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Are Chinese Stock Markets Integrated with International Markets?

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* Key contact and conference presenter. This paper is derived from investigations undertaken in completion of Honours year research.

Abstract

This article investigates whether or not Chinese stock markets are integrated with international markets, based on analysis of daily data of the Shanghai “A”, Shanghai “B”, Shenzhen “A”, Shenzhen “B”, Hang Seng, and Dow Jones Industrial Average indices from 2002 to 2005. Cointegration analysis and Granger Causality tests give rise to results that imply that Chinese stock markets are becoming more integrated to global stock markets. These results further support the assertion that continual financial liberalisation and deregulation of Chinese stock markets will inevitably create a more conducive environment for investment, both domestically and internationally.

I. Introduction

In recent years, studies have focused on the efficiency of stock markets in developing countries. Much of this research suggests that development of stock markets in countries which are at an appropriate stage of economic growth offer tremendous financial benefits to participants (Singh, 1999). China established its national stock exchanges in the early 1990s. Over the subsequent years there has been gradual liberation of regulations governing the financial system and stock markets in particular.

While the Chinese stock markets have been widely praised for their contributions to the economy, they have also been criticised on fundamental issues such as market segmentation, market illiquidity, thin trading, government intervention, and lack of market transparency (Groenewold, Wu, Tang and Fan, 2004). These operational and allocational inefficiencies have inevitably constrained the flow of information, restricted market growth, but have also led to the emergence of predictable elements in Chinese stock market returns (Ma, 2004).

Laurence et al. (1997) study the daily indices data of the Chinese Shanghai (A and B index) and Shenzhen (A and B index), Hang Seng, and the Dow Jones Industrial Average from 1993 to 1996. They test weak-form efficiency in Chinese markets and explore the statistical relationships and Granger (1969) causality among the Chinese stock markets with each other, and with the Hong Kong and U.S. stock markets. They find the existence of (i) weak-form efficiency in the market for A- shares but not B-shares, (ii) statistically weak linkages between the Chinese stock markets, (iii) a weak causal effect from the Hong Kong to the four Chinese stock markets, and (iv) a strong causal effect from the U.S. stock market to all four Chinese stock markets and the Hong Kong stock market. Laurence et al. (1997) conclude that because of the statistically significant cointegrating and causal relationships discovered, Chinese stock markets are becoming more integrated to the global economy.

This article employs statistical techniques, such as, cointegration, and Granger (1969) causality tests to explore whether Chinese stock markets are becoming more integrated to the global economy. Analysis of the integration between Chinese markets is reported in a separate paper by the authors (Niblock and Sloan, 2007) also presented at this conference.

The article is organised as follows: Section II outlines the data required to implement the analysis and highlights the methodologies employed. Empirical results and discussion are presented in Section III. Section IV is a summary and conclusion.

II. Data and Methodology

1. *Data*

The data used in this study consists of 955 daily closing price observations (adjusted for dividends and stock splits) for the Shanghai "A" (SHA), Shanghai "B" (SHB), Shenzhen "A" (SZA), Shenzhen "B" (SZB), Hang Seng (HS), and Dow Jones Industrial Average indices. The chosen sample period is from 4 March 2002 through 28 October 2005. Furthermore, to identify possible time structural changes in the behaviour of the data, the sample is divided into two sub-samples covering the periods March 4 2002 to 31 December 2003, and 1 January 2004 to 28 October 2005. The stock indices data utilised in this study are obtained from Yahoo Finance's historical price database. The econometrics software used to carry out the analysis in this study is GRETL (Cottrell, 2006), and SPSS Version 13.0. The daily stock indices returns are calculated using the continuously compounded formula (Laurence et al., 1997):

$$R_t = \ln\left(\frac{P_t}{P_{t-1}}\right), \tag{1}$$

where Pt is the index at time t, ln is the natural logarithm, and Rt represents the log return series. Note that $Rt = \ln(Pt) - \ln(Pt\text{-}1) = \Delta \ln Pt$.

2. *Cointegration*

Essentially, if the two time series X_t and Y_t are both I(1), then it is necessary that there exists a β such that the sequence:

$$z_t = y_t - \alpha - \beta x_t, \tag{2}$$

is I(0) for X_t and Y_t to be cointegrated (Engle and Granger, 1987). The regression in Equation (2) is known as the cointegrating regression and measures the extent to which the system X_tY_t is out of equilibrium, where z_t is the equilibrium error and β is the cointegrating parameter. The simplest cointegration tests are based on the residuals of the OLS cointegrating regression (Engle and Granger, 1987). This involves regression of one variable on another and testing for the presence of a unit root.

