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THE INFLUENCE OF INTERNATIONAL STOCK MARKETS AND MACROECONOMIC VARIABLES ON THE THAI STOCK MARKET

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Abstract
The paper examines the impact of several stock market price indices and macroeconomic variables on the Thai stock market, using a GARCH-M model and monthly data (1988M1-2004M12). We find that (a) changes in returns in Singapore, Malaysia and Indonesia before the 1997 crisis, and changes in Singapore, the Philippines and Korea after 1997 instantaneously influenced returns in the Thai stock market; (b) changes in oil prices negatively impacted on it only prior to 1997; (c) volatility clustering and a GARCH-M model were present only before 1997; and (d) markets outside the region had no immediate impact on the Thai market.

JEL Classification: E44, G14, G15
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1. Introduction

Stock market volatility appears now to move rapidly across countries. This has been possibly affected by the liberalization of capital markets in the past two decades. A clearer understanding of stock market determinants is very important for investors, regulators and academic researchers. Therefore, increased knowledge of stock market determinants is necessary in the settlement of pricing, hedging and regulatory policy.

A number of analysts have investigated the impact of macroeconomic variables and international linkages on stock returns. Most of these studies, however, have focused on developed markets by using the Autoregressive Conditional Heteroscedasticity (ARCH) model and the Generalized ARCH (GARCH) model. For instance, Schwert (1989) and Flannery and Protopapadakis (2002) tested the effect of domestic macroeconomic variables on stock volatility for the United States. They found weak evidence that such factors could predict stock market returns which are inherently volatile.

Moreover, Hamao, Masulis and Ng (1990), Bae and Karolyi (1994) and Susmel and Engle (1994) focused on the international spillover of stock return volatility between Japan, the United Kingdom and the United States and found some evidence of volatility spillovers between these markets. In addition, the effect of foreign stock markets and macroeconomic news on the Australian stock market were further investigated by Kim and In (2002). The results indicated that the movements of the major stock markets (namely Japan, the United Kingdom and the United States) and some macroeconomic news significantly influence the Australian stock market.

Other studies have examined the impact of macroeconomic variables and international linkages on the Thai stock market. Granger, Huang and Yang (2000) and Phylaktis and Ravazzolo (2005b) employed a cointegration model. Fang (2002) and Caporale, Pittis and Spagnolo (2002) used a GARCH model to analyse the relationship between stock returns and various exchange rates. Most studies find that the exchange rate leads stock returns, positively, in Thailand.

In addition, Liu, Pan and Fung (1996) and Liu, Pan and Shieh (1998) used vector autoregressive analysis and cointegration models to investigate the international linkages between the stock markets of the United States and Asia-Pacific countries. The results indicated that the United States market influenced the conditional volatility of most Asian markets. Japan and Singapore had a significant and persistent impact on other Asian markets. On the other hand, Ng (2002), Baharumshah, Sarmidi and Tan (2003) and Phylaktis and Ravazzolo (2005a) reported no evidence to indicate that the international linkages among the South-East Asian stock markets was significant. In, Kim, Yoon and Viney (2001), however, used a GARCH model and found a significant volatility linkage between Korea and Thailand. Hence there is no consensus on the nature of these relationships.

In the 1990s, most stock markets in Asia experienced considerable growth and turbulence. This process resulted in a profound change in Thailand's economy. The Stock Exchange of Thailand (SET) significantly influences Thai economic development by providing a mechanism for resource re-allocation between different sectors of the Thai economy. As a rapidly developing emerging market the SET also plays an important role in a worldwide context by affecting international capital flows. The experience of the Thai stock market is probably typical of Asian stock markets in general because of its manageable size and diverse characteristics (Bos, Ding and Fetherston, 1998; Chusanachoti and Kamath, 2002). An understanding of the mechanisms of the Thai stock market's dynamics is, therefore, very important.

This is the first study to investigate the impact of international linkages and macroeconomic variables on the Thai stock market using a GARCH model. The primary objective is to examine the impact of international stock markets and domestic macroeconomic variables on the Thai stock market price return, in the pre- and post-1997 Asian crisis period, by applying various GARCH models. The main reason to use GARCH pertains to the fact that the variance of forecast errors depends on the size of the preceding disturbances. A generalized form of the conditional heteroscedasticity allows for lagged variances and further lagged values of the error term. Consequently, it is naturally expected that the GARCH model is an efficient way to deal with volatility clustering observed in residuals which usually occur in stock price data.

The remainder of this paper is organized as follows. The next section describes the data employed and presents the summary statistics as well as the unit root test results. The third section briefly discusses the GARCH models from a theoretical perspective in identifying the major determinants of Thai stock price variations. The fourth section presents various estimates of a model capturing the volatility of stock price returns. The penultimate section discusses the major findings and implications arising from this study. Finally, the last section provides some brief concluding remarks.

2. Data and Empirical Methodology

This study uses the stock price index of Thailand (TH) which is based on market capitalization, and calculated from the prices of all common stock on the market board. Moreover, we utilise fifteen other international stock price indices from various regions, including the following countries: Argentina (AR), Australia (AU), Brazil (BA), Germany (GE), Hong Kong (HK), Indonesia (IN), Japan (JA), Korea (KO), Malaysia (MA), the Philippines (PH), Russia (RU), Singapore (SG), Taiwan (TA), the United Kingdom (UK) and the United States (US). Monthly data are used covering the period January 1988 to December 2004 with a base value of 100 in December 1987, except for the stock price index of Russia covering the period December 1994 to December 2004 which has a base value of 100 in December 1994. This different base year has been modified accordingly. All stock indices were obtained from Morgan Stanley Capital International (MSCI: http://www.msci.com/equity/index2.html).

In addition, the macroeconomic variables selected for Thailand include the consumer price index (CPI), the exchange rate (EX), the interest rate (on money) (MR), the money supply (M2) and oil price (OP) and were obtained from the International Financial Statistics (IFS: http://ifs.apdi.net/imf/logon.aspx) database (these five macroeconomic variables will be included in Equation (1) in the next section). All variables used are monthly observations spanning the time period from January 1988 to December 2004 and are expressed in terms of growth rates.

