Dynamics of Stock Market Cycles: A Systematic Introspection from some recent evidences [1]

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ABSTRACT

Historically, stock-market cycles, crashes and the resultant panic have ended in ultimate devastating impact on the rest of the economy. Proper macroeconomic management and accomplishing macroeconomic objectives require both in terms of depth and width, sound health of the financial system. A fragile financial sector is often identified as the prime factor in generating and aggravating crises. Moreover, with extensive trade and financial integration, crises in one market immediately affect others through dynamic linkages among markets or "contagion". Hence, at this juncture, inquiry into market dynamics becomes crucial. Present study intervenes here focusing on the two past significant stock-market crises namely, the dot-com bubble and the global melt-down of 2007-08. Around the five sub-phases the study found significant volatility transmission channels primarily through past-volatility impacts. In recent era of fluctuation and instability, the stock-markets have become more integrated where innovation and volatility impacts are strong and significantly positive. The news-impacts, however, are always less intense than past-volatility impacts. Moreover, even with increasing financial integration, there remains a basis for global portfolio diversification.

KEY WORDS: *Global stock-market, financial melt-down, internet bubble, financial integration, portfolio diversification, multivariate GARCH, volatility transmission*

INTRODUCTION

The old debate on finance-growth nexus started with Bagehot (1873) and Schumpeter (1912) who emphasized financial sector's potential in promoting economic growth. Subsequently, a school of thought emerged that hailed the finance-growth nexus where financial development leads future growth, capital accumulation, and technological change. Gurley and Shaw (1955), Goldsmith (1969), McKinnon (1973), Shaw (1973) and Levine and Renelt (1998) shared and emphasized this view. An antithetical view however always ran parallel that conjectured finance to be a "side-show" of growth: any correlation between financial development and growth results only from growth-leading-development. Recent era is witnessing resurrection of the issue. Recent global stock market crashes, the resultant panic and their ultimate devastating impact on the rest of the economy has sparked enthusiasm among researchers regarding the dynamics of the financial market. Economic literature often hails that proper macroeconomic management and accomplishing macroeconomic objectives require, both in terms of depth and width, sound health of the financial system. Financial fragility is often identified as a major factor in generating and aggravating crises. It shatters participants' confidence and impedes the ability of financial markets to act as intermediary between the savers and investors. Moreover, given the high degree of trade and financial integration, crises in one market set in motion turmoil in others through long-term and short-term dynamic inter-linkages. These justify the exploration of market dynamics. The price generating mechanism, the factors determining stock-prices, the possibility of having bubble-determined prices, stock-price volatility and its possible propagators are gaining analytical as well as policy significance, particularly after the East-Asian crisis, the dot-com bubble and particularly, the first financial melt-down of the twenty-first Century.

Financial contagion effects were emphasized by Kiyotaki and Moore (1997) who showed how financial crises spread from one segment to others making the entire system unstable. Studies

by Kaminsky and Reinhart (1996, 1999) supported this. Analyzing data for twenty crisis-hit countries they found that during booms asset prices and subsequent borrowing from banks increase considerably. As bubble bursts and asset prices slide, financial institutions exposed to such asset markets plunge into crisis. Volatility contagion and spillover are often found to be crucial in stock-price determination. Stock market inter-linkages often strengthen with global financial integration (Agmon (1972), Hilliard (1979)) and disappear for isolated financial markets (Ripley, 1973). After the US stock market crash of 1987, co-movement of stock indices has increased significantly. Arshanapalli and Doukas (1993) confirmed and Cheung and Ng (1992) supported the dominant role of US in the modern global financial market. Eun and Shim (1989) reinforced this finding using VAR model and impulse-response function. Lee and Kim (1994) and Jeon and Von-Furstenberg (1990) found significant increase in the global stock-price co-movement in the post-crash period. Koch and Koch (1991) used dynamic simultaneous equations to show increasing interdependence in the global and regional markets. Masih and Masih (1997) revealed the presence of regional contagion within the Asian region and established significant influence of the US and the UK markets on them. Existence of interdependence within the European region was established by Koutmos (1996) using multivariate VAR-EGARCH model. Baig and Goldfajn (1998) showed the presence of contagion in Asian financial markets. Glezakos et al (2007) examined the short and long-run interlinkages among major financial markets with particular attention to the Greece. Moreover, sectoral indices, particularly the IT indices are related globally (Suleimann, 2003). Sarkar et al (2009) examined volatility, the possible presence of asset bubbles and financial fragility in India, but the question of transmission mechanism was not adequately addressed. Sharma and Kennedy (1977) found strong link between Indian, US and UK markets. Rao and Naik (1990) using a Cross-Spectral analysis found weak relationship of Indian market with international markets which they attribute to the controlled Indian Economy regime throughout the 70s.

Recently, Wong et al (2005) explored the volatility transmission channels for Indian stock market. Sarkar et al (2009) and Chakrabarti et al (2012) identified volatility transmission channels for Indian market in global markets as well as in domestic sectors. Studies by Chakrabarti (2010) and Chakrabarti and Sen (2012) are noteworthy in this context.

THE TWO FINANCIAL CRISES OF RECENT PAST

The last few years of the twentieth century witnessed significant development of knowledge and knowledge-based products and services that ultimately transformed the low-productive, manufacture-based old economy to a knowledge-based, knowledge-driven, service-oriented, highly-productive 'new' economy. This transformation was easily perceptible in the global stock markets where the new-economy stocks added significant values. This created a euphoria among the investors and their irrational exuberance were being backed by the assertions from the media and similar institutions that "this time is different" – the four most dangerous words in finance. The assertion that the future lies with these stocks and their high prices could be justified by their perceived growth opportunity (no matter, what fundamentals suggest) led ultimately to such a high price that even the most zealous supporter of new economy would found difficult to justify. As the bubble burst, the huge loss in the financial market spilled over to other sectors of the economy all over the globe.

The second crisis in which this study takes interest is the global financial melt-down that was on track since mid 2007. This crisis is often taken as the worst financial crisis since the one that could be related to the Great Depression of the 1930s. The crisis originated in the 'core', spread speedily to the 'periphery' and was truly global in nature affecting almost every sector of the real economy. The US housing price bubble and the subsequent subprime mortgage

crisis created global credit stringency and insolvency threats to financial institutions. With the collapse of the large and unregulated shadow banking system there was significant loss of household wealth, consumption, stock wealth and lending capacity. The crisis magnified when fiscal stimulus, monetary policy expansion and institutional bail-outs failed. This phenomenal disaster has pointed towards the risks, structural flaws and potential vulnerability of an innovative financial system, the possibilities of wider and faster contagion and hence the devastating fall out on the real economy.

Thus, over a couple of years, growing pace of financial deregulation in a market characterized by moral hazards, has often led to financial booms that finally ended in financial melt-down. Over the years, as financial markets plunged, governments introduced corrective measures and bail-outs. Such bail-outs helped further financial expansion which in presence of moral hazards generated financial crises at regular intervals creating the need for further bail-outs. With every recovery, not only the size of the global financial market has expanded but it has become more complex, less transparent and structurally fragile. Over time the growth of the financial sector has outpaced that of the real sector posing a genuine threat to the latter. This situation is clearly not sustainable as it would be increasingly difficult for the real economy to generate cash flow in commensurate with such huge financial claims.

THE DYNAMICS OF STOCK MARKET: CRISIS AND BEYOND

This discussion hence reveals the relevance of the explorations of the functioning of the global financial markets at this crucial juncture. This study while exploring this issue concentrates on the global stock market and inquires into the global market dynamics, their intrinsic natures, common trends and their dynamic interlinkages around the two global stock market crises of

the last twenty years namely the dot-com bubble of 1999-2000 and the financial melt-down of 2007-2008. Specifically, it defines sub-phases as follows:

Period 1: pre-dot-com crisis period (January-1997 to April-2000)

Period 2: post-dot-com crisis period (May-2000 to December-2005)

Period 3: journey towards crisis of 2007-08 (January-2006 to January-2008)

Period 4: post financial crisis period (February-2008 to March-2009)

Period 5: recent period of instability (April-2009 to July-2014)

The study explores whether and how the dynamics and inter-linkages of a market change as it moves closer to a peak, falls from it and recovers. It then explores the relevance of such dynamics for the decision making process of the global market investors. An early study by Chakrabarti (2010) considered the market movements around the crisis of 2007-08. Chakrabarti and Sen (2012) considered the two crises but the analysis never took into consideration the dynamic interlinkage and investment decision around the crises.

