On Volatility Spillovers and Dominant Effects in East Asian: Before and After the 911

Tze-Haw Chan and Chee Wooi Hooy

Multimedia University

2003

On Volatility Spillovers and Dominant Effects in East Asian: Before and After the 911

Chan Tze Haw[*]
Faculty of Business and Law
Multimedia university, Melaka

Hooy Chee Wooi
Faculty of Accountancy and Management,
Universiti Tunku Abdul Rahman

2[nd] Draft
November 2006

Abstract
The present paper examines the dynamic effects of volatility spillovers and dominant role (the second-moment) of the US, Japan and Hong Kong in the East Asian equity markets. To evaluate the recent September 11 (911) impact, two sub periods - before and after the tragedy, are being considered based on daily market returns. The upshots of our findings are five-fold. First, for all markets the constant risk components, as well as the ARCH and GARCH effects are significantly detected, implying the persistency of volatility in East Asian equity markets. Nevertheless, not all indexes show asymmetrical news effects. Though all indexes show leverage effects, they are significant only for certain countries including the US and Japan, which is consistent with empirical literature. Second, the volatilities of these equity markets are bounded in common stochastic trends, at least in the long run. Third, the Hong Kong long run coefficients are more significant than that of US or Japan before the 911 calamity. Nonetheless, there is sufficient evidence showing that the US spillovers were transmitted via Hong Kong. After the 911, the Hong Kong's spillovers trim down while Japanese influence enhance as in Malaysia, Philippines, Thailand and Singapore. Taken as a whole (1998-2002), Japanese spillovers are relatively small and non-significant in some East Asian equity markets. Fourth, the ECT coefficients are significant but small (except for Hong Kong). The East Asian equity markets are thereby endogenously determined and the volatility adjustments to the long run equilibrium are slow, once being shocked. The ECT coefficients slightly improved after 911. Fifth, volatilities in the East Asian equity markets are attributed mainly to the shocks of local and regional factors rather than the world factor. In a nutshell, the volatility spillovers and the Hong Kong- and US-dominant effects have been confirmed. Hitherto, the 911 impact is relatively small and somewhat inconclusive.

JEL Classification: G15, E24, F36

Keyword: East Asian, Spillover Effect, Dominant Effect, EGARCH-M, ARDL Bounds Testing Approach

[*] Corresponding Author
Tel: 012-3702653, 06-2523858
Fax: 06-2318869
E-mail: thchan@mmu.edu.my

1.0 Introduction

Globalization, with its new challenges, possibilities and threats is influencing the affiliation between the East Asian and the world. Though foreign exchange controls and interest ceilings rates of East Asian countries were progressively removed since early 1970s, the restrictions on domestic capital markets were only relaxed gradually a decade ago[†]. Ever since, international capital flows and cross-border investments have augmented, leading to a higher inter- and intra-regional financial integration. Nonetheless, the financial market uncertainty has accelerated simultaneously; implying that future financial crisis in any part of the world would be highly transmissible to the others. For that, studies concerning volatility spillover effects in the equity markets are of priority. Understanding the behavior and sources of volatility not only critical in pricing domestic securities and implementing hedging strategies or asset decisions but also crucial in evaluating the regulatory proposals to restrict international capital flows.

Previous studies have mostly focused on the world factors rather than the regional factor to explain the spillovers and domination effects, including authors like Bekaert and Hodrick (1992), Harvey (1995) and Karolyi and Stulz (1996). Wei *et al.* (1995) in particular, showed that the three global financial centers of New York, Tokyo and London dominated the volatilities of Hong Kong and Taiwan. Cheung and Ng (1996) in addition, documented a significant dominancy of S&P 500 index over Nikkei index in a study of 15-minute data. Brooks and Henry (2000) also found dominancy of daily S&P 500 index over the Australian All Ordinaries index. In addition to that, recent literature suggested that volatilities in the Asian equity markets are attributed to three sources of shocks - local, regional and the world. Bekaert and Harvey (1997) for instance found that the influences of the world capital market on emerging markets are generally small and time-varying. Likewise, Ng (2000) discovered that over and above the impact of world factors, there are significant spillovers from the region to many of

---

[†] see Chan and Baharumshah (2003) for details of financial liberalization process in the East Asian countries.

the Pacific Basin countries. Based on weekly data, Ng (2000) also took concern of the liberalization events such as capital market reform and country fund launching in varying the relative impacts of the world and regional markets factors over time. Additionally, numerous authors have considered the Asian crisis 1997 in their studies and found that volatility spillover effects were greater during the crisis than the pre- and post-crisis era. Yet, the dominant effects in the region are still inconclusive.

The present paper aims to examine the volatility spillover effects in the Pacific Rim, spotlighted on the East Asian equity markets. We combine countries with a wide range of financial developments. These include the US and Japan, four NIE[‡] (Hong Kong, Singapore, South Korea, Taiwan) and four emerging ASEAN members (Indonesia, Malaysia, Philippines, Thailand). The magnitude and changing nature of volatility spillovers are demonstrated via modern econometric techniques, concerning the pre-and post-September 11 calamity (911 hereafter).

