Market Integration and Efficiency of Indian Stock Markets: A Study of NSE

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Abstract

The study tries to explore the dynamics of comovement of stock markets of USA ,Brazil, Mexico, China and India during the period from January, 1996 to July, 2007 using daily closing price data. It attempts to analyze the speed of adjustment coefficients using daily, weekly and monthly data. It also tries to examine the efficiency of the stock market as a result of initiatives and regulatory measures taken by NSE and SEBI respectively.

The long-term relationships among the markets are analyzed using the Johansen and Juselius multivariate cointegration approach. Short-run dynamics are captured through vector error correction models. The analysis reveals that there is an evidence of cointegration among the markets demonstrating that stock prices in the countries studied here share a common trend. The results reveal that the speed of adjustment of Indian stock market is higher than other stock markets of the world.

The analysis of speed of adjustment coefficient reveals that there are significant underreaction and overreaction alongwith full adjustment are observed at both shorter as well as longer differencing intervals during first period i.e. 1996-2001 using daily data while the second period i.e. 2002-2007 indicates significant overreactions with higher speed of adjustment coefficient. The results of event methodology reveal that the stock market become efficient at information processing in recent times with regard to few regulatory measures taken by SEBI.

JEL Classification: G14, C32

Key words: Johansen's cointegration, Vector Error Correction Model, ARMA Estimator, Event Methodology

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Introduction

The efficient market hypothesis states that asset prices in financial markets should reflect all available information; as a consequence, prices should always be consistent with 'fundamentals'. Efficient Stock Markets provide the vehicle for mobilizing savings and investment resources for developmental purposes. They afford opportunities to investors to diversify their portfolios across a variety of assets. In general, ideal market is the one in which prices provide accurate signals for resource allocation so that firms can make productive investment decision and investors can choose among the securities under the assumption that securities prices at any time fully reflect all available information. A market in which prices fully reflect all available information is called efficient.

The integration of Indian stock market with the rest of the world causes the absorption of the news quickly not in the country where the news originates but also in other countries as well. The study attempts to explore the comovement of stock markets of USA ,Brazil, Mexico, China and India to get additional insight of transmission mechanism of news. It also tries to address the issue of determining the speed of adjustment to news over the period using daily, weekly and monthly data of NSE and as such provides direct measure of the degree of over and underreactions. It attempts to investigate whether the efficiency of S & P CNX Nifty has improved over the years as a result of various initiatives undertaken by NSE and SEBI.

The study is divided into three major parts. The first Part A deals with analysis of comovements of stock markets. The Part B focuses on speed of adjustment coefficient. The final Part C of the study analyses the efficiency of the stock market using event study methodology.

A. Analysis of Comovements of Stock Markets:

1. Introduction

The issue of stock market integration and comovements of stock prices across economies has received considerable attention in economic literature. Integration is the process by which markets become open and unified so that participants in one market have an unimpeded access to other markets. The financial market's integration in general implies that in absence of administrative and informational barriers, risk adjusted returns on assets of the same tenor in each segment of the market should be comparable to one another.

Recent globalization and free movements of capital across boundaries of nation have integrated financial market worldwide. Technological innovations have improved market integration. Careful examination of international stock market movements in recent years suggests that there exists a substantial degree of interdependence among national stock markets. It is argued that unexpected development in international stock markets seem to have become important "news" that influences domestic stock markets (Eun & Shim, 1989).

With the automation and liberalization of the Indian stock markets, there has been a perceptible change in the Indian Stock market towards the later part of the 1990s. Trading system in Bombay Stock Exchange (BSE) and National Stock Exchange (NSE) has reached a global standard. It has created a nationwide trading system that provides equal access to all investors irrespective of geographical location. In that sense, technology has brought about equality among the investors across the country. The stock markets introduced the best possible systems; practiced in advanced stock markets like electronic trading system, rolling settlement in place of the account period settlement, increase in trading hour, dematerialization of shares and introduction of derivates etc. The focus on the external sector has prompted many Indian companies, especially those in the area of information technology, to list at the US stock exchanges. With the introduction of advanced practices, transparency has also increased in the stock market. Further, among the significant measures of opening up of capital market, portfolio investment by foreign institutional investors (FIIs) such as pension funds, mutual funds, investment trusts, asset management companies have made the turning point for the Indian stock markets. With the financial sector reforms initiated in 1991, not only FIIs and NRIs are allowed to invest in Indian stock markets, Indian corporate have been allowed to tap the global market with global depository receipts (GDR), American depository receipts (ADR) and foreign currency convertible bonds (FCCB) since 1993. All these changes have led to substantial improvement in market capitalization, liquidity and efficiency of the Indian capital market.

