Causal Relationship between
the United States, Hong Kong and China’s stock markets

BY

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Finance Option

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Abstract

This paper examines the causal relationships between Shanghai “A”, Shanghai “B”, Shenzhen “A”, Shenzhen “B”, Hang Seng Index and the S&P 500 Composite Index. In order to find out whether there exist such relationships before and after China became a member of the World Trade Organization, suitable hypothesis were made and tested by the Granger methodology. And the investigation was divided into two periods, obviously the pre-entering period and the post-entering period.

It is inevitably that there is a feedback relationship between the Hang Seng Index and S&P 500 Composite Index, as they are both important indices in the world financial market. Moreover, the Granger causality results indicated that there were significant changes in the Chinese stock markets for the two periods. The “A” stock markets had leading roles to the Hong Kong market and other Chinese markets in the pre-entering period, while the “B” stock markets Granger caused all the Hong Kong market, Chinese “A” markets and even the US market in the post-entering period. It showed that the China markets which are open to the foreign investors had developed a lot after China became a member of the WTO. It is believed to be caused by a higher market efficiency brought by this open trade policy. Furthermore, these results give a great support to the assertion that the Chinese stock markets are becoming more integrated to the global economy.
1. Introduction

The economic reforms started in 1978 led to the rebirth of the stock markets in China. The Shanghai Stock Exchange and the Shenzhen Stock Exchange are the two major emerging capital markets in China. The Shanghai Stock Exchange commenced operations in December 1990 while the Shenzhen Stock Exchange opened its market in April 1991. Although these stock exchanges only operate for a short period of time when compare with those in the United States and Hong Kong, the rapid expansion of the China markets reflects China’s significant economic growth, thus stimulated many international investors to include Chinese stocks in their portfolio. Hence the knowledge of the linkage between Chinese markets and other foreign markets enables portfolio managers to make more intelligent decisions. As the US and Hong Kong are the two major international trading partners of China, and also the top two direct investors in China, there are very close relationships between China and the US and between China and Hong Kong.

With 1997 handover of Hong Kong to China, the securities industries of the two sides ought to integrate into one market. However, the Basic Law governing Hong Kong maintains unchanged British Law system as well as the life style of Hong Kong capitalist society, at least for the next 50 years. This had ultimately strengthened the relationship between China and Hong Kong.
Moreover, being a new member of the World Trade Organization (WTO) in December 2001 eventually showed that China is gradually opening its market to the world. Practically, this entrance can promote the trade between China and other countries, and information is supposed to be sent more efficiently among the world. So with the stronger efficiency in the market, more and more investors are interested and confident in the China market which has great business opportunities. It would probably enrich the local stock markets.

Therefore, this paper is going to investigate the causality of the Chinese stock markets with each other and with the US and Hong Kong stock markets, in terms of the stock returns, after the entrance of China into the WTO to see whether the Chinese stock markets have integrated into the global economy.

2. Literature Review

There are quite a number of researches on the interrelationship between the world stock markets. However, it appears that they have not provided consistent results. The sizes and signs of correlation coefficients varied depending on the choice of markets, the sample period chosen, the frequency of observations, etc.

A. G. Malliaris and Jorge L. Urrutia (1992) wrote a paper analyzing the lead-lag relationships for six major international stock indexes, including the New York S&P
500, Tokyo Nikkei, London FT-30, Hong Kong Hang Seng, Singapore Straits Times, and Australia All Ordinaries, for the time periods before, during and after the October 1987 market crash. A dramatic increase in unidirectional and bidirectional causality is observed in the month of the crash, compared with the periods before and after the crash. In the crash month, New York showed feedback with London and Hong Kong. London led Hong Kong, and Hong Kong led the other Asian markets. This phenomenon probably suggested that the crash started simultaneously in all the stock markets, making the market crash of October 1987 seems to have been an international crisis of the equity markets.

After analyzing the crash in October 1987, Fok Ka Man in HKBU (2001) investigated the relationship between the United States stock market and the Hong Kong stock market, for the periods before, during and after the 1997 Asian financial crisis. It showed that both Dow Jones Industrial Average (DJIA), NASDAQ composite Index and S&P 500 have substantial impact on the Hong Kong stock market, shown in the Hang Seng Index (HSI). It is clear that the US markets led the Hong Kong market in the pre-financial crisis period and the post- financial crisis period, but the relationship was less significant during the crisis period which was believed to be that the regional factors had much impact on Hong Kong than that from the US.

Concerning the Chinese stock markets, Martin Laurence, Francis Cai and Sun Qian
(1997) investigated the weak-form efficiency and causality tests in Chinese stock markets in terms of daily stock returns. It concluded that there is a causal relationship from “B” stocks markets to the “A” stock markets, meaning the foreign markets exert a significant influence on the markets only open to Chinese nationals. Also, the US stock market exhibits a strong causal relation to all the four Chinese stock markets and the Hong Kong market. This suggested that the Chinese stock markets are gradually being integrated into the global economy.

