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Causality and cointegration of stock markets among the United States, Japan, and the South China Growth Triangle

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Abstract

This paper explores the causality and cointegration relationships among the stock markets of the United States, Japan and the South China Growth Triangle (SCGT) region. Applying the recently advanced unit root and cointegration techniques that allow for structural breaks over the sample period (October 2, 1992 to June 30, 1997), we find that there exists no cointegration among these markets except for that between Shanghai and Shenzhen. By invoking the Granger causality test and considering the non-synchronous trading problem, we will show that stock price changes in the US have more impact on SCGT markets than do those of Japan. More specifically, price changes in the US can be used to predict those of the Hong Kong and Taiwan markets on next day. Similarly, price changes on the Hong Kong stock market lead the Taiwan market by 1 day. Furthermore, the stock returns of the US and Hong Kong markets are found to be contemporaneous. Finally, there is a significant feedback relationship between the Shanghai and the Shenzhen Stock Exchanges.

JEL classification: G15; G12; C32

Keywords: Causality test; South China Growth Triangle; Structural break

1. Introduction

Based on the estimate by Masood and Gooptu (1993), the flow of portfolio investments to emerging financial markets has taken a quantum leap from \$6.2 billion in 1987 to 37.2 billion

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Table 1
Basic information of SCGT stock markets

	1991	1992	1993	1994	1995	1996	1997	1998
China								
No. of listed companies	14	52	183	291	323	540	743	853
Market capitalization	2,028	18,255	40,567	43,521	42,055	113,755	206,366	231,322
Percent of total emerging market	0.22	1.82	2.40	2.27	2.18	5.01	9.38	12.12
Trading value	820	16,715	43,395	97,526	49,774	256,008	369,574	284,766
Percent of total emerging market	0.13	2.65	3.93	5.86	4.78	16.95	13.86	14.55
Turnover ratio (%)		158.9	164	233.4	115.9	329	231	130.1
Taiwan								
No. of listed companies	221	256	285	313	347	382	404	437
Market capitalization	124,864	101,124	195,198	247,325	187,206	273,608	287,813	260,015
Percent of total emerging market	13.75	10.11	11.56	12.93	9.70	12.04	13.08	13.63
Trading value	365,232	240,667	346,487	711,346	383,099	470,193	1,297,474	884,698
Percent of total emerging market	59.29	38.13	31.39	42.72	36.76	31.13	48.66	45.21
Turnover ratio (%)	330.1	209.3	235.5	323.1	174.9	204.4	440	333.2
Emerging market								
Market capitalization	907,871	1,000,319	1,688,781	1,913,273	1,929,050	2,272,184	2,200,591	1,908,258

Percent of total world market	8.00	9.16	12.05	12.65	10.84	11.13	9.36	6.95
Trading value	615,965	631,188	1,103,746	1,665,141	1,042,297	1,510,529	2,666,647	1,956,858
Percent of total world market	12.27	13.20	15.34	18.88	10.20	11.09	13.69	8.55
Hong Kong								
No. of listed companies	333	386	450	529	518	561	658	658
Market capitalization	1,219,86	1,721,06	385,247	269,508	303,705	449,381	413,323	343,394
Percent of total developed market	1.17	1.73	3.13	2.04	1.92	2.48	1.94	1.34
Trading value	38,607	78,598	1,315,50	1,471,58	106,888	166,419	489,365	205,918
Percent of total developed market	0.88	1.89	2.16	2.06	1.16	1.37	2.91	0.98
Market capitalization	10,434,218	9,923,024	12,327,242	13,210,778	15,859,021	18,139,951	21,317,929	25,553,855
Percent of total world market	92.00	90.84	87.95	87.35	89.16	88.87	90.64	93.05
Trading value	4,403,631	4,151,662	6,096,929	7,156,704	9,176,451	12,105,541	16,818,167	20,917,462
Percent of total world market	87.73	86.80	84.74	81.12	89.80	88.91	86.31	91.45
World								
Market capitalization	11,342,089	10,923,343	14,016,023	15,124,051	17,788,071	20,412,135	23,518,520	27,462,113
Trading value	5,019,596	4,782,850	7,194,675	8,821,845	10,218,748	13,616,070	19,484,814	22,874,320

Source: Emerging Stock Market Factbook 1999, International Financial Corporation (in billions of US dollars).

in 1992. The importance of emerging markets cannot be denied, especially for the market of the People's Republic of China (PRC). The growing PRC market consists of the Shanghai Stock Exchange and the Shenzhen Stock Exchange. The former commenced operations in December 1990 while the latter opened its market in April 1991. The rapid expansion of the PRC markets reflects China's significant economic growth. As shown in Table 1, trade volume, market capitalization, and number of listed companies have mushroomed for the 7-year period from 1991–1998. In the beginning, the market capitalization and trade volume accounted for less than 1% of that in the entire emerging markets. However, they have increased to 12.12% and 14.55%, respectively, in 1998. As the PRC gradually opens her markets to international trade, the concept of the South China Growth Triangle (SCGT) begins to take shape. Thus far, the SCGT consists of Hong Kong, Taiwan and the Southern part of the PRC.