The deregulation and market liberalization measures and the increasing activities of multinational companies have accelerated the growth of Indian stock market. Thus, given the newfound interest in the Indian stock markets during liberalization period, it is interesting to know integration of Indian stock markets. The financial markets, especially the stock markets, for developing and developed markets have now become increasingly integrated despite the uniqueness of the specific market and country profile. This has happened specifically due to financial liberalization adopted by most of the countries around the world, technological advancement in communications and trading systems, introduction of innovative financial products and creating more opportunities for international portfolio investments. This has intensified the curiosity in exploring international market linkages.

Eun and Shin (1989) detected the presence of substantial amount of interdependence among national stock markets of USA, UK, Canada, Germany, Australia, France, Japan, Switzerland and Hongkong. Using daily closing price data during the period January 1980 through December 1985, the study found a substantial amount of multi-lateral interactions among the national stock markets. The analysis indicated that innovations in the U.S. were rapidly transmitted to other markets in a clearly recognizable fashion, whereas no single foreign market can significantly explain the U.S. market movements.

Over the past 40 years, stock market prices have been analyzed using different methods and data sets by investors and researchers with an objective to determine the forecastability of price changes. Chung and Ng (1991) have shown that developments in the U.S. market have significant influence on return of Tokyo stock market on the next day, but Tokyo stock market of Japan does not influence the returns of U.S. market. Given the U.S.'s dominant economic and political strength in the world market, this finding does not seem surprising. However, the recent leading role of other stock markets of the world and their interactive participation in the U.S. may possibly signal a reversal of the widely-held notion that the spillover stock market effect is solely from the U.S. to other stock markets.

Bhattacharya and Samantha (2001) investigated the extent to which news on NASDAQ helped price formation at the beginning and at the end of a trading day at the Indian bourses using daily data of stock price indices from January 3, 2000 to October 31, 2000. They analyzed the impact of NASDAQ on SENSEX through Ordinary Least Square (OLS) equations under cointegration and error correction framework[1]. The study showed that the news on NASDAQ had played an important role in price formation at the beginning of the new trading day at the Indian bourses. Thus, the study suggested the integration of the Indian capital market with the US market.

Wong, Agrawal and Du (2004) investigated the long-run equilibrium relationship and short-run dynamic linkage between the Indian stock market and the stock markets in major developed countries (United States, United Kingdom and Japan) after 1990 using the Granger causality and cointegration method. Using weekly closing prices data from January 1, 1991 to December 31, 2003, they found that Indian stock market was integrated with mature markets.

Compared to other emerging stock markets in Asia, the Indian stock market has been recognized as relatively less sensitive to changes of Asian and other developed markets of the world. Therefore, in spite of the fact that Indian stock market has largest number of listed companies, it has received little attention while undertaking studies on interconnectedness of world stock markets. Researchers have rarely included the Indian Stock Market while studying the influence of the U.S. markets on Asian markets and interdependence among Asian stock markets (Wong & Ng, 1992, Ng, 2002). These researches are evidences that Indian stock market has not only received relatively less attention of scholars and researchers in the field of international finance but also the market is considered to be somewhat isolated from international markets.

Ahmad, Ashraf and Ahmed (2005) examined the interlinkages and causal relationship between the Nasdaq composite index in the US, the Nikkei in Japan with that of NSE Nifty and BSE Sensex in India using daily closing data from January 1999 to August 2004. The study used Granger Causality and Johansen cointegration[2] methods to examine

[1]In Cointegration, a linear combination of two series, each of which is integrated of order one, is cointegrated of order zero. Error Correction Model is a time series model in first differences that contains an error correction term which works to bring two I(1)(the series that can be transformed into statationary by taking first difference) series back into long-run equilibrium.