Cheng F. Lee and Oliver M. Rui (2000) examined whether trading volume contains information to predict stock returns in the China’s stock markets, the US and the Hong Kong stock markets. Surprisingly they have an opposite conclusion from that of Martin Laurence, Francis Cai and Sun Qian (1997). They summarized that the US and the Hong Kong financial market information contained in returns, volatility and volume have very weak predictive power for Chinese financial market variables. The China’s financial market is independent of the world financial market.

3. Data and Preliminary Results

The data in this study will be the daily observations for the four Chinese stock market indices, one US and one Hong Kong stock index. The indices for the Chinese market are the Shanghai “A” (SHA), the Shanghai “B” (SHB), the Shenzhen “A” (SZA), and
the Shenzhen “B” (SZB), where “A” shares are for domestic investors and “B” shares are for foreign investors. For the US market, S&P 500 Composite Index (S&P) is used; and for the Hong Kong market, the major stock index Hang Seng Index (HSI) is used.

The causal relationship between all these six stock exchanges is examined. Daily stock indices from January 1, 1999 to December 31, 2004 are used in the analysis. In order to observe the effect of China getting into the WTO to all these stock exchanges, two periods are divided as follows:

Pre-entering period: January 1, 1999 to December 10, 2001

Post-entering period: December 11, 2001, to December 31, 2004

The daily stock returns are calculated using the continuously compounded formula.

\[ R_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \]

where \( P_t \) is the price of the index in day \( t \) and \( \ln \) is natural logarithm.

Since there is time difference among the world, and the trading hours of different markets are different, so the time-zone difference is needed to take into concern. As shown in Figure 1, from the Hong Kong time perspective, the Hong Kong market opens at 10:00 and closes at 16:00, whereas the Chinese stock markets open at 09:30 and close at 15:00, while the US market opens at 22:30 and closes at 05:00 in the following day. The Hong Kong market and the Chinese markets have common time interval, but not with that of the US market. Thus the causality between Hong Kong
and China is of t+1 day, while that between Hong Kong and US, and China and US may be observed on the same trading day.

**Figure 1. Trading Hours for Hong Kong market, Chinese market and US market**

<table>
<thead>
<tr>
<th>Stock Markets</th>
<th>Hong Kong Time (Hours)</th>
<th>Local Time (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong</td>
<td>10:00-12:30, 14:30-16:00</td>
<td>10:00-12:30, 14:30-16:00</td>
</tr>
<tr>
<td>United States</td>
<td>22:30-05:00 (the following day)</td>
<td>09:30-16:00</td>
</tr>
<tr>
<td>China</td>
<td>09:30-11:30, 13:00-15:00</td>
<td>09:30-11:30, 13:00-15:00</td>
</tr>
</tbody>
</table>

As the returns at time t in China ($R_{CN}^t$) and Hong Kong ($R_{HK}^t$) affect returns in US ($R_{US}^t$) on the same calendar day t, a Granger regression investigating if China or Hong Kong is leading US looks as follows.

$$R_{CN}^t = a_0 + \sum_{i=0}^{q} \alpha_i R_{US}^{t-i} + \sum_{i=1}^{p} \beta_i R_{CN}^{t-i} + \varepsilon_t$$

$$R_{HK}^t = a_0 + \sum_{i=0}^{q} \alpha_i R_{US}^{t-i} + \sum_{i=1}^{p} \beta_i R_{HK}^{t-i} + \varepsilon_t$$

On the other hand, the US returns ($R_{US}^t$) at time t may affect returns in China ($R_{CN}^{t+1}$) and Hong Kong ($R_{HK}^{t+1}$) at time t+1. Thus after adjusting for time-zone differences, a Granger regression postulating that US is leading China or Hong Kong looks like this.

$$R_{US}^t = a_0 + \sum_{i=1}^{q} \alpha_i R_{CN}^{t-i} + \sum_{i=1}^{p} \beta_i R_{US}^{t-i} + \varepsilon_t$$

$$R_{US}^t = a_0 + \sum_{i=1}^{q} \alpha_i R_{HK}^{t-i} + \sum_{i=1}^{p} \beta_i R_{US}^{t-i} + \varepsilon_t$$
Moreover, the trading hours of the Chinese stock markets and the Hong Kong stock market are of similar time period. Thus the lead-lag relationship between them can be found in successive days by the following regression models.

\[ R^\text{HK}_t = a_0 + \sum_{i=1}^{q} \alpha_i R^\text{CN}_{t-i} + \sum_{i=1}^{p} \beta_i R^\text{HK}_{t-i} + \varepsilon_t \]

\[ R^\text{CN}_t = a_0 + \sum_{i=1}^{q} \alpha_i R^\text{HK}_{t-i} + \sum_{i=1}^{p} \beta_i R^\text{CN}_{t-i} + \varepsilon_t \]

The vector autoregressions we used for causality tests assume that the variables in the system are stationary. So before estimating the relationship among different markets, a unit root test is performed for each of the six stock indices using the augmented Dickey-Fuller (ADF) test, to test for the stationarity of the stock returns of different markets. The data used for the unit root test are those of the two periods, that is from January 1, 1999 to December 31, 2004.