Improved relationship between the countries, coupled with the return of Hong Kong to the PRC on July 1, 1997, has strengthened ties within the SCGT. Given that the three economies adopt export-led policies, will the interaction become stronger due to greater trade within the SCGT? Are members of the SCGT as much economically tied to the US and Japan as before? These are the questions this paper addresses.

Quite a few papers address the issue of capital markets in emerging economies (Eun & Shim, 1989; Dwyer & Hafer, 1993; Ma, 1993; Heston et al., 1995). The cointegration relationship among different markets was addressed by Wei et al. (1995) and Hu et al. (1997). Despite the analyses of the PRC market by Bailey (1994), Ma (1996) and Su and Heisher (1997), the literature on the market interactions between the PRC and other major economies are lacking. This paper intends to fill some of these gaps. It is to be noted that the three markets have begun to play more important roles in the world economy. For instance, the Taiwan market accounts for 13% and 45% in terms of market capitalization and trade volume in the emerging markets. The Hong Kong market has a share of approximately 2% of the developed markets in both market capitalization and trade volume. Altogether, the three markets of the SCGT account for about 3% to 4% in terms of world market capitalization value, and 5.3% to 11.0% in world trade volume. Owing to their growing importance, a study on interactions within the SCGT is of paramount interest.[1] Although no long-term cointegration relationships have been identified within the members of the SCGT, or between SCGT and the US, or between SCGT and Japan, we demonstrate a significant Granger causality for the markets of Taiwan–US, and Hong Kong–US. In addition, the Hong Kong market is found to lead the Taiwan market. Although the two markets in the PRC exhibit a feedback relationship, they do not appear to have any short-term relationship with other markets of the SCGT, the US or Japan.

The structure of this paper is as follows. The next section reviews the literature. The third section explains the stock markets of the PRC. The fourth section presents data and basic statistics of the U.S., Japanese and SCGT markets. The fifth section discusses unit root and cointegration results of these markets. We then explore the pairwise causality between SCGT and the US, SCGT and Japan, Shanghai and Shenzhen, and among SCGT members. A conclusion is given in the last section.

[1] Refer to Table 1 for basic information on the three markets.

2. Literature review

Recent studies on equity market integration and segmentation include contributions by Errunza and Losq (1987), Bekaert and Harvey (1995), and Heston et al. (1995).[2] They, to various extents, apply statistical models to study the time-varying cointegration property of different equity markets. The study on market interdependence can be traced back to as early as Granger and Morgenstern (1970). Subsequent analyses include Ripley (1973), Lessard (1974, 1976), Panto et al. (1976) and Hilliard (1979). Their conclusions generally point to the following observation: national stock indices are merely a reflection of their economies, and as such only weak correlations are found. This being the case, an international portfolio could be quite advantageous. Hilliard's paper (1979), using spectrum analysis, focused on the correlation relations (contemporaneous lagged daily stock prices) of 10 major markets. Contemporaneous correlation was found to be significant for intercontinental stock prices but weak for intracontinental prices. In other studies (Ripley, 1973; Ibbotson et al., 1982), noticeable stock price comovements were identified due to factors such as geographical proximity, institutional currency relationships, partnerships in trade and cultural or economic base similarities. Recent studies by Schollhammer and Sand (1987), Dwyer and Harter (1988), employing cross correlation techniques or the unit root model (daily or monthly returns) have indicated a lack of correlation in stock prices among the U.S. Japanese, German, and the U.K. markets. However, variations in the stock prices were found to have been correlated before the 1987 market crash. The bottom line is how one accurately estimates the correlation coefficient matrix. Eun and Resnick (1984) compare various techniques of estimating the direct and indirect correlation coefficients with the assumption that securities are correlated with one another only through common factors that respond to the world market index. Their conclusion favors the direct estimation approach. Another important question in estimating correlation coefficients is its stability in terms of long-term and intertemporal periods. For instance, intertemporal stability is refuted by Maldonado and Saunders (1981) who employ the monthly stock prices (1957–1978) in the US, Japanese, German, Canadian and U.K. markets in their study. On the other hand, intertemporal stability is supported by Watson (1980) and Philippatos et al. (1983). More recently, Longin and Solnik (1995) document the evidence of instability of both correlation and covariance coefficients via the multivariate GARCH (1,1) model. Nonetheless, in the wake of unabated and synchronized growth across various countries, there is good reason to believe that interdependence among national stock indices is on the rise.

