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Stock Market Integration Measurement: Investigation of Malaysia and Singapore Stock Markets

B.K. Yeoh, Z. Arsad and C.W. Hooy

***Abstract*—**This paper tests the level of market integration between Malaysia and Singapore stock markets with the world market. Kalman Filter (KF) methodology is used on the International Capital Asset Pricing Model (ICAPM) and the pricing errors estimated within the framework of ICAPM are used as a measure of market integration or segmentation. The advantage of the KF technique is that it allows for time-varying coefficients in estimating ICAPM and hence able to capture the varying degree of market integration. Empirical results show clear evidence of varying degree of market integration for both case of Malaysia and Singapore. Furthermore, the results show that the changes in the level of market integration are found to coincide with certain economic events that have taken placed. The findings certainly provide evidence on the practicability of the KF technique to estimate stock markets integration. In the comparison between Malaysia and Singapore stock market, the result shows that the trends of the market integration indices for Malaysia and Singapore look similar through time but the magnitude is notably different with the Malaysia stock market showing greater degree of market integration. Finally, significant evidence of varying degree of market integration shows the inappropriate use of OLS in estimating the level of market integration.

***Keywords*—**ICAPM, Kalman filter, Stock market integration

I. Introduction

GLOBAL financial integration has increased substantially in the recent decades. In the aftermath of the Bretton Woods era, globalization has manifested itself among the developed countries in the growth of cross border capital flow. This has promoted to the emergence of global financial centers (US, UK, and Tokyo) in the 1980s. In response to the reduction of many trade and financial barriers and restrictions, financial integration subsequently spread to the emerging markets in the early 1990s. Singapore is one of the early beneficiaries with Malaysia receiving the benefits not long after.

Malaysia stock market had gained fast momentum of globalization due to fact that Malaysia is a small but open economy. Before 1990s, Malaysia stock market remained relatively small in terms of market capitalization. Due to the country's successful industrial transformation in the late 1980s, Malaysia economy experienced tremendous growth in the early 1990s. Since then, Malaysia stock market has grown tremendously thanks to many financial liberalization policies that was aims to attract foreign capital in promoting further growth. On the other hand, the Singapore government has been actively undertaking financial liberalization and reforms since 1970s. The focus of financial liberalization in Singapore was to develop the financial sector as the main engine of growth. Singapore has shown a remarkable success as a regional financial centre and the financial services has become a substantial portion of the country's GDP. The Malaysia and Singapore stock markets have a long history dating back to 1930s. In 1960, the Malayan Stock Exchange was set up to serve what is now Malaysia and Singapore. In 1965, when Singapore split from Malaysia, the stock exchange continued to operate as one under the name Stock Exchange of Malaysia and Singapore (SEMS). In 1973, the agreement that allowed for the convertibility at par between the two currencies was terminated. This led to the separation of SEMS into the Kuala Lumpur Stock Exchange (KLSE) and the Stock Exchange of Singapore (SES).

The statistics in Table I show that Malaysia and Singapore stock market experienced high growth in terms of market capitalization and trading value since 1988. By comparing the statistics for 1990 and 1996 (before 97/98 Asian financial crisis), the market capitalization and trading value have changed 639% and 1664% respectively for Malaysia and 446.77% and 285.95% respectively for Singapore. Given that Malaysia was one of the hardest hit countries in the 97/98

TABLE I STATISTICS FOR MALAYSIA AND SINGAPORE STOCK MARKETS

Year	Malaysia		
	Number of listed companies	Market capitalization (US$ billion)	Trading value (US$ billion)
1990	271	47.87	10.70
1996	618	306.17	178.01
1998	731	95.56	26.84
2007	986	325.29	169.72
2008	976	189.09	93.78
Year	Singapore		
	Number of listed companies	Market capitalization (US$ billion)	Trading value (US$ billion)
1990	172	34.27	21.07
1996	296	153.11	60.25
1998	358	94.47	58.51
2007	762	539.18	381.29
2008	767	264.97	259.89

(Source: World Federation of Exchanges, http://www.world-exchanges.org/statistics)

Asian financial crisis, the market capitalization and the trading value for Malaysia stock market showed a dramatic

decrease. Singapore was not spared from this crisis but the deterioration of the stock market is much lesser than Malaysia. It can be observed that in 2007, the performance of Malaysia stock market was about the same as pre Asian crisis period with an obvious increase in the number of listed companies. However, the Singapore stock market showed a tremendous growth in this period. The performances of Malaysia and Singapore markets are affected by the current global financial crisis in 2008. Both markets show dramatic decrease in the values compared to previous year. It can be noticed that the Singapore has surpassed Malaysia since 1998 in both market capitalization and trading value. It is also worth to highlight that there were 312 foreign companies listed in Singapore in year 2008 while there were only 4 foreign companies listed in Malaysia in the same year.