Figures 1 and 2 present the graphs of the variables employed in this study. We present the full data in graphical form separating the pre-Asian crisis period (*i.e*. from January 1988 to December 1997 totaling 120 monthly observations) from the post-Asian crisis period (*i.e.* from January 1998 to December 2004 using 84 monthly observations). The post-1997 period is shown by the shaded areas in Figures 1 and 2.

[Figure 1, Figure 2 and Table 1 about here]

Table 1 presents the descriptive statistics of the data. Sample means, medians, maximums, minimums, standard deviations, skewness, kurtosis as well as the Jarque-Bera statistics and *p*-values are presented. The highest mean return is 0.013 per cent in Russia and the lowest is -0.001 per cent in Japan. The standard deviations range from 0.010 per cent (the least volatile) for the growth rate of the money supply to 0.232 per cent (the most volatile) for the growth of the interest rate. The standard deviations of stock price indices are lowest in the developed economies of the US, UK, Australia, Germany, Japan and Singapore, while, on the other hand, the most volatile are in Russia, Brazil, Argentina, Indonesia, Thailand and Taiwan, respectively. All stock returns have excess kurtosis which means that they have a thicker tail and a higher peak than a normal distribution. The calculated Jarque-Bera statistic and corresponding *p*-value is used to test the null hypothesis that the monthly data follow a normal distribution. Most of the Jarque-Bera statistics and *p*-values reject the normality assumption at any conventional level of significance for all 21 variables, with the only exceptions being the monthly stock returns in Australia, Japan and the United Kingdom.

Figures 3 and 4 show the plots of the stock returns and the monthly growth rates of a number of relevant macroeconomic variables for Thailand. In order to make robust conclusions about the time series properties of the data this study uses the Augmented Dickey-Fuller (ADF) test and the DF-GLS test introduced by Dickey and Fuller (1979) and Elliott, Rothenberg and Stock (1996), respectively. In this paper the lowest value of the Schwarz Criterion (SC) is used to determine the optimal lag length in the testing procedure. These lags augment the relevant regressions to ensure the error term is white noise and free of any serial correlation. Based on the results of the unit root tests presented in Table 2, we conclude that all 21 variables employed in this paper are I(1), as they were non-stationary in levels but stationary in first difference form.

[Figure 3, Figure 4 and Table 2 about here]

3. An Application of the GARCH Model

As discussed earlier, we have segmented the sample period into the pre- and post-1997 Asian crisis. Initially, the following equation was estimated by the OLS method for the two periods separately:

$$\Delta \ln P_t^{TH} = \omega + \sum_{i=1}^{k_1=15} \theta_i \Delta \ln P_t^i + \sum_{i=1}^{k_2=5} \eta_i \Delta \ln M_t^i + u_t \tag{1}$$

However, in the pre-1997 period the estimated correlogram of squared residuals of such a model exhibited significant Autoregressive Conditional Heteroscedasticity (ARCH) effects (see Figure 5). In order, therefore, to capture any possible ARCH and Generalized ARCH (GARCH) effects, we specified a GARCH-in-mean (GARCH-M) in this paper. The GARCH model was developed by Bollerslev (1986) from the ARCH model previously introduced by Engle (1982). Both models establish the patterns of time varying volatility in returns. For a detailed account of these models see *e.g.* Bollerslev, Chou and Kroner (1992) and Pagan (1996). The GARCH-M (Bollerslev, 1986; Engle, Lilien and Robins, 1987) specification provides the forecast variance to vary over time and lag values to be included in the variance equation, which is a convenient and robust measure since it connects conditional volatility to the stock price returns in the following manner:

$$\Delta \ln P_t^{TH} = \omega + \sum_{i=1}^{k_1=15} \theta_i \Delta \ln P_t^i + \sum_{i=1}^{k_2=5} \eta_i \Delta \ln M_t^i + \gamma \sqrt{h_t} + u_t \tag{2}$$

$$u_t = \varepsilon_t \left(\alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} \right)^{1/2} \tag{3}$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} \tag{4}$$

where P_t^{TH} P_t^i and M_t^i denote the value of the Thai stock index, the 15 international stock indices (as outlined in the previous section) and the five macroeconomic variables, respectively. Moreover, ω and α_0 are the corresponding intercept terms in the mean and variance equations, respectively, θ_i shows the instantaneous responsiveness of the Thai stock returns to the i^{th} international stock returns, η_i shows the responsiveness of the Thai stock returns to the i^{th} macroeconomic variables, the estimated coefficient γ is referred to as a measure of the risk-return tradeoff in financial econometrics. In this paper this term indicates that the conditional mean of $\Delta \ln P_t^{TH}$ depends on the conditional standard deviation obtained from Equation (4), h_t is the conditional variance which is dependent on lagged values of squared errors and lagged values of the conditional variance, α_i and β_j are the ARCH and GARCH coefficients, respectively, q is the order of the moving average ARCH term, p is the order of the autoregressive GARCH term. These types of models are usually employed in financial econometrics to test the effect of the expected asset risk on the expected return on an asset. Relevant studies include French, Schwert and Stambaugh (1987), Poon and Taylor (1992), Choudhry (1996), Engle (2001) and Andersen, Bollerslev, Diebold and Labys (2003) among others.