Another key angle in investigating the interdependence of average stock returns focuses on the transmission mechanism. For instance, Eun and Shim (1989) identify some multilateral interactions via the impulse response function of a 9-country VAR model. Innovations from the U.S. market are rapidly transmitted abroad, but the innovations abroad cannot significantly impact US stock returns.[3] In addition, dynamic responses of

[2] Readers are referred to Adler and Dumas (1983), Cho et al. (1986), Gultekin et al. (1989), Korajczyk and Viallet (1989), Ambrose et al. (1992) and Foerster and Karolyi (1993).

[3] Eun and Shim (1989) did not explain the implications of the significance level in terms of statistical testing. Rather, they define the significance level as the one that has any positive absolute value of the impulse response function.

national markets are shown to be generally consistent with the efficient information hypothesis. In another study, Joen and Von Furstenberg (1990) analyze the interaction among major markets (the U.S. Britain, Japan and Germany) by using the impulse response functions of a VAR model. Sifting through the daily returns (January 1986 to November 1988) at market close, they examine the correlation coefficient matrix and find that the role of U.S. leadership has undergone some structural changes after the 1987 crash. That is, the leadership role by the U.S. has somewhat diminished while that of Japan has increased. In addition, the phenomenon of stock price comovement seems to be on the rise continually. Employing recently advanced unit root and cointegration techniques that accommodate structural breaks, we intend to examine lead, lag or feedback relations via the Granger causality among the U.S., Japan and SCGT members. The technique provides more accurate results (Granger et al., 2000) and the topic is potentially interesting and important: Can cultural and linguistic similarity overcome the differences in economic systems?

3. Development of the Chinese stock markets

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 Market was officially opened in 1990 and the Shenzhen Stock Market in 1991. Two types of stocks are traded in the two markets: class A and class B. Class A shares are restricted to Chinese (PRC) citizens and denominated in Chinese currency yuan or Renminbi (RBM), while class B shares can be bought and sold only by foreigners and are settled in foreign currencies (US dollars for Shanghai, Hong Kong dollars for Shenzhen). By the end of 1995, there were 135 companies and 161 stocks listed on the Shenzhen Stock Exchange.[4] Regardless of some inevitable difficulties in its infancy stage, the rapid development of China's capital markets has generated interest among academics, investors and regulators. In this study, we focus our analysis on the relationship of share A markets with four other markets. There are at least two reasons for examining class A share markets. First, the class B shares market has been losing its appeal to foreign investors while the class A share market dominates that of class B shares in terms of the number of listed companies, trade volume and market capitalization. Second, it allows us to address an interesting issue: how the volatility of a market, which is largely closed to foreign investors, is related to the volatility of foreign markets.

4. Data and basic statistics

Sample data included in this study comprise daily stock prices at market close (close quotes October 1, 1992 through June 30, 1997). Specifically, we take (i) the Taiwan weighted

[4] Refer to the basic information in Table 1.

Table 2
Basic statistics of the six stock indices

	HKN	JPN	SHS	SHZ	TWN	USA
Mean	0.0817	0.0138	0.0466	0.0366	0.0747	0.0693
Median	0.0258	0.0000	0.0000	0.0000	0.0000	0.0486
Maximum	5.7072	7.5509	28.8602	27.2152	7.4081	2.6049
Minimum	−8.3484	−5.7611	−17.9047	−18.8833	−7.7818	−3.0823
Std. Dev.	1.4339	1.2151	3.4766	3.1175	1.5100	0.6771
Skewness	−0.4074	0.2715	1.4335	0.9150	0.0206	−0.3383
Kurtosis	6.5837	6.3442	15.4341	13.9098	6.1000	4.9157
JB	696.19*	591.62*	8,392.41*	6,307.30*	495.42*	212.75*
N	1,237	1,237	1,237	1,237	1,237	1,237

Daily rate of return for the six stock markets is calculated based on the conventional first difference of logarithmic prices:

$$r_{t,i} = (\log p_{t,i} - \log p_{t-1,j}) \times 100$$

where $r_{t,i}$ denotes the rate of return for the ith market on day t and $p_{t,i}$ denotes the corresponding stock price index. HKN = Hong Kong, JPN = Japan, SHS = Shanghai, SHZ = Shenzen, TWN = Taiwan. JB = Jarque–Bera Statistic. N = number of observations. Std. Dev. = Standard deviation.

