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Stock Market Contagion, Interdependence and Shifts in Relationship due to Financial Crisis – A Survey [1]

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The purpose of this paper is to conduct an extensive review of both theoretical and empirical research that is followed by review of methodologies applied to the issues of market contagion, independence and structural breaks and shifts in relationship due to global crisis. This study captures all the available literature published on the past crises and explores the need for further research on the issues and recommends appropriate methodologies. The research identifies an emerging need to conduct further research on the topic as the very issue is lacking the requisite evidence. This research is also able to propose the most appropriate methodologies for any future research on market contagion and independence. The paper is basically a theoretical approach and as such there is a possibility to consider this as its limitation. But this paper has, indeed, a plenty of implications, especially with regards to the portfolio diversification benefits being hampered amongst developed and emerging markets due to the financial crises. The unique feature of the study includes a large scale and extensive review of the available literature and methodologies on the issue in both developed and emerging markets, The study, in particular, initiates to capture all literatures available and the major financial crises witnessed during the last three decades.

Keywords: Market Contagion, Market Independence, Structural Break, Financial Crisis
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1. Introduction

Leading economists have called the current Global Financial Crisis as the worst ever comparable only with the Great Depression of the 1930s. The staggering crisis contributed to the failure of key businesses, decline in consumer wealth estimated at trillions of U.S. dollars, substantial financial commitments incurred by governments bundled with a significant decline in economic activity. Many causes have been outlined, with varying weight assigned respectively by different experts. Both the market-based and regulatory solutions have been implemented or are under

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consideration, while significant risks remain for the world economy. The collapse of a global housing market, which peaked in the U.S. in 2006, caused the values of securities tied to housing prices to plummet thereafter, damaging financial institutions globally. Questions regarding bank solvency, declines in credit availability and decaying investor confidence had an obvious impact on global stock markets, which suffered a large amount of losses during 2008-2009. Economies worldwide slowed down in late 2008 and early 2009 as credit tightened and the international trade declined. Critics argue that credit rating agencies and investors failed to accurately price the risk involved with mortgage-related financial products and governments also did not adjust their regulatory practices to address the 21st century financial markets. Financial crises are characterized by the sudden and simultaneous materialization of risks that in times of tranquility were believed to be independent (Mink and Mierau-2009). The opportunities for risk spreading are diminished when they are needed in time of crisis, which can pose a substantial threat to the stability of the international financial system. This break-down of risk spreading opportunities in times of stock market crashes has induced investors to fear that during financial crises shift-contagion occurs, which Allen and Gale (2001), and Rigobon (2002) and Pericoli and Sbracia (2003) define as a shift in the strength of the transmission of shocks from one country's stock market to that of the other.

Market contagion and co-integration/co-movement are the issues of enormous interest in finance literature related to financial crisis and its responses to the market. Dornbush, Park and Classens (2000) adopt the definition of contagion as being the dissemination of market disturbances, most of the time with negative consequences, from one market to another. Pritsker (2001) also defines contagion as the occurrence of a shock in one or more markets, countries or institutions that spread to other markets, countries or institutions. Masson (1998-1999), Masson and Mussa (1995), Calvo and Reinhart (1996), Forbes and Rigobon (2002), Pesaran and Pick (2003), Dornbush et al. (2000), Pritsker (2001), Pericoli and Sbracia (2001) and Corsetti et al. (2003), however, assert that an excessive increase in correlation occurs between the country causing the crisis and all other countries where contagion prevails. Bekaert, Harvey, and Ng (2005) have also identified contagion in equity markets. It refers to the notion that markets move more closely together during periods of crisis. Co-integration, on the other hand, refers to the case that the linear combination of two non-stationary time series generates a stationary time series. The co-integration might mean the existence of a long-term economic equilibrium and indirectly implies that the two time series move in the same direction. Financial markets are closely linked means the crisis will spread contributing to contagion in financial markets in one hand and global portfolio diversification benefits to investors reduces significantly on the other. It is important that co-integration allows departures from equilibrium in short-run but seldom in the long-run.

The current paper brings together the previous empirical and theoretical evidence and reviews methodologies applied in the previous studies on major global events in 1987, 1997-98 Asian crisis, Russia-Mexican Currency Crises and 9/11 market crash in 2001. It contributes to the existing literature by summarizing extensive theoretical and empirical reviews on the major global events, that also helps identify the gap between theory and evidence. This research also provides with the summary of methodologies used in the previous research on contagion and co-integration and proposes future research with more appropriate research method. Rest of the paper is designed as: section II contains overviews of the previous empirical and theoretical evidence on the area of market contagion, co-integration and financial crisis; Methodologies applied in previous research on market co-integration and contagion during crisis including variables are reported in section III; and section IV indicates the implications and direction to future research; while the concluding remarks is registered in section V.

2. Review of Theoretical and Empirical Evidence

2.1 Contagion in Financial Markets

Nowadays, a vast literature on the alternative definitions of contagion is available and the majority of the existing literature asserts that an increase in correlation or high volatility occurs with the advent of contagion. The fundamental variables in individual countries have largely failed to provide an explanation for the frequent international spread of shocks. Many researchers turn to King and Wadhwani's (1990) notion of market contagion They have defined contagion as a significant increase in correlation coefficients across global financial markets. The World Bank's definition of contagion is also similar to the above definitions. It says, “contagion exists when cross-country correlations increase during crisis times relative to correlations during peaceful times.” Therefore, it is clear that contagion is associated with an increase in correlation expected by some interdependence pattern, i.e., contagion would be linked to `an excessive increase' in correlations between the country that is causing the crisis and all other countries. On the other hand, contagion is also defined as the spread of disturbances from a default country to all other countries those are already amidst a bad financial situation like crisis.

We suppose that the following linear relationship exists between two countries so far as the asset returns is concerned in `calm periods':

$$r_i = \beta_1 r_j + \varepsilon_i \text{........(1)}$$

The level of correlation between the returns of country i and j is given by:

$$corr(r_i r_j) = \left(1 + \frac{\text{var}(\varepsilon_i)}{\beta_1^2 \text{ var}(r_j)}\right) \text{.......(2)}$$

The level of correlation of the returns of assets i and j are positively related to the variance of asset j. The point is to be noted that such result was obtained by postulating a fixed structure for the transmission of volatility. Thus, the increase in correlation in crisis periods may be associated only with some conventional transmission mechanism rather than with contagion. Dungey et al. (2004) use the following model for the hypothesis of pre-crisis (no-contagion) for the asset returns under analysis:

$x_{i,t} = \lambda_i w_t + \delta_i u_{i,t \ldots\ldots (3)}$

Where, $x_{i,t}$ = the returns of asset market i during a non-crisis period, i=1,2,3, w_t = common shocks to all markets and ~ (0, 1), λ_i = loadings of common shock for market i, i=1,2,3, $u_{i,t}$ = shock specific for market i and ~ (0,1), δ_i =loadings for shock specific for market i. The market specific shocks are independent across markets and the common shocks are independent from every market specific shock. In this case:

$E(x_{i,t}x_{j,t}) = E(\lambda_i w_t + \delta_i u_{i,t})(\lambda_j w_t + \delta_j u_{j,t})$

$= E(\lambda_i w_t \lambda_j w_t + \lambda_i w_t \delta_j u_{j,t} + \lambda_j w_t \delta_i u_{i,t} + \delta_i u_{i,t} \delta_j u_{j,t})$

$= \lambda_i \lambda_j E(w_t^2) + \lambda_i \delta_j E(w_t) E(u_{j,t}) + \lambda_j \delta_i E(w_t) E(u_{i,t}) + \delta_i \delta_j E(u_{i,t}) E(u_{j,t})$

$= \lambda_i \lambda_j \cdot 1 + \lambda_i \delta_j \cdot 0 \cdot 0 + \delta_i \delta_j \cdot 0 \cdot 0 = \lambda_i \lambda_j$, $\forall\, i \neq j$ ……..(4)

In the same way:

$E(x_{i,t})^2 = \lambda_i^2 + \delta_i^2$, $\forall\, i \ldots\ldots (5)$

But the situation is different in case of crisis notation, i.e., contagion disseminates from market 1 to market 2 or from country 1 to country 2. This notation can be explained as:

$y_{1,t} = \lambda_1 w_t + \delta_1 u_{1,t}$

$y_{2,t} = \lambda_2 w_t + \delta_2 u_{2,t} + \gamma u_{1,t}$

$y_{3,t} = \lambda_3 w_t + \delta_3 u_{3,t \ldots\ldots (6)}$

The difference in covariance between market 1 and market 2 is

$E(y_{1,t}y_{2,t}) - E(x_{1,t}x_{2,t}) = \lambda_1 \lambda_2 + \gamma\delta_1 - \lambda_1 \lambda_2 = \gamma\delta_{1 \ldots\ldots (7)}$

And the difference between variances between market 2 before and in crisis is

$E(y_{2,t})^2 - E(x_{2,t})^2 = \lambda^2 + \delta^2 + \gamma^2 - \lambda^2 + \delta^2 = \gamma^2 \ldots\ldots (8)$

This is a notation of a γ impact from local market1 to local market 2. The significance of the variable can be tested through a hypothesis test, H_0: $\gamma = 0$.