The augmented Dickey-Fuller (ADF) test consists of estimating the following regression model:

\[ \Delta R_t = \beta_1 + \beta_2 t + \varrho \Delta R_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta R_{t-i} + \varepsilon_t \]

where \( \varepsilon_1 \) is a pure white noise error term and \( \Delta R_{t-1} = (R_{t-1} - R_{t-2}) \), \( \Delta R_{t-2} = (R_{t-2} - R_{t-3}) \), etc.

We test whether \( \varrho = 0 \). If it is zero, we conclude that \( R_t \) is nonstationary and has a unit root in it. But if it is negative, we conclude that \( R_t \) is stationary and do not have a
unit root.

The following hypothesis is set up for testing each stock market’s returns.

\[ H_0: \delta = 0, \text{R}_t \text{ is nonstationary} \]

\[ H_1: \delta < 0, \text{R}_t \text{ is stationary} \]

Table 1 presents the ADF statistics for the testing.

**Table 1. Unit Root Tests for the stock returns**

<table>
<thead>
<tr>
<th>Index</th>
<th>Augmented Dickey-Fuller test statistic</th>
<th>( H_0: \text{nonstationary} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSI</td>
<td>-38.19076</td>
<td>Rejected</td>
</tr>
<tr>
<td>SHA</td>
<td>-8.024248</td>
<td>Rejected</td>
</tr>
<tr>
<td>SHB</td>
<td>-17.55805</td>
<td>Rejected</td>
</tr>
<tr>
<td>SZA</td>
<td>-8.110155</td>
<td>Rejected</td>
</tr>
<tr>
<td>SZB</td>
<td>-10.77091</td>
<td>Rejected</td>
</tr>
<tr>
<td>S&amp;P</td>
<td>-40.28853</td>
<td>Rejected</td>
</tr>
</tbody>
</table>

**Note:** HSI is Hang Send Index, SHA is Shanghai “A”, SHB is Shanghai “B”, SZA is Shenzhen “A”, SZB is Shenzhen “B”, and S&P is S&P 500 Composite Index. The critical values for \( t \) with \( \infty \) observations are: -2.57 at 10\%, -2.86 at 5\%, and -3.43 at 1\%.

The ADF test statistics test the hypothesis of a unit root in each series. Statistically insignificant (\( \delta = 0 \)) imply acceptance of the null hypothesis. As shown in Table 1, all
the indices are significant ($\delta < 0$) at 1% level, 5% level, and 10% level, thus we rejected $H_0$ in all the tests and concluded that all the indices are stationary.

4. Methodology

In this paper, Granger Causality Tests are used to investigate lead-lag relationships among the four Chinese stock markets and with that of the US and Hong Kong.

Let $Y_t$ and $X_t$ be the return series for any two markets out of the six. $Y_t$ causes $X_t$ in the Granger sense if present value of $X$ can be predicted by using past values of $Y$ than by not doing so, considering also other relevant information, including past values of $X$. More specifically, $X$ is said to cause $Y$, provided some $\alpha_t$ is not zero in Equation (2).

I) Procedures of the Granger Causality Test

The steps involved in implementing the Granger causality test are as follows.

First, using the technique of vector autoregression (VAR), estimate a restricted equation of order $p$

$$Y_t = \delta + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \epsilon_t$$  \hspace{1cm} (1)

where $Y_t$ represents the return in market $Y$ at time $t$. The lag-length $p$ is determined using the Akaike information criterion (AIC).

Next, estimate an unrestricted equation which includes the past data of the $X_t$ series,
which is
\[ Y_t = \sigma_0 + \sum_{i=1}^{q} \beta_i X_{t-i} + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \mu_t \]  

\( (2)^* \)

*Specific regression model is used for each stock market, considering the corresponding time-zone difference.

The lag-length \( q \) of \( X_t \) is also determined using AIC, given the value of \( p \) from the restricted equation.

Then run the restricted regression and unrestricted regression respectively to obtain the restricted residual sum of squares, \( \text{RSS}_R \) and unrestricted residual sum of squares, \( \text{RSS}_{UR} \).

The F-statistic below
\[ F = \frac{(\text{RSS}_R - \text{RSS}_{UR})/q}{\text{RSS}_{UR}/(n-p-q-1)} \]

where \( n \) is the sample size, provides a formal test for causality. If the computed F value exceeds the critical F value at the chosen level of significance, we concluded that there is a causality relationship from market X to market Y.

**II) Granger Causality Relationship**

Considering the following pair of regressions:
\[ Y_t = a_0 + \sum_{i=1}^{q} \beta_i X_{t-i} + \sum_{i=1}^{p} \alpha_i Y_{t-i} + e_t \]  
\( (I) \)

\[ X_t = c_0 + \sum_{i=1}^{q} \delta_i Y_{t-i} + \sum_{i=1}^{p} \lambda_i X_{t-i} + u_t \]  
\( (II) \)
A unidirectional causality from X to Y is indicated if the estimated coefficients on the lagged X in Equation (I) are statistically different from zero as a group (i.e., \( \sum \beta_i \neq 0 \)) and the set of estimated coefficients on the lagged Y in Equation (II) is not statistically different from zero (i.e., \( \sum \delta_i = 0 \)).

