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Comovement of Asian Stock Markets and the U.S. Influence*

Jin Woo Park†

Using correlation analysis and the extended GARCH model, this paper investigated the linkages between equity markets of 11 Asian countries, including Thailand, Malaysia, Indonesia, Singapore, the Philippines, Korea, Japan, China, Hong Kong, Taiwan, and India; additionally, the dependence structures of these markets to the U.S. equity market for the 2005-2008 period was also evaluated. We noted remarkably high correlation coefficients across the Asian markets, reflecting strong comovement of the Asian markets. Among those, the countries with more developed financial systems (i.e., Japan, Singapore, and Hong Kong in Asia) exhibited stronger linkages to the rest of the Asian markets. China, conversely, evidenced the lowest correlation with other Asian markets. The linkages were stronger for the East Asian markets than for the ASEAN markets generally. A comparison of the results between the first (2005-2006) and second (2007-2008) sub-periods reveals a recent strengthening of the Asian markets. Additionally, we found a significant mean spillover effect from the U.S. equity market to all 11 of the Asian markets. Among those, the stock markets of the Philippines and Japan were the most sensitive to daily changes in U.S. market returns, and the Hong Kong, Korea, Indonesia, Singapore, Taiwan, and India markets are next in respective order in terms of U.S. influence. The influence of the U.S. on the stock markets of Thailand, Malaysia, and China is relatively weak. The mean spillover effect has increased significantly from the first period (2005-2006) to the second period (2007-2008) for most Asian countries, with the exception of Thailand, Indonesia, the Philippines, and Taiwan, where the U.S. market influence is slightly reduced.

Field of Research: Asian stock markets, Linkage, Spillover effect, Comovement

1. Introduction

Asian capital markets, spurred by the phenomenal economic growth, have attracted a great deal of attention from investors in the global markets. Additionally, the integration of Asian capital markets has accelerated since the Asian economic crisis in the late 1990s, with a diminution of government-imposed barriers to capital flow across countries. Furthermore, the recent global financial crisis also focused more attention on the linkages among the stock markets of Asian countries. In an effort to make a contribution to this important process, the present study addresses the issue of linkages between the stock markets of Asian countries. Specifically, this paper evaluates the comovement of equity markets of 11 Asian

* This work is supported by Hankuk University of Foreign Studies Research Fund of 2010.
† Professor, College of Business Administration, Hankuk University of Foreign Studies, 270 Imun Dongdaemun, Seoul 130-791, Korea. Email: jwp@hufs.ac.kr

countries, including five ASEAN (Association of South East Asian Nations) countries (i.e., Thailand, Malaysia, Indonesia, Singapore, and Philippine), five East Asian countries (i.e., Korea, Japan, China, Hong Kong, and Taiwan), and India. Additionally, this paper evaluates the dependence structures of these markets relative to the U.S. equity market. Specifically, the principal objectives of this study are as follows:

First, this paper evaluates the comovement of 11 major Asian stock markets, via correlation analysis. This paper was particularly concerned with measuring the short-run interdependence of the Asian stock markets and comparing the degree of comovement across markets. The results will shed light on the issue of the dependence structure of the Asian equity markets and, by implication, on the issue of the benefits of international portfolio diversification.

Second, assuming that innovations in the U.S. equity market are exogenous in nature, this paper assesses the manner in which these innovations impact the Asian stock markets. More specifically, this paper evaluates the spillover effects from the U.S. equity market to each of 11 Asian stock markets. This paper is interested particularly in the extent to which stock price changes in the U.S. market affect stock prices in the Asian markets and whether changes in the price volatility in the U.S. market are related positively to price volatility changes observed in the Asian markets.

Third, once a market's degree of dependence is established, this paper assesses the nature of the association between the degree of dependence and the economic linkage. In other words, this paper investigates whether the degree of dependence is explained by the economic linkage between the two countries, rather than by other factors. These results provide insight into the issue of the linkage between real economic activity and the stock market.