However, let us explain how it works for multichannel contagion for 3 markets. In case of crisis notation, how contagion disseminates cross markets:

$y_{1,t} = \lambda_1 w_t + \delta_1 u_{1,t} + \gamma_{1,2} u_{2,t} + \gamma_{1,3} u_{3,t}$

$y_{2,t} = \lambda_2 w_t + \delta_2 u_{2,t} + \gamma_{2,1} u_{1,t} + \gamma_{2,3} u_{3,t}$

$y_{3,t} = \lambda_3 w_t + \delta_3 u_{3,t} + \gamma_{3,1} u_{1,t} + \gamma_{3,2} u_{2,t}$ ……..(9)

If the multichannel with structural breaks assumption adds, what differs from above is that the loadings of market specific shocks are allowed to change. They have a poor notation in the article but we will not deviate from it with a view to avoiding a messy situation. The notation will be:

$y_{1,t} = \lambda_1 w_t + \delta_{y,1} u_{1,t} + \gamma_{1,2} u_{2,t} + \gamma_{1,3} u_{3,t}$

$y_{2,t} = \lambda_2 w_t + \delta_{y,2} u_{2,t} + \gamma_{2,1} u_{1,t} + \gamma_{2,3} u_{3,t}$

$y_{3,t} = \lambda_3 w_t + \delta_{y,3} u_{3,t} + \gamma_{3,1} u_{1,t} + \gamma_{3,2} u_{2,t}$ …….(10)

If an analyst gets such information before the crises, it is possible to test the contagion hypothesis by comparing the structure of correlations between periods. In particular, contagion has the effect of causing a structural shift during the crisis period in the conditional covariance $\delta_1 \gamma \sigma_{1t}^2$ and in the conditional variance $\gamma^2 \sigma_{1t}^2$ (Dungey et al., 2004).

Despite relatively extensive empirical literature on contagion in equity markets, the empirical results are divergent. Baig and Goldfajn (1998) investigated contagion effect due to Asian currency crisis in Thailand, Malaysia, Indonesia, South Korea and the Philippines and they have evidenced the presence of contagion between equity and currency markets. Baig and Goldfajn (2000) have also examined whether there was contagion during the Russian crisis with regard to Brazil and they have concluded that contagion occurred and that the mechanism of propagation was the debt securities market. They have also noted the sudden halt in capital flows to Brazil and to Russia. Forbes and Rigobon (2002) have analysed the contagion effect of the Asian and Mexican crises and the 1987 crash of the New York Stock Exchange on the equity markets of emerging and developed countries but they have concluded that most of the changes were due to interdependence. Corsetti, Pericoli and Sbracia (2005) have tested the contagion effect between Hong Kong and Ten emerging and the G7 countries. The evidence suggests that in at least 5 of the 17 countries, there were evidence of contagion.

Rigobon (2003) has tested contagion during Mexican, Asian and Russian crises. For the Mexican crisis, the mechanism for the transmission of crises remained relatively constant, providing evidence of interdependence. At the same time, for the Russian crisis, and especially for the Asian crisis, there was evidence of a structural breakdown. Caporale, Sipolini and Spagnolo (2003), in line with Rigobon (2003), have also concluded that there was evidence of contagion during the Asian crisis. At the same time, Billio, Lo Duca and Pellizzon (2003), the Asian crisis was unable to handle contagion testing due to the inadequate procedure of testing. Longin and Solnik (2001) have identified that the correlations increased during crises but not during periods of tranquility. Bae, Karolyi and Stulz (2003) have noted a few points about their findings as: contagion was more serious in Latin America than in Asia; contagion from Latin America to other regions was more important than that originating in Asia; the United States was not contaminated by the Asian crisis and contagion is predictable subject to prior information. Boschi (2005) has analyzed contagion effects between Argentina with Brazil, Venezuela, Uruguay, Mexico and Russia but he is unable to provide evidence of contagion. Collins and Gavron (2005), however, have conducted 44 events of contagion in 42 countries and found that the Brazilian and Argentinean crisis generated most of the contagion events. Their results suggest that “more incidences of contagion were not significantly recorded within the trade blocs of the crisis countries as opposed to countries outside those trade blocks. Rather the most vulnerable countries to contagion are the smaller, less mature in other areas. (...) This suggests that regional and trade links do not necessarily predispose a country to experiencing contagion from its neighbors.”

Sola, Spagnolo and Spagnolo (2002) have tested for contagion effects on emerging market currency crisis and they have found evidence of contagion from South Korean crisis to Thailand but not for Brazil. Hon, Strauss and Yong (2006) have tested whether the terrorist attack in the US on September 11, 2001, resulted in contagion financial markets and their results indicate that international stock markets, particularly in Europe, responded closely to United States stock market shocks in the three to six months after the crisis than before. Alper and Yilmaz (2004) have presented an empirical analysis of real stock return volatility contagion from emerging markets and they have produced the evidence of volatility contagion from the financial centers, especially in the aftermath of the Asian Crisis to the Istanbul Stock Exchange. Khalid and Kawai (2003) have investigated the inter-linkages among different markets and different countries within the Asian region but they have failed to find any evidence strongly supporting for contagion.

Kawai and Khalid (2001) have analyzed the financial market contagion across regions during ‘‘Tequila Crisis,’’ ‘‘Asian Crisis,’’ and ‘‘Russian Crisis.’’ Specifically, they have analysed the impact of the collapse of Thai baht on the financial markets in Latin America or Europe, besides Asia. Ferna´ndez-Izquierdo and Lafuente (2004) examine the dynamic linkages between international stock market volatility during the Asian crisis in 12 relevant stock exchanges at an international level: Argentina, Chile, Germany, Hong Kong, Italy, Japan, Mexico, Singapore, South Korea, Spain, the United Kingdom, and the United States. In particular, they focus on the contagion hypothesis around the world and their empirical results tend to support the contagion hypothesis, i.e., significant leverage effects are due, not only to negative shocks in the market area itself, but also to foreign negative shocks. Bekaert, Harvey and Ng (2005) have produced no evidence of contagion caused by the Mexican crisis. They, however, find economically meaningful increases in residual correlation, especially in Asia, during the Asian crisis. Dungey and Martin (2001), using a different methodology, find similar results for Asia and explore the role of currency risk in equity market contagion. Using correlation analysis, Lee and Kim (1993) find evidence of contagion in global stock markets after the 1987 U.S. stock market crash.

2.2 Cointegration in Financial Markets

Co-integration/co-movement refers to the case that the linear combination of two non-stationary time series generates a stationary time series. The co-integration might mean the existence of a long-term economic equilibrium and indirectly implies that the two time series move in the same direction. Engle and Granger (1987) argue that if there is a co-integration between two time series, the Granger causality model can be mis-specified and this requires a proper error correction. Lee and Jeon (1992) argue that the existence of a co-integration implies a common stochastic trend between the two markets. Stock markets that are co-integrated have a long-term relationship, so long-run correlations of returns are higher than short-run correlations (Kasa, 1992). Rangvid (2001) points this out by proposing that an increasing number of co-integrating relationships indicates that stock markets become more integrated over time because they are being increasingly driven by the same common stochastic trends.

Previous researchers have investigated capital market co-movement (Wheatley, 1988; Gultekin, Gultekin, and Penati, 1989), equity market co-movements and lead/lag relationships (Grubel and Fadner, 1971; Agmon, 1972; Ripley, 1973; Panton, Lessig, and Joy, 1976; Hilliard, 1979; Shiller, 1989; Hamao, Masulis, and Ng, 1990; Eun and Shim, 1989), and international diversification (Meric and Meric, 1989). This literature has generally supported low correlations among national stock indices, segmented international equity markets, and possible gains through international diversification.

Numerous studies support low correlation between national stock markets and are often presented as evidence supporting the benefit of global portfolio diversification [see DeFusco, Geppert, and Tesetsekos (1996), Levy and Sarnat (1970), Meric and Meric (1989) & Watson (1978)]. Events of global importance tend to have a significant impact on the world's stock markets. Empirical studies show that the co-movement patterns of national stock markets change significantly after major economic events like crises. Malliaris and Urrutia (1992) have demonstrated in this regard that co-movement or co-integration among stock markets of other countries has drastically increased during the crisis. Arshanapalli and Doukas (1993), McInish and Lau (1993), and Meric and Meric (1997) compare the pre-October-1987 and post-October-1987 periods and demonstrate that the correlation between national stock markets increased and global portfolio diversification benefits to investors decreased significantly after the 1987 crash. Hon, Strauss, and Yong (2006) suggest that the benefits of international diversification in times of crisis are substantially diminished. They have also found evidence that major global events like crisis can lead to a change in the cross-country correlation of assets. Khalid and Rajaguru (2006) notes that linkages and/or interdependence amongst financial markets increase because of financial crisis. Ang and Bekaert (2001) and Longin and Solnik (2001) show that cross-correlations of international equity markets are higher in periods of volatile markets and that be true for the major events like financial crisis. Yang, Kolari, and Min (2002) have examined both long-run relationship and short-run dynamics among the U.S., Japanese, and ten Asian stock markets, with particular attention to the 1997-1998 Asian financial crisis and the empirical results reveal that long-run co-integration relationships among these markets were strengthened during the crisis and that these markets have been more integrated after the crisis than before.

Click and Plummer (2005) investigate post-Asian crisis in ASEAN-5 markets over 1998-2002 and the empirical results in this paper demonstrate that the ASEAN-5 stock markets in the period after the Asian financial crisis are co-integrated whether analyzed using daily data or weekly data, and whether analyzed in local currencies, the US dollar, or the Japanese yen but the stock markets are thus not completely segmented by national borders. Wong, Agrawal, and Du (2005) investigate long-term equilibrium relationship and short-term dynamic linkage between Indian market and major developed markets and they conclude that Indian market is integrated with mature markets and sensitive to the dynamics in these markets in a long-run. Indian and mature stock indices form fractionally co-integrated relationship in the long-run with a common fractional, non-stationary component and find that the Johansen method is the best to reveal the co-integration relationship. Cheung and Ng (1992) investigate the dynamic properties of stock returns in Tokyo and New York and find the US market to be an important global factor from January 1985 to December 1989. Lee and Kim (1994) examine the effect of the October 1987 crash and conclude that national stock markets become more interrelated after the crash and find the co-movement among national stock markets to be stronger when the US market is volatile.

