Volatility of FII in India

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Abstract

In this paper, we have examined volatility of the day-to-day movements of foreign institutional investment (FII) in India, along with some other related variables like the stock market returns and the call money rate. For the purpose of this study, a new technique of analysis has been used that defines and examines three different aspects of volatility, viz. strength, duration and persistence of volatility. The results suggest that the over-time movements of the daily values of FII and stock market returns contain a fair amount of volatility. Also, the strength and duration of volatility of stock market returns are more or less similar to those of the FII flows. Another interesting finding is that the strength of volatility of FII flows are positively correlated both with that of stock market returns and call money rate. The overall finding is that the FII and stock market returns in India exhibit quite high volatility in terms of both extent and duration. More importantly, there is also evidence that their volatility is interrelated.

List of Acronyms

BSE : Bombay Stock Exchange
CMR : Call Money Rate
FII : Foreign Institutional Investment
FIIN : Net Foreign Institutional Investment
FIIP : Foreign Institutional Investment—Purchase
FIIS : Foreign Institutional Investment—Sale
NSE : National Stock Exchange
RBI : Reserve Bank of India
SEBI : Securities and Exchange Board of India
VAR : Vector Auto Regression

I. Introduction

The analysis of volatility of such flows is very important from the viewpoint of the policy makers of a country like India where international investment in securities is increasingly assuming importance as external finance.

Since the last decade, India has gradually emerged as an important destination of global investors' investment in emerging markets. But the highly fluctuating nature of such flows has been a matter of concern for economies receiving these investments. Often, such flows are blamed for the Mexican and the East Asian crisis. The large and sudden reversals of foreign equity investments make them extremely volatile in character—a phenomenon which has the potential to destabilise the domestic economy of the recipient country, even if it is otherwise sound. Actually, securities markets in developing countries are typically narrow and shallow, and therefore, participation of foreign portfolio investors may, a priori, induce considerable instability in these markets. The effects of such investments, however, are quite controversial as country experiences differ widely. On the one hand, it is alleged that international investors use 'quick exit' in order to contain downside risk and thus make frequent marginal adjustments to their portfolios. By doing so, they tend to spread crisis even to countries with strong fundamentals since the changes in portfolios are often due to change in their perceptions of country solvency rather than variations in underlying asset value (FitzGerald, 1999).[1] Studies have shown empirically tested instances where foreign investment induces greater volatility in markets compared to domestic investors (Jo, 2002) and stocks mainly traded by such investors experience higher volatility than those in which such investors do not have much interest (Bae et al, 2002). On the contrary, evidences that international investments do not have significant impact in increasing volatility of stock returns (Bakaert and Harvey, 1998) are also there and these render the concern for volatility of such flows largely unwarranted (Errunza, 2001). What comes out from these evidences is that, the issue of volatility cannot be ignored and impacts of portfolio investments differ widely among countries. Hence, the analysis of volatility of such flows is very important from the viewpoint of the policy makers of a country like India where international investment in securities is increasingly assuming importance as external finance.

Virtually no study of the nature of volatility of foreign investment in India has been done so far, though concerns have often been expressed about the possible devastating effect of volatility of such flows on the Indian economy. However, in Gordon and Gupta (2003), an observation is made that the volatility of portfolio flows into India was small in comparison to other emerging markets during 1998 to 2000.[2] While the co-efficient of variation for such flows in India was

[1] The literature has evidences that individuals also can contribute to this destabilisation process by fleeing from funds, particularly mutual funds, forcing fund managers to sell.

[2] They have used the quarterly data for 17 emerging markets and measured volatility in terms of co-efficient of variation.

1.58, the corresponding figures for the Philippines, Thailand, Korea, Chile and Brazil stood at 1.79, 25.07, 1.82, 1.94 and 2.14, respectively. It should be noted that these figures are only indicative and do not specify the nature of the volatility of the flows. In this paper, we measure and analyse the volatility of international equity investments in India. In an earlier paper in Money & Finance, Mukherjee, Bose and Coondoo (2002) have identified the factors that influence the foreign institutional investment flows in India. As a sequel to that analysis, we concentrate, in the present paper, on the volatility of such investment. Here, using a descriptive non-parametric measure of volatility[3] developed by Coondoo and Mukherjee (2003), we compare the volatility of these flows with those of domestic stock market returns and related variables to see if these 'volatilities' are related. As explained later, the volatility measure used here considers three aspects of volatility of a variable, viz., amplitude (i.e., the excess of average dispersion of the variable during volatile state over that during normal state), duration (i.e., proportion of the given sample period the variable is in volatile state) and persistence (i.e., the average duration of a typical volatile state). We look into these three aspects separately, since each of these reveals a different aspect of the volatility present in a given time series data on a variable. The paper is organised as follows: in Section II, we describe the data and explain our methodology; Section III discusses the results; and Section IV concludes the paper.

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II. Data and Methodology

Variables and Data

As already mentioned, here we apply our method of volatility analysis to the data on stock returns, foreign equity investment and the call money rate to see whether the observed volatility of these variables are related in any manner. Though our primary concern is the volatility of the foreign institutional investment (FII), we include other variables in the present analysis essentially because of the fact that we found some relation between the FII and these variables in our earlier study on the FII (Mukherjee et al., 2002). More specifically, in our earlier study two statistically significant results were obtained, viz., a unidirectional causality from stock return[4] to FII and a positive association between FII and call money rate (CMR, which was taken as an indicator of real economic activity). In order to re-confirm these, here we estimate a Vector Autoregression (VAR) model involving the FII, stock return and CMR (Table 1). The VAR result shows that BSE return

[3] Approaches to volatility modeling fall into two categories: procedures based on estimation of parametric models and more direct non-parametric measurements. While the parametric models exploit different assumptions regarding volatility through distinct functional forms, non-parametric methods are data-driven and quantify volatility directly (See Andersen et al., 2002 for details). The recent literature on volatility is moving towards fully non-parametric dimensions.

