STOCK PRICE BEHAVIOUR IN INDIA SINCE LIBERALIZATION

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The study investigates the behaviour of Indian stock price indices for the 12-year period 1990-2001. This period coincides with major changes in the Indian capital market and the opening up of the Indian economy. The stock market witnessed unprecedented swings and volatility during this period, which have had severe repercussions for investors, both individual and institutional. The study also explores other important issues facing the Indian stock market such as return volatility, including its time varying pattern, tests of market, efficiency, impact of foreign capital inflows on the volatility of the indices and correlation of Indian indices with those of some Asian and developed country markets.

The study is based upon three Indian stock market indices from the Bombay and National Stock Exchanges, the BSE-30, BSE-100 and NSE-50 indices. It is organized in six sections. The first section gives a brief overview of the Indian stock market. Section II describes the data considered for the study and summarises its main features. Discussion of the volatility of returns begins in section III, as volatility is considered as an important distinguishing feature of emerging markets. Volatility measures are defined and computed as within-month and within-year standard deviations of continuously compounded daily returns during the period. These are compared to alternate volatility models widely used in the literature to generate an accurate measure of volatility and to test for the presence of asymmetric volatility in Indian stock markets.

Section IV deals with the testing of market efficiency using unit root tests as well as variance ratio tests. A moving window approach to observe the change in market efficiency over the period is presented and this is followed by a study on the characterization of foreign capital flows to India. Using Granger Causality tests the causal relationship between domestic returns and world returns is examined, as well as the relationship between domestic return volatility and foreign portfolio inflows into India. In the last section, the increasing correlation of Indian capital markets

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with important capital markets in the Asia-Pacific region and three developed country markets over time is tested. With Indian capital markets becoming more integrated with regional and international capital markets, they have become more prone to external shocks. By examining the stock price behaviour during the period 1990-2001, the study attempts to draw important lessons relevant to the economic life of India from the perspective of an emerging market.

I. AN OVERVIEW OF THE INDIAN STOCK MARKET

The financial sector in India has undergone rapid change in recent years. The deregulation of the securities markets and the gradual reform of the banking sector have ushered in a new era for the financial sector of the Indian economy. Significant changes have occurred, particularly on the equities side. The repeal of the Capital Issues (Control) Act in 1992 allowing companies to price their issues based on market conditions, rationalization of the process of price discovery in the primary market, enhancing the information content of stock prices through disclosure norms both at the time of issuance as well as while listing, improved trading and settlement practices and promotion of international best practices including rolling settlement are the most important changes in the equity markets. The screen based trading system introduced by the National Stock Exchange (NSE) has greatly enhanced the price formation process and has gradually made market prices reflect the fundamental values. The participation of foreign institutional investors (FIIs) in the capital markets since September 1992 and allowing Indian companies to raise funds from the international capital market have helped broaden the investor class.

Table 1 gives important statistics of the secondary market for the time period covered in this study for reference. The growth of the Indian capital market is evident from the table. The number of listed companies (9,922) in the country is second only to the United States of America. The total market capitalization and the turnover in the market have increased with a cumulative annual growth rate of 21.43 per cent and 46.00 per cent respectively. BSE-Sensex (BSE-30) and S&P CNX-Nifty (NSE-50) are the most popular market indices of the country's two leading stock exchanges, the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE) respectively.

II. DATA DESCRIPTION AND SUMMARY STATISTICS

The data set comprises of three value weighted market indices: BSE-SENSEX (BSE-30), BSE National Index (BSE-100) and S&P CNX-Nifty (NSE-50) comprising 30, 100 and 50 stocks listed in the stock exchanges. We consider monthly return data on these market indices for the 12 years covering the period 1990-2001 to observe the effects of financial market liberalization on the stock market. The National Stock Exchange (NSE) became functional only in 1993; however, the CNX-Nifty has been

Table 1. Selected indicators of secondary markets

At the end of financial year	*No. of listed companies*	*S&P CNX-Nifty*	*BSE-Sensex*	*Market capitalization*	*Market capitalization ratio*	*Turnover*	*Turnover ratio*
1990-91	6 229	366.45	1 167.97	110 279	20.6	–	–
1991-92	6 480	1 261.65	4 285.00	354 106	57.4	–	–
1992-93	6 925	660.51	2 280.52	228 780	32.4	–	–
1993-94	7 811	1 177.11	3 778.99	400 077	45.6	203 703	50.9
1994-95	9 077	990.24	3 260.96	473 349	45.6	162 905	34.4
1995-96	9 100	985.30	3 366.61	572 257	47.0	227 368	39.7
1996-97	9 890	968.85	3 360.89	488 332	34.6	646 116	132.3
1997-98	9 833	1 116.65	3 892.75	589 816	37.7	908 681	154.1
1998-99	9 877	1 078.05	3 739.96	574 064	34.1	1 023 382	178.3
1999-00	9 871	1 528.45	5 001.28	1 192 630	84.7	2 067 031	173.3
2000-01	9 922	1 148.20	3 604.38	768 863	54.5	2 880 990	374.7

Source: Reserve Bank of India, National Stock Exchange.

Note: Amount in rupees cores

back calculated from 1990 by the NSE. The data have been collected from the ISI-Emerging markets database and the NSE. Monthly return data have been considered for all the empirical tests, except otherwise mentioned, to have compatibility across the sections of this study. Charts 1, 2 and 3 present the details of the monthly returns and the movements of BSE-30, BSE-100 and NSE-50 respectively. The charts clearly reveal that growth in the stock market has also been accompanied by high volatility and swings in stock prices.

The summary statistics for the data are presented in table 2 in two panels. Panel A presents the statistics for the whole period i.e. January 1990 to December 2001. However, during the time period used for this study, the Indian stock market witnessed two securities scams that were accompanied by prolonged and persistent upward movement of the market. This persistent movement of the market and the resulting autocorrelation might have confounding effects on the data particularly for the tests for market efficiency done in section IV. Hence we present in Panel B of table 1, the summary statistics of the returns excluding the period of the two securities market scams i.e. July 1991 – April 1992 and April 1999 – February 2000. Apart from the standard statistics such as mean, variance, skewness and kurtosis of return data, Ljung-Box Q statistics are also provided for the significance of the autocorrelations with various lags.