Specifically, our study differs from the existing literature in three significant aspects. First, unlike the existing works that focused on the dominant role of US and Japan, this article incorporates three major equity markets in the Pacific Rim (US, Japan Hong Kong) as anchor force. In other words, the world and regional factors are combined to evaluate the spillover effects and second-moment dominant effects in the East Asian region. Second, the 911 impact has been explored. It is of no interest to reassess the effects of pre- and post-liberalization or pre- and post-crisis which have been extensively investigated. Third, the present study adopts a different methodology to what has been used in the earlier studies. To generate volatilities we employ the newly established Exponential Generalized ARCH in Mean (EGARCH-M) approach. To model the long run and short run spillover effects, the augmented Autoregressive Distributed Lag (ARDL) bounds testing approach advocated by Pesaran *et al.* (2001) is deployed. The main advantage of ADRL approach lies in the fact that it can be applied

[‡] ASEAN represents the member countries of Association of Southeast Asian Nations while NIE denotes the Newly Industrialized Economies in Asia. Though Singapore is geographically one of the ASEAN, it is grouped under NIE.

irrespective of whether the regressors are *I*(0) or *I*(1). This in turn avoids the testing problems associated with standard cointegration analysis which requires the classification of the variables into *I*(1) and *I*(0). Indeed, the volatilities are often *I*(0) in nature and do not fit the conventional cointegration procedures. Additionally, the estimation of the long run coefficients and the error correction model are also accomplished based on the corresponding ARDL model.

The paper proceeds as follows. Section two dwells with the methodological issue including the estimation procedures and data description. The empirical results are presented in section three and finally in section four, we conclude.

2.0 Methodology

EGARCH-M and Volatilities

The conditional volatility of each of the index returns are generated using an EGARCH (1, 1) - M process. The Conditional Volatility Model (univariate) can be estimated by maximum-likelihood method. The mean and variance equation of the univariate EGARCH-M modeling are defined as:

$$R_{i,t} = \mu_i + \theta_i R_{i,t-1} + \phi\sigma_{i,t} + \varepsilon_{i,t} \quad (1)$$

and

$$\log\sigma^2_{i,t} = \omega_i + \beta_i \log\sigma^2_{i,t-1} + \alpha_i \left| \frac{\varepsilon_{i,t-1}}{\sqrt{h_{i,t-1}}} \right| + \gamma_i \frac{\varepsilon_{i,t-1}}{\sqrt{h_{i,t-1}}} \quad (2)$$

where $R_{i,t}$ represents the continuously compounded returns of stock index *i* in period *t*. μ_i and ε_t are intercept and error term with $\sigma^2_{i,t}$ as the conditional variance of ε_t for stock index *i* in period *t*. Additionally, while θ_i and ϕ_i represent the magnitudes of the autoregressive and the risk-return tradeoff parameter; α_i , β_i and γ_i denote the respective parameters of ARCH, GARCH and leverage effects. The EGARCH specification can account for asymmetrical news effects as well as leverage effect of bad news. The GARCH-M specification on the other hand, makes operation the risk-return tradeoff parameter in the equity pricing process, and allows more flexible lag-length structure than the conventional GARCH model. The responses of the index returns (conditional volatility) to good and bad news are asymmetry if $\gamma = 0$, but symmetry if $\gamma \neq 0$. The presence of the leverage effect can be tested by the hypothesis of γ < 0. It should be noted that non-synchronous trading in stock market may induce a first order correlated error term in stock returns. To filter out these autocorrelations, an autoregressive (AR) representation is fitted to the returns. To account for non-normal conditional residual distribution, we use the robust consistent variance-covariance estimator advanced in Bollerslev and Wooldridge (1992).

ARDL Modeling

Following Pesaran and Shin (1995) and Pesaran *et al*. (2001), the augmented Autoregressive Distributed Lag (ARDL) model can be presented as:

$$\phi(L,p)y_t = \sum_{i=1}^{k} \beta_i (L,q_i) x_{it} + \delta' w_t + \mu_t \qquad (3)$$

where

$$\phi(L,p) = 1 - \phi_1 L - \phi_2 L^2 - . \quad . \quad . - \phi_p L^p \qquad (4)$$

$$\beta_i (L,q_i) = 1 - \beta_{i1} L - \beta_{i2} L^2 - . \quad . \quad . - \beta_{iq} L^{qi}, \qquad for \quad i = 1,2. \quad . \quad ., k \qquad (5)$$

L is a lag operator such that $Ly_t = y_{t-1}$, and w_t is a $s \times 1$ vector of deterministic variables such as the intercept term, seasonal dummies, time trends or exogenous variables with fixed lags. All possible values of $p = 0,1,2,..., m; q_i = 0,1,2,..., m; i = 1,2,..., k$ with a total of $(m+1)^{k+1}$ ARDL models can be estimated by OLS. In short, the long run coefficients for the response of y_t to a unit change in x_{it} are estimated by:

$$\hat{\theta}_i = \frac{\hat{\beta}_i(1,\hat{q}_i)}{\hat{\phi}(1,\hat{p})} = \frac{\hat{\beta}_{i0} + \hat{\beta}_{i1} + ...+ \hat{\beta}_{i\hat{q}_i}}{1 - \hat{\phi}_1 - \hat{\phi}_2 - ......- \hat{\phi}_{\hat{p}}}, \qquad i = 1,2,......,k \tag{6}$$

where $\hat{p}$ and $\hat{q}_i, i = 1,2,......,k$ are the selected (estimated) values of p and $q_i, i = 1,2,......,k$. A specified error correction version of our ARDL model (with maximum lag = 4) is then given by:

$$\begin{aligned}\Delta E_t = a_0 + \sum_{i=1}^{4} b_i \Delta E_{t-i} + \sum_{i=1}^{4} c_i \Delta US_{t-i} + \sum_{i=1}^{4} d_i \Delta JP_{t-i} + \sum_{i=1}^{4} e_i \Delta HK_{t-i} \\ + \delta_1 E_{t-1} + \delta_2 US_{t-1} + \delta_3 JP_{t-1} + \delta_4 HK_{t-1} + \mu_t\end{aligned} \tag{7}$$

where E, US, JP and HK are equity price volatilities of East Asian countries, United States, Japan and Hong Kong respectively. We can test the null hypothesis of non-existence of the long run relationship which is defined as:

$$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0 \quad \text{against} \quad H_0 : \delta_1 \neq 0, \quad \delta_2 \neq 0, \quad \delta_3 \neq 0, \quad \delta_4 \neq 0 \tag{8}$$

The critical value bounds of the F-statistics for different numbers of regressors (*k*) are tabulated in Pesaran *et al*. (1996). Two sets of critical values are provided. Upper bound assumes that all the variables in the ARDL model are *I*(1) while lower bound assumes all variables to be *I*(0). Cointegration is confirmed irrespective of whether the variables are *I*(1) or *I*(0) if the computed F-statistic falls outside the upper bound; and rejected if outside the lower bound. Nevertheless, if F-statistic falls within the critical value band, unit root test of stationarity is needed to authentic the order of integration of respective variables.

