

## Volatility and Co-Movement Models: A Literature Review and Synthesis

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### Abstract

This paper reviews literature on volatility and co-movement models applied to Global and Indian Financial Markets. The study examines different econometric methodologies applied to investigate volatility and co-movement specifically for studying sector indices. The study covers several methods such as ARCH family models including GARCH, E-GARCH, GJR-GARCH, VAR models, vector error correction models, impulse response functions, and variance decomposition methodologies. Further, Granger-Causality tests as applied to financial variables are reviewed this paper.

Keywords: Volatility co-movement, GARCH models, Granger-Causality, VECM.

### 1. Introduction

Markets are relatively calm and less volatile until early nineties in India. There used to be controller of capital issues which used to fix the public offer prices. Detailed regulations are placed on the functions of markets. Volatility of stock prices exchange rates, interest rates was usually quite small. The financial reforms after 1991 changed this scenario quite drastically. Complex financial instruments, like futures and options, free pricing of securities, access to global capital markets and aggressive financial intermediaries and institutional investors changed the landscape of Indian financial markets

Volatility is a characteristic of financial markets. Investors normally want to grow their portfolios. But investors like that growth from steady capital appreciation. There is a tendency on behalf of investors to equate volatility with risk and risk with loss. Volatility is the movement of stock prices both up and down.

### Stock market volatility

Volatility plays an important role in several financial market applications such as option pricing, risk management. The Black-schotes option pricing model has the volatility of the underlying asset as one of the inputs in the formula itself.

Volatility is the tendency for the prices to change unexpectedly (Harris 2003) However not all volatility is bad Researchers differentiate between two types of volatility namely fundamental volatility, transitory volatility. Transitory volatility can be attributed to trading activity by uninformed traders. Fundamental volatility can be attributed to unanticipated changes in financial instrument values. The difference between the two is important for traders, portfolio managers and regulators. Market participants generally measure total volatility by using variances (or) standard deviations. The variance of a series can be measured as the average squared difference between the series values and its average. Standard deviation is the square root of variance. Market participants are attentive to volatility because it brings both profits and losses. Regulators are alert to volatility because liquidity may get affected in highly volatile markets. There are several regulatory responses to extreme volatility like trading halts, circuit brakers, changes in margin requirements, modifications to position limits etc. Investors in financial markets aspire to make profits without taking excessive risk. After purchasing financial assets if the price goes up positive revenue will be generated. A successful investor pursues maximum revenue with a given initial capital which is termed as return. Empirical research examines return series rather than price series because asset

returns exhibit more stable statistical properties. Researchers use log returns also called continuously compounded returns.

The following presents a review of empirical studies on various issues of stock market volatility, co-movement models in India and the world. Section 2.1 examines the literature on volatility studies in the global context. Section 2.2 reviews the literature on volatility studies in the Indian context. Section 2.3 examines the studies on co-movement models in the global context where as section 2.4 reviews the studies on co-movement models in Indian context.

**2. Review of different studies**

**2.1 Studies on Stock Market Volatility Other than India**

**Table 1: Studies on Stock Market Volatility Other than India**

Author/s	Data set	Econometric methodology/ models	Findings/Conclusions
Hamao, etal (1990)	Daily opening and closing prices of major stock indexes for Tokyo, London and Newyork stock markets	ARCH family of statistical models	Evidence of price volatility spillovers from Newyork to Tokyo, London to Tokyo and Newyork to London is observed, but no price volatility spillover effects in other directions are found for the pre-october 1987 period.
Turner and Weigel (1992)	Daily S & P and DawJones closing index prices from 1928 through 1989	Standard deviation, Parkinson (1980), Garman and Class (1980) estimators, Inter quartile range	Entrance return days occur, on average following substantial losses in the previous days, and jumps in stock prices are inter temporally clustered. There is roughly a 50/50 chance of extreme - return days following a large jump to be of the same sign.
LeBaron (1992)	S&P daily, weekly, value-weighted, weekly returns for IBM stock	GARCH with an AR(1) component correlation differences, GARCH exponential AR Model	Found that serial correlations are changing over time and are related to stock return volatility. An extension to GARCH model is proposed and estimated.
Karolyi (1995)	Daily stock market Indexes for S&P 500 and TSE 300	Bivarate GARCH model Maximum likelihood techniques	Inferences about the magnitude and persistence of return innovations that originate in either