This study is motivated by a few reasons. First, it is interesting to compare the integration level of Malaysia and Singapore stock markets with the world market due to the history of these two stock markets. Second, most studies that test the inter-relationships between stock markets examine market correlation, long-run cointegration or volatility transmission and then infer indirectly the stock market integration hypothesis. These approaches do not really comply with the definition of market integration as implied by Bekert and Harvey [1]. Third, a weakness of cointegration studies is that a focus on comparative statics does not consider the time-varying nature of equity risk premium. This paper employing Kalman Filter (KF) methodology allows time-varying coefficients of the models and hence able to investigate the varying degree of Malaysian stock market integration with the world. Lastly, although some empirical papers have documented that international stock market integration changes over time, those papers do not explain whether the varying degree of integration can be explained by the economic events. The current paper not only estimated the time-varying market integration, but also attempts to link the economics event take placed with the level of integration to confirm the practicability of the KF approach in studying stock markets integration.

The rest of the paper is organized along the following lines. In Section 2, a brief review is provided on the issues related to stock markets integration worldwide and the approaches of assessing the level of integration in the literature. Section 3 presents the model, the methodology and the data used in this study. The estimation results are presented in Section 4 and Section 5 concludes with the main findings.

II. Literature Review

Bekaert and Harvey [1] point out that a market is completely integrated with the world if its assets have the same expected return with the assets with identical risk level listed in major global market. In an integrated world, the cross section reward to risk is not important as it is common to all integrated markets. However, the reward to risk is different for a segmented market due to different risk exposure for each country. In other words, the law of one price can definitely work as the behavior of stock market integration. The nature and extent of financial market integration thus is prominent for investors as it influences international asset allocation potential and portfolio diversification decision.

The issue of inter-relationships among international stock markets has been examined extensively using different measures and methodologies. In the literature, there are two board categories of financial integration measures, that is, price-based measures and quantity-based measures.[1] Price-based measure is more desirable for regulators and researchers as they prefer to refer to indicators which are quantitatively available. Under price-based measure, cointegration analysis is nowadays the standard methods to examine the long-run relationships among different equity indices. By definition, cointegrated markets exhibit common stochastic trends and in turn limit the amount of independent variation between these markets and limited the diversification opportunities.[2] However, cointegration analysis fails to take into account that convergence is a gradual and on-going process. It only tests for convergence over the whole period under consideration rather than investigating the degree of convergence has been increased lately than earlier. Rangvid [10] takes the effort to detect time-varying cointegration using recursive method, but Pascual [11] points out that the increasing convergence shown by Rangvid [10] may be due to increasing sample size over time. Pascual [11] suggests conducting rolling cointegration test with a fixed sample size and report no evidence of increasing cointegration among the markets.

Another line of literature focuses on the linkages of international market indices. This includes testing on the correlation, lead-lag and volatility transmission between markets. However, most of the efforts in this area focus on static integration. Only a few studies have discussed more on the dynamics of integration across time. Among these, Fraser *et al*. [12] and Manning [13] imply the methodology proposed by Haldane and Hall [14] for measuring convergence of European equity markets. In testing for integration, an external market (to which the markets under study are assumed to be converging) and a dominant local market need to be identified. The principle of this approach is that the coefficient of the model should tend to zero if convergence with local market has occurred. Bekaert and Harvey [1] was perhaps the first to explicitly model time variation in expected stock returns induced by changing covariance with a single world factor. They employ a conditional regime-switching model to assess the degree of capital market integration over time. The results suggest that a number of countries have time-varying integration but there is no overwhelming evidence pointing to increase integration after the developing

[1] See Adam *et al* [2] and Baele *et al*. [3] for detail survey on the literature of market integration research.

[2] Kasa [4] is one of the pioneers in using Johansen [5] multivariate technique to study long-run relationships among the major developed markets, i.e. the US, UK, Japan, Canada and Germany. By using similar methodologies, Chou *et al* [6] found evidence of increased integration in the latter period under study for G7 countries; and Hung and Cheung [7] provide similar findings for Asian markets. On top of that, De Fusco *et al* [8] found no cointegrating vectors exist among emerging markets comprises Korea, Philipines, Taiwan, Malaysia and Thailand over the period 1989-93 and the a weak cointegration result is also highlighted in a later study by Click and Plummer [9]. In short, there is hardly a consensus on market integration from the cointegration approach.

countries relaxed restrictions on foreign equity ownership in the 1990s.