Conversely, a unidirectional causality from Y to X exists if the set of lagged X coefficients in Equation (I) is not statistically different from zero (i.e., \( \sum \beta_i = 0 \)) and the set of lagged Y coefficients in Equation (II) is statistically different from zero (i.e., \( \sum \delta_i \neq 0 \)).

Feedback causality exists when the sets of X and Y coefficients are statistically different from zero in both regressions. (\( \sum \beta_i \neq 0 \) & \( \sum \delta_i \neq 0 \))

Finally, independence is suggested when the sets of X and Y coefficients are not statistically significant in both regressions. (\( \sum \beta_i = 0 \) & \( \sum \delta_i = 0 \))

5. Empirical Results

This section presents the results of the tests of the causality relationship between the four Chinese stock indices, Hang Seng Index and S&P 500 Composite Index. The main results of the Granger Causality tests among the six stock exchanges are presented in Table 2a and Table 2b.
<table>
<thead>
<tr>
<th>X to Y</th>
<th>p</th>
<th>q</th>
<th>n</th>
<th>F-value</th>
<th>Significant Level</th>
<th>Causal Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSI to SHA</td>
<td>3</td>
<td>5</td>
<td>766</td>
<td>2.539867676</td>
<td>2.2141</td>
<td>Yes</td>
</tr>
<tr>
<td>HSI to SHB</td>
<td>3</td>
<td>1</td>
<td>766</td>
<td>0.086301479</td>
<td>3.8415</td>
<td>No</td>
</tr>
<tr>
<td>HSI to SZA</td>
<td>8</td>
<td>5</td>
<td>766</td>
<td>2.005321333</td>
<td>2.2141</td>
<td>No</td>
</tr>
<tr>
<td>HSI to SZB</td>
<td>4</td>
<td>1</td>
<td>766</td>
<td>0.267596703</td>
<td>3.8415</td>
<td>No</td>
</tr>
<tr>
<td>HSI to S&amp;P</td>
<td>3</td>
<td>1</td>
<td>766</td>
<td>6.614352918</td>
<td>3.8415</td>
<td>Yes</td>
</tr>
<tr>
<td>SHA to HSI</td>
<td>4</td>
<td>1</td>
<td>766</td>
<td>8.478388658</td>
<td>3.8415</td>
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<tr>
<td>SHA to SHB</td>
<td>3</td>
<td>1</td>
<td>766</td>
<td>2.994596909</td>
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<td>SHA to SZA</td>
<td>8</td>
<td>1</td>
<td>766</td>
<td>0.156296148</td>
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<td>9.886358452</td>
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<td>Yes</td>
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<tr>
<td>SHA to S&amp;P</td>
<td>3</td>
<td>1</td>
<td>766</td>
<td>1.766495105</td>
<td>3.8415</td>
<td>No</td>
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<tr>
<td>SHB to HSI</td>
<td>4</td>
<td>1</td>
<td>766</td>
<td>2.365885556</td>
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<td>SHB to SHA</td>
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<td>1.885411962</td>
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<td>SHB to SZA</td>
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<td>766</td>
<td>1.852908267</td>
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<td>No</td>
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<td>766</td>
<td>2.165862462</td>
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<td>SHB to S&amp;P</td>
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<td>766</td>
<td>0.255330367</td>
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<tr>
<td>SZA to HSI</td>
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<td>1</td>
<td>766</td>
<td>8.558114604</td>
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<td>Yes</td>
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<td>SZA to SHA</td>
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<td>SZA to S&amp;P</td>
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<td>766</td>
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<td>SZB to HSI</td>
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<td>766</td>
<td>0.845597203</td>
<td>3.8415</td>
<td>No</td>
</tr>
<tr>
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<td>5</td>
<td>766</td>
<td>2.214442335</td>
<td>2.2141</td>
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<td>SZB to SHB</td>
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<td>766</td>
<td>3.180269167</td>
<td>3.8415</td>
<td>No</td>
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<td>SZB to SZA</td>
<td>8</td>
<td>4</td>
<td>766</td>
<td>1.732324105</td>
<td>2.3719</td>
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<td>766</td>
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<td>S&amp;P to HSI</td>
<td>4</td>
<td>4</td>
<td>766</td>
<td>58.84103785</td>
<td>2.3719</td>
<td>Yes</td>
</tr>
<tr>
<td>S&amp;P to SHA</td>
<td>3</td>
<td>1</td>
<td>766</td>
<td>0.119053579</td>
<td>3.8415</td>
<td>No</td>
</tr>
<tr>
<td>S&amp;P to SHB</td>
<td>3</td>
<td>1</td>
<td>766</td>
<td>0.128815373</td>
<td>3.8415</td>
<td>No</td>
</tr>
</tbody>
</table>
From Table 2a, SZA to HSI and SZA to SZB showed unidirectional causalities; HSI and SHA, SHA and SZB, and HSI and S&P showed feedback causalities; while the remaining sets of X to Y markets are independent to each other.
| SZA to HSI | 2 | 8 | 798 | 3.5596361 | 1.9384 | Yes |
| SZA to SHA | 1 | 1 | 798 | 0.439324282 | 3.8415 | No |
| SZA to SHB | 2 | 1 | 798 | 0.927973472 | 3.8415 | No |
| SZA to SZB | 8 | 8 | 798 | 1.852067072 | 1.9384 | No |
| SZA TO S&P | 1 | 3 | 798 | 2.484514931 | 2.6049 | No |