Chart 1: BSE-30 and its Monthly Return: 1990-2001

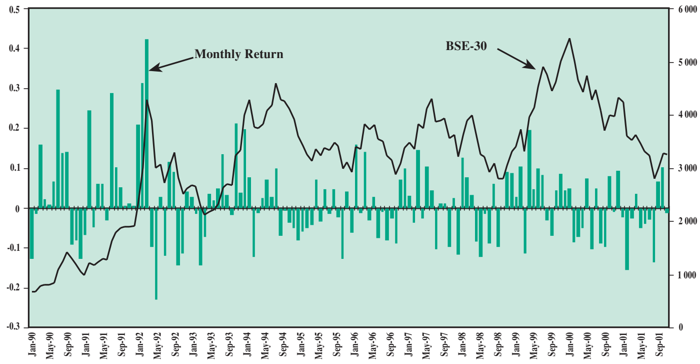


Chart 2: BSE-100 and its Monthly Return: 1990-2001

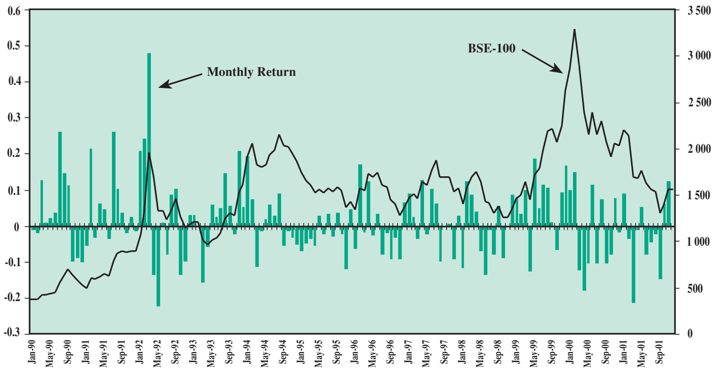


Chart 3: S&P CNX-Nifty and its Monthly Return: 1990-2001

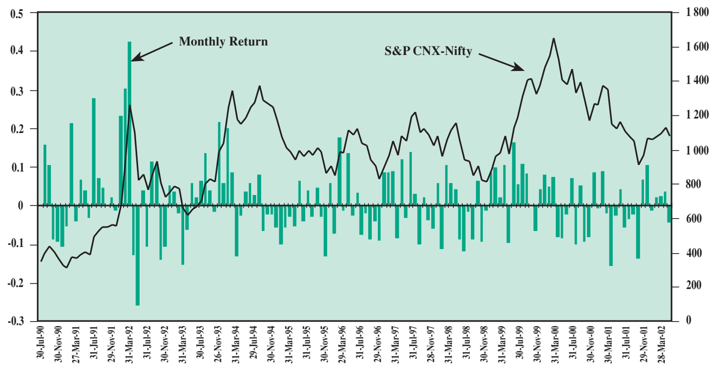


Table 2. Summary statistics for the market proxies

	BSE-100	*BSE-30*	*NSE-50*
	Panel A		
Mean return	0.0097	0.0099	0.0081
Variance	0.0095	0.0092	0.0088
Skewness	0.3268	0.4821	0.3408
Kurtosis	1.0953	0.9252	1.1907
ρ_1	0.1441	0.1455	0.1143
	[3.0527]*	[3.1141]*	[1.8298]
ρ_2	0.0084	0.0297	-0.0001
	[3.0630]	[3.2446]	[1.8298]
ρ_4	-0.1504	-0.1515	-0.1559
	[8.7011]*	[8.6268]*	[7.9497]*
ρ_8	-0.1026	-0.1053	-0.0876
	[20.3905]**	[16.9182]**	[19.4885]**
ρ_{16}	-0.0893	-0.0662	-0.0879
	[42.5297]**	[39.2359]**	[43.1254}**
	Panel B		
Mean return	0.0114	0.0116	0.0096
Variance	0.0140	0.0136	0.0121
Skewness	2.7310	3.2845	2.7920
Kurtosis	14.8135	21.9632	16.6261
ρ_1	-0.0179	0.0269	0.0032
	[0.0405]	[0.0919]	[0.0012]
ρ_2	-0.0427	-0.0332	-0.0434
	[0.2727]	[0.2318]	[0.2273]
ρ_4	-0.0504	-0.0490	-0.0375
	[1.5684]	[1.2668]	[1.2874]
ρ_8	-0.0779	-0.0880	-0.0824
	[5.3469]	[7.0789]	[5.7403]
ρ_{16}	0.0193	0.0119	-0.0590
	[9.8361]	[11.9648]	[9.4112]

Note: Panel A is for the whole period 1990-2001 and Panel B is for the same period excluding the period of security market scams (Jul'91 to Apr'92 and Apr'99 to Feb'00). * denotes Significant at 10 per cent level and ** denotes significance at 5 per cent level on Ljung-Box Q-statistic for serial correlation.

The data reveal the unique features of a typical emerging market return, viz. high mean and variance and highly non-normal distribution of the returns. Also from Panel A, it can be observed that the monthly returns are correlated at different lags and the Ljung-Box Q statistics reveals that they are significant at both 5 per cent and 10 per cent significance levels. Interestingly, once the data for the scam periods are excluded, the autocorrelations are no longer statistically significant (Panel B).

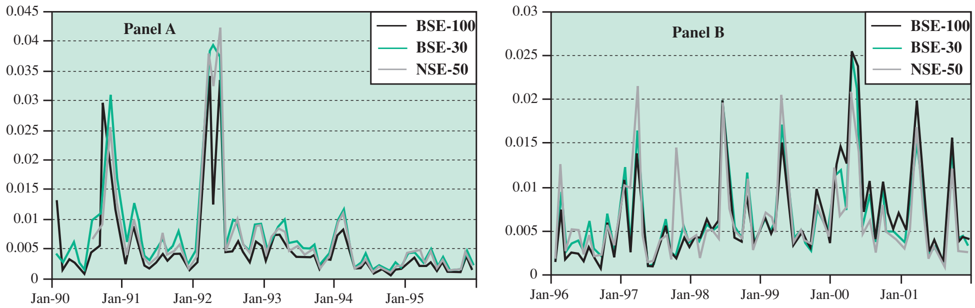
III. VOLATILITY

We start our discussion with volatility, as this is an important feature of the behaviour of emerging market returns. In this section, we study whether the policy changes as well as the operational platforms that have evolved in Indian stock markets have helped in reducing market volatility. Volatility is defined as the standard deviation of the returns and we employ daily returns of the three selected market indices to calculate within-month and within-year volatility. Following Schewart (1989), the standard deviation of the returns within a month is calculated as:

$$\sigma_{a,\,m} = \{[1/(n-1)] \sum_{t=1}^{n} (R_{m,\,t} - \mu_m)^2 \}^{0.5}$$

where μ_m denotes the mean return during the month and n is the number of trading days during the month. And $\sigma_{a,\,m}$ is the monthly volatility, measured as the standard deviation of the returns within the month m. The monthly volatility estimated is summed up to find the annual volatility for the respective years. Chart 4 gives the variance of the market returns in two panels: one for the time period 1990-1995 and the other for 1996-2001. The market was extremely volatile during the first scam period (July 1991 – April 1992) and the annualized variance of the returns was 48 per cent. Barring this period, the second panel is more volatile compared to the first panel. The figures of annual variance given in table 3 also corroborate the fact: volatility in the Indian stock markets has increased during the last few years.

