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ASSOCIATION BETWEEN ASIAN EQUITY MARKETS AND WESTERN MARKETS: EVIDENCE FROM THE INDEXES OF EQUITY MARKETS

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ABSTRACT

This research examined the time series characteristics of stock price indices for Hong Kong, Tokyo, New York (NYSE) and London (FTSE) equity markets or stock exchanges during the period of 1991 to 2012. Specifically, we calculate the rate of return and the volatility of return for all the markets and estimate the serial correlation and co-movement of the four markets. We find that the average rate of return varies dramatically for the four equity markets and across time. Further, we find that stock prices are positively serially correlated in general. In the multivariate regressions, we find that there is little evidence to show that either the rate of return in certain markets universally affects the rate of return in other equity markets. It suggests that the four markets are co-integrated but not universally across time and with each other in pairwise dimensions. Lastly, we studied and made conclusions concerning the mean and variation in the volatility of the rates of return in the four equity markets studied.

Keywords: Volatility, Correlation, Equity Markets.

INTRODUCTION

Our purpose is to study three sets of weekly price indices: Tokyo Composite Index, NYSE Composite Index, London Composite Index and the Hang Seng (Hong Kong, heretofore, Hang Seng) Composite Index provided by common data collected during the period of 1991-2012. Studies of these indices are important because of the rapid growth and influence of the Asian and especially the Chinese economies on the world, balance of trade and growth of Asian and other economies throughout the world (Chow et al. hereafter CMP, 1999; Jarrett and Sun, 2009).

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Previous studies (Chen, 1991; Cheung and Ng, 1998; Liaw, 2007) described China as an economic power offering tremendous opportunities for investment and growing business returns. Their financial markets for the earlier years in their development were thought not to be fully developed when analyzed by the criteria developed by financial economists using criteria for analyzing Western equity markets (Fama, 1990, 1991; Wei and Wong, 1992; and Zhong et al. 1999). Chow and Lawler (2003, data up and till 2002), and later, Jarrett and Sun (2012), analyzed the price index for the Shanghai Stock Exchange in comparison with the New York Stock Exchange Index in terms of its rate of return, volatility and structural changes in the movement of the index. In this study, we propose to analyze the entire period from January 1991 to December 2012 dividing the period into sub periods (sub samples) to analyze change associated with time and especially significant economic events. The comparisons have the purpose of revealing the behavior of stock movements in an emerging market in comparison with an established Western market. Previous studies by Bailey et al. (2009), Jarrett and Sun (2009A, B), Jarrett and Kyper (2010) focused on other issues in Chinese equity markets. We will now focus on two of the largest Asian equity markets because they are central areas of trade and economic activities not expressed only in the Shanghai equity market of China. Although previous studies show that Asian markets became and continue to integrate themselves with other and small Asian equity exchanges (Jarrett and Sun, 2012).

Another question relates to whether there is some integration between the New York and Shanghai markets as seen by studying the co-movement of stock prices in these exchanges. This will enable one to assess the degree of integration of the Chinese economy with the rest of the world as represented by the movement of prices in the New York Stock Exchange (NYSE). We will also look at the correlations among the Shanghai, NYSE and Hong Kong markets (Hang Seng Index) to examine their integration as well. Lastly, one notes that the Chinese financial markets are not open in the Western sense of the term but our study should yield some observations about the relative openness of the Chinese financial markets. We examine both the rate of return and the volatility of the price indexes. The rate of return is the change in the natural logarithm of the price index for a given time period. We follow Chow and Lawler (2003, hereafter CL) and Jarrett and Sun (2012, hereafter, JS) in measuring the volatility by the absolute value of the change rather than by its variance. The absolute value is less sensitive to extreme value as compared with ARCH-type models to study the residual variance of a time series model. Stated differently, we study the volatility of the rate of return itself and not the residual in the time series model of the rate of return. Following CL and JS, (1) the volatility in the rate of return and not the time series regression model residual is the subject of interest in financial research and (2), "since log stock price behaves approximately like a random walk, the rate of return itself and the residual of an auto regression of this rate are almost the same" (CL, p. 18). The data for this study include four sets of weekly price indices: Tokyo Composite Index, London Composite Index, NYSE Composite Index, and Hang Seng Composite Index provided during the period of 1991-2012. The rate of return is

calculated as the change in the natural logarithm of the price index in a given period. The volatility of returns is calculated as the absolute value of the change in the natural logarithm of the price index in a given period. We further divide our sample into three subsamples: before 1997, after 1997 and before 2007, and after 2007. The entire sample period is from October 1987 to October 2012. Both 1997 and 2007 are years in which the economic environment changed. In turn this affected the world's equity markets. Hence, we separated the data into three sub-time-periods. Lastly, we follow CL and JS in choosing the weekly data as the best choice among daily, weekly and monthly data.

To begin, we examine the characteristics of the equity markets. We calculate the mean and variance of the rate of return and the mean and variance of the measure of volatility. If both these measures reflect uncertainty, the volatility in Asian stock prices should be more volatile than those in New York. To study the co-movements of the price in the two markets, we calculate simple correlations and multiple regressions. The multiple regressions include auto regressions as well as ordinary multiple regressions. There was no rational reason to examine curvilinear models since the study of residuals did not indicate nonlinearity in relationships. The remainder of this paper is organized as follows: (1) the characteristics of the rate of return and the volatility of return; (2) correlation coefficients; (3) regressions of the rate of return; (4) regressions of the volatility of return; and (5) conclusions.