* 1% significance level.

volume index (TWN), (ii) the Nikkei 225 Index of Tokyo (JPN), (iii) the Dow Jones Industrial Average of the U.S. (US), (iv) the Hang Seng Index of Hong Kong (HKN), (v) the Shanghai Index (class A shares) or SHS and (vi) the Shenzhen Index (class A shares) or SHZ. All data is obtained from the Datastream database.[5] Daily percentage changes of stock prices for the six stock markets are calculated using the conventional first difference of logarithmic prices [Eq. (1)]:

$$\triangle y_{t,i} = (\log y_{t,i} - \log y_{t-1,i}) \times 100 \tag{1}$$

where $\triangle y_{t,i}$ denotes the percentage change of stock price for the ith market on day t and $y_{t,i}$ denotes the corresponding stock price index. The descriptive statistics reported in Table 2 indicate that emerging markets tend to have greater leptokurtosis with more pronounced fluctuations. It is not surprising that the Shenzhen and the Shanghai markets have the greatest kurtosis.[6] Likewise, both the Shanghai and the Shenzhen markets have the largest standard deviations as well. These results are consistent with the finding by Bekaert and Harvey (1995) that return volatility in emerging markets is greater than that of developed markets.

The autocorrelation functions (ACF) shown in Table 3 exhibit some interesting characteristics: The coefficients of the ACFs of the U.S. and Japanese markets (barring the marginal significances at k = 1 and k = 3) are statistically insignificant for all 12 lags.

[5] We are grateful for the generosity extended by the economics department of UCSD.

[6] Greater kurtosis values for the Shanghai and the Shenzen markets are indicative of the clustering of stock price changes around their mean or median values with a handful of large changes. In other words, the high kurtosis values may have been related to relatively short history of the two markets in which the great majority of price changes occurred around the mean.

Table 3
Coefficients of ACF of the six stock indices

	HKN	JPN	SHS	SHZ	TWN	USA
1	−0.0270	−0.0573*	0.0059	0.0160	−0.0281	0.0404
2	0.0403	0.0020	0.0381	0.0617*	0.0312	0.0133
3	0.0483	−0.0052	0.0899*	0.0132	0.0481	−0.0634*
4	−0.0120	0.0190	0.0423	0.0955*	−0.0072	−0.0316
5	0.0337	−0.0359	0.0140	0.0108	0.0329	0.0068
6	−0.0486	−0.0125	0.0323	−0.0644*	−0.0486	−0.0101
7	−0.0238	−0.0085	−0.0067	−0.0175	−0.0278	0.0077
8	0.0469	0.0052	−0.0738*	−0.0204	0.0490	−0.0222
9	−0.0132	0.0225	0.0677*	0.0157	−0.0114	−0.0043
10	0.0648*	0.0030	−0.0209	−0.0417	0.0635*	0.0169
11	−0.0016	0.0204	0.0842*	−0.0005	−0.0008	−0.0290
12	0.0209	0.0329	0.0741*	0.0360	0.0158	0.0015

* 5% significance level.

In contrast, the Shanghai and the Shenzhen markets exhibit clear statistical significance of varying degrees in the first 12 lags. Between these two extremes, the Taiwan and the Hong Kong markets have their significant ACF coefficients in the 10th lag periods. It verifies the result by Bekaert and Harvey (1995) that the ACFs have some significant lag effects in stock returns of emerging markets.

Trend plots of the six stock indices except that of Japan (Fig. 1) reveal steady growth paths. This growth trend is most conspicuous in the US market, followed by Hong Kong. Moreover, structural changes as manifested in these indices are readily detectable, and as such, proper procedures of unit root and cointegration are necessary for valid statistical estimations.

5. Unit root and cointegration tests with regime shifts

Prior unit root analyses rest largely on the Augmented Dickey–Fuller (ADF) test developed by Dickey and Fuller (1979) in the following equation:

$$\triangle y_t = \alpha + \beta t + (\rho - 1)y_{t-1} + \sum_{i=1}^{k-1} \theta_i \triangle y_{t-i} + a_t \tag{2}$$

where $\triangle = 1-L$, y_t = stock price at time period t, t = trend variable, and a_t obeys white noise with the null hypothesis H_0: $\rho = 1$. Failure to reject the null hypothesis implies a unit root in y_t. Popular as it is, the ADF test statistic can very likely lead to erroneous conclusions in the event of a regime shift such as a depression or an oil shock (Perron, 1989). The crux of the matter is that the traditional ADF test fails to reject the H_0 in the presence of structural break(s). To circumvent this problem Perron and Vogelsang (1992) include a dummy variable in Eq. (2). However, the use of dummy variables has its own problem as pointed out by Zivot and Andrews (1992, pp. 251). A skeptic of Perron's approach would argue that his choices of breakpoints are based on prior observations of the data, and hence problems associated with