III. Methodology And Data

A. The Measure of Market Integration

The Capital Asset Pricing model (CAPM) due to Sharpe [15] and Lintner [16] has become the standard model in finance. The CAPM postulates a stable linear relationship between the expected excess return and the non-diversifiable risk of holding a financial asset. To test for the hypothesis of stock market integration, the domestic CAPM have been extended to an international setting and a single factor International CAPM (ICAPM) can be written as:

$$R_{i,t} - R_{F,t} = \alpha_i + \beta_i (R_{W,t} - R_{F,t}) + \varepsilon_{i,t} \qquad t = 1, 2, ..., n \qquad (1)$$

where $R_{i,t}$, $R_{F,t}$ and $R_{W,t}$ refer to the returns for the market portfolio, world portfolio and international risk free rate respectively, t represents time period with n sample size, i refers to the stock markets under study and $\varepsilon_{i,t}$ is the residual.

According to Korajczyk [17] and Levine and Zervos [18], if a stock market is perfectly integrated with the world, then the pricing error, α_i in Equation (1) should be equal to zero. Levine and Zervos [18] proposed that the estimates of stock market integration can be represented by the negative of the absolute value of α_i. In other words, the adjusted market integration index can be expressed as:

$$MII_{i,t} = -\left|\hat{\alpha}_i\right|. \qquad (2)$$

The index is designed to be positively correlated with the degree of market integration. The index can take any value with the upper bound equal to zero, with the zero index is interpreted as the stock market is perfectly integrated with the world market.

B. KF Technique for Time-varying Market Integration

Although the Ordinary least square (OLS) estimation of Equation (1) is straightforward, in practice it is not reasonable to allow the level of integration to be constant as the risk is expected to vary over time. By applying KF technique, the time-varying ICAPM and the adjusted time-varying market integration index can now be estimated using the following regression:

$$R_{i,t} - R_{F,t} = \alpha_{i,t} + \beta_{i,t} (R_{W,t} - R_{F,t}) + \varepsilon_{i,t} \qquad (3)$$

$$MII_{i,t} = -\left|\hat{\alpha}_{i,t}\right|. \qquad (4)$$

Pioneered by Kalman [19] and Kalman and Bucy [20], the KF technique has played an important role in the space program and has become an important tool for control engineering analyses.[3] The KF technique can be applied to any model that can be written in the state-space form. A state-space model consists of two equations: a measurement equation and a state equation as given in Equation (5) and Equation (6) respectively.

$$Y_t = \delta' Z_t + \varepsilon_t \qquad (5)$$

$$Z_t = AZ_{t-1} + w_t \qquad (6)$$

The measurement equation describes the relationship between the observed variables, Y_t and the unobserved state variables, Z_t. Meanwhile, the dynamics of Z_t is determined by the state equation and the matrix A can take a few forms representing an autoregressive process of order one. The error terms, ε_t and w_t are assumed to be independently distributed as:

$$\varepsilon_t \sim IID(0, \sigma^2), \quad w_t \sim IID(0, Q) \text{ and } E[\varepsilon_t w_t] = 0 \qquad (7)$$

In this study, Y_t represents the term $(R_{i,t} - R_{F,t})$ in Equation (3), $\delta_t^{'} = [1 \quad R_{W,t} - R_{F,t}]$ is the vector of regressor and Z_t is the parameter vector that contains the intercept and beta coefficient of Equation (3), $Z_t = [\alpha_{i,t} \quad \beta_{i,t}]^T$. Also, in this study, the state equation is assumed to follow a random walk process and therefore A is an identity matrix. Based on the information up to time (t – 1), the best estimate of Z_t denoted as $Z_{t|t-1}$ and its corresponding mean square error (MSE) are given by:

$$Z_{t|t-1} = AZ_{t-1} \qquad (8)$$

$$P_{t|t-1} = AP_{t-1}A' + Q \qquad (9)$$

From Equation (8), the one-step-ahead prediction of the state variables is itself the last known value of the variable multiplies with the transition matrix A. The one-step-ahead prediction error of the measurement, e_t and its MSE, f_t is calculated as:

$$e_t = Y_t - \delta' Z_{t|t-1} \qquad (10)$$

$$f_t = \delta P_{t|t-1} \delta' + \sigma^2 \qquad (11)$$

The e_t contains new information about Z_t beyond that contained in $Z_{t|t-1}$. After observing Y_t, the one-step-ahead of the state variables is adjusted by incorporating the new information available. The updating equations for the estimate of the state variables and its corresponding MSE are given by:

$$Z_t = Z_{t|t-1} + P_{t|t-1} \delta' f_t^{-1} e_t \qquad (12)$$

$$P_t = P_{t|t-1} - P_{t|t-1} \delta' f_t^{-1} \delta P_{t|t-1} \qquad (13)$$

The KF procedure continues by iteratively estimating Equation (8) through to Equation (13).

Under the assumption that ε_t and w_t are normally distributed, the sample log likelihood as below can be used to estimate the unknown parameters of the system equations:

[3] KF is a recursive procedure that progresses through the data and yields a minimum mean-square linear estimate of the state variables as well as a covariance matrix of the estimate at each time *t*.

$$\log L = -\frac{n}{2}\log 2\pi \sum_{t=1}^{n}\log|f_t| - \frac{1}{2}\sum_{t=1}^{n} e_t' f_t^{-1} e_t \qquad (14)$$

The likelihood is evaluated by using the KF estimates and must be maximized with respect to the unknown parameters.

C. Data

The stock returns in this study are computed by using weekly index for Malaysia and Singapore stock market from Morgan Stanley Capital International (MSCI). The MSCI All-Country World Index is used as a proxy for world portfolio and the weekly yields on US-3month Treasury bill rate as international risk free rate. These series are in common currency, that is, the US dollar to alleviate exchange rate noise. The data covers from February 1988 to September 2009. The weekly returns were calculated from Wednesday to Wednesday to avoid any contaminating effects from Mondays and weekends as mentioned by Bartholdy and Peare [21].

IV. Result and Discussion

A. Estimation of Market Integration

The result of estimating Equation (1) by the Ordinary Least Square (OLS) is given in Table II. It can be seen that the intercept term, α is not statistically significant different from zero at 5% level for both Malaysia and Singapore. Thus the result shows that based on the market integration index $(MII = -|\hat{\alpha}|)$, these stock markets are integrated with the world market throughout the sample period from February 1988 to September 2009. However, this time-invariant assumption might be unreasonable as the risk premium of equities is indeed changes over time due to various factors and therefore the degree of market integration should be associated with the time-varying nature.

TABLE II RESULTS FROM ORDINARY LEAST SQUARE ESTIMATION

Parameters		Malaysia	Singapore
α	Coefficient	0.0156 (0.1145)	0.0379 (0.0772)
	t-Statistic	0.1364	0.4905
β	Coefficient	0.6348[1] (0.0528)	0.8677[1] (0.0356)
	t-Statistic	12.0222	24.3712

Note: [1]denotes significance at 5% level, standard errors are given in parentheses

To allow for time-varying coefficient in the ICAPM, the KF approach is employed to examine the time-varying nature of market integration index (MII_t). Fig. 1 plots MII_t for Malaysia together with the confidence intervals that were obtained from OLS estimation. In line with Brooks *et al*. [22] and Hearn [23], the first two years of the estimated MII_t values are excluded from the discussion due to the nature of KF approach that generates estimates with large errors at the initial stages. Exclusion of the first two years of the estimates avoids any bias due to start-up problem. From Fig. 1, it is evident that OLS confidence intervals fail to indicate the presence of strong variations of market integration index as suggested by the state-space model. As it can be seen, some estimates of *MII* do not fall inside the OLS confidence intervals implying that the assumption of constant degree of market integration is statistically unreasonable. This observation suggests that the Malaysia stock market is segmented from the world market during periods such as July 1993-August 1994 and July 1997-July 1999. As a consequence, this finding cast strong doubts on the validity of the time-invariant CAPM and its estimation by OLS that have been applied widely.

B. Dating the Estimated Time-varying Market Integration Series for Malaysia Stock Market

From Fig. 1, it is obvious that the values of *MII* have an increasing trend from year 1990 to 1992. This indicates that Malaysia equity market is more integrated with the world markets over time during this period. In the past, Malaysia has been reluctant to relax foreign ownership restrictions in the financial sector. However, in the late 1980s to 1990, Malaysia government had taken some action to reform the capital markets to increase its competitiveness. The initiations include easing the entry barriers to broking activities of foreign institutions, increasing the number of mutual funds and allowing foreign stock brokerage firms to increase their equity share in local brokerage. On top of that, in March 1991, the government issued 190 million in bonds that are convertible into shares of state owned communications firm. This marked the first placement of a convertible sovereign bond in the international market. These factors may explain the integration of Malaysia equity market with the world market in the early 1990s (Bekaert and Harvey [24]).

