Research Article

Integration: Linear or Nonlinear: An Empirical Study Between Indian Stock Markets and Other Developed and Developing Countries of the World

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Abstract

Researchers concluded that in absence of contigration (process developed by Johansen 1988) between two stock markets, investors can minimize the risk of their portfolio by diversification. Okunev and Wilson (1997) proved that there may be nonlinear cointegration in absence of linear relationship. If two stock markets are nonlinearly integrated and getting diverted from equilibrium for some information then there will be an adjustment factor which can bring them back to equilibrium again. Four developed and five developing countries including India had been selected for study. The result shows that only Taiwan and China stock markets are linearly integrated with both the Indian stock markets. Nonlinear integration test has been used for the other stock markets in the sample. Except Japan all markets are nonlinearly liked with the Indian stock markets. Hence international investors can diversify their portfolio between Indian and Japan to minimize the risk.

Key words: Linear Co-integration test, Nonlinearco-integration test, Equilibrium, Adjustment factor, Diversification opportunity

Introduction

Integration of stock markets is a situation where investors earn the same risk-adjusted expected return on similar financial instruments in different national markets and when it does not happen the markets are called segmented (Jorion, Schwartz 1986). Many authors had provided many reasons of integration between capital markets. Rapid increase in the cross-border mobility of private capital inflows (Srikanth 2012) growing globalization among economies (Chaudhuri 1997, Hoque 2007), escalation in liberalization activities of governments, the establishment of common trading blocs(Aktan et. al 2009) are some factors contributing to financial integration.

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India started its globalization and liberalization process of stock markets in the year 1991. Since 1993, Indian corporate sectors were allowed to tap the global market with GDR (global depository receipts), ADR (American depository receipts) and FCCB (foreign currency convertible bonds). As per Indian Security Market a Review 2012 the two stock exchanges of India - Bombay Stock Exchange (BSE) and National Stock Exchange of India (NSE) have been come up with global standards. India ranked eleventh in terms of market capitalization, seventeenth in terms of total value traded in stock exchanges, and thirtieth in terms of turnover ratio. As a result over the past few years, the financial markets of India have become increasingly integrated with global markets (Kumar and Mukhopadyay 2002, Yong et. al 2003, Mukherjee and Mishra 2007, Taneja 2012). Investors will not be able to minimize portfolio risk by diversifying their holdings between the integrated countries. Shocks in one market may spill over to other integrated markets; hence a close cooperation is required among the authorities of these countries. Some researchers concluded that both BSE and NSE are not integrated with all stock markets in the world (Mukherjee and Bose 2008, Patel 2013 and Sanyal et. al 2015). Herper et. al (2013) suggested to check nonlinear relationship in absence of cointegration between two stock markets. If two series are nonlinearly linked and one of them is getting diverted from other for any reason then there will be an adjustment parameter, which will bring back both the series into equilibrium again. If the speed of adjustment is very high then portfolio risk minimization through diversification will be defeated and partial effect of spill over will also be there (Okunev and Wilson 1997 and Lin and Fuerst 2014). This has motivated the author to take up the study. Section II provides the literature review and objectives of the study. Section III outlines the methodology used and indicates the necessary data used. Section IV provides the empirical results and analysis. Finally concluding remarks are given in Section V.

Literature review

Siddiqui (2009) studied the relationship between stock markets of India (Sensex) and eight European countries (Austria: ATX, Belgium: Bel-20, France: CAC 40, Germany: Dax, Netherland: Aex, Italy: Mibtel, Switzerland: Swiss Market and UK: FTSE 100). Using Johansen Co-integration test and Granger Causality test he observed that correlation between indices had changed over time. Johansen Co-integration test proved that there is a long-term relationship between the indices of India and European countries. Taneja (2012) tried to find the cointegration between Indian and other major developed (USA, UK, France and Germany) and developing countrys' (Taiwan, Istanbul and Singapore) stock markets. Using Johansen Co-integration test on data of the sampled countries during 1999 to 2010 he observed that both the Indian stock markets are fully integrated with sampled stock markets of the world. Harper et. al (2013) investigate the relationship between India and five major trading partners' stock markets (China, Japan, Indonesia, Malaysia, Singapore). The study used Co-integration analysis and Vector Error Correction model on monthly data during January 2000 to December 2011. They found a perfect integration between the countries hence left almost no

scope for diversification benefit between India and the sample countries. Spill over in any of these countries can affect Indian stock markets also.