Data Description

The empirical analyses are applied to a sample of daily market returns spanning from May 1998 to December 2002, sourced from DataStream International. Though Karolyi and Stulz (1996) suggested that higher frequency data (i.e. intraday) could be more practical to study the spillovers, many have shown that daily figures are sufficient to capture the size and pattern of market volatilities. In fact, the opening and closing stock prices are not available in many of the East Asian countries. The data utilized include the New York Stock Exchange Composite Index, the Tokyo Stock Price Index, the Hang Seng Index (Hong Kong), the Stock Exchange of Singapore All Share Index, the Korean Composite Stock Price Index (South Korea), the Taiwan Stock Exchange Weighted Price Index, the Jakarta Composite Index (Indonesia), the Kuala Lumpur Stock Exchange Composite Index (Malaysia), the Philippines Composite Index and the Stock Exchange of Thailand Index.

3.0 Empirical Results

EGARCH-M and Volatilities

The time varying volatility modeling of the equity returns are crucial to gauge the dynamic movement of the market. The parameter estimation of the univariate EGARCH-M model is given in Table 1[§]. The results show that almost all indexes have a significant constant term. The ARCH and GARCH effects are significantly modeled by EGARCH-M for all indexes, except for Hong Kong. Nevertheless, not all indexes show asymmetrical news effects. In addition, though all indexes show leverage effect, they are significant only for US, Japan, Taiwan, Singapore and Malaysia.

[Insert Table 1]

[§] Due to space limitation, the summary statistics of the price, returns, and conditional volatility series are not presented in the text. The results can be made available upon request.

Figure 1 and Figure 2 demonstrate the series of price indexes and generated volatilities. Following the Asia crisis 1997, share prices have generally tumbled across the Asia Pacific region. Though regional markets rebounded during the early 2000 and early 2002 respectively, two observable deterioration periods were also recorded at some point between end 1998 to early 1999 and during September 2001.

[Insert Figure 1 and Figure 2]

ARDL Cointegration

The secondary step to identify the volatility spillovers is to test the presence of level relationships between variables. In the main, the analysis has been based on the application of cointegration techniques where US, Japan and Hong Kong are taken as forcing variables. However, the level-stationary market return volatilities would not fit the conventional cointegration tests[**] which require the underlying variables to be first-difference stationary. Hence, the ARDL bounds testing approach is adopted. The results are presented in Table 2. For all cases before and after the 911, the computed F-statistics fall outside the upper bound value (4.738) and highly reject the null hypothesis of no level relationship. The return volatilities among East Asian and US-Japan-Hong Kong are thus cointegrated and bounded by common stochastic trends. This in turn initiates some degree of possible spillover effects. To an extent, future volatilities of market returns in the region can be determined or forecasted, using a part of the information set provided by the US, Japan and Hong Kong.

[Insert Table 2]

ARDL long run Coefficients

Having the comovement of return volatilities confirmed, the ARDL procedure allows us to estimate the long run parameters associated with asymptotic standard errors as reported in Table 3. Prior to 911, the US influences in Asia Pacific are

[**] Namely, by Engle and Granger (1987), Stock and Watson (1988) and Johansen (1991, 1995).

considerably significant, ranging from 0.051 (Indonesia) to 0.401 (Malaysia). Surprisingly, the long run coefficients of Hong Kong are explicitly greater (0.157 to 0.592) but the Japanese role is somewhat diminutive. After the 911, the Hong Kong's spillovers trim down while Japanese influence enhance as in Malaysia, Philippines, Thailand and Singapore. Briefly, the East Asian markets were driven mainly by innovations from Japan and Hong Kong. On the other hand, the US-East Asian relationships were ambiguous where diverse impacts were reported in Philippines, Thailand and Singapore. Taking 1998-2002 as a whole, the world factor (US and Japan) are relatively small and time-varying as compared to the regional factor (Hong Kong) in explaining the return volatilities of East Asian financial markets. This somehow does not necessary imply that Hong Kong was dominating the East Asian equity markets. Indeed, the US coefficients for Hong Kong were always superior to other countries, suggesting that the US influence was transmitted through the Hong Kong channel.

[Insert Table 3]

ARDL Error Correction Modeling

Table 4 presents the unrestricted error correction models (ECM) based on ARDL (3, 3, 3). The regression coefficients for the full ECM are not of great interest and for brevity are not reported here. The computed error correction terms (ECTs) are signed correctly and statically highly significant for all cases, indicating that the East Asian equity markets are endogenously determined. Prior to 911, the ECT coefficients are small (-0.07 to -0.11) except for Hong Kong (-0.28), implying that the speed of convergence to equilibrium are slow. In other words, the East Asian equity markets' sacrifice 9 to 14 days to adjust back to their long run equilibrium, once being shocked. As for Hong Kong, only 4 trading days was needed. After 911, the speed of adjustments improves moderately, approximately 5 to 11 days (-0.09 < ECT < -0.19).

In short, and the markets have learnt to absorb the market information and cushion the external shocks.