Rate of Return and Volatility of Shanghai and New York Price Indices

Table-1 shows the information for the Hong Kong, Tokyo, London and New York stock price indices including the market capitalization and the number of listed stocks. The sizes of the four financial markets indicate that the New York equity market is much larger than the other three equity markets in terms of market capitalization but not the number of listings. London is largest in terms of number of listings indicating that the market capitalization per listing is much smaller. Tokyo and Hong Kong are smaller than New York in terms of market capitalization and especially market capitalization per listing. There is a rich literature on the relationship between market listings and the size of the economy Levine and Zervos (1998). For a summary of current discussion on this topic see Levine (2005).

Table-1. Size and number of stocks

Stock Exchange	Market capitalization (US$ trillion)	Number of Listings
Hang Seng (Hong Kong)	2922	1554
London (FTSE)	3704	2753
New York (NYSE)	16528	2303
Tokyo	3715	2306

Table-2 shows the means and standard deviations (variation) of the rates of return for the four equity markets, while Table-3 presents the means and standard deviations of the volatility of

returns in the same four markets. For Table-2, the means are highest for Hang Seng followed by New York, London and Tokyo which is negative for the time period analyzed. The standard deviation is highest for Hang Seng followed by Tokyo, with New York and London being very close. As expected, we observe that the variations in the Asian markets are greater the Western markets. Observe the differences in the volatility in the rates of return for the same four equity markets. The Asian equity markets have higher volatility in the rates of return for the Western equity markets. The variation (standard deviation) in volatility is again much higher in the Hang Seng market than the others. The Tokyo market's standard deviation is again larger than the two Western markets.

Table-2. Means and variations (standard deviations) in rates of returns

Stock Exchange	Hang Seng	London	New York	Tokyo
Mean	.00154	.000904	.00127	-.00058
Standard deviation	.036744	.024216	.024149	.029756

Table-3. Means and variations (standard deviations) in volatility of returns

Stock Exchange	Hang Seng	London	New York	Tokyo
Mean	.026157	.017257	.016769	.022186
Standard deviation	.025842	.017006	.017418	.019828

The mean rate of return for Hang Seng (0.00154) is about twenty-five percent larger than the mean rates of return for New York (0.00127), more than 50 percent larger than London (0.00090) and the mean rate of return for Tokyo is negative (-0.00058). Thus, mean rate of return for Hang Seng is growing at a rate much larger than for the other equity markets. All three of them represent developed economies whereas Hang Seng, while not underdeveloped, is greatly influenced by the dynamics of the Chinese equity market and economy (Pan et al. 2012) due to shares being cross-listed with the Shanghai stock exchanges. If we were to consider change in price levels for the two nations by examining data onthe consumer price indexes for the four nations (although not a perfect comparison), the changes in prices would not account for the major portion of the differences in the average rates of return. This leads to a conclusion that the greater mean rate of return for the Hang Seng Index is not attributable to factors other than the investment opportunities in its market and the influence of dual-listed equities with those of China.

Volatility (as noted before) as measured by both the standard deviation of the rate of return and by the mean volatility in the rate of return is again larger for the Hang Seng stock market than for the three alternative stock markets. Table-2 shows a much larger variation for the Hang Seng stock index than for the others. Table-3 concurs by showing a much large mean volatility of return for Hang Seng as well. This suggests a great deal of uncertainty in the Hang Seng market in comparison to the other markets. Furthermore, the standard deviation of the measure in Table-3 is also much greater for Hang Seng than it is for New York, London and Tokyo. These results are not a revelation and are similar as those of CL ad JS. This would lead one to observe that the volatility

is subject to a greater degree of variation, that is the spread in the distribution in Hang Seng is greater than the distribution for the other three markets. Again, this is consistent with the previous findings by CL and JS. This is not to say that volatility does not exist or is even small in the other markets, but only to say that a risk-averse investor is better served by the developed markets of New York and London, whereas Tokyo appears not to serve well to any type of investor. To test how the two equity markets behave during extreme events, we sort sample period to three economic sub-periods and examine the mean and volatility of the rate of return during these periods: (1) 1987 through the last week of 1996; (2) 1997 to the end of 2007; and (3) after 2007 until the end of the sample data period. By studying these three periods, one may determine if severe economic changes occurring in 1997 and 2007 affect the two markets and whether the changes are different.

We find that a minuscule change in the mean rate of return for Hang Seng from period 1 to period 2 and the negative mean rate of return in period 3 reported in Table-4, Panel A. The mean rate of return for London remained similar in periods 1 and 2 but became negative in period 3. For New York, the mean rate increased from period 1 to period 2 but became negative slightly in period 3. The Tokyo index was positive slightly in period 1 but declined to a negative value in period 2 and more negative in period 3. After 2007 the declines are very evident in all markets. In studying variation, we observe the standard deviations of the rate of return are largest in all three periods for the Hang Seng Index. In all three time periods the Tokyo exchange had the second largest variation in rates of return but not nearly as large as that for the Hang Seng market. The two Western markets provided very similar results as those of the entire time period. The standard deviations were significantly smaller than Hang Seng and Tokyo, but the variation did increase largely in period 3. In Table-4, Panel B, we observe the changes in the mean and variation in the volatility of the rates of return for the four equity markets across the three time periods. The mean volatility in the rates of return did not change significantly in the three time periods. The order in terms of size of mean did not change. Hang Seng has the largest mean, followed by Tokyo with London and New York being small but very similar. For volatility variation, the standard deviation across all time periods indicated the greatest variation in Hang Seng followed by Tokyo with the London and New York markets varying for third and fourth place depending on the time period. The results demonstrate that mean rate fell in period 3 and variation and volatility increased in period 3 relative to the other periods. Tokyo appeared to have the smallest positive gains and was general in the negative for the mean rate of return. Although Hang Seng may have performed better than the two Western markets and Tokyo according to the mean rates, there is no doubt that the variation is much larger across the time periods in Hang Seng than in the more developed markets of the Western nations and Tokyo. Our results vary from CL and TS due to a lengthier time periods and the notion that we have three more developed markets, i.e. New York, London and Tokyo in comparison to the lesser developed market of Hoang Seng.