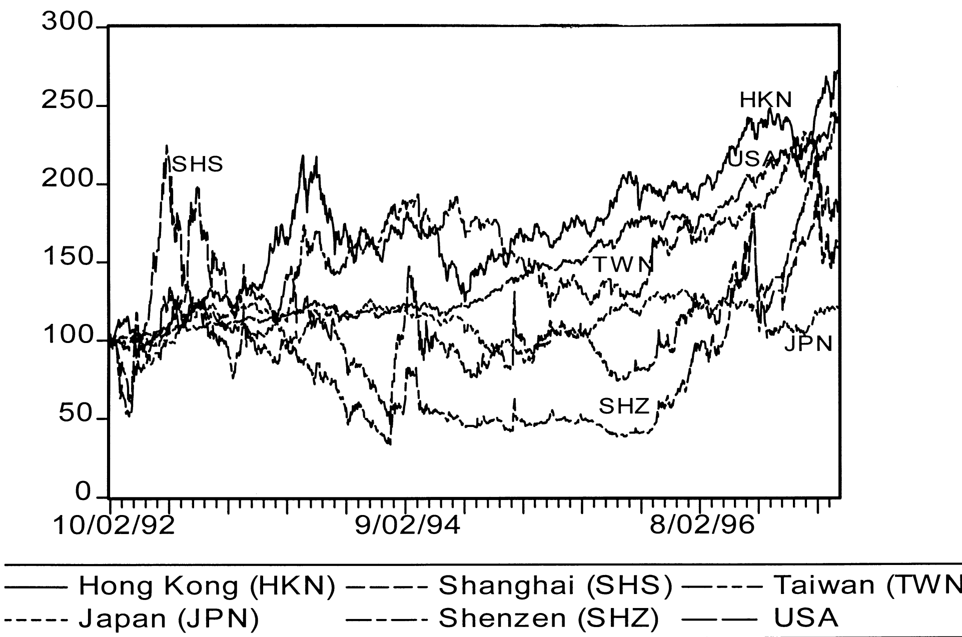

Fig. 1. Stock price trends of the US, Japan, Hong Kong, China, and Taiwan (10/05/1992 = 100).

'pre-testing' are applicable to his method. Consequently, Zivot and Andrews (1992) modify the ADF specification as shown below[7]:

$$\triangle y_t = \alpha + \beta t + \gamma \mathrm{DU}_t(\lambda) + (\rho - 1)y_{t-1} + \sum_{i=1}^{k-1} \theta_i \triangle y_{t-i} + a_t \tag{3}$$

where $\mathrm{DU}_t(\lambda) = 1$ for $t > T\lambda$, otherwise $\mathrm{DU}_t(\lambda) = 1$; $\lambda = T_B/T$ represents the location where the structural break lies; T is sample size; T_B is the date when the structural break occurred. Note that estimation results hinge upon λ. As such, Zivot and Andrews (1992) simulate a set of critical value for different λ.

A perusal of Table 4 reveals that except in the case of Taiwan (with significance level slightly less than 5%), we fail to reject the null hypothesis. This is to say that the logarithmic stock prices in the study are largely of $I(1)$.[8] In their influential work, Engle and Granger (1987) pioneer the cointegration technique especially in the case of $I(1)$ variables. Despite the normalization problem, the Engle–Granger model remains popular for its simplicity and clarity. Unfortunately, it suffers from the same problem as does the ADF model. It could lead to erroneous results in the presence of a structural break. For this reason, Gregory and Hansen (1996) proposed a new test procedure that combines both the Engle and Granger (1987) and

[7] Owing to the presence of trends (Fig. 1), we adopt model A of Zivot and Andrews (1992) which includes a trend variable.

[8] The logarithmic stock prices of Taiwan are considered $I(1)$ and not found to be cointegrated with that of other markets.

Table 4
Unit root test

	HKN	JPN	SHS	SHZ	TWN	USA
Z&A	−3.71 [0.44]	−3.09 [0.67]	−3.66 [0.24]	−3.67 [0.76]	−3.88*[0.53]	−3.67 [0.28]

Z&A = Zivot and Andrews (1992) unit root test based on the following equation:

$$\triangle y_t = \alpha + \beta_t + (\rho - 1)y_{t-1} + \gamma \mathrm{DU}_t(\lambda) + \sum_{t=1}^{k-1} \theta_i \triangle y_{t-i} + a_t$$

where $\mathrm{DU}_t(\lambda) = 1$ for $t > T\lambda$; otherwise, $\mathrm{DU}_t(\lambda) = 0$. $\lambda = T_B/T$ indicates the location of a structural break. T = sample size. T_B = date when a structural break occurred. Numbers in [ ] are break point λ. The sample period spans from 10/01/1992 to 06/30/1997. The smallest test statistics of the Zivot and Andrews (1992) model are used (k = 4) for testing hypothesis.

* 5% significance level.

Zivot and Andrews (1992) models. Theirs is a residual-based cointegration approach that allows for regime shift. It is a two-stage model based on the following multiple regression:

$$y_{1t} = \alpha + \beta t + \gamma \mathrm{DU}(\lambda) + \theta y_{2t} + e_t \tag{4}$$

where y_{1t} and y_{2t} are of $I(1)$; y_{2t} is a variable or a set of variables; $\mathrm{DU}_t(\lambda)$ is the same as in Eq. (3). After estimating Eq. (4) in the first stage, we proceed to test if the residual e_t is of $I(0)$ or $I(1)$. There exists some cointegrating relation(s) between y_{1t} and y_{2t} if e_t is of $I(0)$. The result of using the Gregory and Hansen model (1996) is reported in Table 5.

