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Cointegration and causality among international gold and emerging stock markets in ASEAN

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ABSTRACT

This paper focuses on testing possible linkages among international gold and ASEAN emerging markets based on daily data from July 28, 2000 to March 31, 2009. The Granger causality test and the Johansen cointegration technique were applied to examine possible short-run associations and the long-run cointegrations among the international gold and five emerging stock markets in ASEAN (Indonesia, Malaysia, Philippines, Thailand and Vietnam). Results of the Granger causality test shows that the short-run associations appear in almost all the pairs formed from the selected stock markets. Meanwhile, few evidences of the short-run associations are observed from the gold market to the stock markets as well as from the stock markets to gold market. Results of the Johansen cointegration test for long-run relationships between the selected markets show that the six selected market price indexes are not cointegrated all together. However, they are low cointegrated to each other (only four over 15 market pairs show the presence of cointegrating relations). Especially, Thailand stock and international gold markets are operating independently from other selected markets. The paper suggests that portfolio diversification should be implemented when investing in ASEAN emerging stock markets and gold should be an item included in the portfolio.

1. Introduction

Opening the financial market has generated great opportunities for the Association of South East Asian Nations (ASEAN) in attracting plentiful foreign direct and indirect investment capital flows into the region for decades. This boosts ASEAN's economic position on the global map. Moreover, ASEAN region has been evaluated as the most dynamic economic region in the world. This is highlighted by impressive economic growth rates through the yearly statistic figures of its member countries over a long period that other regions have not achieved yet. However, the liberalization caused severe risks for ASEAN financial systems during the late 1990s. This event sourced from Thailand in the mid-1997 that was defined as a financial and economic crisis. The crisis spread out rapidly to its neighboring countries such as the Philippines, Malaysia and Indonesia, before extensively affecting the world financial and capital markets through its contagion effects (Atmadja, 2005).

In ASEAN, stock exchanges are operating in Singapore, Indonesia,

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Malaysia, Philippines, Thailand and Vietnam only, of which Singapore stock market is classified as an advanced market, while the other five are grouped into emerging markets. Although, Indonesia, Philippines, Malaysia and Thailand have long periods of stock market evolution, Vietnam has just launched its stock market since July 2000. The Vietnam stock market was founded in the context of the country economic renovation towards an international integration. Together with the development in other ASEAN emerging stock markets (Indonesia, Malaysia, Philippines and Thailand), the Vietnam stock market has grown very fast (Table 1). However, in the context of the global economic downturn and declines in the global stock markets in recent years, ASEAN emerging stock markets have also been severely affected, especially in 2008 (Figure 1). In addition, weak US dollar, high inflation and attraction of gold as a substitution investment channel for hedging risks are the reasons caused declines in ASEAN emerging stock markets (Do *et al.,* 2009).

Although, many empirical researches on market linkages and cointegration have been conducted over the world, only few researches on these issues have been found relating ASEAN stock markets. These researches had been done using different methods and different periods under different contexts. For instance, Atmadja (2005) examined linkages among stock market indexes and macroeconomic variables in five ASEAN countries (Indonesia, Malaysia, Philippines, Singapore, and Thailand) using monthly data from July 1997 to December 2003. Granger causality test was employed and showed that there were few Granger causalities between stock price index and macroeconomic variables. Erie and Aldrin (2007) examined cointegration and causal relations among three major stock exchanges in Singapore, Indonesia and Malaysia using daily data from 7th January 1997 to 29th December 2006. The Johansen cointegration techique and error-correction method were employed. They found that the price indexes of the three markets were cointegrated. Lim (2007) focused on long-run relationship among five national stock market indexes in ASEAN (Indonesia, Malaysia, the Philippines, Singapore and Thailand) using daily data from 2nd April 1990 to 31th August 2007. The Granger causality and the Johansen cointegration technique were applied. The author found the presence of at least one long-run cointegrating relationship among these stock market indexes and at least two long-run cointegrating relationships in the post-crisis period. Harjito and Carl (2007*)* investigated the relationship between stock prices and exchange rates in four ASEAN countries (Indonesia, the Philippines, Singapore, and Thailand) over the period 1993–2002 using the Granger causality and Johansen cointegration tests and found that the relationship between stock prices and exchange rates was characterized by a feedback system. The Johansen cointegration test showed that all of the stock prices and exchange rates in the four countries were cointegrated.