THE STOCK MARKETS CHOSEN

The study selects different regional markets all over the globe that suffered from the two financial crises mentioned earlier. These markets taken as a whole would then proxy for the global market.

From the North American Region, the study selects *Dow Jones (US), Mexico IPC (Mexico)* and *S&P/TSX (Canada).* The Dow Jones Industrial Average is the benchmark index in the US market constituted of large thirty stocks of public limited companies that trade in the New York Stock Exchange. The S&P/TSX Composite Index is a stock index of the largest companies on

the Toronto Stock Exchange as measured by market capitalization. IPC is the main benchmark stock index of the Mexican Stock Exchange.

From the European Region, the study selects *CAC-40 (France), DAX (Germany), FTSE 100 (London), ATX (Austria), Madrid General (Spain), AEX General (Netherlands), Swiss Market (Switzerland),* and *Bel 20 (Belgium).* The AEX General index is composed of twenty-five Dutch securities that trade actively on the Amsterdam Stock Exchange. CAC40, the market-capitalization-weighted benchmark index of the French stock market includes forty most significantly valued stocks traded on the Euronext Paris. DAX is a blue-chip stock market index consisting of the thirty major German companies trading on the Frankfurt Stock Exchange. FTSE 100 is an index of the hundred most highly capitalized UK companies listed on the London Stock Exchange. The twenty-stock Austrian Traded Index (ATX) is the most important stock market index and the largest trading place in the Austrian economy. The Swiss Market Index is Switzerland's blue-chip stock market index and includes twenty most liquid large and mid-cap stocks. The Bel-20 is the market index of Belgium.

All Ordinaries Index (AORD), the oldest market-capitalization based stock index is chosen from Australia *MerVal* (Argentina) and *Bovespa* (Brazil) are selected from the South American Region. The BM&FBOVESPA is a São Paulo-based stock and futures exchange with Índice Bovespa (BVSP) as the benchmark index. MERVAL is the most important price-weighted index of the Buenos Aires Stock Exchange.

From the Asian Region, the study selects BSE SENSEX (India); Shanghais Composite (China), Nikkei 225 (Japan), Hang Seng (Hong Kong), Jakarta composite (Jakarta) and KLSE composite (Malaysia), STI (Singapore) and Taiwan stock index. BSE SENSEX is a value-weighted index composed of thirty largest and most actively traded stocks in BSE. The SSE

Composite Index is an index of all stocks traded at the Shanghai Stock Exchange. Nikkei 225 is a stock market index for the Tokyo Stock Exchange. The Hang Seng is a free float adjusted, market capitalization weighted stock market index in Hong Kong that represents the overall market performance in Hong Kong. The Kuala Lumpur Composite Index is a capitalization-weighted stock market index consisted of thirty stocks listed on the Malaysian Main Market. The STI is the benchmark index of Singapore market.

THE GLOBAL MARKET TRENDS: A MULTIVARIATE GARCH ANALYSIS

Every financial crisis owes its origin to severe macroeconomic, structural and/or political imbalance. However, the manner, extent and speed of transmission of such crisis across the globe should not be taken lightly. With the growing financial integration significant channels of volatility transmission have developed that has made the analyses of financial crises more difficult. While examining the nature of stock price dynamics, it would be absolutely vital to consider the interplay of financial markets. As mentioned earlier, literature found stock market interlinkage to strengthen with global financial integration. Studies mentioned earlier, particularly those by Agmon (1972), Hilliard (1979), Ripley (1973), Arshanapalli and Doukas (1993), Cheung and Ng (1992), Eun and Shim (1989), Jeon and Von-Furstenberg (1990), Lee and Kim (1994), Koch and Koch (1991), Masih and Masih (1997) are noteworthy in this context. Volatility contagions in financial markets have been emphasized by Kim and Rogers (1995), Chou et al. (1999), Karunanayake et al. (2008) and others. They considered the importance of past innovation impact as well as past volatility impact on the present volatility. Of different studies, past news impact has been particularly emphasized by Eun and Shim (1989), and Peiro et al (1998). Caporale et al. (2006) on the other hand have emphasized on the past volatility impact. Volatility contagion often is found to exist across regions. Cheung

and Ho (1991), Chaudhury (1997), Worthington and Higgs (2008) established that for the Asian markets; while Christofi and Pericli (1999) identified such channels for other emerging markets. However, one drawback of such studies has been that almost all of them have made use of GARCH family models, particularly univariate GARCH models (Aggarwal et al. [1999], Adrangi et al [1999] and Huang and Yang [2000]). Univariate GARCH models however can hardly take into account the multilateral nature of integrated markets. Some studies have applied multivariate GARCH models to solve the problem. Studies by Tse (2000), Tay and Zhu (2000), Brooks and Henry (2000), Li (2007), Valdkhani et. al, (2004), Karunanayake at al. (2008) are noteworthy in this context.

A large number of studies on financial market integration and volatility transmission have used VAR and Granger Causality techniques. Such techniques, however, cannot capture the time varying nature of stock returns (Gallagher and Twomey, 1998). Transmission of volatility across financial markets could be best captured by multivariate generalized autoregressive conditional heteroscedasticity (MGARCH) model and its variants. This section makes use of Diagonal Vector GARCH (VECH) model of Bollerslev *et al* (1988). In a Diagonal VECH model the variance-covariance matrix of stock market returns is allowed to vary over time. This model is particularly useful, unlike the BEKK model of Baba *et al* .(1990), with more than two variables in the conditional correlation matrix (Scherrer and Ribarits, 2007). However, it is often difficult to guarantee a positive semi definite conditional variance covariance matrix in a VECH model (Engel and Kroner, 1993, Brooks and Henry, 2000). Following the methodology of Karunanayake *et al.* (2008) this study avoids this problem by using the unconditional residual variance as the pre-sample conditional variance. This is likely to ensure positive semi-definite variance covariance matrix in a diagonal VECH model.

Since, we are more interested in volatility co-movement and spill over, the mean equation of the estimated diagonal VECH model contains only the constant term. In the n dimension variance covariance matrix, H, the diagonal terms will represent the variance and the non-diagonal terms will represent the covariances. In other words, in

$$H_t = \begin{pmatrix} h_{11t} & \dots & h_{1nt} \\ \dots & \dots & \dots \\ h_{n1t} & \dots & h_{nnt} \end{pmatrix}$$

h_{iit} is the conditional variance of 'i'th market in time t; h_{ijt} is the conditional covariance between the 'i'th and 'j'th market in period t ($i \neq j$). The conditional variance depends on the squared lagged residuals and conditional covariance depends on the cross lagged residuals and lagged covariances of the other series (Karunanayake *et al*, 2008). The model could be represented as:

$$\text{VECH}(H_t) = C + A.\text{VECH}(\epsilon_{t-1}\epsilon'_{t-1}) + B.\text{VECH}(H_{t-1})$$

A and B are $\frac{N(N+1)}{2} \text{x} \frac{N(N+1)}{2}$ parameter matrices. C is $\frac{N(N+1)}{2}$ vector of constant. a_{ii} in matrix A, that is the diagonal elements show the own spillover effect. This is the impact of own past innovations on present volatility. The cross diagonal terms (a_{ij}, $i \neq j$) show the impact of pat innovation in one market on the present volatility of other markets. Similarly, b_{ii} in matrix B shows the impact of own past volatility on present volatility. Likewise, b_{ij} represents cross volatility spill over or the impact of past volatility of the *i*th market on the present volatility of *j*th market. For our purpose, a_{ij}'s and b_{ij}'s are more important.