| SZA to HSI | 2 | 8 | 798 | 3.594776202 | 1.9384 | Yes |
| SZA to SHA | 1 | 1 | 798 | 2.3425527 | 3.8415 | No |
| SZA to SHB | 2 | 1 | 798 | 0.772440705 | 3.8415 | No |
| SZA to SZA | 1 | 1 | 798 | 1.983218678 | 3.8415 | No |
| SZA to S&P | 1 | 3 | 798 | 3.010797496 | 2.6049 | Yes |

| S&P to HSI | 2 | 8 | 798 | 23.02884119 | 1.9384 | Yes |
| S&P to SHA | 1 | 1 | 798 | 0.006098403 | 3.8415 | No |
| S&P to SHB | 2 | 1 | 798 | 0.64287655 | 3.8415 | No |
| S&P to SZA | 1 | 1 | 798 | 0.027553652 | 3.8415 | No |
| S&P to SZB | 8 | 1 | 798 | 3.20263424 | 3.8415 | No |

**Note:** HSI is Hang Send Index, SHA is Shanghai “A”, SHB is Shanghai “B”, SZA is Shenzhen “A”, SZB is Shenzhen “B”, and S&P is S&P 500 Composite Index. X to Y indicates X leads Y. The values of significant level are chosen at 5%. Yes represents the causal relationship being significant at 5%.

From Table 2b, SHA to HSI, SHB to HSI, SHB to SHA, SHB to SZA, SZA to HSI, SZB to HSI, and SZB to S&P all showed unidirectional causalities; HSI and S&P showed feedback causalities; while the remaining sets of X to Y markets are independent to each other.

To help understand the results in a more concise manner, all the results in Table 2a and Table 2b are summarized in Table 3a and 3b.
I) The pre-entering period

For the period before China became a member of the World Trade Organization, Shenzhen “A” showed leading roles in the cases comparing with Hang Seng Index and Shenzhen “B” respectively. For Shenzhen “A” Granger-caused Hang Seng Index, as Hong Kong hangover to China in 1997, there was a closer relationship between Hong Kong and China, so as the relationship in their stock markets, hence the performance of the Shenzhen “A” affected the HSI’s performance. For the “A” stock markets’ returns leading the “B” stock markets’ returns, it is believed that it was due to the weak market efficiency in the China market.

Table 3a. Summary of causal relationships for the pre-entering period

<table>
<thead>
<tr>
<th></th>
<th>HSI</th>
<th>SHA</th>
<th>SHB</th>
<th>SZA</th>
<th>SZB</th>
<th>S&amp;P</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Y</td>
<td></td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSI</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHA</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHB</td>
<td>N</td>
<td>N</td>
<td></td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SZA</td>
<td>N</td>
<td>N</td>
<td></td>
<td></td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>SZB</td>
<td>N</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>S&amp;P</td>
<td>Y</td>
<td>N</td>
<td></td>
<td>N</td>
<td></td>
<td>N</td>
</tr>
</tbody>
</table>

Note: HSI is Hang Send Index, SHA is Shanghai “A”, SHB is Shanghai “B”, SZA is Shenzhen “A”, SZB is Shenzhen “B”, and S&P is S&P 500 Composite Index. Yes represents the causal relationship being significant at 5%.

As the “B” shares stocks are for foreign investors, they found that it was more difficult, relative to the domestic investors, to acquire and access reliable information
about the local Chinese firms. Thus the performance of the “A” stock markets could be a good predictor to the “B” stock markets. This happened between SZA and SZB.

On the other hand, feedback causal relationships existed between Hang Seng Index and Shanghai “A”, Shanghai “A” and Shenzhen “B”, Hang Seng Index and S&P 500 Composite Index respectively. It showed that there were close inter-relationship between each pair of them. As mentioned before, “A” stock markets in China had a leading role to HSI due to the strengthened relationship between them after the hangover of Hong Kong to China, this happened also between Shanghai “A” and Hang Seng Index. At the same time, SHA showed feedback to the performance of HSI, indicating that Hong Kong, as a financial leader in Asia, does positively influenced the decision of the domestic investors in Shanghai “A”. For Shanghai “A” and Shenzhen “B”, the situation was similar to that of the Shenzhen “A” and Shenzhen “B”. These results indicated that Shenzhen “B” investors relied on the performance of the “A” stock markets. The main difference between them was that Shenzhen “B” performance also worked as a factor of decision to the Shanghai “A” investors, but not to the Shenzhen “A” investors. Thus there was only feedback in the case between SHA and SZB. And for the feedback between Hang Seng Index and S&P 500 Composite Index, it was obvious from the past journals and from the markets that there was very close relationship between the Hong Kong stock market
and the US stock markets, as they are both very important stock exchanges in the
world financial market.