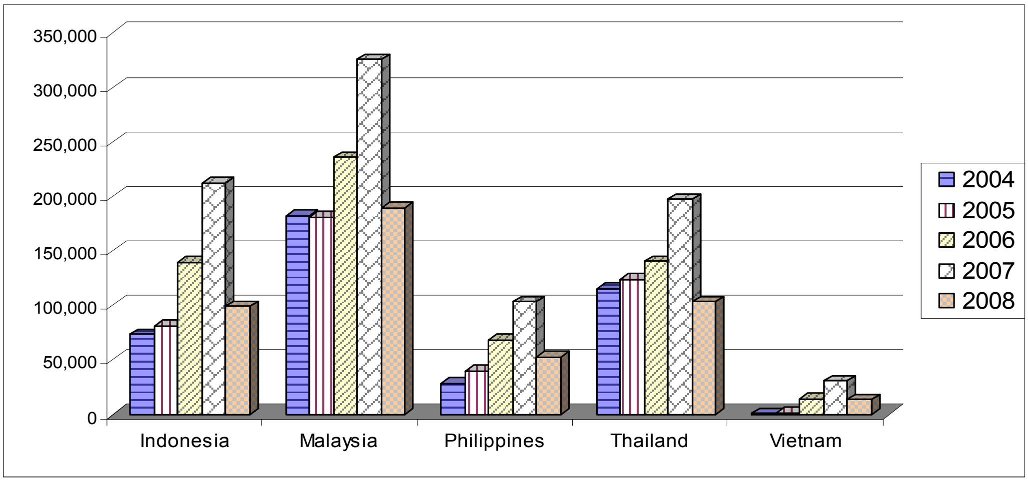
Differences of our study from earlier studies relating to linkages among ASEAN stock markets are as follows (1) we use more updated data, (2) the data set contains the international gold prices and 5 emerging stock market indexes, of which Vietnam stock market is included. The purpose of the paper is to examine the possible short-run associations and long-run cointegrations among the sample data set. The remaining part of this paper is organized as follows: Section 2 shows the data; Section 3 outlines the econometric models; Section 4 presents empirical results of the study; and Section 5 gives concluding remarks.

Table 1: Basic data of the selected stock markets, 2004-2008.

	2004	2005	2006	2007	2008
Number of the listed companies					
Indonesia	331	336	344	383	396
Malaysia	959	1,019	1,025	986	972
Philippines	235	237	239	244	244
Thailand	463	504	518	523	525
Vietnam[a]	27	48	198	247	335
Domestic market capitalization (Million USD)					
Indonesia	73,251	81,428	138,886	211,693	98,760
Malaysia	181,624	180,518	235,581	325,290	189,086
Philippines	28,602	39,819	68,270	103,007	52,030
Thailand	115,390	123,885	140,161	197,129	103,128
Vietnam[a]	471	827	13,607	30,399	13,402

Source: www.world-exchanges.org/reports/annual-report.
[a] Synthesized by author from www.vietstock.com.vn.

Figure 1: ASEAN domestic market capitalization (in US$ million)