The testing procedure follows a two-stage estimation. Firstly, in order to test whether the series are cointegrated, it is important to check that each series is I(1). Testing for the unit root (or non-stationarity) is conducted by utilising the Dickey-Fuller (DF) (Dickey and Fuller, 1979) and augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1981) regressions, which are defined respectively:

$$\Delta y_t = \alpha + \theta y_{t-1} + \varepsilon_t \tag{3}$$

$$\Delta y_t = \alpha + \theta y_{t-1} + \gamma_1 \Delta y_{t-1} + \varepsilon_t \tag{4}$$

To allow for series with time trends, the basic DF and ADF equations are change to:

$$\Delta y_t = \alpha + \delta_t + \theta y_{t-1} + \varepsilon_t \tag{5}$$

$$\Delta y_t = \alpha + \delta_t + \theta y_{t-1} + \gamma_1 \Delta y_{t-1} + \varepsilon_t \tag{6}$$

Once it is found that each series contains a single unit root, that is I(1), the second stage involves testing whether the series ‘X’ and ‘Y’ are cointegrated. Constructing test statistics from the residuals of the cointegrating regression tests presents a formal cointegration procedure:

$$Y_t = a + bX_t + z_t \tag{7}$$

If the series are not cointegrated, then a unit root exists in the residuals, and is therefore the null hypothesis when testing for cointegration between series. For the two series to be cointegrated, the time series of z_t must be I(0), that is, stationary.

The ADF test is then performed on the estimated residuals, z_t, from Equation (7):

$$\Delta z_t = (\rho - 1) z_{t-1} + \sum_{j=1}^{q} \phi_j \Delta z_{t-j} + \mu \quad (8)$$

The methodology used in this study for testing cointegration between the level series ($LSHA_t$, $LSHB_t$, $LSZA_t$, $LSZB_t$, LHS_t, and $LDJIA_t$) consists of the Engle and Granger (1987) residual-based approach to cointegration. Engle-Granger cointegration is tested by constructing test statistics from the residuals of the equation that is based on Equation (7):

$$Y_t = \alpha_0 + \beta_1 X_t + z_t \quad (9)$$

The reverse cointegrating regression of Wahab and Lashgari (1993) is also considered:

$$X_t = \alpha_0' + \beta_2 Y_t + z_t' \quad (10)$$

In terms of Equations (9) and (10), α_0 and α_0' are intercepts, β_1 and β_2 are cointegrating parameters, and z_t and z_t' are the residuals. Also, the long-run equilibrium relationship between Equations (9) and (10) are linear. Ultimately, the linear equilibrium relationship between the two equations examines whether the cointegration test results are sensitive to the choice of the dependent variable.

The residuals of Equations (9) and (10) are then estimated using Ordinary Least Squares (OLS) regression, and can be shown as:

$$\hat{z}_t = Y_t - [\alpha_0 + \beta_1 X_t] \quad (11)$$

$$\hat{z}_t' = X_t - [\alpha_0' + \beta_2 Y_t] \quad (12)$$

Following the estimation of the residuals, $\hat{z}_t$ and $\hat{z}_t'$, the residual-based augmented Dickey-Fuller test (as in Equation (8)) is performed on the estimated residuals of the combined stock indices series:

$$\Delta z_t = (\rho - 1) z_{t-1} + \sum_{j=1}^{q} \phi_j \Delta z_{t-j} + \mu_t \quad (13)$$

If the series share a long-run relationship, then the series are cointegrated (Engle and Granger, 1987). Once it is established that the series are cointegrated, their dynamics can be utilised for the investigation of Granger (1969) causality.

3. *Granger Causality*

When one variable is identified as the "dependent" variable 'Y' and the other as the "explanatory" variable 'X', an implicit assumption that changes in the explanatory variable cause changes in the dependent variable is made. This is the notion of causality in which information about 'X' is expected to affect the conditional distribution of the future values of 'Y' (Ramanathan, 2002). If 'X' causes 'Y' and 'Y' causes 'X', then the two variables are jointly determined, that is, a feedback relationship exists. In many instances the apparent direction of causality is not clear; therefore it is appropriate to test for causal directions between the two variables. Granger (1969) causality tests are designed to examine whether two time series move in a lead-lag relationship, that is, one after the other, or contemporaneously. When 'X' and 'Y' move contemporaneously, one provides no information for characterising the other (Ramanathan, 2002).

Granger (1969) suggests that returns in market 'X' Granger-cause returns in market 'Y' only if it can be shown that the past values of 'X' combined with past values of 'Y' provide statistically significant information on future values of 'Y'. This *does not* necessarily mean that a change of 'X' will cause a subsequent change in 'Y'. Moreover, the assumption that a change of 'X' will cause a subsequent change in 'Y' may be considered a spurious regression problem, whereby regression analysis indicates a relationship between two unrelated time series processes simply because each has a trend, is an integrated time series (such as a random walk), or both (Wooldridge, 2006).