			market
Mookergea & Yu (1995)	Data for Shanghai and Shenzhen exchanges	Descriptive study, Basic statistical methods	China's newly established stock markets in Shanghai and Shenzhen have experienced explosive growth. Inadequacies in their institutional and structural makeup. Reason for inefficiency in China's equally thin markets are market thinning, stock supply problem, shortage of expertise, lack of adequate infrastructure both physical and legal.
Jorion & Goetzmann (1999)	Database of capital appreciation indexes for 39 markets going back to 1920s.	Compound t-test Event studies	Financial archaeology involves digging through reams of financial data in search for answers. Global capital markets have been systematically subject to dramatic changes over this century.
Aggarwal, et al (1999)	Daily closing values for S&P 500, NIKKEI, FT100, DAX, Hangseng, Singapore straits and other international indices for the 10-year period May 1985 - April 1995	Iterated cumulative sums of squares (ICSS) algorithm	The October 1987 crash is the only global event during the period 1985-1995 that caused a significant jump in the volatility of several emerging stock markets.
Beran and Ocker (2001)	19 nominal stock market closing indexes for the period January 1, 1992 to November 10,	SEMIFAR Model	The estimates indicate that there is long memory in the volatility of stock market indexes, either in the form of local deterministic trend (for the developed markets

	1995		and some (merging markets) or in the form of long-range dependence in the stochastic component (for the emerging market and small developed markets) resulting in local spurious trends
Andreou & Ghysles (2002)	Daily data from stock and FX markets. Four international stock market return indices; FTSE, Hongsens, NIKKEI and S&P 500 during 4/1/1989 - 19/10/2001	Structural break tests -ARCH and SV type of processes	The results find multiple breaks associated with the Asian and Russian financial crises. Volatility dynamics of asset returns. Changed in the samples prior & post breaks.
Onyeaso and Rogers (2004)	Daily closing prices for small cap 600 stock price Index from January 3, 1995 to August 19, 2002	Econometric models TGARCH ARCH GARCH	Hypothesis of the proposition that the volatility of small cap 600 is not predictable is rejected
Maysami, etal (2004)	Monthly data from November 1996 to November 2000	Johansen's (1988) Vector Error Correction Model (VECM)	Existence of long run co integrating relationship both between the US and Singapore electronic sectors in general and more specifically among the three dually listed stock under consideration
Rawashdeh & Squalli (2006)	Four sectors of the Amman stock exchange daily sectoral indexes between 1992 and 2004	Variance ratio and Runs test	Study finds that random walk and weak form EMH is rejected for all sectors. It is found that returns fit a mean-reverting process which may suggest abnormally