[Insert Table 4]

Variance Decomposition Analysis

Unlike previous section, the following discussion concerns of the generalized variance decomposition (VDCs) based on daily market returns. VDCs can be termed as out-of-sample causality tests, by partitioning the variance of the forecast error of a certain variable (i.e., equity price of a country) into proportions attributable to innovations (or shocks) in each variable in the system, including its own. VDCs enable us to gauge the extent of external shocks in one country being explained by other countries. A variable which is optimally forecast from its own lagged values will have all its forecast error variance accounted for by its own disturbance and vise versa. Reported results show that the US is the most exogenous since over 95% of the variance is explained by its own innovations (see Table 5a). For all forcing variables considered here, shocks and innovations from Hong Kong have explained the regional forecast errors variance by the biggest proportion (especially for Singapore), above the impact of US and Japan. Taking average, only 6% to 13% of the forecast error variances are being explained by the US. While for Japan, the proportions are far more insignificant. This is in line with the findings by Bekaert and Harvey (1997) and Ng (2000) that regional factor is indeed greater than world factor. In addition, innovations of home countries have explained approximately 50% to 80% of their own variance (Table 5b), suggesting that local factor is indeed the most significant force in explaining the shocks.

4.0 Conclusion

Five major findings can be abstracted from the previous discussion. First, the persistency of volatility in East Asian equity markets and volatility spillovers are significant detected. Second, the volatilities of these equity markets are bounded in common stochastic trends, at least in the long run. Future volatilities of regional market returns can be determined or forecasted, using a part of the information set provided by the US, Japan and Hong Kong. Third, the Hong Kong's direct influences on the regional equity market before and after 911 are greater than that of US and Japan. However, there is sufficient evidence showing that the US spillovers were transmitted via Hong Kong. Forth, for most East Asian countries, the speed of adjustment following a shock in equity market are slow before 911 (9 to 14 days) but slightly improved after 911(5 to 11 days). Fifth, volatilizes volatilities in the East Asian equity markets are attributed mainly to the shocks of local and regional factors rather than the world factor. In a nutshell, the volatility spillover effect has been proved while the Hong Kong- and the US-dominant effects have been confirmed. However thus far, the 911 impact is somewhat inconclusive.

References:

Brooks, C. and Henry, O.T. (2000) Linear and Non-linear Transmission of Equity Return Volatility: Evidence from the US, Japan and Australia, *Economic Modeling*, 17, 497-513.

Bollerslev, T. and Wooldridge, J. (1992) Quasi-maximum likelihood estimation and inference in dynamic models with time-varying covariances, *Econometric Reviews*, 11, 143-172.

Chan, T.H. and A.Z. Baharumshah (2003) Financial Deregulation in East Asian: Before and After the Crisis. *Working Paper*, Department of Economics, FEP, Universiti Putra Malaysia.

Cheung, Y.W. and Ng, L.K. (1996) A Causality-in-variance Test and Its Application to Financial Market Prices. *Journal of Econometric*, 72, 33-48.

Engle, R. F., and Granger, C. W. J. (1987) Cointegration and Error Correction: Representation Estimation and Testing. *Econometrica*. 55, 251-276.

Johansen, S. (1991) Estimation and Hypothesis Testing of Cointegrating Vectors in Gaussian Vector Autoregressive Models. *Econometrica*, 59, 1551-1580.

Johansen, S. (1995) Likelihood Based Inference in Cointegrated Vector Autoregressive Models. Oxford University Press: Oxford.

Ng, A. (2000) Volatility Spillover Effects from Japan and the US to the Pacific-Basin. *Journal of International Money and Finance*, 19, 207-233.

Pesaran, M.H., and Y. Shin (1995) An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. *DAE Working Paper, No. 9514,* Department of Applies Economics, University of Cambridge.

Pesaran, M.H., Y. Shin and R.J. Smith (1996) Testing for the Existence of a Long Run Relationship. *DAE Working Paper, No. 9622,* Department of Applies Economics, University of Cambridge.

Pesaran, M.H., Y. Shin and R.J. Smith (2001) Bounds Testing Approaches to the Analysis of Level Relationships. *DAE Working Paper, No. 9907, Third Revision,* Department of Applies Economics, University of Cambridge.

Stock, J. and M.W. Watson (1988) Testing for Common Trends. *Journal of the American Statistical Association*, 83, 1097-1107.

Wei, J.K.C., Liu, Y.J., Yang, C.C. and Chaung, G.S. (1995) Volatility and Price Change Spillover Effects Across the Developed and Emerging Markets, *Pacific-Basin Finance Journal 3*, 113-136.