Furthermore, it should be noted that causality is defined in terms of an ideal randomised controlled experiment in which different values of 'X' are applied experimentally and the subsequent effects on 'Y' are observed. In contrast, Granger causality implies that if market

‘X’ Granger-causes market ‘Y’, then market ‘X’ is a useful predictor of market ‘Y’, given the other variables in the regression (Ramanathan, 2002). Specifically, what this *does* mean is that the past values of ‘X’ appear to contain information that is useful for forecasting changes in ‘Y’, beyond that contained in the past values of ‘Y’. While “Granger predictability” is a more accurate term than “Granger causality”, the latter has become part of the jargon of econometrics (Stock and Watson, 2003).

The empirical procedure for testing Granger (1969) causality from market ‘X’ to market ‘Y’ and market ‘Y’ to market ‘X’ involves estimating the following autoregressive (AR) models of order *p* and *q*:

$$Y_t = \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{j=1}^{q} \beta_j X_{t-j} + \mu_t \tag{14}$$

$$X_t = \sum_{i=1}^{p} \alpha_i X_{t-i} + \sum_{j=1}^{q} \beta_j Y_{t-j} + \nu_t \, , \tag{15}$$

where μ_t and ν_t are white noise, *p* is the order of the lag Y, and *q* is the order of the lag for X (Stock and Watson, 2003). Essentially, the orders of the lags *p* and *q* are arbitrary and are usually chosen to be large. Alternatively, tests can be carried out for different values of the lags to ensure that conclusions are robust and not model-dependent (Ramanathan, 2002).

The restricted models are therefore:

$$Y_t = \sum_{i=1}^{p} \alpha_i Y_{t-i} + \nu_t \tag{16}$$

$$X_t = \sum_{i=1}^{p} \alpha_i X_{t-i} + \nu_t \tag{17}$$

The standard Wald *F*-statistic provides a formal test for Granger causality:

$$F = \frac{(SSR_1 - SSR_2)/q}{SSR_2/(n-p-q)} , \tag{18}$$

where *n* is the number of observations used in the unrestricted models of Equations (14) and (15), SSR_1 is the sum of squared residuals for Equations (14) and (15), respectively, SSR_2 is the sum of squared residuals for Equations (16) and (17), respectively, and *p* and *q* are as defined previously (Stock and Watson, 2003). Specifically, a statistically significant *F*-statistic indicates unidirectional Granger causality from market 'X' to market 'Y', or unidirectional Granger causality from the interchanged market 'Y' to market 'X'. If both sets of 'X' and 'Y' *F*-statistics are statistically significant, then a feedback or bidirectional Granger causal relationship exists. Moreover, if the *F*-statistics are statistically insignificant in both regressions than Granger causal independence is evident (Stock and Watson, 2003).

III. Results and Discussion

1. *Summary Statistics Results*

The results for the summary statistics are illustrated in Table 1. For the Shanghai and Shenzhen markets the annualised daily log returns are all negative, except for SHA Period 1 and SZB Period 1. The large negative returns, particularly in Period 2, suggest poor index performances across all four markets. However, the standard deviations are also large, indicating that the Chinese stock indices displayed volatile behaviour over all periods. The measures of central tendency and dispersion indicate that the Chinese stock markets underperformed in all periods and were riskier than the established markets of Hong Kong and the U.S. Moreover, strong economic growth is normally linked to positive stock market performance (Wooldridge, 2006). Considering the explosive growth of the Chinese economy in recent times, the poor performance of Chinese stock markets is uncharacteristic.

2. *Results for Unit Root Tests*

Table 2 reports the most significant results of the standard DF and ADF tests for the level series ($LSHA_t$, $LSHB_t$, $LSZA_t$, $LSZB_t$, LHS_t, and $LDJIA_t$). With only a few exceptions, the results suggest non-stationarity of the indices across all periods. Overall, the evidence fails to lead to the rejection of the null of a unit root in the level series at the 5% or 1% significance level, indicating that $LSHA_t$, $LSHB_t$, $LSZA_t$, $LSZB_t$, LHS_t, and $LDJIA_t$ are non-stationary.

The differenced series (ΔSHA_t, ΔSHB_t, ΔSZA_t, ΔSZB_t, ΔHS_t, and $\Delta DJIA_t$) are then checked for the presence of a unit root. The most significant results for the DF and ADF unit root tests on the differenced series are presented in Table 3. The results clearly show that the first differenced series are stationary for all periods, at all lag lengths, whether a trend is included in the DF and ADF equation or not. Ultimately, the DF and ADF tests comprehensively reject the null hypothesis of a unit root at the 5% or 1% significance level for the first differenced series. This implies that the differenced series, ΔSHA_t, ΔSHB_t, ΔSZA_t, ΔSZB_t, ΔHS_t and $\Delta DJIA_{t,}$ are stationary and thus I(0). Therefore, the original level series, $LSHA_t$, $LSHB_t$, $LSZA_t$, $LSZB_t$, LHS_t, and $LDJIA_t$, are I(1), that is, contain a single unit root.

3. *Results for Engle-Granger Cointegration Tests*

Significant results are illustrated in Table 4. The results indicate that cointegrating relationships exist between some Chinese stock indices over different time periods and lag lengths[1]. Out of interest, the established markets of HS and DJIA are also included in the cointegration analysis. The strong statistical significance suggests that the HS is cointegrated with the DJIA over the combined periods and at all lags.

