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Abstract

Members of the Association of Southeast Asian Nations (ASEAN) have recently made progress in forming a free trade area and investment zone, and are now examining the possibility of stock market integration. Regional integration may be fostered by simply coordinating existing national stock markets or, at an extreme, by creating a supranational exchange. Financial theory suggests that an integrated regional market is more efficient than segmented national markets, and this is what's driving the interest in ASEAN stock market integration -- particularly after of the Asian financial crisis of 1997-1998. From the perspective of a portfolio investor, integration of markets suggests that the separate markets move together and have high correlations, so there is less benefit from portfolio diversification across countries. The issue of stock market integration is thus of interest to ASEAN policymakers and international portfolio investors alike.

This paper considers the degree to which the five stock markets in the original ASEAN countries (ASEAN-5) are correlated as a way to assess the feasibility of ASEAN stock market integration and the implications for portfolio investors. In particular, this paper considers whether the ASEAN-5 markets are integrated or segmented using the time series technique of cointegration to extract a long-run relation. The empirical results suggest that the ASEAN-5 stock markets are cointegrated and are thus not completely segmented by national borders. However, there is only one cointegrating vector, leaving four common trends among the five variables. We therefore conclude that ASEAN-5 stock markets are integrated in the economic sense, but that integration is not complete. On a policy level, initiatives to further integrate the stock markets are feasible, and in fact desirable. From the perspective of the international portfolio investor, benefits of international portfolio diversification across the five markets are reduced but not eliminated.

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1. Introduction

This paper examines stock market integration in Indonesia, Malaysia, the Philippines, Singapore, and Thailand in the aftermath of the Asian financial crisis. These five countries are the original members of the Association of Southeast Asian Nations (ASEAN), which now also includes Brunei, Cambodia, Laos, Myanmar, and Vietnam. Over the past few years, ASEAN member countries have made tremendous progress in forming a free trade area and investment zone -- witness the ASEAN Free Trade Area (AFTA) and the ASEAN Investment Area (AIA). They are now examining the possibility of capital market integration for national bond markets and stock markets alike. ASEAN countries, in fact, are beginning to discuss the feasibility of a currency union as well, which suggests that the countries are interested in multilateral approaches to many regional economic and financial issues. The five original ASEAN countries (the ASEAN-5) are the most likely candidates to undertake integrative measures first, and therefore provide the focus for this paper.

Integration in the ASEAN capital markets may include initiatives to coordinate the five national capital markets which already exit, or at an extreme may involve the creation of supranational regional bond and stock exchanges. A separate paper (Plummer and Click, 2002) examines the bond markets (and see the references therein), so this paper considers only the stock markets. The issue is integration as opposed to stock market development more generally, although one motivation for integration is typically to foster development of the market.

Interest in stock market integration arises because an integrated regional stock market is more efficient than segmented national capital markets. Capital market efficiency in Southeast Asia has become even more important after of the Asian financial crisis of 1997-1998, as countries seek to reduce the traditional dependence of firms on bank loans rather than bond and stock issuances, at the same time that they seek new capital from outside the region. With an integrated regional stock market, investors from all member countries will be able to allocate capital to the locations in the region where it is the most productive. With more cross-border flows of funds, additional trading in individual securities will improve the liquidity of the stock markets, which

will in turn lower the cost of capital for firms seeking capital and lower the transaction costs investors incur. These suggest a more efficient allocation of capital within the region.

An integrated regional stock exchange will also be more appealing to investors from outside the region, who would find investment in the region easier or more justifiable. As shares become more liquid and transaction costs fall, fund managers become increasingly willing to take positions in the stocks. In addition, outside investors may take notice of the regional stock exchange instead of dismissing a collection of small national exchanges: the whole (one regional stock exchange) might be greater than the sum of the parts (individual country exchanges). For example, Freeman (2000) makes the argument that total equity market capitalization is important to investment managers outside the region: "Institutional investors with global portfolios may simply dispense altogether with equity markets that have low asset allocation recommendations, as resources – such as research – are limited (p. 2)." He suggests that, except for Malaysia and Singapore, equity markets in Southeast Asia may be edging toward irrelevance, and that one way to overcome the problem is to band together. Thus, an integrated stock market within the ASEAN-5 will help link the region with the world stock markets and bring more capital into the countries from abroad. This will allow ASEAN companies to expand their shareholder base and lower their cost of capital even further.

In addition to interest from policy makers and investment practitioners, stock market integration also carries interest from an academic perspective. Recent advances in time series analysis allow investigation of a "long run" equilibrium among stock markets using the methods of cointegration. As Kasa (1992) points out, stock markets which are cointegrated have a long-run relationship, so long-run correlations of returns are higher than short-run correlations typically examined. If n variables have p cointegrating relationships, they have $n-p$ common trends. When $n-1 = 1$, as in the case of the five developed-country stock indices investigated in Kasa (1992), correlations of returns converge to unity and there is no diversification potential in the long run. In this situation, the individual stock markets are completely and perfectly integrated. However, Richards (1995) points out that a major reason for the findings in Kasa (1992) is an inappropriately

long lag length used in the estimation process. With shorter lags, Richards (1995) finds that the five developed-country stock indices are not cointegrated. In this situation, the individual stock markets are completely segmented.

This paper specifically considers whether the stock markets of Indonesia, Malaysia, the Philippines, Singapore, and Thailand are currently cointegrated. We examine the period after the Asian financial crisis, specifically July 1, 1998 through December 31, 2002, in order to consider the recent experiences of the ASEAN-5 markets rather than a long history.[1] The database thus suffers from being a short four-and-a-half year span of time from which to extract a long-run relationship, but also has the advantage of being a well-defined period during which we can reasonably say that there have been few structural breaks or shifts in the data.

There are three key features in our modeling strategy. One is that we consider both daily data and weekly (Friday or end-of-week) data over this period in order to examine what happens as analysts move from higher-frequency to lower-frequency data. In particular, the lower-frequency data may contain less noise and relatively more information to estimate a long run relation. A second feature is that we consider data denominated in local currencies, in U.S. dollars, and in Japanese yen. Analysis is often done in local currencies, but investors outside the ASEAN countries have to convert local currency returns into their home currencies, of which the dollar and the yen are the most widely used. In the period before the Asian financial crisis, the ASEAN countries were typically pegging their exchange rates to the dollar. This meant that the choice of local currency versus the dollar did not matter much, but the stock market values denominated in yen were of course sensitive to fluctuations in the yen/dollar exchange rate. Currency issues have become more important in the aftermath of the Asian financial crisis, as countries have allowed their currencies to float against the dollar. A third feature is that we carefully examine the lag structures of the models, and estimate cointegrating relationships in models with differing lag lengths. This allows us to determine whether our results are sensitive to the number of lags

[1] For a thorough analysis of the pre-crisis period 1986-1996, see Sharma and Wongbangpo (2002).

chosen.