			high volatility, other inflated stock prices and frequent market corrections from a bubble effect.
Bhar and Nikolova (2007)	Index returns over the period January 1995 to December 2004 for BRIC Economics	Two stage GARCH in mean approach (GARCH-M) specified by Liu and Pan (1997)	China is the only country where there exists a negative relationship between volatility spillover effects on a regional and global basis. This suggests existence of di-verification opportunity for investment manages.
Olowe and Ayodeji (2009)	Daily returns over the period 4 January 2004 to March 2, 2009	EGARCH-in-mean model	Nigerian stock market returns show that volatility is persistent and there is a leverage effect. The study found little evidence open the relationship between stock returns and risk as measures by its aim volatility.
Neokosmidis (2010)	Six years data for four US stock indices i.e., DOWJONES, NASDAQ, NYSE, S & P500	ARCH, GARCH (1, 1), EGARCH (1, 1) Multivariate volatility models such as DVEC(1, 1)	The study concludes that EGARCH model is that best fitted process for all the sample data based on AIC minimum criterion. It is observed that there are high volatility periods at the beginning and at the end of our estimation period for all stock indices.
Priyadarshani (2011)	Weekly stock market data of Australia, Singapore, UK, US for the period from Jan 1992 to June 2010	MGARCH Model, Diagonal BEKK model and GARCH techniques	Positive return spillover effects are only unidirectional and run from both US and UK (the bigger markets) to Australia and Singapore (the smaller markets). Shocks arising from the US market can impact on all of the other markets in the

			sample.
Kouki, etal (2011)	5 sectors daily data covering period from January 01, 2002 to October 10, 2009	VAR Framework one lag, BEKK (1, 1) model	International financial markets are not integrated in all the sectors. Results find that three highly integrated sectors; bank, real estate and oil.
Koutmos (2012)	Shanghai stock exchange Ten industries sector indices daily data ranging from Jan 9, 2009 to June 15, 2012	Volatility estimation AR(1) EGARCH (1, 1)	Time varying beta risk of industry sector indices in Shanghai stock exchange Results show that industries betas respond positively to rises in such non diversifiable risk. Reports on the volatility persistence of the various industry sectors and identifies which industries have high & low persistence.
Li & Wang (2013)	China stock indices, six industry indexes, January 2006 to June 2012	ARMA - GARCH Model, GARCH (1, 1), TGARCH (1, 1), EGARCH (1, 1)	The paper examined the leverage effect and information a symmetry. Both ARCH and GARCH models can explain volatility clustering phenomena and have been quite successful in modeling real data in various applications.

2.2 Studies an Indian Stock Market Volatility

Table 2: Studies an Indian Stock Market Volatility

Author/s	Data set	Econometric methodology/ models	Findings/Conclusions
Shah & Thomas (1998)	Methodology paper	-Tracking error -Liquidity measurement -Index auto correlation	- Proposes methods where liquidity influences index construction -Liquidity generates noise in index, increases the tracking error experienced by index funds.
Biswal & Kamaiah (2001)	Monthly data from 1991 : 1 through 1998 : 12	Unit root test, Perron Technique, Regression with dummy variables	Indian stock market grew and became more liquid after liberalisation. In respect of volatility the market had not exhibited any significant changes.
Kumar, K.K & Mukhopadhyay. C (2002)	Intra-daily data of 1999-2001 period	-Correlation -Granger causality -GARCH models	-Granger causality results indicate unidirectional G-causality running from US stock markets to Indian stock market. -Previous day's day time returns of both NASDAQ composite and NSE NIFTY have significant impact on the NSE NIFTY over night return of the following day.
Kaur (2004)	Data period from January 1993 to March 2003 Daily returns of Sensex & NIFTY	ARCH GARCH models Box-Jenkuis Methodology Unit root tests	-Volatility in Indian stock market exhibits auto correlation and negative a symmetry in daily return. -No conclusive evidence of the existence of aggregate market level sympathy between US and