Though opposite views had also been recorded in the literature. Mukherjee and Bose (2008) found the relationship between India (sensex) and other seven countries USA (Dow Jones Industrial Average, S&P 500), Japan (Nikkie 225), Hongkong (HSI), Malaysia (KLSE), Korea (KOSPI), Singapore (STI) and Taiwan (TWI). They considered daily data form 1st January 1999 to 30th June, 2005 and converted all data into US$ term and did not find any relationship when US stock price was considered for analysis but find the opposite result when Japan and India was considered for analysis. Using monthly data from January 2000 to August 2012, Patel (2013) found neither long nor short term relationship between the stock markets of India and seven developed countries (US: NASDAQ, UK: FTSE100, Germany: DAX, Canada: TSX, Australia: AORD, France: CAC 40, Japan: Nikkie 225). Vector error correction model also supported the findings.

The co-integration test developed by Johansen (1988) is applicable for testing the linear relationship (Okunev and Wilson 1997, Jawadi et. al 2010, Lin and Fuerst 2014). Okunev and Wilson (1997) and Lin and Fuerst (2014) discussed the methodology of finding non linear relationship between two time series in absence of linear cointegration. Lin and Fuerst (2013) used the methodology developed by Okunev and Wilson (1997) on quarterly transaction based housing price index and stock market index during the period January 1980 to September 2012 for all nine Asian economies (China, Japan, Taiwan, South Korea, Hong Kong, Singapore, Thailand, Malaysia and Indonesia). The result indicates that linear integration exists in Taiwan, Malaysia, Indonesia, Singapore, Hong Kong and South Korea, whereas nonlinearity persist in Singapore and South Korea. Okunev and Wilson (1997) and Lin and Fuerst (2014) concluded that spill over in any of the nonlinearly integrated stock markets will partially effect others.

Objectives of the study

The literatures pertaining to the study revel that Indian stock markets – BSE and NSE are not linearly linked with all stock markets of the world. Nonlinear relationship may exist in absence of linear relationship between two stock markets, in case of nonlinear relationship diversification opportunity will depend upon the speed of reverting back to equilibrium of two stock indices. Hence the objectives of the study are as follows:-

i) To measure the linear integration of Indian stock markets with other stock markets of developed and developing countries of the world.
ii) To find out the non-linear integration in absence of linear one.
iii) To measure the speed of adjustment factor which brings back the indices of India and other stock markets of the world to equilibrium in case of disequilibrium.

Data

Data: Monthly closing prices of representative indices of five developing and four developed countires (table-1) during June 2002 to March 2017 have been considered. This data sample had been considered because it contains stock market crash of 2008 and structural reforms after that. The reasons behind the selection of stock markets are as follows (Taneja, 2012):-

- S&P 500 of United States and FTSE 100 are two strongest financial indices of the world.
- Singapore and Japan are the two developed countries of Asian region.
- China, India, Malaysia and Taiwan are some of the developing counties, which have organised and properly regulated stock markets.

The closing prices have been converted into index return series by using logarithm tools. All data have been collected from yahoo finance.

Methodology:

Linear Co-integration test:

If *I*(1) (stationary at their first difference) variables are integrate, then they may share a common linear trend in long run and linear combination of these variables in there level forms will be stationary. Vector autoregressive (VAR) process will also be stable. The nonlinear methodology developed by Okunev and Wilson (1997) also based on the same principle.

One of the two Indian indices (Sensex or S&P CNX Nifty) and any one of the rest indices from the sample have been accepted for cointegration test at a time, because

1. Nonlinear model developed by Okunev and Wilson (1997) and Lin and Fuerst (2013) is applicable between two variables at a time and non linear cointegration has been applied when linear cointegration does not exist.
2. All researchers had used cointegration test taking all series together in their sample. If any one time series is not integrated with rest series then there will not exist a single cointegrating vector and it will be very difficult to locate that nonintegrating series.

