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The Response of Indian Equities to US Stock Market Movements of the Prior Trading Day

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Abstract

The aim of this chapter is to glean empirical evidence about the interconnections between Indian and US markets, in terms of price and volatility spillovers. The analysis also investigates the promptness of the Indian market response to US movements, any asymmetric properties of such response and how the latter is affected by liquidity factors such as the number of companies traded and transaction size.

JEL Classification: G12; G14; G15
Keywords: Stock Markets, National Stock Exchange of India, Volatility Spillovers, Emerging Markets, Market Integration

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1. Introduction

The aim of this chapter is to glean empirical evidence about the interconnections between emerging and developed markets. This issue has attracted much academic and practitioner interest given that as emerging markets become more integrated with established ones, their traditional diversification potential may change. Specifically, this analysis considers the connections between Indian and US markets, in terms of how the former market reacts to the prior US trading day price changes. Analysing the Indian markets offers the advantage of access to a large base of shares which are considerably more liquid as compared to those of other emerging markets.

This chapter first tackles the price (returns) and volatility (squared returns) responses between the above two markets. The analysis also delves into the nature of the Indian responses to US market movements by considering asymmetries and whether the response timing may be deemed consistent with an efficient market. The final investigation relates to whether the Indian response to US market fluctuations is affected by liquidity factors such as trading activity and transaction size.

2. Indian Securities Markets and Related Data

Indian capital markets went through a regulatory reform in the early 1990s, moving away from a policy where share issues were controlled by the government. Subsequent improvements included efforts to enhance transparency and settlement systems, and curbing market manipulation.

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This analysis uses data from the National Stock Exchange of India (NSE). NSE is one of the major Indian exchanges, together with the Bombay Stock Exchange (BSE). NSE trading activity commenced in 1994, and around 1630 equity issues were trading in 2008. Most major stocks are quoted on both NSE and BSE and therefore these exchanges compete both for listings and for order flow. On average, around 5.5 million transactions were processed on each trading day on NSE in January 2008. Brokers interact through an automated limit order book and there are no designated market makers.

The NSE Nifty Index (N) comprises the fifty most liquid stocks whereas the Nifty Junior Index (NJ) includes the next 50 liquid stocks, jointly accounting for a substantial part of market capitalisation. The data comprise N and NJ daily observations from January 1998 to May 2008. The data were filtered by deleting those Indian trading days when the market opened in the absence of a prior US trading day which was yet unaccounted for on the Indian markets. For instance if the 4^{th} July is a US trading holiday, the Indian observations of the 5^{th} July were deleted, since one would expect no information spillovers from the US in such instances. The final data thus consisted of 2514 daily observations. The S&P 500 Index was used as a proxy for daily US market movements. Subsidiary data included volume statistics for NSE. Intra-day data for the Indian indices were available for the period March 1999 till March 2000, comprising 263 trading days. One should note that due to time-zone differences, Indian and US trading hours do not overlap. Figure 1 shows a plot of the daily closing values (levels) of the indices.