However, after reversing the cointegration equation (Equation (9) in Section II) it is apparent that the number of stock indices combinations where the null hypothesis is accepted diminishes. This implies that the selection of the dependent variable is sensitive in the cointegration equation (see Equations (9) and (10) in Section II) and thus supports the use of this technique (Wahab and Lashgari, 1993). Overall, the results suggest that the HS is not cointegrated with the domestic (A-share) and international (B-share) Chinese stock markets.

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[1] Two cointegrating equations are tested and involve the forward and reverse cointegrating equations, that is Equation's (9) and (10) (in Section II), and are labelled as specifications one and two, respectively (Wahab and Lashgari, 1993).

Ultimately, despite a more established market and close economic ties with mainland China, Hong Kong markets do not lead Chinese stock markets.

The reversal of the cointegration equation reveals similar significant results to specification one. This implies that some bivariate stock indices combinations have interchangeable cointegrating relationships between each other (Wahab and Lashgari, 1993). Once again, this supports the use of the reverse cointegration equation. Specification two results reveal that the DJIA is cointegrated with both the domestic and international Chinese stock markets at almost all lag lengths in Period 2. The results also suggest that there is a strong statistical relationship between the DJIA and the Chinese markets between Lags 7 and 9 in Period 2. This may indicate that Chinese stock markets are becoming more integrated with the U.S. Moreover, the statistical significance of relationships between the DJIA and the HS implies a robust cointegrating relationship across all periods and the majority of lags. It remains a point of interest whether over time the DJIA will lead the developing Chinese stock markets with the same ascendancy. Overall, the results support the proposition of increased integration with international markets as financial liberalisation proceeds.

4. *Results for Granger Causality Tests*

Considering the outcomes of the Engle-Granger cointegration tests, it is appropriate to conduct Granger causality tests in an attempt to understand whether the lead-lag relationships of Chinese and international stock indices returns "Granger-cause" each other amongst themselves in a unidirectional or bidirectional causal sense. Significant results are shown in Table 5. For Granger causality from the Chinese markets to Hong Kong and the U.S., the results reject the null hypothesis of non-Granger causality on some occasions. Moreover, this supports the notion that some Chinese stock indices combinations with the HS and DJIA are representative of causal associations in the Granger sense. Unidirectional Granger causality is shown by *SHA* Granger-causing the *DJIA* in Period 1, *SZA* Granger-causing the *HS* in the combined periods, and *SZA* Granger-causing the *DJIA* in Period 1. Effectively, this is surprising considering the unidirectional Granger causal influence the DJIA has on most global stock markets (Laurence et al., 1997). The results also indicate that the domestic Shenzhen A-share market drives the HS. This could be explained by the close proximity of the Shenzhen and Hong Kong stock exchanges and Shenzhen gradually becoming the model centre of economic development and reform in China (Laurence et al., 1997).

For Granger causality from Hong Kong to the Chinese and the U.S. markets, some of the results reject the null hypothesis of non-Granger causality. Moreover, this substantiates that the statistically significant HS combinations with the Chinese and DJIA markets is representative of causal relationships in the Granger sense. Unidirectional Granger causality is shown by the *HS* Granger-causing *SHA* in Period 2, the *HS* Granger-causing *SHB* in the combined periods, and the *HS* Granger-causing *SZB* in Period 1 and Period 2. This suggests that the HS has a significant Granger causal effect on the international B-share markets of China. Feedback or bidirectional Granger causal relationships exist between the *HS* and *SHA* in the combined periods, and the *HS* and *SZB* in the combined periods. These markets show evidence that they have a significant influence on each other over longer periods of time.

For Granger causality from the U.S. to the Chinese and Hong Kong markets, the results reject the null hypothesis of non-granger causality consistently. Moreover, this confirms that the statistically significant DJIA combinations with the Chinese and HS markets are representative of causal relationships in the Granger sense. Unidirectional Granger causality is indicated by the *DJIA* Granger-causing *SHA* in Period 2; the *DJIA* Granger-causing *SZA* in Period 2; the *DJIA* Granger-causing *SZB* in Period 1, Period 2, and the combined periods; and the *DJIA* Granger-causing the *HS* in Period 1, Period 2, and the combined periods. The DJIA has a significant effect on the domestic Chinese A-share markets and international Chinese B-share markets, with the exception of SHB. It should be noted that the combination of the DJIA and SHB fails to reject the null hypothesis at the 5% (3.01) or 1% (4.63) level of significance. This suggests that the international SHB market is Granger-causally independent of the DJIA. Moreover, strong statistical significance running from the DJIA to SZB and the HS, particularly, the HS, is evidenced across all periods. The close proximity and robust statistical relationships of the international markets of SZB and the HS with each other may help explain the strong Granger causal association with the DJIA. The DJIA drives the returns in these two markets and are evidently the most statistically significant results discovered across all combinations of stock indices, lags, and time periods in the Granger causality testing. Also, a feedback or bidirectional Granger causal relationship exists between the DJIA and SHA in the combined periods, and the DJIA and SZA in the combined periods. The U.S. market has an overwhelming influence on these markets, particularly Hong Kong's. The robust one-day Granger causal effects running from the DJIA to the other markets therefore supports Fama's (1970) Efficient Market Hypothesis, in that information is immediately flowing from the more established and efficient market of the U.S. to the other lesser-developed markets. Notably, China's stock markets open each day shortly after the DJIA closes, so information flows are rapid.