[4] Refers to the BSE return, calculated from BSE Sensex.

TABLE 1
Results of VAR among all the variables

	BSE	NSE	CMR	FIIN	FIIP	FIIS
BSE-1	0.03	0.47	-1.90	1973.28	794.45	-1179.27
t-values	0.32	5.18	-0.31	3.44	1.35	-2.64
BSE-7	-0.03	0.03	-3.18	957.15	1458.43	500.80
t-values	-0.32	0.29	-0.49	1.59	2.37	1.07
BSE-15	-0.08	-0.12	2.41	-419.32	-152.79	267.19
t-values	-0.85	-1.25	0.38	-0.71	-0.25	0.58
NSE-1	0.03	-0.43	4.83	-531.79	104.11	636.14
t-values	0.30	-4.62	0.76	-0.90	0.17	1.39
NSE-7	0.09	0.02	5.92	-597.54	-1023.91	-425.88
t-values	0.94	0.20	0.90	-0.98	-1.63	-0.89
NSE-15	0.04	0.06	-5.12	289.31	-199.57	-489.67
t-values	0.36	0.63	-0.79	0.48	-0.32	-1.05
CMR-1	0.0001	0.0002	0.76	0.68	1.74	1.06
t-values	0.34	0.62	31.89	0.31	0.77	0.61
CMR-7	0.0005	0.0005	0.06	-1.06	-0.62	0.43
t-values	1.42	1.37	2.67	-0.48	-0.28	0.25
CMR-15	-0.0004	-0.0005	0.01	-0.69	4.02	4.71
t-values	-1.12	-1.38	0.57	-0.32	1.80	2.77
FIIN-1	-0.01	-0.01	0.09	-0.26	-13.20	-12.94
t-values	-1.67	-1.86	0.24	-0.01	-0.36	-0.46
FIIN-7	0.003	0.003	0.02	11.35	-26.13	-37.48
t-values	0.44	0.47	0.06	0.32	-0.71	-1.35
FIIN-15	-0.002	-0.003	0.03	15.24	-1.70	-16.95
t-values	-0.38	-0.60	0.07	0.43	-0.05	-0.61
FIIP-1	0.01	0.01	-0.09	0.44	13.43	13.00
t-values	1.67	1.86	-0.24	0.01	0.37	0.47
FIIP-7	-0.003	-0.003	-0.02	-11.32	26.21	37.53
t-values	-0.44	-0.47	-0.06	-0.32	0.72	1.35
FIIP-15	0.002	0.003	-0.03	-15.12	1.90	17.03
t-values	0.38	0.60	-0.07	-0.42	0.05	0.61
FIIS-1	-0.01	-0.01	0.09	-0.48	-13.07	-12.59
t-values	-1.67	-1.86	0.24	-0.01	-0.36	-0.45
FIIS-7	0.003	0.003	0.02	11.40	-25.97	-37.36
t-values	0.44	0.47	0.06	0.32	-0.71	-1.34
FIIS-15	-0.002	-0.003	0.03	15.21	-1.66	-16.88
t-values	-0.38	-0.60	0.07	0.43	-0.05	-0.61
C	0.00004	0.001	1.35	10.61	1.74	-8.89
t-values	0.01	0.26	5.53	0.47	0.08	-0.50
Adj. R-squared	0.01	0.04	0.63	0.09	0.31	0.38

Note: Critical values taken: 1.96 at 5% l.o.s. and 2.58 at 1% l.o.s.
Highlighted figures denote significance.

and CMR are significant covariates of FII. In the analysis that follows, we consider three FII variables {viz., sale (FIIS), purchase (FIIP) and net FII (FIIN)[5] }; two stock return variables (viz., the returns implied by the day-to-day movements of the Sensex stock price index of the Bombay Stock Exchange and the Nifty stock price index of the National Stock Exchange denoted as BSE_RET and NSE_RET, respectively); and the CMR. Daily data on FIIP, FIIS and FIIN are obtained from the SEBI website, the corresponding data on the Sensex and Nifty from the BSE and the NSE website, respectively, and the daily data on the CMR are taken from the RBI website. The sample period covered by this data set is from January 1999 to May 2002.[6]

Methodology

Suppose we have time series data on a variable that turns volatile from time to time. Typically, volatility in the data will show up as fluctuation with much larger amplitude of the observed value of the variable in some time intervals than in others. Such periods of greater fluctuation may be called volatile periods and those of milder fluctuation normal periods. Let us assume for convenience of exposition that the given time series is stationary and does not contain a trend and/or perceptible cyclical component[7] and consider the series in the deviation from mean form. Observed values of the variable, therefore, fluctuate around the zero mean level, sometimes violently and sometimes gently.

Periods of greater fluctuation may be called volatile periods and those of milder fluctuation normal periods.

The nature of volatility implicit in the given time series data may be fully characterised by three different aspects of the observed fluctuation of the given time series. First, the strength of volatility, shown by the excess of the average amplitude for the volatile periods over that of the normal periods. Next, the duration of volatility, i.e., the proportion of sample time units (i.e., the proportion of minutes, hours, days, weeks, or months, as the case may be) falling in volatile periods, all put together, out of the total number of sample time units. Finally, the persistence of volatility, i.e., the average duration of a typical volatile state in the given time series.

To obtain measures of these three aspects of volatility, we consider the absolute value of individual observed values of the given time series (the series being one of deviations, both positive and negative values are there). This will be a set of non-negative numbers measuring the extent of fluctuation on either side of the mean level at

[5] Basically, the investor's actions are aggregated into two basic measures—sales and purchase and an overall measure of net purchase, i.e. purchase - sales denoted as net FII.