Figure 1: Nifty, Nifty Junior and S&P Daily Index Values

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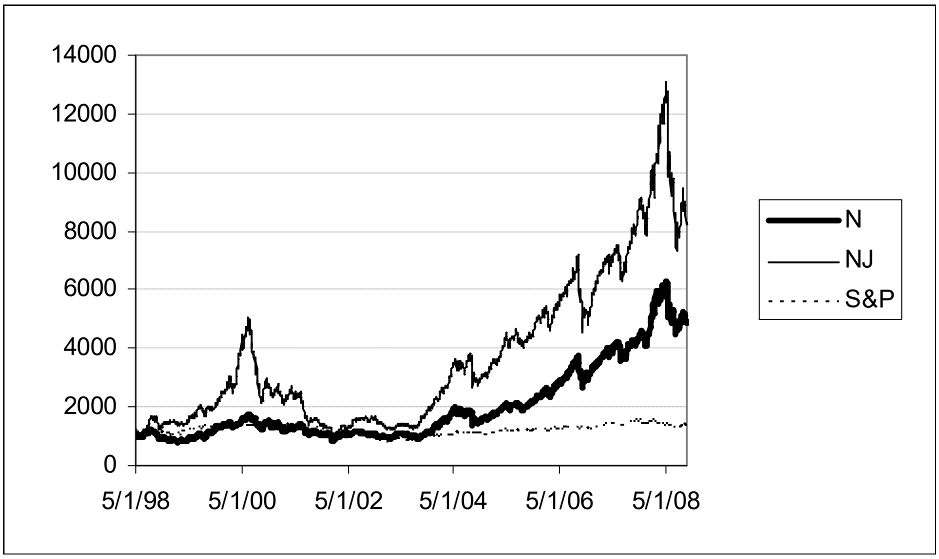

3. Interconnections between Indian and US Stock Markets

This section investigates the price and volatility connections between the Indian and US markets. We first study whether the Indian markets have become more integrated with US ones over the years. We then estimate VAR models to test for spillovers across markets using the daily observations.

3.1 The Level of Market Integration over the Years

Market integration may be thought of as the tendency for emerging markets to become similar to developed ones and moving more in line with the latter as different assets across markets command the same expected risk-adjusted return. One factor which makes markets more inter-connected is the cross-listing of stocks on overseas exchanges. Purfield *et. al.* (2006) presented statistics which show that the number of Indian cross-listings increased in absolute value since the year 2000, yet it has decreased in relative terms when considered as a proportion of local market capitalisation. When considering simple

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correlation results shown in Table A Panel A, we get an idea that correlation between US and Indian markets increased in the post-2000 period.

Table A: Integration of Indian Markets with US ones.

Panel A: Correlation Between Indian and US Daily Returns

	1998-2000	**2001-2008**
Correlation: N - S&P	0.187	0.255
Correlation: NJ - S&P	0.117	0.191

Panel B: Regression Estimations with Integration Variable

	α	β	γ [DSP]	R^2
N Model	0.0006	0.2736	0.0900	0.0536
	(1.70)	(5.90)	(1.55)	
NJ Model	0.0007	0.2221	0.0946	0.0266
	(1.80)	(3.89)	(1.32)	

DSP is the product of the S&P daily log return and D_I – a dummy variable with a value of one after the year 2000, and zero otherwise.

T-ratios are shown in brackets underneath the respective coefficients.

We further investigate this issue to inquire whether the level of integration between Indian and US markets increased after the year 2000. We estimated the model shown in Equation 1 where $r_{i,t}$ is the log return of the respective Indian Index on day t , r_{St} is the S&P log return, and $\varepsilon_{i,t}$ is a random error term. We created a Dummy Variable D_I which takes a value of 1 after the year 2000, and zero otherwise. In order to gauge whether integration between the US and Indian markets increased, we use a variable DSP_t, being the product of D_I and r_{St}.

$$r_{i,t} = \alpha_i + \beta_i r_{S,t-1} + \gamma_i DSP_{t-1} + \varepsilon_{i,t} \qquad \text{(Equation 1)}$$

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Results shown in Table A Panel B, indicate that *DSP* is positive yet insignificant.[1]

The resulting price connections due to market integration may be of a long-term nature, and therefore should not necessarily be tested for through the co-movement of daily returns. For instance cointegration tests may be more appropriate. Different tests were specified to infer whether the US and Indian indices are cointegrated. Such tests uniformly failed to reject the null hypothesis of no cointegration at the 95% confidence level and therefore are not being reported. Overall, these results suggest that whilst the interconnections between the Indian and US markets may be increasing, India is still fairly autonomous. This may possibly be attributed to the relatively low participation rate on part of institutional investors whose actions tend to materialise in higher integration. For instance, Purfield *et. al.* (2006) argue that Indian assets held by institutional investors are still relatively low, and this may be due to restrictions over the types of assets which such investors may purchase.