Finally, the question of the evolution of the linkages between the equity markets of the Asian countries is one that is worth investigating. Thus, this paper analyzes the data divided into two sub-periods, and evaluates the stability of the linkages. The null hypothesis is that, as barriers to the free flow of information have been reduced, the linkages have strengthened.

2. Literature Review

The question of the nature and the form of the interdependence of international stock markets has long been an issue in the financial literature. However, owing largely to the enhanced importance of the financial markets of the developed countries to the global markets, extant research regarding

relationships among international capital markets has focused, primarily, on the financial markets of developed countries (see Becker, Finnerty, and Gupta (1990), Eun and Shim (1989), Hilliard (1979), and Joy, Panton, Reilly, and Martin (1976)). Despite the growing importance of Asian capital markets, academic researchers have paid relatively little attention to these markets (see Park and Fatemi (1993) and Wei, Liu, Yang, and Chaung (1995)).

In addressing the question of international capital market interrelationships, the researchers have employed a variety of research methodologies. Earlier studies, such as those conducted by Levy and Sarnat (1970), Joy, Panton, Reilly, and Martin (1976), and Hillard (1979), were concerned principally with the contemporaneous and/or lagged correlations in the rates of return across equity markets in developed countries. Recent research into this topic has generally been more concerned with the transmission mechanisms of stock returns and variances across international equity markets. Eun and Shim (1989) evaluated the structures of interdependence among stock markets in nine major nations, using vector autoregression (VAR) analysis. Hamao, Masulis, and Ng (1990), on the other hand, evaluated the short-run interdependence of prices and price volatility across three major international markets (U.S., U.K., and Japan), using the autoregressive conditional heteroskedastic (ARCH) model.

3. Data and Methodology

3.1 Data

The countries covered in this paper include the U.S. and 11 countries in the Asian region, including five ASEAN countries (i.e., Thailand, Malaysia, Indonesia, Singapore, and Philippine), five East Asian countries (i.e., Korea, Japan, China, Hong Kong, and Taiwan), and India.[1] The data analyzed in this paper are daily rates of return on the market indices, which are measured in units of the local currency. The data source was FnGuide.

The indices selected to represent the stock markets of the 12 countries are as follows: SET for Thailand, KLCI for Malaysia, JSX for Indonesia, STI for Singapore, PSI for the Philippines, KOSPI for Korea, Nikkei225 for Japan, SSEC for China, Hang Seng for Hong Kong, TWII for Taiwan, BSESN for India, and S&P500 for the U.S. The period covered in this paper is January 2005 through December 2008. In order to evaluate the stability of the results, this paper analyzes the data divided into two parts--period 1 (January, 2005 - December, 2006) and period 2 (January, 2006 - December, 2008)--as well as the full sample period.

3.2 Methodology

This paper utilized correlation analysis and the extended GARCH (generalized autoregressive conditional heteroskedastic) model as an investigative technique.[2] The rationale for using the GARCH model lies in the fact that GARCH is considered the methodology of choice for evaluating the mean and volatility spillover effects across international stock markets. This paper adopts the GARCH(1,1) model using the results of AIC (Akaike's Information Criterion) and SBC (Schwartz-Bayesian Criterion) tests.[3] Additionally, considering the autocorrelation of the conditional mean as determined by Ljung-Box statistics, the MA(1) process was included in the GARCH model. As a consequence, the following MA(1)-GARCH(1,1) model was utilized in this paper:

$$R^i_t = \alpha + \varepsilon_t + \theta\varepsilon_{t-1},\ \varepsilon_t \mid \Omega_{t-1} \sim N(0, h_t)$$
$$h_t = a + b\epsilon^2_{t-1} + ch_{t-1}$$

In this equation, R^i_t is the daily rate of return on stock market i, and h_t represents the conditional variance of R^i_t at day t. Ω_{t-1} refers to the set of all the available information up to day t-1.