4. Empirical Results

There are 20 explanatory variables on the right hand side of Equation (1). We used the general-to-specific modelling approach to omit the insignificant variables in Equation (1) on the basis of a battery of maximum likelihood tests. At first we estimated this equation for the pre-1997 period. After excluding the insignificant variables a cursory look at the correlogram of residuals (See Figure 5) of the estimated parsimonious model, which does not capture the ARCH and GARCH effects, reveals a serious type of volatility clustering. However, once the ARCH and GARCH effects, or the conditional heteroscedasticity in the residuals, are modelled, as described in Equations (2) to (4), the correlogram of the resulting residuals appear to be more statistically acceptable (see Figure 6). According to Gujarati (2003) the correlogram of residuals at various lags that drift around zero imply that the estimated model is probably stationary. Table 3 presents the estimation results for Equations (1) and (2). As can be seen from the results, the parsimonious model estimated by OLS does not pass the ARCH test using various lags. However, once the ARCH effects are taken into account the reported GARCH-M model passes the diagnostic tests in Table 3. The Lagrange Multiplier (LM) test is used for testing serial correlation. The null hypothesis of the LM test is that there is no serial correlation up to lag order *p* (a pre-specified integer). The results show no serial correlation up to order twelve for the estimated GARCH models.

Therefore, it is important to capture these effects by a GARCH(p, q) process as in Equation (2). Assuming that $\gamma \neq 0$, Table 3 presents the econometric results of the GARCH-M model using the maximum likelihood method. One can observe that the estimated γ is highly significant and positive (*i.e.* +0.379) supporting the view that the higher the stock market volatility, the higher would be the rate of return. It should be noted that our preferred model has the lowest SC, the highest adjusted R^2, passes various ARCH tests reported in Table 3 and its resulting correlogram is well-behaved (see Figure 6). From Bollerslev (1986) the preferred equation also satisfies the stationarity of the parsimonious model, GARCH-M(q = 2, p = 0), as $\sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j < 1$. It should be noted that the SC and significant spikes in the relevant correlogram of squared residuals are used to determine the optimum values of p and q. In order of magnitude the estimated coefficients for Singapore (0.586), Malaysia (0.383) and Indonesia (0.122) were highly significant at the 1 per cent significance level, whereas the remaining 12 stock market returns were not statistically significant at any conventional level. Out of the five macroeconomic variables in the model only the oil price was significant, suggesting that higher growth rates in oil price can cause returns on the Thai stock market to plummet. The insignificant variables were excluded from the final reported models.

We have also used the OLS method and Equation (1) to model the Thai stock return in the post-1997 crisis, and the results are reported in Table 4. As can be seen from Figure 7, the correlogram of residuals for this model shows no sign of ARCH or GARCH effects. In addition, the estimated model passes the ARCH LM test with various lags and, compared to various estimated models (which are not reported in this paper due to the lack of space but they are available from the authors upon request), has the lowest value of the SC. Therefore, we do not need to use the ARCH and GARCH models for this period. In fact, the estimated ARCH and GARCH and γ coefficients were all insignificant, and as a result they have not been reported in Table 4. So we can conclude that the stock returns in the Philippines (0.529), Korea (0.411) and Singapore (0.402) were the only major variables that instantaneously impacted on the Thai stock market.

[Figure 5, Figure 6 and Figure 7 about here]

[Table 3 and Table 4 about here]

5. Major Findings and Implications

Based on Tables 3 and 4 the major findings of the paper can be summarized as follows. First, it appears that Singapore is the only country whose stock returns are positively related to that of Thailand in both the pre- and post-1997 crisis periods. This evidence is not surprising because Singapore is a major regional financial hub with extensive investment throughout the region, a price leader with its dominance in the Asian market and also the major producer of information. Moreover, international investors often overreact to news from Singapore's market and place less weight on information from other Asian markets. Thus, innovations in Singapore could be used as an indicator to predict the performance of the Thai stock market. Second, apart from Singapore, in the pre-1997 period changes in stock returns in Indonesia and Malaysia were the most significant determinants of the returns in Thailand, but post-1997 the Philippines and Korea replaced these. This shift in importance in the post-1997 period is a result of capital controls imposed in Malaysia during 1998 and the economic turbulence in Indonesia, while Korea has attained more economic integration with Thailand. However, the case of the Philippines is more difficult to explain. Third, none of the stock markets in other countries outside the region played an important role in explaining the variation of Thai stock market returns before or after 1997. Fourth, consistent with previous studies, the effect of macroeconomic variables on the dependent variable was insignificant, with the only exception being changes in the price of oil. It appears that a rise in oil prices had a negative effect on stock returns prior to 1997 but became insignificant after 1997. Finally, the significant estimated coefficient γ on the time varying conditional variance $\sqrt{h}$ indicates that volatility itself exerted a positive impact on Thai stock market returns in the pre-Asian crisis period only.

6. Concluding Remarks

The main purpose of this empirical research has been to investigate how fifteen international stock markets and five relevant Thai macroeconomic variables influenced monthly stock market returns in Thailand in the pre- and post-1997 Asian crisis eras. It was found that the Singapore stock market influenced the Thai stock market significantly in both the pre- and post-1997 periods. Before 1997 the Indonesian and Malaysian stock markets were significantly related to the Thai stock market whereas after the crisis, Korea and the Philippines played a dominant role in explaining sources of variation in the monthly returns in the Thai stock market. Therefore, to a large extent one may conclude that the Thai stock market is very much influenced by the performance of its neighboring countries' stock markets, but non-regional markets exerted an insignificant effect. This goes some way to explaining why the financial crisis of 1997 remained a primarily regional crisis.