[6] Before 1999, daily data on FII was not available.

[7] If the time series is long and covers a long historical time (say, 50 years), a part of the observed variations of the series may be due to trend and/or cyclical movement. We assume that such variations, if present in the given time series, have been eliminated using an appropriate filtering device.

different time points. Further, let us divide the series of absolute values by the standard deviation of the series so as to get a set of standardised values that are comparable across variables measured in different units. Let us consider the empirical distribution (i.e., the sample relative frequency distribution) of these observed absolute (deviation) values. The mode of this distribution should be an indicator of the average amplitude of variation in normal periods. Let us call this M_1. Similarly, the mean of all observed absolute values equal to or greater than M_1 should be an indicator of the average amplitude of variation in volatile periods. Let us call this M_2. Thus, $S=M_2-M_1$ may be taken as an empirical measure of the strength of volatility, i.e., the excess amplitude due to volatility. It may be noted that S is non-negative, by definition, and a larger value of S indicates greater volatility. Also, the values of S for different variables are comparable as these are based on standardised absolute values of deviation from the sample mean of individual variables.

Next, let us consider the area under the distribution of absolute value to the right of M_1 and call this D. Evidently, D is an indicator of the duration of volatility, i.e., the proportion of total sample period the variable is in volatile state. Like S, D is also a non-negative number, by definition, and a larger value of D is suggestive of a more enduring volatile state. Finally, a measure of auto-correlation of the observed absolute values {i.e., the correlation of the current value with its previous realisation(s)} should be a good indicator of persistence of volatility. We consider the auto-correlation of the sample absolute (deviation) values and call this P, a measure of persistence of volatility. The value of P is bounded between -1 and +1 and a positive value of P means a tendency for a large (small) observed value to follow a large (small) observed value. Larger the value of P, greater will be this inertia. The value of P, thus, can be an indicator of the persistence of volatility, mentioned above. In the empirical exercise, we have studied auto-correlation up to three lags, viz., first, second and third order auto-correlation, and used the first order auto-correlation as measure of persistence.[8] Thus, S, D and P are our proposed empirical measures for the three aspects of volatility of a given time series.

The pattern of volatility of a variable may change over time. For example, if one has a time series of daily observations covering a number of years, the pattern of volatility of the observed values may change gently over time within the given sample period or may abruptly change from one sample sub-period to another. To bring out such changing volatility hidden in an observed time series, one may consider a moving sample sub-period, have the three measures of volatility estimated separately for each sub-period and then examine if

To bring out such *changing volatility* hidden in an observed time series, one may consider a *moving* sample sub-period, have the three measures of volatility estimated separately for each sub-period and then examine if the estimated value of an individual measure is systematically related to time.

[8] The pattern of auto-correlation up to three lags showed that the first order auto-correlation is sufficient for measuring persistence.

the estimated value of an individual measure is systematically related to time. To clarify this, suppose we have a time series of daily observations on a variable covering a period of two years (i.e., the series consists of 730 daily observations). One may take a sample sub-period of 90 days comprising the observed values for the first 90 days, say, and work out the values of the three measures. Again, taking the observed values for the 2nd to the 91st day, the values of the three measures for this second sample sub-period may be worked out and the process may be repeated until the sample sub-period consisting of the last 90 days of the series has been reached. One may next examine separately for each measure of volatility whether the estimated sub-period-wise values show a systematic pattern of movement over time that is statistically significant. If they do, that will be indicative of a changing volatility for the variable under consideration.

For the present exercise, we have examined volatility for each of the variables using the procedure described above. Three different sample sub-periods, viz., 15 days, 30 days and 90 days, have been used to examine if the volatility patterns of individual variables have changed over time. The sample sub-period-wise relative frequency distribution of absolute (deviation) values of individual variables required for the purpose has been estimated using the non-parametric density function estimation technique (see Hardle, 1990).

The strength of volatility (i.e., S) is greatest for CMR among all variables and for FIIS among the FII variables. Also the value of S for FIIS is larger than that for the BSE or the NSE return.

III. Results

The method of volatility analysis explained above requires elimination of the trend and other non-stationary elements, if any, from the given observed time series. We, therefore, have first tested stationarity of the given time series of individual variables using the Augmented Dickey-Fuller unit root test procedure. Summary statistics and results of unit root test are presented in Tables 2A and 2B, respectively. As these results show, the given time series of all the six variables are stationary.

Given the stationarity of the observed time series, we next estimate the three measures of volatility, viz., S, D and P, separately for each variable using the entire sample and the methodology described above. The estimated values of these measures are shown in Table 3. It may be noted that for individual measures the estimated values for different variables are not very different from each other. However, the strength of volatility (i.e., S) is greatest for CMR among all variables and for FIIS among the FII variables. It is also interesting to note that the value of S for FIIS is larger than that for the BSE or the NSE return.

Coming to the duration of volatility as measured by D, CMR has the highest proportion of volatile days. Among the other variables, BSE return and FIIN experience more volatile days than other variables. As regards the persistence of volatility as measured by P (i.e., the auto-correlation coefficients), it is observed that the estimated first, second and third order auto-correlation coefficients are all positive for every variable considered.[9] Except for CMR, these are all not large in magnitude. Moreover, the strength of auto-correlation declines as the lag increases. Such a pattern of values of the auto-correlation coefficients perhaps suggests that for the variables under study, the volatility would show up in rather short spells.

Let us next examine for individual variables how the pattern of volatility changes over time. For this purpose, we have estimated the volatility measures by moving sample sub-periods separately for each variable, taking sub-periods of 15, 30 and 90 days, in turn. We thus have, for each variable and each measure of volatility, three time series of estimated values relating to 15, 30 and 90-day moving sample sub-periods, respectively. These three sample sub-periods are supposed to show the pattern of movement of volatility over time in the very short term, short term and medium term, respectively.