Chart 4. Monthly variance for 1990-1995 (Panel A) and 1996-2001 (Panel B)



The financial literature has established and well documented that the phenomenon of volatility is time varying with the change in expected returns (see Bekaert and Wu, 2000). Studying the time varying volatility for an emerging market is all the more important because if the market is segmented, volatility is priced under

Table 3. Annual variance during 1990-2001

Annual variance	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*
BSE-30	0.12	0.07	0.18	0.06	0.04	0.03	0.05	0.06	0.08	0.07	0.11	0.07
BSE-100	0.10	0.04	0.13	0.05	0.03	0.02	0.04	0.06	0.08	0.08	0.14	0.08
NSE-50	0.07	0.05	0.18	0.06	0.04	0.03	0.05	0.08	0.07	0.08	0.10	0.06

the conditional CAPM framework (Bekaert and Harvey, 1997). Another branch of volatility studies that is gaining increased attention in the literature is the asymmetric reaction of volatility to positive and negative news. For the same size of shocks in returns, negative news increase the volatility more than positive news. This has been attributed to changes in shocks across the markets. Hence, one would expect an emerging market like India to show a significant asymmetric volatility pattern. In order to investigate the dynamics of Indian stock market volatility and to test for the presence for asymmetric volatility, we estimate the conditional variance using three volatility models that are widely used in the financial literature. We use GARCH (1, 1) of Bollerslev (1986), Exponential GARCH (1, 1) of Nelson (1991) and the GJR-GARCH model of Glosten, Jagannathan and Rundle (1993). EGARCH and GJR-GARCH are asymmetric volatility models to test the presence of asymmetric volatility in Indian market. The parameterization of the variance under these models is given in table 4 for reference.

Table 4. Variance equations of volatility models

GARCH (1, 1) model (Bollerslev (1986))

$$h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \beta h^2_{t-1}$$

EGARCH (1, 1) model (Nelson (1991))

$$\log (h_t) = \omega + \beta \log (h_{t-1}) + \gamma \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} + \alpha \left[\frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{\frac{2}{\pi}} \right]$$

GJR-GARCH model (Glosten, Jagannathan and Runkle, 1993)

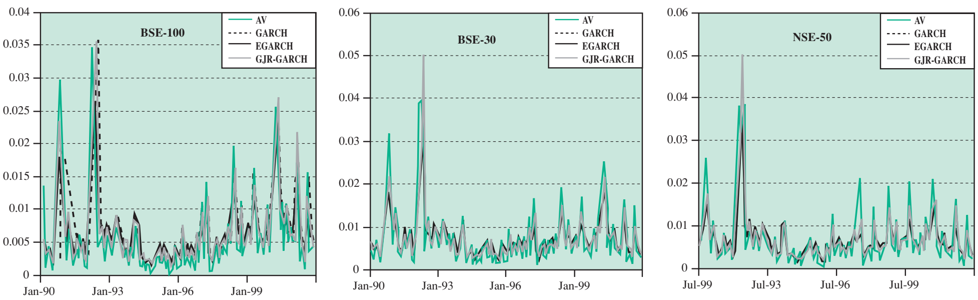
$$h_t = \omega + \beta h_{t-1} + \alpha \varepsilon^2_{t-1} + \gamma S^-_{t-1} \varepsilon^2_{t-1} \quad \text{where } S^-_t = 1 \text{ if } \varepsilon_t < 0,\ S^-_t = 0 \text{ otherwise}$$

For estimating these models, the conditional mean of the returns needs to be specified. We define the relation between conditional mean and conditional variance as:

$$E_t\,[R_{t+1}] = \beta\,\sigma_t^2$$

where R_{t+1} is the nominal returns on the market index and σ_t^2 is the variance estimated at time t. This follows the intertemporal relation derived between risk and return. Though the original derivation is for excess returns, we assume that it holds for nominal returns, following Schewart (1989). We fit the models for the daily returns data using Maximum Likelihood procedures (see Engle and Ng, 1993). From the daily variance, monthly variance of the returns is estimated by summing up the daily variance for all the trading days of the respective month. Chart 5 plots the actual variance along with the volatility estimated using the three volatility models.

Chart 5. Monthly volatility charts for BSE-30, BSE-100 and NSE-50



Four standard loss functions viz., Mean Error (ME), Mean Absolute Error (MAE), Root Mean Square Error and Mean Absolute Percentage Error (MAPE) are employed to find the performance of these models for explaining the return volatility. Table 5 gives the estimation of the standard loss functions.

The error statistics for the three volatility models are provided in table 6 for comparison. It is evident that asymmetric models outperform the simple GARCH model, and GJR-GARCH model generates fewer errors than the other two models. Also the coefficients for the asymmetric component are statistically significant. We have not attempted to study the impact of asymmetry for typical shocks that have occurred in the Indian stock market on the lines of Bekaert and Wu (2000) and Nelson (1991) as our objective was only to test for the presence of asymmetric volatility. Nevertheless, a detailed study of the asymmetric volatility on Indian stock markets would offer very interesting insights. Besides, the results of this subsection need to be read with caution because no out-of-sample forecasting has been done and the forecasting performance of the asymmetric volatility models is not known.

Table 5. Standard loss functions

$$ME = \frac{1}{N}\sum_{T=1}^{N}(\hat{\sigma}_T^2 - \sigma_T^2)$$

$$MAE = \frac{1}{N}\sum_{T=1}^{N}\left|\hat{\sigma}_T^2 - \sigma_T^2\right|$$

$$\text{RMSE} = \sqrt{\frac{1}{N}\sum_{T=1}^{N}(\hat{\sigma}_T^2 - \sigma_T^2)}$$

$$MAPE = \frac{1}{N}\sum_{T=1}^{N}\left|(\hat{\sigma}_T^2 - \sigma_T^2)/\sigma_T^2\right|$$

Table 6. Error statistics of volatility models

Market indices	*Volatility models*	*ME*	*MAE*	*RMSE*	*MAPE*
BSE-30	GARCH (1, 1)	0.00057	0.00205	0.00307	0.48065
	EGARCH	0.00041	0.00218	0.00253	0.48688
	GJR-GARCH	0.00059	0.00207	0.00241	0.48048
BSE-100	GARCH (1, 1)	0.00071	0.00267	0.00489	0.69044
	EGARCH	0.00049	0.00191	0.00272	0.53793
	GJR-GARCH	0.00076	0.00177	0.00241	0.53416
NSE-50	GARCH (1, 1)	0.00051	0.00199	0.00294	0.48319
	EGARCH	0.00030	0.00224	0.00348	0.49923
	GJR-GARCH	0.00053	0.00202	0.00301	0.48528

IV. MARKET EFFICIENCY

This section is devoted to testing weak form efficiency of the Indian stock market using unit root tests and variance ratio tests. We adjust the data for the second major securities market scam that occurred during the study period. Thus we do our tests for the whole time period as well as excluding scam periods and show that excluding the scam periods makes the autocorrelation of the returns statistically insignificant. Next we introduce a moving window approach following Yilmaz (2001) to observe the change in market efficiency over time (see Pant and Bishnoi, 2001).