As a second stage of modeling, this paper employs the following model in order to measure the spillover effects of mean and variance between stock markets.

$$R^i_t = \alpha + \beta R^j_t + \varepsilon_t + \theta\varepsilon_{t-1},\ \varepsilon_t \mid \Omega_{t-1} \sim N(0, h_t)$$
$$h_t = a + b\epsilon^2_{t-1} + ch_{t-1} + \delta\varepsilon^2_{R^j_t}$$

In this equation R^i_t and R^j_t represent the daily rates of return on stock markets i and j, respectively. Additionally, the volatility shock, $\varepsilon^2_{R_t{}^i}$ and $\varepsilon^2_{R_t{}^j}$, which are estimated from the MA(1)-GARCH(1,1) model of stock markets i and j are added to the equation. Therefore, the coefficients, β and δ, measure the transmission effects of the mean and variance, respectively. In other words, the significance of these coefficients shows that information occurring in stock market j influences return and volatility in stock market i.

4. Empirical Results

4.1 Descriptive Statistics

The descriptive statistics for the daily rates of return on the market indices of the 12 countries (i.e., Thailand, Malaysia, Indonesia, Singapore, Philippine, Korea, Japan, China, Hong Kong, Taiwan, India, and the U.S.)

for the period from January 2005 to December 2008 are reported in Table 1. The majority of Asian countries, with the exceptions of India and Indonesia, evidence negative mean returns owing to market collapses occurring as the result of the 2008 global economic crisis. Among those, Singapore and Taiwan recorded the lowest average daily returns, of -0.059 and -0.052, respectively. Thailand, Malaysia, and Hong Kong are next in the order, with mean returns of -0.040, -0.032, and -0.030, respectively. In terms of market volatility, as measured by the standard deviation of daily stock market returns, China evidenced the highest value, followed by India, Hong Kong, Japan, Indonesia, and Korea (in order).

Table 1. Descriptive Statistics of Daily Stock Market Returns

	Thailand	Malaysia	Indonesia	Singapore	Philippine	Korea	Japan	China	Hong Kong	Taiwan	India	USA
Mean	-0.040	-0.032	0.000	-0.059	-0.005	-0.005	-0.018	-0.010	-0.030	-0.052	0.010	0.009
Std. Dev.	1.463	0.924	1.681	1.310	1.524	1.589	1.751	2.093	1.760	1.366	1.898	1.449
Maximum	11.16	3.43	7.63	5.78	9.82	6.14	14.15	9.45	14.35	5.82	8.22	11.58
Minimum	-14.84	-9.50	-10.38	-8.33	-6.01	-10.57	-11.41	-8.84	-8.65	-6.51	-10.96	-9.03
Skewness	-1.21	-1.87	-0.95	-0.91	0.21	-1.06	-0.15	-0.07	0.16	-0.61	-0.30	0.53
Kurtosis	23.11	19.67	9.35	8.39	7.13	9.70	14.95	5.93	13.17	6.31	6.64	19.24
J-B	12,430	8,846	1,331	983	522	1,497	4,327	260	3,139	376	412	8,024
Prob.	0	0	0	0	0	0	0	0	0	0	0	0

The skewness and kurtosis of the stock market distribution indicate non-symmetric distribution with fat tails as compared with normal distribution. For all the market returns in the sample, therefore, Jarque-Bera statistics to test the normality of distribution reject the hypothesis that the stock market returns are distributed normally.

4.2 Correlation Analysis

Correlation analysis is the statistical methodology that has been utilized most frequently in previous studies to evaluate the comovement of stock markets. Therefore, this paper begins with a correlation analysis designed to examine the inter-dependence structure of 12 countries, including Thailand, Malaysia, Indonesia, Singapore, Philippine, Korea, Japan, China, Hong Kong, Taiwan, India, and the U.S.[4] The results for the entirety of the sample period from 2004 to 2008 are provided in Table 2. Consistent with previous empirical evidence (see Levy and Sarnat (1970) and Park and Fatemi (1993)), the correlation coefficients across all the countries in our sample were shown to be significantly positive. This result indicates strong comovement across Asian countries and the U.S. over our 2005-2008 sample period. However, in terms of intensity, there are some variations across the markets.