It may be noted that for every measure and every variable the time series graph becomes flatter as the length of the sub-period is increased.

TABLE 2A
Descriptive Statistics

	BSE_RET	NSE_RET	CMR	FIIN	FIIP	FIIS
Mean	-0.00004	0.00011	8.38	34.07	219.34	185.27
Median	0.00092	0.00032	8.03	23.10	183.75	161.80
Maximum	0.09	0.10	22.50	983.20	1307.10	840.80
Minimum	-0.07	-0.11	0.50	-509.50	2.90	2.80
Std. Dev.	0.02	0.02	2.10	120.04	141.72	113.39
Skewness	-0.07	-0.15	2.58	0.76	1.75	1.49
Kurtosis	5.33	7.29	13.99	9.66	8.74	6.68
Jarque-Bera	190.15	647.96	5160.66	1632.13	1581.99	785.46
Probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Observations	840	840	840	840	840	840

TABLE 2B
Unit Root Tests

	BSE_RET	NSE_RET	CMR	FIIN	FIIP	FIIS
ADF-statistic						
level	-16.48	-16.87	-7.73	-9.11	-8.6	-5.95
Critical Value at 5%	-1.94	-2.57	-3.97	-2.87	-2.87	-2.87
Model Selected	No trend or intercept	No trend or intercept	Trend and intercept	Intercept	Intercept	Intercept
lag order	2	2	3	4	2	4
Series	**I(0)**	**I(0)**	**I(0)**	**I(0)**	**I(0)**	**I(0)**

Note: The ADF test statistics show that the null hypothesis of existence of unit root at level are rejected at 5% level of significance implying all series are I(0). The ADF test is performed against MacKinnon critical values.

[9] Here, we present only the first order auto-correlation co-efficients.

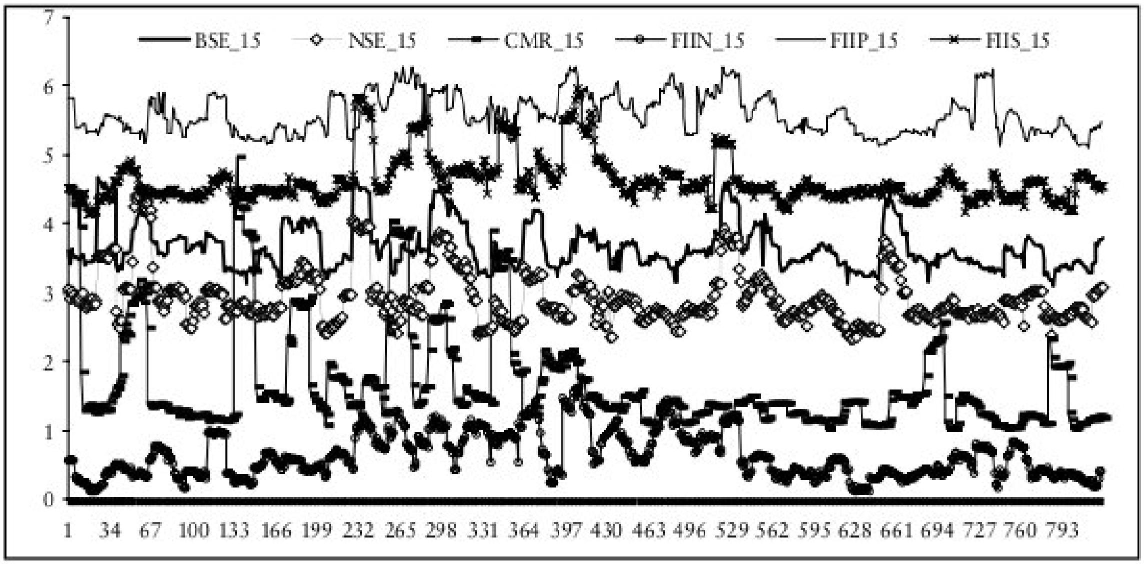
TABLE 3
Measures of Volatility

	BSE Return	NSE Return	CMR	FIIN	FIIP	FIIS
Amplitude of fluctuation						
1 Normal phase	0.295	0.303	0.133	0.256	0.337	0.328
2 Volatile phase	0.987	0.992	0.847	0.929	0.978	1.035
Difference between Volatile and Normal Phase	0.692	0.689	0.714	0.673	0.641	0.708
Duration of fluctuation						
3 Proportion of days volatility is experienced	0.773	0.754	0.807	0.769	0.733	0.751
Persistence of fluctuation						
4 Autocorrelation co-efficients of						
Lag-1	0.25	0.25	0.51	0.22	0.18	0.23
Lag-2	0.18	0.15	0.36	0.20	0.12	0.15
Lag-3	0.11	0.09	0.25	0.20	0.14	0.18

Note: Normal Phase: Mode
Volatile Phase: Mean
Difference between Volatile and Normal Phase is Mean—Mode
Duration: Area to the right of the Mode

Charts 1.1-1.3 present the graphs of over-time movement of the estimated S measure of volatility for individual variables based on the three different moving sample sub-periods.[10] It may be noted that for

CHART 1.1
S measure of variables for 15-day sub-period



[10] The charts have been drawn by shifting scale wherever required. Similar charts for D and P measures are available with the authors. For illustration, we provide charts for the 15-day sub-period for these two measures in appendix.

every measure and every variable the time series graph becomes flatter as the length of the sub-period is increased. This is only to be expected. Because, the difference between the estimated values of a measure for two consecutive sub-periods is only due to the difference in the first and last values of these two sub-periods and as the length of the sub-period increases, more values for two consecutive sub-periods become common. In Table 4 we present in brief, the findings of this entire exercise with moving sub-periods which are summarised below.