3.2 Daily Volatility Spillovers (Squared Returns VAR)

We now test the daily connections between the US and Indian markets, through the estimation of VAR models, using SURE methodology. Various studies such as Koutmos and Booth (1995), report a more significant relationship across markets when investigating volatility responses as compared to price responses. This might be due to the possibility that larger markets affect overseas ones at times in the same direction and occasionally in the opposite direction depending on the nature of particular events. For instance adverse news from the US may have negative impacts on the Indian markets due to a

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[1] Given that research suggests that the level of integration may change when markets go through a crisis period (Yang, Kolari and Min, 2003; Gębka and Serwa, 2006), the observations coinciding with the Asian Financial Crisis of 1998 were eliminated, and the models were re-estimated using the data for 1999-2008. Results (unreported) showed that whilst *DSP* significance increased, it was still below the 95% confidence level.

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possible reduction in demand for Indian exports. Conversely, adverse US news may lead investors to sell US stocks and seek shelter in alterative markets, causing a price change in the opposite direction. Such intricacies do not apply when analysing squared returns, since in such cases the direction of the responses is irrelevant.

A preliminary VAR (5) model was estimated as suggested by the Schwarz Bayesian Criterion. More compact models were then estimated, eliminating some insignificant lags. Results are reported in Table B. The S&P volatility of the prior US trading session is highly significant in the NJ Equation, yet it is insignificant in the N Equation. Similarly the NJ model has a better explanatory power than the N model. One would usually expect the most liquid companies to be more affected by overseas factors as compared to less liquid ones, since for instance overseas investors might confine their holdings to the more liquid stocks. This is not the case with the former results; it might be that stocks comprising the NJ are more prone to international movements due to the nature of their business. The models also show that Indian Index volatility is insignificant in the S&P equations. These notions were confirmed through four Wald-tests, where the null hypothesis that the S&P volatility had no impact on the N model could not be rejected, and the null hypotheses that the N and NJ volatility had no impact on the S&P models could not be rejected. Yet, the null that the S&P volatility had no impact on the NJ model was rejected at the 99% level of confidence. Overall, the explanatory power of the models is meagre and largely emanates from the lagged observations of the dependent variable, rather than from interconnections between the US and Indian markets.

Table B: SURE Estimations On Squared Returns

N – S&P Estimation			**NJ – S&P Estimation**		
N Equation			***NJ Equation***		
Intercept	0.0002	(9.73)	Intercept	0.0002	(8.24)
N (t-1)	0.2351	(11.87)	NJ (t-1)	0.2602	(13.18)
N (t-2)	0.0323	(1.60)	NJ (t-2)	0.0837	(4.12)

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N (t-3)	0.1005	(5.11)	NJ (t-3)	0.0975	(4.95)
S&P (t-1)	0.0593	(1.24)	S&P (t-1)	0.2415	(3.62)
Explanatory Statistics:			Explanatory Statistics:		
R-Bar-Squared		0.0835	R-Bar-Squared		0.1275
F-Statistic (4, 2503)		58.12	F-Statistic (4, 2503)		92.59
S&P Equation			***S&P Equation***		
Intercept	0.0001	(9.16)	Intercept	0.0001	(9.19)
S&P (t-1)	0.0957	(4.81)	S&P (t-1)	0.0946	(4.74)
S&P (t-2)	0.0958	(4.86)	S&P (t-2)	0.0936	(4.72)
S&P (t-3)	0.0983	(4.99)	S&P (t-3)	0.0981	(4.95)
S&P (t-4)	0.0629	(3.19)	S&P (t-4)	0.0630	(3.17)
S&P (t-5)	0.1180	(6.00)	S&P (t-5)	0.1207	(6.10)
N (t) *	0.0074	(0.96)	NJ (t) *	0.0046	(0.85)
Explanatory Statistics:			Explanatory Statistics:		
R-Bar-Squared		0.0711	R-Bar-Squared		0.0710
F-Statistic (6, 2501)		32.98	F-Statistic (6, 2501)		32.94

T-ratios are shown in brackets next to the respective coefficients. For all the models, the F-Statistics reject the null hypothesis that all the regressors (except the intercept) are zero at the 99% confidence level.