Ripley (1973), Lessard (1976), and Hilliard (1979) generally find low correlations between national stock markets, supporting the benefits of international diversification. Eun and Shim (1989) find evidence of co-movements between the US market and other world equity markets. Jeon and Von-Furstenberg (1990) show that the degree of international co-movement in stock price indices has increased significantly since the 1987 crash. However, Koop (1994) reports no common trends in stock prices across countries. Corhay et al (1995) study the stock markets of Australia, Japan, Hong Kong, New Zealand and Singapore and find no evidence of a single stochastic trend for these countries.

Lim, Brooks, and Kim (2008) investigates the effects of the 1997 financial crisis on the efficiency of eight Asian stock markets on a country-by-country basis, the results demonstrate that the crisis adversely affected the efficiency of most Asian stock markets, with Hong Kong being the hardest hit, followed by the Philippines, Malaysia, Singapore, Thailand and Korea. However, most of these markets recovered in the post-crisis period in terms of improved market efficiency. Given that the evidence of nonlinear serial dependencies indicates equilibrium deviation resulted from external shocks, the present findings of higher inefficiency during the crisis are not surprising as in the chaotic financial environment, when investors would overreact not only to local news, but also to news originating in the other markets, especially when the news events are adverse.

Roll (1988) notes that international equity market co-movements are typically low, but that during the October 1987 crash all major world stock markets declined simultaneously. Roll shows that a country's beta was the most significant factor in determining the extent of the decline. Using daily data for the years 1986-1989, Lau and McInish (1996) extends previous work in several ways. The question of whether the increased level of international equity market co-movements identified by Roll continued in the post-crash period is examined. In addition, changes in the lead/lag structure of international equity market co-movements between the pre- and post-crash periods are investigated. Previous work using weekly and monthly data typically has failed to find significant lead/lag relationships between international equity markets (e.g., Granger and Morgenstern, 1970; Agmon, 1972; and Branch, 1974). Cross-correlations among returns for various international equity markets have implications for international investment since high correlations reduce the benefits of international diversification. The evidence presented indicates that the responses of world equity markets are becoming more closely linked and that this process accelerated at the time of the October 1987 crash. Arshanapalli, Dukas and Lang (1995) have found the presence of a common stochastic trend between US and Asian stock market movements during post October 1987. Co-integration structure that ties these (US and Asia) markets together and that has increased substantially since October 1987.

Kolari and Min (2003) examines both the long-run relationship and short-run dynamics among the U.S., Japanese, and ten Asian stock markets, with attention in particular to the 1997-1998 Asian financial crisis. Extending related empirical studies, comparative analyses of pre-crisis, crisis, and post-crisis periods are conducted to comprehensively evaluate how stock market integration is affected by financial crises. The empirical results reveal that long-run cointegration relationships among these markets were strengthened during the crisis and that these markets have been more integrated after the crisis than before the it. Their findings for the U.S. and Japanese stock markets' impact on emerging Asian markets agree with the previous studies (e.g., Masih and Masih, 1999; Bessler and Yang, 2003) on the roles of these two markets in the international stock markets. The U.S. substantially influenced the Asian markets in all three sample periods but was almost unaffected by the Asian markets. Conversely, Japan has little or no influence on the Asian markets except during the financial crisis. Moreover, empirical evidence indicates that Japan, Taiwan and the Philippines are fairly isolated markets, which is consistent with Dekker, Sen, and Young (2001), among others. Unlike prior studies Janakiramanan and Lamba (1998), Ghosh, Saidi, and Johnson (1999), and Dekker, Sen, and Young (2001) find that Indonesia and Thailand are integrated with several other Asian markets during non-crisis periods, rather than being isolated markets. Korea, India and Pakistan appear to be fairly endogenous and the important implication of these findings is that the degree of integration among countries tends to change over time, especially around periods marked by financial crises.

As Bekaert and Harvey (1995) have noted, previous research assumes that stock markets are either perfectly integrated, perfectly segmented, or partially integrated but the extent of integration is constant over time. Based on evidence gathered from regime-switching models, Bekaert and Harvey (1995) showed that this assumption does not hold. Extending their proposition to the case of the Asian financial crises, they also find that Asian stock market integration can be time variant. Nevertheless, Hon, Stauss and Yong, (2004) report that international stock markets, particularly in Europe, responded closely to United States stock market shocks in the three to six months after the crisis than before. Their evidence suggests that the benefits of international diversification in times of crisis are substantially diminished.

3. Review of Methodologies

3.1 Contagion in Financial Markets

Current studies on contagion offer many methods for measuring the propagation of international shocks across countries. Some of the more widely used processes include the cross-market correlation coefficient procedures (e.g., King and Wadhwani 1990), analysis with a co-integrating vector between markets (e.g., Longin and Solnik 1995), probit-logit models (e.g., Eichengreen, Rose, and Wyplosz 1996), and autoregressive conditional heteroskedasticity (ARCH) or GARCH models (e.g., Hamao, Masulis, and Ng 1990). Goldstein, Kaminsky, and Reinhart (2000) and Forbes and Rigobon (2002) survey other prevailing contagion procedures.

Corsetti, Pericoli and Sbracia (2005) use a factor model to estimate equity returns during the Asian crisis, checking the relationship between returns from the Hong Kong stock exchange, and the stock markets for 10 emerging countries and the G7 countries. Igobon (2003) applies the dynamic correlation model (DCC) to the countries involved in the Mexican, Asian and Russian crises. At the same time, Billio, Lo Duca and Pellizzon (2003) analyse the Asian crisis by applying the determinant test for the change in Rigobon (2003) covariance matrix, conclude that this procedure is not adequate for detecting contagion, since there is a rejection of stability when there is a change in the parameter or a violation of the hypothesis of heteroscedasticity and there is a loss of power of the test when several markets or countries are analyzed.

Longin and Solnik (2001) used the theory of extreme values to model the multivariate distribution of tails of distributions of returns for the period 1958-1996 using monthly data. They observe that negatively correlated returns above a certain level did not converge to zero with an increase in this level and that the hypothesis of multivariate normality of the same was not verified. The contrary occurred with positive correlations, i.e. these tended to zero with an increase in the level and had a normal multivariate distribution. This implies that correlations increased during crises but not during periods of tranquility. Bae, Karolyi and Stulz (2003) use the theory of extreme values to analyse contagion, since the phenomenon is non-linear. Boschi (2005) analyzed contagion effects between Argentina with Brazil, Venezuela, Uruguay, Mexico and Russia. The author analyzes exchange rates, stocks and bonds. The econometric methodology consisted in estimating a VAR and then analyzing the instant correlation coefficient corrected for heteroscedasticity as suggested by Forbes and Rigobon (2002). They contend that to gain an accurate measure of contagion, the calculated correlation coefficients must be adjusted for the presence of heteroskedasticity between samples.

Collins and Gavron (2005) used the VAR methodology to model the stocks returns with US T-bill rate as an exogenous variable in the system. Sola, Spagnolo and Spagnolo (2002) estimate a Markov switching model in volatility to test for contagion effects. Nagayasu (2000) uses VAR approach to test Granger causality between exchange rate and stock indices. Nevertheless, the empirical results using higher-frequency and lower-frequency data could be changed substantially. Actually, to compare whether lower-frequency data contains less noise and relatively more information to estimate a long-run relationship and vice versa, we put forward the brief picture of a number of significant studies in the table below:

Table 1: Summary of Methodologies Used in major Studies on Contagion

Author and Year	Event Captured	Data Type	Variables	Methods
1.Alper and Yilmaz, 2004	Asian Crisis	Daily market indices from 1992-201for Turkey	Stock returns, volatility and contagion	unconditional volatility estimates, LS Rolling Regression, ARCH and GARCH
2. Fernandez-Izquierdo and Lafuente, 2004	Asian Crisis	Daily market indices from 1997-2001 for 12 Asian Markets	Stock market returns, Variables found from factor analysis	SUR, PCM and Factor analysis, ARCH, Lagrange Multiplier, Volatility transmission with GARCH , ML-estimation, Ljung Box test
3.King and Wadhwani, 1990	1987 Crisis	Hourly data from 1987-1988 for New York, London, and Tokyo	Percentage return and change in price	Contagion Modeling
4. Khalid and Kawai, 2003	Asian Crisis	Daily data from 1997-1998 for nine countries	Exchange rates, Stock price indices and Interest rates	Correlation coefficients, Unit root tests with ADF and PP, VAR model, Granger causality, Cholesky decomposition
5. Khalil and Gulasekaran, 2003	Asian Crisis	Daily data from 1994-2002 for 10 Asian and Pacfic Countries	Exchange rates	Augmented Dickey Fuller (unit root test), GARCH-MGARCH-BEKK, VAR, Granger causality test, Fractional Vector Error Correction Model (FVECM), and Autoregressive Fractionally Integrated Moving Average ARFIMA
6. Bekaert and Harvey, 2005	1987 and Asian Crisis	Data from 1980-1998 for 22 countries including Asia, Europe, and Latin America.	Equity indices, dividend yield, exports-imports, and size of trade	CAPM, GARCH, Likelihood ratio test, and Walds test
7. Tai and Jones, 2007	Asian Crisis	Monthly Dollar denominated return indices, local bilateral spot exchange rates from 19080-2001 for Asian and Pacific Countries.	rate of return of local stock market index, rate of appreciation(depreciation), conditional covariance	ICAPM under the absence of PPP, MGARCH model called BEKK model, QML - quasi-maximum likelihood estimation
8. Yoon, 2005	Computer Simulation	5000 simuationas for 1100 days	returns	STUR
9. Forbes and Rigobon, 2002	1987 crash And Asian Crisis	Russian, Mexican and Latin American Currency Crises and data from 10 largest markets.	Stock market returns Short term interest rates	VAR
10. Longstaff, 2008	Subprime Credit Crisis	Weekly data from 2006-2007	on-the-run ABX index, Treasury yields, percentage changes in the size of the commercial paper market, the ratio of the aggregate weekly trading volume	VAR
11. Essaadi, Jouini, and Khallouli, 2009	Asian Crisis	Return of stock indices from 1995-1999 for Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand.	Stock Index Returns	AR, GARCH
12. Chiang, Jeon, and Li, 2007	Asian Crisis	Daily stock-price indices from 1990-2003 for eight Asian countries	Stock returns	multivariate GARCH DCC-GARCH

3.2 Co-integration in Financial Markets

Results from earlier empirical studies vary depending on the methodology used. Most early research on international co-movements in financial markets focuses on correlations in cross-country returns (Agmon 1972). Masih and Masih (1999) uses VECM approach to test the causality. Technique of multivariate cointegration has been used extensively to study financial market integration around the world (Kasa, 1992; and Richards, 1995). Lim, Brooks, and Kim (2008) investigate the effects of the 1997 financial crisis on the efficiency of eight Asian stock markets, applying the rolling bi-correlation test statistics for the three sub-periods of pre-crisis, crisis and post-crisis.