CHART 1.2
S measure of variables for 30-day sub-period

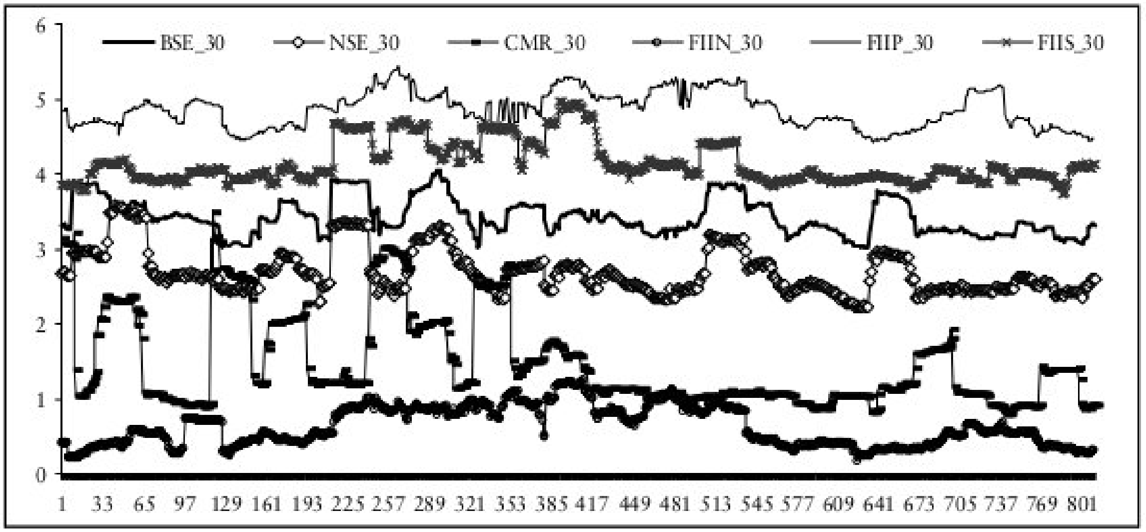


CHART 1.3
S measure of variables for 90-day sub-period

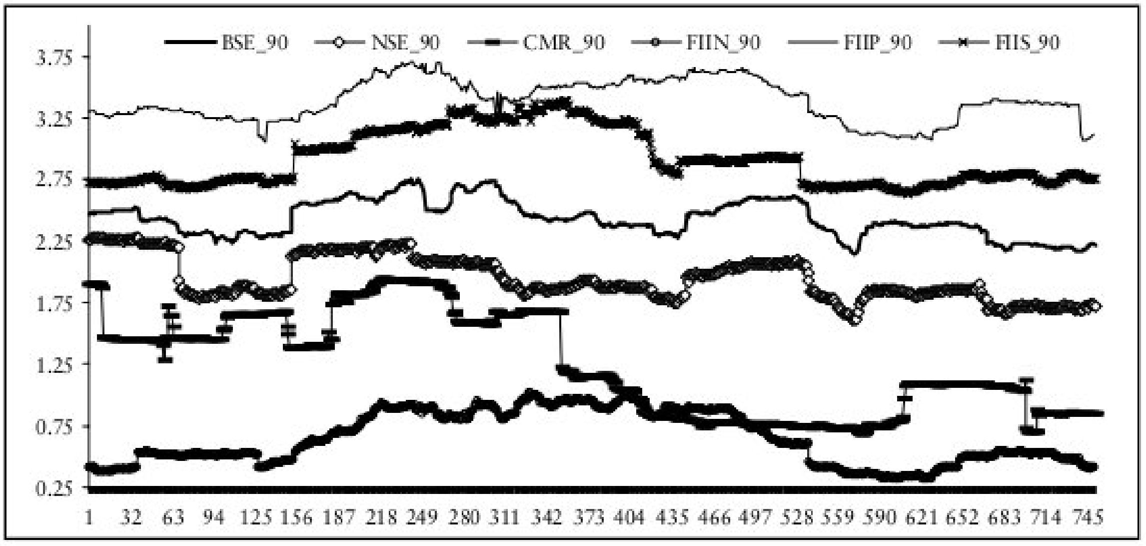


TABLE 4
Results of the analysis with moving sample sub-periods

Measure	Sub-period	Mean/Cv	Variable					
			BSE Return	NSE Return	CMR	FIIP	FIIS	FIIN
S	**15-day**	mean	0.66	0.68	0.67	0.59	0.63	0.63
		cv	0.51	0.58	1.12	0.49	0.53	0.51
	30-day	mean	0.67	0.69	0.72	0.60	0.64	0.63
		cv	0.36	0.44	0.86	0.39	0.43	0.41
	90-day	mean	0.68	0.69	0.75	0.64	0.67	0.65
		cv	0.22	0.25	0.54	0.26	0.33	0.33
	Entire sample		**0.692**	**0.689**	**0.714**	**0.641**	**0.708**	**0.673**
D	**15-day**	mean	0.60	0.60	0.72	0.57	0.60	0.63
		cv	0.23	0.22	0.12	0.25	0.19	0.17
	30-day	mean	0.65	0.66	0.76	0.62	0.64	0.67
		cv	0.16	0.13	0.08	0.17	0.13	0.10
	90-day	mean	0.70	0.71	0.79	0.67	0.70	0.71
		cv	0.09	0.04	0.05	0.09	0.06	0.06
	Entire sample		**0.773**	**0.754**	**0.807**	**0.733**	**0.751**	**0.769**
P	**15-day**	mean	-0.01	-0.03	0.24	0.01	-0.05	-0.01
		cv	-47.31	-9.50	0.91	44.21	-4.62	-15.78
	30-day	mean	0.10	0.06	0.37	0.05	0.01	0.03
		cv	1.99	3.54	0.50	4.14	14.43	5.92
	90-day	mean	0.20	0.18	0.45	0.08	0.10	0.08
		cv	0.67	0.98	0.33	1.37	1.37	1.54
	Entire sample		**0.25**	**0.25**	**0.51**	**0.18**	**0.23**	**0.22**