			Indian markets
Pandey (2005)	During 1999-2001 High frequency data set of five minute returns	-Traditional volatility estimators -Extreme value volatility estimators -Conditional volatility model -Implied volatility GARCH EGARCH	-Results indicate that while conditional volatility models perform well in estimating volatility for the past in terms of bias, extreme value estimators based on observed trading range perform well on efficiency criteria.
Biswas (2006)	Yearly data from 1991 to 2005	Volatility Return Calculations	Expansion of the Indian stock market in the post-liberalisation period is impressive. But trading has become increasingly concentrated in some sectors and companies.
Singh, etal (2008)	Fifteen world indices including an Indian market index	AR-GARCH, bivariate VAR, Multivariate GARCH (BEKK) model	There is significant positive volatility spillover from other markets to Indian market, mainly from Hong kong, Korea, Japan and Singapore and US market. Indian market affects negatively the volatility of US and Pakistan
Joshi (2010)	Daily closing price from 1 <sup>st</sup> January 2005 to 12 <sup>th</sup> May 2009	-BDS Test -ARCH-LM test -GARCH (1, 1) model	Persistence of volatility is more than Indian stock market
Tripathy & Gil-Alana (2010)	Daily OHLC values of NSE index returns from 2005-2008	Five models 1) Historical/rolling window moving average estimator 2) EWMA 3) GARCH models 4) Extreme value indicators	- A GARCH and VIX models, proved to be the best methods - Extreme value models fail to perform because of low frequency data



		5) Volatility index (VIX)	
Dhanaiah, etal (2012)	Daily data of NIFTY & India VIX covering March 2009 to November 2011	OLS Regression method	- Inverse relationship between movements in India VIX and NIFTY - Asymmetric nature of volatility Index – market return relationship
Mahesh Chandra (2012)	Daily return of BSE and NSE stock indices	ARFIMA, FIGARCH models -Long memory	-Absence of long memory in return series of the Indian stock market -Strong evidence of long memory in conditional variance of stock indices -Long memory property of BSE is revealed to be stages than NSE
Shanmuga Sundaram Benedict (2013)	Daily data of six indices from 01/01/2004 to 30/04/2012	Two sample t-test one way ANOVA	There is no difference in the standard deviation among various sectoral indices There is a significant difference in the mean scores of various time intervals.
Purohit, etal (2014)	Daily closing data from November 2014 for NIFTY, NIFTY Junior	-ADF Test -Johansen’s co-integration test -GARCH (1, 1) model	-Empirical results found that one month futures do not bring volatility in the VIX. It’s NIFTY index that brings volatility in VIX
Shalini (2014)	Daily data of sectoral indices for the period of January 2001 to June 2014	ARMA (1, 1) GARCH (1, 1)	-Return of the BSE sectoral indices exhibit the characteristics of normality, stationarity and hetero skedasticity

Joshi (2014)	Daily sensex data from January 1, 2010 to July 4, 2014	GARCH (1, 1) EGARCH (1, 1) GJR-GARCH (1, 1) -RMSE, MAE, MAPE, TK	-Stock market exhibits the persistence of volatility, mean reversion behavior and volatility clustering. -The results show the presence of leverage effect implying impact of good and bad news is not name
Sarkar & Verma (2016)	Select indices of NSE over a period of fifteen quarters. Daily data from April 1, 2012 to December 31, 2015	Kruskal-Wallis ANOVA by Ranks Test	Significant differences in volatility between broad market index and one or more sectoral indices in every quarter. Volatility also differs away the sectoral indices
Guha, etal (2016)	Monthly closing prices of all sectoral indices of NSE from January 2004	-Regression methods -Beta -Factor analysis	-Sectors having higher sensitivity are Realty, Metal and IT -Defensive sectors are FMCG, Pharma & Auto