* The N and NJ variables in the S&P equations are labelled as contemporaneous since they occur on the same trading day as the S&P observations. Yet, since the Indian trading session typically terminates by the time US markets open, this is really a lagged relationship.

3.3 Daily Price Connections (Returns VAR)

A similar approach was taken for the estimation of the returns VAR. We started with a VAR(5) model as suggested by the Aikaike Information Criterion, however a more compact model was re-estimated, eliminating insignificant lags. We ended up with the models shown in Table C. Looking at the models for the Indian indices, we should start by cautioning about the negative explanatory power statistic. The first S&P lag is negative and significant, which indicates that the Indian markets tend to move in the opposite

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direction of US ones. Yet, the third S&P lag is significantly positive, suggesting that the Indian markets might initially over-react to the US movement, and this is subsequently corrected.

Table C: SURE Estimations On Returns

N – S&P Estimation			**NJ – S&P Estimation**		
N Equation			***NJ Equation***		
Intercept	0.0007	(1.80)	Intercept	0.0009	(1.70)
N (t-1)	0.0785	(3.17)	NJ (t-1)	0.1675	(6.56)
N (t-2)	-0.0706	(-3.55)	NJ (t-2)	-0.0507	(-2.54)
S&P (t-1)	-0.7071	(-25.3)	S&P (t-1)	-1.1100	(-32.47)
S&P (t-2)	0.0181	(0.51)	S&P (t-2)	-0.0041	(-0.09)
S&P (t-3)	0.1062	(3.01)	S&P (t-3)	0.1114	(2.52)
Explanatory Statistics:			Explanatory Statistics:		
R-Bar-Squared		-0.4522	R-Bar-Squared		-0.5721
F-Statistic (5, 2502)		NIL	F-Statistic (5, 2502)		NIL
S&P Equation			***S&P Equation***		
Intercept	0.0002	(0.68)	Intercept	0.0002	(0.71)
S&P (t-1)	-0.0378	(-1.85)	S&P (t-1)	-0.0299	(-1.48)
S&P (t-2)	-0.0396	(-1.99)	S&P (t-2)	-0.0389	(-1.95)
S&P (t-3)	-0.0379	(-2.36)	S&P (t-3)	-0.0403	(-2.59)
S&P (t-4)	-0.0108	(-0.68)	S&P (t-4)	-0.0136	(-0.88)
S&P (t-5)	-0.0517	(-3.24)	S&P (t-5)	-0.0482	(-3.11)
N (t) *	0.0516	(3.63)	NJ (t) *	0.0318	(2.74)
Explanatory Statistics:			Explanatory Statistics:		
R-Bar-Squared		0.0079	R-Bar-Squared		0.0055
F-Statistic (6, 2501)		4.31	F-Statistic (6, 2501)		3.33

T-ratios are shown in brackets next to the respective coefficients. In case of the S&P equations, the F-Statistics reject the null hypothesis that all the regressors (except the intercept) are zero at the 99% confidence level.

* The N and NJ variables in the S&P equations are labelled as contemporaneous since they occur on the same trading day as the S&P observations. Yet, since the Indian trading session typically terminates by the time US markets open, this is really

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a lagged relationship.