Figure 1: Stock Indexes of the US and East Asian Countries, 1998-2002

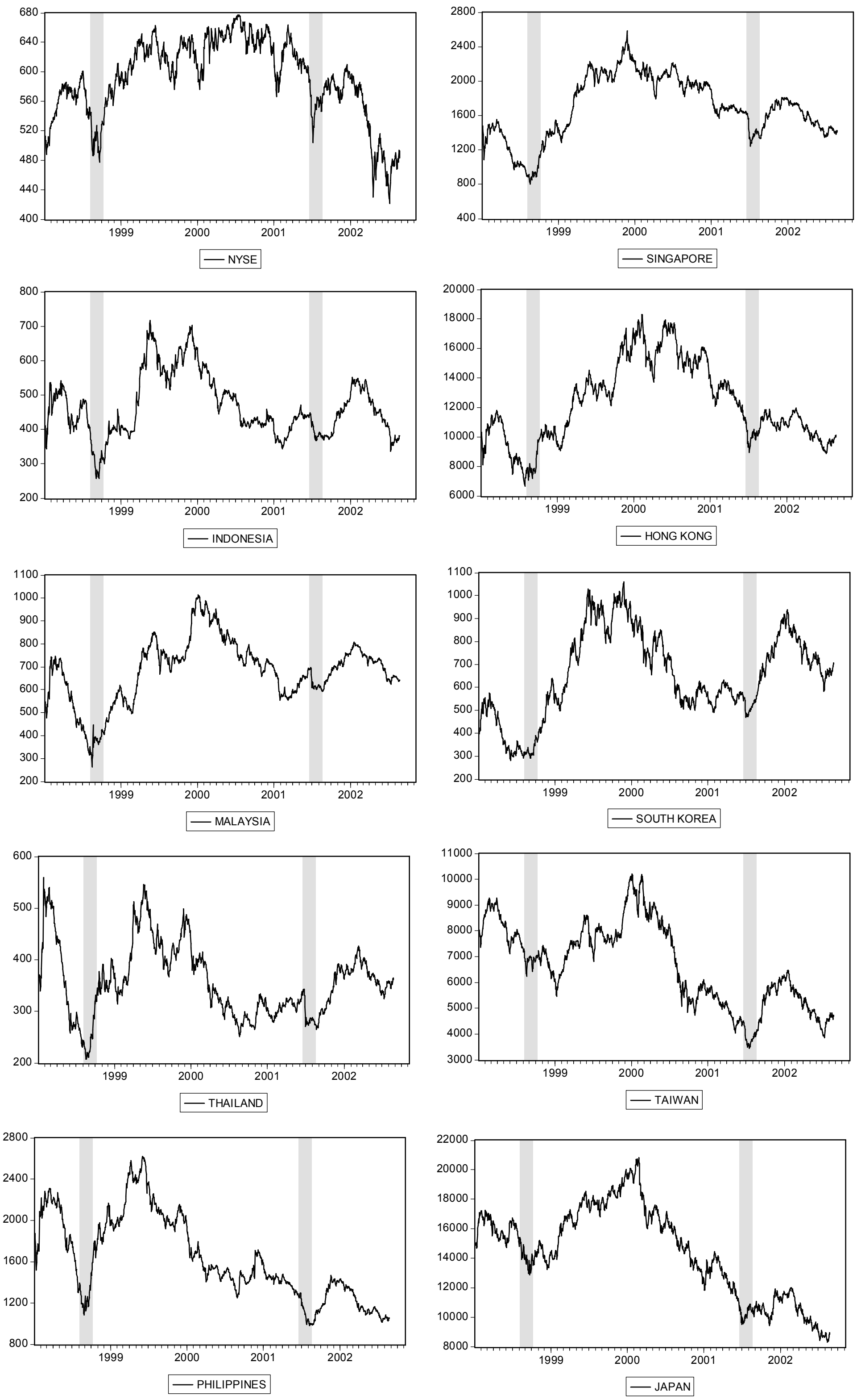

Figure 2: Stock Price Volatilities of the US and East Asian Countries, 1998-2002

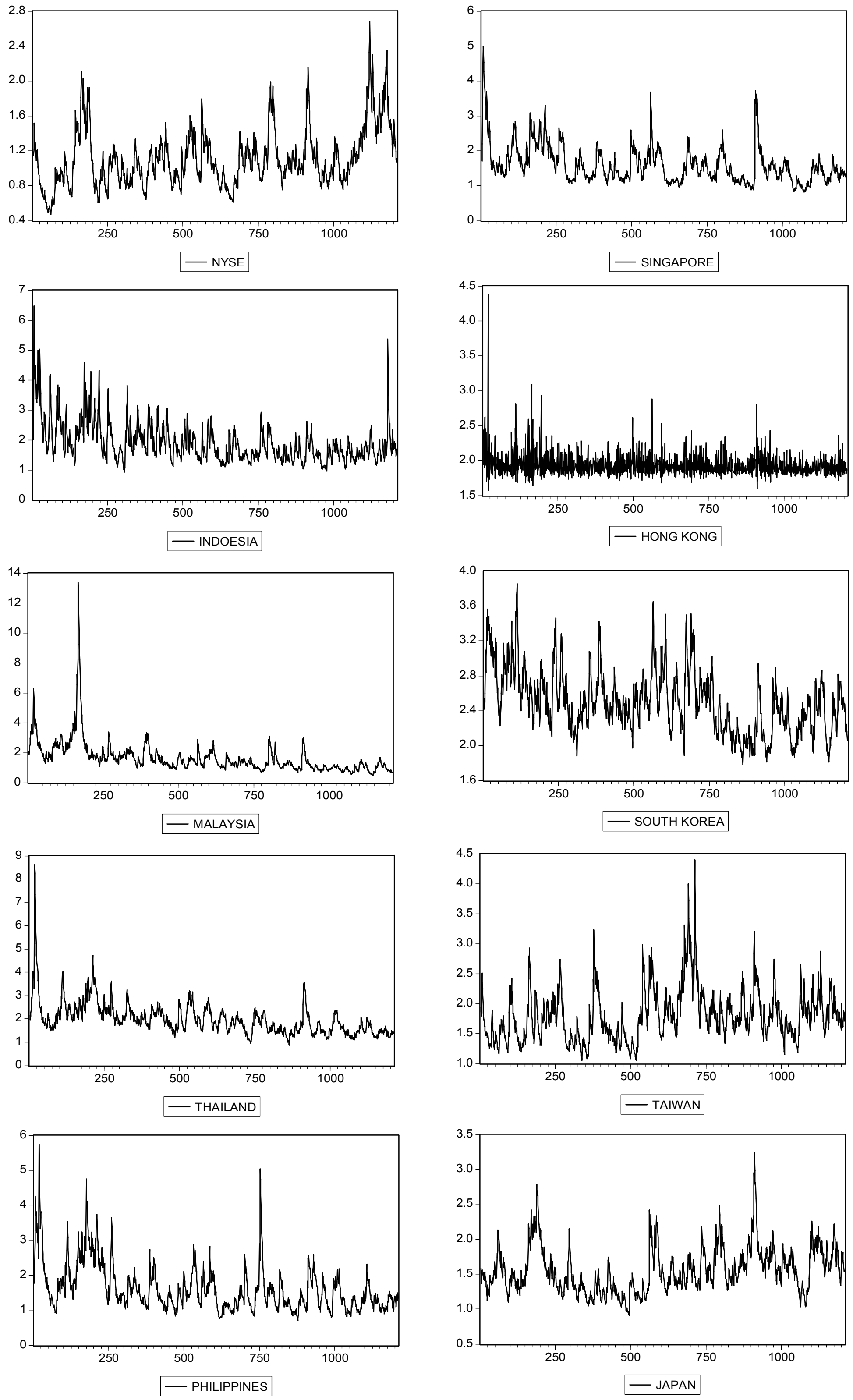

Table 1: EGARCH (1,1)-M Estimation for the US and East Asia Equity Indexes

	NYSE	JAP	HK	KOR	TW	SNG	INDO	MAL	PHI	THAI
μ	-0.1764	-0.2730	-2.3368	-0.5571	-0.2210	-0.2932	-0.2655	-0.0732	-0.2960	0.1728
	(0.1257)	(0.2372)	(0.0581)*	(0.2750)	(0.3141)	(0.0318)**	(0.1814)	(0.3832)	(0.0130)**	(0.3913)
θ	0.0649	0.0082	0.0548	0.0926	0.0889	0.0965	0.1655	0.1803	0.1467	0.0954
	(0.0331)**	(0.7846)	(0.2792)	(0.0026)***	(0.0017)***	(0.0025)***	(0.0000)***	(0.0000)***	(0.0001)***	(0.0174)**
ϕ	0.1498	0.1497	1.2047	0.2358	0.0900	0.1756	0.1357	0.0632	0.1392	-0.0899
	(0.1923)	(0.3425)	(0.0583)*	(0.2651)	(0.4942)	(0.0937)*	(0.2358)	(0.3720)	(0.1067)	(0.4263)
ω	-0.0602	-0.0787	1.5920	0.0150	-0.0691	-0.1453	-0.1556	-0.2171	-0.1890	-0.1468
	(0.0016)***	(0.0047)***	(0.0014)***	(0.7480)	(0.0248)**	(0.0000)***	(0.0018)***	(0.0000)***	(0.0000)***	(0.0021)***
α	0.0838	0.1560	0.2100	0.1503	0.1972	0.2476	0.3942	0.3170	0.3168	0.2463
	(0.0004)***	(0.0001)***	(0.0067)***	(0.0003)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***
β	0.9625	0.9499	-0.3263	0.9286	0.9262	0.9509	0.884	0.9710	0.9568	0.9710