Interestingly, Shanghai “B” had no apparent influence on all the other five stock
exchanges. All F-values are statistically insignificant. It showed that it had no leading
role in the China, US and Hong Kong markets. It had a very weak predictive power in
all these markets during the tested period.

Also, all Chinese stock markets are independent to the US S&P 500 Composite Index,
this showed that the Chinese stock markets did not follow the performance of the US
market, which is one of the important financial markets in the world, and neither had
any predictive power to the US market.

II) The post-entering period

After China became a member of the WTO on December 11, 2001, the causal
relationships among the six stock exchanges had some changes.

First, the predictive power of HSI to the Chinese stock markets seen in the
pre-entering period disappeared, indicating that the Chinese stock markets were
independent to the Hong Kong market in the post-entering period.

Second, the results showed that Hang Seng Index had a lagging position in all the
cases with the other five exchanges, which means that both the China and US markets
led the Hong Kong market. The previous trading day performance in these markets strongly influenced the trading day performance of Hong Kong in the following days. And Hang Seng Index only showed feedback to the S&P 500 Composite Index, but not for the Chinese stock markets, indicating that the Hong Kong market and the US market affect each other, which was the same as the period before being a member of the WTO.

Table 3b. Summary of causal relationships for the post-entering period

<table>
<thead>
<tr>
<th></th>
<th>HSI</th>
<th>SHA</th>
<th>SHB</th>
<th>SZA</th>
<th>SZB</th>
<th>S&amp;P</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSI</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>SHA</td>
<td></td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>SHB</td>
<td></td>
<td></td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>SZA</td>
<td></td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>SZB</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>S&amp;P</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
</tbody>
</table>

Note: HSI is Hang Send Index, SHA is Shanghai “A”, SHB is Shanghai “B”, SZA is Shenzhen “A”, SZB is Shenzhen “B”, and S&P is S&P 500 Composite Index. Yes represents the causal relationship being significant at 5%.

Besides, the stock exchanges in China that open to the foreigners, that is the Shanghai “B” and Shenzhen “B”, showed leading status in different tests. Shanghai “B” led both Hang Seng Index, Shanghai “A” and Shenzhen “A”, while Shenzhen “B” led S&P 500 Composite Index. This phenomenon proved that the “B” stock markets in the China market experienced a leading role within the local stock markets, and also
to the US and Hong Kong markets in the post-entering period. It is thus believed that there was a positive effect to the Chinese stock markets with the status of being a member of the WTO. Information were more easily available to the foreign investors, thus they could make their investment decision more concisely and confidently, which made the “B” stock markets in China having a increased predictive power not only to the China market, but also the Hong Kong and US markets in the post-entering period.

6. Limitations

There are three main limitations in this paper.

1. The exact date of becoming a WTO member, December 11, 2001, is used as the separation day for the two periods of data. However, this news was announced some days before, the influence of it on the stock markets may already be reflected in the indices. Thus the results in the post-entering period may not be that much significant for comparison.

2. About 3 years’ data is used for each period, it may not be sufficient enough to observe the real situation. However, it is still a short period of time for China being a member of the WTO. In order to have a comparative time length for comparison, such time period was chosen for this paper.
3. When using the Akaike information criterion (AIC) to find out a suitable lag length for the Granger causality tests, a maximum 10 lagged terms was used for the trial and error in each case. Though the causality relationship might be reflected in more than 10 days, it was reasonable to do so as in most of the cases, information could be transferred and reflected within 10 lagged terms.

7. Conclusion and Discussion

This paper analyzed possible causal relationships among the Chinese stock markets, the Hong Kong stock market and the US stock market before and after China became a member of the World Trade Organization. Lead-lag relationships among six stock exchanges returns were investigated.

Granger Causality tests results showed no changes in the lead-lag relationship between the Hang Seng Index in the Hong Kong market and the S&P 500 Composite Index in the US market. They have a feedback relationship in regardless of the event that China became a member of the WTO. But to the Chinese stock markets, there were significant influences resulted.

At the time China not yet become a member of the WTO, the “A” stock markets in China, that is the Shanghai “A” and Shenzhen “A”, mostly led the other markets just like the Hang Seng Index and Shenzhen “B”. This showed that foreigners could
hardly get the information accurately from the China markets than the domestic citizens could, thus the performance of the “A” stock markets became one of the better prediction means to the Chinese markets to the foreign investors.