Considering the S&P models, the first lag of the respective Indian Index is significant and has a positive sign which suggests that US markets are not indifferent to the Indian market. This is somewhat in line with the findings of Cuardo Sáez, Fratzscher and Thinmann (2007) who documented that developed markets are sensitive to emerging market fluctuations, yet the authors specified that US markets are more sensitive to Latin American markets as compared to Asian ones. It should also be noted that the same Indian Index lag was insignificant in the Squared Returns Model (Table B). This indicates that whilst the US markets react to Indian (or emerging) market movements, there is no substantial volatility spillover from the Indian to the US market. Indeed, a look at Figure 1 confirms that the Indian markets are more volatile than US ones.

A series of Wald tests was conducted on the variables which relate to the interconnections between the Indian and US markets. In case of the N and NJ equations, the null hypotheses that the first lag of the S&P has no impact on the model, were rejected at the 99% confidence level. Similarly, the Wald tests rejected the null hypothesis that the respective Indian Index had no impact on the S&P models at the 99% level of confidence. Overall, whilst the squared returns VAR has a higher explanatory power as compared to the returns one, the latter model highlights the interconnections between markets more clearly when considering the statistical significance of US (Indian) lags in the Indian (US) model.

4. The Nature of Indian Responses to US Stock Price Movements

This section delves into select characteristics of the Indian response to US price movements, in terms of asymmetric properties and promptness.

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4.1 Asymmetric Responses

We now investigate whether the response to negative US returns is larger than the response to US positive returns. We use a dummy variable D_A which takes a value of one when the prior day US return is negative and a value of zero otherwise. The model shown in Equation 2 was estimated using N and NJ data.

$$r^2{}_{i,t} = \alpha_i + \beta_i r^2{}_{S,t-1} + \gamma_i D_A + \varepsilon_{i,t} \qquad \text{(Equation 2)}$$

Results are presented in Table D. The dummy is positive in both estimations, indicating that the response to negative US returns is larger than the response to positive ones. The dummies are significant at the 95% and 90% confidence levels respectively. The pronounced volatility following negative overseas returns is in line with other research papers including Koutmos and Booth (1995) in the context of other markets.

Table D: Asymmetric Properties of the Indian Responses

	α	***β***	***γ [D_A]***	***R²***
N Model	0.0002 (9.31)	0.3966 (8.02)	0.0001 (2.04)	0.0269
NJ Model	0.0003 (10.05)	0.5365 (7.62)	0.0001 (1.84)	0.0242

D_A is a dummy variable taking a value of one when the prior day US return is negative and zero otherwise. T-ratios are shown in brackets underneath the respective coefficients.

4.2 The Promptness of Indian Responses to US Market Movements

Camilleri, S.J., 2010, "Response of Indian Equities to U.S. Stock Market Movements of the Prior Trading Day" In G.N. Gregoriou (ed.) *Emerging Markets: Performance, Analysis and Innovation*, CRC Press – Taylor and Francis Group, Florida. pp. 493-508.

Following market efficiency arguments, Indian stocks should react to the previous US trading session early during the day and subsequent returns should be unrelated to US movements. This notion was tested by investigating the relationship between the Indian return during the first six trading minutes and the prior US trading session return. We then test for the relationship between the Indian return from the sixth to the twentieth minute and the prior US trading session return – these returns should be unrelated in an efficient market. Similarly the Indian return from the sixth minute to the closing should be unrelated to the prior US return.

We thus used the data period for which intra-day observations were available (March 1999-March 2000) and estimated the model:

$$r_{i,t} = \alpha_i + \beta_i r_{S,t-1} + \varepsilon_{i,t} \qquad \text{(Equation 3)}$$

where Indian returns $r_{i,t}$ were defined as the first six minute return in the first estimation, the return between the sixth to the twentieth minute in the second estimation, and the return from the sixth minute to the closing in the third estimation.

