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Interdependence and Volatility Spillovers from the US to Indian Stock Market

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Abstract

There are several reasons to analyze the cross-border volatility spillovers as one of the determinants of stock return volatility of domestic market in addition to various domestic factors. In this paper an attempt has been made to examine the long run and short run return and volatility relationship between the stock prices of India and its major trading partners US stock market. It also examines whether such a relationship, if it exists, is affected by the second generation reforms that began in 1998 using daily data for the period 1 July 1997 to 25 February 2010. The results of the study make clear that these stock markets move together, and are integrated. Further, the study nas also shown that volatility relationship between the stock prices of India and its major trading partners US stock market have been found for all three periods under study. Thus, results identify the US market as the main source of volatility spillovers for Indian stock market. Further it is also clear from the study that volatility spillovers from the US have become quite pronounced after the second generation reforms. Finally, it is suggested from the study that investing in these stock markets will not generate any long term gain to portfolio diversification.

INTRODUCTION

The increasing regionalization of economic activities and the liberalization financial markets since the late 1980s have resulted in regional economic integrations around the world. The growing issues of financial market integration have recently attracted the attention of investors and academics. The spillover or contagion effect across financial assets has been the focus of much interest from academics and financial market regulators in recent years. Generally, changes in the stock indices are influenced by the flow of market information. Studying the stock market movements is joint study of the spillover of price changes and the volatility of price changes. Transmission mechanisms between the returns and volatilities of different stocks are important for a number of reasons. The transmission mechanisms tell us something about market efficiency. Before investing in asset investors incorporate information about price movements and volatility in the same asset and related assets listed in different countries. This issue is an important concern for portfolio investors because greater integration among world markets implies stronger co-movements between markets, therefore nullify much of the gain out of diversification across borders, besides being vulnerable to the caprices of global capital. Financial market volatility also affects real economic activity and the proper function of financial markets. Thus, the understanding of inter-market volatility is important for the pricing of securities within and across the markets for international diversification strategies, for hedging strategies and for regulatory policy. The rest of this paper is organized as follows : Section 2 presents a brief and critical review of existing literature relevant with this study. Section 3 gives comprehensive description of the research methodology applied in the study. The analysis of major empirical findings is shown in section 4 followed by the conclusion in section 5.

REVIEW OF LITERATURE

Due to the increasing interdependence of major financial markets, the transmission of stock return movements among them has become a much researched topic. Empirical studies have showed mix results.

Asim Gosh (1999) proved that the stock markets of Indonesia, Philippines and Singapore were linked with the stock markets of Japan, Hong Kong and India. The study further revealed that the stock markets of Taiwan and Thailand were not influenced by the stock markets of the US or Japan. Masih and Masih (1999) found cointegration in a block of OECD and Asian countries including US, Japan, UK, Germany, Singapore, Malaysia, Hong Kong, and Thailand. Rao and Naik (1990) inferred a poor interrelationship among Indian market and that of USA and Japan.

Kiran Kumar (2002) investigated the short run dynamic inter linkages between the US and Indian stock market using daytime and overnight returns of the S&P, CNX, NIFTY and the NASDAQ Composite from July, 1990 to June 2001. The study showed that the US stock markets significantly influenced Indian stock markets and not vice versa. Kumar and Mukhopadyay (2002) used Granger causality test and univariate GARCH model to study the return and volatility linkage between the Indian and the US markets.. They found significant return and volatility spillover from the US to India. Another study in the similar line by Biswal and Mohanty (2003) failed to establish any empirical support of volatility spillover between Indian and the US market.

Sharma and Wongbangpo (2002) found a long-run cointegrating relationship among the stock markets of Indonesia, Malaysia, Singapore and Thailand. The study concluded that the Philippine market did not share the relationship. Tatsuyoshi Miyukohsi (2003) examined the magnitude of return and volatility spillovers from Japan and the US to seven Asian equity markets and concluded that only US influences Asian market returns; there was no influence form Japan. Second, the volatility of the Asian market is influenced more by the Japanese market than by the US. Third, there exists an adverse influence of volatility from the Asian market to the Japanese market.