As pointed out by Karunanayake *et al.* (2008) an important issue in estimating a diagonal VECH model is the number of parameters to be estimated. To solve the problem, Bollerslev

et al. (1988) suggested use of a diagonal form of A and B. A related issue is to ensure the positive semi-definiteness of the variance covariance matrix. The condition is easily satisfied if all of the parameters in A, B and C are positive with a positive initial conditional variance covariance matrix (Bauwens *et al.*, 2006). Bollerslev *et al.* (1988) suggested some restrictions to impose that have been followed by Karunanayake *et al.* (2008). They used maximum likelihood function to generate these parameter estimates by imposing some restriction on the initial value. If θ be the parameter for a sample of T observations, the log likelihood function will be:

$$L_T(\theta) = \sum_{t=1}^{T} l_t(\theta), \text{ where } l_t(\theta) = \frac{N}{2}\ln(2\pi) - \frac{1}{2} ln|H_t| - \frac{1}{2}\epsilon_t' H_t^{-1}\epsilon_t$$

The pre sample values of θ can be set to be equal to their expected value of zero (Bollerslev *et al.*, 1988). The Ljung Box test statistic could further be used to test for remaining ARCH effects. For a stationary time series of T observations and a multivariate process of order (p, q) the Ljung Box test statistic is given as:

$$Q = T^2 \sum_{j=1}^{s} (T - j)^{-1}\, tj\{C_{Y_t}^{-1}(0) C_{Y_t}(j) C_{Y_t}^{-1}(0) C_{Y_t}'(j)$$

Y_t is vech($y_t y'_t$), $C_{Y_t}(j)$ is the sample auto covariance matrix of order j, s is the number of lags used, T is the number of observations. For large sample, the test statistic is distributed as a χ^2 under the null hypothesis of no remaining ARCH effect.

DIAGONAL VECH ESTIMATION FOR PERIOD 1

Period 1 is characterized by a continuous rise in global stock prices as the Internet stocks flourished. On the basis of Akaike Information Criterion and Schwarz Criterion, VECH (1, 1) model turns out to be the best fit. The results are summarized in Table 1.

Table 1. Past News and past volatility impact: Period 1

Past News impact: Period 1																			
	Australia	Austria	Belgium	Brazil	France	Canada	Germany	England	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan	US
Australia	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Austria		0.029	0.063	0.068	0.014	0.029	0.025	-0.006	-0.017	-0.009	0.055	0.019	0.027	-0.007	0.033	0.069	0.029	-0.023	0.027
Belgium			0.138	0.150	0.032	0.064	0.054	-0.012	-0.037	-0.020	0.120	0.042	0.058	-0.015	0.073	0.152	0.064	-0.051	0.058
Brazil				0.163	0.034	0.069	0.058	-0.013	-0.040	-0.022	0.131	0.046	0.063	-0.017	0.079	0.165	0.070	-0.055	0.063
France					0.007	0.015	0.012	-0.003	-0.008	-0.005	0.028	0.010	0.013	-0.004	0.017	0.035	0.015	-0.012	0.013
Canada						0.029	0.025	-0.006	-0.017	-0.009	0.056	0.019	0.027	-0.007	0.034	0.070	0.030	-0.023	0.027
Germany							0.021	-0.005	-0.014	-0.008	0.047	0.016	0.023	-0.006	0.029	0.059	0.025	-0.020	0.023
England								0.001	0.003	0.002	-0.011	-0.004	-0.005	0.001	-0.006	-0.013	-0.006	0.004	-0.005
Hongkong									0.010	0.005	-0.032	-0.011	-0.015	0.004	-0.019	-0.040	-0.017	0.013	-0.009
Indonesia										0.003	-0.018	-0.006	-0.009	0.002	-0.011	-0.022	-0.009	0.007	-0.020
Argentina											0.105	0.037	0.051	-0.013	0.064	0.133	0.056	-0.044	-0.022
Mexico												0.013	0.018	-0.005	0.022	0.046	0.020	-0.016	-0.005
Japan													0.025	-0.007	0.031	0.065	0.027	-0.022	-0.009
India														0.002	-0.008	-0.017	-0.007	0.006	-0.008
China															0.039	0.081	0.034	-0.027	0.020
Singapore																0.168	0.071	-0.056	0.027
Switzerland																	0.030	-0.024	-0.007
Taiwan																		0.019	0.034

Table 1 continued… Past volatility impact																			
	Australia	Austria	Belgium	Brazil	France	Canada	Germany	England	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan	US
Australia	0.829	0.887	0.002	0.830	0.893	0.888	0.889	0.898	0.904	0.895	0.814	0.891	0.872	0.886	0.866	0.638	0.884	0.819	0.002
Austria		0.949	0.002	0.888	0.956	0.950	0.951	0.962	0.968	0.958	0.871	0.954	0.934	0.948	0.927	0.683	0.946	0.877	0.892
Belgium			0.000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.960
Brazil				0.831	0.894	0.889	0.890	0.899	0.905	0.896	0.815	0.892	0.873	0.887	0.867	0.638	0.885	0.820	0.955
France					0.962	0.957	0.958	0.968	0.974	0.964	0.877	0.960	0.940	0.954	0.933	0.687	0.953	0.883	0.955
Canada						0.952	0.952	0.963	0.969	0.959	0.872	0.955	0.935	0.949	0.928	0.683	0.948	0.878	0.966
Germany							0.953	0.963	0.970	0.960	0.872	0.955	0.935	0.950	0.929	0.684	0.948	0.878	0.972
England								0.974	0.980	0.970	0.882	0.966	0.946	0.960	0.939	0.691	0.959	0.888	0.889
Hongkong									0.987	0.977	0.888	0.972	0.952	0.966	0.945	0.696	0.965	0.894	0.951
Indonesia										0.967	0.879	0.962	0.942	0.957	0.935	0.689	0.955	0.884	0.002
Argentina											0.799	0.875	0.856	0.869	0.850	0.626	0.868	0.804	0.890
Mexico												0.958	0.938	0.952	0.931	0.686	0.951	0.880	0.958
Japan													0.918	0.932	0.912	0.671	0.931	0.862	0.952
India														0.947	0.926	0.682	0.945	0.875	0.691
China															0.905	0.666	0.924	0.856	0.696
Singapore																0.491	0.680	0.630	0.689
Switzerland																	0.944	0.874	0.683
Taiwan																		0.809	0.684
																			0.691

The own (a_{ii}'s) and cross innovation (a_{ij}'s) impacts were not significant for the eighteen markets. The own and cross volatility impacts (b_{ii}'s and b_{ij}'s) are also not significant.

From the diagnostic tests, all the standardized residuals are negatively skew and appear to be stationary according to the Augmented Dickey Fuller test. The results for system residual portmanteau test for autocorrelation using the Cholesky orthogonalization method suggests that the null hypothesis of no autocorrelation cannot be rejected for lags up to 12 at 5 percent level of significance. This has been true for all subsequent sub-period estimation results (tables may be produced on demand).

Thus, as the global economy approached the dot-com crisis, markets were free from any volatility contagion. While the crisis was looming large, the current volatility in one market was not affected by innovations either in the concerned market or in other markets. Similarly, past volatilities in a market were not affecting present volatilities in any of the chosen markets. The correlation coefficient matrix provides further insight regarding the movements in the market return during the period (Table 2). Out of the 153 possible correlation coefficients, 69 are negative and significantly low: an indication of possible lack of integration among the global markets in terms of return movements. This bears significant implications for the investors. The presence of very low, negative correlation among the market returns and the absence of volatility spill-over might imply enough scope for global portfolio diversification for the investors.

Table 2. Correlation coefficients for market returns: Period 1

	Australia	Austria	Belgium	Brazil	France	Canada	Germany	UK	HongKong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan
Austria	-0.034																	
Belgium	0.031	0.046																
Brazil	-0.007	0.054	-0.017															
France	0.066	-0.057	0.034	-0.080														
Canada	0.016	0.024	-0.052	0.010	-0.013													
Germany	-0.096	-0.021	-0.053	-0.009	-0.004	-0.001												
UK	-0.012	0.052	-0.007	0.024	0.011	0.011	0.056											
Hongkong	0.002	0.002	-0.044	-0.049	0.033	-0.018	-0.009	0.080										
Indonesia	0.013	-0.001	-0.009	-0.010	0.047	0.000	0.065	0.040	0.009									
Argentina	-0.070	0.043	0.005	0.070	0.006	-0.017	0.014	0.036	0.003	0.007								
Mexico	0.022	-0.028	0.000	-0.002	-0.070	-0.004	0.009	0.008	-0.021	0.020	0.027							
Japan	0.007	0.033	-0.038	-0.023	-0.011	0.041	-0.036	-0.036	0.015	-0.004	0.156	-0.017						
India	-0.027	0.087	-0.004	0.048	0.075	-0.025	-0.047	0.124	0.035	-0.010	0.003	0.020	0.006					
China	-0.031	-0.020	-0.054	0.013	0.033	-0.115	0.052	0.017	0.065	-0.050	0.017	0.033	-0.050	0.037				
Singapore	0.021	-0.018	-0.083	-0.057	-0.035	-0.003	0.021	-0.024	0.048	0.009	0.030	0.049	0.052	-0.04	0.003			
Switzerland	-0.067	0.011	-0.031	-0.035	-0.012	-0.031	0.017	0.007	-0.009	-0.043	0.003	0.044	0.005	-0.04	0.008	-0.016		
Taiwan	0.016	-0.034	-0.033	0.049	0.027	0.005	-0.020	-0.070	0.025	0.045	0.043	0.012	0.038	-0.03	0.021	0.007	-0.063	
US	-0.070	0.043	0.005	0.070	0.006	-0.017	0.014	0.036	-0.031	-0.020	-0.054	0.013	0.033	0.017	0.065	-0.050	0.017	0.033