A p th order VAR model of two indices are given by

$$Y_t = \pi_1 Y_{t-1} + \pi_2 Y_{t-2} + \ldots\ldots\ldots\ldots\ldots + \pi_p Y_{t-p} + \varepsilon_t$$

Where $Y_t' = [Y_{1t}, Y_{2t}]$ Y_{1t} is either Sensex or S&P CNX Nifty and Y_{2t} is any one of the rest stock indices in the sample, $\pi_j = \begin{bmatrix} \pi_{11,j} & \pi_{12,j} \\ \pi'_{21,j} & \pi_{22,j} \end{bmatrix}$, $\varepsilon_t' = [\varepsilon_1, \varepsilon_2]$ are innovations relative to the information set

$$Y'_{t-i} = [Y_{1t-i,} Y_{2t-i}] \; i = 1,2,\ldots\ldots\ldots\ldots, p$$

Error correction model (ECM) of VAR helps to locate the cointegrating equations and ECM of above VAR is

$$\Delta Y_t = \alpha Z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \vartheta(L)\varepsilon_t$$

Where Y is a *(2×1)* vector of *I(1)* variables, and $Z_{t-1} = \beta' Y_{t-1}$ are the r linear cointegrating combinations among two variables, with β the (2×1) matrix of cointegrating vector. is a lag polynomial. Γ_1 , Γ_2 ,..., are Γ_{q-1} matrices. The Johansen co-integration test is based on two likelihood ratio test - the trace and maximum eigenvalue statistics to determine the number of co-integration vector.

Nonlinear co-integration test:

In absence of linear integration, nonlinear integration may exist in the markets (Okunev and Wilson 1997 Lin and Fuerst 2014). Method developed by Okunev and Wilson (1997) and supported by Lin and Fuerst (2014) applied here to test the nonlinear integration. The relationship between the two stock markets is given by

$$S_t = P_t^{\beta} e^{[\alpha(t)+K]} \text{ ---------- (1)}$$

$$\log S_t = \beta \log P_t + K + \alpha(t) \text{ ---------- (2)}$$

Where S_t is the price of Sensex or Nifty, P_t is the price of other country's stock index, β is a parameter, K is constant and $\alpha(t)$ is interest rate function. Equation 2 is the logarithmic and linear equation. If stock indices are cointegrated and *I(1)* then their linear combination will be *I(0)*. Hence $\alpha(t)$ needs to be *I(0)*. If β is zero then both the markets are segmented if β is one then both are linearly linked if β lies between 0 and 1 then the markets would be nonlinearly related. Interest rate function can be explained in stochastic differential equation process. Ornstein-Uhlenbeck process of stochastic differential equation explains this function as follows:

$$d\alpha(t) = \lambda(\mu - \alpha(t))d(t) + \delta dz(t) \text{ ---------- (3)}$$

where λ is speed of adjustment in disequilibrium, μ is the long term mean, δ is the standard deviation related to the Winer process *dz(t)*, which is a brownion motion and hence can not be linear. Out of many forms of stochastic differential equation Ornstein-Uhlenbeck process has been accepted because it is stationary and means reverting. Equation (1) is a nonlinear motion because of the behaviour of β an d *(dz(t)* . Again this process provides the solutions for $\alpha(t)$ of equation (3).

$$\alpha(t) = \mu\left(1 - e^{-\lambda t}\right) + e^{-\lambda t} \int_0^t \delta e^{\lambda s} dZ(s) \text{ ---------- (4)}$$

$\alpha(t)$ has a mean μ and standard deviation $\delta^2 / 2\lambda$. Stationarity of $\alpha(t)$ will depend on . If is zero then equation (4) will be a function of (equation 5) and will be nonstationary. As a result equation (2) will not be a cointegrating equation.

$$\alpha(t) = \alpha(0) + \int_0^t \delta e^{\lambda s} dZ(s) \text{ ----------(5)}$$