We study market efficiency using two separate tests, viz. unit root tests and variance ratio tests. The Ljung-Box Q statistics for autocorrelation reported along with the summary statistics can be considered as the first test in this regard. The Q statistics for a particular lag (i) test the null hypothesis that all the autocorrelations till the lag i are jointly zero. Monthly returns at the market level are used for the variance ratio tests because daily returns might have spurious correlation due to problems such as non-synchronous trading and the inference may not be correct (Campbell and others, 1997). Though weekly returns would have given a better picture, to ensure compatibility with other sections of the study we proceed with calculating the variance ratios for monthly returns.

We start by performing the conventional Augmented-Dickey-Fuller (ADF) statistic of Dickey and Fuller (1981), and the Phillips-Perron (1988) test statistic to determine whether or not the stock price indices are stationary.

$$\Delta X_t = \alpha + \beta X_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta X_{t-i} + e_t$$

Ho: $\beta = 0$ versus H_1: $\beta > 0$, so that the null hypothesis implies a unit root, implying that the series is stationary. We use the indices as well as their first differences for both the tests, and conduct the tests for the whole period as well as for the two sub-periods. The results presented in table 7 reveal that the null hypothesis of the existence of unit roots is rejected at the level form of the indices, but is accepted in the first difference form, when both the ADF and Phillips-Perron (P-P) tests are conducted. The series are therefore found to be I(1) in levels but stationary in their first differences.

It is to be noted here that the unit root test is a necessary but not a sufficient condition for random walk tests. The unit root tests of the above form tests only whether the returns are stationary and it is the permanent/temporary nature of shocks to X_t concerns the unit root tests instead of its predictability. Also it is possible to have non-random walk alternatives in the unit root null hypothesis, which cannot be identified through this method (Campbell and others, 1997).

We further use variance ratios test developed by Lo and Mackinlay (1988) to test market efficiency. In the case of the random walk process (efficient market) the variance of random walk increments must be a linear function of the time interval and the variance ratio test exploits this property to test the informational efficiency. For example, in the case of efficient markets, the sum of the variances of r_t and r_{t-1} must be twice the variance of r_t and this is tested by checking whether their ratio is statistically indistinguishable from one. In general terms, if we have nq+1 observations of logarithmic stock prices, we can obtain nq compounded returns r_0, r_1, r_2, .r_{nq} at equal intervals. The variance ratio test implies, that for any q greater than unity, the

Table 7. ADF and PP tests of unit roots in the Indian stock market

Time period	*Augmented Dickey-Fuller (ADF)*		*Phillips-Perron (P-P)*	
	Levels	*First difference*	*Levels*	*First difference*
BSE-30				
1990-2001	-2.132591	-5.398679	-2.456334	-10.93776
1990-1995	-2.011239	-5.122836	-1.986359	-6.632107
1996-2001	-2.178902	-5.183755	-2.002590	-8.865657
BSE-100				
1990-2001	-2.148115	-5.471261	-2.547507	-10.37392
1990-1995	-1.887661	-5.132758	-1.901104	-6.801123
1996-2001	-2.087326	-5.496198	-1.946581	-7.617739
NSE-50				
1990-2001	-2.420289	-5.176936	-2.477680	-10.71467
1990-1995	-1.632413	-4.780187	-1.811893	-6.324638
1996-2001	-2.182246	-5.165078	-2.082684	-8.968228

Notes: The Mackinnon (1991) critical value of ADF statistic for 139 observations with a trend and a intercept is -4.0263 at 1 per cent, -3.4426 at 5 per cent, and -3.1457 at 10 per cent level of significance, respectively. The corresponding values for the P-P statistic are -4.0245, -3.4417 and -3.1452, respectively.

ratio of 1/q of the variance of $(r_t - r_{t-q})$ to the variance of $(r_t - r_{t-1})$ which can be written as follows:

$$VR(q) = \sigma_b^2(q) / q * \sigma_a^2$$

where $\sigma_b^2(q)$ is an unbiased estimate of the variance of the q^{th} difference of r_t and σ_a^2 is an unbiased estimator of the variance of the first difference of r_t. They can be estimated as given below.

$$\sigma_a^2 \equiv (1/nq - 1) \sum_{k=1}^{nq} (P_k - P_{k-1} - \mu)^2$$

$$\sigma_b^2 \equiv (1/m) \sum_{k=q}^{nq} (P_k - P_{k-q} - q\mu)^2$$

where $m \equiv q\,(nq - q + 1)\,(1 - 1/n)$ and $\mu = (P_{nq} - p_0)/nq$.

Lo and Mckinlay (1988) derive the asymptotic distribution of the variance ratios and offer two test statistics Z (q) and $Z^*(q)$. The first test statistic Z (q) is for testing the random walk process that assumes that the errors are IID and the $Z^*(q)$ is for testing the random walk process allowing for heteroscedasticity in the error term. The test statistics are given as:

$$Z\,(q) = [\mathrm{VR}(q) - 1]/\sqrt{[\phi\,(q)]} \approx N\,(0, 1)$$

where $[\phi\,(q)] = [2(2q - 1)(q - 1)]/[3q\,(nq)]$

$$Z^*\,(q) = [\mathrm{VR}(q) - 1]/\sqrt{[\phi^*\,(q)]} \approx \mathrm{N}\,(0, 1)$$

where $\phi^*\,(q) = (\theta / nq)$

$$\theta = 4 \sum_{k=1}^{q-1} [\{1-k / q\}\delta_k]$$

$$\delta_k = [nq \sum_{j=k+1}^{nq} (P_j - P_{j-1} - \mu)^2\,(P_{j-k} - P_{j-k-1} - \mu)^2] \,/\, [\sum_{j=1}^{nq} (P_j - P_{j-1} - \mu)^2]^2$$

ϕ (q) and ϕ^* (q) are the homoscedastic and heteroskedastic asymptotic variance of the process (see Campbell and others, 1997). Under the null hypothesis, the prices follow random walk process RW1 or RW3. The test statistics as given by equations (8) and (10) are asymptotically normally distributed and the values obtained from the study if greater than the critical value of the standard normal process would mean rejecting the null hypothesis which is a random walk process and hence signifies market efficiency.