DIAGONAL VECH ESTIMATION FOR PERIOD 2

During Period 2 the global economy, surpassing the dot-com crisis was eventually approaching a relatively stable state with little fluctuations in stock prices. The results of MVGARCH estimation suggest absence of cross country innovation impacts: present information in a market was not affecting future volatilities in others. However, all own innovation effects are significantly positive implying that all the markets were significantly affected by information or news spread in their own markets. However, there have been some significant own and cross volatility impacts. All the own volatility impacts are high and significantly positive. While the values range from 0.94 (for Taiwan) to 0.71 (for China), most of the coefficients are close to 0.90. The cross volatility impacts are significant in some cases. Significant volatility transmission channels exist between market pairs but there are no regional patterns as such. The global markets are integrated to some extent as out of a total of 153 cross volatility coefficients 95 are significantly positive. Moreover, the past volatility impacts have been significantly greater than the innovation or news impacts (Table 3).

Table 3. Past News and past volatility impact: Period 2

Past News impact																			
	Australia	Austria	Belgium	Brazil	France	Canada	Germany	England	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan	US
Australia	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Austria		0.029	0.063	0.068	0.014	0.029	0.025	-0.006	-0.017	-0.009	0.055	0.019	0.027	-0.007	0.033	0.069	0.029	-0.023	0.027
Belgium			0.138	0.150	0.032	0.064	0.054	-0.012	-0.037	-0.020	0.120	0.042	0.058	-0.015	0.073	0.152	0.064	-0.051	0.058
Brazil				0.163	0.034	0.069	0.058	-0.013	-0.040	-0.022	0.131	0.046	0.063	-0.017	0.079	0.165	0.070	-0.055	0.063
France					0.007	0.015	0.012	-0.003	-0.008	-0.005	0.028	0.010	0.013	-0.004	0.017	0.035	0.015	-0.012	0.013
Canada						0.029	0.025	-0.006	-0.017	-0.009	0.056	0.019	0.027	-0.007	0.034	0.070	0.030	-0.023	0.027
Germany							0.021	-0.005	-0.014	-0.008	0.047	0.016	0.023	-0.006	0.029	0.059	0.025	-0.020	0.023
England								0.001	0.003	0.002	-0.011	-0.004	-0.005	0.001	-0.006	-0.013	-0.006	0.004	-0.005
Hongkong									0.010	0.005	-0.032	-0.011	-0.015	0.004	-0.019	-0.040	-0.017	0.013	-0.009
Indonesia										0.003	-0.018	-0.006	-0.009	0.002	-0.011	-0.022	-0.009	0.007	-0.020
Argentina											0.105	0.037	0.051	-0.013	0.064	0.133	0.056	-0.044	-0.022
Mexico												0.013	0.018	-0.005	0.022	0.046	0.020	-0.016	-0.005
Japan													0.025	-0.007	0.031	0.065	0.027	-0.022	-0.009
India														0.002	-0.008	-0.017	-0.007	0.006	-0.008
China															0.039	0.081	0.034	-0.027	0.020
Singapore																0.168	0.071	-0.056	0.027
Switzerland																	0.030	-0.024	-0.007
Taiwan																		0.019	0.034

Table-3 continued…Past volatility impact																			
	Australia	Austria	Belgium	Brazil	France	Canada	Germany	England	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan	US
Australia	0.829	0.887	0.002	0.830	0.893	0.888	0.889	0.898	0.904	0.895	0.814	0.891	0.872	0.886	0.866	0.638	0.884	0.819	0.002
Austria		0.949	0.002	0.888	0.956	0.950	0.951	0.962	0.968	0.958	0.871	0.954	0.934	0.948	0.927	0.683	0.946	0.877	0.892
Belgium			0.000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.960
Brazil				0.831	0.894	0.889	0.890	0.899	0.905	0.896	0.815	0.892	0.873	0.887	0.867	0.638	0.885	0.820	0.955
France					0.962	0.957	0.958	0.968	0.974	0.964	0.877	0.960	0.940	0.954	0.933	0.687	0.953	0.883	0.955
Canada						0.952	0.952	0.963	0.969	0.959	0.872	0.955	0.935	0.949	0.928	0.683	0.948	0.878	0.966
Germany							0.953	0.963	0.970	0.960	0.872	0.955	0.935	0.950	0.929	0.684	0.948	0.878	0.972
England								0.974	0.980	0.970	0.882	0.966	0.946	0.960	0.939	0.691	0.959	0.888	0.889
Hongkong									0.987	0.977	0.888	0.972	0.952	0.966	0.945	0.696	0.965	0.894	0.951
Indonesia										0.967	0.879	0.962	0.942	0.957	0.935	0.689	0.955	0.884	0.002
Argentina											0.799	0.875	0.856	0.869	0.850	0.626	0.868	0.804	0.890
Mexico												0.958	0.938	0.952	0.931	0.686	0.951	0.880	0.958
Japan													0.918	0.932	0.912	0.671	0.931	0.862	0.952
India														0.947	0.926	0.682	0.945	0.875	0.691
China															0.905	0.666	0.924	0.856	0.696
Singapore																0.491	0.680	0.630	0.689
Switzerland																	0.944	0.874	0.683
Taiwan																		0.809	0.684
																			0.691

Table 4. Correlation coefficients for market return: Period 2

	Australia	Austria	Belgium	Brazil	France	Canada	Germany	England	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan
Austria	0.006																	
Belgium	0.012	0.010																
Brazil	-0.025	0.037	0.014															
France	0.000	0.013	0.787	0.001														
Canada	0.007	0.005	-0.014	0.000	0.003													
Germany	0.008	-0.005	-0.016	-0.028	-0.027	0.031												
England	0.025	-0.030	-0.032	-0.050	-0.050	-0.049	0.000											
Hongkong	0.035	-0.048	-0.013	0.032	-0.009	-0.027	-0.008	0.058										
Indonesia	-0.052	-0.010	-0.008	0.002	0.002	-0.016	-0.024	-0.010	-0.019									
Argentina	0.042	0.009	-0.010	0.033	0.015	-0.015	-0.003	0.014	0.014	-0.007								
Mexico	0.018	0.025	-0.011	-0.026	0.001	0.040	-0.032	0.019	0.033	0.032	0.015							
Japan	-0.003	-0.012	0.001	-0.016	-0.022	-0.010	-0.026	0.013	0.024	0.010	0.021	-0.036						
India	-0.040	0.010	-0.044	0.056	-0.041	-0.016	0.044	0.023	0.031	0.021	-0.004	0.013	0.017					
China	-0.064	0.008	0.025	-0.016	0.018	-0.011	0.050	-0.019	-0.022	-0.029	-0.008	0.011	-0.045	-0.049				
Singapore	0.116	-0.005	-0.023	-0.004	-0.020	-0.014	-0.006	0.044	-0.034	0.014	-0.029	-0.044	-0.029	-0.033	-0.05			
Switzerland	-0.048	-0.005	0.057	0.036	0.029	-0.009	0.024	-0.057	-0.031	-0.023	0.001	-0.016	0.030	0.030	-0.06	-0.022		
Taiwan	-0.020	0.064	0.029	0.102	0.029	0.053	0.020	-0.005	0.014	-0.036	0.000	-0.032	0.017	0.014	0.104	0.026	-0.058	
US	0.042	0.009	-0.010	0.033	0.015	-0.015	-0.003	0.014	0.014	-0.007	0.044	0.023	0.031	0.021	0.015	-0.015	-0.003	-0.045

While the period was characterized by significant volatility transmission across markets, the correlation coefficients among market returns remained significantly lower and negative in some cases (Table 4). This once again bears implications for investors. Although the scope for global portfolio diversification in the period was limited compared to the first one, there had indeed been some scope for global portfolio diversification.