Strength of Volatility

(i) For none of the variables, the estimated value of S shows any perceptible rising or declining time trend;

(ii) The mean level of S is very similar and around 0.64 for all the variables in the case of the 15-day sub-period, around 0.66 for all the variables in the case of the 30-day sub-period and around 0.68 for all the variables in the case of the 90-day sub-period;

(iii) For every choice of sub-period length, the day-to-day fluctuation in S value is much greater for CMR than those for the other variables. The coefficient of variation of day-to-day fluctuation of S for CMR is 112 per cent, whereas for the remaining variables it ranges from 48 (FIIP)–58 per cent (NSE return) in the case of the 15-day sub-period. The corresponding figures are 86 per cent and 36 (BSE)–44 (NSE) per cent in the case of the 30-day sub-period and 54 per cent and 22 (BSE)–33 (FIIS) per cent in the case of the 90-day sub-period;

(iv) Among the FII variables, the level of S for FIIP is a little lower in the case of the 15-day sub-period. The same pattern also holds in the case of the other two sub-periods.

The fact that CMR has the largest average value and smallest coefficient of variation perhaps indicates that over the entire period considered, the day-to-day fluctuation of CMR is perceptibly greater than those for the other variables.

Duration of Volatility

(v) For none of the variables, the estimated value of D shows any perceptible time trend;

(vi) The mean level of D is very similar and around 0.62 for all variables except CMR in the case of the 15-day sub-period, around 0.67 for all the variables in the case of the 30-day sub-period and around 0.71 for all the variables in the case of 90-day sub-period. For CMR, the corresponding values are 0.72, 0.76 and 0.79 for the 15, 30 and 90-day sub-periods, respectively;

(vii) Compared to S, the day-to-day fluctuation of the value of D is much less for all the variables for every choice of the length of sub-period. Among the variables, the day-to-day fluctuation of D value is lowest for CMR, barring the 90-day sub-period only. In the case of the 15-day sub-period, the coefficient of variation of day-to-day fluctuation of D for CMR is 12 per cent, whereas for the remaining variables it ranges from 17 (FIIN)-25 per cent (FIIP) in the case of the 15-day sub-period. The corresponding figures are 8 per cent and 10 (FIIN)–17 (FIIP) per cent in the case of the 30-day sub-period and 5 per cent and 4 (NSE)–9 (FIIP) per cent in the case of the 90-day sub-period. The fact that CMR has the largest average value and smallest coefficient of variation perhaps indicates that over the entire period considered, the day-to-day fluctuation of CMR is perceptibly greater than those for the other variables.

Persistence of Volatility

(viii) An interesting pattern is observed in respect of the over-time movement of the estimated P measure of volatility. As to be expected, the mean value of the measure tends to increase as the length of the sample sub-period is increased.[11]

(ix) The mean level of P is positive for CMR and FIIP and negative for other variables in the case of the 15-day sub-period. This implies that for the variables other than CMR and FIIP a large (small) observed value tends to follow a small (large) observed value and hence a state of volatility, once started, does not continue long for these variables. Moreover, the magnitudes of mean value of the auto-correlation coefficients for these variables are small, ranging from –0.01 to –0.05. The magnitude of the mean value of auto-correlation coefficients for FIIP, though positive, is also very small. The mean value of auto-correlation coefficients is quite large only for CMR (0.24).

[11] As the length of the sub-period is increased, the change in only two observations in the continuously moving sub-period figures less, i.e. in the case of wider intervals such a change matters less compared to the narrower ones. Thus, the estimated auto-correlation does not seem to change much over time if a broader sub-period is chosen. This explanation is also true to some extent for the same pattern among intervals observed in the case of the other two measures.

(x) As in the case of D, the over-time fluctuation of P is lowest for CMR among all the variables. For CMR, the over-time fluctuation of P is found to be greatest in the case of the 15-day sub-period. For the other sub-periods too, the fluctuation is larger compared to S and D. For the 15-day sub-period the coefficient of variation of P for CMR is 91 per cent. For other variables, it ranges from 462 (FIIS) to 4731 per cent (BSE). The corresponding figures for the 30-day and 90-day sub-periods are 50 per cent and 199 (BSE) to 1443 (FIIS) per cent, respectively and 33 per cent and 67 (BSE) to 154 (FIIN) per cent, respectively. This pattern clearly suggests that for the 30-day and 90-day period, persistence of volatility is greatest for CMR among all the variables. However, since the mean values are quite small, volatility persists for a short time.

Next, let us see how the volatility patterns for different variables are correlated. To do so, we examine, separately for each of the three aspects of volatility, the correlation coefficient of the estimated measures for different pairs of variables. This study of correlation is also done taking estimates of the measures of the three aspects of volatility based on 15-, 30- and 90-day moving sub-periods, in turn. The results of the correlation analysis are presented in Tables 5A-I. It may be mentioned that such a study of the pattern of correlation among the three measures of volatility across variables is important, because the results may help discover interdependence of volatility across variables and thus formulate appropriate policies for containing volatility of the variables concerned, if necessary. The results of these tables may be summarised as follows:

A study of the pattern of correlation among the three measures of volatility across variables is important, because the results may help discover interdependence of volatility across variables and thus formulate appropriate policies for containing volatility of the variables concerned.