Darrat A.F. and Benkato (2003) investigated relation between the Istanbul Stock Exchanges (ISE) and the major matured markets of the United States, Japan and Europe. Several conclusions emerged form the empirical analysis. First, there was a significant cointegration between ISE and the four matured markets. Second, Turkish market significantly integrated with the global market particularly in the post liberalization period. Third, the volatility in the ISE significantly linked with volatilities in the four matured markets only after the lifting of capital controls. Choudhry (2004) studies, inter alia, interlinks of the Indian stock market with the US and the Pakistani stock markets. He finds a two-way linkage between Indian and Pakistani markets while one way influence of the US market on these two markets.

In a recent study by Kumar and Mukhopadyay (2002), short run linkage between National Stock Exchange (NSE) and NASDAQ was examined and the study concluded only unidirectional spillover from the US market to the Indian market but not vice versa. By applying the Granger causality test and the Geweke measure of feedback, Mukherjee (2005) have examined the stock market inter-linkages (in terms of returns) among India and the world equity markets.

Khan Masood Ahmad et. al (2005) attempted to detect the casual relationship and dynamic linkages between the NASDAQ Composite Index in the US and the NSE, S&P, CNX and Nifty in India during the period from 1999-2004 using intra daily data. The main findings of the study were that Granger Causality results indicated unidirectional causality running form the USA to Indian markets and the ARCH model gave evidence of volatility clustering in each series and the VAR analysis showed that the spillover of volatility form NASDAQ to S&P, CNX and Nifty was significant during 1999-2001 while it was not so during 2002-2004.

Morana and Beltratti (2008) in their paper have found a progressive integration of four developed stock markets viz. US, UK, Germany and Japan, and have revealed an increasing co-movements in prices, returns, volatilities and correlations among all the four markets, especially the European markets.

Although there is a vast amount of literature on spillover of return and volatility on the different stock markets of world is available. In the Indian context, however, the literature offers very few studies relating to co-movement of Indian stock markets vis-à-vis other markets. Therefore, this study aims to bridge this gap.

RESEARCH METHODOLOGY

Objective and Scope of Study

The main purpose of this paper is to empirically examine whether and to what extent, Indian stock market is integrated with stock market in the United States. It also addresses the issue of whether such a relationship, if it exists, is affected by the second generation reforms that began in 1998. Data employed in this study are daily closing stock market indices for the United States (S&P-500) and Indian (Nifty). The time period of the data is form 1-7-1997 to 25-02-2010. Closing values of indices are used to represent the market. However, when the cointegration tests are conducted, some daily observations are deleted because of different holiday. The pair wise cointegration test is conducted between the stock market index of India and the US stock market. To know the impact of the second generation reforms on the level of integration, the full sample period is sub divided into two periods. The first sub-sample is from 1 July 1997 to 31 March 2004, while the second sub-sample is from 1 April 2004 to 25 February 2010. For each country, daily returns Rt are computed as the first differences of the natural logarithm of Pt (which is the daily close values of the indices).

Methodology

Following methods are used to test correlation, stationary of time series, co-integration and causalities between the stock markets.

Unit Root Tests

If y_t is a random walk, then Δy_t must be stationary. A data series must be stationary if its mean and variance are constant (non-changing) over time and the value of covariance between two time periods depends only on the distance or lag between the two time periods and not on the actual time at which the covariance is computed. The correlation between a series and its lagged values are assumed to depend only on the length of the lagand not when the series started. A series observing these properties is called a stationary time series. . It is also referred to as a series that is integrated of order zero or as I (0). The unit root test checks whether a series is stationary or not. Stationary condition has been tested using Augmented Dickey-Fuller (ADF). The ADF approach controls for higher-order correlation by adding lagged difference terms of the dependent variable to the right-hand side of the regression. To perform the ADF test the following regression is estimated.

$$\Delta y_1 = \alpha_0 + \beta_0 t + \lambda y_{t-1} + \sum_{i=1}^{P} \gamma i \, \Delta y_{t-i} + \mu_1$$

To test for stationary, the null hypothesis is: $H0 : \lambda = 0$

And alternative hypothesis is : $H1 : \lambda < 1$

Engle-Granger Cointegration test :

Let Y_t and X_t be two time series whose co-movement is to be tested. First of all, both of these time series should be non-stationary. Secondly, they should be integrated of the same order. To carry out this test, we proceed as follow:

Regress Y_t on X_t as : $Y_t = \alpha + \beta X_t + \mu_t$

The estimated residuals should be tested for stationary using Augmented Dickey Fuller test. However, while performing the test, the trend component should not be included (Stock and Watson, 2004). Further, we should regress X_t on Y_t and obtain the residuals as discussed above and test for its stationary using ADF test. If the residuals of regression of Y_t on X_t and X_t on Y_t are both stationary, the two time series in question are cointegrated.