Table-4. Rate of return and volatility in three subsamples of time

Panel-A: Rate of return				
Before 1997	Hang Seng	London	New York	Tokyo
Mean	.002211	.00139	.001782	.000739
Standard deviation	.034593	.023234	.023377	.028932
1997-2007	Hang Seng	London	New York	Tokyo
Mean	.002375	.001343	.002007	-.0007
Standard deviation	.035467	.023152	.022162	.028911
After 2007	Hang Seng	London	New York	Tokyo
Mean	-.001	-.00053	-.0000536	-.00292
Standard deviation	.04304	.028973	.027447	.033904
Panel-B: Volatility of return				
Before 1997	Hang Seng	London	New York	Tokyo
Mean	.025867	.016402	.016929	.021376
Standard deviation	.024536	.015325	.015986	.017019
1997-2007	Hang Seng	London	New York	Tokyo
Mean	.026117	.017385	.016929	.021269
Standard deviation	.027727	.016204	.016744	.018854
After 2007	Hang Seng	London	New York	Tokyo
Mean	.026143	.015731	.015945	.021745
Standard deviation	.031060	.015707	.014756	.019406

The economic change occurring in the world during the three time periods kept the Hang Seng market more volatile and more profitable than the ones in New York, London and Tokyo. Risk-averse investors were better off in New York and London after 2007 because of the smaller level of volatility but they are giving up the possibility of higher return. The Tokyo market appeared to be the least wise choice for all three time period and also tended to be more risky than markets of New York and London. The differences in the sample statistics for the three time periods suggest that the rates of return and volatility in stock prices in nominal terms for the entire time period studied were not covariate stationary time series. This is the same conclusion for a much larger time period than observed by CL and TS. Their conclusions at this point are not disputed but only enhance by the study of the new and expanded analysis of the four markets. The previous studies only observe one Western and one Asian market (Shanghai, which is less developed and not much larger than Hang Seng).

The Correlation in Price Movements

Following CL and JS, we arrive at a preliminary view of the level of integration among the Han Seng, London, New York and Tokyo Exchanges by examining the simple (Pearson) correlation coefficients. Table-5 contains the Person Product Moment correlation coefficients of the four exchanges. All data came from known public sources. Note that the New York and London markets for the rate of return (Panel A) have a correlation of 0.710, indicating that almost 50% of variation in the two markets is associated with each other. The same Pearson Product Moment Correlation coefficients for all other two-by-two combination have coefficients between 0.437 and 0.5500. Although smaller, these coefficients are all significant at the .01 level of significance and indicate some relationship between the rates of return in each market. For volatility (Panel B,

Table-5) in the rates of return, again the London-New York combination indicates far greater correlation than for the other possible combination. However, the other combinations taken two at a time and Shanghai-Kong Kong are 0.022 and 0.096. Hence, the association between volatility in the rates of return are statistically different (at 1% level of significance), therefore, the association between the volatility in the rates of return among these four markets taken two at a time are differ in the statistical sense. Unlike TS and to some extent CL, we observe that these markets influence each other. Table-5 indicates that at first glance that the four exchanges covariate or are related to each other over the time period studied. Whereas the London and New York markets do show more co-variation, therefore they are often influenced by the same economic factors. The smaller but non insignificant correlation coefficients for the rate of return and volatility of return for the other combinations of exchanges suggest that these equity markets operate with each other and pairwise independence does not exist. These differ from the earlier studies of CL and JS and therefore lead us to different conclusion. However, the CL and JS study followed the relation of Shanghai and New York in a small time environment. These results would never be the same but our conclusions suggest a different pattern of behavior.

Table-5. Rates of return and volatility in three subsample time periods

Panel-A: Rates of return				
	Hang Seng	London	New York	Tokyo
Hank Seng	1			
London	.550034	1		
New York	.43722	.71018	1	
Tokyo	449219	.449219	.471573	1
Panel-B: Volatility of return				
	Hang Seng	London	New York	Tokyo
Hank Seng	1			
London	.443104	1		
New York	.391989	.649569	1	
Tokyo	.319339	.385721	.353906	1

Previous research on the relations between large and small stock returns in six Asian (Pacific-Basin) nations and the association among the same six Asian financial markets is exemplified by Jarrett and Sun (2009A). Their purpose was to provide evidence of the cross-autocorrelation of stock returns in a lengthy time period. Evidence was brought to bear as to the theoretical explanations for stock market behavior of Pacific-Basin nations including those with large financial markets, i.e. Japan and Hong Kong, and those with small financial markets, i.e. Thailand and Malaysia. This study though different than ours indicates clearly the relationship of large and small equity markets and give us further desire to learn more about the cointegration of equity markets throughout the world. We can now still learn more about the level of integration in these four markets by analyzing multiple regressions, and in doing so we exclude the influence of the delayed effects of lagged explanatory variables.