With five stock market variables, the number of common trends (*n*-*p*) can range from one to five, and this range forms something of a continuum from perfect integration to complete segmentation. If the stock markets are not cointegrated, resulting in five common trends, we infer that they are nationally segmented in the economic sense, and are not yet suitable for a supranational regional stock market. However, if these stock markets are cointegrated in the econometric sense, we infer that they are integrated in the economic sense. If the number of common trends is more than one, we conclude that there is a degree of interdependence somewhat short of complete convergence, so policy initiatives to further integrate the stock markets are appropriate. If the number of common trends is exactly one, we conclude that the stock markets are completely, perfectly integrated and are ready for the establishment of a supranational regional stock market.

The empirical results in this paper demonstrate that the ASEAN-5 stock markets in the period after the Asian financial crisis are cointegrated whether analyzed using daily data or weekly data, and whether analyzed in local currencies, the US dollar, or the Japanese yen. In addition, the finding does not depend on the number of lags used in estimation once a relevant range of lags is determined. The stock markets are thus not completely segmented by national borders. However, there is only one cointegrating vector among the five stock markets, leaving four common trends among the five variables. Once again, this finding is robust to the frequency of the data, the currency denomination considered, and the lag lengths chosen. Perhaps surprisingly, the coefficients in the cointegrating vectors are remarkably similar across all forms of the model, suggesting that data frequency, currency denomination, and lag length have relatively little impact on the long-run equilibrium estimated. We therefore conclude that ASEAN-5 stock markets are integrated in the economic sense, but that integration is not complete. On a policy level, initiatives to further integrate the stock markets are feasible, and in fact desirable. From the perspective of the international portfolio investor, benefits of international portfolio diversification across the five markets are reduced but not eliminated.

This paper is organized into four sections. After this introduction, section 2 provides background on stock markets and integration in ASEAN. The first subsection considers public policies pertaining to ASEAN stock markets, with an emphasis on integrative efforts, and the second subsection surveys the academic literature on Southeast Asian stock market integration. Section 3 then considers the empirical analysis of stock market integration in ASEAN after the Asian financial crisis. The subsections consider data sources, short-run correlations of returns, unit root tests, lag length tests, and, most importantly, cointegration results. The final section is the conclusion.

2. Background

The stock markets of the ASEAN-5 countries generally have market capitalizations in line with the sizes of their economies. Using 2000 data[2], Singapore and Malaysia have market capitalizations as a percent of gross domestic product quite similar to the United States; 165.7% and 130.4%, respectively, versus 153.5% for the U.S. The Philippines, where stock market capitalization is 69.9% of GDP, is quite similar to the level of Japan, at 65.2%. Thailand and Indonesia are the smallest markets, at 24.1% and 17.5%, respectively, but not out of line with emerging markets around the world. These figures suggest that there is a general level of equity market development which may be conducive to integration. In contrast, the stock markets of Brunei, Cambodia, Laos, Myanmar, and Vietnam are either under-developed or non-existent.

2.1. Public Policies on ASEAN Stock Markets

Attempts to coordinate ASEAN stock markets are not new. Wellons (1997, p. 28) points

[2] Data on stock market capitalization come from the Standard & Poor's Emerging Stock Markets Factbook 2001. The market capitalizations of the markets are as follows: Singapore, $152 billion; Malaysia, $117 billion; the Philippines, $52 billion; Thailand, $29 billion; and Indonesia, $27 billion. For comparison, the market capitalizations of the U.S. and Japan are $15,104 billion and $3,157 billion, respectively. Data on GDP come from the World Development Indicators of the World Bank.

out that the ASEAN-5 countries agreed to form the Federation of ASEAN Stock Exchanges in 1978, but never followed through. The Singapore and Malaysian stock markets were fairly well linked at this time, as many Malaysian registered companies traded on the Stock Exchange of Singapore (SES). However, financial crises in Singapore during 1985-1986 spilled over into Malaysia, and actually caused dis-integration of the stock markets.

In 1989 the government of Malaysia delisted Malaysian companies from the SES. The decision to delist first appeared in the budget speech of the Finance minister on October 27, 1989. Sun, Tang, and Tong (2002) report that:

> He cited the need for the KLSE [Kuala Lumpur Stock Exchange] to develop its own identity and to become a leading regional finance center. To achieve that, a total separation from the SES could not be avoided. The second reason, as cited by the Minister, was to minimize the high correlation between the two markets. The Malaysian government has long been wary of developments in Singapore affecting the KLSE.

Similarly, according to Bank Negara Malaysia (1999), the "move represented the Government's effort to develop the domestic capital market by establishing KLSE as an independent exchange, to confine dealings in Malaysian counters to the local exchange, to attract international investors as well as to reduce the market's vulnerability to unfavorable developments on the SES (p. 316)." In response to the Malaysian government's action, the SES almost immediately announced a similar delisting of Singaporean companies from the Malaysian Stock Exchange and a plan to develop an over-the-counter market to trade Malaysian stocks. The over-the-counter market, known as CLOB International, actually functioned up until September 1998, when the government of Malaysia announced that all dealings in shares listed on the exchange must be done through the Kuala Lumpur Stock Exchange or one recognized by KLSE.[3] Wellons (1997) also points out that the Singapore Declaration of 1992 "raised the prospect of stronger capital market cooperation as part of an effort to direct ASEAN economic cooperation (p. 28)." More generally,

[3] For more on the 1989 delistings and the history of CLOB, see Sun, Tang, and Tong (2002).

presidents of stock exchanges in the region call for cooperation from time to time to facilitate cross-border trading. "In 1993, for example, the SES president said that the time had come to promote intra-ASEAN markets. He saw the opportunity to cross-list and trade a handful of larger stocks on markets throughout ASEAN. (p. 28)" In 1995, "the president of the Thai exchange urged closer cooperation among exchanges in the region (p. 28)" to boost poor trading volumes. And, according to Freeman (2000), the governor of the Bank of Thailand "proposed a joint venture between the Bangkok, Kuala Lumpur and Singapore equity markets (p. 9)" in 2000.