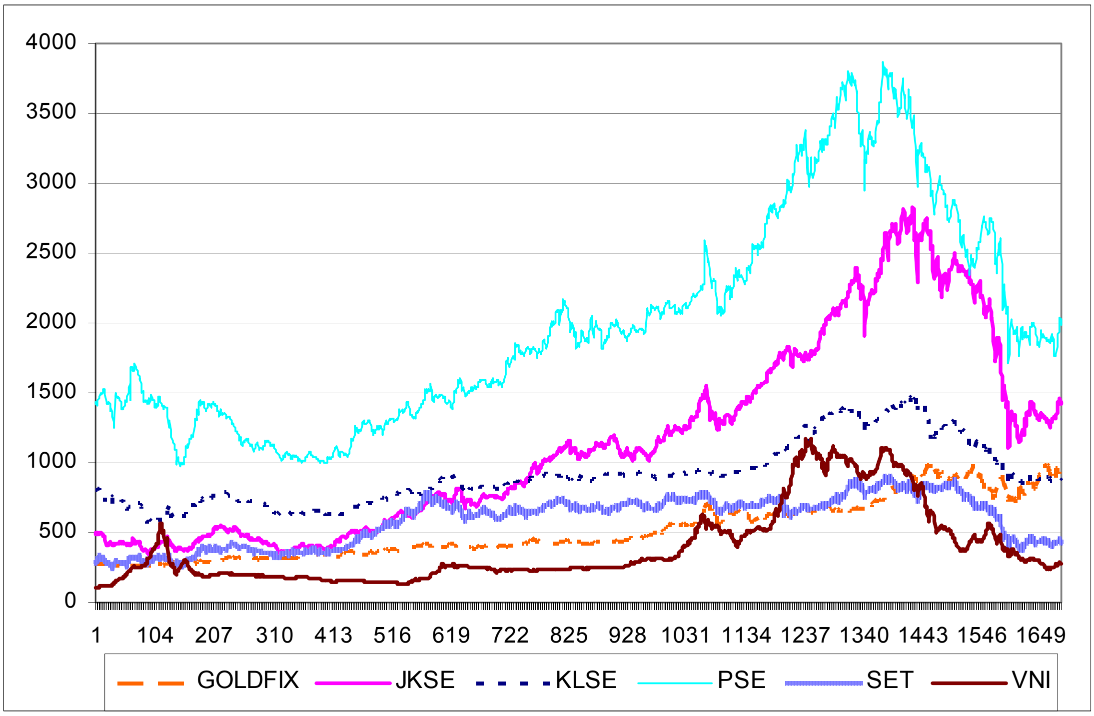


2. Data

The set of time series data used in this paper consists of the daily closing indexes of the 5 emerging stock markets in ASEAN, namely VN-index, SET-index, KLSE-index, JKSE-index, and PSE-index, respectively representing for the stock markets of Vietnam, Thailand, Malaysia, Indonesia and the Philippines, and a series of international gold price based on the PM London Gold Fix (GoldFix, in short). As we know that working time of London gold market (local time) starts from 8:30 AM to 4:00 PM, of which the daily fixing prices are recorded twice at 10:30 AM and 3:00 PM and they can be used as the benchmarks for the official gold trading around the world. The sample period is selected from July 28, 2000 through March 31, 2009. The reason to select the starting time in the sample period is that the Vietnam stock market, a new established stock market, started opening the first trading on that day. The daily closing data of the five indexes were downloaded from Reuter, while the daily data of the PM London Gold Fix were obtained from website, http://www.kitco.com.

In this study, daily prices at the PM London Gold Fix per ounce are expressed in the international standard currency (USD), while daily data of the five stock market indexes are expressed in domestic currencies to avoid the problem associated with price transmission due to fluctuations in cross-country exchange rates and also to avoid the restrictive assumption that relative purchasing power parity holds (Kasa, 1992). Other studies of Alexander and Thillainathan (1995), and Alexander (2001) also support for the idea that local currency should be used in testing cointegration. Figure 2 shows the plots of the selected price index series. Intuitively, there is a slightly up trend and down trend together in all the series over the sample period.

Figure 2: The plots of the London Gold Fix and ASEAN emerging stock market indexes (28 July, 2000 to 31 March, 2009)



3. Econometric models

To examine linkages among the sample markets, we employed the Johansen's bivariate and multivariate cointegration tests (Johansen, 1988; Johansen and Juselius, 1990). The purpose of the test is to determine whether or not a group of non-stationary series is cointegrated. If the existence of cointegrating relation in the sample market price indexes is evident, there is a basis for forming the vector error correction models (VECM). Together with the Johansen test, we also perform unit root tests and the Granger causality test (Granger, 1969) for the data set.

- **Unit root tests**

Prior to employing the Johansen technique, it is essential to test the order of integration in the data series used the study. Two most common methods, namely the Augmented Dickey Fuller (ADF) and Phillips and Perron (PP) tests for unit root are implemented for a set of the selected market price indexes, using the specification given in (1). The null hypothesis in the ADF and PP tests is that x_t is non-stationary or is containing a unit root.

$$\Delta x_t = \alpha_0 + \alpha_1 trend + \psi_1 x_{t1} + \sum_{j=1}^{p} \alpha_j \Delta x_{t-j} + u_t \quad (1)$$

where Δx is the first difference of x_t and p is the lag-length of the augmented terms for x_t. If the null hypothesis of a unit root in the level series is failed to reject, we conclude that the level series are nonstationary. However, if the null hypothesis of a unit root in the first differences of the level series can be rejected, these series are integrated of order one. Therefore, it is sufficient for performing cointegration tests for the level series.