Like the Engle-Granger cointegration tests, the Granger causality tests have established direct statistical associations between the stock indices. Finally, the results suggest that both the domestic A-share and international B-share markets in China are becoming more integrated into global markets.

IV. Summary and Conclusions

This article explored the presence of cointegrating and Granger (1969) causing influences amongst the Shanghai "A", Shanghai "B", Shenzhen "A", Shenzhen "B", Hang Seng, and Dow Jones Industrial Average indices.

The summary statistics indicated that all four Chinese stock markets have under-performed in recent times. They also highlighted the volatile behaviour of Chinese stock market returns compared to the established Hong Kong and U.S. markets, suggesting a highly speculative and uncertain trading environment.

The Dickey-Fuller unit root tests confirmed that the level series of stock indices after first differencing contained a unit root and were integrated of the same order. After establishing that the level series of stock indices contained a unit root, the cointegration tests of Engle and

Granger (1987) were employed. The results provided statistical confirmation that some combinations of the stock indices, such as those of the Dow Jones Industrial Average with each of the four Chinese stock markets, were cointegrated. However, the adoption of the forward and reverse cointegrating regressions used by Wahab and Lashgari (1993) revealed that the test results were sensitive to the choice of the dependent variable. The most statistically significant combination was the Hang Seng to the Dow Jones Industrial Average (specification one and two). Ultimately, the results showed the statistical interrelationships that exist between the Chinese markets and the established markets of Hong Kong and the U.S.

The Granger (1969) causality tests indicated statistically significant relationships between the Chinese stock indices returns and the returns of the Hang Seng and the Dow Jones Industrial Average. The results suggested that the Hang Seng exerted a significant Granger-causing effect on all Chinese stock indices, with the exception of Shenzhen “A”. The Dow Jones Industrial Average exhibited a definitive Granger causal relation to all Chinese stock markets (with the exception of Shanghai “B”) and to the Hang Seng market. The most conclusive results confirmed strong unidirectional Granger causal flows from the Dow Jones Industrial Average to the Hang Seng, and, perhaps more importantly, from the Dow Jones Industrial Average to Shenzhen “B”, a finding which indicated that the Chinese stock markets are being integrated into global markets.

In conclusion, the success of further financial liberalisation and reform depends upon the degree of the government’s active commitment to increasing liberalisation and on its overall ability to remove the strict bureaucracy surrounding China’s markets. The removal of obstructive regulations and the development of more appropriate legislation will ultimately create a more conducive and liquid investing environment for all investors concerned, thus creating more optimal conditions for market efficiency and further integration with global markets.

References

Cottrell, A. (2006). GNU Regression, Econometrics and Time-Series Library (GRETL). Department of Economics, Wake Forest University. Winston-Salem, NC.

Dickey, D. and Fuller, W. (1979). Distribution of the Estimates for Autoregressive Time Series with a Unit Root. Journal of the American Statistical Association. 74:427-432.

Dickey, D. and Fuller, W. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. Econometrica. 49:1057-1072.

Engle, R.F. and Granger, C.W.J. (1987). Cointegration and Error Correction: Representation, Estimation, and Testing. Econometrica. 55(2):251-276.

Fama, E. F. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. Journal of Finance. 25:382-417.

Granger, C.W.J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. Econometrica. 37:424-438.

Groenewold, N., Wu, Y., Tang, S.H.K., and Fan, X.M. (2004). The Chinese Stock Market: Efficiency, Predictability and Profitability. Cheltenham, UK: Edward Elgar Publishing Limited.

Laurence, M., Cai, F., and Qian, S. (1997). Weak-form Efficiency and Causality Tests in Chinese Stock Markets. Multinational Finance Journal. 1(4):291-307.

Ma, S. (2004). The Efficiency of China's Stock Market. Aldershot, UK: Ashgate Publishing Limited.

MacKinnon, J.G. (1996). Numerical Distribution Functions for Unit Root and Cointegration tests. Journal of Applied Econometrics. 11:601-618.

Niblock, S. and Sloan, K. (2007). Are Chinese Stock Markets Weak-form Efficient? Paper presented at the 12th Finsia-Melbourne Centre for Financial Studies Banking and Finance Conference, Melbourne.

Ramanathan, R. (2002). Econometrics with Applications, 5th edition. Ohio, USA: South-Western / Thomson Learning.