The dream of a regional stock market in ASEAN has not come to fruition, and there are reasons to believe that markets remain segmented. In particular, Malaysia's imposition of selective currency and capital controls in dealing with Asian financial crisis (which went into effect on September 1, 1998) suggested that the stock market in Malaysia, which had been well integrated with Singapore, would be separated from both world and regional stock markets.[4] The exchange controls eliminated access to the ringgit by non-residents from sources in Malaysia and abroad, effectively closing down the offshore ringgit market.[5] The ringgit was also pegged to the U.S. dollar at the same time, and the peg has been successfully maintained since then. Some capital controls have been relaxed, suggesting that the Malaysian stock market is not completely segmented from world and regional stock markets. Initially, capital controls required foreigners to hold stocks for at least 12 months, but this was replaced with a 10% repatriation levy in February 1999. The Kuala Lumpur Stock Exchange was dropped from the Morgan Stanley Capital International index in late 1998, but was re-added at the end of May 2000. Currently, the Philippines has the most extensive capital controls on portfolio investments of the ASEAN-5, generally imposing a ceiling on foreign ownership of 40% and in some cases requiring a separate class of shares (Standard & Poors, 2001).

[4] See Johnson and Mitton (2003) for discussion of the Malaysian capital controls, particularly with respect to the thesis that the capital controls provided a screen behind which favored firms could be supported.

[5] For more on this, see Bank Negara Malaysia (1999).

2.2 Academic Literature

The issue of stock market integration in Southeast Asia has also been studied in the academic empirical finance literature, particularly using the techniques of cointegration. The main issue being addressed is whether individual stock markets are highly (positively) correlated, although more recently the issue has been recast to address "contagion" across markets. There are several other aspects being examined as part of this general issue. One considers what the appropriate econometric technique for examining the correlations should be. A second addresses the time period to examine, and whether there have been changes over time such as convergence of markets or structural breaks or shifts in relationships (such as those related to liberalization of equity markets or to financial crises). A third is whether the empirical analysis should be conducted in the local currencies, U.S. dollars, Japanese yen, or some other unit. A fourth is whether the local markets are influenced by the U.S. market, or the Japanese market, or both.

Taken together, the conclusions in the literature regarding the integration of Southeast Asian stock markets are contradictory. This might be partially attributable to different methodologies, even when using cointegration techniques. Since several studies have examined Asian stock markets in the light provided by Kasa (1992), we restrict our focus to these. Conflicting and inconclusive results are still apparent, due in part to the wide range of sample periods and sampling frequencies considered; the selection of countries considered; and the exact modeling strategy being implemented.

DeFusco, Geppert, and Tsetsekos (1996) examine weekly data for January 1989 - May 1995 denominated in U.S. dollars. They conclude that there is no cointegration in a block of Asia-Pacific countries consisting of U.S., Korea, Philippines, Taiwan, Malaysia, and Thailand. They also conclude that there is no cointegration in the other two other regions they examine, thus capital markets are segmented.

Masih and Masih (1999) use daily data over 2/14/92-6/19/97 denominated in real U.S. dollars. They find cointegration in a block of OECD and Asian countries including U.S., Japan,

U.K., Germany, Singapore, Malaysia, Hong Kong, and Thailand, but conclude that there is at most one cointegrating vector, leaving seven independent common stochastic trends.

Manning (2002) examines both weekly and quarterly data over January 1988 - February 1999, denominated in both local currency and in U.S. dollars. The system includes Hong Kong, Indonesia, Japan, South Korea, Malaysia, Philippines, Singapore, and Thailand, and alternately includes/excludes the U.S. The general conclusion is that there are two common trends, indicating "partial convergence" of the indices.

Phylaktis and Ravazzolo (undated) examine monthly data for January 1980 - December 1998 (split into two periods: 1980-1989 and 1990-1998) denominated in local currency, U.S. dollars, and real U.S. dollars. The sample consists of the U.S., Japan, Hong Kong, South Korea, Malaysia, Singapore, Taiwan, and Thailand, and cointegration is found for both subperiods in all units of measurement. However, relatively few countries participate in the cointegrating vectors. This leads Phylaktis and Ravazzolo to conclude that the stock markets under investigation are not linked. A subsystem consisting of Taiwan, Thailand, Japan, and the U.S. seems to reveal the strongest financial integration. In this subsystem, the estimated common trends suggest that the U.S. has influence in the Pacific Rim, but that Japan plays a more significant role and is equally important as Thailand.

Sharma and Wongbangpo (2002) examine monthly data from January 1986 through December 1996 for the ASEAN-5 markets denominated in local currencies. They find a long-run cointegrating relationship among the stock markets of Indonesia, Malaysia, Singapore, and Thailand, but conclude that the Philippine market does not share the relationship. Furthermore, there is only one cointegrating vector among the four markets, leaving three common trends. One particularly interesting finding is that Malaysia and Singapore move together one-for-one in the cointegrating vector, ostensibly because of the distribution of inward foreign direct investment flow, the strength of trade between the two economies, the geographical proximity, and cultural factors (p. 307).

Taking these five studies together, it is certainly not clear what to expect for stock market

integration in ASEAN in the aftermath of the Asian financial crisis. A few additional studies use cointegration techniques to determine whether the local markets are influenced by the U.S. market, or the Japanese market, or both, and generally add to the confusion; see Fernandez-Serrano and Sosvilla-Rivero (2001), Jang and Sul (2002)[6], and Darrat and Zhong (2002). In addition, VAR approaches using differenced data without a cointegrating constraint offer even more positions. Two such studies are worth mentioning.

Dekker, Sen, and Young (2001) use daily data in local currencies and dollars over the period 1987-1998 in ten-variable VARs to examine linkages among U.S., Japan, and eight other countries' stock markets including Malaysia, Philippines, Singapore, and Thailand. The results indicate that the four ASEAN markets are linked to the U.S. market, which exerts a great deal of influence, but that the Japanese market is segmented. Furthermore, the Malaysian, Singapore, and Hong Kong markets are closely linked, but the Philippine and Thai markets are segmented.