- **Granger causality test**

The Granger causality tests are applied to determine directions of causality between the market pairs. Since the Granger-causality test is very sensitive to the number of lags included in the regression, both the minimum Akaike information criteria (AIC) and Schwarz criteria (SC) should be considered to identify an appropriate lag length for each pair. The Granger causal relations are inferred through the generalized F statistic, which measures if the lagged terms of an exogenous variable significantly improve the autoregression of another. For instance, time series x_1 is said to Granger-cause x_2 if it can be shown the statistically significant information about future values of x_2 through the F-test for the overall statistical significance of coefficients on the lagged values of x_1 and x_2 itself. Usually, causal relations are tested for both directions, from x_1 to x_2 and vice versa.

- **Johansen cointegration test**

In our study, the long-run equilibrium relationship and the short-run dynamics among the six selected markets under the study are examined by employing the Johansen (1988) and Johansen & Juselius (1990) test framework. If the sample market price indexes have a common stochastic trend, then they are said to be cointegrated. Basically, cointegration of two or more variables implies a long-run equilibrium relationship, given by the linear combinations between them, called the cointegrating vectors. If the presence of cointegrating vectors is evident in the test, there exists the VECM that measures speed of adjustment to the long-run equilibrium in the cointegrated variables. In order to test cointegration among the sample markets, we begin with a vector autoregressive (VAR) model of order p below

$$x_t = \omega + \sum_{i=1}^{p} A_i x_{t-i} + \varepsilon_t \qquad (2)$$

where x_t is an $(m \ x \ 1)$ vector of variables $(x_{1t}\ ,\ x_{2t}, \ldots,\ x_{mt})'$, which are m level series, ω is a vector of constants, A_i is a $(m \ x \ m)$ matrix of coefficients and ε_t is a vector of error terms, and p is the number of lags in the variables in the system. If the variables in the vector x_t are integrated of order one, I(1), it implies that the linear combination of one or more of these series may exhibit a long-run relationship in (2). This leads to using the Johansen (1988) and Johansen & Juselius (1990) method for further explorations in the sample market price indexes. The method can be briefly expressed as follows

$$\Delta x_t = \omega + \sum_{i=1}^{p} \Gamma_i \Delta x_{t-i} + \Pi x_{t-1} + \varepsilon_t \qquad (3)$$

where x_t is a $(m \times 1)$ vector of the sample market price indexes, ω is the $(m \times 1)$ vector of constant terms and ε_t is a vector of error terms. Γ_i denotes the $(m \times m)$ matrix of coefficients, containing information regarding the short-run relationships between the sample market price indexes. Meanwhile, Π are $(m \times r)$ matrix, reflecting the possible long-run relationship between the sample market price indexes, where r is the rank of Π so that $r \leq m - 1$. The Johansen procedure is to decompose the matrix Π into two $(m \times r)$ matrices, α and β, such that $\Pi = \alpha\beta'$. The matrix β is called the matrix of cointegrating vectors, representing the possible long-run relationship between the sample market price indexes, and α is defined as the matrix of error correction coefficients that measure speed of adjustment in the variables to their long-run equilibrium.

The Johansen technique is based on the maximum likelihood estimation of α and β' and the two computed statistics, namely the trace statistic and the maximum eigen-value statistic in order to test for the presence of r cointegrating vectors in the systems. The trace statistic tests the null hypothesis of at most q cointegrating vectors against the alternative hypothesis of $r = n$ cointegrating vectors. The maximum eigen-value statistic also tests for the presence of r cointegrating vectors against the alternative hypothesis of $r+1$ cointegrating vectors.