Results are reported in Table E. Column A shows a significant relationship between the Indian return during the first six minutes and the prior US trading day return. Column B shows that the Indian return between the sixth and twentieth trading minute is unrelated to the returns of the prior US trading session. Column C yields similar indications when the Indian return between the sixth and the closing is considered. Despite this the S&P return becomes significant at the 90% confidence level in case of the NJ estimation. One should note that whilst the initial Indian returns are in the same direction as the US prior day return, the subsequent Indian returns are in the opposite direction of the US market. This may suggest that the initial return may constitute an overreaction to the US market movement which is subsequently reversed during the rest of the trading day. Indeed, a look at the first S&P lag in the N and

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NJ models shown in Table C (estimated on the whole sample of ten years of data), points that the Indian markets would have significantly fluctuated in the opposite direction of the US markets by the end of the day.

Table E: The connection between Indian Intra-day returns and US returns

	Column A: First 6 minutes		**Column B: 6th - 20th minute**		**Column C: 6th minute - closing**	
	α	*β*	*α*	*β*	*α*	*β*
N Models	0.0040 (6.06)	0.1530 (2.80)	-0.0009 (-2.45)	-0.0068 (-0.21)	-0.0036 (-3.47)	-0.0628 (-0.73)
	$R^2 = 0.0291$		$R^2 = 0.0002$		$R^2 = 0.0020$	
NJ Models	0.0042 (5.71)	0.1141 (1.89)	-0.0009 (-2.17)	-0.0125 (-0.35)	-0.0030 (-2.30)	-0.1894 (-1.76)
	$R^2 = 0.0135$		$R^2 = 0.0005$		$R^2 = 0.0118$	
T-ratios are shown in brackets underneath the respective coefficients.						

The nature of the intra-day Indian volatility was investigated further through GARCH estimations on high frequency data. The data set consisted of 13 continuous trading days (9-25 June 1999) sampled at two minute intervals, yielding 2149 observations. The modelling of the Indian response is particularly tricky, since this coincides with the typically highly volatile period at the beginning of the day. Higher opening volatility is well documented in market microstructure literature [e.g. Wood, McInish and Ord (1985)] and one should endeavour to separate the opening volatility from the response to the US return. Two dummy variables were thus created: an opening dummy (D_O) and a response dummy (D_R). A visual inspection of the data set indicated that the pronounced opening volatility takes place during the first six minutes of trading. In this way, D_O took a value of one for the first three observations of each trading day, and a value of zero for the rest of the day. The former investigation suggested that the Indian response to US

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volatility took place *within* six trading minutes, and therefore D_R took a value of one for the first two observations of each trading day and zero for the rest of the day.[2] In estimating GARCH models we did not include D_R directly in the equation, but the variable was multiplied by the US prior trading day return. In this way the new variable ($D_R r_S$) captured the dummy effect and it was also sensitive to the magnitude of the US return. A note is warranted regarding the possibility that the inclusion of D_O and $D_R r_S$ induces multicollinearity. One symptom of the latter is that the correlated variables would be individually insignificant in the model, yet jointly significant. This is *not* the case with the results we obtained.

Tests for asymmetric volatility following Engle and Ng (1993), indicated that it was not necessary to account for this feature.[3] In this way we estimated GARCH (1,1) models where returns are modelled as an AR(1) process, whilst heteroskedasticity is modelled as shown in Equation 4:

$$h_{i,t} = \omega_i + \alpha_i \varepsilon^2_{i,t-1} + \beta_i h_{i,t-1} + \gamma_i D_O + \rho_i D_R r_{S,t-1} \qquad \text{(Equation 4)}$$

where $h_{i,t}$ is the conditional variance of the respective index which depends on past information, and $\varepsilon_{i,t}$ is the unexpected return observed during period *t*.

GARCH estimations are shown in Table F. The variable $D_R r_S$ is highly significant in both models, yet the negative coefficient is in the unexpected direction, since this indicates that the response to the US returns induces a lower conditional variance. Perhaps this might be interpreted as a sign that the information from US markets, is a yardstick which reduces uncertainty at the opening, although this explanation would

[2] Specifying D_R which takes a value of one during the first three observations did not lead to materially different results.