Tan and Tse (2002) use daily data in local currencies over 1988-2000 in a nine-variable VAR to examine the linkages among U.S., Japan, and seven Asian stock markets including Malaysia, Philippines, Singapore, and Thailand. By truncating the data at the end of 1996 and restarting the data in mid-1998 to create a pre-crisis and post-crisis comparison, they find that markets appear to be more integrated after the crisis than before, and that Asian markets are most heavily influenced by the U.S. but that the influence of Japan is increasing. The most noteworthy effect among the ASEAN-5 is that Malaysia is apparently an outlier; Malaysia is less affected by the U.S. and Japan after the crisis, which can be attributed to the success of its capital and currency controls, but Singapore and Malaysia still affect each other strongly, which can be attributed to geographic proximity, economic linkages, and structural symmetry.

[6] Jang and Sul (2002) also offer bivariate cointegration tests among the three ASEAN-5 markets studied. Thailand and Indonesia are cointegrated during the crisis and well after the crisis; Thailand and Singapore are cointegrated immediately after the crisis and maybe well after the crisis; Indonesia and Singapore may be cointegrated before the crisis but not during or afterwards.

3. Empirical Examination

This section considers the empirical characteristics of the ASEAN-5 stock indices. The indices themselves, denominated in local currencies, are considered foremost. However, the indices converted into U.S. dollars and into Japanese yen are also considered in order to have the indices in common currency units. These series implicitly represent the sum of the returns on two assets, the stock index and the currency. The indices in local currencies, although representing a mix of currency units, are obtainable when the currency risk is perfectly hedged.[7]

3.1 Data

The data consist of daily stock index quotes in local currencies over the four-and-a-half-year period from July 1, 1998 through December 31, 2002, for a total of 1175 observations. From this, we also consider weekly stock index data by taking the Friday (or other end of week) observations over the same period, for a total of 235 observations. We begin with mid-1998 because the bulk of the Asian financial crisis had ended by then.[8] The data are from Datastream, and represent composite stock price indices in Indonesia, Malaysia, Philippines, Singapore, and Thailand. We convert the local currency index into U.S. dollars [Japanese yen] by multiplying the local currency index level by the dollars-per-foreign-currency [yen-per-foreign-currency] exchange rate, also obtained from Datastream.

[7] We cannot convert from nominal currency units to real currency units because price level data do not exist at daily or weekly frequency. However, the stock market and exchange rate data are not materially influenced by inflation during the short time period under consideration, so such an adjustment would not need to be done anyway.

[8] Tan and Tse (2002) use mid-1998 as the beginning of the post-crisis period. The crisis may or may not have been "over" at that date, however. Jang and Sul (2002) begin the post-crisis period earlier, on February 1, 1998, because the Thai, Indonesian, and Korean currencies reached record lows in January. Additional adjustments were yet to come, such as Malaysian currency and capital controls introduced September 1, 1998.

3.2 Short-run Correlations

Table 1 presents the simple correlation coefficients among the five stock markets. Panel A utilizes the daily data and Panel B utilizes the weekly data, and within each panel is a matrix for correlations of data denominated in local currency units, U.S. dollars, and Japanese yen. Overall, the correlations are not very high -- averaging just 0.336. Comparing the daily correlations to the weekly correlations suggests that correlations may be higher for the weekly data; the average correlation for the daily data is 0.294 and the average for the weekly data is 0.379. Among the 30 correlations, only 4 are lower in the weekly data than in the daily data. Although we don't know whether this difference is statistically significant, it seems plausible that correlations among the five stock markets rise when moving from higher-frequency to lower-frequency data. The concern that correlations will converge to unity in the long run is precisely the motivation for using cointegration analysis to examine the long run relationship.

3.3 Unit Root Tests

In preparation for cointegration analysis, the univariate properties of the stock index data need to be examined to verify that the data series are nonstationary, or contain a unit root. Table 2 presents Augmented Dickey-Fuller (ADF) and Phillips-Perron tests allowing for a constant in the regression but no time trend. Once again, Panel A utilizes daily data and Panel B utilizes weekly data. The tests suggest that all of the series contain unit roots; the hypothesis of a unit root cannot be rejected at the 5% level for any of the 60 tests (and cannot be rejected at the 10% level for 58 of the tests). The number of lags utilized in the reported ADF tests is chosen using the Akaike Information Criterion, but the unit root finding is really invariant to the number of lags chosen. The number of lags in the reported Phillips-Perron tests is set to four, but again the results are invariant to the number of lags chosen. Since all series are nonstationary, cointegration analysis is appropriate.

3.4 Lag Length Tests

The number of lags in the vector autoregression (VAR) used to estimate the cointegrating relationship is an important issue because the number of lags has been shown to affect the number of cointegrating vectors detected (e.g., Richards, 1995). Table 3 thus presents lag length tests from VARs of different orders. It considers the Akaike Information Criterion (AIC), the Schwartz Bayesian Criterion (SBC), and Likelihood Ratio Tests of exclusion restrictions on incremental lags which are distributed χ^2 with 25 degrees of freedom.

With daily data (analyzed in Panel A), most statistics suggest that only one lag is appropriate in the VAR. The AIC indicates that some additional information may be captured around the one week lag: the minimum AIC occurs at 6 days of lags for the estimation in local currency and 5 days of lags for estimation in U.S. dollars and Japanese yen. However, the SBC achieves minima at one lag in all three daily models, and the likelihood ratio tests indicate that no additional lags beyond the first are statistically significant. In addition to the likelihood ratio tests reported in Table 2, we also calculated likelihood ratio tests of 5 lags versus 1 lag and 6 lags versus l lag, yet still cannot reject the null hypothesis that coefficients on the blocks of additional lags are jointly zero.[9] We therefore estimate the cointegrating vector in two different VARs -- one with 1 lag and another with 5 lags -- in order to see what effect the number of lags might have on the cointegration analysis.