Table 2. Correlation Coefficients across Stock Markets for the Period 2005-2008

	Thailand	Malaysia	Indonesia	Singapore	Philippine	Korea	Japan	China	Hong Kong	Taiwan	India	USA (t-1)
Thailand	1											
Malaysia	.443**	1										
Indonesia	.477**	.537**	1									
Singapore	.536**	.567**	.627**	1								
Philippine	.286**	.441**	.416**	.375**	1							
Korea	.475**	.499**	.561**	.717**	.431**	1						
Japan	.387**	.438**	.479**	.635**	.451**	.710**	1					
China	.151**	.284**	.208**	.289**	.192**	.278**	.249**	1				
Hong Kong	.496**	.480**	.555**	.794**	.400**	.710**	.660**	.415**	1			
Taiwan	.427**	.502**	.539**	.632**	.476**	.720**	.604**	.283**	.627**	1		
India	.422**	.384**	.520**	.613**	.272**	.517**	.434**	.222**	.589**	.448**	1	
USA(t-1)	.229**	.376**	.358**	.386**	.584**	.371**	.589**	.172**	.389**	.423**	.234**	1

** significant at the 1% level

When we examine the correlation coefficients between the U.S. and 11 Asian countries, Japan and the Philippines evidence the highest values, at over 0.5, whereas China has the lowest, at 0.172. The correlation coefficients of other Asian markets with the U.S. range between 0.229 and 0.423. Across Asian countries, Japan exhibits profound correlations with Hong Kong, Korea, and Taiwan, ranging over 0.7, and Singapore is also very strongly correlated with Hong Kong and Korea, with coefficients of 0.794 and 0.717, respectively. In fact, Singapore evidences correlation coefficients of over 0.5 with many other Asian countries, including Japan, Taiwan, Indonesia, India, Malaysia, and Thailand. The correlation coefficients of Hong Kong with other Asian markets are also relatively high, ranging between 0.400 and 0.710. These results indicate that the countries with more developed financial systems (i.e., Japan, Singapore, and Hong Kong in Asia) are strongly linked to the rest of the Asian markets. Some other Asian countries--such as Korea, Taiwan, Thailand, Malaysia, and Indonesia--evidence relatively high correlation coefficients. On the other hand, China was correlated least strongly with the other Asian markets. The correlation coefficients between China and the other Asian countries are below 0.3, with the exception of a coefficient of 0.415 between China and Hong Kong.

One of the most important results noted in Table 2 is the correlation coefficients across the neighboring countries. Among the ASEAN countries, the correlation coefficients across Malaysia, Indonesia, and Singapore are all greater than 0.5, reflecting strong comovement of these three markets.

The Philippines exhibit relatively low correlation coefficients with the remainder of the ASEAN countries. Among East Asian countries, extremely strong linkages were detected across Korea, Japan, Hong Kong, and Taiwan, showing correlation coefficients in a range between 0.604 and 0.720. These findings indicate that the linkages are stronger for the East Asian markets than those in the ASEAN markets. These results reveal that the degree of dependence between equity markets is associated with the economic linkages among countries.

Table 3. Correlation Coefficients across Stock Markets for the Period 2005-2006

	Thailand	Malaysia	Indonesia	Singapore	Philippine	Korea	Japan	China	Hong Kong	Taiwan	India	USA (t-1)
Thailand	1											
Malaysia	.420**	1										
Indonesia	.373**	.345**	1									
Singapore	.403**	.396**	.543**	1								
Philippine	.218**	.250**	.316**	.291**	1							
Korea	.270**	.279**	.413**	.542**	.274**	1						
Japan	.279**	.299**	.396**	.553**	.278**	.625**	1					
China	.060	.144**	.064	.089	-.012	.149**	.121*	1				
Hong Kong	.359**	.333**	.519**	.622**	.277**	.583**	.575**	.193**	1			
Taiwan	.257**	.318**	.392**	.539**	.274**	.588**	.556**	.143**	.521**	1		
India	.262**	.178**	.479**	.486**	.214**	.411**	.392**	.056	.496**	.366**	1	
USA(t-1)	.230**	.279**	.378**	.431**	.380**	.322**	.352**	.122*	.425**	.368**	.330**	1