[2] It is applied when series are non stationary and integrated of the same order. The purpose of the test is to determine whether a group of non-stationary series is co-integrated or not.

short run and long term relationship among the stock markets respectively. The results of Co-integration test revealed that there was no long-term relationship of the Indian equity market with that of the US and Japanese equity markets. Granger causality test suggested that there was a unidirectional relationship from Nasdaq and Nikkei to Indian stock markets.

Hoque(2007) explored the dynamics of stock price movements of an emerging market such as Bangladesh with that of USA, Japan and India using daily closing price data starting from January 1, 1990 to December 31, 2000. The indices used for Bangladesh, India, Japan and USA were Dhaka Stock Exchange(DSE) All Share Price Index, BSE30, Nikkei 225 and S&P500 respectively. They analyzed the long term relationships among the markets using the Johansen multivariate cointegration approach and short-term dynamics were captured through vector error correction models. Vector Auto Regression[3] was used to study the impact of shocks of these markets on own markets and other markets. The analysis showed that there was evidence of long term cointegration among the markets suggesting that stock prices in the countries share a common stochastic trend. Impulse response analysis shows that shocks to US market do have an impact on Bangladesh stock market. The response of Bangladesh stock market to shocks Indian stock market is weak. Shocks to Japanese stock market do not generate a response in the Bangladesh stock market.

Although there is no dearth of literature on financial integration, there are only a few studies related to India. Our literature review suggests that there are few studies on integration of Indian stock markets with U.S.A and developed and developing stock markets of Asia. With liberalization in India, changes in the economic environment of the world and growing interdependence of the American and other countries like India, China, Brazil and Maxico, it is interesting to investigate the integration of stock price movements of India with respected to American and other stock markets. The purpose of the paper is to provide such analysis with a special emphasis on integrating relationship of selected stock markets.

The organization of the paper is as follows. Section 2 discusses research design. Results are presented in section 3. Section 4 summarizes.

[3] A model for two or more time series where each variable is modeled as a linear function of past values of all variables plus disturbances that have zero means given all past values of the observed variables.

2. Research Design

2.1 Sample and Period of study

The study uses data on daily closing price of NSE of India, Shanghai Stock exchange of China, IPC of Maxico, Bovespa of Brazil and Standard and Poor (S&P) 500 of United States from 1st January 1996 to 31st December, 2007. We drop the data when any series has a missing value due to no trading. Thus all data are collected on the same dates across the stock exchanges and there are 2951 observations for each series. Many changes took place during the period like introduction of rolling settlement, transactions in futures and options, the bull run and the highs in the indices, increased FII inflows across the world stock markets, gradual lifting of restrictions on capital flows and relaxation of exchange controls in many countries etc. These changes might have influenced the degree of comovement among the stock markets. It will be instructive to examine the cointegration of the stock markets.

2.2 Methodology

Daily returns are identified as the difference in the natural logarithm of the closing index value for the two consecutive trading days. It can be presented as:

$$R_t = \log(P_t / P_{t-1}) \text{ or } R_t = \log(P_t) - \log(P_{t-1}) \qquad \textbf{Equation 1}$$

Where R_t is logarithmic daily return at time t. P_{t-1} and P_t are daily prices of an asset at two successive days, t-1 and t respectively.

2.2.1 Unit root test

Augmented Dickey-Fuller (ADF) test is employed to test the validity of market integration hypothesis. A unit root test is a statistical test for the proposition that in an autoregressive statistical model of a time series, the autoregressive parameter is one. It is a test for detecting the presence of stationarity in the series. The early and pioneering work on testing for a unit root in time series was done by Dickey and Fuller (Dickey and Fuller 1979 and 1981). If the variables in the regression model are not stationary, then it can be shown that the standard assumptions for asymptotic analysis will not be valid. In other words, the usual "t-ratios" will not follow a t-distribution; hence they are inappropriate to undertake hypothesis tests about the regression parameters.