We examine weekly data because we are interested in the effects of moving from higher-frequency to lower-frequency data. However, it is also somewhat more appropriate given that daily data may reveal some information at the one week lag but not before then. Utilizing weekly data may therefore be a more parsimonious way to estimate a VAR and cointegrating

[9] The likelihood ratio test of 5 lags versus 1 lag is distributed $\chi^2(100)$ and the likelihood ratio test of 6 lags versus 1 lag is distributed $\chi^2(125)$. The critical values for the 90% confidence level are 118 and 140, respectively. For local currency, $\chi^2(100) = 46.90$ and $\chi^2(125) = 64.02$. For U.S. dollars, $\chi^2(100) = 44.00$ and $\chi^2(125) = 48.55$. For Japanese yen, $\chi^2(100) = 38.71$ and $\chi^2(125) = 43.63$.

relationships. The lag length tests of weekly data reported in Panel B of Table 3 are broadly consistent with the daily data, but with some reversals of particular tests. With the weekly data, both the AIC and the SBC indicate that only one lag is appropriate. However, the likelihood ratio tests suggest that two lags may be appropriate for the local currency model and three lags might be appropriate for the dollar and yen models. In fact, likelihood tests of 3 lags versus 1 lag reject the hypothesis that coefficients on the blocks of additional lags are jointly zero for all three models. In local currency $\chi^2(50) = 74.23$, which is significant at the 5% level. In U.S. dollars, $\chi^2(50) = 72.52$, which is significant at the 5% level. And in Japanese yen, $\chi^2(50) = 78.69$, which is significant at the 1% level. As a result, we estimate the cointegrating vector using the weekly data in three different VARs -- 1 lag, 2 lags, and 3 lags – to see once again what effect the number of lags might have on the cointegration analysis.

3.5 Cointegration Results

Having established the unit root characteristics of the data and identified relevant ranges for lag length, we are ready to proceed with the examination of cointegration. In this section, we consider three inter-related questions. First, are the ASEAN-5 stock markets cointegrated? If so, how many cointegrating relationships are there? To answer these questions, we rely on the λ_{max} and λ_{trace} statistics. The λ_{max} statistic tests the null hypothesis that the number of cointegrating vectors is r (ranging from 0 to 4) against the alternative of $r+1$ cointegrating vectors. The λ_{trace} statistic tests the null hypothesis that the number of distinct cointegrating vectors is less than or equal to r against a general alternative. Second, which countries participate in the cointegrating relationships? To answer this, we conduct individual exclusion tests of the null hypothesis that the coefficient on a variable in the cointegrating vector is zero. These tests are distributed χ^2 with one degree of freedom. Third, what are the coefficients in the cointegrating vectors, and do they have reasonable magnitudes for interpretation? To answer this, we report the cointegrating vector and qualitatively discuss the coefficients.

Table 4 reports the results of the cointegration analysis. Panel A again considers daily data,

and reports the results for VARs with 1 lag and with 5 lags. Panel B again considers weekly data, and reports the results for VARs with 1, 2, and 3 lags. Within each panel and lag length, models are estimated using the three currency denominations: local currencies, the dollar, and the yen. There are thus 15 VARs estimated, and the results are astonishingly consistent across all versions.

Tests for cointegration utilize both the λ_{max} and λ_{trace} statistics, reported on the left of the various tables. Models denominated in local currencies are estimated without a constant in the cointegrating vector because an exclusion test of the hypothesis that the constant is zero could not reject the null for any of the specifications. Models denominated in dollars and yen are estimated with a constant in the cointegrating vector because exclusion tests of the hypothesis that the constant is zero reject the null for all of the specifications. The inclusion of a constant in the cointegrating vector alters the critical values of the λ_{max} and λ_{trace} statistics; we use Table B of Enders (1995, p. 420) for both sets of critical values. Taken together, the λ_{max} and λ_{trace} statistics consistently (somewhat overwhelmingly) indicate that there is only one cointegrating vector regardless of currency denomination, lag length, or data frequency.

Since cointegration determines whether the different stock markets have a long run relationship, coefficients in the cointegrating vector can tell us *how* the stock markets are related in the long run. To the right of the λ_{max} and λ_{trace} statistics, the cointegrating vectors are reported along with exclusion tests of each variable. The reported cointegrating vectors (only one for each model) are normalized around Indonesia; in addition to being the first country alphabetically, it is also the smallest stock market and cointegrating vectors might be usefully interpreted in that context. Taken together, the coefficients appear remarkably similar across all versions of the model. As mentioned above, one difference among the models is that the local currency versions exclude a constant from the cointegrating vector while the dollar and yen versions include a constant.[10] Another difference between the local currency models and the dollar and yen models is

[10] The table reveals that the constant in the dollar models is between 7.9 and 8.9, averaging 8.7. The yen models have a constant ranging from 13.0 to 15.2, averaging 14.2. Not much importance can be attributed to these, as they are simply constants in the levels of the stock market indexes, so we do not consider them further.

that the coefficients in the former are generally a bit larger in absolute value than the coefficients in the latter. Since we cannot say whether these differences are statistically significant, we consider the qualitative implications of all models taken together. The exclusion tests of the variables suggest that each variable indeed participates in the long-run cointegrating vector; no country's stock market index should be removed from the analysis.

Since the cointegrating vectors are all normalized around Indonesia, we can easily rewrite the cointegrating vector as if the Indonesian stock index were the dependent variable and all other variables were independent variables. Since the coefficients are similar across all models, we consider a representative cointegrating vector:

$$\text{INDON} = -3.1\ \text{MALAY} - 1.8\ \text{PHILI} + 3.3\ \text{SINGA} + 3.3\ \text{THAIL}$$

which is, in fact, simply a collection of the average coefficients across the fifteen models. The long-run relationship suggests that a 1% increase in the Malaysian stock index lowers the Indonesian index by 3.1%, and a 1% increase in the Philippine stock index lowers the Indonesian index by 1.8 percent. Similarly, a 1% increase in the Singapore or Thai stock index increases the Indonesian index by 3.3%. Since Indonesia is the smallest market, the coefficients appear reasonable because they suggest that Indonesia is heavily influenced by the two largest markets (Malaysia and Singapore) and somewhat less influenced by the smaller Philippine market. Admittedly, the high magnitude of the coefficient on Thailand is somewhat puzzling, but is consistent with results in Phylaktis and Ravazzolo (undated) concerning the influence of Thailand. It is particularly interesting that Indonesia is inversely related to Malaysia and the Philippines, as economic integration usually implies that markets move together with a positive correlation coefficient. However, there are some circumstances in which markets will be systematically inversely related; any macroeconomic shock (e.g., an oil shock) which is favorable for Malaysia and the Philippines but unfavorable for Indonesia (and vice versa) will produce such a result.