** significant at the 1% level
* significant at the 5% level

To assess the stability of the results, this paper analyzes the data divided into two sub-periods: January 2005-December 2006 and January 2006-December 2008. The results are shown in Tables 3 and 4, respectively. By comparing the results between Tables 3 and 4, we find that for the majority of Asian countries, the correlation coefficients increase from the first period (2005-2006) to the second period (2007-2008). In general, a more significant increase in the linkages is noted across ASEAN countries, as compared to the East Asian markets. At the individual country level, China and India recorded noticeable increases in correlations. For example, China evidenced insignificant correlation coefficients with Thailand, Indonesia, Singapore, Philippine, and India during the first period (2005-2006). However, all the correlation coefficients between China and the rest of Asian countries became significant during the second period (2007-2008). India also evidenced a marked increase in correlation coefficients with

Thailand from 0.262 to 0.520, and with Malaysia from 0.178 to 0.442. In the case of the U.S., however, its correlation coefficients with Singapore, Hong Kong, and India decreased slightly from the first period (2005-2006) to the second period (2007-2008), whereas the correlation coefficients with Philippine and Japan increase significantly, from 0.380 to 0.661 and from 0.352 to 0.631, respectively. These results demonstrate that the comovement of the Asian stock markets and their inter-dependence structures with the U.S. have strengthened over time.

Table 4. Correlation Coefficients across Stock Markets for the Period 2007-2008

	Thailand	Malaysia	Indonesia	Singapore	Philippine	Korea	Japan	China	Hong Kong	Taiwan	India	USA (t-1)
Thailand	1											
Malaysia	.487**	1										
Indonesia	.545**	.593**	1									
Singapore	.628**	.596**	.652**	1								
Philippine	.329**	.507**	.455**	.405**	1							
Korea	.595**	.551**	.610**	.762**	.492**	1						
Japan	.455**	.464**	.503**	.650**	.513**	.732**	1					
China	.199**	.314**	.252**	.334**	.267**	.314**	.279**	1				
Hong Kong	.593**	.500**	.575**	.823**	.445**	.745**	.676**	.461**	1			
Taiwan	.528**	.547**	.588**	.655**	.556**	.760**	.616**	.323**	.657**	1		
India	.520**	.442**	.530**	.653**	.293**	.551**	.446**	.276**	.625**	.474**	1	
USA(t-1)	.256**	.389**	.365**	.380**	.661**	.386**	.631**	.182**	.383**	.442**	.220**	1

** significant at the 1% level

4.3 Spillover Effects

Although correlation analysis has proven useful in examining the comovement of stock markets, it is not an appropriate method to identify the mechanism underlying transmission across stock markets. Rather, the extended GARCH model allows us to evaluate the spillover effects of stock returns and volatility across markets. Thus, using the extended GARCH model, in which the U.S. market returns are included as exogenous variables, this paper analyzes the spillover effects from the U.S. to 11 Asian countries, including Thailand, Malaysia, Indonesia, Singapore, the Philippines, Korea, Japan, China, Hong Kong, Taiwan, and India. The results for the full sample period (2005-2008) are provided in Table 5.