Stationarity time series is one whose mean, variance and covariance are unchanged by time shift. Nonstationary time series have time varying mean or variance or both. If a time series is nonstationary, we can study its behaviour only for a time period under consideration. It is not possible to generalize it to other time periods. It is, therefore, not useful for forecasting purpose.
The presence of unit root in a time series is tested with the help of Augmented Dickey-Fuller Test. It tests for a unit root in the univariate representation of time series. For a return series R_t, the ADF test consists of a regression of the first difference of the series against the series lagged k times as follows:

$$\Delta r_t = \alpha + \delta r_{t-1} + \sum_{i=1}^{p} \beta_i \Delta r_{t-i} + \varepsilon_t$$

Equation 2

$$\Delta r_t = r_t - r_{t-1}; r_t = \ln(R_t)$$

The null hypothesis is H0: $\delta = 0$ and H1: $\delta < 1$. The acceptance of null hypothesis implies nonstationarity.
We can transform the nonstationary time series to stationary time series either by differencing or by detrending. The transformation depends upon whether the series are difference stationary or trend stationary.

2.2.2 Co-integration Test

The purpose of the co-integration test is to determine whether a group of nonstationary series is co-integrated or not. The presence of cointegrating relation forms the basis of the Vector Error Correction (VEC) model specification. The test for the presence of cointegration is performed when all the variables are non-stationary and integrated of the same order. Cointegration exists for variables means despite variables are individually nonstationary, a linear combination of two or more time series can be stationary and there is a long-run equilibrium relationship between these variables. In the present study, we use method proposed by Johansen (1991). This method can be explained by considering the following general autoregressive representation for the vector Y.

$$Y_t = A_0 + \sum_{j=1}^{p} A_j Y_{t-j} + \varepsilon_t$$

Equation 3

where Y_t is a nx1 vector of nonstationary variables, A is a nx1 vector of constants, p is the number of lags, A_j is nxn matrix of coefficients and ε is assumed to be a nx1 vector of Gaussian error terms.
In order to use Johansen's test, the above vector autoregressive process can be reparametrized and turned into a vector error correction model of the form:

$$\Delta Y_t = A_0 + \sum_{j=1}^{p=1} \Gamma_j \Delta Y_{t-j} + \Pi Y_{t-p} + \varepsilon_t$$

Equation 4

where

$$\Gamma_j = -\sum_{i=j+1}^{p} A_j \quad \text{and} \quad \Pi = -\mathrm{I} + \sum_{i=j+1}^{p} A_j$$

Equation 5

Δ is the difference operator and I is nxn identity matrix.

The issue of potential cointegration is investigated when we compare the both sides of equation 4. As Y_t is integrated of order 1 i.e. I(1), ΔY_t is I(0), so are ΔY_{t-j}. This implies that left-hand side of equation 4 is stationary since ΔY_{t-j} is stationary; the right hand side of equation 4 will also stationary ΠY_{t-p} is stationary. The Johansen test centres on an examination of the ∏ matrix. The ∏ can be interpreted as a long run coefficient matrix. The test for cointegration between the Y's is calculated by looking at the rank of the ∏ matrix via eigenvalues. The rank of the matrix is equal to the number of its characteristic roots (eigenvalues) that are different from zero. The information on coefficient matrix between the levels of the ∏ is decomposed as ∏=αβ, where the relevant elements, the α matrix are adjustment coefficients and β matrix contains the cointegrating vectors.

There are two test statistics for cointegration under the Johansen method to test for number of characteristic roots. There are trace and the maximum eigenvalues test:

$$\lambda_{trace}(r) = -\mathrm{T} \sum_{i=r+1}^{g} \ln(1-\hat{\lambda})$$

Equation 6

and

$$\lambda_{\max}(r, r+1) = -\mathrm{T} \ln(1-\hat{\lambda}_{r+1})$$

Equation 7

where $\hat{\lambda}$ is the estimated values of the characteristic roots obtained from the estimated ∏ matrix, T is the number of usable observations and r is the number of cointegrating vectors.