To convey the sense of proportions, as well as consider another perspective, we can re-normalize the cointegrating vectors around a different country. We briefly consider normalization around Singapore, the largest market. The representative cointegrating vector can

be rewritten:

$$SINGA = 0.3\ INDON + 0.9\ MALAY + 0.5\ PHILI - 1.0\ THAIL$$

and reinterpreted. The Singapore stock index is positively affected by the Indonesian, Malaysian, and Philippine indexes with fairly reasonable magnitudes. For example, a 1% increase in the Malaysian market is associated with 0.9% increase in the Singapore market. The Singapore market is less affected by changes in the Philippine and Indonesian markets. Finally, a 1% increase in the Thai stock market is associated with a 1% decrease in the Singapore stock market, which again seems puzzling but might reflect shocks which are favorable for Thailand and unfavorable for Singapore (and vice versa).

Taken together, the results of cointegration analysis convincingly reveal that the ASEAN-5 stock markets are cointegrated, and have only one cointegrating relationship. In addition, all five countries participate in the cointegrating relationship. Finally, the coefficients in the cointegrating vector are all reasonable, although some puzzles remain with regard to the magnitude associated with Thailand and inverse relationships among some market pairs. It is worth pointing out once again that these results are completely robust to the frequency of the data (daily versus weekly), the currency denomination examined (local currencies, dollars, or yen), and the number of lags chosen for the VAR (within an appropriate range indicated pre-testing). Such consistent results are rare in time series studies of this type, but may not be too surprising in this particular case. Cointegration is able to pick out a long run relationship equally well from daily and weekly data. The fact that currency denomination does not matter most likely reflects a strong relationship in the underlying stock markets which is not substantially altered when the effects of exchange rates are added in. Finally, the cointegrating relationship is, not surprisingly, reasonably invariant to small changes in the number of lags utilized in the VAR.

4. Conclusions

The empirical results in this paper demonstrate that the stock markets of Indonesia, Malaysia, Philippines, Singapore, and Thailand in the period after the Asian financial crisis (July 1,

1998 through December 31, 2002) are cointegrated whether analyzed using daily data or weekly data, and whether analyzed in local currencies, the US dollar, or the Japanese yen. In addition, the finding does not depend on the number of lags used in estimation over a reasonable range. The stock markets are thus not completely segmented by national borders. However, there is only one cointegrating vector among the five stock markets, leaving four common trends among the five variables. We therefore conclude that ASEAN-5 stock markets are integrated in the economic sense, but that integration is not complete. Exclusion tests of the variables suggest that each country index participates in the long-run cointegrating vector, so no market should be removed from the analysis. In addition, the coefficients in the cointegrating vector are remarkably similar across all versions of the models, and are reasonable in magnitude and interpretation.

One implication of cointegration is that there is less long-run diversification benefit from investing in all five countries than the short-run correlation coefficients indicate. On a policy level, cointegration suggests that initiatives to further integrate the stock markets are quite feasible, and in fact desirable from the standpoint of efficiency. In particular, since there is less long-run diversification benefit from investing across all five countries, a regional stock exchange will nudge investors to spread their money into smaller markets where they otherwise may not. In fact, investors from outside the region may value the benefits of a regional stock exchange (such as higher liquidity and lower transaction costs) and allocate more capital to the region than they otherwise would. This will allow ASEAN companies to expand their shareholder base and lower their cost of capital.

From the stock market perspective, regional integration suggests that even currency unification would be feasible. Although this issue needs to consider other financial and macroeconomic issues as well,[11] the point here is that efficient flows of capital across borders

[11] For more on the issue of ASEAN currency unification, see Eichengreen and Bayoumi (1999), Bayoumi, Eichengreen, and Mauro (2000), Bayoumi and Mauro (2001), Ling (2001), Zhang, Sato, and McAleer (2001), and Madhur (2002). These studies typically examine the nature of national aggregate supply shocks to determine whether they are positively correlated across countries (and thus more characteristic of an optimal currency area).

within the region have the capacity to mitigate the effects of any asymmetric macroeconomic shocks. The inverse relationships in cointegrating vectors among some stock market pairs suggest that such cross-border flows are already occurring. Stock market integration is thus an important component of overall economic integration and might be a useful precondition for monetary unification.

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TABLE 1
SHORT-RUN CORRELATIONS OF STOCK INDEX RETURNS
July 1, 1998 through December 31, 2002

Panel A: Daily Data

Local Currency

	Indonesia	Malaysia	Philippines	Singapore
Malaysia	0.17			
Philippines	0.25	0.14		
Singapore	0.27	0.29	0.28	
Thailand	0.28	0.28	0.28	0.43

U.S. Dollars

	Indonesia	Malaysia	Philippines	Singapore
Malaysia	0.19			
Philippines	0.27	0.14		
Singapore	0.26	0.25	0.28	
Thailand	0.30	0.26	0.32	0.44

Japanese Yen

	Indonesia	Malaysia	Philippines	Singapore
Malaysia	0.26			
Philippines	0.32	0.27		
Singapore	0.31	0.37	0.38	
Thailand	0.33	0.34	0.38	0.48

Panel B: Weekly Data

Local Currency

	Indonesia	Malaysia	Philippines	Singapore
Malaysia	0.22			
Philippines	0.36	0.26		
Singapore	0.30	0.27	0.37	
Thailand	0.44	0.28	0.50	0.56

U.S. Dollars

	Indonesia	Malaysia	Philippines	Singapore
Malaysia	0.20			
Philippines	0.42	0.25		
Singapore	0.36	0.25	0.40	
Thailand	0.46	0.27	0.54	0.59

Japanese Yen

	Indonesia	Malaysia	Philippines	Singapore
Malaysia	0.21			
Philippines	0.41	0.34		
Singapore	0.35	0.36	0.47	
Thailand	0.45	0.32	0.55	0.60

TABLE 2
UNIT ROOT TESTS
July 1, 1998 through December 31, 2002

Panel A: Daily Data

			ADF test		Phillips-Perron test	
		lags	τ_μ	ρ	τ_μ	ρ
Local Currencies						
	Indonesia	1	-1.19	0.998	-1.19	0.998
	Malaysia	15	-2.10	0.995	-1.92	0.995
	Philippines	10	-1.24	0.998	-0.70	0.999
	Singapore	1	-1.56	0.997	-1.57	0.997
	Thailand	19	-2.46	0.992	-2.23	0.994
U.S. dollars						
	Indonesia	1	-1.25	0.998	-1.23	0.998
	Malaysia	5	-2.12	0.995	-2.08	0.995
	Philippines	11	-0.92	0.999	-0.39	0.997
	Singapore	1	-1.43	0.997	-1.44	0.997
	Thailand	2	-1.96	0.995	-1.87	0.996
Japanese yen						
	Indonesia	23	-1.81	0.996	-1.27	0.998
	Malaysia	5	-2.21	0.993	-2.15	0.993
	Philippines	11	-1.12	0.998	-0.68	0.999
	Singapore	1	-1.50	0.996	-1.54	0.996
	Thailand	12	-2.27	0.993	-1.90	0.995

