Co-integration and Causality Among Jakarta Stock Exchange, Singapore Stock Exchange, and Kuala Lumpur Stock Exchange

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15 October 2007

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Abstract

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For both risk management and portfolio selection purposes, modeling the linkage across financial markets is crucial, especially among neighboring stock markets. In investigating the dependence or co-movement of three or more stock markets in different countries, researchers frequently use co-integration and causality analysis. Nevertheless, they conducted the causality in mean tests but not the causality in variance tests.

This paper examines the co-integration and causal relations among three major stock exchanges in Southeast Asia, i.e Jakarta Stock Exchange, Singapore Stock Exchange, and Kuala Lumpur Stock Exchange. It employs the recently developed techniques for investigating unit roots, co-integration, time-varying volatility, and causality in variance. For estimating market risk of portfolio, this paper employs Value-at-Risk with delta-normal approach.

Keywords: Risk Management, Causality, Co-integration, Stock Markets

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1 Introduction

In regional and international investment activities, investors, portfolio managers, and policy makers require a model that can reveal linkage and causality across financial markets, especially markets in a neighboring area. The model will provide them better view of the markets' movement and, therefore, enable them to appropriately price underlying assets and their derivatives, as well as to hedge the associated portfolio risks. Cointegration analysis has been the most popular approach employed by academicians and stock market researchers in developing such a linkage and causality model.

Cointegration analysis was firstly developed 19 years ago, starting with the seminal contributions by Granger (1981), Engle & Granger (1987), and Granger & Hallman (1991). It can reveal regular stochastic trends in financial time series data and be useful for long-term investment analysis. The analysis considers the I (1) − I (0) type of cointegration in which linear permutations of two or more I (1) variables are I (0) (Christensen & Nielsen, 2003). In the bivariate case, if y_t and x_t are I (1) and hence in particular nonstationary (unit root) processes, but there exists a process e_t which is I (0) and a fixed β such that : $y_t = \beta' x_t + e_t$ then x_t and y_t are defined as cointegrated. Consequently, the nonstationary series shift together in the sense that a linear permutation of them is stationary and therefore a regular stochastic trend is shared.

Granger & Hallman (1991) proves that investment decisions merely-based on short-term asset returns are inadequate, as the long-term relationship of asset prices is not considered. They also shows that hedging strategies developed based on correlation require frequent rebalancing of portfolios, whereas those developed strictly based on cointegration do not require rebalancing. Lucas (1997) and Alexander (1999), using applications of cointegration analysis to portfolio asset allocation and trading strategies, have proven that Index tracking and portfolio optimization based on cointegration rather than correlation alone may result in higher asset returns. Meanwhile, Duan and Pliska (1998), by developing a theory of option valuation with cointegrated asset prices, reveal that cointegration method can have a considerable impact on spread option price volatilities. Furthermore, economic policy makers must have comprehensive knowledge on transmission of price movements in regional equity markets, especially during periods of high volatility. Appropriate policy may be designed to lessen the degree of financial crises. Therefore, a research on cointegration and causality among regional equity markets is essential. Cointegration approach complements correlation analysis, as correlation analysis is appropriate for short-term investment decisions, while cointegration based strategies are necessary for long-term investment.

2 Objectives and Structure of The Study

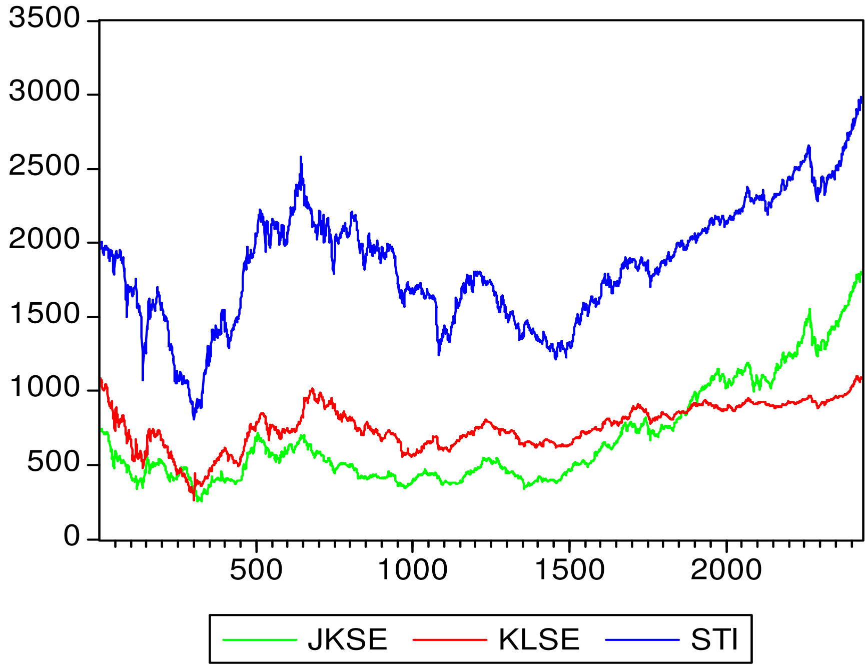
This paper is aimed at identifying the long-run equilibrium relationship among three major stock exchanges in Southeast Asia, i.e Jakarta Stock Exchange, Singapore Stock Exchange, and Kuala Lumpur Stock Exchange from 1997 to 2006. The paper also aims at explaining risk performance of the observed market.