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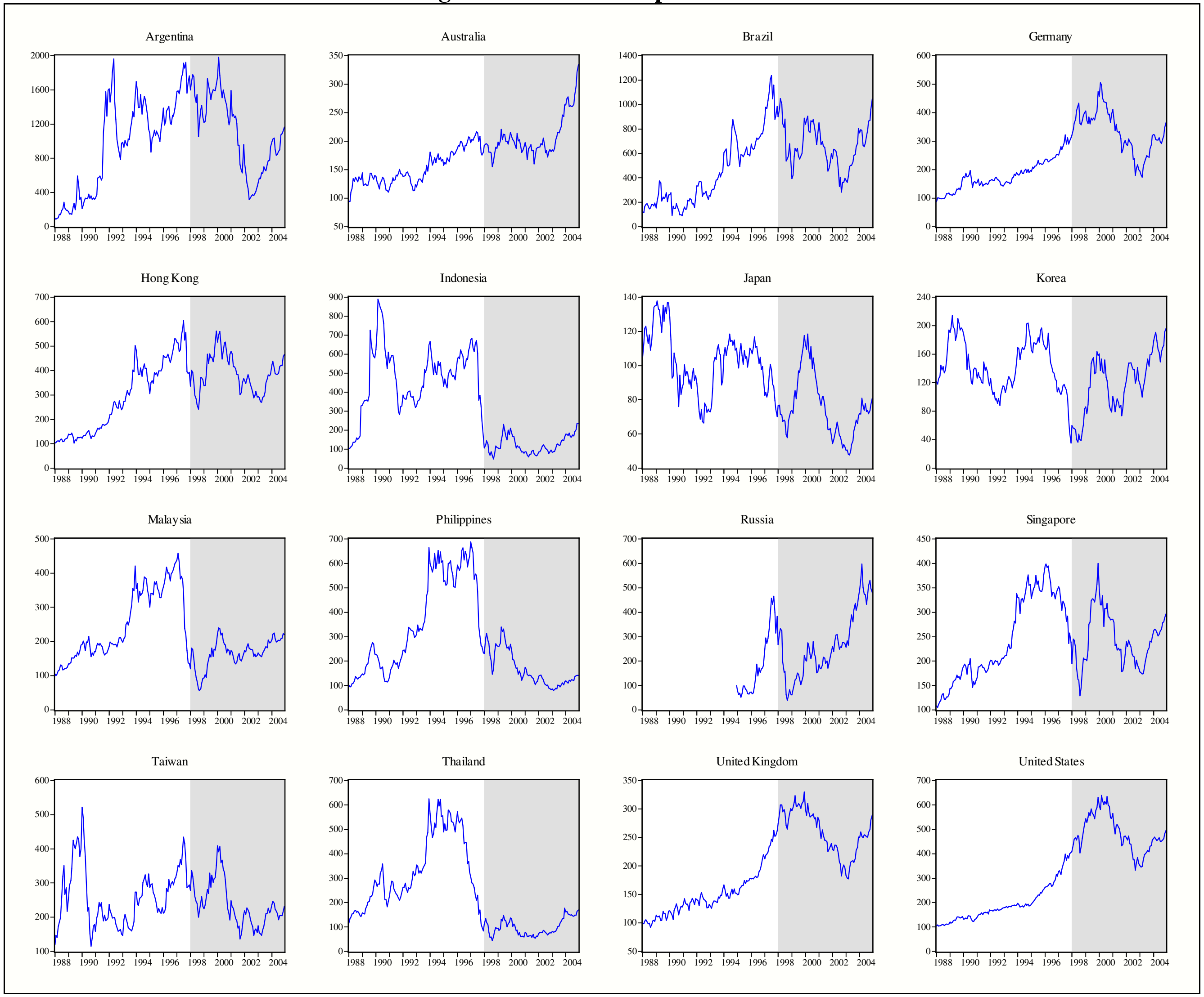
Table 1. Descriptions of the data employed, January 1988-December 2004

Variable	Mean	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis	Jarque-Bera	*p*-value
$\Delta \ln P_t^{TH}$	0.003	0.007	0.359	-0.416	0.121	-0.386	4.649	28.164	0.000
$\Delta \ln P_t^{AR} = \Delta \ln P_t^{1}$	0.012	0.015	0.670	-0.486	0.155	0.617	6.581	121.319	0.000
$\Delta \ln P_t^{AU} = \Delta \ln P_t^{2}$	0.006	0.005	0.157	-0.166	0.054	-0.225	3.413	3.162	0.206
$\Delta \ln P_t^{BA} = \Delta \ln P_t^{3}$	0.011	0.023	0.595	-1.107	0.172	-1.366	12.020	751.402	0.000
$\Delta \ln P_t^{GE} = \Delta \ln P_t^{4}$	0.006	0.008	0.202	-0.279	0.065	-0.691	5.363	63.715	0.000
$\Delta \ln P_t^{HK} = \Delta \ln P_t^{5}$	0.008	0.007	0.284	-0.344	0.079	-0.195	5.133	39.983	0.000
$\Delta \ln P_t^{IN} = \Delta \ln P_t^{6}$	0.004	0.007	0.662	-0.525	0.148	0.423	7.077	147.384	0.000
$\Delta \ln P_t^{JA} = \Delta \ln P_t^{7}$	-0.001	-0.003	0.217	-0.216	0.068	0.100	3.377	1.550	0.461
$\Delta \ln P_t^{KO} = \Delta \ln P_t^{8}$	0.003	-0.007	0.534	-0.375	0.113	0.341	5.889	74.940	0.000
$\Delta \ln P_t^{MA} = \Delta \ln P_t^{9}$	0.004	0.007	0.405	-0.361	0.093	-0.206	6.444	102.270	0.000
$\Delta \ln P_t^{PH} = \Delta \ln P_t^{10}$	0.002	0.002	0.360	-0.347	0.097	-0.009	4.632	22.644	0.000
$\Delta \ln P_t^{RU} = \Delta \ln P_t^{11}$	0.013	0.030	0.477	-0.931	0.195	-0.988	6.934	96.906	0.000
$\Delta \ln P_t^{SG} = \Delta \ln P_t^{12}$	0.005	0.008	0.228	-0.231	0.073	-0.483	5.175	48.173	0.000
$\Delta \ln P_t^{TA} = \Delta \ln P_t^{13}$	0.004	0.002	0.381	-0.410	0.115	-0.035	4.039	9.220	0.010
$\Delta \ln P_t^{UK} = \Delta \ln P_t^{14}$	0.005	0.004	0.138	-0.111	0.046	0.051	3.047	0.107	0.948
$\Delta \ln P_t^{US} = \Delta \ln P_t^{15}$	0.008	0.012	0.106	-0.151	0.041	-0.570	3.807	16.588	0.000
$\Delta \ln M_t^{CPI} = \Delta \ln M_t^{1}$	0.003	0.003	0.026	-0.007	0.005	0.847	5.577	80.811	0.000
$\Delta \ln M_t^{EX} = \Delta \ln M_t^{2}$	0.002	0.000	0.172	-0.154	0.029	1.729	20.795	2793.245	0.000
$\Delta \ln M_t^{MR} = \Delta \ln M_t^{3}$	-0.006	0.011	0.928	-0.855	0.232	-0.050	5.213	41.715	0.000
$\Delta \ln M_t^{M2} = \Delta \ln M_t^{4}$	0.010	0.009	0.046	-0.044	0.010	-0.151	6.807	123.981	0.000
$\Delta \ln M_t^{OP} = \Delta \ln M_t^{5}$	0.004	0.007	0.457	-0.246	0.083	0.568	6.800	133.715	0.000