Panel B: Weekly Data

			ADF test		Phillips-Perron test	
		lags	τ_μ	ρ	τ_μ	ρ
Local Currencies						
	Indonesia	7	-1.57	0.983	-1.32	0.988
	Malaysia	2	-2.18	0.976	-2.03	0.979
	Philippines	2	-1.35	0.986	-1.13	0.993
	Singapore	1	-1.60	0.984	-1.63	0.984
	Thailand	4	-2.35	0.960	-2.40	0.964
U.S. dollars						
	Indonesia	2	-1.48	0.984	-1.43	0.987
	Malaysia	7	-2.83*	0.968	-2.14	0.977
	Philippines	2	-0.92	0.993	-0.75	0.997
	Singapore	1	-1.52	0.985	-1.55	0.986
	Thailand	4	-2.09	0.970	-2.05	0.974
Japanese yen						
	Indonesia	3	-1.71	0.981	-1.50	0.986
	Malaysia	7	-2.79*	0.957	-2.17	0.970
	Philippines	2	-1.14	0.990	-1.04	0.994
	Singapore	1	-1.68	0.976	-1.61	0.978
	Thailand	4	-1.99	0.968	-2.05	0.971

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

TABLE 3
LAG LENGTH TESTS
July 1, 1998 through December 31, 2002

Panel A: Daily Data

	===== Information Criteria =====			=== Likelihood Ratio Tests ===	
	lags	AIC	SBC	comparison	$\chi^2(25)$
Local Currency	10	-48292	-46990	11 vs. 10 lags	1.91
	9	-48313	-47146	10 vs. 9 lags	4.05
	8	-48299	-47261	9 vs. 8 lags	1.89
	7	-48314	-47406	8 vs. 7 lags	9.12
	6	-48336#	-47551	7 vs. 6 lags	8.12
	5	-48328	-47669	6 vs. 5 lags	17.32
	4	-48317	-47784	5 vs. 4 lags	10.24
	3	-48332	-47927	4 vs. 3 lags	8.16
	2	-48324	-48044	3 vs. 2 lags	7.94
	1	-48262	-48110#	2 vs. 1 lag	20.95
U.S. Dollar	10	-47043	-45751	11 vs. 10 lags	2.51
	9	-47046	-45880	10 vs. 9 lags	7.96
	8	-47032	-45993	9 vs. 8 lags	5.63
	7	-47063	-46150	8 vs. 7 lags	2.13
	6	-47080	-46295	7 vs. 6 lags	3.52
	5	-47082#	-46423	6 vs. 5 lags	4.74
	4	-47065	-46534	5 vs. 4 lags	9.05
	3	-47080	-46675	4 vs. 3 lags	3.16
	2	-47074	-46795	3 vs. 2 lags	2.25
	1	-46992	-46840#	2 vs. 1 lag	29.95

Japanese Yen	10	-46641	-45348	11 vs. 10 lags	4.55
	9	-46651	-45485	10 vs. 9 lags	5.97
	8	-46643	-45604	9 vs. 8 lags	7.14
	7	-46670	-45757	8 vs. 7 lags	3.80
	6	-46679	-45893	7 vs. 6 lags	8.06
	5	-46682#	-46023	6 vs. 5 lags	5.09
	4	-46659	-46127	5 vs. 4 lags	9.08
	3	-46670	-46265	4 vs. 3 lags	4.71
	2	-46663	-46385	3 vs. 2 lags	2.18
	1	-46631	-46479#	2 vs. 1 lag	23.07

Panel B: Weekly Data

	===== Information Criteria =====			=== Likelihood Ratio Tests ===	
	lags	AIC	SBC	comparison	$\chi^2(25)$
Local Currency	4	-7779	-7415	5 vs. 4 lags	23.11
	3	-7797	-7521	4 vs. 3 lags	28.46
	2	-7808	-7618	3 vs. 2 lags	36.61*
	1	-7817#	-7714#	2 vs.1 lag	38.48**
U.S. Dollar	4	-7495	-7132	5 vs. 4 lags	25.82
	3	-7516	-7239	4 vs. 3 lags	26.67
	2	-7521	-7331	3 vs. 2 lags	41.31**
	1	-7538#	-7434#	2 vs.1 lag	31.92
Japanese Yen	4	-7424	-7061	5 vs. 4 lags	21.26
	3	-7450	-7173	4 vs. 3 lags	22.53
	2	-7455	-7265	3 vs. 2 lags	41.82**
	1	-7465#	-7362#	2 vs.1 lag	37.72*

# denotes minimum value
*significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

TABLE 4
ANALYSIS OF COINTEGRATION
July 1, 1998 through December 31, 2002
Panel A: Daily Data
VAR with 1 Lag (1 day)

	===== Cointegration Tests =====				========== Cointegrating Vectors (Exclusion Tests) ==========					
Model	H_0	λ_{max}	H_0	λ_{trace}	Indonesia	Malaysia	Philippines	Singapore	Thailand	Constant
Local Currency	r=0	75.19***	r=0	113.03***	1.000 (8.60***)	3.792 (35.16***)	2.012 (9.42***)	-3.452 (25.00***)	-3.768 (52.36***)	
	r=1	18.38	r≧1	37.84						
	r=2	10.03	r≧2	19.46						
	r=3	8.30	r≧3	9.43						
	r=4	1.13	r≧4	1.13						
U.S. Dollar	r=0	74.82***	r=0	107.68***	1.000 (12.37***)	3.199 (41.92***)	1.727 (20.93***)	-3.230 (33.49***)	-3.344 (54.53***)	7.937 (7.94***)
	r=1	12.76	r≧1	32.86						
	r=2	9.97	r≧2	20.09						
	r=3	8.05	r≧3	10.12						
	r=4	2.07	r≧4	2.07						
Japanese Yen	r=0	62.50***	r=0	91.97***	1.000 (15.17***)	2.715 (31.78***)	1.421 (14.59***)	-3.086 (29.74***)	-2.827 (46.31***)	12.965 (10.07***)
	r=1	13.08	r≧1	29.48						
	r=2	8.61	r≧2	16.40						
	r=3	5.12	r≧3	7.79						
	r=4	2.67	r≧4	2.67						