[3] Tests for ARCH effects following the Engle (1982) methodology indicated that the null hypothesis of no ARCH effects cannot be rejected; nonetheless the estimation of GARCH models was proceeded with.

Camilleri, S.J., 2010, "Response of Indian Equities to U.S. Stock Market Movements of the Prior Trading Day" In G.N. Gregoriou (ed.) *Emerging Markets: Performance, Analysis and Innovation*, CRC Press – Taylor and Francis Group, Florida. pp. 493-508.

conflict with the former observation that the initial response to US movements might constitute an over-reaction since it tends to reverse subsequently.

Table F: GARCH (1,1) Estimations

N Model			**NJ Model**		
Log Return AR(1) Process:			Log Return AR(1) Process:		
Intercept	*Lag*	R^2	*Intercept*	*Lag*	R^2
0.000005	0.2667	0.2861	-0.000011	0.2284	0.0528
(0.31)	(11.67)		(-0.87)	(9.82)	
Conditional Variance Equation:			Conditional Variance Equation:		
ω	α	β	ω	α	β
0.0000	0.1819	0.5267	0.0000	0.1207	0.7246
(0.11)	(6.83)	(23.32)	(0.03)	(5.88)	(41.09)
γ $[D_O]$		ρ $[D_R r_S]$	γ $[D_O]$		ρ $[D_R r_S]$
0.000014		-0.0003	0.000004		-0.0001
(7.50)		(-2.96)	(1.89)		(-38.46)
R-Bar-Squared = 0.0263			R-Bar-Squared = 0.0506		
F-Statistic (5, 2141) = 12.61			F-Statistic (5, 2141) = 23.88		

T-ratios are shown in brackets underneath the respective coefficients.

The F-statistics reject the null hypothesis that all the regressors (except the intercept) are equal to zero, at the 99% confidence level.

5. Liquidity-Related Factors

This section considers whether the Indian response to US fluctuations is affected by liquidity factors. In particular, when a stock does not trade or if there are only a few transactions in a particular stock, the latter might fail to reflect the impact of recent news or overseas developments. In this way, one would expect a more significant Indian response when the number of companies traded and the number of transactions on the exchange are higher. Similarly, we investigate whether the Indian response is more intense, when the trading day is characterised by larger transactions. This might be due to the possibility that the typically larger transactions of professional fund managers may be more likely to reflect overseas developments if the former diversify their portfolios internationally.

5.1 Response to US Market Movements and Trading Activity

The effect of the number of companies traded (c_t) on the Indian response was investigated by estimating the following OLS regression on N and NJ daily data:

$$r^2{}_{i,t} = \alpha_i + \beta_i r^2{}_{S,t-1} + \gamma_i c_t + \varepsilon_{i,t} \qquad \text{(Equation 5)}$$

The variable c_t was highly significant and positive as shown in Table G Panel A, implying that the number of companies traded positively impacts on the transmission of volatility.

Table G: The Effects of Liquidity Factors on Indian Responses

Panel A: Number of Companies Traded (c_t)				
	α	β	γ [c_t]	R^2
N Model	-0.0001	0.3942	0.0000003	0.0313
	(-1.16)	(7.99)	(3.94)	
NJ Model	-0.0003	0.5299	0.000001	0.0348
	(-2.59)	(7.57)	(5.57)	
Panel B: Number of Transactions Per Company Traded (t_t)				
	α	β	γ [t_t]	R^2
N Model	0.0002	0.4060	0.0000	0.0257
	(7.83)	(8.13)	(1.03)	

Camilleri, S.J., 2010, "Response of Indian Equities to U.S. Stock Market Movements of the Prior Trading Day" In G.N. Gregoriou (ed.) *Emerging Markets: Performance, Analysis and Innovation*, CRC Press – Taylor and Francis Group, Florida. pp. 493-508.