Regressions of the Rate of Return

We define the rate of return to be the change in the natural logarithm of the stock price from period t-1. According to the efficient markets hypothesis (EMH), the rate of return is difficult to predict with any reasonable level of accuracy. Hence, we wish to determine if there is validity in this hypothesis and whether rates of return in the four markets are correlated after excluding the influence of their own lagged values. We construct a model to explain the Hang Seng rate of return by its own past values. By constructing a model with many lagged values of the rate of return and calculate the Akaike Information Criterion (AIC), we find that AIC is minimized at a lag of one. In turn, we find the first-order auto regression which appears in column (2) of Table-6. The coefficient (H_1) is 0.0551 with a *t-statistic* of 1.48 for all data which is not significant at the reasonable level of $\alpha \leq 0.05$ (the p-value being large). According to this result the weak form of the efficient markets hypothesis does hold for this time period. For London, L1 is 0.0912 (*t-statistic* =3.34), for New York, N1 is -0.0555 (*t-statistic* = -2.03), and for Tokyo, T1 is 0.0777 (*t-statistic* = 2.85). The results are mixed but all have *t-statistics* that are significant at $\alpha \leq .05$. Next, we will further investigate this phenomenon by dividing the time series data into the same three sub-periods analyzed previously. For all four equity markets, we subdivide the data into the three time periods noted previously. In all three time periods the lagged variable of one resulted in coefficients of 0.143, 0.0021 and -0.0161 for Hang Seng, but only the first had a sufficiently large enough *t*-statistic to reject the null hypothesis of the parameter equaling zero. Thus, the results are mixed for the Hang Seng market. For the auto regression of London, we find the L1 coefficients to be 0.1394, 0.0277 and 0.1168. However, only the coefficient for period (before 1997) is significant at $\alpha \leq 0.05$. Again the London market yields mixed results. For New York, N1 = -0.0282, -0.0947 and -0.0433. Only the period 1997-2007 had a significant *t-statistic.* Lastly, for Tokyo, the coefficients for T1 are 0.0770, 0.0348 and 0.1396. Only the period after 2007 has a significant *t-statistic.* These results are not entirely the same as those of CL or JS, but do indicate that change occurred among the three sample sub-periods studied. The results are mixed in all four equity markets indicating different effects during the entire time period and differential effect in each of the sub periods. CL and JS observed that lack of strong correlation between the equity markets of New York and Shanghai which corroborate an earlier and similar study of Bekaret and Harvey (1995). With the continued and dynamic development of the of the Asian equity markets, we should now observe the more recent analysis of their cointegration exhibited in Table-7 (panels A and B). In column 2, Table-7, we note the value of L2 and its related ***t****-statistic* of 0.5910 and 12.13.

The values indicate that the current Hang Seng rate of return (the response variable) associated with the current London rate of return (the explanatory variable) is both small and significant. Further, with a ***t***-statistic of 2.17 (for N0), we find that the coefficient of the contemporaneous New York rate has association with the Hang Seng rate of return for the entire time period studied. For NO, N1 and T0, with T2 in column 2 in Panel B (All Data), one observes small and significant *t-statistics*. This supports the notion that the two markets are integrated and have some association

with each other during the entire time period studied. By examining the three sub periods (e.g. before 1997, 1997 – 2007 and after 2007) one continues to observe the small and some significant *t-statistics* among all the equity markets paired with each other. In general, the latter two sub periods provide *t-statistics*were not significant. This is the only noticeable change associated with change in time period. Hence, only for the periods starting in 1997 did the relationship change between the equity markets studied for the four equity markets. Additional tests such as the Chow test based on the *F*-distribution do not reject the hypothesis that the coefficients of the three sub sample time periods are the same.

Table-6. Auto regressions of the rates of return on equities listed in the four exchanges

	Hang Seng				**London**			
	all	before 97	97-07	after 07	all	before 97	97-07	after 07
cH	0.0015	0.0028	0.0012	-0.0011				
T	1.4757	1.7151	0.8313	-0.4567				
H1	0.0551	0.1434	0.0021	-0.0161				
T	2.0134	3.2739	0.0495	-0.2525				
cL					0.0008	0.0014	0.0007	-0.0004
T					1.2288	1.5526	0.7924	-0.1834
L1					0.0912	0.1394	0.0277	0.1168
T					3.3412	3.1726	0.6644	1.8460
	New York				**Tokyo**			
	all	before 97	97-07	after 07	all	before 97	97-07	after 07
cN	0.0013	0.0020	0.0015	-0.0007				
T	1.9943	2.2560	1.7130	-0.2925				
N1	-0.0555	-0.0282	-0.0947	-0.0433				
T	-2.0316	-0.6400	-2.2701	-0.6816				
cT					-0.0006	0.0000	-0.0005	-0.0019
T					-0.6899	-0.0382	-0.3874	-0.8348
T1					0.0777	0.0770	0.0348	0.1396
T					2.8492	1.7506	0.8335	2.2147

Regressions of the Volatility of Rates of Return

We construct a regression model with the purpose of explaining the volatility in the Hang Seng and the other three equity markets. First, we account for the effects of their own volatility associated with their past values. Following CL and JS the appropriate number of lagged explanatory variables to include in the respective models is determined by (1) the significance of individual parameter estimates; (2) by minimizing the AIC value; and (3) the presence or absence of serial correlation in the residual. By including one lagged response variable at a time, we follow CL and JS and observe the three criteria to construct a model explaining the current volatility in the four stock exchanges.