Cointegrating vector is a big issue in cointegration analysis. Click and Plummer (2005) have noted only one cointegrating vector among the five stock markets, leaving behind four common trends among the five variables. Corhay, Taurani Rad, and Urbain (1993) have examined integration in five European stock markets over 1975-1991 and ended in finding only one cointegrating vector. Chung and Liu (1994) have studied on the US and five East Asian markets over 1985-1992 and found two cointegration relationship. However, Chen, Firth, and Rui (2002) have studied the integration amongst Argentina, Brazil, Chile, Colobia, Mexico, and Venezuela over 1995-2000 and found just one cointegrating vector. Chung and Liu (1994), have investigated the U.S., Japan, Taiwan, Hong Kong, Singapore, and South Korea. Using weekly data denominated in local currencies over the period 1/7/85–5/18/92, they find 1, 2, and 4 cointegrating vectors in models with 12, 24, and 36 lags, respectively. Masih and Masih (1999) conclude that there is at most one cointegrating vector. Dekker, Sen, and Young (2001) have studied 10-variable VARs to examine linkages among US, 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 US 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) have studied a nine-variable VAR to examine the linkages among US, Japan, and seven Asian stock markets including Malaysia, the 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 have found that markets appear to be more integrated after the crisis than before, and that Asian markets are most heavily influenced by the United States 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 United States and Japan after the crisis, which can be attributed to the influence 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.

Studies that have estimated short-run dynamic causal linkages seek to better understand the propagation mechanism driving stock market fluctuations in different countries, especially with respect to market crashes (Masih and Masih, 1997, 1999; Ghosh, Saidi, and Johnson, 1999; Sheng and Tu, 2000). These and other related studies (Chung and Liu, 1994; Arshanapalli, Doukas, and Lang, 1995; Cheung, 1997;

Janakiramanan and Lamba, 1998; Dekker, Sen, and Young, 2001) employ vector autoregressive (VAR) techniques, including cointegration, Granger Causality, impulse response analysis, and forecast error variance decomposition. In general, the empirical evidence presented in these studies is mixed with respect to both long-run relationships and short-run dynamic causal linkages. To have a general picture of the methodologies applied in co-movement/co-integration studies, we have summarized a number of significant studies on this area shown in the table below:

Table 2: Summary of Methodologies Used in major Studies on Cointegration

Author and Year	Event Captured	Data Type	Variables	Methods
1.Arshanapalli and Doukas, 1993	1987 Crash	Daily data from Wall Street Journal from 1980-1990 for US	Stock Market Indices	Unit root, DF, and ADF
2.Arshanapalli and Doukas and L. Lang, 1995	1987 Crash	Daily data from 1986-1992 for Asian Pacific Counties	Indices	PP test, Johansen Test
3.Byers and Peel, 1993	1987 Crash	Monthly indices from 1979-1989 for UK, US, Germany, Japan, and Netherlands	Log of Monthly Indices	PP, VAR (Unrestricted), Cointegration Tests, Granger Causality
4.Chan, Gup and Pan, 1997	1987 Crash	Monthly price indices from 1961-1992 for EU, UK, Noth America, and Asian Pacific	Log of Stock Indices	Unit Root, PP, VAR, Johansen Multivariate
5.DeFusco, Geppert and Tsetsekos, 1996	Post-1987 Crash	Weekly Indices from 1989-1993 for 13 emerging markets	Stock indices	PP, VAR, Johansen Multivariate
6.Gerrits, and Yuce, 1999	Post 1987 Crash	Daily price index from 1990-1994 for UK, Germany, Netherlands, and US	Stock Indices	Granger Causality, Cointegration test
7.Gilmore and McManus, 2002	Asian Crisis and 9/11	Weekly indices from 1995-2001 for Central Europen and US	Stock Indices	ADF, PP, VAR (Johansen)
8. Hung and Cheung, 1995	1987 Crash	Weekly indices from 1981-1991 for five Asian Pacific Countries	Stock Indices	Johansen Cointegration, VECM,
9. Jang and Sul, 2002	Asian Crisis	Market indices from 1996-2000 for five Asian Markets	Stock Indices	Granger Causality, Cointegration test, ADF, VECM
10. Kanas, 1998	1987 and Asian Crisis	Daily Indices from 1983-1996 for UK, US, and	Stock Indices	ADF, Cointegration (Philips and Ouliarris), Johansen, Bierens' Test (nonparametric test for cointegration).
11. Meric and Meric, 1997	1987 Crash	Monthly equity market indiuces from 1981-1994 for 12 European markets	Equity Indices	Box's M statistic, and Principal Component analysis
12. Lau, and McInish, 1993	1987 Crash	Daily Market indices from 1986-1989 for 10 Major Global Equity Markets	Log of Market Indices	Box M, ARIMA, and Correlation analysis
13. Meric, Leal, Ratner, and Meric, 2001	1987 crash	Daily market indices from 1987-1994 for 4 Latin American Equity Markets	Market Index	Box M test, Principal Component analysis, Minimum variance portfolio, and Correlation analysis
14. Longin and Solnik, 2001	1987 Crash	Monthly Equity Indices from 1959-1996 for US, UK, France, Germany, and Japan	Index Returns	Conditional Pareto distribution
15. Patev, Kanaryan, and Lyroudi, 2006	Asian Crisis	Daily US dollar return from 1996-2001 for Central and East European Countries	US Dollar Return	Augmented Dickey–Fuller, Phillips–Perron test, Johansen co-integration test, Granger-causality tests, and VAR
16. Yang, Kolari, and Min, 2003	Asian Crisis	Daily Stock Indices from 1995-2001 for 10 Asian Emerging markets	Stock Indices	VAR
17. Longin and Solnik, 1995	1987 Crash	Monthly data from 1960-1990 for seven major markets	Asset returns, Excess returns, Dividend yield, and Short-term interest rate	GARCH and CCC-GARCH
18. Hamao, Masulis and Ng, 1990	1987 Crash	Daily and intraday stock-price activity from 1985-1988 for three stock markets	conditional mean returns and conditional variances	autocorrelation and autoregression, ARCH, and GARCH
19. Click and Plummer, 2005	Asian Crisis	Daily and weekly stock index in local currencies from 1998-2002 for ASEAN markets	Cointegration vector consisting of the stock indices and currency	Cointegration models with differing lags, Unit root tests - Augmented Dickey-Fuller and Phillips-Perron tests, Lag length tests with

4. Implications and Directions to Future Research:

4.1 Implications

A large proportion of the now extensive empirical body of literature is surrounded by these and related issues of stock market dynamics employing times series techniques can be broadly classified under two groups.

One group follows the prescription provided by Kasa (1992) involving multivariate co-integration techniques to examine the number of common stochastic trends in a system of national stock market prices. This provides insights into how integrated markets have become and the popular intuitive notion of whether or not stock markets share long-run relationships over time. Indeed, such interest has provoked a number of studies like Chung and Liu (1994) and Corhay et al. (1995) on Pacific-Rim country stock markets, Blackman et al. (1994) on 17 OECD markets, Jeon and von Furstenberg (1990) and Kwan et al. (1995) on major world equity markets.

The second group has attempted to investigate lead–lag relationships among prices of national stock markets (e.g., Eun and Shim, 1989; Cheung and Mak, 1992; Malliaris and Urrutia, 1992; Arshanapalli and Doukas, 1993; Smith et al., 1993; Brocato, 1994; Chowdhury, 1994) but has employed, due to data limitations or methodological drawbacks, simple bivariate lead–lag relationships among two markets, or standard Granger F-tests in a VAR framework which are only useful in capturing short-run temporal causality (Granger, 1986; Masih and Masih, 1998). While examinations of bivariate relationships may provide additional insight, they are not entirely useful for purposes of policy and serve at best as a pre-requisite for a more thorough analysis of relationships amongst stock market indices in a multivariate setting.

In fact, even those studies that have employed a multivariate framework (for example, Mathur and Subrahmanyam, 1990) on linkages between Nordic and US stock markets have done so using ordinary first-difference VARs, are not taking into account any presence of long-run relationships inherent in the multivariate system. Recent important methodological studies by Toda and Phillips (1993) and King et al. (1994) have shown that in the presence of co-integration, VARs must be augmented by constraints via error-correction mechanisms which account for any long-term information essentially lost through differencing.

This paper has conducted an extensive theoretical research on market contagion and co-integration/co-movement in the financial markets in the developed and developing economies due to major financial events like crisis, which has huge implications with regards to the portfolio diversification benefits hampered amongst developed and emerging markets.