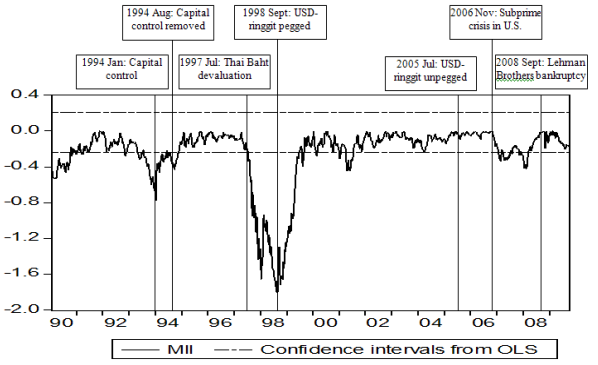

Fig. 1: Time-varying Market Integration Index from Kalman Filter Approach and Confidence Intervals of OLS estimation

Starting from January 1994, Malaysia government has adopted some capital control measures to curb short-term capital inflows. Government announced that residents are prohibited to sell certain kind of Malaysian securities to non-residents. In February 1994, British firms were prevented from participating in public sector contract bidding and residents were prohibited to sell all forms of private debt securities with a remaining maturity of one year or less to non-residents, and the restrictions on the sale of Malaysian

securities to non-residents was extended to both the initial issue of the relevant security and the subsequent secondary market trade. Fig. 1 shows that the *MII* started decreases before the announcement of capital control measures and achieve its lowest when such control was implemented in January 1994.

The restriction on the sale of Malaysian securities was lifted and residents were permitted to sell any local securities to non-residents in August 1994. Furthermore, Malaysian cabinet lifted its seven months ban preventing British firms from participating in public sector contract bidding. As expected, the degree of integration of Malaysia market with the world market has increased after the abolition of capital inflow control. According to the estimated values, Malaysia market is particularly integrated with world market from February 95 to April 97 as the *MII* is close to zero.

The devaluation of Thai Baht on the 2nd July 1997 set off a massive meltdown of the foreign currency markets in the region. The exchange rate crisis has led to the collapse of the stock markets in ASEAN 5, Korea, Japan and Hong Kong. The foreign direct investment (FDI) in Malaysia fell at an alarming rate and the Ringgit has depreciated substantially from MYR 2.50 per USD to much lower level (up to MYR 4.80 per USD at its bottom) as capital flowed out of the country. Although the Asian crisis has spilled over to global market, the extent of vulnerability for the rest of the countries is much lesser as compared to certain Asian countries. This explains why the Malaysia stock market was significantly segmented from the world market from July 97 to August 98. The level of integration of Malaysia to the world market tumbled to the all-time low on August of 1998.

On the 1st September 1998, the exchange rate of the ringgit to US dollar was fixed at 3.8 RM/US$ and a wide range of currency and capital controls were instituted. The capital control measures have contributed to the stock market recovery. Many foreign investors were attracted to Malaysia by the very capital controls although they may once have condemned soon after they were first introduced in September 1998. From the foreign investors' point of view, Malaysia offers a portfolio investment haven relatively sheltered from the volatility of global capital markets. Also, foreigners locked in until 1 September 1999 have withdrawn their funds from the bank which offering low interest rates, to take advantage of the stock market upturn after the great depth of the Malaysia stock market fall in the Asian financial crisis. This clarifies why the *MII* rise sharply after the ringgit pegged against the US dollar.

According to the statistics of Masud *et al.* [25], Malaysia remained as a favorable economy to foreign investors as implied by the FDI position which grew from MYR 129.1 billion in year 2001 to MYR 253.8 billion in year 2007. The continuous reinvestment as well as new capital injection among the existing foreign companies indicated their confidence in the investment climate of Malaysia. Note that the abandonment of fixed exchange rate regime on July 2005 did not have obvious impact on the level of integration. The US market experienced subprime crisis starting at the end of year 2006 and through to year 2007 and the crisis started to spread to the developed European countries. Due to small direct exposures of Malaysian economy to the subprime related markets, the financial market in Malaysia were very much not affected by subprime crisis in the US and this is demonstrated by the segmentation of Malaysia market as shown in Fig. 1; the *MII* in 2007 is slightly lower compare to the previous year.