We start with the testing of the weak form efficiency (both RW1 and RW3) for the full period (1990:01 to 2001:12) as well as after excluding the scam period. The variance ratios and test statistics Z (q) and Z* (q) are provided in table 8. With both the test statistics, we could not reject the null hypotheses of random walk for both the indices for all the four lags considered. The variance ratios estimated for the NSE-50 are more close to unity suggesting that NSE-50 might be more efficient compared to other market indices. The VR statistics in Panel B, suggest that, as expected, the variance ratio moves closer to unity on excluding the data during the scam period and the null hypothesis could not be rejected in any of the cases. Also VR (16) for Panel B is in the range of 0.58 to 0.75 which suggests mean reversion of the returns. This can be corroborated by the significant negative correlation reported in the summary statistics for the same lag.

In principle, stock market liberalization should improve the efficiency of the markets. This is because the investor base becomes wider with the participation of

Table 8. Variance ratios for monthly market returns

Market portfolio	*No of observations*	*VR(2)*	*VR(4)*	*VR(8)*	*VR(16)*
Panel A					
BSE-100	144	1.1520 [1.8247] (1.2674)	1.1814 [1.1637] (0.7956)	1.1852 [0.7516] (0.5515)	1.0582 [0.1585] (0.1238)
BSE-30	144	1.1458 [1.7502] (1.2378)	1.2038 [1.3071] (0.9104)	1.2021 [0.8197] (0.6036)	1.0745 [0.2030] (0.0999)
NSE-50	137	1.1149 [1.3460] (0.9289)	1.1056 [0.6609] (0.4435)	1.1083 [0.4288] (0.3073)	0.9581 [-0.1113] (-0.0863)
Panel B					
BSE-100	123	0.9901 [-0.1103] (-0.1303)	0.9934 [-0.0393] (-0.0436)	0.9620 [-0.1425] (-0.1532)	0.6906 [-0.7797] (-0.8323)
BSE-30	123	1.0292 [0.3232] (0.3973)	1.0611 [0.3621] (0.4008)	1.0097 [0.0364] (0.0382)	0.7503 [-0.6291] (-0.6456)
NSE-50		1.0056 [0.0604] (0.0824)	1.0125 [0.0721] (0.0734)	1.0026 [0.0095] (0.0078)	0.5858 [-1.0136] (-0.7578)

Foreign Institutional Investors (FII) on Indian stocks and also with the international listing of Indian stocks directly or through ADR/GDRs (American or General Depository receipts. Allowing the setting up of private mutual funds also contributes, and has contributed, to the increased scrutiny and increased trading of Indian stocks. Besides, the introduction of screen-based trading has removed the deficiencies of the open outcry system and improved the price discovery process. The logical conclusion of these arguments is that market efficiency should improve over time.

Hence we proceed to test this conjecture with the help of a moving window technique. For this purpose, we construct moving windows of constant width (60 months) and this would move from 1990:01 till the end of the data period. The selection of 60 months as window width is purely for the sake of convenience and so as to have sufficient data points in every window. Also, it is quite conventional in asset pricing studies spanning longer time periods to keep the length of sub periods as five years. The moving window construction can be pictorially represented as is done below.

Construction of moving window with constant width

1990:02 1995:01

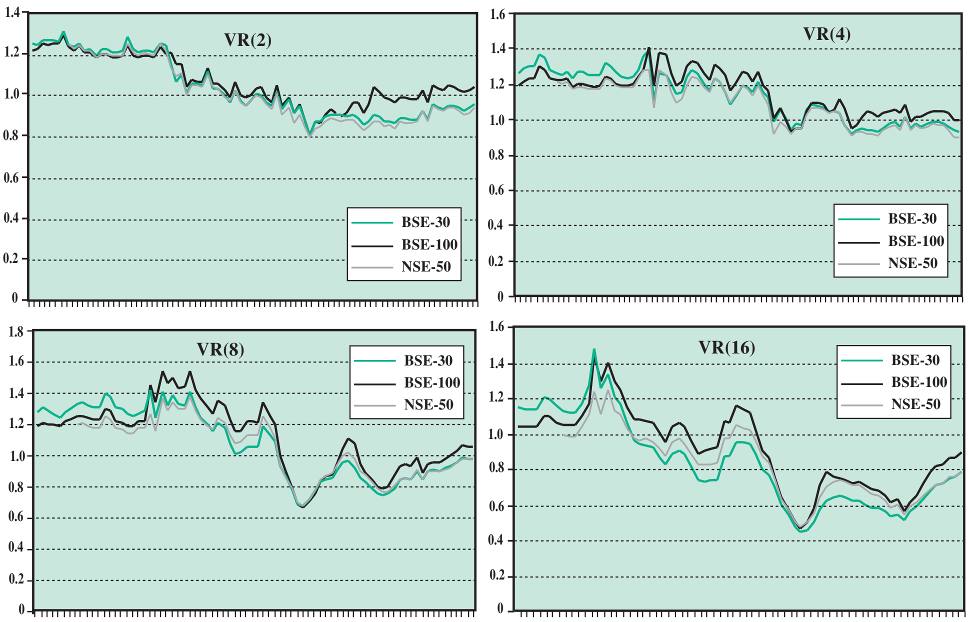
1990:03 1995:02

....
....

1997:01 2001:12

The Z-statistics obtained for the moving windows are plotted against time to observe the change in informational efficiency. The critical values to reject the null hypothesis of random walk is 1.96 at a 5 per cent significance level. The moving windows at the end would contain data for the latest period and the test statistics for them must be better than the test statistics for the windows at the beginning if the market is becoming more efficient. Or, in other words, the plot of the test statistics for the moving windows should be dropping in case of increasing market efficiency (chart 6). As expected, the test statistics fall smoothly as we consider the latest data and move away from the critical values. Taken together, the empirical evidence based on the variance ratio and unit root tests reveal the evolving market efficiency in Indian stock price indices.

Chart 6. Evidence on increasing market efficiency



V. FOREIGN PORTFOLIO INFLOWS

Foreign portfolio flows play a very important role for emerging economies by providing the much needed capital for economic growth. The Indian stock market after opening to Foreign Institutional Investors (FII) has attracted considerable capital flows into the stock exchanges. During 2000/01 foreign portfolio investments in India accounted for over 37 per cent of total foreign investments and 47 per cent of the total current account deficit, the corresponding figures for the preceding year being 59 per cent and 64 per cent respectively (Chakravarti, 2001).