For instance, if the null hypothesis (*i.e.*, H_0. $r = 0$ at the most) is failed to reject then stop the test, this means that there is no cointegrating relation among the system. On the contrary, if this null hypothesis is rejected, increase the value of r at the most and continue the test until the null hypothesis (*i.e.*, H_0. $r=q$ at the most) can not be rejected. This indicates that there exist q cointegrating vectors in the system. Then, the VECM can be formed in the cointegrating relationships to measure speed of adjustment, for which the divergences of the endogenous variables in the system from their long-run equilibrium are controlled step by step to achieve the long-run equilibrium, while short-run dynamics remain unrestricted. In our study, the Johansen cointegration test procedure has conducted on the Eviews 6 econometric package software.

4. Empirical results

In this section, we start with Augmented Dickey Fuller (ADF) and Phillips and Perron (PP) tests for the presence of a unit root in the time series data. Table 2 reports results of the tests. It indicates that the null hypothesis of the presence of a unit root in the 6 level series cannot be rejected, since all the t-statistics obtained from two methods are greater than the critical values at the 1%, 5% and 10% levels of significance. Therefore, nonstationarity exists in 5 stock market indexes and gold prices. However, the null hypothesis of a unit root in the first different (daily returns) series of the 6 market price indexes is clearly rejected, since all the t-statistics are less than the critical values. Therefore, these return series are stationary. In other words, all the level series of the selected markets are integrated of order one, I(1), implying that the linear combination or cointegrating relationship of one or more of these series may exhibit a long-run relationship. This satisfies the sufficient condition for the series of the selected stock market indexes and international gold prices to perform VAR and VEC methods.

Table 2: Unit root tests for time series data of the sample markets

	Level series		First different	
	ADF	PP	ADF	PP
JKSE	-1,0633	-1,0132	-35,3578	-35,1234
KLSE	-1,0982	-1,1099	-36,7340	-36,8703
PSE	-1,1189	-1,1238	-39,4164	-39,3867
SET	-1,5598	-1,4097	-38,6609	-38,6636
VNI	-1,2833	-1,4081	-30,3913	-30,4501
GOLDFIX	-0,1902	-0,1902	-39,6778	-39,6791

Notes: Critical values at the 1%, 5% and 10% significant levels are -3.434, -2.863 and -2.568, respectively.

In order to investigate the causal relations between the selected stock market indexes and gold prices, we employ the Granger causality tests. Prior to conducting the test, it is necessary to identify the optimal lag length in each market pair. This can be done using VAR approach. For the optimum lag length selection, we use a maximum lag length of ten and perform VAR model in Eviews 6. Commonly, the two important information criteria such as Akaike information criteria (AIC) and Schwarz criteria (SC) are applied in many studies. This paper uses the optimal lag length suggested by SC for each market pair, which is based on the least value of SC among different lag lengths. The reason is that the optimal lag lengths suggested by SC for each pair are robust as we change the lag lengths, while those suggested by AIC are not so. Then Granger causality test for each pair can be conducted. Results of the Granger causality tests are reported in Table 3, and a summary of the significant directions of Granger causality between each pair is shown in Table 4.

Table 3: Granger causality test for the market pairs at the level series

Ho	Lags	F-test	Ho	Lags	F-test
GOLDFIX→JKSE	2	1.2384 (0.085)	PSE→GOLDFIX	1	2.9065 (0.088)
GOLDFIX→KLSE	1	2.4234 (0.120)	PSE→JKSE	2	6.0801 (0.002)*
GOLDFIX→PSE	1	1.2601 (0.262)	PSE→KLSE	2	5.1434 (0.006)*
GOLDFIX→SET	1	4.6033 (0.032)*	PSE→SET	2	5.5586 (0.004)*
GOLDFIX→VNI	2	8.6072 (<0.001)*	PSE→VNI	2	6.2154 (0.002)*
JKSE→GOLDFIX	2	2.4662 (0.290)	SET→GOLDFIX	1	1.4091 (0.235)
JKSE→KLSE	2	18.552 (<0.001)*	SET→JKSE	2	3.1371 (0.044)*
JKSE→PSE	2	25.4272 (<0.001)*	SET→KLSE	2	7.8597 (<0.001)*
JKSE→SET	2	9.5471 (<0.001)*	SET→PSE	2	20.3805 (<0.001)*
JKSE→VNI	2	21.759 (<0.001)*	SET→VNI	2	5.1997 (0.006)*
KLSE→GOLDFIX	1	3.1837 (0.075)	VNI→GOLDFIX	2	4.3975 (0.012)*
KLSE→JKSE	2	4.4448 (0.012)*	VNI→JKSE	2	6.0441 (0.002)*
KLSE→PSE	2	11.4878 (<0.001)*	VNI→KLSE	2	9.6886 (<0.001)*
KLSE→SET	2	0.9517 (0.386)	VNI→PSE	2	4.0499 (0.018)*
KLSE→VNI	2	14.826 (<0.001)*	VNI→SET	2	0.2540 (0.776)

Notes: The arrow indicates the direction of the Granger causality test.
The figures in parentheses are the p-values.
* denotes the level of statistical significance at least at the 5%.