2.3 Global studies on Co-movement

Table 3: Global studies on Co-movement

Author/s	Data set	Econometric methodology/models	Findings/Conclusions
Hilliard (1979)	Daily data during July 7, 1973 to April 30, 1974 of International equally market indices	Spectral analysis Cramer decomposition theorem	While Intra-continental prices tend to move together, Inter-continental prices were independent
Karolyi and Stulz (1996)	Transactions data from 1988 to 1992	GARCH (1, 1) model	Large shocks to broad based market indices (NIKKEI and S&P 500) Positively impact both the magnitude and persistence of the return correlations
Copeland and Copeland (1998)	Daily returns between 1992 and 1997 of region (the Americas, Europe and the Pacific) by Country and by Industry	Lead-lag relationship, OLS regressions	Strong contemporaneous relationships among regional exchanges that is open at the same time. Americas lead Europe and the Pacific by one day
Metin and Muradoglu (2001)	Stock returns of 16 emerging markets from three continents and three world leaders from those continents. Weekly observation covering Dec 29, 1988 to Jan 29, 1998	ADF tests Engle - Granger (1987) two step procedure ECM and VAR models	This paper, the degree of market integration is investigated in order to forecast national markets according to their international co-movements
Wassal (2005)	Monthly data of stock returns in 12 emerging economics from 1988 to 2000	Johanson co-integration and Granger causality tests	Long run relationship between stock market liquidity and size and real activity, privatization and stock returns in five countries. (India, Korea, Malyasia, Philippines and

			Zimbabwe)
Phylaktis and xia (2009)	Sector returns for a set of 29 countries grouped into three regions- Europe, Asia and Latin america during 1990-2004	Two-factor asset pricing model, GARCH model	This paper takes an asset pricing approach to examine the equity market co-movement and contagion. The results confirm the sector heterogeneity and contagion. There are sectors which can provide a channel for international diversification benefits.
Kasibhatla, etal (2006)	European equality markets - London (FTSE 100), Frank first (DAX 30) and Paris (CAC40)	Co-integration and Vector Error Correction Methodology	Presence of one co-integrating vector and two common trends. CAC index is found to be weakly exogenous
Cheng, etal (2007)	Monthly data for the period from March 1974 to Febraury 2005	Granger causality, Error-correction models Dickey-Fuller and Philipps-perron tests	No causal relationship between consumer prices and exchange rates. Results suggest that exchange rates have Granger caused wholesale prices for all four US trading partners and considerable evidence that the opposite is true for Canada and Japan
Greenwood (2008)	298 stocks that were present in the index for at least 200 days between 1 september 1993 and 29 August 2003	Returns, Univariate time series regressions	Strong positive relationship between overweighting and the co-movement of a stock with other stocks in the NIKKEI index and a negative relationship between index overweighting and co-movement with stocks outside of the index

<p>Maggiara and Skerman (2009)</p>	<p>8 year (April 2001-April 2009) daily closing prices of the S/P 500, FTSE 100, DAX 30, CAC40, OMX30 indices</p>	<p>Co-integration analysis using the Johansen method on 3 different sample periods</p>	<p>Evidence of one co-integrating vector in the 2 and 8 year samples while the 4 year data gave mixed results. Findings suggest that the economic shock (Global Financial Crisis) of 2007 and onwards may have affected the results. The study concludes that there are little diversification benefits between the markets studied in the long term, but see possible opportunity for excess return in the short term.</p>
<p>Sohail Hussain &amp; (2009)</p>	<p>Monthly data from December 2002 to June 2008</p>	<p>VECM Analysis Variance decomposition</p>	<p>Results show a negative impact of CPI on stock index, returns, while industrial production index, real effective exchange rate, money supply had a significant positive effect on the stock returns in the long term.</p>
<p>Maniya and Magnnsson (2010)</p>	<p>Five international stock indices: S&amp;P 500, NIKKE 225, KSE 100, BSE 30, Hang seng. Daily closing Index levels and data from 4 January 1989 to 30 December 2009</p>	<p>ARCH, GARCH models GARCH-BEKK model correlation, unit root tests, granger-causality test</p>	<p>This study compared correlation in the 20 year period into 3 sub periods namely the Dotcom crisis (1992-2002), the Bullish period (2004, Mid 2007) and the financial crises (mid 2007 - mid 2009). Time varying correlation increases in bearish spells whereas bullish periods do not have a big "Statistical" impact on correlation.</p>
<p>Princ (2010)</p>	<p>Daily returns of Prague stock exchange Index and other 11 major stock indices during 1994 to 2009</p>	<p>DCC-MVGARCH model of Engle (2002)</p>	<p>The study found an existence of increasing trend in conditional correlations among a whole European region. Results show the unidirectional influence of foreign markets</p>