The bivariate cointegration tests are performed between (1) members of the SCGT and the US, (2) members of the SCGT and Japan, (3) the Shanghai and Shenzhen Stock Exchange, and among SCGT members. The trivariate cointegration test is applied to the members of the SCGT. A moment's inspection indicates that the test statistics are greater between members of SCGT and the US than between the SCGT and Japan. However, they are not statistically significant according to the critical values provided by Gregory and Hansen (1996). This implies that there exists no long-term cointegrating relation in the stock markets between SCGT members, and either the US or Japan.

The emergence of the SCGT could profoundly tilt the balance of economic power within the region.[9] Despite the similarities in culture and language and close geographical proximity, there does not seem to exist a stable cointegration within the SCGT. In some sense it is not surprising to see three segmented capital markets, because each market has varying degrees of restrictions on capital movements (Wei et al., 1995). The Shanghai market, facing severe restrictions on foreign exchange, has the stiffest controls, followed by Taiwan. Viewed from this perspective, capital controls, more than any other factors, may have played a major role in economic integration or segmentation. As a consequence, we cannot support the notion of cointegrating relations among the capital markets in the SCGT, despite the fact that the intraregional trades have intensified. The presence of the two equity markets in the PRC along with the two-tier system (class A and B shares) offers an interesting case for studying capital market integration and segmentation effects

[9] The Shanghai market is taken to represent the PRC. Results remain similar if the Shenzhen market is used.

Table 5
Cointegration test results

HKN on USA	−4.67	HNK on JPN	−3.78
USA on HKN	−4.55	JPN on HKN	−3.02
SHS on USA	−4.32	SHS on JPN	−3.78
USA on SHS	−3.96	JPN on SHS	−3.09
SHZ on USA	−4.98	SHZ on JPN	−4.03
USA on SHZ	−3.96	JPN on SHZ	−3.04
TWN on USA	−3.84	TWN on JPN	−3.92
USA on TWN	−3.76	JPN on TWN	−3.58
SHS on SHZ	−5.35*	TWN on HKN	−3.91
SHZ on SHS	−5.29*	HKN on TWN	−3.68
SHS on HKN	−3.69	SHS on TWN	−3.70
HKN on SHS	−3.77	TWN on SHS	−3.93
SHZ on HKN	−4.10	SHZ on TWN	−4.02
HKN on SHZ	−3.83	TWN on SHZ	−3.89
HKZ on TWN SHS	−3.81	SHS on SHZ	−5.35*
TWN on HKN SHS	−3.95	SHZ on SHS	−5.29*

The first stage of the Gregory and Hansen cointegration model is to estimate the multiple regression that takes into consideration structural breaks:

$$\triangle y_t = \alpha + \beta_t + \gamma \mathrm{DU}_t(\lambda) + \theta_1 y_{2t} + e_t$$

where y_{1t} and y_{2t} are of $I(1)$ and y_{2t} is a variable or a set of variables. $\mathrm{DU}_t(\lambda) = 1$ for $t > T\lambda$; otherwise, $\mathrm{DU}_t(\lambda) = 0$. The second stage involves a unit root test (ADF or Phillips–Perron test) on e_t. If e_t is of $I(0)$, a cointegrating relation is ascertained. The sample period spans from 10/01/1992 to 06/30/1997. The smallest test statistics of Zivot and Andrews (1992) model are used for testing hypothesis. The second stage is based on the ADF test with $k = 4$.

* 5% significance level.

within a socialist economy. These two markets are expected to exhibit the cointegration since they reflect similar fundamental economic forces. As shown in Table 4, the test statistics indicate that we reject the null hypothesis at 5% significance level; that is, there exists a statistically significant cointegrating relation between the Shanghai and the Shenzhen markets.

6. Causality test

In the absence of long-term equilibrium (cointegration) relations between either the US or Japan and the SCGT members, a study on short-term interactions is in order. We apply the Granger (1969) model, based on the following bivariate VAR model:

$$\triangle y_{1t} = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \triangle y_{1t-i} + \sum_{i=1}^{k} \alpha_{2i} \triangle y_{2t-i} + \varepsilon_{1t}$$

$$\triangle y_{2t} = \beta_0 + \sum_{i=1}^{k} \beta_{1i} \triangle y_{1t-i} + \sum_{i=1}^{k} \beta_{2i} \triangle y_{2t-i} + \varepsilon_{2t} \quad (5)$$