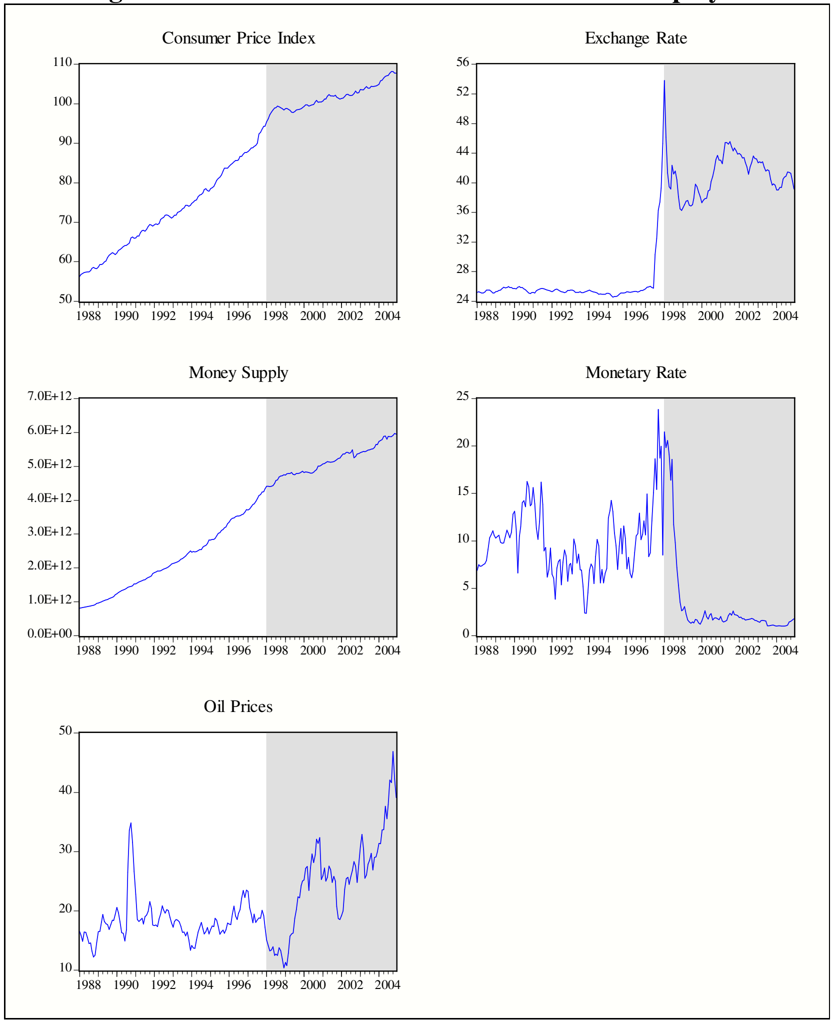
Sources: (1) http://www.msci.com/equity/index2.html and (2) http://ifs.apdi.net/imf/logon.aspx

Figure 1. Plot of stock price indices



Sources: http://www.msci.com/equity/index2.html

Figure 2. Plot of five macroeconomic variables employed



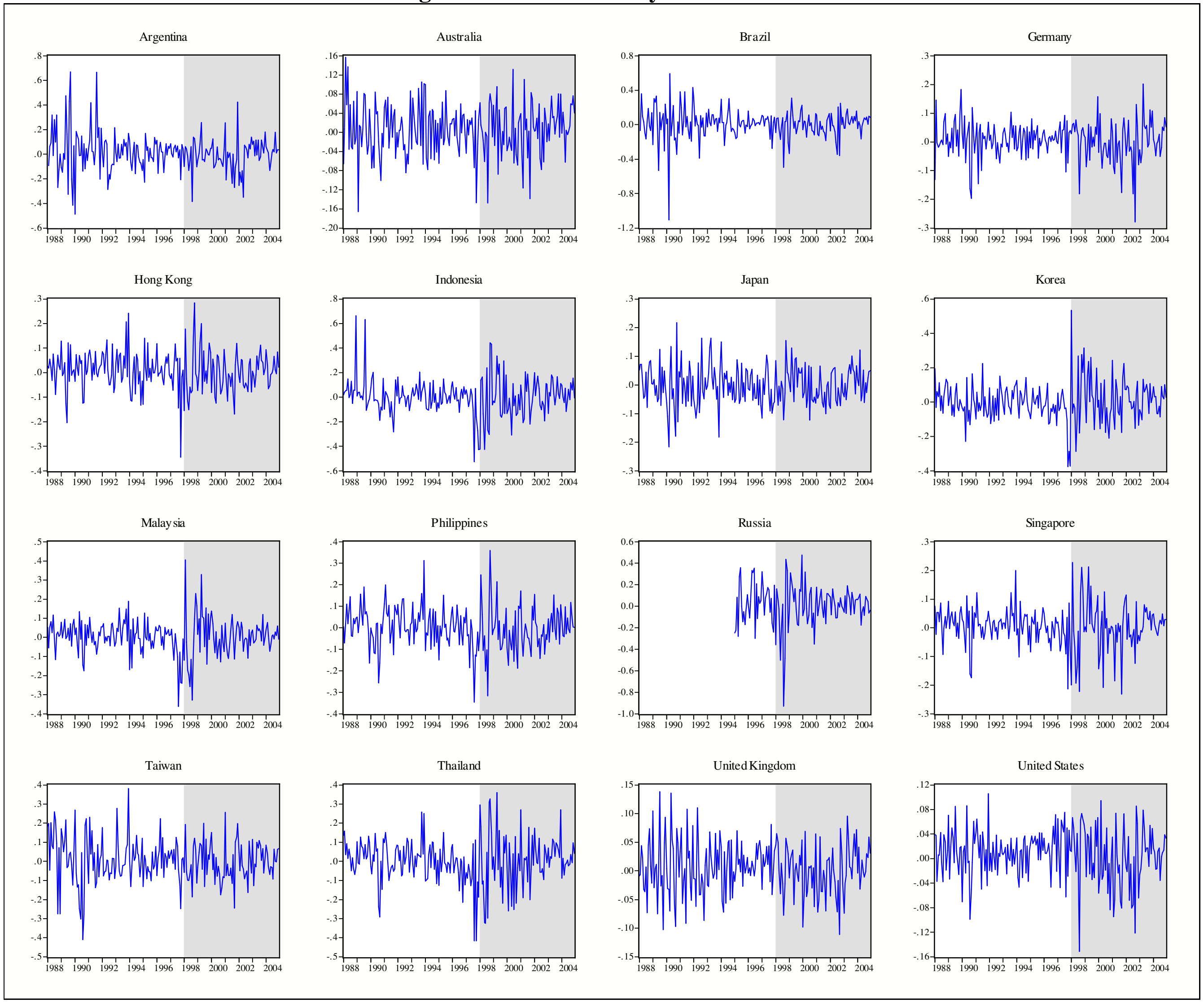
Sources: http://ifs.apdi.net/imf/logon.aspx