Earlier part (section 3) of this paper focuses on one or more of the observed markets and the associated linkage among the three markets, through sample data and key descriptive statistics. It is then followed by a brief description of VEC Model of Price Indices and Returns (section 4). In the following section (section 5), the paper describes empirical estimation and results, followed by some conclusion in Section 6.

3 Sample Data and Descriptive Statistics

The sample consists of daily closing index prices of JKSE, KLSE, and STI from 7^{th}, 1997 through 29^{th}, 2006. The daily closing price data of the three indices is gained from (www.finance.yahoo.com). All the indices have been adjusted to stock-splits, mergers and acquisition. We avoid transforming the three indices into a common currency, instead we use the nominal indices in domestic currency to evade problems associated with transformation due to fluctuations in cross-country exchange rates and also to avoid the restrictive assumption the relative purchasing power parity holds. In addition, we also implicitly assume that dividends are not vital to our analysis, as in general, dividends do not reveal the level of volatility that would be necessary to influence the null hypothesis of 'no cointegration', among a set of stock price indices (see Dwayer and Wallace 1992).

Figure 1
Graph of JKSE, KLSE, and STI Indices Movement



The first three sample moments of the daily closing price indices in logs, daily returns in log first difference multiplied by 100, the simultaneous correlations of price indices and daily returns in the three stock markets are reported in Tables 1, 2, 3 and 4.

Table 1
Daily closing Price Indices in Natural Logs

	LOGJKSE	LOGKLSE	LOGSTI
Mean	6.411378	6.610082	7.495731
Median	6.271480	6.627148	7.529833
Maximum	7.498604	7.004610	8.001633
Minimum	5.548414	5.571013	6.690892
Std. Dev.	0.439583	0.221266	0.232586
Skewness	0.690814	-1.096242	-0.553081
Kurtosis	2.375497	4.626768	3.209271
Jarque-Bera	233.3386	756.5160	128.6400
Probability	0.000000	0.000000	0.000000
Sum	15618.12	16102.16	18259.60
Sum Sq. Dev.	470.5222	119.2145	131.7244
Observations	2436	2436	2436

Source: (www.finance.yahoo.com).

The averages of the indices are pretty close. STI index average is slightly higher than those of JKSE and KLSE. The JKSE series shows slightly higher standard deviation relative to KLSE and STI indices. Moreover, only JKSE index show positive value, while those of KLSE and STI are negative. Both KLSE and STI show excess kurtosis (>3), while JKSE shows kurtosis of 3.

Table 2
Correlation Matrix of Daily Closing Price indices in Log

	LOGJKSE	LOGKLSE	LOGSTI
LOGJKSE	1.000000	0.776497	0.795766
LOGKLSE	0.776497	1.000000	0.881324
LOGSTI	0.795766	0.881324	1.000000

As can be seen on Table 2, the daily closing stock price indices show strong positive correlation during the observed period. The Jarque-Bera test, an asymptotic test of normality, indicates that none of the price indices is normally distributed. The test statistic is computed as :

$$\frac{n}{6}\left[S^2+\frac{(K-3)^2}{4}\right] \qquad (1)$$

Where S is skewness, and K is Kurtosis.
The skewness and kurtosis employ $\chi 2$ distribution with degree of freedom of 2. For normally distributed variable, skewness is zero and K-3=0, so that the test statistic is zero. At 5% level of significance, the null hypothesis of normal distribution is rejected.