Table-7. Regressions of rate of return in all four markets

	Hang Seng				London			
Panel A	All	before 97	97-07	after 07	all	before 97	97-07	after 07
C	0.0007	0.0010	0.0004	0.0001	0.0000	0.0001	-0.0002	0.0002
T	0.8419	0.6892	0.0004	0.0729	-0.0486	0.0988	-0.4164	0.2861
H0					0.1686	0.1883	0.1345	-0.0113
T					12.1268	8.3645	6.8969	-0.2899
H1	-0.0226	0.0294	-0.0248	-0.1408	0.0124	0.0518	-0.0212	-0.0270
T	-0.9182	0.7560	-0.6451	-2.3505	0.9422	2.4745	-1.1437	-0.7393
H2								
T								
L0	0.5910	0.6441	0.5756	-0.0310				
T	12.1268	8.3645	6.8969	-0.2899				
L1								
T								
L2	0.1263	0.2140	0.0604	0.0770	0.0144	0.0436	-0.0157	0.0150
T	3.2723	2.9532	1.0191	1.1213	0.6968	1.1051	-0.5461	0.3610
N0	0.1055	0.0120	0.1918	0.4586	0.5420	0.3063	0.6467	0.7613
T	2.1745	0.1551	2.2049	4.4974	25.4771	7.7579	20.0077	18.5142
N1	0.2338	0.4311	0.1693	0.2348	0.0012	0.0841	-0.0008	0.0323
T	6.1920	5.8711	2.5904	3.6223	0.0603	2.0590	-0.0243	0.8060
N2								
T								
T0	0.2517	0.1395	0.2853	0.4518	0.0993	0.1334	0.0481	0.1233
T	7.8635	2.5713	5.9649	6.9886	5.7496	4.6138	2.0240	2.9351
T1								
T								
T2	-0.0606	-0.1300	0.0041	-0.0565	-0.0038	0.0077	0.0029	-0.0334
T	-1.9513	-2.4176	0.0885	-0.9525	-0.2286	0.2649	0.1277	-0.9351
S.E. of Reg	0.0293	0.0311	0.0290	0.0221	0.0156	0.0168	0.0140	0.0133
R-squared	0.3709	0.3046	0.3563	0.6706	0.5865	0.3631	0.6124	0.8426

Table-7. Regressions of rate of return in all four markets

Panel B	New York				Tokyo			
	All	before 97	97-07	after 97	all	before 97	97-07	after 07
C	0.0009	0.0017	0.0010	0.0002	-0.0015	-0.0012	-0.0014	-0.0015
t	1.9022	2.0707	1.7059	0.2124	-2.2647	-1.0395	-1.3933	-1.2074
H0	0.0336	0.0040	0.0443	0.1688	0.1766	0.0923	0.2069	0.3730
t	2.1745	0.1551	2.2049	4.4974	7.8635	2.5713	5.9649	6.9886
H1	0.0024	-0.0240	0.0289	0.0965	-0.0559	-0.0572	-0.0371	-0.1466
t	0.1700	-1.0728	1.5668	2.6635	-2.7234	-1.8115	-1.1347	-2.7041
H2								
t								
L0	0.6054	0.3464	0.6399	0.7712	0.2443	0.3020	0.1492	0.2800
t	25.4771	7.7579	20.0077	18.5142	5.7496	4.6138	2.0240	2.9351
L1								
t								
L2	-0.0076	-0.0334	0.0276	-0.0485	0.0071	0.0135	-0.0470	0.1192
t	-0.3498	-0.7959	0.9687	-1.1651	0.2185	0.2275	-0.9304	1.9202
N0					0.2904	0.1848	0.2757	0.2284
t					7.2744	2.9663	3.7519	2.3954
N1	-0.1095	-0.1224	-0.1079	-0.1464	0.1449	0.0766	0.2089	0.1812
t	-5.1170	-2.8262	-3.4506	-3.7269	4.5541	1.2429	3.7779	3.0529
N2								
t								
T0	0.1319	0.0923	0.0879	0.1018				0.0015
t	7.2744	2.9663	3.7519	2.3954				0.0276
T1								
t								
T2	0.0021	-0.0132	-0.0064	0.0408	0.0615	0.0827	0.0381	
t	0.1198	-0.4255	-0.2882	1.1337	2.3657	1.8862	0.9668	
S.E. of Reg	0.0165	0.0179	0.0140	0.0134	0.0245	0.0253	0.0247	0.0201
R-squared	0.5357	0.1767	0.5892	0.8628	0.3268	0.1582	0.2655	0.7049

In Table-8, we find for Hang Seng (All Data) that all lagged variables have significant *t-statistics* (12.23, 4.19, 1.98, and 3.59). Tests for serial correlation applied to the model having four lagged values yield a small and significant *t-statistics*. Column 2 (All Data) and Column (5) of Table-8 Panel A, and columns (2) and (5) of Panel B show the results for all four stock exchanges. London (All Data) has large significant coefficients for lags 1, 2 and 3 but small and non-significant marginal coefficients for lag 4. For New York, significant lags were found at 1, 2 and 3 but not 4.

Table-8. Auto regressions of volatility of equity prices in four exchanges.

	Hang Seng				**London**			
	All	before 97	97-07	after 07	all	before 97	97-07	after 07
C	0.0170	0.0182	0.0153	0.0175	0.0097	0.0091	0.0109	0.0121
T	12.2321	8.1431	7.3969	5.0847	11.5282	7.5243	8.5444	4.6571
VOL_HANG(-1)	0.1147	0.1217	0.1227	0.0551				
T	4.1947	2.7296	2.9777	0.8625				
VOL_HANG(-2)	0.0826	0.1113	0.0382	0.1084				
T	2.9990	2.4720	0.9221	1.7173				
VOL_HANG(-3)	0.0546	0.0044	0.0731	0.1549				
T	1.9811	0.0976	1.7642	2.4531				
VOL_HANG(-4)	0.0985	0.0297	0.1841	0.0777				
T	3.5851	0.6577	4.4608	1.2173				
VOL_LONDON(-1)					0.1474	0.2004	0.1382	0.1006
T					5.3820	4.5407	3.3050	1.5719
VOL_LONDON(-2)					0.1530	0.1560	0.1298	0.1497
T					5.5544	3.4634	3.0772	2.3843
VOL_LONDON(-3)					0.1027	0.0069	0.0358	0.2128
T					3.7277	0.1531	0.8491	3.3881
VOL_LONDON(-4)					0.0325	0.0592	0.0423	0.0058
T					1.1855	1.3295	1.0124	0.0902
	New York				**Tokyo**			
	All	before 97	97-07	after 97	all	before 97	97-07	after 07
C	0.0076	0.0077	0.0109	0.0102	0.0138	0.0094	0.0189	0.0165
T	10.1294	7.7845	8.3144	4.1345	12.5892	6.1758	10.2829	5.6281
VOL_NYSE(-1)	0.2746	0.3989	0.0982	0.2763				
T	10.0024	8.9669	2.3469	4.3211				
VOL_NYSE(-2)	0.0835	0.0005	0.0298	0.1122				
T	2.9678	0.0107	0.7129	1.7216				
VOL_NYSE(-3)	0.1532	0.0817	0.1303	0.1887				
T	5.4426	1.7115	3.1231	2.8964				
VOL_NYSE(-4)	0.0333	0.0680	0.0798	0.0137				
T	1.2087	1.5041	1.9035	0.2145				
VOL_TOKYO(-1)					0.1761	0.1847	0.0902	0.2315
T					6.4201	4.2169	2.1535	3.6229
VOL_TOKYO(-2)					0.0596	0.0528	0.0384	0.0548
T					2.1547	1.1963	0.9174	0.8410
VOL_TOKYO(-3)					0.1223	0.1348	0.0898	0.1226
T					4.4214	3.0507	2.1449	1.8797
VOL_TOKYO(-4)					0.0233	0.1660	-0.0517	0.0624
T					0.8477	3.7830	-1.2354	0.9759