Singh, A. (1999). Should Africa Promote Stock Market Capitalism? Journal of International Development. 11(3):343-365.

Stock, J.H. and Watson, M.W. (2003). Introduction to Econometrics, International edition. Boston, MA: Pearson Education Inc.

Wahab, M. and Lashgari, M. (1993). Price Dynamics and Error Correction in Stock Index and Stock Index Futures: A Cointegration Approach. The Journal of Futures Markets. 13(7):711-742.

Wooldridge, J.M. (2006). Introductory Econometrics: A Modern Approach 3rd Edition. Mason, OH: Thomson South-Western.

Table 1. Descriptive Statistics for Shanghai, Shenzhen, Hong Kong, and U.S. Markets

Statistics	Period 1	Period 2	Combined Periods
SHA Market			
Annualised Daily Return	0.08%	-16.92%	-8.41%
Standard Deviation	1.17%	1.28%	1.23%
Skewness	1.423	0.633	0.966
Kurtosis	8.098	1.503	4.244
Min. Return	-3.16%	-3.96%	-3.96%
Max. Return	8.84%	5.64%	8.84%
Observations	478	477	955
SHB Market			
Annualised Daily Return	-15.82%	-29.86%	-22.84%
Standard Deviation	1.36%	1.59%	1.48%
Skewness	1.025	-0.119	0.318
Kurtosis	7.142	4.855	5.855
Min. Return	-4.57%	-8.78%	-8.78%
Max. Return	9.23%	6.90%	9.23%
Observations	478	477	955
SZA Market			
Annualised Daily Return	-6.95%	-19.03%	-12.99%
Standard Deviation	1.20%	1.38%	1.29%
Skewness	1.092	0.381	0.658
Kurtosis	6.51	1.124	3.188
Min. Return	-3.52%	-5.15%	-5.15%
Max. Return	8.65%	5.45%	8.65%
Observations	478	477	955
SZB Market			
Annualised Daily Return	11.91%	-19.78%	-3.92%
Standard Deviation	1.50%	1.55%	1.52%
Skewness	0.923	-0.050	0.403
Min. Return	-4.38%	-6.13%	-6.13%
Max. Return	9.29%	5.51%	9.29%
Observations	478	477	955
HS Market			
Annualised Daily Return	9.81%	6.43%	8.12%
Standard Deviation	1.09%	0.86%	0.98%
Skewness	0.093	-0.203	-0.002
Kurtosis	0.754	1.746	1.233
Min. Return	-4.18%	-3.64%	-4.18%
Max. Return	3.60%	3.52%	3.60%
Observations	478	477	955

Table 1. (*Continued*)

Statistics	Period 1	Period 2	Combined Periods
DJIA			
Annualised Daily Return	0.43%	-0.26%	0.09%
Standard Deviation	1.33%	0.66%	1.05%
Skewness	0.408	0.031	0.418
Kurtosis	1.987	0	3.606
Min. Return	-4.75%	-1.88%	-4.75%
Max. Return	6.16%	2.04%	6.16%
Observations	478	477	955

Note: SHA is Shanghai "A", SHB is Shanghai "B", SZA is Shenzhen "A", SZB is Shenzhen "B", HS is Hang Seng, and DJIA is Dow Jones Industrial Average. Period 1 is from 4/3/02 to 31/12/03 and Period 2 is from 1/1/04 to 28/10/05. Data are collected from Yahoo Finance. Annualised Daily Returns are calculated as: Arithmetic Mean x 250 (trading days).

TABLE 2. DF and ADF Unit Root Tests for the Level Series of Stock Indices

	Lag Order	DF/ADF (No Trend)	Lag Order	DF/ADF (Trend)
SHA				
Period 1	12	-2.3856	4	-2.9802
Period 2	14	-1.1452	1	-2.9705
Combined Periods	14	-1.2962	3	-2.5103
SHB				
Period 1	19	-1.3810	1	-2.8240
Period 2	14	-1.1396	11	-2.9620
Combined Periods	12	-1.0343	12	-3.3704
SZA				
Period 1	4	-1.3413	1	*-3.6257
Period 2	14	-1.1013	14	-3.0947
Combined Periods	14	-1.0344	1	-3.2262
SZB				
Period 1	18	-1.221	7	-1.6374
Period 2	14	-1.7066	14	-2.8855
Combined Periods	14	-2.0547	14	-1.943
HS				
Period 1	11	-0.5155	11	-0.7487
Period 2	4	-1.4597	19	-2.9317
Combined Periods	18	-0.7887	7	-2.5486
DJIA				
Period 1	0	-1.6749	0	-1.6958
Period 2	9	*-3.3059	9	*-3.4534
Combined Periods	0	-1.6697	12	-3.2077

Note: SHA is Shanghai "A", SHB is Shanghai "B", SZA is Shenzhen "A", SZB is Shenzhen "B", HS is Hang Seng, and DJIA is Dow Jones Industrial Average. Period 1 is from 4/3/02 to 31/12/03 and Period 2 is from 1/1/04 to 28/10/05. Critical values -2.86 (5% level) and -3.43 (1% level) for No Trend, and critical values -3.41 (5% level) and -3.96 (1% level) for Trend obtained from MacKinnon (1996). * Statistically significant at the 5% level. ** Statistically significant at the level 1% level.