Table 3
Daily Returns: JKSE, KLSE, and STI

	DLOGJKSE	DLOGKLSE	DLOGSTI
Mean	0.000371	7.16E-06	0.000168
Median	0.000442	0.000160	0.000254
Maximum	0.131278	0.208174	0.088523
Minimum	-0.127318	-0.241534	-0.091535
Std. Dev.	0.017648	0.017259	0.014072
Skewness	0.055903	0.587101	-0.154297
Kurtosis	10.52704	45.34574	9.585716
Jarque-Bera	5749.530	182071.1	4410.078
Probability	0.000000	0.000000	0.000000
Sum	0.903343	0.017428	0.410125
Sum Sq. Dev.	0.758057	0.725061	0.481995
Observations	2435	2435	2435

Source: Processed Data

Overall, non-synchronous trading, weekend and holiday effects, time varying risk premiums, and to some extent irrational over or under-reaction of investors plus factors such as market opening and closing time differences (Lo, and MacKinlay 1990) are responsible for explaining the revealed autocorrelation. Moreover, squared daily returns in the observed markets (not shown) exhibit very high positive skewness and excess kurtosis. Volatility clustering and conditional non-normality are the usual factors for the reported leptokurtic distribution of returns in the three markets.

Table 4
Correlation Matrix of Average Daily Returns on The Three Indices

	DLOGJKSE	DLOGKLSE	DLOGSTI
DLOGJKSE	1.000000	0.090318	0.365352
DLOGKLSE	0.090318	1.000000	0.101729
DLOGSTI	0.365352	0.101729	1.000000

Source: Processed Data

During the observed period, JKSE index shows the highest average rate of return, which is followed by the STI index. Standard deviation of returns on JKSE is higher than that on KLSE or STI. None of the average returns series shows normal distribution as per the JB test. All coefficients of correlation are positive. Coefficient of correlation of JKSE-STI is the highest, which is followed by that of KLSE-STI, and JKSE-KLSE, consecutively.

4 VEC Model of Price Indices and Returns

This study assess the long-term equilibrium relationship as well as the short-term dynamics among the three equity markets using the Johansen and Juselius (1990) model. If the three stock price indices share a common stochastic trend, then they are considered cointegrated (Christensen & Nielsen, 2003). The presence of cointegration relation forms the basis of the Vector Error Correction (VEC) specification. Below is vector autore-gressive (VAR) model of order *p:*

$$X_t = \mu \sum_{i=1}^{p} A X_{t-i} + \varepsilon_t \qquad (2)$$

where, X_t is a column vector of variables, here, the log price indices, μ, is a vector of constants, and ε_t is a vector of innovations, random errors usually assumed to be contemporaneously correlated but not autocorrelated, and p is the number of lags of variables in the system.

If the variables in the vector X, are integrated of order, say one, 1(1), and are also cointegrated, that cointegration restriction has to be included in the VAR in equation (2). The Granger Representation Theorem (Engle and Granger, 1987) states that variables, individually determined by permanent shocks, are cointegrated, if and only if there exists a vector error correction representation of the time series data. With this restriction imposed, a VAR model, is referred to as VEC. Variables in the model enter the equation in their first derivatives, and the error correction terms are added to the model. Consequently, the VEC has cointegration relations built into the specification so that it confines the long-term behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-term dynamics. Biases from long-term equilibrium are corrected through a series of partial short-term adjustments.

The VEC representation of equation (3), following Johansen and Juselius is:

$$\Delta X_t = \mu + \sum_{i=1}^{p} \Gamma \Delta X_{t-1} + \alpha \beta' X_{t-1} + \varepsilon_t \qquad (3)$$

where,
Γ are (m x m) coefficient matrices (i = 1,2, ..., k),
α, β are (m x r) matrices, so that $0 < r < m$,
where r is the number of linear combinations of the elements in X_t that are affected only by transitory shocks.

Matrix β is the cointegrating matrix of r cointegrating vectors, β_1 β_2,...., β_i. The β vectors represent estimates of the long-run cointegrating relationship between the variables in the system. The error correction terms, B' X_{t-1}, are the mean reverting weighted sums of cointegrating vectors. The matrix a is the matrix of error correction coefficients that measure the speed at which the variables adjust to their equilibrium values. It is obvious that the model in equation 3 is the standard VAR in the first differences of X_t, augmented by the error correction terms, *a* B' X_t. The JJ method provides maximum likelihood estimates of a and B'

5 Empirical Estimation and Results

The very early phase in the estimation process is deciding the order of integration of the individual price index series in natural log levels. The logs of the indices, denoted as JKSE, KLSE, and STI, are tested for unit roots using the augmented Dickey-Fuller (ADF) (1979) test using the lag structure indicated by Schwarz Bayesian Information Criterion (SBIC). The p-values used for the tests are the

MacKinnon (1996) one-sided *p*-values. The test results, as can be seen on Table 5, indicate that the null hypothesis, the price index in log levels contains a unit root, cannot be rejected for each of the three price series. Then, unit root tests are performed on each of the price index series in log first differences. The null hypothesis of a unit root could be rejected for each of the time series. No further tests are performed, since each of the series is found to be stationary in log first differences. The finding that each price series is non-stationary implies that each observed market is weakly efficient.