Hence λ needs to be greater than zero. Substituting $\alpha(t)$ defined by equation (4) in equation (1) and after simplification the nonlinear equation can be summarized as (Okunev and Wilson 1997, Lin and Fuerst 2014):

$$\log\frac{(P_{t+1})}{P_t} = \gamma_0 + \gamma_1 \log\frac{S_{t+1}}{S_t} + \gamma_2 \log S_t + \gamma_3 \log P_t + e_t \text{ ---------- (8)}$$

Here $\gamma_1 = \beta$, in equation 1, γ_2 represents the change in the mean reversion characteristics and the speed of adjustment of mean reversion can be calculated from γ_3, since $\gamma_3 = e^{-\lambda t} - 1$.

Empirical Analysis & Results:

As investors are more concern about the return of the stock market, hence monthly return of the indices has been calculated with the help of logarithmic differences of two consecutive data. According to table 2 Sensex and Nifty and JKSE had provided highest return in the sample period among the selected indices. Highest volatility (standard deviation) also had been recorded in this period for these indices. Probability distribution of 1st difference of logarithmic transformation of data are negatively skewed, platykurtic (kurtosis are more than 3). Probability of J-B statistics (table-2) is zero hence null hypothesis of normal probability distribution of return of indices may be rejected in favour of alternative hypothesis. Hence returns are not normal and behavior of return will change with the change of sample period. The results are in line with earlier researches like - Kumar and Mukhopadyay (2002), Yong et. al (2003), Mukherjee and Mishra (2007), Taneja (2012), Mukherjee and Bose (2008), Patel (2013) and Sanyal et. al (2015).

Verification of stationarity is very essential before integration test, because cointegration test can be used between level forms of those time series, which are stationary at their first difference. Time series data are not only depend on the other variables in the economy but also depend on their own lag values. If they are depending on their own lags then data will be nonstationay. Patterson (2000) mentioned that this relationship may have three forms – with intercept, with intercept and trend, without intercept and trend. It will be very difficult which form will be applicable at any point of time. Augmented Dickey Fuller test developed by Dickey and Fuller (1979) used to check the nonstationarity in three forms (table 3).

Null hypothesis of non-stationarity cannot be rejected in logarithmic form of data in case of all series. Null hypothesis has been rejected in case of all series at their first difference form. Hence all series are stationary at first difference. Minimum lag length and value of SIC are 23 and -8.246. The results are in line with other researches on this topic (Kumar and Mukhopadyay 2002, Siddiqui 2009, Taneja 2012).

Table 4 depicts the Johansen Co-integration test result. Calculated Trace and Maximum Eigenvalue Statistics are more than their respective critical values when Johansen Cointegration test had been used between Indian indices (Sensex and Nifty) and indices of China (Hang Seng) and Taiwan (TWI) stock exchange. Hence these stock markets are fully integrated with both Bombay Stock Exchange and National Stock Exchange of India. Rests stock markets in the sample are not cointegrated with Indian stock market.

Nonlinear co-integration test result has been provided in table 5. γ_1 , i.e. β s are significant at ninety nine percent confidence level and between 0 and 1. As they are equal to neither zero nor one hence none of the trading partner countries stock indices are segmented or linearly linked with Sensex and Nifty. Except Nikkie 225 values of all γ_3 s are statistically different from zero. Except Nikkie 225 all λ s are positive in both the cases of Sensex and Nifty. Hence $\alpha(t)$ in equation (4) is non stationary only incase of relationship between Japan (Nikkie 225) and Indian indices (Sensex and S&P CNX Nifty). This implies that except Japan all stock markets in table 5 are nonlinearly linked with Indian stock market. The main reason of non-existence of relationship between Japan's and Indian stock markets is the construction methodology of Nikkie225. It is prepared based on the value-weighted method; whereas all other indices are prepared by the free float market capitalisation method (Majid et al., 2009). If any one point of time a spread is getting created between prices of Indian indices and any of the sampled indices in this study except Nikkie 225 then it dies out exponentially with time. Hence Indian stock market investors get an opportunity to diversify their portfolio with stock exchange of Japan to minimise their risk or vice versa. Spill over in any of the stock markets of China and Indonesia will directly transmitted to India whereas the same of Jakarta, Malaysia, United Kingdom, United States of America and Singapore will partially effect Indian Stock markets.