DIAGONAL VECH ESTIMATION FOR PERIOD 3

During this sub-phase the global economy was experiencing the crisis. This phase needs consideration because during no other crisis, did the world face such a prolonged period of continuous loss. During the period, the own news impact remained significant, but the cross news impacts were not. The own (ranging between0.60 to 0.89) and cross (ranging between 0.60 and 0.93) volatility impacts, however were significant making the global economy integrated via past volatility transmission channels during the crisis (Table 5).

Table 5. Past News and past volatility impact: Period 3

Past News impact																			
	Australia	Austria	Belgium	Brazil	France	Canada	Germany	UK	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	TAIWAN	US
Australia	0.034	0.030	0.029	0.018	0.019	0.085	0.039	0.085	0.019	0.039	0.021	0.095	0.169	0.097	0.104	0.110	0.117	0.123	0.130
Austria		0.173	0.023	-0.013	0.010	0.033	0.035	0.003	0.008	0.059	-0.002	0.108	0.091	0.124	0.083	0.091	-0.002	0.110	0.221
Belgium			0.159	0.098	0.145	0.119	0.159	0.058	0.098	0.117	-0.002	0.110	0.089	0.154	0.064	0.089	0.019	0.085	0.151
Brazil				0.066	0.060	0.042	0.034	0.030	0.029	0.018	0.019	0.085	0.039	0.085	0.019	0.039	0.021	0.095	0.169
France					0.138	0.096	0.153	0.064	0.094	0.118	0.021	0.095	0.075	0.114	0.060	0.075	0.040	0.079	0.118
Canada						0.091	0.073	-0.012	0.051	0.102	0.040	0.079	0.034	0.091	0.045	0.034	0.030	0.084	0.139
Germany							0.137	0.032	0.037	0.102	0.030	0.084	0.065	0.121	0.057	0.065	-0.001	0.094	0.188
UK								0.159	0.003	0.050	-0.001	0.094	0.088	0.099	0.063	0.040	-0.034	0.108	0.249
Hongkong									0.117	0.075	-0.034	0.108	0.062	0.111	0.057	0.033	0.062	0.170	0.278
Indonesia										0.307	0.062	0.170	0.107	0.180	0.093	0.025	0.023	0.132	0.241
Argentina											0.079	0.090	0.049	0.075	0.043	0.018	0.024	0.138	0.252
Mexico												0.163	0.064	0.105	0.054	0.011	0.025	0.144	0.264
Japan													0.113	0.084	0.052	0.003	0.026	0.151	0.275
India														0.171	0.038	-0.004	0.028	0.157	0.287
China															0.084	-0.011	0.029	0.164	0.298
Singapore																-0.018	0.030	0.170	0.310
Switzerland																	0.031	0.176	0.321
Taiwan																		0.183	0.332
US																			0.171

Table-5 continued… Past Volatility impact																			
	Australia	Austria	Belgium	Brazil	France	Canada	Germany	UK	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan	US
Australia	0.80	0.71	0.76	0.81	0.81	0.78	0.76	0.81	0.79	0.65	0.78	0.77	0.84	0.78	0.87	0.84	0.81	0.79	0.77
Austria		0.80	0.77	0.83	0.77	0.81	0.78	0.77	0.83	0.66	0.83	0.79	0.84	0.83	0.85	0.82	0.77	0.83	0.89
Belgium			0.80	0.79	0.81	0.80	0.80	0.76	0.81	0.62	0.77	0.75	0.82	0.78	0.86	0.86	0.76	0.81	0.85
Brazil				0.89	0.81	0.87	0.82	0.82	0.93	0.72	0.82	0.81	0.86	0.87	0.89	0.85	0.82	0.93	1.04
France					0.82	0.85	0.82	0.80	0.76	0.68	0.81	0.82	0.85	0.81	0.85	0.86	0.80	0.76	0.72
Canada						0.86	0.79	0.83	0.85	0.68	0.78	0.80	0.80	0.76	0.81	0.62	0.80	0.83	0.87
Germany							0.82	0.83	0.83	0.70	0.78	0.87	0.82	0.82	0.93	0.72	0.80	0.84	0.88
UK								0.83	0.83	0.67	0.79	0.85	0.82	0.80	0.76	0.68	0.80	0.84	0.88
Hongkong									0.89	0.77	0.83	0.86	0.79	0.83	0.85	0.68	0.80	0.84	0.89
Indonesia										0.61	0.71	0.84	0.85	0.79	0.79	0.79	0.81	0.85	0.89
Argentina											0.81	0.82	0.80	0.83	0.83	0.83	0.81	0.85	0.90
Mexico												0.86	0.82	0.77	0.81	0.81	0.81	0.85	0.90
Japan													0.82	0.82	0.93	0.93	0.81	0.86	0.91
India														0.81	0.76	0.76	0.81	0.86	0.91
China															0.85	0.85	0.82	0.87	0.92
Singapore																0.83	0.82	0.87	0.92
Switzerland																	0.82	0.87	0.93
Taiwan																		0.88	0.93
US																			0.94

Table 6. Correlation coefficients for market returns: Period 3

	Australia	Austria	Belgium	Brazil	France	Canada	Germany	England	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan
Austria	-0.028																	
Belgium	-0.062	-0.043																
Brazil	0.011	0.033	0.011															
France	-0.053	-0.037	0.915	-0.006														
Canada	0.045	-0.064	0.264	-0.056	0.259													
Germany	-0.051	-0.007	0.019	0.000	0.008	-0.049												
England	0.001	0.021	-0.049	-0.057	-0.032	-0.038	-0.049											
Hongkong	0.013	-0.013	-0.046	0.028	-0.055	-0.077	-0.047	-0.009										
Indonesia	-0.0001	-0.114	-0.036	-0.034	-0.024	-0.047	-0.077	0.092	-0.015									
Argentina	-0.026	0.026	-0.018	0.031	0.001	0.020	0.025	0.058	-0.024	-0.013								
Mexico	-0.076	0.005	0.032	0.033	0.014	0.019	0.044	0.052	0.036	0.058	-0.027							
Japan	0.084	-0.023	0.050	0.022	0.062	0.026	0.028	-0.064	0.088	0.021	0.038	-0.030						
India	0.039	0.139	-0.087	0.088	-0.064	-0.029	0.020	-0.053	-0.022	-0.079	-0.023	-0.053	-0.097					
China	0.031	0.089	-0.049	0.012	-0.021	0.012	-0.020	-0.044	0.021	-0.092	0.020	0.009	-0.019	0.015				
Singapore	-0.034	-0.060	0.033	-0.042	0.035	0.056	0.014	0.036	0.028	-0.004	0.119	-0.060	-0.058	0.016	0.013			
Switzerland	0.009	0.041	0.166	0.020	0.146	-0.052	0.011	-0.037	0.028	0.016	-0.012	-0.001	0.026	0.013	-0.10	-0.037		
Taiwan	-0.016	0.051	0.052	0.044	0.087	0.024	-0.041	-0.015	0.008	-0.059	-0.023	-0.035	-0.058	0.100	-0.07	0.030	-0.010	
US	-0.016	0.051	0.052	0.044	0.087	0.024	-0.041	-0.015	0.008	-0.059	-0.023	-0.035	-0.058	0.100	-0.07	0.030	-0.010	-0.029

The correlation coefficients among the market return were low and negative in 48% cases. This again is significant for global investors. Even in integrated markets there is still some scope for portfolio diversification (Table-6).

DIAGONAL VECH ESTIMATION FOR PERIOD 4

Period 4 is characterized by post-crisis adjustments in the global stock market. As the markets plunged into crisis the news impact lost its vigor. The trend continued in the post-crisis era too. The past volatility impacts however remained positive. Own and cross coefficients values (ranging between 0.80 and 0.90) were significantly high and positive (Table-7).