However, after China became a member of the WTO, the Granger Causality tests results altered. The “B” stock markets in China had a leading role towards most of the other stock exchanges, just like Shanghai “B” led Hang Seng Index and the two “A” stock markets, and Shenzhen “B” Granger caused S&P 500 Composite Index. These results probably suggested that the Chinese stock markets were gradually being integrated into the global economy as a consequence of becoming a member of the World Trade Organization.
References


5. Fok Ka Man, “The Relationship between United States stock market and Hong Kong stock market”, Honours Degree Project, 2001


Appendix I

Unit Root Test for Hang Seng Index

Null Hypothesis: HSI has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on AIC, MAXLAG=23)

<table>
<thead>
<tr>
<th>Augmented Dickey-Fuller test statistic</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>-38.19076</td>
<td>0.0000</td>
<td></td>
</tr>
</tbody>
</table>

Test critical values:
- 1% level: -3.434328
- 5% level: -2.863184
- 10% level: -2.567693


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(HSI)
Method: Least Squares
Date: 04/09/05   Time: 13:30
Sample (adjusted): 2 1564
Included observations: 1563 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSI(-1)</td>
<td>-0.965205</td>
<td>0.025273</td>
<td>-38.19076</td>
<td>0.0000</td>
</tr>
<tr>
<td>C</td>
<td>0.000235</td>
<td>0.000369</td>
<td>0.637464</td>
<td>0.5239</td>
</tr>
</tbody>
</table>

R-squared                      0.483033  Mean dependent var  1.84E-05
Adjusted R-squared             0.482702  S.D. dependent var  0.020281
S.E. of regression             0.014587  Akaike info criterion -5.616147
Sum squared resid             0.332133  Schwarz criterion    -5.609295
Log likelihood                4391.019  F-statistic          1458.534
Durbin-Watson stat            1.996843  Prob(F-statistic)     0.000000
Unit Root Test for Shanghai “A” Index

Null Hypothesis: SHA has a unit root

Exogenous: Constant

Lag Length: 20 (Automatic based on AIC, MAXLAG=23)

<table>
<thead>
<tr>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-8.024248</td>
</tr>
</tbody>
</table>

Test critical values:
- 1% level: -3.434382
- 5% level: -2.863208
- 10% level: -2.567706


Augmented Dickey-Fuller Test Equation

Dependent Variable: D(SHA)

Method: Least Squares

Date: 04/09/05   Time: 13:30

Sample (adjusted): 22 1564

Included observations: 1543 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHA(-1)</td>
<td>-0.893620</td>
<td>0.111365</td>
<td>-8.024248</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(SHA(-1))</td>
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<td>0.109323</td>
<td>-0.803884</td>
<td>0.4216</td>
</tr>
<tr>
<td>D(SHA(-2))</td>
<td>-0.119345</td>
<td>0.106946</td>
<td>-1.115940</td>
<td>0.2646</td>
</tr>
<tr>
<td>D(SHA(-3))</td>
<td>-0.067876</td>
<td>0.104697</td>
<td>-0.648305</td>
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</tr>
<tr>
<td>D(SHA(-4))</td>
<td>-0.040897</td>
<td>0.102343</td>
<td>-0.399606</td>
<td>0.6895</td>
</tr>
<tr>
<td>D(SHA(-5))</td>
<td>-0.078152</td>
<td>0.099674</td>
<td>-0.784078</td>
<td>0.4331</td>
</tr>
<tr>
<td>D(SHA(-6))</td>
<td>-0.105142</td>
<td>0.096872</td>
<td>-1.085372</td>
<td>0.2779</td>
</tr>
<tr>
<td>D(SHA(-7))</td>
<td>-0.091028</td>
<td>0.093697</td>
<td>-0.971516</td>
<td>0.3314</td>
</tr>
<tr>
<td>D(SHA(-8))</td>
<td>-0.076193</td>
<td>0.090350</td>
<td>-0.843306</td>
<td>0.3992</td>
</tr>
<tr>
<td>D(SHA(-9))</td>
<td>-0.087038</td>
<td>0.087174</td>
<td>-0.998436</td>
<td>0.3182</td>
</tr>
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<td>D(SHA(-10))</td>
<td>-0.091681</td>
<td>0.083251</td>
<td>-1.101263</td>
<td>0.2710</td>
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<td>D(SHA(-11))</td>
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<td>-1.483656</td>
<td>0.1381</td>
</tr>
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<td>D(SHA(-12))</td>
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<td>0.075312</td>
<td>-0.472049</td>
<td>0.6370</td>
</tr>
<tr>
<td>D(SHA(-13))</td>
<td>-0.078659</td>
<td>0.071101</td>
<td>-1.106298</td>
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<td></td>
<td></td>
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<td>D(SHA(-14))</td>
<td>-0.068321</td>
<td>0.066490</td>
<td>-1.027539</td>
<td>0.3043</td>
</tr>
<tr>
<td>D(SHA(-15))</td>
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<td>0.061348</td>
<td>-0.382561</td>
<td>0.7021</td>
</tr>
<tr>
<td>D(SHA(-16))</td>
<td>-0.010686</td>
<td>0.055998</td>
<td>-0.190823</td>
<td>0.8487</td>
</tr>
<tr>
<td>D(SHA(-17))</td>
<td>0.031602</td>
<td>0.050588</td>
<td>0.624696</td>
<td>0.5323</td>
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<tr>
<td>D(SHA(-18))</td>
<td>0.036565</td>
<td>0.044209</td>
<td>0.827100</td>
<td>0.4083</td>
</tr>
<tr>
<td>D(SHA(-19))</td>
<td>0.006060</td>
<td>0.035825</td>
<td>0.169143</td>
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<tr>
<td>D(SHA(-20))</td>
<td>0.058923</td>
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<tr>
<td></td>
<td>6.88E-05</td>
<td>0.000347</td>
<td>0.198131</td>
<td>0.8430</td>
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<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>R-squared</td>
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<td>Mean dependent var</td>
<td>4.82E-06</td>
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<tr>
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<td>S.D. dependent var</td>
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<td>S.E. of regression</td>
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<td>Akaike info criterion</td>
<td>-5.738639</td>
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<td>Sum squared resid</td>
<td>0.282649</td>
<td>Schwarz criterion</td>
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<tr>
<td>Log likelihood</td>
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<td>F-statistic</td>
<td>75.32679</td>
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<tr>
<td>Durbin-Watson stat</td>
<td>1.996843</td>
<td>Prob(F-statistic)</td>
<td>0.000000</td>
<td></td>
</tr>
</tbody>
</table>
Unit Root Test for Shanghai “B” Index