Bekaert and Harvey (2000) documents significant reduction in the cost of capital for 18 emerging markets including India after they opened their capital market to foreign investors. The presence of foreign investors changes the marginal investor in the market and pushes up share prices thus reducing the cost of capital. This reduced cost of capital is one of the reasons for the economic booms witnessed in emerging economies immediately following liberalization (Henry, 2000 and Kim and Singhal, 2000). But the benefits from foreign portfolio flows do not come without cost. Often they also are blamed for the increase in volatility of the domestic returns. This is substantiated by the empirical literature that foreign investors engage in return chasing and exert significant influence on local market variances (see Bohn and Tesar, 1996, Clark and Berko, 1997, Choe and others, 1999). This has resulted in countries like Malaysia re-imposing some constraints for foreign investors. Charts 7A and 7B display the time series behaviour of net FII flows into India along with the trends in BSE-100 and its volatility, generally establishing the volatility causation.

Chart 7A. FII Flows BSE-100

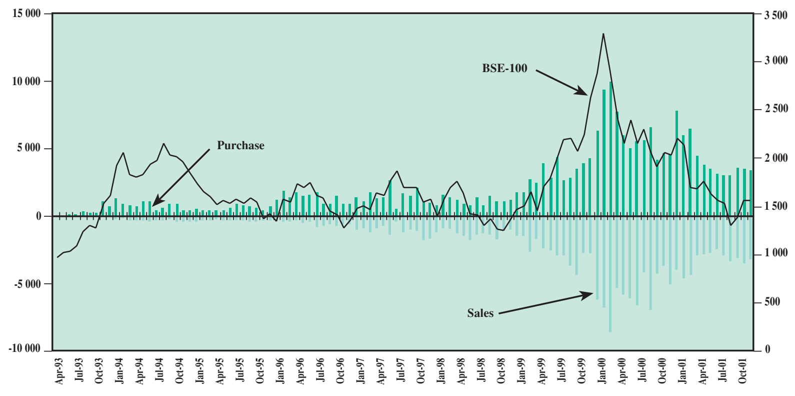
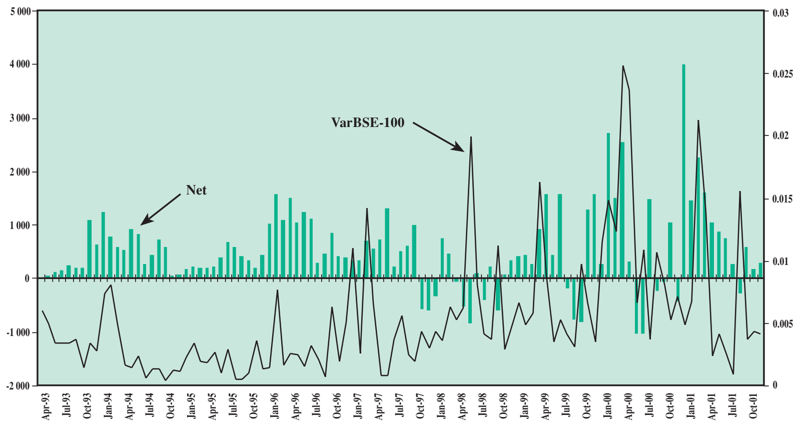


Chart 7B. Net FIl Flows and Varance of BSE-100



In this section, we test whether foreign investors have played a role in the increase in volatility in the Indian stock market. We employ Granger causality testing to establish the causal relationship between the FII in flows and the domestic market returns and its variance. Additionally we use other important variables such as rupee-US dollar exchange rates and MSCI indices for the US to characterize foreign portfolio flows to India. Taken together these variables would indicate the primary factors that determine the FII flows to India.

Typically the Granger causality test involves the estimation of the bivariate regressions as given below:

$$Y_t = a_0 + a_1 Y_{t-1} + ... + a_l Y_{t-l} + \beta_l X_{t-1} + ...\beta_l X_{t-l}$$

$$X_t = a_0 + a_1 X_{t-1} + ... + a_l X_{t-l} + \beta_1 Y_{t-1} + ...\beta_l Y_{t-l}$$

We estimate the F-statistics for the test of joint hypothesis $\beta_1 ......\beta_l = 0$. The null hypothesis set as X does not Granger cause in the first regression, and Y does not Granger cause (GC) X in the second regression. The choice of lag length is restricted to two months, without stretching the variables too far.

Pair-wise Granger causality tests between monthly net FII flows and variables such as monthly return on BSE-30, BSE-100 indices and NSE-50, within-month variance in return in these indices, rupee-US dollar exchange rate and return on MSCI-USA are calculated for the period March 1993-December 2001. As revealed from table 9, there is evidence of returns causing portfolio inflows and this in turn affecting the behaviour of returns and their variances in the Indian stock markets. We have

Table 9. Results of the pair-wise Granger Causality tests

Null hypothesis	*F-statistics*	*Probability*
Granger Causality between BSE-30 return and FII flows (net)		
Returns on BSE does not GC FII flows (net)	7.08680	0.00133
FII flows (net) does not GC returns on BSE	2.16850	2.16850
BSE return does not GC FII flows (purchase)	2.80657	0.06528
FII flows (purchase) does not GC BSE return	1.35658	0.26233
Granger Causality between variance in BSE-30 return and FII flows (net)		
Variance in BSE returns does not GC FII flows (net)	1.41449	0.24797
FII flows (net) does not GC variance in BSE returns	2.34943	0.10078
Variance in BSE return does not GC FII flows (sales)	1.20445	0.30426
FII flows (sales) does not GC variance in BSE return	6.46262	0.00231
Granger Causality between NSE return and FII flows (net)		
Returns on NSE does not GC FII flows (net)	4.11977	0.01914
FII flows (net) does not GC returns on NSE	1.34019	0.26655
NSE return does not GC FII flows (purchase)	2.63408	0.07686
FII flows (purchase) does not GC NSE return	0.98209	0.37818
Granger Causality between variance in NSE return and FII flows (net)		
Variance in NSE returns does not GC FII flows (net)	0.93118	0.39755
FII flows (net) does not GC variance in NSE returns	1.44817	0.23998
Variance in NSE return does not GC FII flows (sales)	0.89831	0.41058
FII flows (sales) does not GC variance in NSE return	3.27055	0.04217
Granger Causality between the rupee -dollar exchange rate and FII flows		
Exchange rate does not GC FII flows (net)	1.58927	0.20929
FII flows (net) does not GC exchange rate	0.99344	0.37400
Granger Causality between the MSCI index and FII flows		
Return on MSCI-US index does not GC FII flows (net)	0.78294	0.45990
FII flows (net) does not GC return on MSCI-US index	2.73511	0.06984

also examined the causation between the return and purchases and between variances and sales. The returns on the indices seem to be causing the FIIs to purchase, and the variance to cause selling pressures in the Indian stock markets. The causality of rupee-US dollar exchange rate and MSCI-US to the FII inflows is rather weak in the Indian situation. Taken together the evidence shows the influence of FII inflows on volatility in Indian stock markets.