			affecting Czech market.
Heilmann (2010)	Weekly data of eight Asian stock price Indices and the American S&P 500 index	Engle and Granger (1987) test Pairwise co-integration ADF tests Johansen (1988) co-integration test VEC model Gregory and Hansen (1996) co-integration test	Asian financial crises of 1997/98 significantly changed the co-integration relationship between same countries, specifically US and Japan. Results are mostly robust to a change to a common US dollar denomination.
Hellstrand & Korobova (2010)	Daily data from 1 January 2000 to 31 December 2009. FTSE oil & gas and financial indices for US, UK, Japan, Russia, Brazil and India	Augmented Engle-Granger test for Co-integration, VECM and VAR model	Results show that for both sectors causality increases between time periods (most likely due to volatility and contagion)
Gallimore, etal (2010)	Seven US sectoral REITS period from March 1984 to December 2009. Monthly returns	Co-integration tests Short term Granger causality tests VAR model	Results show that unexpected inflation significantly and negatively influence the co-integrative disequilibrium. Containing the redundant co-integrated sectors shatter portfolio diversification.
Ahmed (2011)	Daily closing prices of twelve sectoral indices of Egyptian stock market covering January 3, 2007 and January 18, 2010	Multivariate co-integration analysis, Granger's causality analysis	Short run causal relationships between sectoral indices are considerably limited. If and where the relationships exist they are unidirectional. There are benefits to portfolio diversification in the short run but not in the long term horizon.
Assidenou (2011)	Daily closing prices of international stock markets indices from	Co-integration test Unit root tests	Local investors in Asian Capital markets cannot avoid any influence from outside capital markets even if same

	September 2, 2008 to August 31, 2009		local markets are still entirely not opened to International investors
Chen (2012)	Three largest markets in the world. Newyork, London and Tokyo as well as those of Hong kong, Shanghai and Shenzen	Granger causality test, VAR model, VEC model, Variance decomposition, Impulse response function, Co-integration and GARCH models	Evidence shows that five stock markets are in the process of increasing integration. The periodic break down of co-integrating relationship is advantageous to foregin investors.
Osoble (2013)	Industry sectors of USA and twelve leading emerging markets: Brazil, Malasis and South Africa between Jan 2000 and Dec 2009.	Unit root tests: ADF, DF-GLS and KPSS tests, VAR models, Granger-causality, VEC model, State-space and Kalman-filter	This study indicates that the international investors may be albe to obtain diversification benefit by investors in the segmented sector of the emerging markets. Results show relatively weak interdependence between the US and the emerging markets Industry sectors especially in the pre-crisis period.
Katzke (2013)	Daily closing prices of six largest industrial sector composite total return indices during January 2, 2002 to 30 April 2013	AR (1) model, MV-GARCH models, DCC models, VECH and BEKK techniques. GJR-GARCH model	The results show that global and domestic economic uncertainty as well as local asset market segment, significantly influence both the short run dynamics and the aggregate level of co-movement between local sector pairs.
Guesmi and Fattoum (2014)	Monthly frequencies of stock indexes and oil price covering 100 OECD countries for the period of January 1990-sept 2012	Time-varying conditional correlation by employing Engle's (2002) Dynamic conditional correlation (DCC) method	Time varying correlation of oil and stock prices do not differ for different groups of economies. Precautionary demand side oil price shocks tend to influence some groups of countries in the same way.