Conclusion

This paper had tried to find the nonlinear integration in absence of liner integration between stock markets of India and other developed and developing countries of the world. The result proves that the leading two stock indices of India i.e. Sensex and S&P CNX nifty are linearly integrated with the indices of China and Taiwan stock markets. Hence any spillover in these markets will directly affect the Indian stock markets. Indian stock markets are nonlinearly liked with stock markets of Indonesia, Malaysia, UK, USA and Singapore. Any up and down ward movement will partially affect Indian stock markets. Based on Johansen's (1988) cointegration test result they can diversify their portfolio to minimize the risk, but their purpose will not be hundred percent fulfilled. Indian indices are neither linearly nor nonlinearly integrated with the stock market Japan. Hence international investors can diversify their portfolio between the stock markets of Indian and Japan to minimize the risk. Movement of Japan stock market will be transmitted to neither Bombay Stock Exchange nor National Stock Exchange of India. Probability distributions of data are not normal

hence it is very difficult to generalize the received result, because data behavior will be different with different sample period.

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Table 1: Stock markets and their indices

Country	**Stock market**	**Index**
India	Bombay Stock Exchange	Sensex (Sensex)
	National Stock Exchange	S&P CNX Nifty (Nifty)
Developing countries		
China	Hong Kong Stock Exchange	Hang Seng index (Hang Seng)
Indonesia	Jakarta stock exchange	Jakarta composite index (JKSE)
Malaysia	Kuala Lumpur Stock Exchange	Kuala Lumpur composite index (KLCI)
Taiwan	Taiwan Stock Exchange	Taiwan weighted index (TWI)
Developed countries		
United Kingdom	London Stock Exchange	FTSE 100 (FTSE)
United States	New York Stock Exchange	S&P 500 (S&P)
Singapore	Singapore Exchange	Straits times index (STI)
Japan	Tokyo Stock Exchange	Nikkei 225 (Nikkie)

Source: Table 1–6: International comparison of global stock markets, ISMR Indian security markets a review 2013, page no. 13. Short form in parentheses have been used for the rest of the paper.

Table 2 : Descriptive statistics of 1st difference of logarithmic transformation of price

	Mean	Standard Deviation	Skewness	Kurtosis	J-B Statistics	Probability of J -B Statistics
Sensex	0.01246	0.0666	-0.5246	5.30145	47.274	0.0000
Nifty	0.01219	0.06884	-0.6800	5.8848	75.0177	0.0000
Hang Seng	0.00457	0.06021	-0.6988	4.9571	42.6553	0.0000
JKSE	0.01342	0.06281	-1.48386	10.6863	500.659	0.0000
KLCI	0.00480	0.03666	-0.53959	6.14868	81.70612	0.0000
TWI	0.00359	0.05597	-0.4829	4.11796	16.0967	0.0000
FTSE	0.00259	0.03979	-0.80688	4.18001	29.4753	0.0000
S&P	0.00479	0.04149	-0.96051	5.49803	73.2363	0.0000
STI	0.00405	0.05072	-1.02868	8.74243	274.4105	0.0000
NIKKIE	0.00346	0.056374	-0.88001	5.37084	64.2992	0.0000

Table 3: Unit test result (Augmented Dickey Fuller test, ADF)

		At level			At first difference		
		None	With Trend and Intercept	With intercept	None	With Trend and Intercept	With intercept
Sensex		2.441	-2.1432	-2.2024	-11.539*	-11.945*	-11.879*
Nifty		2.318	-2.334	-2.0536	-12.067*	-12.464*	-12.409*
Hang Seng		0.991	-2.2495	-1.9935	-11.817*	-11.895*	-11.855*
JKSE		2.1694	-1.9890	-1.8883	-10.184*	-10.689*	-10.590*
KLCI		1.689	-1.6236	-1.3823	-11.819*	-11.997*	-11.981*
TWI		0.8671	-3.2197	-1.9259	-11.925*	-11.919*	-11.948*
FTSE		-1.439	-2.242	1.029	-13.463*	-13.475*	-13.514*
S&P		1.7456	-1.4614	-0.4674	-11.400*	-11.527*	-11.544*
STI		0.8700	-2.2939	-2.1246	-10.843*	-10.894*	-10.881*
NIKKIE		0.889	-1.3144	-0.9865	-11.295*	-11.292*	-11.314*
Critical	1% Level	-3.434	-3.964	-3.434	-2.566	-3.964	-3.434