Johansen Cointegration Test

Tests for cointegration were performed using Johansen's (1988) procedure. The Johansen procedure is based on the vector autoregressive (VAR) system of n x_1 vector of I(1) variable X_t.

$$X_t = \mu + r_1 + X_{t-1} + \ldots\ldots\ldots\ldots\ldots\ldots + r_p X_{t-p} + \xi_t$$

Where r_1............. r_p are n x n matrices of coefficients, p is the lag length and ξ_t is assumed to be the i.i.d Gaussian process. Utilizing maximum likelihood estimation, Johansen developed two statistics to test for the null hypothesis of no integration, namely the Trace and the Maximum Eigen value (Max-L) statistic. These are computed as follows :

$$\text{Trace} = -T \sum_{i=r+1}^{n} \text{Log}\,(1 - \lambda_i)$$

$$\lambda\text{-max} = -T\ \text{Log}\,(1 - \lambda_{r+1})$$

Where r is the number of cointegrating vectors, and λ_i ………… λ_n are the N squared canonical correlations between the X_{t-p} and ΔX_t series. If the computed value is below the critical value, then we can not reject the null hypothesis of no cointegration.

The Granger Test

The dynamic linkage is examined using the concept of Granger causality test. The intuition behind the granger causality test is quite straightforward. Suppose X variable causes Y but Y does not granger cause X, then past values of X should be able to predict future values of Y, but past values of Y should not be helpful in the forecast of X. The econometric procedure to evaluate if these two conditions hold consists of two steps. First, we test the null hypothesis that X does not cause Y by running the follow regressions.

Restricted regression :

$$Y = \sum_{i=1}^{m} \alpha_i Y_{t-i} + e_t \tag{1}$$

And the unrestricted regression:

$$Y = \sum_{i=1}^{m} \alpha_i Y_{t-i} + \sum_{i=1}^{m} \beta_i X_{t-i} + e_t \tag{2}$$

An F test using the sum of squared residuals from each regression in order to test is the group of coefficients B is significantly different from zero at some significance level is as follows :

$$F = (N-k)\frac{(ESS_r - ESS_{ur})}{q(ESS_{ur})}$$

ESSr and ESSur are the sums of squared residuals in the restricted and unrestricted regressions; N is the number of observations; k is the number of estimated parameters in the unrestricted regression and q is the number of parameter restrictions. The statistic follows a F(q, N–k) distribution. We can reject the null hypothesis that "X does not cause Y" (β_1, β_2, ...β_m = 0) if the group of coefficients added to the restricted regression is significantly different from zero.

The next step is to test the null hypotheses "Y does not cause X". We should run the same regressions as above, but now switching X and Y. If we can not reject the null hypothesis that "Y does not cause X" then we can conclude that X Granger causes Y.

Testing for ARCH/ GARCH Model

The null hypothesis of there is no autocorrelation in the error variance (no ARCH) is given by an ARCH (p) process. Uncertainty is measured by looking at volatility in individual series. Estimation of volatility is of crucial importance because higher volatility makes financial investment more risky. The Lagrange Multiplier (LM) Test is used to check ARCH/GARCH effects in the series under analysis.

Empirical Results :

The analysis has been conducted for sample period 1997-2010 and also for 1997-2004 and 2004-2010. Table 1 presents the descriptive statistics for the daily stock return of NSE and S&P-500. It is very clear form the Table 1 that NSE exhibits the highest average daily return and highest variability among the two markets as measured by the standard deviation of returns. Further, the results also observed that the Nifty return series follows non normal distribution in all three periods under study, which is given by measures of skewness and kurtosis. The higher value of sample kurtosis, however, implies that the distributions of nifty returns are leptokurtic or tailed.

Table 1

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
Whole Period						
India	-11.81	15.99	.0409	1.78026	-.072	5.139
US	-9.47	10.96	.0012	1.35409	-.214	7.667
Pre IInd generation reforms						
India	-11.60	15.99	.0750	1.94080	.143	6.018
US	-9.47	10.96	.0015	1.50406	-.290	10.660
Post IInd generation reforms						
India	-11.81	8.59	.0179	1.66320	-.316	3.613
US	-7.11	5.57	.0009	1.24305	-.118	2.460

In order to test whether the two market indices are cointegrated, it is necessary to first determine, if each index series is stationary. If they are stationery, the index series are then examined to determine whether they are cointegrated.