<p>Sinsukthavom and Alfredsson (2014)</p>	<p>Three different sized US stock indices during a twenty two year long period S&amp;P 500, MSCI US small cap 1750 and MSCI US midcap 450 and London gold Bullion daily price data from June 1, 1992 to April 1, 2014</p>	<p>Conditional correlation model, Asymmetric generalized dynamic conditional correlation model</p>	<p>Results show that there is a asymmetry in the dynamic conditional correlation of these stock indices and gold. The asymmetric effect is not the same for large and small firms.</p>
<p>Nicola, etal (2014)</p>	<p>Monthly data between 1970 and 2013 of 11 major energy and agricultural commodities</p>	<p>Un conditional and conditional correlations using a uniform spacing's testing approach, a multivariate dynamic conditional correlation model and a rolling regression procedure.</p>	<p>The authors find that 1) The price returns of energy and agricultures commodities are highly correlated. 2) The overall level of co-movement among comodites increased in recent years, especially between energy and agricultural comodities 3) Stock market volatility is positively associated with co-movement of price returns across markets, especially since 2007</p>
<p>Kapusuzoglu, etal (2014)</p>	<p>Data set of 2006 daily data from 22 indices traded on istanbul stock exchange (ISE) and Euro exchange rate in the period between 2002 : 01 and 2010 : 01</p>	<p>Johanson co-integration test, Granger causality test, unit root test</p>	<p>Findings suggest that when making short term investment decision and managing their portfolios, investors can make predictions about the probable changes in Euro by an analysis and examination of the indices and can manage their investments accordingly</p>



<p>Kalsie &amp; Kalra (2015)</p>	<p>NIFTY and six major NSE sectoral indices during 2001-2011</p>	<p>Randomness tests, non-stationarity tests - runs test, unit root tests, ACF, correlograms and other econometric methods.</p>	<p>The study results state that Indian markets are not weak from EMH. Equity markets in the emerging economies are not efficient and to some degree can also explain the less optimal allocation of portfolios into these markets.</p>
<p>Shankar, etal (2015)</p>	<p>Weekly data for thirteen stock indices from April 2003 to May 2015</p>	<p>Pairwise co-integration test</p>	<p>Contrary to expectation of a long term equilibrium relationship between these global indices with Indian equity index, the study funds no evidence of co-integration</p>
<p>Ahmed (2016)</p>	<p>Daily stock index closing prices for Individual April 3, 2011 to market sectors from May 31, 2015</p>	<p>Unit root tests, Johansen's multivariate co-integration analysis, Granger's casualty analysis.</p>	<p>There exists a single co-integrating vector within the sample sector indices. Granger's causality analysis shows that short term causal relationships between sector indices are limited.</p>

2.4 Studies on Indian Markets Co-movement

Table 4: Studies on Indian Markets Co-movement

Author/s	Data set	Econometric methodology/models	Findings/Conclusions
Mukherjee and Bose (2008)	Daily data for a period of six and half years from Jan 1, 1999 to June 30, 2005. Two developed markets: USA & Japan. Five Asia-pacific markets: Hong kong, Korea, Malaysia, Singapore and Taiwan Indian market : BSE SENSEX	Co-integration, vector auto regression, vector error-correction models and Granger causality	Study funds that, through there is definite information leadership from US market to all Asian markets, US indexes do not uniquely influence the integration of Asian markets. Japan is found to play a unique role in the integration of Asian markets.
Sanati (2010)	Period between 1990 to 2007	Johnsen - Juselius co-integration test, ADF test Engle - Granger (1987) test	Co-movement among the domestic money, capital and foreign exchange markets with strong co-movement between the short term money and foreign exchange markets.
Krishnan kurty & Tiwari (2011)	Daily data of sectoral indices spanning from Feb 1, 1999 to March 31, 2011	Fractional co-integration test, Rescaled range analysis of long memory	No evidence of co-integration in the sectoral indices of BSE and conclude that there is benefit to domestic investor for sectoral diversification in the BSE sectoral indices of Indian stock market
Suresh and Tiwari (2012)	Daily data on nine sectoral indexes for the period 23rd August 2004-31st June 2010	VECM, impulse response functions and variance decomposition analysis, co-integration analysis	The co-movements between the sectoral indices indicate that Indian stock markets are not weak form EMH and the sectoral portfolio diversification possibility is limited.