	(0.0000)***	(0.0000)***	(0.3126)	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***
γ	-0.1425	-0.0852	0.0074	-0.0262	-0.1194	-0.0758	-0.0388	-0.0654	-0.0545	-0.0021
	(0.0000)***	(0.0003)***	(0.8990)	(0.3483)	(0.0000)***	(0.0309)**	(0.4367)	(0.0298)**	(0.1619)	(0.9551)
LogL	-1791.864	-2220.312	-2507.136	-2809.802	-2390.171	-2227.515	-2436.570	-2164.550	-2218.605	-2492.523

Notes: Asterisks *, ** and *** denote significant at 10%, 5% and 1% level respectively. P-values are presented in the parentheses.

Table 2: ARDL Test of Long Run Relationship

	1998-2001	*2001-2002*	*1998-2002*
INDO	12.24	10.88	16.19
MAL	6.97	9.30	6.80
PHI	8.02	4.98	8.95
THAI	7.29	7.16	8.00
SNG	9.29	4.82	10.76
SK	9.27	4.80	10.95
TW	6.94	5.62	9.75
HK	46.28	19.92	54.11

Notes: The estimated ARDL models contain intercepts without trends. For each country, the long run volatilities spillover relationship is examined with respect to US-Japan-Hong Kong. As for Hong Kong, the 'forcing variables' are US and Japan. The appropriate critical values bounds of the ARDL F-statistics are 3.219 and 4.738 at 5% significant level, as tabulated in Pesaran *et al*. (1996). The following notations apply in all the forthcoming tables: INDO=Indonesia, MAL=Malaysia, PHI=Philippines, THAI=Thailand, SNG=Singapore, SK=South Korea, TW=Taiwan, HK=Hong Kong.