4.2 Direction to Future Research

Several studies have been conducted on contagion, co-integration and co-movement on the previous crises like 1987, Asian and Latin American Currency Crisis, Rissian and

Mexican Currency Crises and 9/11 crash but no study, what so ever, is well recognized on the current global crisis, which is the most severe in terms of its long lasting consequences since the Great depression; therefore, it is proposed to pursue further studies on the recent global finaical crisis. The major issues should be research are: contagion, structural shift/break due to crisis and co-movement/co-integration to explore its potential impact on the global portfolio diversification. The research methodologies could be proposed on these areas as below:

4.2.1 Contagion Modeling

The existence of contagion must involve evidence of a dynamic increment in correlations. The multivariate GARCH model proposed by Engle (2002), which is used to estimate dynamic conditional correlations (DCC) in this paper, has three advantages over other estimation methods. Firstly, the DCC-GARCH model estimates correlation coefficients of the standardized residuals and thus accounts for heteroskedasticity directly. Secondly, the model allows us to include additional explanatory variables in the mean equation to ensure that the model is well specified. In this connection, we include the U.S. stock returns as an exogenous global factor, rather than using the source of contagion (e.g., stock returns in Sweden) as an independent variable. Thirdly, the multivariate GARCH model can be used to examine multiple asset returns without adding too many parameters. The parsimonious parameter setting permits us to deal with up to 45 pair-wise correlation coefficient series in a single representation. The resulting estimates of time-varying correlation coefficients provide us with dynamic trajectories of correlation behavior for national stock-index returns in a multivariate setting. This information enables us to analyze the correlation behavior when there are multiple regime shifts in response to shocks, crises and credit rating changes.

To start with, we specify the return equation as:

$$r_t = \gamma_0 + \gamma_1 r_{t-1} + \gamma_2 r_{t-1}^{US} + \varepsilon_t$$

$$\text{where } \mathrm{r_t} = (r_{1,t}, r_{2,t}, ...r_{n,t}),\ \varepsilon_{\mathrm{t}} = (\varepsilon_{1,t}, \varepsilon_{2,t}, ...\varepsilon_{n,t}) \text{ and } \varepsilon_{\mathrm{t}} \big| \Im_{t-1} \approx N(0, \mathrm{H}_t) ....(11)$$

Following the conventional approach, an AR(1) term and the one-day lagged U.S. stock return are included in the mean equation. The lagged U.S. stock returns have often been used to account for a global factor (Dungey, et al., 2003). The inclusion of the lagged U.S. stock returns is also based on the empirical finding that U.S. stock returns play an important role in determining stock returns in other countries and that other countries stock returns have no significant dynamic effect on the U.S. stock returns. Next, we specify a multivariate conditional variance as:

$$\mathrm{H}_t = D_t R_t D_t ......(12)$$

where D_t is the (nxn) diagonal matrix of time-varying standard deviations from univariate GARCH models with $\sqrt{h_{ii,t}}$ on the i^{th} diagonal, i = 1,2,...,n; R_t is the (nxn) time-varying correlation matrix. The DCC model proposed by Engle (2002) involves two-stage estimation of the conditional covariance matrix H_t. In the first stage, univariate volatility models are fitted for each of the stock returns and estimates of $\sqrt{h_{ii,t}}$ are obtained. In the second stage, stock return residuals are transformed by their estimated standard deviations from the first stage. That is, $u_{i,t} = \varepsilon_{i,t} / \sqrt{h_{ii,t}}$ **,** where $u_{i,t}$ is then used to estimate the parameters of the conditional correlation. The evolution of the correlation in the DCC model is given by:

$$Q_t = (1-\alpha-\beta)\overline{Q} + \alpha u_{t-1}u'_{t-1} + \beta Q_{t-1}.........(13)$$

where Q_t is given by: $q_{ij,t} = (1-\alpha-\beta)\overline{\rho}_{ij} + \alpha u_{i,t-1}u_{j,t-1} + \beta q_{ij,t-1}$ and $\overline{\rho}_{ij}$ is the unconditional correlations of $u_{i,t}u_{jt}$.

α and β are nonnegative scalar parameters satisfying (α + β) < 1. Since Qt does not generally have ones on the diagonal, we scale it to obtain a proper correlation matrix R_t .

$$R_t = (\mathrm{diag}(Q_t))^{-1/2} Q_t (\mathrm{diag}(Q_t))^{-1/2}$$

$$\text{where } (\mathrm{diag}(Q_t))^{-1/2} = diag\left(\frac{1}{\sqrt{q_{11,t}}}........\frac{1}{\sqrt{q_{nn,t}}}\right)......(14)$$

Now R_t in equation (4) is a correlation matrix with ones on the diagonal and off-diagonal elements less than one in absolute value, as long as Q_t is positive definite. A typical element of R_t is of the form:

$$\rho_{ij,t} = q_{ij,t} \Big/ \sqrt{q_{ii,t}q_{jj,t}}$$

$$i, j = 1,2,.....n. \text{ but } i \neq j.......(15)$$

Expressing the correlation coefficient in a bivariate case, we have:

$$\rho_{12,t} = \frac{(1-\alpha-\beta)\overline{q}_{12} + \alpha u_{1,t-1}u_{2,t-1} + \beta q_{12,t-1}}{\sqrt{[(1-\alpha-\beta)\overline{q}_{11} + \alpha u_{1,t-1}^2 + \beta q_{11,t-1}]}\sqrt{[(1-\alpha-\beta)\overline{q}_{22} + \alpha u_{2,t-1}^2 + \beta q_{22,t-1}]}}.....(16)$$

As proposed by Engle (2002), the DCC model can be estimated by using a two-stage approach to maximizing the log-likelihood function. Let θ denote the parameters in D_t, and φ the parameters in R_t, then the log likelihood fund is:

$$\iota_t(\theta,\phi) = \left[-\frac{1}{2}\sum_{t=1}^{T}(n\log(2\pi) + \log\left|D_t\right|^2 + \varepsilon_t D_t^{-2}\varepsilon_t\right] + \left[-\frac{1}{2}\sum_{t=1}^{T}(\log\left|R_t\right| + u'_t R_t^{-1}u_t - u'_t u_t\right].....(17)$$

The first part of the likelihood function in Equation (7) is volatility, which is the sum of individual GARCH likelihoods. The log-likelihood function can be maximized in the first stage over the parameters in D_t. Given the estimated parameters in the first stage, the correlation component of the likelihood function in the second stage (the second part of Equation 7) can be maximized to estimate correlation coefficients.

4.2.2 Detecting Structural Breaks in Cross-market Co-movement

Let $y_t = \beta x_t^T + \varepsilon_t$ where $t = 1,\ldots,n$ and $y_t = \frac{q_{ij,t}}{\sqrt{q_{ii,t} q_{jj,t}}}$ for a certain pair where ε_t are (0,σ^2).

The regression structure will produce $y_t = \beta_0 + \beta_1 \cdot y_{t-1} + \varepsilon_t \ldots (18)$

If there are m breaks at time points $(n_1, \ldots n_m)$ finding those is the same as finding the set of time- points that minimizes $RSS_n(n_1,\ldots,n_m)$ which give the lowest value of the Bayesian Information Criteria the BIC which is[1]: $BIC = \frac{RSS}{\sigma^2} + k \cdot \ln g$ where k are the number of regressors including the constant and g is the number of data points in the sample. Also the n is the number of regressions performed. m that gives the lowest BIC is chosen.

4.2.2.1 Detecting Structural Break using IO Model:

Estimating the timing of the break endogenously using Innovational Outlier (IO) model as:

1) IO1 version of the model that allows for gradual change in the intercept only:

$$y_t = \mu + \theta DU_t + \beta t + \delta D(T_b)_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t \ldots (19)$$

Where, DU_t is the intercept dummy (=1 when $t > T_b$), $D(T_b)_t$ is the crash dummy ($D(T_b)_t$ =1 if t=Tb+1 and zero otherwise)

2) IO2 version of the model allows for gradual change in both the intercept and the slope of the trend function, as follows:

$$y_t = \mu + \theta DU_t + \beta t + \gamma DT_t + \delta D(T_b)_t + \alpha y_{t-1} + \sum_{i=1}^{K} c_i \Delta y_{t-i} + \varepsilon_t \ldots (20)$$

Where, DT_t is the slope dummy ($DT_t = T_t$ t > T_b and zero elsewhere). Three different methods in estimating the break date: a) minimizing the value of the t statistic for testing α =1, b) maximizing the absolute value of the t statistic on the break parameters associated with a change in either the intercept (| t_θ |) or the slope (| t_γ |), and c) minimizing the value of the t statistic on the break parameters associated with the change in either the intercept (|t_θ |) or the slope (| t_γ |).

K, is determined using the data-dependent method proposed by Ng and Perron (1995). The optimum k (or k*) is selected such that the coefficient on the last lag in an autoregression of order k* is significant and that the last coefficient in an auto-regression of order greater than k* is insignificant

4.2.2.2 Detecting Structural Break Using AO Model
First, the series is detrended by regressing it on the trend components (including constant, time-trend and dummy break

$$y_t = \mu + \beta t + \gamma DT_t^* + \tilde{y}_t \; \ldots .(21)$$

The second step uses the following regression, without trend function, to the residual of the first step in order to test for a change in the slope coefficient:

$$\tilde{y}_t = \alpha \tilde{y}_{t-1} + \sum_{i=1}^{K} c_i \Delta y_{t-i} + \varepsilon t \; \ldots .(22)$$

The null hypothesis is rejected if the t-statistic for α is larger in absolute value than the corresponding critical value. An alternative, which is more widely used, is to select T_b as the value over all possible break dates that minimizes (or maximizes) the value of the t-statistic on γ=0

4.2.3 Modeling Co-integration

This section describes the proposed research methods for long-term and short-term co-movements of international markets during a global event like financial crisis:

4.2.3.1 Long Run Co-movement of International Markets

Granger (1986) and Engle and Granger (1987) introduce the concept of co-integration. Co-integration is a property possessed by some non-stationary time series. If two non-stationary time series are co-integrated, there exists a linear combination relationship, which is stationary. Co-integration allows for departures from equilibrium in the short-run but not in the long run. Co-integration implies that national stock market indexes have a long-run relationship. Thus it limits the benefit of international portfolio diversification.