Table 3. DF and ADF Unit Root Tests for the First Differenced Series of Stock Indices

	Lag Order	DF (No Trend)	DF (Trend)	Lag Order	ADF (No Trend)	ADF (Trend)
SHA						
Period 1	0	**-21.049	**-21.027	1	**-14.783	**-14.767
Period 2	0	**-20.849	**-20.833	1	**-15.121	**-15.112
Combined Periods	0	**-29.688	**-29.688	1	**-21.167	**-21.171
SHB						
Period 1	0	**-21.522	**-21.499	1	**-15.244	**-15.225
Period 2	0	**-19.704	**-19.688	1	**-14.538	**-15.529
Combined Periods	0	**-29.587	**-29.571	1	**-21.237	**-21.225
SZA						
Period 1	0	**-20.924	**-20.917	1	**-14.672	**-14.670
Period 2	0	**-20.241	**-20.231	1	**-14.958	**-14.955
Combined Periods	0	**-29.240	**-29.237	1	**-20.970	**-20.971
SZB						
Period 1	0	**-21.682	**-21.716	1	**-15.016	**-15.057
Period 2	0	**-19.452	**-19.457	1	**-14.888	**-14.900
Combined Periods	0	**-28.923	**-28.931	1	**-21.097	**-21.110
HS						
Period 1	0	**-20.776	**-20.941	1	**-14.777	**-14.951
Period 2	0	**-20.093	**-20.072	1	**-14.939	**-14.924
Combined Periods	0	**-28.895	**-28.894	1	**-21.010	**-21.014
DJIA						
Period 1	0	**-23.098	**-23.276	1	**-15.789	**-15.983
Period 2	0	**-21.890	**-21.867	1	**-16.148	**-16.130
Combined Periods	0	**-32.266	**-32.234	1	**-22.506	**-22.521

Note: SHA is Shanghai "A", SHB is Shanghai "B", SZA is Shenzhen "A", SZB is Shenzhen "B", HS is Hang Seng, and DJIA is Dow Jones Industrial Average. Period 1 is from 4/3/02 to 31/12/03 and Period 2 is from 1/1/04 to 28/10/05. Critical values -2.86 (5% level) and -3.43 (1% level) for No Trend, and critical values -3.41 (5% level) and -3.96 (1% level) for Trend obtained from MacKinnon (1996). * Statistically significant at the 5% level. ** Statistically significant at the level 1% level.

Table 4. Engle-Granger Residual-based Bivariate Cointegration Tests of the Stock Indices

	Lag Order	Specification One	Lag Order	Specification Two
		SHA - HS		*HS - SHA*
Period 1	12	-2.4131	7	-0.0775
Period 2	14	-2.5025	14	-2.5978
Combined Periods	14	-2.0197	11	-1.8310
		SHA - DJIA		*DJIA - SHA*
Period 1	12	-2.3621	3	-1.6892
Period 2	15	-1.3571	9	**-3.4265
Combined Periods	12	-1.7014	4	-2.1020
		SHB - HS		*HS - SHB*
Period 1	9	-1.4795	8	-0.8451
Period 2	14	-2.3936	7	-2.5673
Combined Periods	9	-2.0935	7	-2.2242
		SHB - DJIA		*DJIA - SHB*
Period 1	6	-1.4900	3	-1.8431
Period 2	15	-1.1654	9	**-3.3933
Combined Periods	6	-2.1041	6	-2.6790
		SZA - HS		*HS - SZA*
Period 1	12	-1.6993	9	-1.0667
Period 2	14	-2.4444	14	-2.5859
Combined Periods	12	-2.2259	11	-2.2102
		SZA - DJIA		*DJIA - SZA*
Period 1	15	-1.6028	12	-1.8725
Period 2	15	-1.2851	9	**-3.4414
Combined Periods	12	-2.0083	6	-2.5116
		SZB- HS		*HS - SZB*
Period 1	23	*-2.8967	24	-2.5028
Period 2	14	-2.4515	13	-2.2489
Combined Periods	14	-1.9249	24	-0.6583
		SZB - DJIA		*DJIA - SZB*
Period 1	23	-2.4980	18	-2.7044
Period 2	14	-1.5242	9	*-3.2869
Combined Periods	14	-2.5711	14	-2.0893
		HS - DJIA		*DJIA - HS*
Period 1	1	*-2.8706	1	**-3.4637
Period 2	1	-2.2810	1	**-3.6776
Combined Periods	1	**-3.8831	1	**-4.1909

Note: SHA is Shanghai "A", SHB is Shanghai "B", SZA is Shenzhen "A", SZB is Shenzhen "B", HS is Hang Seng, and DJIA is Dow Jones Industrial Average. Period 1 is from 4/3/02 to 31/12/03 and Period 2 is from 1/1/04 to 28/10/05. Critical values for the t-statistics [-2.76 (5% level) and -3.34 (1% level)] are obtained from MacKinnon (1996). * Statistically significant at the 5% level. ** Statistically significant at the level 1% level.