Tables 3-4 reveal the presence of short-run associations among almost all ASEAN emerging stock markets, except only one pair (SET, VNI). It means that these markets are interdependent, especially JKSE has lead-lag Granger causality with all the other selected stock market indexes in ASEAN. Meanwhile, some evidences of the short-run associations are observed from the gold market to ASEAN emerging stock markets *i.e.*, from GOLDFIX to SET, and from GOLDFIX to VNI. In the reverse direction, the short-run associations from the selected stock markets to gold market seem to be insignificant, except from VNI to GOLDFIX.

Table 4: Summary of the Granger causality tests for the market pairs

	JKSE	KLSE	PSE	SET	VNI
GOLDFIX	–	–	–	→	↔
JKSE		↔	↔	↔	↔
KLSE			→	←	↔
PSE				↔	↔
SET					–

Notes: The arrows point out significant directions of causality at the p-value < 0.05 (or at least at the 5% level) under the Granger sense.
The symbol "–" means no directional effect, while →, ←, and ↔ denote forward, backward and bi-directions of causality, respectively.

By using the Johansen (1988) and Johansen and Juselius (1990) method, we target on examining whether or not there exist cointegrations in the six level series, both bivariate and multivariate Johansen techniques are applied in the study. Using multivariate Johansen, we conduct a test for all the six market price indexes to see if there exist cointegrating vectors in the system. Actually, the test results show that no cointegrating relation is observed in the whole system (results are not reported here, but available upon request).This highlights a feasibility of portfolio diversification when investing in these markets. As a result, we now focus on using the bivariate Johansen test to examine in detail the cointegration issue in all the fifteen market pairs, which are formed from a set of the six selected markets. The empirical results of the bivariate Johansen tests in all the market pairs, based on the predetermined lag lengths, are given in Table 5. For each market pair, two null hypotheses are considered, (i) there is no cointegrating vector ($r = 0$), and (ii) there is one cointegrating vector ($r = 1$). Both trace statistic and maximum eigen-value statistic tests are used to justify the conclusions.

In Table 5, four market pairs *i.e.,* (JKSE, KLSE), (JKSE, PSE), (KLSE, PSE) and (KLSE, VNI) show the cointegrating relations in the long-run, because the computed trace statistics for these pairs are greater than the critical value at the 5% level of significance. Consequently, the null hypothesis of no cointegrating vector in each of these pairs is rejected. In addition, results of the maximum eigen-value test for these market pairs are also consistent with those obtained from the trace tests, for which the null hypothesis of no cointegrating vector in each pair is rejected at the 5% level of significance. Alternatively, the null hypothesis of one cointegrating vector in each pair is examined using both trace and maximum eigen-value tests. The test results reveal that the null hypothesis of one cointegrating vector can not be rejected, since the calculated trace and maximum eigen-value statistics are less than their critical values at the 5% significant level. Therefore, we conclude that there exists one cointegrating vector in each of these pairs. Among these four pairs, KLSE appears most frequently (3 over 4), followed by JKSE, PSE (2 over 4) and VNI (1 over 4). The existence of cointegrating relation in the market pairs is a basis for predicting the market indexes by forming an ECM to obtain a long-run equilibrium.

