asymptotic standard error.

Figure 4.5
Time Paths of Impulse Responses of ASEAN Markets to One Standard Deviation of Innovations to Philippines

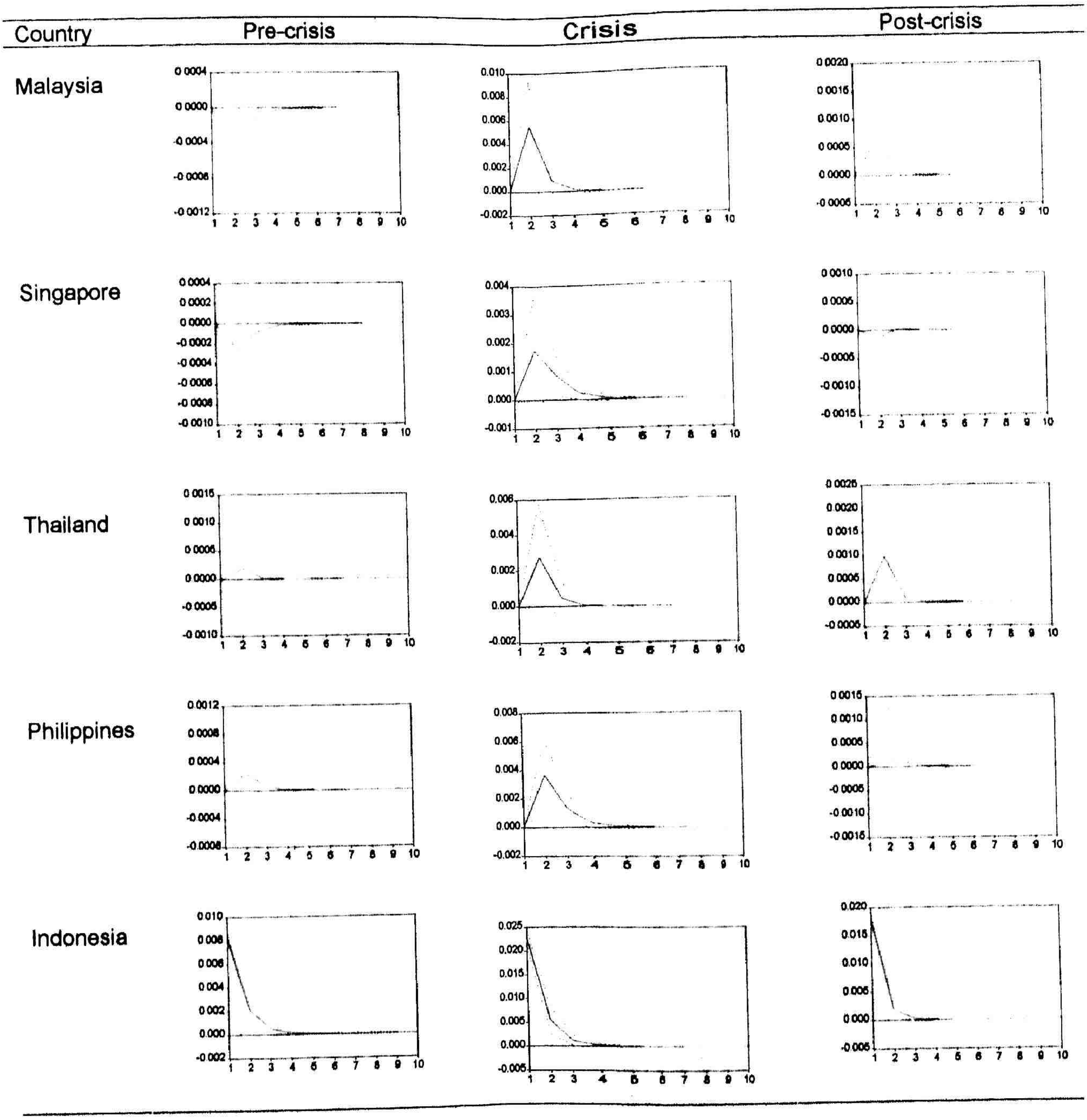


Ordering: Malaysia, Singapore, Thailand, Philippines, Indonesia

The blue line represents the time path of the impulse response.

The red dotted lines represent the 95% confidence band based on the asymptotic standard error.

Figure 4.6
Time Paths of Impulse Responses of ASEAN Markets to One Standard Deviation of Innovations in Indonesia



Ordering: Malaysia, Singapore, Thailand, Philippines, Indonesia
The blue line represents the time path of the impulse response.
The red dotted lines represent the 95% confidence band based on the asymptotic standard error.