The multivariate test for co-integration and the vector error correction model are developed by Johansen (1988, 1991) and Johansen and Juselius (1990, 1991). The Johansen procedure extends the Engle-Granger test for co-integration for a multivariate framework. Their procedure has the advantage of taking into account the error structure of the underlying process. It can incorporate different short and long run dynamics of a system of economic variables. It enables us to estimate and test the equilibrium relationship among non-stationary series while abstracting from short-term deviations from equilibrium. Thus, it provides us with relatively powerful tests when the model is correctly specified**.** The proposed vector autoregressive model with Gaussian errors is:

$$X_t = \beta_1 X_{t-1} + \cdots \ldots + \beta_k X_{t-k} + \alpha + \theta_t \qquad t = 1, \ldots \ldots \ldots, T \ldots \ldots \ldots (23)$$

where X_t is a nx1 vector of stochastic variables ; all X_{t-1} are predetermined; α is a nx1 vector of constant, θ_t is a vector of normal distributed error with zero mean and constant variance; and k is the maximum number of lag length processing the white noise.

In order to distinguish between stationarity by linear combinations of the variables and differencing of equation (1), the system is rewritten as:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots\ldots + \Gamma_k \Delta X_{t-k} + \Pi X_{t-1} + \mu + \varepsilon_t \; \ldots\ldots\ldots\ldots (24)$$

or

$$\Delta X_t = \sum_{i=1}^{k} \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \mu + \varepsilon_t \; \ldots\ldots (25)$$

In equation 3, the long-run information of the co-movement of the stock markets in the X_t process is summarized by the long-run impact matrix, Π. The number of co-integrating vectors is determined by the rank of this matrix. If the matrix Π has rank r, then there are r co-integrating relationships among the elements of X_t . When r=0, there is no long-run relationship amongst international markets and equation would be reduced to a vector autoregressive model (VAR) of the first difference.

The number of co-integrating relationships is given by the number of non-zero eigenvalues. Their significance can be tested with a sequence of likelihood ratio (LR) tests of which limiting distribution is expressed in terms of vector Brownian motions (see Johansen (1988, 1991)). The trace statistics is used to test the hypothesis of the existence of r co-integrating vectors. The LR test statistic for the hypothesis that there are at most r co-integrating vectors is given by:

$$Tr = -T \sum_{i=r+1}^{n} ln(1 - \lambda_i) \; \ldots\ldots\ldots (26)$$

where T is the sample size, n is the number of variables in the system and the eigenvalues of matrix Π are real numbers λ such that 0 ≤ λ <1. In the equation 4 the estimates of these eigenvalues are ordered so that $\hat{\lambda}_1 > \hat{\lambda}_2 > \cdots \ldots > \hat{\lambda}_n$ so the Tr statistic decreases as r increases.

4.2.3.2 Short Run Dynamic Co-movement of International Markets

We also propose to use a Vector Auto Regressive (VAR) model to investigate whether international markets behave like a single, integrated regional market. The VAR is suitable for the analysis of dynamic linkages among markets because it identifies the main channels of interactions and detects the response of a given market to shocks in other markets. Each variable in VAR is treated as endogenous and is regressed on lagged values of all variables in the system. Shachmurove (1996) applies the following VAR specification analysing dynamic co-movement of Latin American stock markets:

$$Y(t) = C + \sum_{s=1}^{L} A(s).Y(t-s) + e(t) \dots \dots (27)$$

where Y (t) is an nx1 vector of daily returns of stock markets, C is an nx1 vector of constants, A (s) is nxn matrices of coefficients, and e (t) is nx1 column-vector of forecast errors. The model assumes that e (t) is uncorrelated with all past values of Y(t). The i,j-th component of A (s) measures the direct effect that a change in the return of the j-th market would have on the i-th market in time periods.

To select appropriate lag length, following Thaneepanichskul (2001), we can start from 15 lags and then reduce them to 10 lags, 5 lags, 2 lags, and 1 lag. We choose the optimal lag length on the basis of Akaike information criterion (AIC). Most studies investigating the linkages among stock markets use Granger causality test. It determines whether a particular market is affected by innovations in other markets. The advantage of this test is that it is unaffected by the ordering of the VAR system. Granger test requires stationary data, so we apply both tests for unit root Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test.

Unit Root Test: To ensure the robustness of the test results, the more commonly used unit-root tests, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) will be conducted.

$Y_t = \rho Y_{t-1} + e_t$ ....(28)

(autoregressive with $\rho = 1$, also called unit root, or integrated of order 1 [I(1)]).

Variance decomposition is used to analyse the impact of innovations in a particular market on other markets. Variance decomposition of the forecast errors of the returns of a given market indicates the relative importance of the various markets in causing fluctuations in returns of that market. Variance decomposition allocates the variance of the forecast error into percentages that are accounted for by innovations in all market's own innovations. Variance decomposition is sensitive to the assumed origin of the shock and to the order in which it is transmitted to other markets. In this paper, the US stock market is ordered prior to the international stock markets since we assume that shocks to global markets have a strong impact on the international stock markets.

We propose to analyse the residuals daily returns correlation for a VAR. The residuals daily returns represent the component of the returns, which is not explained by the past returns of all stock markets. The correlation coefficients indicate the extent of shared responses of all markets to new information in one market. Eun and Shim (1989) and Shachmurove (1996, 2001) use the correlations of residuals daily returns as an indicator for portfolio diversification since they measure the degree to which new information produces an abnormal return in one market

5. Conclusion

We have outlined the results of numerous studies on several financial crises witnessed around the world during the last two decades. The study extensively reviews the theoretical, empirical and methodological aspects of the crises. Three aspects of financial crises namely contagion, co-integration and co-movement are the center of our attention. These aspects are of immense interests, since they concern themselves with i) how and to what extent financial markets impact one another and ii) the benefit of investment diversification.

We have identified a vast literature on the alternative definitions of contagion and many researchers turn to King and Wadhwani's (1990) notion of market contagion, where they define contagion as a significant increase in correlation coefficients across global financial markets. We also find that empirical results on contagion are mixed; out of the crises, included in this study, stock market crises in the US appear to be the only one where contagion is identified with any degree of significance. Co-integration/ co-movement refers to the case that the linear combination of two non-stationary time series generates a stationary time series. We find that results from earlier empirical studies vary depending on the methodology used. The most early research on international co-movements in financial markets, focused on correlations in cross-country returns and techniques of multivariate co-integration, has been used extensively to study financial market integration.

Thus, this research captures five major financial crises in the past and aims at serving as a reference for future researchers on the current and future global financial crises. We identify gaps between theory and evidence as well as areas well researched and under-researched. This paper helps to identify the proposed empirical research areas. From a methodological perspective, the study has identified the common and the most appropriate methods alike on contagion, co-movement and structural break. As a normative contribution for global portfolio investors, this study has highlighted diminishing diversification benefits in time of crisis which may be of tremendous help in setting up strategies of portfolio diversification in times of crisis. The paper is basically a theoretical paper, which focuses on the existing research on market contagion modeling and suggests the methods to be tested on the financial market data; therefore, this, indeed, is considered to be the limitation of the paper because one can say that the model is a valid model until it is tested with the real market data. Finally, conducting an empirical study in applying the proposed models could be recommended for further research.

References

Agmon, T 1972, ‘The relations among equity markets: A study of share price co-movements in the United States, United Kingdom, Germany and Japan,’ *Journal of Finance*, vol. 27, pp. 839-855.

Allen, F & Gale, D 2001, ‘Financial contagion,’ *Journal of Political Economy*, vol. 108, pp. 1-33.

Alper, CE, & Yilmaz, K 2004, 'Volatility and contagion: Evidence from the Istanbul Stock Exchange,' *Economic Systems,* vol. 28, pp. 353-367

Ang A, & Bekaert, G 2001, 'Stock return predictability: Is it there?,' *Review of Financial Studies*, vol. 20, no. 3, pp.651-707.

Ang, A, & Bekaert, G 2002, 'International asset allocation with regime shifts,' *Review of Financial Studies,* vol. 15, no. 4, pp. 1137–87.

Arouri, ME, Bellalah, M and Nguyen, DK 2008, 'The co-movement in international stock markets: New evidence from Latin American Emerging Countries,' *ISC Paris School of Management Working Paper No. halshs-00202943*.

Arshanapalli, B & Doukas, J 1993, 'International stock market linkages: evidence from the pre- and post-October 1987 period,' *Journal of Banking and Finance*, vol. 17, pp. 193–208

Arshanapalli, B, Doukas, J & Lang, L 1995, 'Pre and post-October 1987 stock market linkages between U.S. and Asian markets,' *Pacific-basin Finance Journal,* vol. 3, pp. 57-73.

Bae, KG, Karolyi, and Stulz, R 2003, 'A new approach to measuring financial contagion,' *The Review of Financial Studies*, vol. 16, pp. 717-763.

Baig, T & Goldfajn, I 1999, 'Financial market contagion in the Asian crisis', *IMF Staff Papers, International Monetary Fund,* vol. 46, no. 2, pp. 167–195.

Baig, T & Goldfajn, I 2000, 'The Russian default and the contagion to Brazil', *IMF Working Paper WP/00/160.*

Bekaert, G & Harvey, CR 1995, 'Time-varying world market integration', *Journal of Finance*, vol. 50, pp. 403–44

Bekaert, Harvey & Ng, V 2005, 'Market integration and contagion', *Journal of Business*, vol, 78, no. 1, pp. 39-69.