Table 2. Unit root test results

Variables	ADF				ERS DF-GLS			
	Constant	Optimal lag	Constant and trend	Optimal lag	Constant	Optimal lag	Constant and trend	Optimal lag
$\Delta \ln P_t^{TH}$	-8.289***	1	-8.266***	1	-1.656*	6	-6.776***	1
$\Delta \ln P_t^{AR} = \Delta \ln P_t^{1}$	-13.721***	0	-13.841***	0	-11.064***	0	-12.470***	0
$\Delta \ln P_t^{AU} = \Delta \ln P_t^{2}$	-15.331***	0	-15.301***	0	-0.255	2	-1.678	2
$\Delta \ln P_t^{BA} = \Delta \ln P_t^{3}$	-16.334***	0	-16.306***	0	-14.416***	0	-15.580***	0
$\Delta \ln P_t^{GE} = \Delta \ln P_t^{4}$	-15.115***	0	-15.105***	0	-14.781***	0	-15.048***	0
$\Delta \ln P_t^{HK} = \Delta \ln P_t^{5}$	-13.425***	0	-13.448***	0	-9.493***	0	-12.321***	0
$\Delta \ln P_t^{IN} = \Delta \ln P_t^{6}$	-11.957***	0	-11.959***	0	-11.927***	0	-12.018***	0
$\Delta \ln P_t^{JA} = \Delta \ln P_t^{7}$	-13.871***	0	-13.836***	0	-3.713***	2	-13.735***	0
$\Delta \ln P_t^{KO} = \Delta \ln P_t^{8}$	-13.644***	0	-13.620***	0	-1.433	5	-2.539	5
$\Delta \ln P_t^{MA} = \Delta \ln P_t^{9}$	-7.317***	1	-7.323***	1	-6.357***	1	-7.163***	1
$\Delta \ln P_t^{PH} = \Delta \ln P_t^{10}$	-11.301***	0	-11.396***	0	-11.321***	0	-11.407***	0
$\Delta \ln P_t^{RU} = \Delta \ln P_t^{11}$	-9.529***	0	-9.485***	0	-2.127**	3	-8.071***	0
$\Delta \ln P_t^{SG} = \Delta \ln P_t^{12}$	-13.900***	0	-13.931***	0	-10.656**	0	-13.153***	0
$\Delta \ln P_t^{TA} = \Delta \ln P_t^{13}$	-12.712***	0	-12.708***	0	-2.398**	3	-6.390***	1
$\Delta \ln P_t^{UK} = \Delta \ln P_t^{14}$	-12.112***	1	-12.097***	1	-4.959***	5	-8.944***	0
$\Delta \ln P_t^{US} = \Delta \ln P_t^{15}$	-14.741***	0	-14.796***	0	-2.494**	6	-12.015***	0
$\Delta \ln M_t^{CPI} = \Delta \ln M_t^{1}$	-10.910***	0	-10.544***	1	-3.602***	4	-5.381***	4
$\Delta \ln M_t^{EX} = \Delta \ln M_t^{2}$	-9.879***	0	-9.853***	0	-9.106***	0	-9.630***	0
$\Delta \ln M_t^{MR} = \Delta \ln M_t^{3}$	-15.849***	0	-15.825***	0	-15.373***	0	-15.801***	0
$\Delta \ln M_t^{M2} = \Delta \ln M_t^{4}$	-3.113**	5	-14.073***	0	-0.703	11	-8.823***	0
$\Delta \ln M_t^{OP} = \Delta \ln M_t^{5}$	-10.743***	0	-10.730***	0	-8.291***	0	-10.038***	0