Table 5. Spillover Effect from the U.S. Market for the Period 2005-2008

$$R^{i}_{t} = \alpha + \beta R^{USA}_{t-1} + \varepsilon_{t} + \theta\varepsilon_{t-1},\ \varepsilon_{t} \mid \Omega_{t-1} \sim N(0,h_{t})$$

$$h_{t} = a + b\varepsilon^{2}_{t-1} + ch_{t-1} + \delta\varepsilon^{2}_{R^{USA}_{t-1}}$$

	Thailand	Malaysia	Indonesia	Singapore	Philippine	Korea	Japan	China	Hong Kong	Taiwan	India
α	0.0716	0.0080	0.1103*	0.0291	0.0095	0.0875*	0.0154	0.0785	0.0358	0.0252	0.1182*
β	0.2633**	0.2285**	0.5063**	0.4939**	0.6382**	0.5219**	0.6378**	0.2686**	0.5810**	0.4798**	0.4216**
θ	0.0701	0.1313**	0.0531	-0.1255**	0.0352	-0.0809	-0.1335**	0.0187	-0.0709	-0.0439	0.0232
a	1.1154**	0.0215*	0.1794**	0.0235**	0.2816**	0.1269**	0.0131	0.0352*	0.0130	0.0480*	0.1003**
b	0.3592**	0.2603**	0.1688**	0.1108**	0.1379**	0.0644*	0.0765**	0.0705**	0.0802**	0.0729**	0.1405**
c	0.0788	0.6752**	0.6274**	0.8253**	0.6409**	0.7532**	0.8943**	0.9262**	0.8855**	0.8376**	0.7557**
δ	0.0417	0.0355**	0.2324**	0.0463**	0.0340	0.1473**	0.0337**	0.0002	0.0480**	0.0673*	0.1645**
R^2	0.0265	0.1518	0.1217	0.1192	0.3383	0.1375	0.3636	0.0279	0.1520	0.1721	0.0398

** significant at the 1% level
* significant at the 5% level

As mentioned previously, the coefficients, β and δ, are used to measure the transmission mechanisms of return and volatility, respectively. First, we noted that the β coefficients were all significantly positive at the 1% level, thereby implying that the stock returns on the U.S. market exert a significant impact on the market returns of the 11 Asian markets. Among those, the stock markets of the Philippines and Japan are most sensitive to the daily changes of U.S. market returns, and Hong Kong, Korea, Indonesia, Singapore, Taiwan, and India are next in order in terms of U.S. influence. It is interesting to note the relatively weak influence of the U.S. on the stock markets of Thailand, Malaysia, and China.

In Table 5, we also note that the δ coefficients are significantly positive for the eight countries, thereby implying that a volatility surprise in the U.S. market affects the return volatility in the stock markets of Malaysia, Indonesia, Singapore, Korea, Japan, Hong Kong, Taiwan, and India. Among those, the Indonesian stock market is the most sensitive daily changes in U.S. market volatility, and India and Korea are next in order. However, U.S. market volatility exerts no impact on return volatility in the stock markets of Thailand, the Philippines, and China.

Table 6. Spillover Effect from the U.S. Market for the Period 2005-2006

$$R^i_t = \alpha + \beta R^{USA}_{t-1} + \varepsilon_t + \theta\varepsilon_{t-1},\ \varepsilon_t \mid \Omega_{t-1} \sim N(0,h_t)$$

$$h_t = a + b\varepsilon^2_{t-1} + ch_{t-1} + \delta\varepsilon^2_{R^{USA}_{t-1}}$$

	Thailand	Malaysia	Indonesia	Singapore	Philippine	Korea	Japan	China	Hong Kong	Taiwan	India
α	0.0473	0.0093	0.1303*	0.0671*	0.0513	0.1037*	0.0893	0.1213	0.0773*	0.0257	0.1833**
B	0.4262**	0.1656**	0.6605**	0.4240**	0.6751**	0.4914**	0.5110**	0.2644*	0.5141**	0.4921**	0.3872**
θ	-0.0608	0.1098	0.0777	-0.1419*	0.0476	-0.0448	-0.0596	0.0243	-0.0707	-0.0305	0.0678
a	0.1151	0.0211	0.2200**	0.0414*	0.0650*	0.1348	0.0010	0.0861	0.7509**	0.0527	0.1074
b	0.0171*	0.1430**	0.2084**	0.1104**	0.0803**	0.0615	0.0585*	0.0494*	-0.0365	0.0436*	0.1523**
c	0.9505**	0.7154**	0.5321**	0.7612**	0.8613**	0.7539**	0.9231**	0.8997**	-0.4410*	0.8369**	0.7020**
δ	-0.1387**	0.0311*	0.3195**	0.0387	0.0208	0.1453	0.0477	0.0344	0.1862*	0.0930	0.3060*
R^2	0.0749	0.0755	0.1327	0.1894	0.1450	0.1031	0.1231	0.0141	0.1813	0.1339	0.0768