Table 3: Estimated ARDL Long Run Coefficients

	US	JAP	HK
1998-2001			
INDO	0.051 (0.080)	0.115 (0.067)*	0.330 (0.027)***
MAL	0.401 (0.091)***	0.067 (0.117)	0.592 (0.048)***
PHI	0.325 (0.085)***	0.209 (0.071)***	0.412 (0.029)***
THAI	0.282 (0.090)***	0.055 (0.075)	0.545 (0.032)***
SNG	0.273 (0.057)***	0.287 (0.048)***	0.386 (0.020)***
SK	-0.131 (0.047)***	-0.033 (0.039)	0.157 (0.016)***
TW	0.223 (0.062)***	0.224 (0.052)***	-0.079 (0.020)
HK	0.564 (0.091)***	0.013 (0.009)	-
2001-2002			
INDO	0.465 (0.058)***	-0.089 (0.095)	0.113 (0.052)**
MAL	0.079 (0.040)*	0.377 (0.067)***	0.186 (0.036)***
PHI	-0.152 (0.054)***	0.515 (0.089)***	0.233 (0.049)***
THAI	-0.174 (0.046)***	0.370 (0.077)***	0.122 (0.041)***
SNG	-0.040 (0.039)	0.479 (0.066)***	0.315 (0.035)***
SK	0.251 (0.038)***	-0.047 (0.063)	0.072 (0.034)**
TW	0.349 (0.043)***	0.045 (0.070)	0.124 (0.038)***
HK	0.223 (0.062)	0.071 (0.010)***	-
1998-2002			
INDO	0.032 (0.055)	-0.012 (0.057)	0.349 (0.023)***
MAL	0.297 (0.098)***	0.015 (0.101)	0.357 (0.023)***
PHI	0.006 (0.058)	0.212 (0.060)***	0.450 (0.024)***
THAI	0.366 (0.061)***	0.045 (0.063)	0.574 (0.027)***
SNG	0.058 (0.039)	0.340 (0.041)***	0.434 (0.017)***
SK	-0.064 (0.033)*	0.098 (0.035)***	0.180 (0.014)***
TW	0.240 (0.041)***	0.205 (0.043)***	0.144 (0.017)
HK	0.316 (0.066)**	0.021 (0.007)***	-

Notes: Asterisks *, ** and *** denote significant at 10%, 5% and 1% level respectively. Standard errors are reported in the parentheses.

Table 4: Estimated Error Correction Terms based on ARDL Approach

	1998-2001	*2001-2002*	*1998-2002*
INDO	-0.11 [-7.23]***	-0.19 [-5.46]***	-0.12 [-8.51]***
MAL	-0.04 [-4.42]***	-0.08 [-4.99]***	-0.04 [-4.86]***
PHI	-0.06 [-5.08]***	-0.09 [-4.07]***	-0.06 [-6.01]***
THAI	-0.06 [-4.89]***	-0.10 [-4.36]***	-0.06 [-5.41]***
SNG	-0.07 [-4.84]***	-0.09 [-2.99]***	-0.07 [-5.06]***
SK	-0.07 [-5.56]***	-0.09 [-3.90]***	-0.07 [-6.21]***
TW	-0.07 [-4.90]***	-0.18 [-4.71]***	-0.08 [-5.97]***
HK	-0.28 [-4.12]***	-0.31 [-4.89]***	-0.24 [-5.25]***

Notes: Asterisks *, ** and *** denote significant at 10%, 5% and 1% level respectively. T-statistics are reported in the parentheses. Negative error correction coefficients indicate that the system once being shocked, there will be adjustments back to the long run equilibrium.

Table 5a: Generalized Variance Decomposition

% of		explained by innovations in									
variance	Horizon	NYSE	JAP	HK	KOR	TW	SNG	INDO	MAL	PHI	THAI
NYSE	2	**95.52**	0.62	2.46	0.48	0.01	0.32	0.50	0.03	0.04	0.00
	4	**95.59**	0.41	2.18	0.37	0.06	0.52	0.48	0.04	0.34	0.01
	8	**95.32**	0.33	2.06	0.32	0.05	0.80	0.47	0.08	0.50	0.08
	16	**94.68**	0.27	1.94	0.30	0.03	1.19	0.49	0.14	0.62	0.34
	24	**94.01**	0.25	1.87	0.30	0.02	1.52	0.52	0.18	0.68	0.65
JAP	2	5.10	**82.19**	12.12	0.16	0.03	0.00	0.17	0.09	0.07	0.08
	4	7.97	**77.86**	13.34	0.11	0.17	0.01	0.40	0.05	0.04	0.06
	8	9.01	**76.09**	13.98	0.08	0.22	0.01	0.50	0.03	0.02	0.07
	16	9.27	**75.41**	14.27	0.07	0.22	0.03	0.56	0.03	0.01	0.14
	24	9.20	**75.30**	14.34	0.06	0.21	0.05	0.58	0.03	0.01	0.21
HK	2	6.30	0.01	**92.96**	0.29	0.01	0.00	0.42	0.00	0.01	0.00
	4	10.88	0.01	**88.00**	0.40	0.07	0.00	0.51	0.07	0.05	0.02
	8	12.11	0.01	**86.72**	0.41	0.08	0.00	0.50	0.07	0.10	0.01
	16	12.46	0.00	**86.33**	0.42	0.07	0.01	0.50	0.06	0.14	0.01
	24	12.41	0.00	**86.35**	0.42	0.06	0.02	0.51	0.05	0.15	0.03
SK	2	3.28	3.74	15.03	**77.18**	0.00	0.09	0.56	0.03	0.02	0.08
	4	5.61	3.98	16.82	**71.65**	0.11	0.36	0.47	0.53	0.07	0.41
	8	6.88	3.89	17.71	**68.62**	0.21	0.64	0.39	0.78	0.05	0.83
	16	8.04	3.83	18.07	**65.91**	0.34	0.97	0.33	0.98	0.04	1.49
	24	8.73	3.80	18.11	**64.23**	0.44	1.21	0.30	1.09	0.04	2.04
TW	2	2.37	2.43	7.03	1.69	**85.56**	0.01	0.41	0.44	0.01	0.05
	4	4.35	3.02	9.00	1.46	**80.24**	0.01	0.74	1.15	0.00	0.04
	8	5.55	3.30	9.67	1.31	**77.77**	0.01	0.91	1.46	0.01	0.02
	16	6.41	3.43	9.97	1.23	**76.44**	0.01	0.96	1.52	0.01	0.03
	24	6.87	3.46	10.05	1.19	**75.88**	0.02	0.96	1.48	0.01	0.08
SNG	2	6.86	1.88	31.49	1.98	0.08	**49.65**	3.37	1.83	1.10	1.77
	4	9.75	1.82	31.80	2.54	0.39	**44.22**	4.47	1.33	1.29	2.39
	8	10.77	1.84	32.14	2.71	0.54	**41.86**	4.92	1.12	1.47	2.63
	16	11.21	1.85	32.40	2.81	0.60	**40.70**	5.17	1.05	1.56	2.66
	24	11.31	1.85	32.54	2.85	0.61	**40.32**	5.27	1.03	1.60	2.62
INDO	2	0.75	0.09	6.91	0.26	0.01	0.02	**91.47**	0.14	0.16	0.19
	4	1.01	0.32	6.72	0.33	0.11	0.13	**89.30**	0.36	0.55	1.16
	8	1.38	0.45	6.79	0.33	0.28	0.42	**86.54**	0.57	0.69	2.55
	16	2.23	0.54	6.92	0.32	0.58	0.96	**81.96**	0.83	0.79	4.87
	24	2.97	0.58	6.98	0.31	0.83	1.44	**78.26**	1.00	0.83	6.80
MAL	2	1.87	1.28	10.20	0.35	0.04	0.04	4.07	**82.12**	0.01	0.02
	4	3.97	2.47	9.50	0.44	0.45	0.12	5.51	**77.39**	0.07	0.07
	8	5.97	3.10	9.37	0.41	0.97	0.07	5.99	**73.34**	0.13	0.65
	16	8.86	3.45	9.54	0.37	1.77	0.23	5.84	**66.96**	0.20	2.78
	24	10.97	3.54	9.61	0.35	2.40	0.58	5.51	**61.69**	0.25	5.10
PHI	2	3.38	0.23	12.82	1.42	0.05	0.26	4.92	2.09	**74.82**	0.01
	4	6.31	0.45	15.78	1.86	0.03	0.22	5.07	1.43	**68.55**	0.31
	8	8.97	0.52	16.78	1.86	0.10	0.59	4.55	0.91	**64.15**	1.57
	16	12.56	0.60	16.90	1.71	0.45	1.66	3.84	0.47	**56.73**	5.09
	24	14.90	0.63	16.45	1.56	0.83	2.66	3.33	0.29	**50.92**	8.43
THAI	2	2.06	0.70	17.65	2.56	0.04	0.18	8.23	5.10	3.85	**59.65**
	4	3.58	1.60	18.83	3.21	0.28	0.13	10.51	3.62	3.86	**54.39**
	8	4.41	1.94	19.46	3.36	0.42	0.16	11.34	2.83	3.81	**52.27**
	16	4.90	2.08	19.62	3.39	0.52	0.20	11.56	2.41	3.74	**51.59**
	24	5.13	2.12	19.58	3.38	0.57	0.23	11.54	2.24	3.68	**51.55**