Unit Root Test

Augmented Dickey-Fuller test is used on the market index levels and their first differences to test for unit root in the data. The ADF test results prove that all the stock market indices are non stationary at the logs of prices. However, it is observed that the hypothesis of unit root test based on returns computed using first difference of logs of prices is rejected (Table 2). So it can be said that all the variables contain a unit root, that is, non-stationary in their level forms, but stationary in their first differenced forms, thereby supporting the random walk hypothesis.

Table 2

The ADF tests for Unit Roots

Variable	Level		First Difference	
	With Constant	With Constant and Trend	With Constant	With Constant and Trend
Whole Period				
India	-0.2636	-2.2022	-39.3711*	-39.3852*
US	-2.4190	-2.4044	-43.0974*	-43.1017*
Pre IInd generation reforms				
India	-1.0692	-1.5374	-30.0931*	-30.136*
US	-2.0166	-2.1865	-31.4912*	-31.4881
Post IInd generation reforms				
India	-1.7064	-1.7105	-25.2302*	-25.2347*
US	-1.3170	-1.6717	-29.0831*	-29.0771*

* Significant at 1 per cent level of significance

** Significant at 5 per cent level of significance

COINTEGRATION RESULTS

Engle-Granger Cointegration Test

Cointegration analysis is used to investigate long term relationship between Indian and US stock market. The analysis recognizes the non-stationary of the time series. Economically speaking, two variables will be cointegrated if they have long term or equilibrium relationship between them (Engle and Granger 1987). Because all the stock price indices are non-stationary, Engle Granger Cointegration test is conducted. The results shown in Table 3 depict that there is long term relationship between the stock markets in all three periods under study. The null hypothesis of no cointegration is rejected for all pair-wise cases.

Table 3

Engle-Granger Cointegration Test Result

Name of the Country	Computed ADF Test Statistics	p-value
Whole Period		
India on US	-32.5943*	0.000
US on India	-35.2833*	0.000
Pre IInd generation reforms		
India on US	-24.2506*	0.000
US on India	-25.2506*	0.000
Post IInd generation reforms		
India on US	-21.6731*	0.000
US on India	-24.5438*	0.000

Note : The critical values of ADF tests are -3.511 and -2.897 at 1 per cent and 5 per cent level of significance respectively.

Johansen Cointegration Test

Similarly, the results of Johansen's cointegration test are presented in Table 4. The methodology adopted here does not correspond to pair-wise cointegration: rather we make an attempt to test for co-movement among all the indices taken together. In line with the discussion carried out above, both trace and max statistics has confirmed the existence of cointegrated relationships between these markets. Thus, the inference drawn through Engle-Granger test gets reinforced by Johansen test.

Table 4

Johansen Cointegration Test Results:

Rank	Eigenvalue	Trace test	p-value	Lmax test	p-value
Whole Period					
0	0.42343	2851.7	[0.0000]	1652.5	[0.0000]
1	0.32941	2022.6	[0.0000]	1199.2	[0.0000]
Pre IInd generation reforms					
0	0.38227	1544.5	[0.0000]	862.25	[0.0000]
1	0.31692	682.25	[0.0000]	682.25	[0.0000]
Post IInd generation reforms					
0	0.64504	1920.4	[0.0000]	1253.3	[0.0000]
1	0.42381	667.09	[0.0000]	667.09	[0.0000]

Note : Trace test and Max-Eigen value test indicates no cointegration at both 1 per cent and 5 per cent level of significance

Granger Causality Test Results

In the presence of long run relationship between the stock prices of India and its major trading partner US stock market, the Granger causality test is used to examine the pair- wise short run interactions between two stock markets. According

Table 5

Pair wise Granger Causality Test Result

Null-Hypothesis	F-Statistics	Accept/Reject
Whole Period		
India does not cause US	17.6336*	Reject
US does not cause India	47.1423*	Reject
Pre IInd generation reforms		
India does not cause US	8.1360**	Reject
US does not cause India	3.5373*	Reject
Post IInd generation reforms		
India does not cause US	64.1140*	Reject
US does not cause India	10.0668*	Reject

* Significant at 1 per cent level of significance

** Significant at 5 per cent level of significance to the results presented in the Table 5 in the short term, there, bidirectional granger causality between India and US in the whole sample period , pre second generation reforms period and post second generation reforms period. The degree of Granger causality was very high in the post second generation reforms period.