- As regards the strength of volatility (see Tables 5A-C), the patterns of correlation based on the 15- and 30-day sub-periods are very similar and that based on the 90-day sub-period is a little different. As expected, the correlation of S values for BSE and NSE return are positive and rather high for all the three choices of the sub-period length. Among the other pairs of variables, the correlation coefficients for pairs of the three FII variables are also reasonably high. The S measure for CMR shows a positive but not high correlation with that of FIIS, but not with those of the other two FII variables. The strength of correlation tends to increase systematically as the length of the sub-period is increased. In the case of the 90-day sub-period, the correlation of S values is systematically much higher for different pairs of variables. For this choice of the sub-period length, the strength of volatility of BSE return also turns out to be reasonably correlated with those of the three FII variables.

- In the case of duration of volatility (see Tables 5D-F), the correlation is found to be much weaker for different pairs of variables. Here also the strength of correlation is generally somewhat higher in the case of the 90-day sub-period com-

TABLE 5A
Correlation co-efficients of S for 15-day sub-period

	BSE 15	NSE 15	CMR 15	FIIN 15	FIIP 15	FIIS 15
BSE15	1.00	0.87	-0.02	0.23	0.17	0.27
NSE15		1.00	0.10	0.14	0.10	0.23
CMR15			1.00	0.06	0.02	0.16
FIIN15				1.00	0.69	0.59
FIIP15					1.00	0.42
FIIS15						1.00

TABLE 5B
Correlation co-efficients of S for 30-day sub-period

	BSE 30	NSE 30	CMR 30	FIIN 30	FIIP 30	FIIS 30
BSE30	1.00	0.86	0.01	0.23	0.20	0.34
NSE30		1.00	0.12	0.14	0.11	0.28
CMR30			1.00	0.12	0.01	0.27
FIIN30				1.00	0.78	0.77
FIIP30					1.00	0.54
FIIS30						1.00

TABLE 5C
Correlation co-efficients of S for 90-day sub-period

	BSE 90	NSE 90	CMR 90	FIIN 90	FIIP 90	FIIS 90
BSE90	1.00	0.80	0.43	0.51	0.50	0.59
NSE90		1.00	0.51	0.23	0.34	0.28
CMR90			1.00	0.25	0.14	0.43
FIIN90				1.00	0.86	0.88
FIIP90					1.00	0.67
FIIS90						1.00

TABLE 5D
Correlation co-efficients of D for 15-day sub-period

	BSE 15	NSE 15	CMR 15	FIIN 15	FIIP 15	FIIS 15
BSE15	1.00	0.47	-0.14	0.05	-0.04	0.12
NSE15		1.00	-0.03	0.03	-0.16	0.06
CMR15			1.00	0.06	-0.12	-0.14
FIIN15				1.00	0.06	-0.06
FIIP15					1.00	-0.01
FIIS15						1.00

TABLE 5E
Correlation co-efficients of D for 30-day sub-period

	BSE 30	NSE 30	CMR 30	FIIN 30	FIIP 30	FIIS 30
BSE30	1.00	0.42	-0.24	0.08	0.08	0.18
NSE30		1.00	-0.10	-0.09	-0.24	-0.04
CMR30			1.00	0.10	-0.14	-0.06
FIIN30				1.00	0.08	-0.11
FIIP30					1.00	0.09
FIIS30						1.00

TABLE 5F
Correlation co-efficients of D for 90-day sub-period

	BSE 90	NSE 90	CMR 90	FIIN 90	FIIP 90	FIIS 90
BSE90	1.00	0.47	-0.38	0.23	-0.04	0.34
NSE90		1.00	-0.20	0.33	0.02	0.06
CMR90			1.00	0.19	-0.04	-0.25
FIIN90				1.00	-0.01	0.30
FIIP90					1.00	0.01
FIIS90						1.00

TABLE 5G
Correlation co-efficients of P for 15-day sub-period

	BSE 15	NSE 15	CMR 15	FIIN 15	FIIP 15	FIIS 15
BSE15	1.00	0.71	-0.12	0.07	0.02	-0.10
NSE15		1.00	-0.08	-0.09	-0.07	-0.01
CMR15			1.00	0.05	0.06	0.08
FIIN15				1.00	0.22	0.02
FIIP15					1.00	-0.10
FIIS15						1.00

TABLE 5H
Correlation co-efficients of P for 30-day sub-period

	BSE 30	NSE 30	CMR 30	FIIN 30	FIIP 30	FIIS 30
BSE30	1.00	0.75	-0.10	0.07	-0.10	-0.05
NSE30		1.00	-0.08	-0.02	-0.11	0.06
CMR30			1.00	0.16	0.20	0.08
FIIN30				1.00	0.26	-0.04
FIIP30					1.00	-0.32
FIIS30						1.00

TABLE 5I
Correlation co-efficients of P for 90-day sub-period

	BSE 90	NSE 90	CMR 90	FIIN 90	FIIP 90	FIIS 90
BSE90	1.00	0.84	-0.21	-0.16	-0.15	-0.05
NSE90		1.00	-0.06	-0.13	-0.02	-0.12
CMR90			1.00	0.42	0.48	-0.24
FIIN90				1.00	0.47	0.00
FIIP90					1.00	-0.39
FIIS90						1.00

Note: Highlighted figures imply significant correlation.

pared to what they are for the other two choices of sub-period length. The correlation of D values for BSE and NSE return is observed to be systematically positive, though not high for all the three choices of sub-period length. The correlation of the D measure for CMR with those for all the other variables except FIIN turns out to be systematically negative and low thus suggesting an inverse relationship of duration of volatility of CMR with that for the other variables, except FIIN. This may be because during periods of very high volatility in CMR, stock markets tend to be much more cautious and market players hesitate to make a big move. Unlike in the case of correlation of the S measure, the correlation coefficients for different pairs of the FII variables are all quite low.