Table 5
Augmented Dickey Fuller (ADF) Unit Root Test of Price Indices

Daily Closing Price Indices	Lag	Test Statistic	SIC Values
JKSE	**1**	-41.35554	-5.260840
KLSE	**1**	-21.75525	-5.284718
STI	**1**	-44.42636	-5.693793

Source: Processed Data
*** at 1% level of Significance
** at 5% level of Significance
* at 5% level of Significance

The second phase involves an assessment on the three market series for cointegration. The cointegration test is to determine whether or not the three non-stationary price indices share a common stochastic trend. The estimated cointegrating equation is as follows:

$$LJKSE_t = \alpha_0 + \alpha_1 KLSE_t + \alpha_2 LSTI_t + e_t \quad (4)$$

In the equation (4), the cointegrating relationship is normalized on the log of JKSE index. If it is normalized, say, on the log of JKSE, then (4) becomes:

$$LJKSE_t = \frac{\alpha_0}{\alpha_1} - \frac{1}{\alpha_1} LKLSEx_t - \frac{\alpha_2}{\alpha_1} LSTI_t - \frac{1}{\alpha_1} e_t \quad (5)$$

We do not survey cointegration results that are normalized on the largest stock market based on capitalization. Instead, we report results that are normalized on JKSE that has the smallest market capitalization value among the three markets.

JJ estimation procedure that uses the maximum likelihood method is then employed. The cointegration tests assume no deterministic trends in the series and use lag intervals 1 to 1 as suggested by the SBIC for appropriate lag lengths. However, it would not have made any difference even if we had chosen AIC (Akaike Information Criterion) because both the AIC and SBIC suggested the same lag length as well as the assumptions for the test. The assumptions of the test are that the indices in log levels have no deterministic trends and the cointegrating equation has an intercept but no intercept in the VAR. The results of cointegration tests are presented in Table 6. The trace test, which tests the null hypothesis of r cointegrating relations against k cointegrating relations, where k is the number of endogenous variables, for r = 0,1, ……k. If there are k cointegrating relations, it implies that there is no cointegration between the three series. The maximum eigen value test which tests the null of r cointegrating relations against the alternative of r + 1 cointegrating relations, results indicated one cointegrating equation at the 5% percent level of significance. The critical values used from Osterwald-lenum (1992) are slightly different from those reported in JJ (1990). The cointegrating relationship is normalized on *Ijkse.* The cointegrating vector of the three daily price indices, JKSE, KLSE, and STI, normalized on JKSE is: [1 -1.0 -0.44]. The cointegrating equation indicates that JKSE and KLSE indices adjust one-to-one in the long-run, and a smaller adjustment occurs between JKSE index and STI index.

We test for market indices cointegration between JKSE and KLSE, JKSE and STI, KLSE and STI. All the above pairs are cointegrated, but the test results are not presented, as our focus is the relationship among the three markets.

The finding that the market indices are cointegrated means that there is one linear combination of the three price series that forces these indices to have a long-term equilibrium relationship even though the indices may wander away from each other in the short-run. It also implies that the returns on the indices are correlated in the long-term. The message for long-term international investors is that it does not matter, in terms of portfolio returns, whether investors in the three countries hold a fully diversified portfolio of stocks contained in all the three indices or hold portfolios consisting of all stocks of only one index. Cointegration between the portfolio and the index is assured when there is at least one portfolio of stocks that has stationary tracking error, that is, the difference between the portfolio of stocks and the stock index is stationary, or to put it differently, the price spread between the two is mean-reverting. However, in the short-run, the two may deviate from each other with the potential for higher returns on the portfolio relative to the index. So, investors may still be able to earn excess returns in the short-run by holding a portfolio of stocks from the three markets.

The final phase is the estimation of the three variable VEC model. In terms of this study analysis, the estimated vector error-correction model of price indices has the following form:

$$\Delta IJKSE_t = \alpha_0 + \sum \beta_{1t} \Delta IJKSE_{t-1} + \sum \beta_{2t} \Delta IKLSE_{t-1} + \lambda_1 z_{t-1} + \varepsilon_{t1}$$

where $\Delta IJKSE$, $\Delta IKLSE$ and $\Delta ISTI$ are the first log differences of the three market indices lagged *p* periods, z_{t-1} are the equilibrium errors or the residuals of the cointegrating equations, lagged one period, and λ_3 are the coefficients of the error-correction term. The lag lengths for the series in the system are determined according to the SIC. The suggested lag lengths are one to one. No restrictions are imposed in identifying the cointegrating vectors. The coefficients of the error correction terms are denoted by λ . Estimated results can be seen on Table 6. The estimated coefficient values of the lagged variables along with the t-statistics are presented without the asymptotic standard errors corrected for degrees of freedom for want of space, and will be available from the authors. At the bottom of the output on Table 6 the log likelihood values, the AIC and SBIC are reported.