Lastly, for Tokyo, significant coefficients were found at lags 1, 2 and 3 but not 4. Hence, in all four markets, there tended to be significant autocorrelation up to lag 3. Similar results were found also when we observe the results of studying the individual three sub periods noting that the sample sizes for sub periods are smaller than for the entire time period. Table-8 shows that significant auto regressive coefficients in equity markets indicate an association with its own lagged variables. It is a well-known that observations from previous studies including CL and JS resulted in a similar analysis and conclusion. As before, we test for structural change in each equity market by dividing our time period into three sub periods. Columns 3, 4, 5, 6, 7, and 8 of Table-8, Panels A and B. Although the results are universally similar, for the most part, the auto regressions for all four equity markets exhibit outcomes that are very similar to each other. Tests for equality among the three sub periods for each market would show the same results. In conclusion, all four markets suggest that each market has some parameter stability during the lengthy period studied and the effect of changes in time as expressed by the three sub periods indicate that this is true for each market but with some disparities.

At this point, we introduce lagged values of the other markets to ascertain whether the volatility in the former market indicates *Granger causality* (Granger, 1969). To determine *Granger causality* in Hang Seng volatility, we choose the number of lagged values of New York, London and Tokyo volatility according to the criteria noted before (e.g. AIC and the absence of serial correlation in the residuals). Our results for the whole sample period (All Data), reported in column 2 of Table 9, we have only lag 1 for New York, lag 1 for London, and lag 1 for Tokyo. The *t-statistic* for New York is 7.1744, and therefore is significant at a very small probability, (significance level of $\alpha \leq 0.01$). This indicates that the volatility in the Hang Seng equity market is associated with the lagged value in New York. Since the *t-statistics* are not significant for London and Tokyo, we cannot draw the same conclusion. CL and the JS comparisons were not for Hang Seng but for Shanghai, thus these results differ. Hence, we conclude that only the New York volatility at one lag was associated with Hang Seng for the entire time period. Thus, *Granger causality* exists between Hang Seng and New York but not for the others. Hence, this indicates that the volatility in the markets for the entire time period were likely independent of each other. Unlike CL, we did not observe negative coefficients for N1 and N2 in the entire time period studied.

To be consistent with the findings of CL, we observed only the H_1 (lag of 1) and this time the coefficient is not significant (at $\alpha = 0.05$ or less). The AIC value suggests not including any lagged values of the Hang Seng variables. In addition, the Breusch-Godfrey test revealed the absence of serial correlation in the autoregressive model. The model with one Shanghai lagged variable (S1) is contained in column 7 of Table-9. The negative coefficient corroborates the results of CL but in this study this coefficient is not significant. Hence, by *Granger causality*, the Shanghai volatility and New York volatility do not have a *Granger* cause relationship. Lastly, when we compare the Root MSE of the Shanghai and New York models, we not that the small residual variation in the

New York regression and hence, it is more predictable than Shanghai volatility. An additional question relates to whether or not there is significant co-variation of volatility in a multivariate setting. To incorporate instantaneous causality in explaining Hang Seng volatility, one adds the current value of the variable in the other markets in the auto regression. One observes the result for Hang Seng in column 2 of Table-9, Panel A and the results for New York in column 6 of Table-9, Panel A. The coefficients for the New York variables (All Data) show some positive coefficients but only N1 is significant. This would indicate that extended time period in this study resulted in some Hang Seng volatility being related to New York volatility in a lagged time period. A wholly different interpretation results when we observe the *t-statistics* for N1 in the sub periods. The coefficient is significant only before 1997. The latter two time periods yield no significant coefficient. If we go line by line and column by column through all the data in Table-9, we do not find consistency from period to period in pairwise combinations. Thus, we could conclude that the relationships among the markets change during the sub periods indicating the dynamic aspects of the four equity markets studied. Volatility is present and changes the relationships of markets due to economic conditions, law affecting these markets the growth of emerging markets versus more established markets. There is little doubt that market volatility is ever changing and the prediction of this volatility is not easily accomplished.