Table 7. Past News and past volatility impact: Period 4

Past News impact																			
	Australia	Austria	Belgium	Brazil	France	Canada	Germany	UK	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan	US
Australia	0.148	0.121	0.112	0.122	0.117	0.110	0.113	0.098	0.128	0.128	0.138	0.102	0.127	0.128	0.117	0.110	0.113	0.117	0.128
Austria		0.161	0.123	0.117	0.109	0.107	0.115	0.118	0.132	0.137	0.156	0.113	0.135	0.137	0.109	0.107	0.115	0.109	0.137
Belgium			0.122	0.110	0.113	0.114	0.117	0.095	0.106	0.122	0.112	0.081	0.101	0.122	0.113	0.114	0.117	0.113	0.122
Brazil				0.141	0.111	0.107	0.092	0.092	0.099	0.117	0.119	0.094	0.121	0.117	0.111	0.107	0.092	0.111	0.117
France					0.116	0.112	0.116	0.085	0.121	0.117	0.132	0.099	0.124	0.117	0.109	0.109	0.094	0.109	0.117
Canada						0.110	0.107	0.095	0.107	0.116	0.120	0.085	0.119	0.116	0.108	0.109	0.089	0.108	0.116
Germany							0.117	0.097	0.126	0.128	0.120	0.089	0.120	0.128	0.107	0.109	0.083	0.107	0.128
UK								0.113	0.106	0.125	0.101	0.091	0.109	0.125	0.106	0.108	0.077	0.106	0.125
Hongkong									0.158	0.109	0.121	0.098	0.129	0.110	0.104	0.108	0.071	0.104	0.109
Indonesia										0.173	0.139	0.109	0.143	0.107	0.103	0.108	0.065	0.103	0.173
Argentina											0.185	0.119	0.164	0.114	0.102	0.108	0.059	0.102	0.136
Mexico												0.125	0.121	0.107	0.101	0.108	0.054	0.101	0.137
Japan													0.166	0.112	0.099	0.108	0.048	0.099	0.139
India														0.110	0.098	0.107	0.042	0.098	0.140
China															0.097	0.107	0.036	0.097	0.142
Singapore																0.107	0.030	0.096	0.143
Switzerland																	0.024	0.094	0.145
Taiwan																		0.018	0.147
US																			0.148

Table-7 continued… Past Volatility impact

	Australia	Austria	Belgium	Brazil	France	Canada	Germany	UK	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan	US
Australia	0.848	0.838	0.836	0.845	0.854	0.854	0.847	0.852	0.863	0.835	0.835	0.862	0.824	0.835	0.862	0.824	0.829	0.823	0.817
Austria		0.859	0.854	0.856	0.857	0.845	0.854	0.866	0.852	0.835	0.840	0.860	0.821	0.840	0.860	0.821	0.822	0.812	0.803
Belgium			0.884	0.862	0.881	0.888	0.878	0.861	0.860	0.840	0.855	0.888	0.850	0.855	0.888	0.850	0.860	0.857	0.855
Brazil				0.857	0.863	0.866	0.875	0.858	0.839	0.845	0.839	0.876	0.837	0.839	0.876	0.837	0.849	0.848	0.847
France					0.884	0.887	0.884	0.870	0.853	0.857	0.834	0.875	0.845	0.834	0.875	0.845	0.862	0.867	0.872
Canada						0.908	0.880	0.885	0.867	0.861	0.853	0.892	0.840	0.853	0.892	0.840	0.849	0.842	0.836
Germany							0.888	0.880	0.873	0.862	0.830	0.876	0.848	0.830	0.876	0.848	0.868	0.877	0.886
UK								0.906	0.868	0.855	0.838	0.884	0.848	0.841	0.833	0.826	0.818	0.811	0.804
Hongkong									0.858	0.847	0.854	0.854	0.863	0.840	0.864	0.804	0.768	0.745	0.722
Indonesia										0.839	0.857	0.857	0.852	0.840	0.863	0.782	0.718	0.679	0.640
Argentina											0.881	0.881	0.860	0.840	0.862	0.760	0.668	0.613	0.558
Mexico												0.891	0.839	0.839	0.861	0.739	0.618	0.547	0.476
Japan													0.853	0.839	0.859	0.717	0.568	0.481	0.394
India														0.839	0.858	0.695	0.518	0.415	0.312
China															0.858	0.673	0.468	0.349	0.230
Singapore																0.867	0.839	0.863	0.845
Switzerland																	0.853	0.852	0.840
Taiwan																		0.860	0.848
US																			0.826

Table 8. Correlation coefficients for market returns: Period 4

	Australia	Austria	Belgium	Brazil	France	Canada	Germany	England	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan
Austria	0.03																	
Belgium	0.07	-0.04																
Brazil	0.01	0.33	-0.07															
France	0.09	0.01	0.86	-0.08														
Canada	0.15	-0.04	0.44	-0.03	0.51													
Germany	0.12	0.05	0.66	-0.04	0.75	0.40												
England	-0.11	0.01	-0.02	-0.01	0.03	-0.08	-0.04											
Hongkong	0.44	-0.10	0.10	-0.09	0.14	0.05	0.11	-0.04										
Indonesia	0.04	0.01	0.12	-0.04	0.15	0.15	0.17	0.02	0.01									
Argentina	0.01	-0.08	0.04	0.12	0.08	0.06	0.08	0.04	0.03	0.21								
Mexico	0.13	-0.01	0.03	-0.03	-0.01	0.08	-0.06	0.06	0.21	-0.06	-0.11							
Japan	-0.01	-0.05	-0.04	0.09	-0.05	0.03	-0.01	0.00	-0.12	0.04	0.08	0.00						
India	-0.05	0.22	-0.03	0.05	-0.04	-0.09	-0.07	-0.05	-0.03	-0.04	-0.13	0.07	0.12					
China	-0.03	0.01	-0.07	-0.03	-0.07	-0.02	-0.07	0.05	-0.04	0.02	-0.02	0.08	-0.01	0.03				
Singapore	-0.06	0.04	0.07	-0.07	0.10	0.14	0.06	0.06	-0.03	0.04	0.01	-0.04	-0.01	0.00	0.01			
Switzerland	0.02	0.02	-0.15	-0.02	-0.19	-0.15	-0.11	0.06	-0.06	0.02	0.08	0.03	0.02	-0.04	0.06	-0.09		
Taiwan	0.10	-0.01	0.02	0.01	0.02	-0.03	0.09	0.02	0.12	0.01	-0.08	0.07	0.01	0.02	0.06	-0.01	-0.02	
US	0.05	0.66	-0.04	-0.04	0.09	-0.05	0.03	-0.01	-0.03	0.01	-0.07	-0.03	0.06	0.08	0.04	0.03	0.02	0.00

The correlation coefficients among the market returns were significantly low and negative in 41% cases. Hence, financial markets, although integrated in the aftermath of crisis still offer scopes for global portfolio diversification (Table-8).

DIAGONAL VECH ESTIMATION FOR PERIOD 5

Period 5 is the most recent phase in the aftermath of the crisis. The period is characterized by presence of significant volatility transmission channels in global market. Significantly positive own and cross news impact exists in 80% of the total cases. The past volatility impacts are more significant than the news impacts. All own and cross past volatility coefficients are significantly positive and are higher than the news coefficients. Thus, in the recent years, financial markets have become more integrated in terms of volatility transmission there by increasing the risk and probability of distress in the financial market and the risk of making financial investment (Table 9).

Table 9. Past news and past volatility impact: Period 5

Past news impact																			
	Australia	Austria	Belgium	Brazil	France	Canada	Germany	UK	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan	US
Australia	0.088	0.078	0.057	0.051	0.057	0.042	0.055	0.063	0.058	0.076	0.057	0.068	0.083	0.041	0.027	0.057	0.060	0.033	0.060
Austria		0.092	0.068	0.065	0.069	0.043	0.059	0.054	0.050	0.073	0.065	0.057	0.074	0.038	0.033	0.059	0.065	0.038	0.065
Belgium			0.093	0.062	0.089	0.066	0.087	0.057	0.043	0.081	0.067	0.057	0.086	0.049	0.030	0.073	0.050	0.044	0.050
Brazil				0.082	0.056	0.065	0.062	0.050	0.068	0.084	0.067	0.056	0.070	0.031	0.032	0.047	0.058	0.040	0.058
France					0.095	0.067	0.090	0.064	0.047	0.083	0.073	0.065	0.081	0.052	0.040	0.071	0.052	0.047	0.052
Canada						0.091	0.076	0.060	0.036	0.067	0.059	0.062	0.073	0.035	0.037	0.066	0.045	0.038	0.045
Germany							0.092	0.064	0.044	0.068	0.059	0.071	0.077	0.036	0.031	0.071	0.067	0.030	0.067
UK								0.099	0.045	0.080	0.072	0.060	0.079	0.042	0.034	0.069	0.105	0.038	0.068
Hongkong									0.063	0.060	0.053	0.049	0.069	0.044	0.019	0.047	0.037	0.045	0.057
Indonesia										0.063	0.060	0.053	0.049	0.069	0.044	0.019	0.047	0.037	0.057
Argentina											0.149	0.095	0.084	0.104	0.055	0.042	0.086	0.078	0.059
Mexico												0.109	0.065	0.083	0.056	0.044	0.072	0.074	0.052
Japan													0.098	0.082	0.052	0.023	0.067	0.061	0.048
India														0.131	0.064	0.057	0.076	0.082	0.063
China															0.057	0.023	0.044	0.049	0.031
Singapore																0.037	0.036	0.035	0.028
Switzerland																	0.101	0.071	0.043
Taiwan																		0.100	0.026
US																			0.019