VI. IMPACT OF FOREIGN SHOCKS

The volatility and correlations in emerging markets have received increasing academic attention during the last decade. As barriers to foreign investment have been dismantled and with the trend towards greater globalization, the stock markets in many emerging markets have shown stronger co-movements. However, this has also been accompanied by greater volatility. Volatility in the major emerging markets has been traditionally associated with local political and economic events (Aggarwal and others, 1999) or when global factors dominate domestic ones such as oil crises, the Gulf war and the Asian financial crises affecting all financial markets (Longin and Solnik, 1995). Bekaert and Harvey (1995) document the time varying integration of 12 emerging markets with the world wherein they find evidence for a movement towards higher level of integration for India. This would imply that the Indian capital market has become more prone to external shocks.

In this section, we test whether the contemporaneous correlation of Indian stock market returns have increased over time with the returns of eight Asian emerging markets and three developed markets. The Morgan Stanley Capital Index (MSCI) has been used for finding the returns of the Asian emerging markets as well as the developed markets. Chart 8 presents the MSCI movements for the whole period for all the countries selected. The correlation between the markets is presented in table 10 for the whole period (1990-2001) as well as for before the Asian crisis (1990-1996) and after the Asian crisis (1998-2001).

It can be observed from table 10 that the correlation based on US dollar returns are higher among Asian countries, although their values are well below unity. The high correlation among Asian stock market indices suggests the possibility of increased market integration in the post-1997 period. With further reduction in barriers to foreign investment, it is possible for stronger co-movements among these markets.

We compute the pair-wise Granger causality tests of the returns to see the direction of impacts of Asian markets on India. The results of the tests are presented in table 11. It is interesting to observe that Asian markets do affect Indian stock markets, prominent among them are Hong Kong, China; the Republic of Korea; Malaysia; Pakistan; the Philippines; and Thailand. However, the impact of India on the Asian markets seems to be non-existent.