On the other hand, the remaining eleven pairs show no cointegrating relationship in each pair, since both of the calculated trace statistic and maximum eigen-value statistic for each of these pairs are less than their critical values at the 5% level of significance. Thus, it can be concluded that the null hypothesis of no cointegrating vector in each of these pairs can not be rejected, and because of that, it is not necessary to test the null hypothesis of one cointegrating in each pair. As a result, two indexes in each of these pairs are not cointegrated, implying that they are operating independently. It is important to note that GOLDFIX is not integrated with all ASEAN emerging stock market indexes. And, among five ASEAN emerging stock markets, there exist ten market pairs. The empirical results show that they are low integrated with each other, since six over ten market pairs such as (JKSE, SET), (JKSE, VNI), (KLSE, SET), (PSE, SET), (PSE, VNI) and (SET, VNI) exhibit no cointegration. Especially, SET index appears to be independent from other stock indexes. In terms of international investment in the region, realization of market cointegrations is an important issue, because if the stock market indexes move together then investing in these markets will provide no long-term gains from portfolio diversification. Moreover, if the market indexes are found to be closely linked then it is risky for investors as shocks to this market transmit easily to others.

Table 5: Pairwise cointegration tests based on the Johansen technique

Pairwise cointegration (optimal lag)	H_0 (Trace test)		H_0 (Max. test)	
	r = 0	r ≤ 1	r = 0	r ≤ 1
GOLDFIX, JKSE(2)	6.9203	2.4477	4.4726	2.4477
GOLDFIX, KLSE(1)	5.4406	2.1851	3.2555	2.1851
GOLDFIX, PSE(1)	5.1540	2.2452	2.9087	2.2452
GOLDFIX, SET(1)	7.6591	1.2085	6.4506	1.2086
GOLDFIX, VNI(2)	7.5395	3.1444	4.3951	3.1444
JKSE, KLSE (2)	*16.4589*	*1.2106*	*15.2483*	*1.2106*
JKSE, PSE (2)	*17.3708*	*1.8625*	*15.5083*	*1.8625*
JKSE, SET (2)	9.4645	3.6934	5.7711	3.6934
JKSE, VNI (2)	15.4892	2.6360	12.8532	2.6360
KLSE, PSE (2)	*17.0227*	*1.2662*	*15.7565*	*1.2662*
KLSE, SET (2)	7.7514	1.8886	5.8627	1.8886
KLSE, VNI (2)	*22.0553*	*2.4149*	*19.6404*	*2.4149*
PSE, SET (2)	5.0971	1.7777	3.3193	1.7777
PSE, VNI (2)	11.5039	1.2646	10.2393	1.2646
SET, VNI (2)	4.7439	1.5959	3.1480	1.5959

Notes: For trace-test, critical values at the 5% significance level are 15.4947 for r = 0, r = 1; 3.8415 for r= 1, r= 2.
For max-test, critical values at the 5% significance level are 14.2646 for r = 0, r = 1; 3.8415 for r= 1, r= 2.

5. Concluding remarks

This paper, through examining the linkages among international gold and ASEAN emerging stock markets, brings an insight on the interdependencies among the five ASEAN emerging stock and international gold markets. In order to explore the long-run relationships and the short-run association among the sample markets, this study used different techniques including unit root test, Johansen cointegration test and Granger causality test over a sample period from 28th July 2003 to 31st March, 2009.

Results of using the Granger causality test indicated that the presence of short-run associations is found in almost all ASEAN emerging stock markets, except only the pair (SET, VNI) indexes. Meanwhile, some evidences of the short-run associations are observed from the gold market to ASEAN emerging stock markets *i.e.,* from GOLDFIX to SET index, and from GOLDFIX to VNI index. On the revert direction, the short-run associations from the selected stock markets to gold market are insignificant, except the one from VNI index to GOLDFIX.

Understanding market cointegration is an important issue for international investment and for regional cooperation to help markets absorb potential shocks and spillovers from one to others, especially when stock markets are closely linked. Results of the Johansen cointegration test for long-run relationships among the selected markets show that they are not cointegrated all together, but are low cointegrated to each other. This is expressed by only four market pairs (JKSE, KLSE), (JKSE, PSE), (KLSE, PSE) and (KLSE, VNI) among the fifteen market pairs that exhibit the presence of cointegrating relationships in the long-run. Moreover, the finding indicates that the Thailand stock and international gold markets are operating independently from other selected markets in the long-run. Meanwhile, KLSE shows the most cointegrating relations, followed by JKSE and PSE (medium cointegration), and VNI (low cointegration). Therefore, portfolio diversifications are suggested when investing in ASEAN emerging stock markets. And, gold is an item that should be included in the portfolio.

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