Table-9 continued… Past volatility impact																			
	Australia	Austria	Belgium	Brazil	France	Canada	Germany	UK	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan	US
Australia	0.919	0.907	0.891	0.898	0.898	0.899	0.898	0.908	0.921	0.878	0.885	0.911	0.866	0.927	0.928	0.899	0.889	0.922	0.866
Austria		0.912	0.894	0.901	0.889	0.893	0.898	0.886	0.921	0.875	0.879	0.894	0.865	0.913	0.920	0.893	0.889	0.914	0.865
Belgium			0.891	0.885	0.899	0.907	0.906	0.885	0.908	0.865	0.866	0.891	0.857	0.917	0.924	0.892	0.871	0.909	0.857
Brazil				0.890	0.887	0.903	0.892	0.883	0.911	0.862	0.874	0.892	0.861	0.903	0.919	0.894	0.893	0.906	0.861
France					0.898	0.909	0.905	0.893	0.900	0.863	0.873	0.895	0.849	0.908	0.908	0.900	0.874	0.902	0.849
Canada						0.916	0.903	0.905	0.912	0.877	0.875	0.908	0.865	0.918	0.931	0.902	0.886	0.916	0.865
Germany							0.908	0.896	0.908	0.865	0.882	0.892	0.865	0.911	0.919	0.897	0.882	0.915	0.865
UK								0.917	0.916	0.872	0.876	0.897	0.860	0.913	0.918	0.908	0.903	0.913	0.860
Hongkong									0.935	0.891	0.886	0.912	0.882	0.928	0.931	0.906	0.889	0.932	0.882
Indonesia										0.871	0.857	0.873	0.841	0.894	0.898	0.873	0.862	0.891	0.841
Argentina											0.874	0.874	0.841	0.895	0.904	0.876	0.865	0.896	0.878
Mexico												0.910	0.862	0.912	0.915	0.893	0.882	0.917	0.875
Japan													0.835	0.881	0.893	0.860	0.852	0.872	0.865
India														0.943	0.939	0.913	0.908	0.935	0.862
China															0.950	0.922	0.914	0.946	0.863
Singapore																0.908	0.889	0.913	0.877
Switzerland																	0.890	0.898	0.865
Taiwan																		0.942	0.872
US																			0.891

Table 10. Correlation coefficients for market returns: Period 5

	Australia	Austria	Belgium	Brazil	France	Canada	Germany	England	Hongkong	Indonesia	Argentina	Mexico	Japan	India	China	Singapore	Switzerland	Taiwan
Austria	0.031																	
Belgium	-0.011	-0.011																
Brazil	-0.023	0.150	0.006															
France	-0.008	0.015	0.920	0.005														
Canada	-0.035	-0.030	0.152	0.040	0.163													
Germany	-0.004	0.021	0.508	-0.019	0.523	0.210												
England	-0.003	-0.001	-0.037	0.028	-0.021	-0.018	-0.020											
Hongkong	0.174	-0.070	0.015	0.006	0.005	0.012	0.004	0.033										
Indonesia	0.043	0.034	0.016	0.017	0.019	-0.021	0.031	0.007	-0.042									
Argentina	0.019	0.002	0.003	-0.024	-0.008	0.002	0.046	-0.002	0.070	0.023								
Mexico	-0.007	0.008	0.053	0.034	0.042	0.050	-0.009	0.048	0.094	-0.055	-0.017							
Japan	0.019	0.020	0.027	0.071	0.013	0.044	0.043	0.052	0.038	-0.010	0.059	0.008						
India	0.022	0.032	0.024	-0.032	0.028	-0.006	0.010	0.022	-0.009	0.024	0.001	-0.070	-0.049					
China	-0.014	-0.048	0.006	0.003	-0.010	-0.021	0.039	0.040	-0.002	-0.062	0.044	0.014	0.062	-0.004				
Singapore	-0.013	-0.003	0.147	-0.003	0.137	0.091	0.126	0.036	-0.006	-0.018	-0.038	0.006	0.005	0.066	0.038			
Switzerland	-0.024	-0.009	-0.030	0.001	-0.047	-0.014	-0.071	0.145	-0.028	0.014	0.002	0.030	0.063	0.045	0.030	0.015		
Taiwan	0.020	-0.017	0.056	0.051	0.058	0.001	0.052	0.006	-0.013	-0.038	-0.002	-0.002	0.042	0.066	0.056	-0.022	-0.012	
US	-0.007	0.008	0.053	0.034	0.042	0.050	-0.009	0.032	0.024	-0.032	0.028	-0.006	0.010	0.022	-0.009	0.010	0.022	-0.009

The correlation coefficients among market returns however, are generally low and negative for 37% cases. Thus, while the risk of investment is substantially higher, the period still offers some scope for diversification.

SPILL OVER AMONG INTEGRATED MARKETS OVER THE PHASES – A SUMMARY

The study thus far reveals some significant trends in the global market. It considered five sub-phases around the last two significant global financial crises. As the world was approaching the dot-com crisis, there were no significant volatility transmission channels. However, as they were moving towards the second crisis, the markets started becoming more integrated. While the cross news effects were not significant, the own news effect became so. The past volatility coefficients were somewhat significant. Similar results were obtained for the third and the fourth periods. During the more recent years when the global market has pulled itself out of the crisis and has entered a new era of fluctuation and instability, the markets have become more integrated. The innovation as well as volatility effects are all strong and significantly positive. The news impacts, however, have always been less than the past volatility impacts. With increasing integration in the global financial market, there is still a basis for global portfolio diversification. This is evidenced by the low and mostly negative correlation coefficients among the market returns. The study now moves on to consider the possibilities of global portfolio diversification over the different phases.

GLOBAL PORTFOLIO DIVERSIFICATION AROUND THE CRISES

The standard portfolio-construction theory asserts that different types of financial assets have unique risk-return profiles making them respond differently to different economic events and cycles. The idea of combining various asset classes, each with distinct attributes, is the basis for building a diversified portfolio. A rational, risk-averse investor aims at selecting a "perfect" portfolio constituted of low-risk assets providing high return. For a global investor the appropriate choice of global assets is crucial. In selection of 'perfect' portfolio, however, mere consideration of the risk-return profile of assets is not sufficient (Markowitz, 1952). One might follow the basic rule that *one should not put all the eggs in one basket* and be prone to reduce investment risks by combining more than one stock. The risk of such diversified portfolio will of course be less than the risk inherent in holding single, individual stocks (provided the risks of the various stocks are not positively related). Effective investment, however, does not mean either picking or combining stocks at random: the combination of stocks indeed matters. Theoretically, risk associated with individual stock returns may be decomposed into two: (i) the non-diversifiable market risks and (ii) the unique risk specific to individual stocks that can be diversified by increasing the number of stocks in the portfolio. For a well-diversified portfolio, individual stock risks add very little to portfolio risk. Instead, it is the correlation between individual stocks' return that determines overall portfolio risk.

While selecting global portfolio an investor is assumed to allocate his wealth among different stock indexes to minimize the portfolio risk. Stated alternatively, he attaches weights to different assets in a portfolio such that the portfolio variance is minimized. Hence, The minimum variance portfolio $X = (X_1, X_2, \ldots, X_n)'$ in an n-asset case solves the constrained minimization problem:

$$\min_{X_1, X_2, \ldots X_n} \sigma_{PF}^2 = X_1^2\sigma_1^2 + \cdots + X_n^2\sigma_n^2 + 2\sum_{i,j} X_i X_j \sigma_{ij}$$

Such that $X_1 + X_2 + \ldots + X_n = 1$

The study allows short-selling. Short-selling involves selling of a stock that a seller does not own now, but promise to deliver in future. Short-selling might invite troubles in a distressed market. People want to short sell in anticipation of a profit that will be rendered by decreasing prices in future. If, however, everybody wants to short-sell, expectations would be self-fulfilling leading to a crisis.