Null Hypothesis: SHB has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic based on AIC, MAXLAG=23)

<table>
<thead>
<tr>
<th></th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-17.55805</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Test critical values:
- 1% level -3.434336
- 5% level -2.863187
- 10% level -2.567695


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SHB)
Method: Least Squares
Date: 04/09/05   Time: 13:29
Sample (adjusted): 5 1564
Included observations: 1560 after adjustments

<table>
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<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHB(-1)</td>
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<td>-17.55805</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(SHB(-1))</td>
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<td>-1.992609</td>
<td>0.0465</td>
</tr>
<tr>
<td>D(SHB(-2))</td>
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<td>0.0815</td>
</tr>
<tr>
<td>C</td>
<td>0.000522</td>
<td>0.000568</td>
<td>0.918279</td>
<td>0.3586</td>
</tr>
</tbody>
</table>

R-squared 0.458759  Mean dependent var -3.58E-05
Adjusted R-squared 0.457367  S.D. dependent var 0.030405
S.E. of regression 0.022397  Akaike info criterion -4.756565
Sum squared resid 0.780039  Schwarz criterion -4.739410
Log likelihood 3715.121  F-statistic 329.5074
Durbin-Watson stat 1.998688  Prob(F-statistic) 0.000000
Unit Root Test for Shenzhen “A” Index

Null Hypothesis: SZA has a unit root
Exogenous: Constant
Lag Length: 20 (Automatic based on AIC, MAXLAG=23)

<table>
<thead>
<tr>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
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Test critical values:
- 1% level: -3.434382
- 5% level: -2.863208
- 10% level: -2.567706


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SZA)
Method: Least Squares
Date: 04/09/05   Time: 13:29
Sample (adjusted): 22 1564
Included observations: 1543 after adjustments

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Unit Root Test for Shenzhen “B” Index

Null Hypothesis: SZB has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic based on AIC, MAXLAG=23)

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Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SZB)
Method: Least Squares
Date: 04/09/05   Time: 13:29
Sample (adjusted): 9 1564
Included observations: 1556 after adjustments

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R-squared     | 0.465248 | Mean dependent var | -3.44E-05|
Adjusted R-squared | 0.462482 | S.D. dependent var | 0.031404|
S.E. of regression | 0.023024 | Akaike info criterion | -4.698808|
Sum squared resid  | 0.820059 | Schwarz criterion | -4.667864|
Log likelihood   | 3664.672 | F-statistic | 168.2411|
Durbin-Watson stat | 1.996593 | Prob(F-statistic) | 0.000000|
**Unit Root Test for S&P 500 Composite Index**

Null Hypothesis: \( S_P \) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic based on AIC, MAXLAG=23)

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Test critical values:

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Augmented Dickey-Fuller Test Equation

Dependent Variable: D(S_P)

Method: Least Squares

Date: 04/17/05   Time: 00:05

Sample (adjusted): 2 1564

Included observations: 1563 after adjustments

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R-squared 0.509762  Mean dependent var -2.72E-07

Adjusted R-squared 0.509448  S.D. dependent var 0.017564

S.E. of regression 0.012302  Akaike info criterion -5.956879

Sum squared resid 0.236229  Schwarz criterion -5.950028

Log likelihood 4657.301  F-statistic 1623.166

Durbin-Watson stat 2.000140  Prob(F-statistic) 0.000000
### Appendix II

**Akaike information criterion (AIC) Results for the pre-entering period**

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* indicates the chosen value for the lagged length