Table 5b: Generalized Variance Decomposition of East Asian Countries

percentage of variance	Horizon	explained by innovation in NYSE	JAP	HK	**Local**	**Sub-regional**
HK	2	6.30	0.01	-	**92.96**	**0.73**
	4	10.88	0.01	-	**88.00**	**1.11**
	8	12.11	0.01	-	**86.72**	**1.17**
	16	12.46	0.00	-	**86.33**	**1.21**
	24	12.41	0.00	-	**86.35**	**1.25**
SK	2	3.28	3.74	15.03	**77.18**	**0.78**
	4	5.61	3.98	16.82	**71.65**	**1.94**
	8	6.88	3.89	17.71	**68.62**	**2.90**
	16	8.04	3.83	18.07	**65.91**	**4.16**
	24	8.73	3.80	18.11	**64.23**	**5.13**
TW	2	2.37	2.43	7.03	**85.56**	**2.61**
	4	4.35	3.02	9.00	**80.24**	**3.40**
	8	5.55	3.30	9.67	**77.77**	**3.72**
	16	6.41	3.43	9.97	**76.44**	**3.76**
	24	6.87	3.46	10.05	**75.88**	**3.74**
SNG	2	6.86	1.88	31.49	**49.65**	**10.13**
	4	9.75	1.82	31.80	**44.22**	**12.41**
	8	10.77	1.84	32.14	**41.86**	**13.40**
	16	11.21	1.85	32.40	**40.70**	**13.84**
	24	11.31	1.85	32.54	**40.32**	**13.98**
INDO	2	0.75	0.09	6.91	**91.47**	**0.79**
	4	1.01	0.32	6.72	**89.30**	**2.64**
	8	1.38	0.45	6.79	**86.54**	**4.84**
	16	2.23	0.54	6.92	**81.96**	**8.34**
	24	2.97	0.58	6.98	**78.26**	**11.21**
MAL	2	1.87	1.28	10.20	**82.12**	**4.53**
	4	3.97	2.47	9.50	**77.39**	**6.67**
	8	5.97	3.10	9.37	**73.34**	**8.22**
	16	8.86	3.45	9.54	**66.96**	**11.19**
	24	10.97	3.54	9.61	**61.69**	**14.19**
PHI	2	3.38	0.23	12.82	**74.82**	**8.75**
	4	6.31	0.45	15.78	**68.55**	**8.92**
	8	8.97	0.52	16.78	**64.15**	**9.57**
	16	12.56	0.60	16.90	**56.73**	**13.22**
	24	14.90	0.63	16.45	**50.92**	**17.10**
THAI	2	2.06	0.70	17.65	**59.65**	**19.96**
	4	3.58	1.60	18.83	**54.39**	**21.60**
	8	4.41	1.94	19.46	**52.27**	**21.92**
	16	4.90	2.08	19.62	**51.59**	**21.81**
	24	5.13	2.12	19.58	**51.55**	**21.62**

Notes: Abstracted from Table 3, the Local figures take account of the innovations from home countries. Figures in Sub-regional comprises of accumulated innovations from neighboring countries other than US, Japan, and Hong Kong.