Stock Market Volatility

Analyzing the possible impact of second generation reforms on the market volatility is profoundly important for policy makers and regulators in their deliberations on the costs and benefits of liberalization programs. Therefore, besides examining stock return inter-dependencies between the Indian and US stock market volatility inter-dependencies across these markets have been explored.

Testing for ARCH/GARCH Effects

ARCH process is used to measure volatility in stock returns of the two markets under study. Estimation of volatility is of crucial importance because higher volatility makes financial investment more risky. The Lagrange Multiplier (LM) Test is used to check ARCH/GARCH effects in the series under analysis. We start with the residual term in the mean equation for four lag. The results obtained are shown in Tables 6 and 7. The regression test reveals that the coefficients for one, two, three and four are significant at 1 per cent level of significance. Further, it is clear from the analysis that the observed F value exceeds the LM test statistic. Therefore, we overwhelmingly reject the null hypothesis and conclude that there are sufficient ARCH effects. The results reveal that there is significant ARCH effect (volatility clustering in each series).

Table 6

Test for ARCH/GARCH for India

	Coefficient	std. error	t-ratio	p-value
Intercept	1.8218300	0.175448	10.38*	0.000
alpha(1)	0.1349720	0.0181082	7.454*	0.000
alpha(2)	0.0883641	0.0182342	4.846*	0.000
alpha(3)	0.0672410	0.0182342	3.688*	0.000
alpha(4)	0.1350710	0.0181083	7.459*	0.000

Note : Null hypothesis: no ARCH effect is present

Test statistic : LM = 206.895

with p-value = P(Chi-Square(4) > 206.895) = 1.23644e–043

Table 7
Test for ARCH/GARCH for US

	Coefficient	std. error	t-ratio	p-value
Intercept	0.716445	0.105011	6.823*	0.000
alpha(1)	0.0996772	0.0179284	5.560*	0.000
alpha(2)	0.222807	0.0179395	12.42*	0.000
alpha(3)	0.0935224	0.0179398	5.213*	0.000
alpha(4)	0.193147	0.0179287	10.77*	0.000

Note : Null hypothesis : no ARCH effect is present
Test statistic : LM = 527.086
with p-value = P(Chi-Square(4) > 527.086) = 9.27295e–113

Time-Varying Conditional Spillovers from US Market to India

Final task in this paper is to examine whether US stock market constitutes main casual force behind volatility in the Indian stock market or not. To examine the spillover effect of volatility from US stock market to India, Granger causality test is applied to the residual series.

Granger Causality Test

Table 8 reports the volatility spillovers from the US stock market to volatility in the Indian stock market. It is clear from the table that US market has significant effect on the volatility in Indian stock market. Further, it also suggests that volatility spillovers from US to Indian stock market have been very high after the second generation reforms.

Table 8
Time-Varying Conditional Spillovers from US Market to India: Granger Causality Test

Period	F-Statistics
Whole Period	1.7377**
Pre IInd generation reforms	2.8439**
Post IInd generation reforms	10.0668*

* Significant at 1 per cent level of significance
** Significant at 5 per cent level of significance

CONCLUSION

There are several reasons to analyze the cross-border volatility spillovers as one of the determinants of stock return volatility of domestic market in addition to various domestic factors. In this paper an attempt has been made to examine the long run and short run relationship and volatility relationship between the stock prices of India and its major trading partners US stock market. It also examines whether such a relationship, if it exists, is affected by the second generation reforms (that began in 1998), using daily data for the period 1 July 1997 to 25 February 2010. The results of the study make clear that these stock markets move together, and are integrated. Further, the study has also shown that volatility relationship between the stock prices of India and its major trading partners US stock market have been found for all three periods under study. Thus, results identify the US market as the main source of volatility spillovers for Indian stock market. It is also suggested from the volatility spillovers from US have become quite pronounced after the second generation reforms. Finally, it is suggested from the study that investing in these stock markets will not generate any long term gain to portfolio diversification.

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