** significant at the 1% level
* significant at the 5% level

Table 7. Spillover Effect from the U.S. Market for the Period 2007-2008

$$R^i_t = \alpha + \beta R^{USA}_{t-1} + \varepsilon_t + \theta\varepsilon_{t-1},\ \varepsilon_t \mid \Omega_{t-1} \sim N(0,h_t)$$

$$h_t = a + b\varepsilon^2_{t-1} + ch_{t-1} + \delta\varepsilon^2_{R^{USA}_{t-1}}$$

	Thailand	Malaysia	Indonesia	Singapore	Philippine	Korea	Japan	China	Hong Kong	Taiwan	India
α	0.0328	0.0362	0.0427	-0.0770	-0.0602	0.0692	-0.0764	-0.1045	-0.0327	0.0144	0.0157
β	0.2713**	0.2932**	0.4088**	0.5526**	0.6182**	0.5436**	0.6964**	0.3211**	0.6422**	0.4429**	0.4349**
θ	0.0583	0.1503	0.0512	-0.1400*	0.0274	-0.1147	-0.2299**	0.0811	-0.0794	-0.0514	-0.0206
a	0.0883	0.1605**	0.1246*	0.1097	0.4391*	0.0990*	-0.0010	6.3267**	0.0504	0.0373	0.0859
b	0.1209**	0.3360**	0.1079**	0.1185*	0.1623**	0.0724	0.0778**	0.2137**	0.1204**	0.1032**	0.1407**
c	0.7907**	0.5098**	0.7103**	0.7534**	0.5416**	0.7517**	0.8841**	-0.1913	0.8320**	0.8685**	0.7720**
δ	0.0401	0.0321	0.2048**	0.0675	0.0288	0.1552*	0.0456*	0.1006	0.0664	0.0192	0.1472**
R^2	0.0437	0.1453	0.1303	0.0786	0.4343	0.1430	0.4401	0.0254	0.1365	0.1873	0.0237

** significant at the 1% level
* significant at the 5% level

In order to evaluate the stability of the spillover effects, this study also analyzed the data divided into two sub-periods: i.e. January 2005-

December 2006, and January 2006-December 2008. The results are provided in Tables 6 and 7, respectively. By comparing the results between Tables 6 and 7, we determined that the mean spillover effect from the U.S. market to the stock markets of Malaysia, Singapore, Korea, Japan, China, Hong Kong, and India had increased from the first period (2005-2006) to the second period (2007-2008). In particular, Japan, Hong Kong, and Singapore evidence a significant increase in the influence of the U.S. On the other hand, in the cases of Thailand, Indonesia, Philippine, and Taiwan, the influence of the U.S. market was reduced from the first period (2005-2006) to the second period (2007-2008). Additionally, the volatility spillover effect from the U.S. market to the Asian stock markets yielded mixed results between the two sub-periods. Indonesia and India are only two countries that have a positively significant coefficient of δ in both sub-periods. Korea and Japan evidenced positively significant δ coefficients only in the second period (2007-2008), whereas Malaysia and Hong Kong evidenced a positively significant δ coefficient only in the first period (2005-2006).