Table 4: Unrestricted cointegration rank test

		Sensex			Nifty		
		Eigen Values	Trace	Maximum Eigen values	Eigen Values	Trace	Maximum Eigen values
Hang seng	None	0.8838	19.87117**	16.00792**	0.0806	17.5621**	14.5418**
	At Most one	0.0221	3.563251**	3.863251**	0.0173	3.0203	3.0203
	Cointegrating equation		2	2		1	1
JKSE	None	0.038276	10.22017	6.751810	0.038041	10.56993	6.709547
	At Most one	0.019849	3.468359	3.468359	0.022067	3.860386	3.860386
	Cointegrating equation		Not a single one	Not a single one		Not a single one	Not a single one
KLSE	None	0.034760	9.765925	6.120506	0.032170	9.482642	5.656829
	At Most one	0.020851	3.645419	3.645419	0.021872	3.825813	3.825813
	Cointegrating equation		Not a single one	Not a single one		Not a single one	Not a single one
TWII	**None**	**0.094382**	**23.75442****	**17.18903****	**0.093932**	**22.75731****	**17.06494****
	At Most one	0.037239	6.565392**	6.565392**	0.032368	5.692361**	5.692361**
	Cointegrating equation		2	2		2	2
FTSE 100	None	0.043270	12.37149	7.652494	0.039386	11.60525	6.951670
	At Most one	0.026909	4.718998	4.718998	0.026541	4.653584	4.653584
	Cointegrating equation		Not a single one	Not a single one		Not a single one	Not a single one
S&P 500	None	0.039770	7.676328	7.020745	0.036538	7.229535	6.439436
	At Most one	0.003782	0.655583	0.655589	0.004557	0.790099	0.790099
	Cointegrating equation		Not a single one	Not a single one		Not a single one	Not a single one
STI	None	0.066019	13.51361	11.81581	0.062418	14.99190	11.15012
	At Most one	0.026790	4.697797	4.697797	0.021962	3.841783	3.841783
	Cointegrating equation		Not a single one	Not a single one		Not a single one	Not a single one
Nikkie 225	None	0.033524	8.714455	5.899027	0.030421	8.213532	5.344518
	At Most one	0.016142	2.815428	2.815428	0.016447	2.869014	2.869014
	Cointegrating equation		Not a single one	Not a single one		Not a single one	Not a single one

** indicates the significance at ninety five percent confidence level

Table 5: Non Linear cointegration test

	Sensex					Nifty				
	$_0$	$_1$	$_2$	$_3$	λ	$_0$	$_1$	$_2$	$_3$	λ
JKSE	-0.0051	0.8040*	-0.0014	-0.0041**	0.0041	0.00489	0.67379*	-0.00182	-0.00392**	0.00393
KLSE	-0.0063	0.4135*	-0.0009	-0.0026***	0.0026	-0.00781***	0.33585*	-0.001223	-0.002534***	0.00254
FTSE 100	-0.0021**	0.3757*	-0.0004	-0.0029**	0.0029	-0.021965*	0.309361*	-0.000484	-0.003006***	0.00301
S&P 500	-0.0095**	0.4961*	-0.0001	-0.0024***	0.0024	-0.0093**	0.103600*	-0.0001000	-0.00286**	0.00284
STI	-0.0134**	0.6385*	-0.0011***	-0.0030**	0.0030	-0.01362**	0.52979*	-0.001162***	-0.002951**	0.00296
Nikkie 225	-0.0099***	0.4784*	0.0002	0.0009	-0.0009	-0.00952***	0.40386*	0.000150	0.000866	-0.000866