Bessler, DA & Yang, J 2003, 'The structure of interdependence in international stock markets', *Journal of International Money and Finance*, vol. 22.

Billio, M & Pelizzon, L 2003, 'Contagion and interdependence in stock markets: have they been misdiagnosed?', *Journal of Economics and Business,* vol. 55, pp. 405-426.

Branch, B 1974, 'Common stock performance and inflation: an international comparison', *Journal of Business*, vol. 47, pp. 48-52.

Brocato, J 1994, 'Evidence on adjustments in major national stock market linkages over the 1980s', *Journal of Business Finance and Accounting*, vol. 21, pp. 643–667

Byers, J & Peel, D 1993, 'Some evidence of interdependence of national stock markets and the gains from international portfolio diversification', *Applied Financial Economics,* vol. 3, pp. 239-234

Calvo, S & Reinhart, C 1995, 'Capital inflows to Latin America: Is there evidence of contagion effects?', *World Bank and International Monetary Fund*, mimeo.

Caporale, GM, Cipollini, A & Spagnolo, N 2002, 'Testing for contagion: A conditional correlation analysis', Discussion Paper No. 01-2002, *Centre for Monetary and Financial Economics*, South Bank University

Chan, KC, Gup, BE & Pan, MS 1997, 'International stock market efficiency and integration: a study of eighteen nations', *Journal of Business Finance & Accounting,* vol. 24, pp. 803-813

Chen, GM, Firth, M, & Meng-Rui, O 2002, 'Stock market linkages: Evidence from Latin America', *Journal of Banking & Finance*, vol. 26, pp. 1113–1141.

Cheung, Y & Ng, LK 1992, ‘Stock price dynamics and firm size: An empirical investigation’, *The Journal of Finance*, vol. 47, pp. 1985-1997.

Chiang, T, Jeon, B & Li, H 2007, ‘Dynamic correlation analysis of financial contagion: Evidence from Asian Markets’, *Journal of International Money and Finance*, vol. 26, pp. 1206-28.

Chowdhury, AR 1994, ‘Stock market interdependencies: evidence from the Asian NIEs’, *Journal of Macroeconomics*, vol. 16, pp. 629–651

Chung, PJ, & Liu, DJ 1994, ‘Common stochastic trends in Pacific Rim stock markets’, *Quarterly Review of Economics and Finance*, vol. 34, pp. 241–259.

Cheung, YL, & Mak, S 1992, ‘The international transmission of stock market fluctuations between the developed markets and the Asian–Pacific markets’, *Applied Financial Economics*, vol. 2, pp. 43–47

Click, RW & Plummer, MG 2005, ‘Stock market integration in ASEAN after the Asian financial crisis’, *Journal of Asian Economics*, vol. 16, pp. 5–28.

Corhay, A, Tourani-Rad, A & Urbain, JP 1993, ‘Common stochastic trends in European stock markets’, *Economics Letters*, vol. 42, pp. 385–390.

Corhay, A, Tourani-Rad, A & Urbain, JP 1995, ‘Long-run behavior of Pacific-Basin Stock Prices’, *Applied Financial Economics*, vol. 5, pp. 11-18.

Corsetti, G, Pericoli, M & Sbracia, M 2005, ‘Some contagion, some interdependence: more pitfalls in testing for contagion’, *Journal of International Money and Finance*, vol. 24, pp. 1177-99.

Dadic, T & Vizek, M 2010, ‘Long-run co-movements and short-run dynamics between CEE and developed countries' equity markets’, *www.ssrn.com.*

Dornbusch, R, Park, YC & Claessens, S 2000, ‘Contagion: Understanding how it spreads’, *The World Bank Research Observer*, vol. 15, no. 2, pp. 177-97.

DeFusco, RA, Geppert, JM & Tsetsekos, GP 1996, ’Long-run diversification potential in emerging stock markets’, *The Financial Review*, vol. 31, pp. 343–363.

Dekker, A, Sen, K, & Young, M 2001, ‘Equity market linkages in the Asia Pacific region: A Comparison of the orthogonalized and generalised VAR approaches’, *Global Finance Journal*, vol. 12, pp. 1–33.

Dungey, M, Fry, R, Gonzalez-Hermosillo, B, & Martin, V 2003, ‘Unanticipated shocks and systemic influences: the impact of contagion in global equity markets in 1998’, *IMF Working Paper WP/03/84.*

Dungey, M & Martin, VL 2001, ‘Contagion across financial markets: An empirical assessment’, *New York Stock Exchange Conference Paper*, February 16-17.

Dungey, MR, Fry, BGM, & Martin, V 2005, ‘Empirical modelling of contagion: A review of methodologies’, *Quantitative Finance*, Vol. 5, pp. 9-24.

Eichengreen, B, Rose, AK & Wyplosz, C 1996, ‘Contagious currency crises’, *NBER Working Paper*, 5681.

Engle, R 2002, ‘Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models’, *Journal of Business and Economic Statistics*, Vol. 20, pp. 339-50.

Engle, R & Granger, CWJ 1987, ‘Co-integration and error correction: representation, estimation, testing’, *Econometrica,* 55, 251-276.

Essaadi, E, Jouini, J & Khallouli, W 2009, ‘The Asian crisis contagion: A dynamic correlation approach analysis’, *Panoeconomicus,* Vol. 56, no. 2, pp 241-260.

Eun, CS & Shim, S 1989, 'International transmission of stock market movements', *Journal of Financial and Quantitative Analysis*, vol. 24, pp. 41-56.

Ferna´ndez-Izquierdo, A, & Lafuente, JA 2004, 'International transmission of stock exchange volatility: Empirical evidence from the Asian crisis', *Global Finance Journal*, vol. 15, pp. 125-137.

Forbes, K, & Rigobon, R 2002, No contagion, only interdependence: Measuring stock market co-movement', *The Journal of Finance*, Vol. 57, pp. 2223-61.

Ghosh, A, Saidi, R & Johnson, K 1999, 'Who moves the Asia-Pacific stock markets–US or Japan? Empirical evidence based on the theory of cointegration, *Financial Review*, vol. 34, pp. 159–70.

Gerrits, RJ & Yuce, A 1999, 'Short and long-term links among European and US stock markets', *Applied Financial Economics*, vol. 9, pp.1-9

Gilmore, CG & McManus, GM 2002, 'International portfolio diversification: US and Central European equity markets', *Emerging Markets Review*, vol. 3, pp. 69-83

Goldstein, M, Kaminsky, G & Reinhart, CM 2000, 'Assessing jinancial vulnerability: An early warning system for emerging markets', *Washington, D.C.: Institute for International Economics*.

Granger, CWJ 1986, 'Developments in the study of cointegrated economic variables', *Oxford Bulletin of Economics and Statistics*, vol. 48, pp. 213–228.

Granger, CWJ & Morgenstern, O 1970, 'Predictability of stock market prices', Lexington, MA, *Heath- Lexington Books*.

Grubel, H, and Fadner, K 1971, 'The Interdependence of international equity markets', *Journal of Finance*, Vol. 26, pp. 89-94.

Gultekin, M, Gultekin, B & Penati, A 1989, 'Capital controls and international capital market segmentation: The evidence from the Japanese and American stock markets', *Journal of Finance*, Vol. 44, pp. 849-869.

Hamao, Y, Masulis, R & Ng, V 1990, 'Correlations in price changes and volatility across international stock markets', *Review of Financial Studies*, Vol. 3, pp. 281-307.

Hilliard, J 1979, 'The Relationship between equity indices on World exchanges', *Journal of Finance*, vol. 34, pp. 103-114.

Hon, S & Yong 2004, 'Contagion in financial markets after September 11 - myth or reality?', *Journal of Financial Research*, vol. 27, pp. 95-114.

Hoyoon J & Wonsik, S 2002, 'The Asian financial crisis and the co-movement of Asian Stock markets', *Journal of Asian Economics*, vol. 13, pp. 94-104.

Hung, B & Cheung, Y 1995, 'Interdependence of Asian emerging equity markets', *Journal of Business Finance and Accounting*, vol. 22, pp. 281-288.

Janakiramanan, S & Lamba, AS 1998, 'An empirical examination of linkages between Pacific-Basin stock markets', *Journal of International Financial Markets, Institutions and Money*, vol. 8, pp. 155–73

Jang, H & Sul, W 2002, 'The Asian financial crisis and the co-movement of Asian stock markets', *Journal of Asian Economics*, vol. 13, pp. 94–104.

Jeon, B & Furstenberg, V 1990, 'Growing international co-movement in stock price indexes', *Quarterly Review of Economics and Finance*, vol. 30, pp. 17-30

Johansen, S 1988, 'Statistical analysis of cointegrating vectors', *Journal of Economic Dynamics and Control*, vol. 12, pp. 231–54.

Johansen, S 1991, 'Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models', *Econometrica*, vol. 59, pp. 1551–1580.

Johansen, S & Juselius K 1990, 'Maximum likelihood estimation and inferences on cointegration – with applications to the demand for money', *Oxford Bulletin of Economics and Statistics*, vol. 52, no. 2, pp. 169–210.

Kanas, A 1998, 'Linkages between the US and European equity markets: further evidence from cointegration tests', *Applied Financial Economics*, vol. 8, pp. 607-614.

Kasa, K 1992, 'Common stochastic trends in international stock markets', *Journal of Monetary Economics*, vol. 29, pp. 95–124.

Kawai, M & Khalid, AM 2001, 'Financial market contagion: investigation cross-market–cross-country linkages using VARs and impulse responses', *The World Bank*, Washington, DC.