<p>Gupta &amp; Guidi (2012)</p>	<p>Daily closing stock index prices of India (BSE 30), Hong kong (Hangseng), Japan (Nikkei 225), US (S&amp;P 100), Singapore (STI) from Aug 31, 1999 - June 17, 2009</p>	<p>Engle - Grager co-integration methods ADF unit root test Johansen's methodology</p>	<p>There is no stable long run relationship among these stock markets. Gregond-Hansen approach identifies no co-integration with structural breaks among these markets. Indian stock market has a weak interdependence with other developed Asian markets and the US market.</p>
<p>Kumar (2014)</p>	<p>Daily closing price data of eight sectoral indices associated with Indian NSE, Bank NIFTY, CNX FMCG, CNX INFRA, CNX PHARMA, CNX SERVICE, CNX ENERGY, CNX IT, CNX MNC.</p>	<p>Detruded fluctuation analysis (DFA) approach and the local whittle (LW) approach by means of Monte Carlo Simulation experiments</p>	<p>The monte carlo simulation experiments indicate that the DFA approach and LW approach provides good estimates of the scaling exponent as the sample size increases. This study finds that the efficiency characteristics of Indian sectoral indices and their stages of development are dynamic in nature.</p>
<p>Noor, etal (2014)</p>	<p>Daily sector indices data from the period January 4, 2010 to May 21, 2013</p>	<p>Johnsen co-integration, Granger causality tests</p>	<p>FMCG sector earned highest average daily return with the lowest standard deviation among the entire sectors. Johnsen co-integration has revealed one co-integrating equation which shows the integration and an existence of long run equilibrium among the sectors. The findings imply that there are benefits from</p>

			portfolio diversification.
Deo (2014)	Fair indices of Indian stock market VIZ, CNX small cap, CNX midcap, CNX NIFTY and CNX NIFTY 500 Period 30 Jan 2004 to 29 June 2012	Engle - Granger test Johnsen co-integration test	Results confirm the presence of at least are co-integrating relationship between the four indices
Vardhan, Sinha and Vij (2015)	Daily closing prices for SENSEX and ten BSE sector indices during March 10, 2009 to Dec 31, 2010	Vector error correction model (VECM), generalized impulse response and variance decomposition analysis, stationarity tests - ADF, FP and KPSS lag length - AIC and SBC Johansen and Juselius technique for co-integration	Limited lead lag short run relationships between sector indices were observed. Banking Index played a predominant and integrating role moving other indices. The study for post sub-prime crisis period helps to understand the importance and behavior of integrated sector indices & sensex
Maheshwari and Rao (2015)	Sector indices of the BSE and select Macro economic variables	Johansen and Juselius vector error correction frame work	Stock indices and macro economic variables are co-integrated and possess a long run equilibrium relationship The relationship has been found to be significantly negative with 11P, USD - INR exchange rate, Forex reserves & WPI Significantly positive with monthly supply
Joshi & Giri (2015)	Quartery time series data from 2003 : Q4 to 2014 : Q4	Ng-Perron unit root test ARDL bounds testing VECM VDC	Sectoral price indices are significantly influenced by changes in the respective sectoral GDP in the long-run where as crude oil price is an important

			factor influencing the sectoral prices in the short-run
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### 3. Conclusions

The literature has mainly focused on studies on volatility and co-movement using empirical methods on various financial markets around the Globe and in India. There has been lot of research on financial market volatility due to increasing availability of data and computing power. The popularity of different ARCH family models has increased in the recent past. This survey all though it is brief and selective attempts to give the reader an idea of various methods found in empirical literature.

It is found that numerous methodologies like GARCH models, Johansen models, VECM, Impulse response functions, Granger causality tests are employed widely in studying volatility and co-movement across countries and also among sectors with in a country.

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