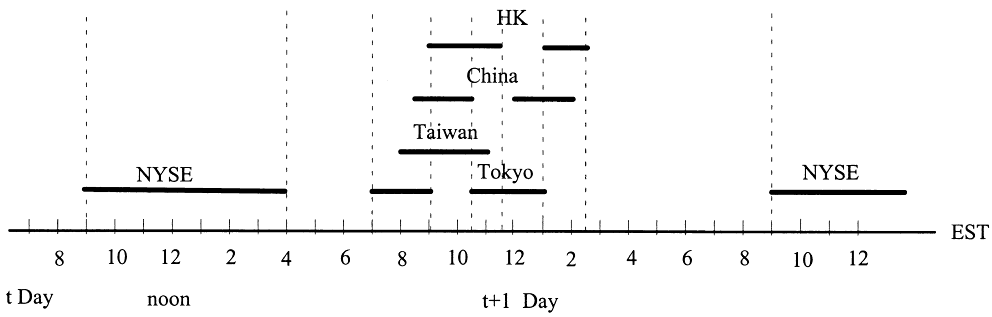

Fig. 2. Trading time pattern (EST, New York Time).

where y_{1t} and y_{2t} denote stock prices of two different countries, and ε_{1t} ε_{2t} are assumed to be serially uncorrelated with zero mean and finite covariance matrix. When the null hypothesis H_0:$\alpha_{21} = \alpha_{22} = \ldots = \alpha_{2k} = 0$ is retained, it suggests that y_{2t} does not Granger-cause y_{1t}. Conversely, if the null hypothesis H_0:$\beta_{11} = \beta_{12} = \ldots = \beta_{1k} = 0$ is not rejected, it implies that y_{1t} does not Granger-cause y_{2t}. The main problem with the use of daily returns across countries is the nonsynchronous trading periods for different markets around the world. This institutional feature of markets has been the focus of a large literature on international returns and volatility spillovers.[10] Fig. 2 illustrates the trading hours of the five markets in terms of the Eastern Standard Time.

Evident from Fig. 2, the trading hours of all the five markets except the US occur on the same calendar day. The trading hours of the US market take place 1 calendar day before that of other markets. This is to say that we lag the US stock prices by 1 day in performing the Granger causality tests between the US and other markets. On the other hand, we use the price change data of the same calendar day for the markets of Japan and SCGT. The results of the Granger causality are reported in Table 6.

A perusal of Table 6 reveals that there exists no causal relationship between the US and the Shanghai markets. In contrast, the US market is found to lead both the Hong Kong and the Taiwan markets by 1 day in terms of price changes. However, price changes of SCGT members (except Hong Kong) do not lead the US market. Such a 1-day causality is consistent with the result from Wei et al. (1995). The result that the previous day's price movement in the US market has a positive impact on the following day's price movement in the Taiwan and Hong Kong markets is logical. The Hong Kong dollar has been pegged to the U.S. dollar since 1983. As a result, if the U.S. market movement is to reflect the expected change in the interest rate in the U.S., the movement of the U.S. market will have an immediate spillover effect to Hong Kong. On the other hand, high technology industry in Taiwan can actually serve and reflect its counterpart industry in the U.S. This is especially true as the high technology stocks account for between 50% and 60% of the total market capitalization in Taiwan. It is not unexpected, therefore, that the U.S. market has a

[10] See Hamao et al. (1990), Bae and Karolyi (1994), Lin et al. (1994), and Connolly and Wang (1995).

Table 6
Granger causality test results

Null hypothesis	F-statistic	Probability
USA–/→HKN	144.52	0.00
HKN–/→USA	0.55	0.46
USA–/→SHS	0.31	0.58
SHS–/→USA	2.34	0.13
USA–/→TWN	5.88	0.02
TWN–/→USA	1.31	0.25
JPN–/→HKN	0.12	0.73
HKN–/→JPN	0.00	0.96
SHS–/→JPN	1.77	0.18
JPN–/→SHS	1.37	0.24
TWN–/→JPN	0.31	0.58
JPN–/→TWN	1.63	0.20
SHS–/→HKN	0.11	0.75
HKN–/→SHS	0.01	0.91
TWN–/→HKN	0.22	0.64
HKN–/→TWN	5.75	0.02
TWN–/→SHS	0.00	0.99
SHS–/→TWN	0.12	0.73

–/→denotes does not Granger-cause. The test procedure is based on the bivariate VAR(k) model. The optimal k is based on the Schwartz Criterion (SC). $k = 1$ is found in all cases according to the SC.

major impact on Taiwan. Surprisingly, no such causal relation is found between Japan and SCGT members. The impact from the U.S. market on the SCGT markets seems to be noticeably greater than that from the Japanese market. This may be explained by the favorable trade balances the SCGT members enjoy with the US despite the most-favored-nation status dispute. From this viewpoint, an unexpected change in demand conditions of the U.S. market would certainly have a profound impact on the economic growth of SCGT members. On the other hand, stock price in Hong Kong could have an impact on the US market since it serves as the financial center in Asia. It is little wonder that the globalization of financial markets has intensified the repercussion effect, with news announcements now simultaneously transmitted across continents.[11] As for intraregional stock market interactions, it can be seen that price changes of the Hong Kong market lead that of the Taiwan market.