However, the downside pressures on the US economy and further downturn in the US housing sector has started to develop into a global economic shocks. The rising uncertainty and concern over the problems in the global financial markets and the health of the global economy has led to increase in the volatility in the regional equity markets, particularly towards the end of the year. Starting from January 2008, the increasing value of *MII* towards zero indicates the high degree of integration of Malaysia with the world market. Malaysia as an emerging country is inevitable from this global crisis. This phenomenon is very different from the 97/98 Asian financial crisis, where the Malaysia stock market was obviously segmented from the world market during the crisis.

C. Comparison of the Time-varying Market Integration Index for Malaysia and Singapore Stock Markets

Fig. 2 provides valuable insights and demonstrates the difference in the level of market integration between the Malaysia and Singapore stock markets. It can be seen from Fig. 2 that the trends of the market integration indices for Malaysia and Singapore look similar over time in general but the magnitude is notably different. It can be observed that the magnitude of market integration index for Singapore is much smaller as compared to that for Malaysia. This indicates that Singapore is largely integrated with the world as compared to Malaysia in the sample period. The finding is not a surprise as Singapore is often seen as the only developed country in South East Asia and it is a major financial service hub in the region. Furthermore, according to Phylaktis and Ravazzolo [26], Singapore has started open up the financial market since 1978 while Malaysia liberalized their stock market ten years later; that is in 1988. With these reasons, it is expected that Singapore has a more efficient and mature stock market and the integration level of Singapore is higher as compared to Malaysia.

Fig. 2 illustrates that the market integration indices for Malaysia and Singapore showing a downward trend since May 1997. Statistically and significantly different from zero value of the index implies that Malaysia and Singapore markets were segmented from the world market during the 97/98 Asian crisis. However, the level of segmentation for Singapore was much less pronounced as compared to Malaysia; one of the most severely hit countries in the region. The modest segmentation of Singapore stock market during this crisis period may be due to regional contagion effect rather than the weak fundamentals. Both countries demonstrate increasing trends starting from middle year of 1998 and the *MII* have returned to the pre-crisis level. Noticed that subprime crisis that started in the US has slightly different impact on the *MII* of both countries. Close observation of Fig. 2 shows that the estimated *MII* for Singapore remains to be inside the confidence intervals during the period from the end of 2006 through to the end of 2007. Meanwhile Singapore is

integrated with the world market since the recovery from the 97/98 Asian crisis. In all, Singapore market shows shorter period of segmentation as compared to Malaysia. Perhaps the number of foreign companies listed in the Singapore share market, the role of Singapore as a premier financial centre in Asia, the financial services provided by the Singapore financial sector to international financial institutions and firms doing business in the region have contributed to the differences of market integration between Malaysia and Singapore.

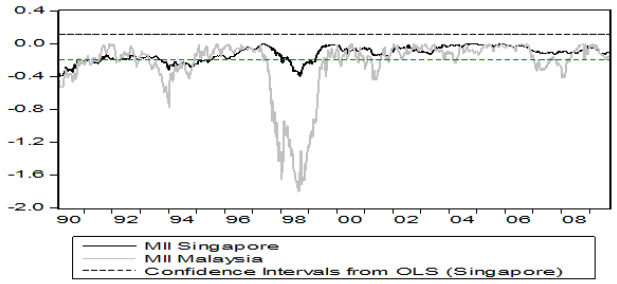

Fig. 2: Time-varying market integration index for Singapore and Malaysia and the confidence intervals of OLS estimation for Singapore

V. Conclusion

This study examines the degree of stock market integration of Malaysia and Singapore stock markets with the world market over the period February 1988 – September 2009. The time-varying KF technique is employed to capture the dynamic degree of stock market integration. Unlike prior studies that only shows the degree of integration among countries tends to change over time, this paper attempt to explain the varying degree of integration with the economic events that have taken place. For Malaysia, the findings generally show that the capital reform and capital control measure that imposed by Malaysia government have affected the level of integration of Malaysia market with the world market. Furthermore, the results show that the Malaysia stock market is segmented from the world market during the 97/98 Asian financial crisis but integrated with the world market during the present global crisis. As compared to Malaysia, Singapore stock market generally shows similar trend of time-varying integration however with notably magnitude.

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