Table 6
VEC Estimated Results

Variables $\Delta lJKSE$, $\Delta lKLSE$, $\Delta lSTI$, t-statistics in ( )			
	$\Delta lJKSE$	$\Delta lKLSE$	$\Delta lSTI$
Error Correction term (λ_i)	0.000513	-0.015962***	-0.004392
	(0.001374)	(0.003274)	(0.002792)
$\Delta lJKSE$(-1)	0.157553***	0.007263	0.038247**
	(0.021518)	(0.018581)	(0.017256)
$\Delta lKLSE$ (-1)	-0.014337	-0.041414**	0.048733***
	(0.020548)	(0.019102)	(0.016514)
$\Delta lSTI$ (−1)	0.059970**	0.408875***	0.083409***
	(0.026964)	(0.023533)	(0.021742)
R-Squared	0.032494	0.125136	0.017711
F-Statictic	20.39475	86.82242	10.94870
Log likelihood	6412.923	6586.442	6945.653
SIC	-5.253434	-5.398233	-5.691174

Source: Processed Data
*** at 1% level of Significance
** at 5% level of Significance
* at 5% level of Significance

Three types of inference, concerning the dynamics of the three markets, can be drawn from the reported results of the VEC model in Table 6. The first one concerns whether the left hand side variable in each equation in the system is endogenous or weakly exogenous. The second type of inference is about the speed, degree, and direction of adjustment of the variables in the system to restore equilibrium following a shock to the system. The third type of inference is associated with the direction of short-run causal linkages between the three markets.

Adjustment to Shocks:
In general, a cursory look at the statistical significance of the reported coefficients of the error-correction terms (λ_i) of *Aljkse, Alklse,* and *Alsti* equations provides us an idea whether the left-hand side variable in each equation of the system is exogenous or endogenous. If the coefficient of the error-correction term is not significantly different from zero, it usually implies that that variable is weakly exogenous, otherwise, it is endogenous.

Reviewing the results on Table 6, we see that the coefficient of the error correction term, λ_3, in the *Alsti* equation is not significantly different from zero implying that the STI index is weakly exogenous to the system. The weak exogeniety of STI index means that it is the initial receptor of external shocks, and it in turn, will transmit the shocks to the other markets in the system. As a result, the equilibrium relationship of the three markets is disturbed. The adjustment back to equilibrium can be inferred from the signs and magnitude of the coefficients, λ_1, *(AlJKSE* equation) and λ_2 *(AlKLSE* equa-tion). The sign of λ_t is positive and its magnitude, in absolute terms, is relatively small (0.000513), and the sign of λ_2 is negative and larger (-0.015962). While λ_3 shows slightly smaller magnitude of -0.004392.

Meanwhile, the risk performance of each of the observed markets is assessed using delta normal based Value at Risk. Using variance of each market displayed on Table 1, with number of observations of 2,436 for each market, and using significance level of 95%, our calculation ends up with the following delta-normal-based-Value at Risk:

Table 7
VEC Estimated Results

	JKSE	KLSE	STI
Delta Normal VaR	0.317869	0.080537	0.088988

Source: Processed Data

The delta normal VaR of JKSE index is the largest, meaning the market is the riskiest among the three markets. Delta normal VaR of KLSE is slightly smaller than that of STI. If this risk measure is compared with the markets' return, we can say that the longtime rule of financial management, i.e. high risk means high return, does not hold. JKSE index records the lowest average return, while revealing the highest risk. On contrary, STI market records the highest growth level with relatively low risk level. In some extent, this phenomenon can be explained by the associated domestic political and economic stability influencing the market.

6 Summary and Conclusions

This paper examines the long-term equilibrium relationship among the three major South-East Asian equity markets (i.e. JKSE, KLSE, and STI) from January 1997 to December 2006. Particularly, we examine if equity index prices in these three equity markets are cointegrated. By employing cointegration and error-correction methodo we find that the price indices of the three markets are cointegrated and that the Value at Risk of JKSE is the highest during the sample period examined. The existence of a linear combination of the three indices that forces these indices to have a long-term equilibrium relationship implies that the indices are perfectly correlated in the long run and diversification among these three equity markets can not benefit international portfolio investors. However, there can be excess returns in the short run.

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