[11] For instance, during the Asian financial crisis starting October of 1997, the plummeting of the Hang Seng Index (1438 points) transmits its impact to the Dow Jones index (554.26-point fall).

Table 7
Cointegration and ECM results of the Shanghai and the Shenzen markets

ECM $_{t-1}$	C	LSHZ_{t-1}		
LSHS_{t-1}	3.6286	0.5696		
		[6.3573]		
			VAR(1)	
	C		SHS_{t-1}	SHZ_{t-1}
SHS_t	0.0005	−0.0197	−0.027	0.0692
	[0.4601]	[−2.7531]	[−0.7248]	[1.6737]
SHZ_t	0.0003	0	0.0667	−0.0319
	[0.3917]	[0.0044]	[1.9939]	[−0.8572]

LSHS and LSHZ denote logarithmic stock price indices of Shanghai and Shenzen, respectively; SHS and SHZ denotes first difference of logarithmic stock price indices of Shanghai and Shenzen, respectively; t-statistics are reported in brackets; ECM reflects a long-term equilibrium relationship; C is the intercept term.

The existence of cointegrating relations between the Shanghai and Shenzhen markets suggests the use of the error correction term in testing for causality. The causality test based on the error correction model (ECM) is shown in Eq. (6):

$$\triangle y_{1t} = \alpha_0 + (y_{1t-1} - \gamma y_{2t-1}) + \sum_{i=1}^{k} \alpha_{1i} \triangle y_{1t-i} + \sum_{i=1}^{k} \alpha_{2i} \triangle y_{2t-i} + \varepsilon_{1t} \tag{6}$$

$$\triangle y_{2t} = \beta_0 + (y_{1t-1} - \gamma y_{2t-1}) + \sum_{i=1}^{k} \beta_{1i} \triangle y_{1t-i} + \sum_{i=1}^{k} \beta_{2i} \triangle y_{2t-i} + \varepsilon_{2t}$$

where δ_1 and δ_2 reflect the speeds of adjustment to the equilibrium, and other specifications remain similar to Eq. (5). According to Engle and Granger (1987), the existence of cointegrating relations implies causality, and as such $|\delta_1| + |\delta_2| > 0$. Reported in Table 6 are long-term equilibrium relations and results of the ECM between the two stock markets.

Table 7 indicates a long-term equilibrium relation between the Shenzhen and the Shanghai stock markets: 1% price change in the former is accompanied by 0.57% price changes in the latter. Based on the transaction data (December 1994 to June 1997), volume in the Shanghai market is 2.1 times as large as that of the Shenzhen market and thus, the magnitude of price changes are within the expected range. In the price change (Shanghai) equation of the ECM, the error correction term is found to be statistically significant, and lagged price changes (by one period) of the Shenzhen market can be used to predict current price changes of the Shanghai market within 10% significance level. This implies that the Shenzhen stock market leads the Shanghai market both in the long run and short run. In the price change (Shenzhen) equation of the ECM, the error correction term is insignificant, but the lagged price changes of Shanghai stocks are good predictors for that of Shenzhen stocks with a 5% significance level. This is indicative of the leadership role of the Shanghai market in the short run. That is, the bilateral leadership role leads inevitably to a double feedback relation between the two markets.

As discussed above, the two markets of PRC exhibit a long-term cointegration relationship between them. However, they do not form any relationship with other members of SCGT, the US or Japan, be it long-run or short-run. The Hong Kong market leads the Taiwan market while the price changes (1 day before) of the US markets impact those of both markets. In short, we conclude that the PRC markets are the most segregated, followed by Taiwan. The Hong Kong market, being the most internationalized financial center in Asia, plays an important role in the analysis.

7. Concluding remarks

Despite the recent economic slumps in Association of South East Nations (ASEAN), economic growth is still on the rise for SCGT members. One may surmise that common culture (Confucianism) and language (Chinese) and other traits ought to give rise to an integrated capital market. Much to our surprise, this is not the case even though the Shanghai and the Shenzhen markets are found to be statistically cointegrated. We suggest that an ease of restrictions on capital movements among SCGT members could serve as a catalyst in forging greater market integration. In addition, Japan does not form any cointegrating relation with members of SCGT. There exists a stronger Granger causality between the US and members of SCGT. US price changes can be used to predict subsequent day price changes in the Hong Kong and the Taiwan stock markets. We have also shown that price changes in the Hong Kong market lead that in the Taiwan market. Finally, we have identified a strong feedback interaction between the Shanghai and the Shenzhen markets.

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