Chart 8. Morgan Stanley Capital Index for various markets

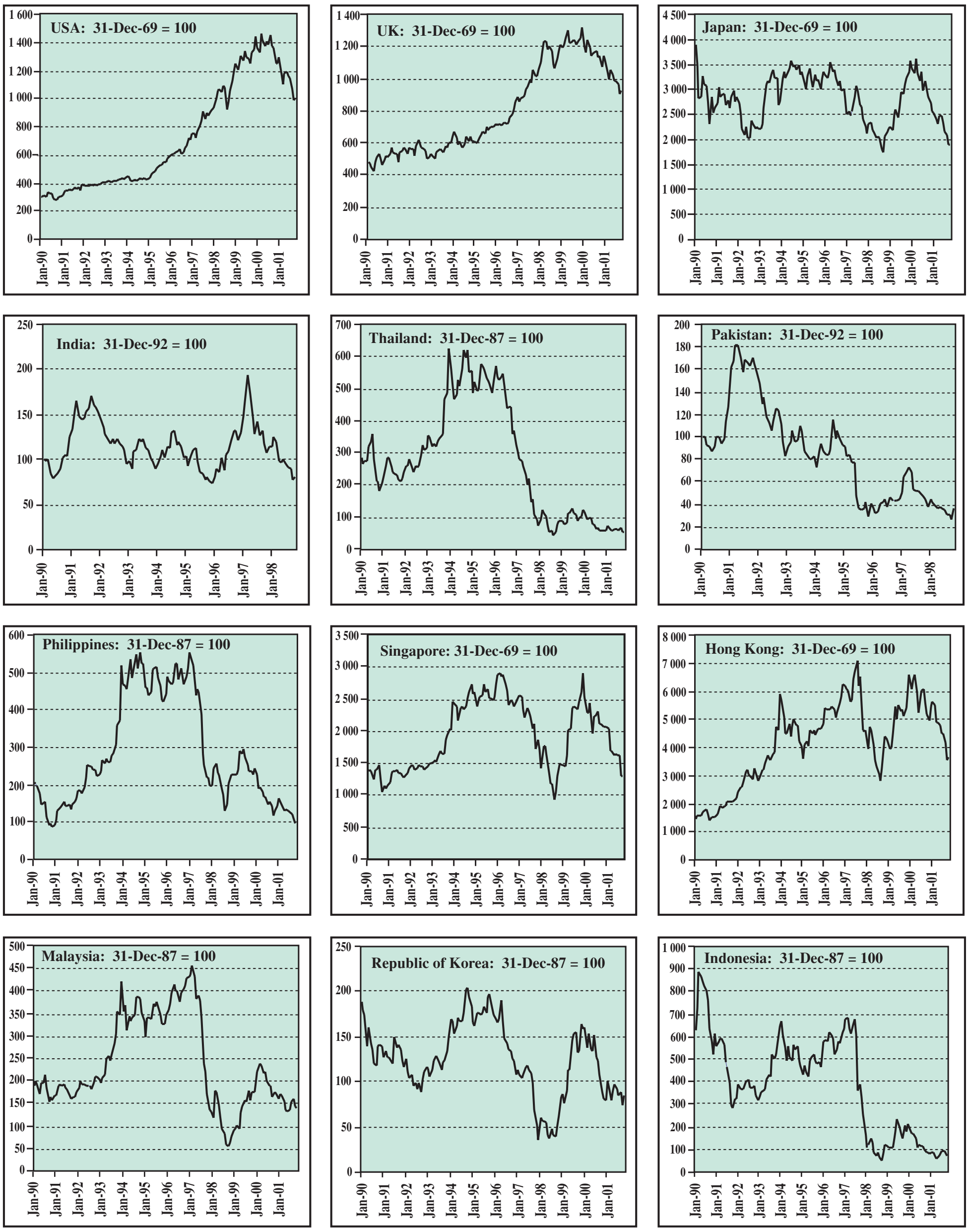


Table 10. Contemporaneous correlation among markets

Panel A: For the time period 1993-2001

	Hong Kong,China	*India*	*Indonesia*	*Japan*	*Korea (Republic of)*	*Malaysia*	*Pakistan*	*Philippines*	*Singapore*	*Thailand*	*UK*	*USA*
Hong Kong, China	1											
India	0.22	1										
Indonesia	0.53	0.28	1									
Japan	0.36	0.14	0.289	1								
Korea (Republic of)	0.32	0.21	0.382	0.52	1							
Malaysia	0.56	0.28	0.603	0.24	0.31	1						
Pakistan	0.25	0.42	0.174	0.04	0.14	0.23	1					
Philippines	0.64	0.2	0.594	0.29	0.35	0.62	0.12	1				
Singapore	0.77	0.28	0.648	0.42	0.36	0.61	0.27	0.68	1			
Thailand	0.62	0.20	0.595	0.35	0.60	0.60	0.27	0.75	0.68	1		
UK	0.54	0.10	0.289	0.45	0.29	0.31	0.15	0.33	0.51	0.35	1	
USA	0.54	0.20	0.403	0.43	0.35	0.31	0.13	0.42	0.54	0.46	0.67	1

Panel B: For the time period 1993-1996

	Hong Kong,China	*India*	*Indonesia*	*Japan*	*Korea (Republic of)*	*Malaysia*	*Pakistan*	*Philippines*	*Singapore*	*Thailand*	*UK*	*USA*
Hong Kong, China	1											
India	0.03	1										
Indonesia	0.7	0.35	1									
Japan	0.08	-0.1	0.029	1								
Korea (Republic of)	0.22	0.22	0.166	0.34	1							
Malaysia	0.72	0.16	0.485	0.18	0.22	1						
Pakistan	0.29	0.35	0.283	-0	0.24	0.3	1					
Philippines	0.72	0.16	0.528	-0	0.07	0.64	0.44	1				
Singapore	0.71	0.21	0.575	0.29	0.37	0.79	0.28	0.68	1			
Thailand	0.74	0.15	0.568	0.02	0.29	0.6	0.44	0.79	0.67	1		
UK	0.49	0.11	0.365	0.3	0.22	0.44	0.05	0.24	0.51	0.24	1	
USA	0.51	-0.1	0.51	0.17	0.05	0.22	-0	0.17	0.3	0.31	0.55	1

Panel C: For the time period 1998-2001

	Hong Kong,China	*India*	*Indonesia*	*Japan*	*Korea (Republic of)*	*Malaysia*	*Pakistan*	*Philippines*	*Singapore*	*Thailand*	*UK*	*USA*
Hong Kong, China	1											
India	0.3	1										
Indonesia	0.53	0.25	1									
Japan	0.47	0.27	0.324	1								
Korea (Republic of)	0.31	0.22	0.343	0.65	1							
Malaysia	0.48	0.31	0.581	0.18	0.25	1						
Pakistan	0.21	0.44	0.117	0.1	0.13	0.2	1					
Philippines	0.65	0.23	0.591	0.48	0.44	0.55	-0	1				
Singapore	0.81	0.36	0.70	0.50	0.35	0.59	0.28	0.71	1			
Thailand	0.57	0.23	0.552	0.52	0.66	0.56	0.19	0.79	0.71	1		
UK	0.55	0.08	0.318	0.59	0.44	0.3	0.16	0.47	0.55	0.44	1	
USA	0.55	0.24	0.403	0.64	0.5	0.37	0.06	0.57	0.61	0.55	0.79	1

Table 11. Pair-wise Granger Causality between stock market indices

Null Hypothesis:	1993-2001		1993-1996		1998-2001	
	F-Statistic	Probability	F-Statistic	Probability	F-Statistic	Probability
India does not Granger Cause Hong Kong, China	0.5801	0.4481	0.0000	0.9977	0.6672	0.4185
Hong Kong, China does not Granger Cause India	5.8694	0.0172	6.5179	0.0143	0.8646	0.3576
Indonesia does not Granger Cause India	1.7408	0.1900	1.7677	0.1907	0.6073	0.4401
India does not Granger Cause Indonesia	0.0875	0.7680	0.1158	0.7353	0.2174	0.6434
Japan does not Granger Cause India	0.3391	0.5617	0.2859	0.5956	0.0462	0.8308
India does not Granger Cause Japan	0.0018	0.9660	0.1039	0.7487	0.1850	0.6693
Rep. of Korea does not Granger Cause India	6.4661	0.0125	2.0317	0.1613	3.1542	0.0828
India does not Granger Cause Rep. of Korea	0.2362	0.6280	0.2397	0.6269	0.0108	0.9176
Malaysia does not Granger Cause India	11.9218	0.0008	2.1869	0.1465	9.6747	0.0033
India does not Granger Cause Malaysia	0.1429	0.7062	0.0027	0.9585	0.5264	0.4721
Pakistan does not Granger Cause India	3.6565	0.0587	8.0547	0.0069	1.4131	0.2411
India does not Granger Cause Pakistan	3.0360	0.0845	2.7186	0.1065	0.2141	0.6459
Philippines does not Granger Cause India	5.3433	0.0228	6.8032	0.0125	0.4067	0.5270
India does not Granger Cause Philippines	1.0071	0.3180	1.7734	0.1900	0.1631	0.6883
Singapore does not Granger Cause India	2.1016	0.1503	3.2637	0.0778	0.1487	0.7017
India does not Granger Cause Singapore	0.0075	0.9314	0.0229	0.8805	0.0015	0.9696
Thailand does not Granger Cause India	4.8737	0.0295	14.3993	0.0005	1.0705	0.3066
India does not Granger Cause Thailand	0.2353	0.6287	1.0149	0.3194	0.0041	0.9494
UK does not Granger Cause India	2.4234	0.1227	0.7850	0.3805	1.4722	0.2316
India does not Granger Cause UK	0.1993	0.6562	1.7318	0.1952	0.1383	0.7118
USA does not Granger Cause India	0.4731	0.4931	0.7675	0.3859	0.2664	0.6084
India does not Granger Cause USA	0.1710	0.6801	1.2423	0.2712	0.0308	0.8616

VII. CONCLUSIONS

We have studied the stock price behaviour in India for the period 1990-2001. Various tests of market efficiency suggest that the Indian stock market is becoming informationally efficient and efficiency has increased over time. The volatility of the returns has been found to increase over the period under study and this can be partly attributed to the impact of foreign portfolio flows. Also there is significant asymmetric volatility i.e. negative news have more impact on the variance of the returns than positive news. Granger Causality tests suggest that domestic returns affect foreign portfolio flows and, in turn, affect domestic returns and its variance. Finally, the correlation with the other Asian markets has increased post the Asian crisis, although the impact of India on the 1997 Asian markets seems to be non-existent.

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