- Finally, in the case of persistence of volatility (see Tables 5G - I), the correlation is found to be positive and strong only for the pair of return variables, viz., BSE and NSE return. As the results for the 90-day sub-period show, the P measures for BSE and NSE return are negatively correlated with that for each of the FII variables, although the strength of such correlation is not high. Among the FII variables, the correlation of persistence of volatility turns out to be consistently positive for the FIIP-FIIN pair and negative for the FIIP-FIIS pair.

Summary of Results

Let us now summarise our observations regarding the over-time movement of the three aspects of volatility for each of the six variables. It may be mentioned that the results we have obtained from this detailed analysis of the available set of daily data based on different choices of the varying sub-period are quite consistent with those based on the entire data set taken as a whole. Let us enumerate the important results:

- CMR is the most volatile variable among all the variables considered here in terms of amplitude, duration and persistence of volatility.
- Among the FII variables, the S measure of volatility is consistently largest for FIIS, followed by FIIN and then FIIP. In terms of the D measure, it is FIIN which tends to be in the volatile state for the largest proportion of days in the given period of time. In terms of the P measure, for all the variables, volatility is found to persist for a short time only, with persistence being the greatest for CMR.
- BSE and NSE returns show very similar patterns of volatility in terms of all the three measures.
- Significant interdependence of volatility for different pairs of variables is found only in respect of the S measure of volatility. In other words, the volatility of one variable affects that of the

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- The results obtained suggest the following ranking of the variables in descending order in terms of individual aspects of volatility:

Amplitude of volatility:	CMR > FIIS > BSE > NSE > FIIN > FIIP
Duration of volatility:	CMR > BSE > FIIN > NSE > FIIS > FIIP
Persistence of volatility:	CMR > BSE = NSE > FIIS > FIIN > FIIP

IV. Conclusion

Significant interdependence of volatility for different pairs of variables is found only in respect of the S measure of volatility. In other words, the volatility of one variable affects that of the other only in terms of strength and not duration or persistence.

In this paper, we have examined volatility of the day-to-day movements of FII operations and some other related variables like the stock market returns and the call money rate. The set of six variables considered are BSE and NSE returns, call money rate, FII sale, FII purchase and net FII flow. For the purpose of this study, a new technique of analysis has been used that defines and examines three different aspects of volatility. These three aspects have been called the strength of volatility, the duration of volatility and the persistence of volatility.

Using time series of daily observations, for each of the six variables we have estimated these three measures for the entire sample period covering January 1999 to May 2002 and also for moving sample sub-periods of 15-, 30- and 90-day length. The exercise based on moving sub-periods has been done essentially to see if the pattern of volatility has changed over time for individual variables.

As the results suggest, the over-time movements of the daily values of all the variables contain a fair amount of volatility. However, for none of the variables considered, the pattern of volatility seems to have changed systematically over time following a rising or declining trend. Our results also suggest that the strength and duration of volatility of stock market returns are more or less similar to those of the three FII flows. Interestingly, the volatility of the call money rate turns out to be the strongest of all the variables in terms of all three measures. The estimated values of the S measure of volatility of these variables indicate that the mean of excess amplitude of fluctuations during volatile periods over that in non-volatile periods ranges from 0.64 to 0.71. As the estimates of the D measure of duration of volatility suggest, the volatile phase accounts for 73 to 81 per cent of the days of the entire sample period of around 1,250 days. Examination of the degree of association of individual aspects of volatility between pairs of variables has revealed some interesting results. Important among these are the following: the strength of volatility of individual FII variables are positively correlated both with stock market returns and call money rate. However, for the other two aspects of volatility, the correlation by and large turns out to be weak for different pairs of variables. These findings may be of interest to the policymakers, since the figures speak of a quite high volatility in terms of both extent and duration and their inter-relatedness across the set of relevant variables.

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CHART 1
D measure for 15-day sub-period

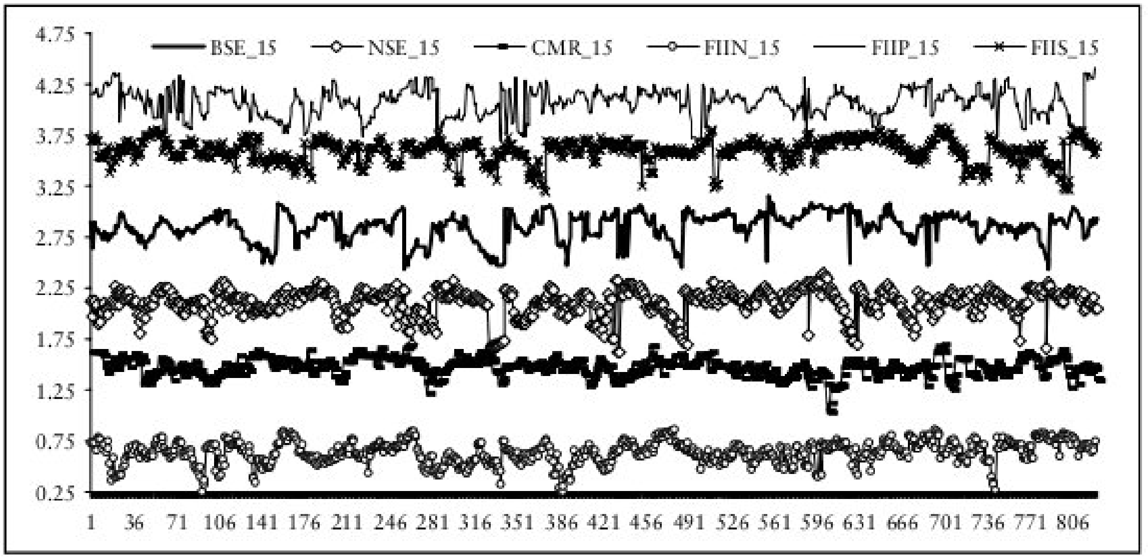

CHART 2
P measure for 15-day sub-period