Optimum portfolio weights in different phases are shown in table 11.

Table 11. Optimum portfolio weights: Phase 1-5

	Phase1		Phase2		Phase3		Phase4		Phase5	
	weight	Return	weight	return	weight	Return	weight	Return	weight	Return
Argentina	0.01	0.00001	0.01	0.0007	0.08	-0.0001	0.006	-0.002	0.006	0.0016
Australia	0.10	0.00012	0.08	0.0003	0.08	0.0003	0.002	-0.002	0.002	0.0003
Austria	0.06	-0.00001	0.10	0.0008	0.05	0.0002	0.003	-0.001	0.003	0.0003
Belgium	0.09	-0.00004	0.05	0.0002	0.08	0.0001	0.005	-0.001	0.005	0.0003
Brazil	0.01	0.00000	0.02	0.0005	0.04	0.0026	-0.002	-0.002	-0.002	0.0002
Canada	0.09	0.00008	0.09	0.0001	0.08	0.0000	0.019	-0.002	0.019	0.0003
China	0.06	0.00002	0.07	-0.0003	-0.03	-0.0001	-0.012	-0.001	-0.012	-0.0001
France	0.05	0.00001	0.01	-0.0001	0.07	0.0005	0.006	-0.001	0.006	0.0002
Germany	0.06	0.00004	0.03	-0.0002	0.04	0.0016	0.000	-0.001	0.000	0.0005
HongKong	0.02	0.00001	0.05	0.0000	0.07	0.0019	0.012	-0.003	0.012	0.0002
India	0.03	0.00000	0.04	0.0004	0.06	0.0000	-0.007	-0.001	-0.007	0.0007
Indonesia	0.01	0.00001	0.05	0.0004	0.04	0.0009	0.003	-0.002	0.003	0.0010
Japan	0.04	0.00005	0.04	-0.0001	0.04	0.0006	0.006	-0.001	0.006	0.0004

Mexico	0.02	-0.00002	0.04	0.0006	0.04	0.0009	-0.002	-0.001	-0.002	0.0006
Singapore	0.04	0.00002	0.07	0.0001	0.10	0.0002	0.029	-0.003	0.029	0.0003
Switzerland	0.08	0.00001	0.06	0.0001	0.09	0.0003	0.002	-0.002	0.002	0.0003
Taiwan	0.05	-0.00001	0.02	-0.0002	0.05	0.0004	-0.002	-0.002	-0.002	0.0005
UK	0.07	0.00002	0.07	-0.0001	0.03	0.0012	0.006	-0.001	0.006	0.0004
US	0.10	0.00012	0.11	0.0006	0.04	0.0005	0.000	-0.001	0.000	0.0004

During phase-1, as the economy approached the dot-com crisis, investor's optimum choice was not to use short-selling. The portfolio return and variance were 0.000318 and 0.000013 respectively. In the portfolio selection, there was no regional bias. Positive portfolio weights in phase-2 reveal non-desirability of short-selling. Once again, there is no regional pattern in investment and the portfolio return and variances are 0.0002 and 0.000008 respectively. Choice and pattern in phase-3 with no short-selling and regional bias, is similar to that in phase-2. Portfolio expected return was 0.0005 and variance was same as that in phase-2. Crisis period (phase-3) was characterized by negative individual market returns and short-selling in some cases. This is natural, as crises are often characterized by short-selling. Any regional bias, however, is still absent. Finally, in recent years, some of the assets are short-sold. The regional bias is still absent but now the individual market returns are positive.

Analysis of optimum portfolio selection over the five phases reveals no significant common trends. However, with increasing financial integration, the desirability of short-selling has increased that is likely to increase investment risk. One distinct trend however, is perceptible. The optimum choices remain unchanged over the last two phases that followed the financial melt-down of 2007-08. Thus, the nature and implications of the two crises, in terms of volatility transmission mechanism as well as portfolio choices, have been different for investors. This is perhaps because the dot-com crisis was confined only to those who

transformed themselves from a traditional old-economy to a knowledge-based ‘new’ one. This crisis was not truly global by nature. The financial melt-down of 2007-08 was truly global with acute devastating impact on the rest of the economy. This difference in the nature of the two crises perhaps is reflected in the trends in global market and in optimum investment choice.

CONCLUSION AND FURTHER ISSUES TO EXPLORE

The present study focused on the two past significant stock-market crises namely, the dot-com bubble and the global melt-down of 2007-08. Around the five sub-phases the study found significant volatility transmission channels primarily through past-volatility impacts. In recent era of fluctuation and instability, the stock-markets have become more integrated where innovation and volatility impacts are strong and significantly positive. The news-impacts, however, are always less intense than past-volatility impacts. Moreover, even with increasing financial integration, there remains a basis for global portfolio diversification.

Such volatile and intertwined global stock-market reveals further research opportunities, particularly into its intrinsic nature. Fluctuations and crashes might well be manifestations of the inherent instability or at best, the knife-edge stability of the global market. Fluctuation might be endogenous to the system, rather than aberration and markets might be characterized by non-periodic limit cycles. Hence, no external shock will be required to gear financial crisis at regular intervals. And, with financial integration, crisis will reverberate across the globe in no time. At this juncture the issue of the possible chaotic nature of stock markets gains analytical significance. Macroeconomists and financial economists often hail that stock markets are governed by nonlinear, particularly by the chaotic dynamics. And, it is this chaotic behavior that could possibly explain the market fluctuations, bubbles and crashes.

A chaotic system is inherently deterministic but appears random. In a chaotic framework, there is no stable equilibrium from which deviations (triggered exclusively by external shocks) will be self-correcting. The system follows non-linear dynamics where fluctuations are self-generating and would never die down. More specifically, a chaotic series is characterized by the presence of strange attractor. By definition, an attractor is a state that defines equilibrium for a specific system. This perception of equilibrium however is different from that which is described in economics. An attractor is the level to which a system reverts after absorbing the shocks. With a chaotic attractor, cycles exist but are only of non-periodic nature. Hence, the notion of equilibrium applies to a region, and not to a particular point or orbit. Equilibrium is essentially 'dynamic'. This is in contrast to the notion of equilibrium defined in Economics where a system converges to equilibrium (a point attractor) or varies around equilibrium in a periodic fashion (a limit cycle). Therefore, a linear framework explains oscillations and non-oscillations under which the system is stable or explosive. A non-linear system, however, is an irregular oscillatory process sensitive to an initial condition. This particular ability of a chaotic system to capture abrupt changes in volatility and sporadic movements has attracted the attention of the analysts interested in explaining the movements in financial markets. This is particularly because in reality, most financial time series are indeed non-periodic. The sensitive dependence on initial condition (SDIC) of a non-linear process makes it more appealing to the financial economists. With SDIC history matters, having further implication for a financial market as it puts the Efficient Market Hypothesis (EMH) on trial. With EMH invalidated investment strategies such as trend analysis, market timing, value investing and tactical asset allocation work well, while portfolio insurance strategies, Capital Asset Pricing Model and most option-pricing theories break down. Moreover, the traditional econometric techniques often cannot capture the irregular cycles of a chaotic market. The dynamic nature of stock-market equilibrium necessitates modifications in the class of models based on static

mean reversion. But, even with a dynamic quantitative technique, it would be unwise to predict future movements because long-term economic forecasting is no longer feasible. The short-term however, could be predicted accurately. Further, mistaking a non-linear system to be a linear will have severe policy implications. A policy prescription based on a pre-supposedly linear system and executed on an inherently non-linear one might have devastating and unpredicted impacts. Hence, exploration of the stock-market dynamics in light of the recent financial crisis might involve exploration into the possible chaotic nature of the global stock markets. This opens up a new avenue for further research.

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KEYWORDS DEFINED

Global stock-market: The world-wide stock market constituted of all or major regional stock markets.

Financial melt-down: A collapse in financial market leading to steep fall in stock price, decline in asset value, loss of wealth with ultimate devastating impact on the rest of the economy.

Internet bubble: The irrational exuberance of 1999-2000 about the Internet Stocks leading to their overvaluation.

Financial integration: The interconnection among the financial markets.

Portfolio diversification: Investing in a number of stocks so as to reduce the risk of investment.

Multivariate GARCH: A GARCH family model that allows the variance-covariance matrix of the relevant variable to vary over time.

Volatility transmission: The mechanism through which volatility of the core spills over to territories.