Table-9, Panel B, contains the analysis for London and Tokyo. Note, for London and Hang Seng only H_0 and H_1 have significant *t-statistics* for all data and pre-1997. The coefficients then do not have significant *t-statistics* for the '97 to '07 and the post '07 sub periods. The same is true for the relationship of Tokyo and Hang Seng. Tokyo, although a Pan-Pacific exchange is not an emerging market and often reacts more like the Western markets studied here than the Hang Seng market. Without going through the analysis to compare individual coefficients, we observe the different effects of change in time and the pairwise relationship of markets. As long as economic conditions change, the results include temporal instabilities in markets. Our study is lengthy and exhaustive but much of its results are not unnerving since we already know that markets vary in prices and volatility, but these factors have components that are predictable when using modern time series analysis. For example, see Ray, Chen and Jarrett (1997) where the authors show that firms listed on the Tokyo exchange contain components (permanent and temporary) which may in turn, lead to better predictions. Lastly, the results for the models for the volatility in equity returns for all the equity markets, we find the effect of the Asian equities leading to the same for of temporal instability of the parameters of the Western equity markets. Simply stated the inclusion of the Hang Seng or Tokyo variables do not result in stable relationships throughout the three sub periods studied. There are observed structural changes related to each time period. Hence, we conclude that the concept of temporal stability is not present.

Table-9. Regressions of Volatility of Equity Returns (Panel-A)

	Hang Seng (Hong Kong)				**New York**			
Lag	all data	pre 1997	1997 - 2007	post 2007	all data	pre 1997	1997 - 2007	post 2007
constant	0.0067	0.0040	0.0043	0.0081	0.0016	0.0062	0.0035	-0.0009
t	4.6933	1.5682	1.6954	3.6023	2.1719	5.0352	2.4732	-0.6762
H0					0.0626	0.0181	0.0820	0.1252
t					4.1032	0.7816	3.5951	3.1320
H1	0.0367	-0.0022	0.0363	-0.0192	-0.0606	-0.0810	-0.0174	-0.0111
t	1.3350	-0.0497	0.8348	-0.3316	-3.9419	-3.5288	-0.7534	-0.2770
H2	0.0579	0.1038	0.0035	0.0634				
t	2.3569	2.5838	0.0882	1.5126				
H3	0.0175	0.0018	0.0603	0.0168				
t	0.7159	0.0442	1.5171	0.3983				
H4	0.0706	0.0251	0.1688	0.0563				
t	2.8910	0.6263	4.2549	1.3289				
N0	0.1872	0.0905	0.2525	0.2694				
t	3.8715	1.0520	3.0637	3.2627				
N1	0.1498	0.5880	0.0390	-0.1122	0.1378	0.2721	0.0568	0.0895
t	3.0287	6.3924	0.4711	-1.2774	4.9332	5.5828	1.2885	1.4580
N2					0.0384	-0.0086	0.0324	0.0352
t					1.7116	-0.1738	0.8943	1.0850
N3					0.0753	0.0302	0.0649	0.0806
t					3.3684	0.6562	1.7885	2.5036
N4					0.0287	-0.0701	0.0393	0.0330
t					1.3237	-1.6226	1.0867	1.0462
L0	0.4059	0.3856	0.4499	0.0881	0.5317	0.2503	0.4692	0.7194
t	8.2119	4.2872	5.7096	1.0350	21.7637	5.3655	12.4378	17.4484
L1	-0.0294	0.0431	0.1281	-0.0797	0.0429	0.1629	0.0387	0.0243
t	-0.5805	0.4795	1.5739	-0.9163	1.5139	3.4054	0.8976	0.4019
L2								
t								
L3								
t								
L4								
t								
T0	0.1979	0.2145	0.0810	0.4361	0.0862	0.0538	0.0258	0.0742
t	5.7443	3.4252	1.4350	8.3078	4.4295	1.6570	0.8596	1.8575
T1	-0.0807	-0.1282	-0.0500	0.1020	-0.0642	-0.0903	-0.0490	-0.0860
t	-2.3109	-2.0419	-0.8811	1.7423	-3.2810	-2.7869	-1.6379	-2.1385
R-squared	0.2562				0.4841			
S.E. of reg	0.0224				0.0126			

Table-9. Regressions of Volatility of Equity Returns

Panel B. London and Tokyo								
	London				Tokyo			
Lag	all data	pre 1997	1997 - 2007	post 2007	all data	pre 1997	1997 - 2007	post 2007
constant	0.0006	0.0020	0.0008	0.0018	0.0072	0.0054	0.0152	0.0013
t	0.7497	1.5375	0.5430	1.2907	6.3991	3.0480	6.8879	0.6632
H0	0.1172	0.0918	0.1278	0.0507	0.1234	0.1060	0.0560	0.4345

t	8.0873	4.2819	5.6012	1.2682	5.8244	3.5039	1.6488	8.1495
H1	0.0413	0.0509	0.0163	-0.0198	0.0067	0.0045	0.0234	0.0607
t	2.7839	2.3904	0.6943	-0.4978	0.3123	0.1497	0.6922	1.0449
H2								
t								
H3								
t								
H4								
t								
N0	0.5008	0.2231	0.5014	0.7094	0.1644	0.1150	0.0584	0.1863
t	22.1211	5.4647	12.7519	17.4139	4.3452	1.9392	0.8976	2.2223
N1	0.0320	0.2150	-0.0820	0.0926	0.0514	0.0255	0.0285	0.1386
t	1.1845	4.7276	-1.8273	1.5363	1.3212	0.3881	0.4386	1.5838
N2								
t								
N3								
t								
N4								
t								
L0					0.2164	0.1326	0.1644	0.2316
t					5.5036	2.1230	2.5887	2.7207
L1	-0.0372	-0.0060	0.0489	-0.1211	-0.1048	-0.1848	0.0255	-0.0451
t	-1.3597	-0.1372	1.1041	-2.0478	-2.6452	-3.0423	0.3968	-0.5102
L2	0.0468	0.0631	0.0982	-0.0307				
t	2.2473	1.5748	2.7415	-0.9894				
L3	0.0145	0.0050	-0.0188	-0.0068				
t	0.6975	0.1258	-0.5303	-0.2171				
L4	-0.0133	0.0609	0.0029	-0.0665				
t	-0.6457	1.5616	0.0833	-2.1433				
T0	0.1026	0.0687	0.0807	0.1045				
t	5.4818	2.2466	2.6591	2.6538				
T1	0.0510	0.0398	0.0528	0.0892	0.1408	0.1982	0.0439	-0.0006
t	2.6956	1.2914	1.7264	2.2505	5.1117	4.5193	0.9916	-0.0109
T2					0.0487	0.0579	0.0177	0.0004
t					1.9108	1.3472	0.4079	0.0085
T3					0.0709	0.1243	0.0338	-0.0010
t					2.7797	2.9151	0.7801	-0.0239
T4					0.0152	0.1694	-0.0458	-0.1175
t					0.6017	3.9937	-1.0610	-2.8570
R-squared	0.4946				0.2229			
S.E. of reg	0.0122				0.0176			