VAR with 5 Lags (5 days)

	===== Cointegration Tests =====				========== Cointegrating Vectors (Exclusion Tests) ==========					
Model	H_0	λ_{max}	H_0	λ_{trace}	Indonesia	Malaysia	Philippines	Singapore	Thailand	Constant
Local Currency	r=0	66.62***	r=0	102.30***	1.000 (8.89***)	3.581 (29.57***)	1.994 (9.42***)	-3.431 (23.95***)	-3.752 (48.20***)	
	r=1	17.80	r≧1	35.68						
	r=2	9.09	r≧2	17.88						
	r=3	8.01	r≧3	8.79						
	r=4	0.78	r≧4	0.78						
U.S. Dollar	r=0	59.90***	r=0	94.13***	1.000 (13.03***)	2.671 (28.35***)	1.500 (16.00***)	-2.903 (27.59***)	-3.116 (44.75***)	8.941 (10.67***)
	r=1	13.95	r≧1	34.23						
	r=2	9.92	r≧2	20.28						
	r=3	7.97	r≧3	10.36						
	r=4	2.39	r≧4	2.39						
Japanese Yen	r=0	53.17***	r=0	83.28***	1.000 (13.75***)	2.548 (24.37***)	1.429 (13.18***)	-3.141 (27.48***)	-2.851 (39.56***)	15.189 (12.57***)
	r=1	13.39	r≧1	30.11						
	r=2	7.81	r≧2	16.72						
	r=3	6.10	r≧3	8.91						
	r=4	2.81	r≧4	2.81						

Panel B: Weekly Data

VAR with 1 Lag (1 week)

	===== Cointegration Tests =====				========== Cointegrating Vectors (Exclusion Tests) ==========					
Model	H_0	λ_{max}	H_0	λ_{trace}	Indonesia	Malaysia	Philippines	Singapore	Thailand	Constant
Local Currency	r=0	78.57***	r=0	118.75***	1.000 (8.45***)	3.995 (36.81***)	2.337 (12.15***)	-3.769 (28.57***)	-4.161 (56.98***)	
	r=1	21.20	r≧1	40.17						
	r=2	10.10	r≧2	18.97						
	r=3	8.18	r≧3	8.87						
	r=4	0.70	r≧4	0.70						
U.S. Dollar	r=0	74.08***	r=0	110.09***	1.000 (13.36***)	3.015 (38.88***)	1.753 (22.63***)	-3.192 (35.16***)	-3.396 (55.43***)	8.684 (10.28***)
	r=1	15.13	r≧1	36.00						
	r=2	9.98	r≧2	20.87						
	r=3	8.78	r≧3	10.89						
	r=4	2.11	r≧4	2.11						
Japanese Yen	r=0	63.80***	r=0	95.03***	1.000 (14.10***)	2.905 (32.96***)	1.698 (18.87***)	-3.434 (33.82***)	-3.132 (48.22***)	14.607 (11.78***)
	r=1	14.08	r≧1	31.23						
	r=2	7.93	r≧2	17.15						
	r=3	6.44	r≧3	9.22						
	r=4	2.78	r≧4	2.78						

VAR with 2 Lags (2 weeks)

	===== Cointegration Tests =====				========== Cointegrating Vectors (Exclusion Tests) ==========					
Model	H_0	λ_{max}	H_0	λ_{trace}	Indonesia	Malaysia	Philippines	Singapore	Thailand	Constant
Local Currency	r=0	50.86***	r=0	87.15***	1.000 (8.70***)	3.150 (20.31***)	1.762 (7.13***)	-3.103 (18.56***)	-3.310 (31.91***)	
	r=1	18.73	r≧1	36.29						
	r=2	10.14	r≧2	17.56						
	r=3	7.10	r≧3	7.41						
	r=4	0.32	r≧4	0.32						
U.S. Dollar	r=0	52.79***	r=0	89.71***	1.000 (14.72***)	2.428 (24.25***)	1.315 (13.44***)	-2.671 (25.71***)	-2.839 (36.24***)	8.848 (11.67***)
	r=1	15.84	r≧1	36.92						
	r=2	11.52	r≧2	21.08						
	r=3	7.52	r≧3	9.57						
	r=4	2.05	r≧4	2.05						
Japanese Yen	r=0	47.77***	r=0	79.77**	1.000 (15.58***)	2.289 (20.85***)	1.218 (10.21***)	-2.836 (24.24***)	-2.603 (33.03***)	14.548 (12.73***)
	r=1	14.73	r≧1	32.00						
	r=2	8.72	r≧2	17.27						
	r=3	6.24	r≧3	8.55						
	r=4	2.30	r≧4	2.30						

VAR with 3 Lags (3 weeks)

	===== Cointegration Tests =====				========== Cointegrating Vectors (Exclusion Tests) ==========					
Model	H_0	λ_{max}	H_0	λ_{trace}	Indonesia	Malaysia	Philippines	Singapore	Thailand	Constant
Local Currency	r=0	49.09***	r=0	92.17***	1.000 (5.70**)	4.010 (19.50***)	2.436 (8.96***)	-3.945 (18.52***)	-3.945 (25.51***)	
	r=1	23.43	r≧1	43.08						
	r=2	12.17	r≧2	19.65						
	r=3	7.28	r≧3	7.48						
	r=4	0.20	r≧4	0.20						
U.S. Dollar	r=0	44.94***	r=0	82.62**	1.000 (8.83***)	3.041 (21.14***)	1.769 (14.37***)	-3.332 (22.80***)	-3.229 (24.57***)	8.856 (7.18***)
	r=1	18.72	r≧1	37.68						
	r=2	10.50	r≧2	18.96						
	r=3	6.64	r≧3	8.46						
	r=4	1.81	r≧4	1.81						
Japanese Yen	r=0	42.22***	r=0	76.04**	1.000 (6.72***)	3.774 (22.46***)	2.310 (15.85***)	-4.339 (24.63***)	-3.604 (22.92***)	13.863 (4.82**)
	r=1	17.01	r≧1	33.82						
	r=2	8.30	r≧2	16.81						
	r=3	6.73	r≧3	8.51						
	r=4	1.78	r≧4	1.78						

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level