NJ Model	0.0003 (9.15)	0.5397 (7.60)	-0.0000 (-0.02)	0.0229
Panel C: Average Transaction Size (z_t)				
	α	β	γ [z_t]	R^2
N Model	0.0002 (5.25)	0.3879 (7.84)	0.0176 (3.08)	0.0290
NJ Model	0.0001 (3.34)	0.5088 (7.26)	0.0484 (5.98)	0.0366
T-ratios are shown in brackets underneath the respective coefficients.				

A similar approach was adopted when investigating the effect of the number of transactions in each company. The average number of transactions per company was computed by dividing the total number of transactions on the exchange for the particular day, by the number of companies traded during the same day. We then estimated the model:

$$r^2_{i,t} = \alpha_i + \beta_i r^2_{S,t-1} + \gamma_i t_t + \varepsilon_{i,t} \qquad \text{(Equation 6)}$$

where t_t is the average number of transactions per company traded on day *t*. As shown in Table G Panel B, the coefficients of t_t are insignificant in both estimations. This suggests that the Indian response to US volatility is independent of the number of transactions per company and somewhat contradicts the well-established notion that volume may constitute an additional response to information, apart from price changes (Verrechia; 1981). The reason behind such result might be that most of the Indian response to US volatility takes place during the first six minutes of trading (Section 4.2), and therefore it materialises even after a relatively few transactions have been executed.

5.2 Response to US Market Movements and Transaction Size

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We now consider whether the Indian response is more intense, when the average transaction size is larger. The total traded value was divided by the number of transactions for each trading day, in order to obtain the average transaction size z_t. We then estimated the model shown in Equation 7.

$$r^2{}_{i,t} = \alpha_i + \beta_i r^2{}_{S,t-1} + \gamma_i z_t + \varepsilon_{i,t} \qquad \text{(Equation 7)}$$

Results in Table G Panel C show that transaction size is highly significant, suggesting that larger transactions may be associated with higher volatility responses. Overall, the results point that volatility spillovers from the US to India become more intense as the number of traded companies and average transaction size on the latter market increase.

6. Conclusion

This analysis investigated the price and volatility connections between Indian and US markets. Indian markets are sensitive to US price changes particularly when considering volatility spillovers (rather than the price effect). This might be due to the possibility that US fluctuations affect Indian markets at times in the same direction, whilst at times the markets move in the opposite direction depending on the nature of the event to which they are responding. The Indian markets react fairly early in the trading day to US price changes; the reaction is asymmetric and its intensity is also affected by liquidity factors. We also found evidence that US markets are not indifferent to Indian markets, although this may possibly constitute a reaction to mutual factors across emerging markets or the possibility that both markets respond to common news. The low explanatory power of most models suggests that the majority of price fluctuations on the Indian markets may not be explained by US factors. Coupled with the cointegration tests where the null hypothesis of no cointegration was not rejected, the results point that the Indian markets should have offered considerable diversification potential for US investors over the sample period.

A note about the limitations of this study is warranted. Due to time zone differences, the markets' reaction to a given event might at times occur on the same trading date, or at times on different trading days. In this way, an international event occurring during Indian trading hours would firstly be accounted for by the Indian markets and subsequently by the US ones; giving the impression that the former markets influence the latter. Conversely, an event occurring during the US trading hours is priced by the Indian markets on the subsequent day, which might be mistaken for direct US influence on the Indian markets. Another limitation emanates from the fact that the analysis involves stock market data spanning over a long period of time. This implies that the conditions which underlie the pricing process are likely to change due to possible modifications in trading protocols and other factors which are unaccounted for.

As for future research topics, the efficiency of the Indian response to US movements may be analysed in further detail; whilst the above results suggest that Indian markets respond early in the day to US fluctuations, the initial response may also constitute an overreaction since it seems to reverse at a subsequent stage.

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