Table 5. Bivariate Granger Causality Tests

Causality Among the Chinese, Hong Kong, and U.S. Markets

	SHA to HS				HS to SHA		
	Lag Order (*p*)	Lag Order (*q*)	*F*-stat	*Causal Flow*	Lag Order (*p*)	Lag Order (*q*)	*F*-stat
Period 1	6	6	2.0082		10	10	2.0194
Period 2	1	1	2.4579	→	6	6	*3.7239
Combined Periods	6	6	*3.3803	↔	5	5	*3.4172

	SHA to DJIA				DJIA to SHA		
	Lag Order (*p*)	Lag Order (*q*)	*F*-stat	*Causal Flow*	Lag Order (*p*)	Lag Order (*q*)	*F*-stat
Period 1	5	5	*3.1421	←	6	6	2.3564
Period 2	10	10	2.5342	→	5	5	*3.8319
Combined Periods	5	5	**4.6386	↔	6	6	**4.9571

	SHB to HS				HS to SHB		
	Lag Order (*p*)	Lag Order (*q*)	*F*-stat	*Causal Flow*	Lag Order (*p*)	Lag Order (*q*)	*F*-stat
Period 1	9	9	2.5315		5	5	2.8724
Period 2	3	3	1.9826		1	1	2.8485
Combined Periods	1	1	2.3467	→	1	1	*3.4195

	SHB to DJIA				DJIA to SHB		
	Lag Order (*p*)	Lag Order (*q*)	*F*-stat	*Causal Flow*	Lag Order (*p*)	Lag Order (*q*)	*F*-stat
Period 1	5	5	2.4690		5	5	2.9002
Period 2	3	3	2.5985		1	1	2.7871
Combined Periods	5	5	2.9644		1	1	2.5424

	SZA to HS				HS to SZA		
	Lag Order (*p*)	Lag Order (*q*)	*F*-stat	*Causal Flow*	Lag Order (*p*)	Lag Order (*q*)	*F*-stat
Period 1	6	6	2.4090		5	5	2.2696
Period 2	1	1	2.3547		6	6	2.3061
Combined Periods	6	6	*3.7353	←	1	1	2.1730

Table 5. (*Continued*)

	SZA to DJIA				DJIA to SZA		
	Lag Order (*p*)	Lag Order (*q*)	*F*-stat	*Causal Flow*	Lag Order (*p*)	Lag Order (*q*)	*F*-stat
Period 1	5	5	*3.3380	←	6	6	2.2331
Period 2	10	10	1.9994	→	5	5	*3.3298
Combined Periods	5	5	*4.4317	↔	6	6	*4.0742

	SZB to HS				HS to SZB		
	Lag Order (*p*)	Lag Order (*q*)	*F*-stat	*Causal Flow*	Lag Order (*p*)	Lag Order (*q*)	*F*-stat
Period 1	6	6	1.9455	→	10	10	*3.1710
Period 2	1	1	2.2465	→	1	1	*4.3609
Combined Periods	1	1	*3.9292	↔	1	1	*4.4986

	SZB to DJIA				DJIA to SZB		
	Lag Order (*p*)	Lag Order (*q*)	*F*-stat	*Causal Flow*	Lag Order (*p*)	Lag Order (*q*)	*F*-stat
Period 1	8	8	1.8987	→	7	7	*3.0186
Period 2	10	10	1.9266	→	1	1	*4.3020
Combined Periods	8	8	1.8166	→	1	1	*3.7941

	HS to DJIA				DJIA to HS		
	Lag Order (*p*)	Lag Order (*q*)	*F*-stat	*Causal Flow*	Lag Order (*p*)	Lag Order (*q*)	*F*-stat
Period 1	8	8	2.9456	→	1	1	**50.7451
Period 2	10	10	1.6350	→	1	1	**27.4580
Combined Periods	8	8	2.6619	→	1	1	**81.7615

Note: SHA is Shanghai "A", SHB is Shanghai "B", SZA is Shenzhen "A", SZB is Shenzhen "B", HS is Hang Seng, and DJIA is Dow Jones Industrial Average. Period 1 is from 4/3/02 to 31/12/03 and Period 2 is from 1/1/04 to 28/10/05. "→" and "←" symbolises unidirectional causality, while "↔" symbolises bidirectional or feed back causality. Critical values for the *F*-statistics (3.01 (5% level) and 4.63 (1% level)) are obtained from Cottrell (2006). * Statistically significant at the 5% level. ** Statistically significant at the level 1% level.