5. Summary and Conclusions

This study addressed the issue of linkages between the stock markets of 11 Asian countries. Specifically, this paper evaluated the comovement of equity markets in Thailand, Malaysia, Indonesia, Singapore, the Philippines, Korea, Japan, China, Hong Kong, Taiwan, and India, as well as the dependence structures of these markets to the U.S. equity market. This paper utilizes the technique of correlation analysis and the extended GARCH model as the method of investigation. The data utilized herein consisted of the daily rates of return, measured in units of the local currency, on the market indices. The sample period covered spanned January 2005 through December 2008. The primary results of this study can be summarized as follows.

First, this paper evaluates the comovement of Asian stock markets and the U.S. market, using correlation analysis. We detected a strong linkage across the Asian markets and the U.S. market. We noted that the correlation coefficients across the Asian markets are remarkably high, thereby indicating the strong comovement of the Asian markets. Among those, the countries with more developed financial systems (i.e., Japan, Singapore, and Hong Kong in Asia) evidence stronger linkages to the rest of the Asian markets. On the other hand, China evidences the lowest levels of correlation with other Asian markets. These linkages are stronger in the East Asian markets than in those of the ASEAN countries. This suggests that the degree of dependence between equity markets is associated with the economic linkages among countries. A comparison of the results

between the first (2005-2006) and second (2007-2008) sub-periods demonstrates a recent strengthening of the linkages among the Asian markets. Generally, more significant increases in the linkages were observed across ASEAN countries as compared to the East Asian markets. At the individual country level, China and India recorded particularly profound increases in those correlations.

Second, using the extended GARCH model in which the U.S. market returns are included as an exogenous variable, this paper evaluates the spillover effects from the U.S. to the 11 Asian countries. We identified a significant mean spillover effect from the U.S. equity market to all 11 Asian markets. Among those, the stock markets in the Philippines and Japan were shown to be the most sensitive to daily changes in the U.S. market returns, and the markets of Hong Kong, Korea, Indonesia, Singapore, Taiwan, and India are next in order in terms of U.S. influence. U.S. influence on the stock markets of Thailand, Malaysia, and China is relatively weak. The mean spillover effect increased significantly from the first period (2005-2006) to the second period (2007-2008) for the majority of Asian countries, with the exception of Thailand, Indonesia, the Philippines, and Taiwan, in which U.S. market influence has decreased slightly. Additionally, a volatility spillover effect from the U.S. market to the stock markets of Malaysia, Indonesia, Singapore, Korea, Japan, Hong Kong, Taiwan, and India was observed. Among those, the Indonesian stock market was found to be most sensitive to daily changes in U.S. market volatility, and India and Korea are next in order. However, U.S. market volatility has no impact on return volatility in the stock markets of Thailand, the Philippines, and China. Additionally, the volatility spillover effect from the U.S. market to the Asian stock markets shows mixed results between the two sub-periods.

In conclusion, this study showed that the daily stock market movements of the Asian countries were closely linked to one another, and were influenced significantly by the U.S. market. These linkages have strengthened over time as these markets have grown in size and as government regulations have eased. The results of this paper have some implications regarding the potential benefits from the diversification of portfolios into the Asian equity markets. The benefits of such diversification appear to be rather small, as the linkages across the Asian stock markets and the U.S. market are rather strong. Therefore, greater attention should be paid to the Asian markets by global investors who seek to diversify their investment portfolios.

Endnotes:

[1] The ASEAN (Association of South East Asian Nations) is composed of 10 countries--including Thailand, Malaysia, Indonesia, Singapore, Philippine, Brunei, Vietnam, Myanmar, Laos, and Cambodia. Owing to the availability of stock market data, this paper analyzes five countries: Thailand, Malaysia, Indonesia, Singapore, and Philippine.

[2] Engle (1982) developed the ARCH model, wherein the conditional variance is a linear function of past squared errors as well as possible exogenous variables. Bollerslev (1986) generalized the ARCH model by construing conditional variance as a function not only of the past period's error squared, but also of its conditional variance.

[3] To save space, the results of statistical tests are not reported in this paper, but they are available upon request.

[4] In this paper, considering the trading time lag between the Asian countries and the U.S., the lagged daily returns (t-1) are used for the U.S. stock market data.

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