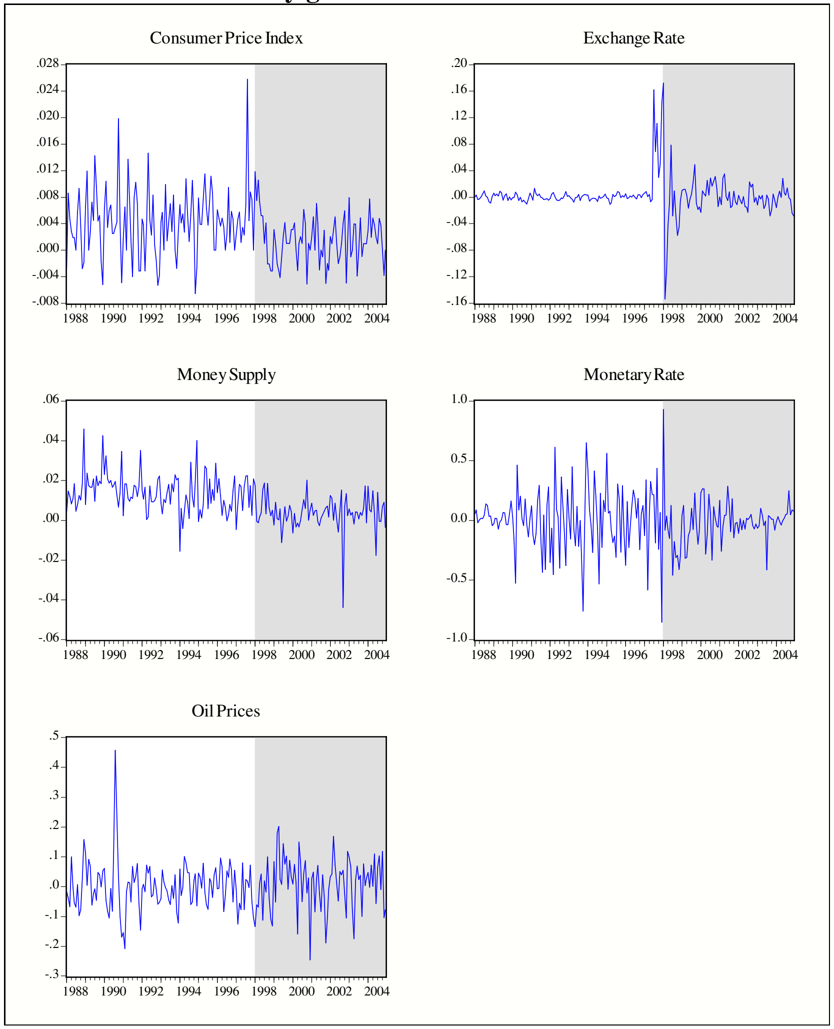
Note: ** and *** indicates that the corresponding null hypothesis is rejected at the 5 and 1 per cent significance level, respectively.

Figure 3. Plot of monthly stock returns



Sources: http://www.msci.com/equity/index2.html

Figure 4. Plot of the monthly growth rate of the five macroeconomic variables



Sources: http://ifs.apdi.net/imf/logon.aspx

Figure 5. Correlogram of squared residuals before capturing GARCH effect for pre-Asian crisis period

Sample: 1988M01-1997M12

Included observations: 120

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.001	0.001	0.0003	0.987
		2	0.283	0.283	9.9488	0.007
		3	0.089	0.096	10.948	0.012
		4	0.105	0.029	12.333	0.015
		5	0.127	0.085	14.382	0.013
		6	-0.047	-0.096	14.663	0.023
		7	0.211	0.155	20.447	0.005
		8	0.006	0.032	20.452	0.009
		9	0.211	0.132	26.323	0.002
		10	0.086	0.069	27.317	0.002
		11	0.001	-0.109	27.317	0.004
		12	0.022	-0.090	27.381	0.007
		13	-0.059	-0.056	27.860	0.009
		14	-0.030	-0.083	27.987	0.014
		15	-0.080	-0.033	28.880	0.017
		16	-0.016	-0.013	28.916	0.025
		17	-0.045	-0.040	29.210	0.033
		18	-0.076	-0.078	30.043	0.037
		19	-0.062	-0.070	30.602	0.045
		20	-0.077	-0.015	31.470	0.049
		21	-0.105	-0.037	33.113	0.045
		22	-0.118	-0.044	35.179	0.037
		23	-0.103	-0.022	36.775	0.034
		24	-0.044	0.046	37.068	0.043
		25	-0.085	-0.009	38.186	0.044
		26	-0.062	-0.022	38.792	0.051
		27	-0.071	-0.012	39.595	0.056
		28	-0.091	-0.037	40.906	0.055
		29	0.005	0.070	40.911	0.070
		30	-0.153	-0.080	44.721	0.041
		31	-0.046	-0.043	45.069	0.049
		32	-0.115	-0.051	47.265	0.040
		33	-0.015	-0.004	47.302	0.051
		34	-0.101	-0.076	49.030	0.046
		35	-0.029	0.013	49.176	0.056
		36	0.112	0.154	51.367	0.047

Source: authors' calculations.

Figure 6. Correlogram of squared residuals after capturing GARCH effect for pre-Asian crisis period

Sample: 1988M01-1997M12
Included observations: 120

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.010	0.010	0.0114	0.915
		2	0.026	0.026	0.0975	0.952
		3	0.020	0.019	0.1470	0.986
		4	0.024	0.023	0.2195	0.994
		5	-0.022	-0.024	0.2838	0.998
		6	-0.031	-0.032	0.4089	0.999
		7	0.136	0.137	2.7925	0.904
		8	0.059	0.060	3.2519	0.918
		9	0.059	0.054	3.7107	0.929
		10	0.101	0.095	5.0604	0.887
		11	-0.011	-0.025	5.0780	0.927
		12	0.047	0.046	5.3821	0.944
		13	-0.033	-0.027	5.5347	0.961
		14	-0.107	-0.129	7.1082	0.930
		15	-0.071	-0.082	7.8135	0.931
		16	-0.006	-0.019	7.8191	0.954
		17	0.000	-0.027	7.8191	0.970
		18	0.015	0.016	7.8506	0.981
		19	0.009	-0.015	7.8635	0.988
		20	-0.113	-0.136	9.7416	0.973
		21	-0.105	-0.084	11.365	0.955
		22	-0.123	-0.104	13.626	0.914
		23	-0.063	-0.035	14.224	0.920
		24	-0.045	-0.002	14.535	0.934
		25	-0.023	-0.010	14.613	0.950
		26	-0.072	-0.073	15.427	0.949
		27	-0.048	-0.027	15.795	0.957
		28	-0.048	-0.042	16.168	0.963
		29	0.065	0.109	16.841	0.965
		30	-0.113	-0.059	18.903	0.942
		31	-0.020	0.011	18.968	0.955
		32	-0.061	-0.020	19.593	0.958
		33	-0.032	-0.004	19.768	0.967
		34	-0.101	-0.098	21.489	0.953
		35	0.055	0.052	22.016	0.957
		36	0.156	0.131	26.272	0.883

Source: authors' calculations.