Table-9. Regressions of Volatility of Equity Returns (Panel-B)

	London				**Tokyo**			
Lag	all data	pre 1997	1997 - 2007	post 2007	all data	pre 1997	1997 - 2007	post 2007
constant	0.0006	0.0020	0.0008	0.0018	0.0072	0.0054	0.0152	0.0013
t	0.7497	1.5375	0.5430	1.2907	6.3991	3.0480	6.8879	0.6632
H0	0.1172	0.0918	0.1278	0.0507	0.1234	0.1060	0.0560	0.4345
t	8.0873	4.2819	5.6012	1.2682	5.8244	3.5039	1.6488	8.1495
H1	0.0413	0.0509	0.0163	-0.0198	0.0067	0.0045	0.0234	0.0607
t	2.7839	2.3904	0.6943	-0.4978	0.3123	0.1497	0.6922	1.0449
H2								
t								
H3								

t								
H4								
t								
N0	0.5008	0.2231	0.5014	0.7094	0.1644	0.1150	0.0584	0.1863
t	22.1211	5.4647	12.7519	17.4139	4.3452	1.9392	0.8976	2.2223
N1	0.0320	0.2150	-0.0820	0.0926	0.0514	0.0255	0.0285	0.1386
t	1.1845	4.7276	-1.8273	1.5363	1.3212	0.3881	0.4386	1.5838
N2								
t								
N3								
t								
N4								
t								
L0					0.2164	0.1326	0.1644	0.2316
t					5.5036	2.1230	2.5887	2.7207
L1	-0.0372	-0.0060	0.0489	-0.1211	-0.1048	-0.1848	0.0255	-0.0451
t	-1.3597	-0.1372	1.1041	-2.0478	-2.6452	-3.0423	0.3968	-0.5102
L2	0.0468	0.0631	0.0982	-0.0307				
t	2.2473	1.5748	2.7415	-0.9894				
L3	0.0145	0.0050	-0.0188	-0.0068				
t	0.6975	0.1258	-0.5303	-0.2171				
L4	-0.0133	0.0609	0.0029	-0.0665				
t	-0.6457	1.5616	0.0833	-2.1433				
T0	0.1026	0.0687	0.0807	0.1045				
t	5.4818	2.2466	2.6591	2.6538				
T1	0.0510	0.0398	0.0528	0.0892	0.1408	0.1982	0.0439	-0.0006
t	2.6956	1.2914	1.7264	2.2505	5.1117	4.5193	0.9916	-0.0109
T2					0.0487	0.0579	0.0177	0.0004
t					1.9108	1.3472	0.4079	0.0085
T3					0.0709	0.1243	0.0338	-0.0010
t					2.7797	2.9151	0.7801	-0.0239
T4					0.0152	0.1694	-0.0458	-0.1175
t					0.6017	3.9937	-1.0610	-2.8570
R-squared	0.4946				0.2229			
S.E. of reg	0.0122				0.0176			

CONCLUDING REMARKS

We collected, analyzed and interpreted an extensive database of the stock market indices for equity markets of New York, London, Tokyo and Hong Kong (Hang Seng). Our purpose is to draw conclusions concerning the relationships of the various equity markets expressed by an analysis of the mean and volatility of rates of return in the four stock exchanges over a lengthy period of time and during three distinct sub periods. We first examined the time series characteristics of stock price indices for all four exchanges during the period of 1987 to 2012. Specifically, we calculated the rate of return and the volatility of returns for the four markets and estimate the serial correlation and co-movement of the equity markets. We find that the mean rates of return in vary for the four equity markets and noting that Hang Seng and Tokyo have differences in their rates of return. Volatility in the rates of return also differs among the four equity exchanges. Across the three sub periods defined by time the relationship are not stable. This, perhaps, is the most crucial of the general findings of this analysis. Relationships among the markets across time periods change.

Investigations into the influences of the economic environment in which the markets operate would indicate what some of the causes are or at least associations with changes in mean and variability of rates of return and volatility in the rates of return would add to ones knowledge of explaining and predicting relationship among the four market specific exchanges.

Furthermore, we find that serial correlation also differs in the four equity markets. The use of multivariate time series analysis (see Kuvita, 2010; Chen, Minary and Lai, 2005; and Juselius, 2006) may provide further evidence for the lack of co-integration in these stock exchanges. One last suggestion is to examine each individual index to access where there are temporary and permanent components in these indices in the manner of Ray et al. (1997) for the Japanese market. This would answer questions concerning temporal stability in the indices of Chinese equity markets. In the future, we expect studies to continue in areas of the so-called emerging markets of Asia (and South America as well) to relate in a similar context to show correlations among emerging markets, i.e. India, China and so forth, and the developed nations of Europe, North America and Japan. These studies may also use highly regarded multivariate time series analysis including Transformation and Intervention analyses.

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