Khalid, M & Kawai AM 2003, 'Was financial market contagion the source of economic crisis in Asia? Evidence using a multivariate VAR model', *Journal of Asian Economics*, vol. 14, no. 1, pp. 133-159.

Khalid, AM, & Rajaguru, G 2006, 'Financial market contagion or spillovers: Evidence from Asian crisis using multivariate GARCH approach', *Bond University Working Paper*.

Khalil, AM, & Rajaguru, G 2003, 'Financial Market Contagion: Evidence from the Asian crisis using multivariate GARCH Approach', *Journal of Asian Economics*, vol. 14, no. 1, pp. 131-156.

King, M, & Wadhwani S 1990, 'Transmission of volatility between stock markets', *The Review of Financial Studies*, vol. 3, pp. 5-33.

King, MA, Sentana, E, & Wadhwani, S 1994, 'Volatility and links between national stock markets', *Econometrica*, vol. 62, pp. 901–933.

Koop, G 1994, 'An objective Bayesian analysis of common stochastic trends in international stock prices and exchange rates', *Journal of Empirical Finance*, vol. 1, pp. 343-364.

Kwan, ACC, Sim, AB, & Cotsomitis, JA 1995, 'The causal relationships between equity indices on world exchanges', *Applied Economics*, vol. 27, pp. 33–37.

Lau, S & McInish, T 1993, 'Co-movements of international equity returns: A comparison of pre- and post-October 19, 1987, periods', *Global Finance Journal,* vol. 4, pp. 1-19.

Lee, B. S., and Jeon, B. N. (1992). Common Stochastic Trends and Predictability of International Stock Prices. University of Minnesota Working Paper.

Lee, S, & Kim, K 1993, 'Does the October 1987 crash strength the co-movements among national stock markets', *Review of Financial Economics*, vol. 3, pp. 89-102.

Lee, S, & Kim, K 1994, 'Does the October 1987 crash strength the co-movement in stock Price indexes', *Quarterly Review of Economics and Business*, vol. 3, no. 1-2, pp. 89-102.

Lessard, D 1973, 'World, national and industry factors in equity returns', *Journal of Finance*, vol. 29, pp. 379-391.

Lessard, DR 1976, 'International diversification', *Financial Analysts Journal*, vol. 29, pp. 32-38.

Lessard, DR 1979, World, country and industry factors in equity returns: Implications for risk reductions through international diversification', *Financial Analysts Journal*, vol. 32, pp. 32-38.

Levy, H & Sarnat, M 1970, ‘International diversification of investment portfolios’, *American Economic Review*, vol. 60, no. 3, pp. 668-675.

Lim, KP, Brooks, RD & Kim, JH 2008, Financial crisis and stock market efficiency: Empirical evidence from Asian countries’, *International Review of Financial Analysis*, vol. 17, pp. 571–591

Longin, F, & Solnik, B 1995, ‘Is the correlation in international equity returns constant: 1970-1990?’, *Journal of International Money & Finance*, vol. 14, pp. 3-26.

Longin, F, & Solnik, B 2001, ‘Extreme correlation of international equity markets’, *The Journal of Finance*, vol. 56, no. 2, pp. 649-676.

Longstaff, FA 2008, ‘The sub-prime credit crisis and contagion in financial markets’, *UCLA working paper.*

Malliaris, AG, & Urrutia, J 1992, ‘The international crash of October 1987: causality test’, *Journal of Financial and Quantitative Analysis*, vol. 27, pp. 353-364.

Masih, AMM, & Masih, R 1998, ‘Does money cause prices or the other way around? Some multi-country econometric evidence including error-correction modelling from Southeast Asia’, *Journal of Economic Studies,* vol. 25, no. 3, pp. 138–160.

Masih, AMM, & Masih, R 1999, ‘Are Asian stock market fluctuations due mainly to intra-regional contagion effects? Evidence based on Asian emerging stock markets’, *Pacific-Basin Finance Journal,* vol. 7, pp. 251–282.

Masson, P 1998, ‘Contagion: macroeconomic models with multiple equilibria’, *Journal of International Money and Finance*, vol. 18, pp. 587-602.

Masson, P 1999, ‘Contagion: monsoonal effects, spillovers, and jumps between multiple equilibria’, in Agenor, P.R., Miller, M., Vines, D. and Weber, A. (eds), *The Asian Financial Crisis: Causes, Contagion and Consequences, Cambridge University Press*, Cambridge, UK.

Mathur, I & Subrahmanyam, V 1990, ‘Interdependencies among the Nordic and US stock markets’, *Scandinavian Journal of Economics*, vol. 92, no. 4, pp. 587–597.

Meric, I & Meric, G 1989, ‘Potential gains from international portfolio diversification and inter-temporal stability and seasonality in international stock market relationships’, *Journal of Banking and Finance*, vol. 13, pp. 627-640.

Meric, I & Meric, G 1997, ‘Co-movements of European equity markets before and after the 1987 crash’, *Multinational Finance Journal*, vol. 2, pp.137-152

Meric, G, Leal, R, Ratner, M & Maric, I 2001, ‘Co-movements of US and Latin America equity markets before and after the 1987 crash’, *International Review of Financial Analysis*, vol. 10, pp. 219-235

Mink, M & Mierau, JO 2009, ‘Measuring stock market contagion with an application to the sub-prime crisis’, *DNB Working Paper*, No. 217/2009.

Nagayasu, J 2000, ‘Currency crisis and contagion: evidence from exchange rates and sectoral stock indices of the Philippines and Thailand’, *IMF Working Paper*, No. WP/00/39.

Ng, S & Perron, P 1995, ‘Unit root tests in ARMA models with data dependent methods for the selection of the truncation lag’, *Journal of the American Statistical Association*, vol. 90, pp.268-281.

Panton, D, Lessig, I & Joy, M 1976, ‘Comovement of international equity markets: A taxonomic approach’, *Journal of Financial and-Quantitative Analysis*, vol. 11, pp. 415-432.

Patev, P, Kanaryan, N & Lyroudi, K 2006, "Stock market crises and portfolio diversification in central and eastern europe', *Managerial Finance*, vol. 32, no. 5, pp. 415-432.

Pericoli, M & Sbracia, M 2003, 'A primer on financial contagion', *Journal of Economic Survey*, vol. 17, pp. 571-608.

Pesaran, H & Pick, A 2003, 'Econometric issues in the analysis of contagion", *Mimeo, University of Cambridge.*

Rangvid, J 2001, 'Increasing convergence among European stock markets? A recursive common stochastic trends analysis', *Economics Letters*, vol. 71, pp. 383–389.

Richards, AJ 1995, 'Comovements in national stock market returns: Evidence of predictability, but not cointegration', *Journal of Monetary Economics*, vol. 36, pp. 631–654.

Rigobon, R 2002a, 'International financial contagion: theory and evidence in evolution', *The Research Foundation of AIMR*, Charlottesville, Virginia.

Rigobon, R 2002b, 'The curse of non-investment grade countries', *Journal of Development Economics*, vol. 69, pp. 423-449.

Ripley, DM 1973, 'Systematic elements in the linkage of national stock market indices', *Review of Economics and Statistics*, vol. 55, no. 3, pp. 356-361.

Roll, R 1988, 'The international crash of October 1987', *Financial Analysts Journal*, September/October, pp. 19-35.

Shachmurove, Y 1996, 'Dynamic daily returns among Latin American and other major world stock markets", *CARESS Working Paper* #96-03.

Shachmurove, Y 2001, 'Dynamic co-movements of Stock Indices: The emerging Middle Eastern and the United States markets', *www.econ.upenn.edu/Centers/CARESS/CARESSpdf/01-18.pdf*

Shachmurove, Y 2001, 'Optimal portfolio analysis for the Czech republic, Hungary and Poland during 1994-1995 period', *CARESS Working Paper,* no. 00-12.

Shiller, R 1989, 'Comovements in stock prices and comovements in dividends', *Journal of Finance*, vol. 44, pp. 719-729.

Smith, KL, Brocato, J & Rogers, JE 1993, 'Regularities in the data between major equity markets: evidence from Granger causality tests', *Applied Financial Economics*, vol. 3, pp. 55–60.

Tan, KB & Tse, YK 2002, 'The integration of the east and south-east Asian equity markets', *International Center for the Study of East Asian Development Working Paper,* No. 2002-11. Available at http://www.icsead. or.jp/indexe.htm.

Tai, CS & Jones, JH 2007, 'Market integration and contagion: Evidence from Asian emerging stock and foreign exchange markets', *Emerging Markets Review*, vol. 8, pp. 264-283

Thaneepanichskul, S 2001, 'The co-movements of U.S. and other national markets', www.apfa2001.com

Toda, HY & Phillips, PCB 1993, 'Vector autoregressions and causality', *Econometrica*, vol. 61, no. 6, pp. 1367–1393.

Watson, J 1978, 'A study of possible gains from international investment', *Journal of Business Finance and Accounting*, vol. 5, no. 2, pp. 195-206.

Wheatley, S 1988, 'Some tests of international equity integration', *Journal of Financial Economics*, vol. 21, pp. 177-212.

Wong, WK, Agrawal, A & Du, J 2005, 'Financial integration for India stock market: a fractional cointegration approach, *NUS working paper* No. 0501, http://nt2.fas.nus.edu.sg/ecs/pub/wp/wp0501.pdf

Yang, J, Kolari, JW & Min, I 2003, 'Stock market integration and financial crises: the case of Asia', *Applied Financial Economics*, vol. 13, pp. 477–486

Yoon, G 2005, 'Correlation coefficients, heteroskedasticity, and contagion of financial crisis', *Manchester School,* vol. 73, No. 1, pp. 92-100.

Vizek, M & DADIĆ, T 2006, 'Integration of correlation, CEE and EU Equity Markets: Cointegration Approach", *Ekonomski Pregled*, vol. 57, pp. 631-646.