Figure 7. Correlogram of squared residuals before capturing GARCH effect for post-Asian crisis period

Sample: 1998M01-2004M12

Included observations: 84

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.047	-0.047	0.1920	0.661
		2	-0.066	-0.068	0.5749	0.750
		3	0.108	0.102	1.6209	0.655
		4	-0.030	-0.025	1.7028	0.790
		5	-0.083	-0.073	2.3339	0.801
		6	-0.049	-0.071	2.5520	0.863
		7	-0.074	-0.085	3.0642	0.879
		8	0.005	0.005	3.0663	0.930
		9	0.056	0.057	3.3672	0.948
		10	0.061	0.077	3.7345	0.959
		11	-0.068	-0.072	4.1894	0.964
		12	0.013	-0.016	4.2061	0.979
		13	0.000	-0.030	4.2061	0.989
		14	-0.025	-0.004	4.2721	0.994
		15	-0.015	-0.001	4.2959	0.997
		16	-0.064	-0.060	4.7310	0.997
		17	-0.053	-0.061	5.0361	0.998
		18	-0.056	-0.092	5.3777	0.998
		19	0.098	0.092	6.4343	0.997
		20	0.091	0.109	7.3637	0.995
		21	-0.039	-0.007	7.5342	0.997
		22	0.058	0.017	7.9207	0.997
		23	-0.053	-0.109	8.2587	0.998
		24	0.047	0.057	8.5259	0.998
		25	0.098	0.128	9.7005	0.997
		26	-0.113	-0.036	11.285	0.995
		27	-0.057	-0.063	11.701	0.995
		28	0.153	0.090	14.702	0.981
		29	0.090	0.108	15.757	0.978
		30	-0.116	-0.071	17.547	0.965
		31	-0.032	-0.049	17.686	0.973
		32	0.019	-0.030	17.734	0.980
		33	-0.053	-0.035	18.125	0.983
		34	-0.072	-0.086	18.871	0.983
		35	0.103	0.143	20.432	0.976
		36	-0.049	0.012	20.801	0.980

Source: authors' calculations.

Table 3. Estimation results for the Thai monthly return model, $\Delta \ln P_t^{TH}$, in the pre-1997 crisis period

Variables	OLS			GARCH-M		
	Coefficient	*t*-statistic	*p*-value	Coefficient	*z*-statistic	*p*-value
Mean equation						
Intercept	-0.007	-1.117	0.266	-0.030***	-4.022	0.000
$\Delta \ln P_t^{IN}$	0.156***	2.938	0.004	0.122***	2.647	0.008
$\Delta \ln P_t^{MA}$	0.402***	3.204	0.002	0.383***	3.277	0.001
$\Delta \ln P_t^{SG}$	0.588***	3.381	0.001	0.586***	3.851	0.000
$\Delta \ln M_t^{OP}$	-0.234***	-2.811	0.006	-0.207***	-3.670	0.000
$\sqrt{h_t}$	-	-	-	0.379***	2.708	0.007
Variance equation						
Intercept	-	-	-	0.001**	1.991	0.047
u_{t-1}^2	-	-	-	-0.083***	-3.121	0.002
u_{t-2}^2	-	-	-	0.358***	2.703	0.000
h_{t-1}^2	-	-	-	0.423***	2.770	0.006
Adjusted R^2	0.544			0.514		
Log-L	149.370			158.469		
Akaike	-2.406			-2.474		
Schwarz	-2.290			-2.242		
Overall *F*-stat	36.494***		0.000	15.010***		0.000
ARCH LM *F*-stat						
1 lag	0.000		0.987	0.011		0.917
2 lag	6.038***		0.003	0.054		0.948
3 lag	4.388***		0.006	0.054		0.983
4 lag	4.180***		0.003	0.060		0.993
8 lag	2.967***		0.005	0.365		0.938
12 lag	2.965***		0.002	0.448		0.939
Jarque-Bera	0.048		0.976	1.799		0.407

Note: ** and *** indicates that the corresponding null hypothesis is rejected at the 5 and 1 per cent significance level, respectively.

Table 4. Estimation results for the Thai monthly return model, $\Delta \ln P_t^{TH}$, in the post-1997 crisis period

Variables	Coefficient	*t*-statistic	*p*-value
Mean equation			
Intercept	0.002	0.237	0.814
$\Delta \ln P_t^{KO}$	0.411^{***}	5.681	0.000
$\Delta \ln P_t^{PH}$	0.529^{***}	4.678	0.000
$\Delta \ln P_t^{SG}$	0.402^{***}	3.081	0.003
$\sqrt{h_t}$	-	-	-
Variance equation			
Intercept	-	-	-
u_{t-1}^2	-	-	-
h_{t-1}^2	-	-	-
Adjusted R^2	0.679		
Log-L	94.992		
Akaike	-2.166		
Schwarz	-2.050		
Overall *F*-stat	59.420^{***}		0.000
ARCH LM *F*-stat			
1 lag	0.190		0.664
2 lag	0.234		0.792
3 lag	0.711		0.549
4 lag	0.694		0.599
8 lag	0.475		0.870
12 lag	0.878		0.573
Jarque-Bera	1.723		0.423

Note: *** indicates that the corresponding null hypothesis is rejected at the 1 per cent significance level.