The trace test statistics, test the null hypothesis that the number of distinct cointegration vectors is less than or equal to r against the alternative hypothesis of more than r cointegrating relationships. From the above, it is clear that λ_{trace} equals zero when all $\hat{\lambda}$=0. The maximum eigenvalue statistics test the null hypothesis that the number of cointegrating vectors is less than or equal to r against the alternative of r+1 cointegrating vectors.

Johansen and Juselius (1990) provided critical values for the two statistics. If the test statistics is greater than the critical value from Johansen's table, reject the null hypothesis in favour of the alternative hypothesis discussed above.

2.2.3 Short-run dynamics of the system

Short run dynamics of the system is examined through error correction model. The discussion on the model is given in the following section.

2.2.3.1 Error Correction Model

If variables are nonstationary and are cointegrated, the adequate method to capture short run dynamics is Vector Error Correction Models (VECMs). It examines the responses of a variable to changes and innovations in other variables and the adjustments that it takes to correct for any deviations from the long-run equilibrium relationship. Under cointegration, the VECM can be written as:

$$\Delta Y_t = \alpha\beta' Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + A_t + \varepsilon_t$$

Equation 8

where α is the matrix of adjustment or feedback coefficients, which measures how strongly deviations from equilibrium, the r stationary variables $\beta' Y_{t-1}$, feedback into the system. If there are 0<r<p cointegrating vectors, then some of the elements must be non zero.

3. Results and Discussion

A prerequisite for testing cointegration between the stock indices is the all variables are non-stationary. The first phase in the estimation process is deciding the order of integration of the individual price index series in natural log levels. The log of the indices, denoted as LNSE, LSSE, LIPC, LBovespa and LSP500, are tested for unit roots using the Augmented Dickey-Fuller (ADF) test using lag structure indicated by Schwarz Bayesian Information Criterion (SBIC). The results of the Augmented Dickey Fuller test for unit root test are given in Table 1. It shows that all the variables are non-stationary at their log level. However, they are stationary at their first difference and are integrated of order one as the actual values reported in the Table 1 exceed MacKinnon 's critical values of -3.43, -2.86 and -2.56 at 1%, 5% and 10% levels respectively. Thus, all the series under investigation are I(1). This means that all the series are individually integrated.

Table 1 Unit root test

Stock markets	Log Level	First Difference of Logarithmic series
LNSE	0.931 (0.996)	-48.506 (0.000)
LSSE	(-0.454) 0.897	-53.227 (0.000)
LIPC	-0.008 (0.957)	-50.331 (0.000)
LBovespa	-0.779 (0.824)	-52.491 (0.000)
LSP500	-2.293 (0.174)	-56.350 (0.000)

Johansen cointegration test is sensitive to the lag length(Enders, 2004). We employ AIC and SBC criteria to select the lag length to include in the analysis. The results of lag length selection criteria are reported in the Table 2.

Table 2: Lag Length Selection

Lag	AIC	SBC
0	-0.653423	-0.643105
1	-27.17176	-27.10986*
2	-27.18652*	-27.07302
3	-27.18292	-27.01783
4	-27.18125	-26.96457
5	-27.18097	-26.9127
6	-27.18149	-26.86163
7	-27.1808	-26.80935
8	-27.18448	-26.76144

Here, AIC selects the model with two lags and the SBC selects the model with one lag. We can also determine lag-length using a likelihood ratio test. Under the null hypothesis, we can restrict lag 1 of all coefficients in all five equations to be zero. If this restriction is binding, we reject the null hypothesis. The calculated Chi-square value is 92.97. It rejects the null hypothesis of one lag. Thus, AIC and likelihood ratio test both select the two-lag model.

The second phase involves an assessment on the five market series for cointegration. The cointegration test is to determine whether or not the five nonstationary price indices share a common stochastic trend. Table 3 presents the results of cointegration tests pertaining to the indices. The results reveal the presence of significant cointegrating relationships between the stock market indices under investigation. Both the λ_{trace} and λ_{max} test show two significant cointegrating ranks. This indicates the presence of long-run equilibrium relations between the USA, Chinese, Indian, Brazil and Maxico stock markets. In other words, by and large all the stock indices are moving together.

Table 3 Johansen's Cointegration Test Results Five Indices

λ_{trace}				
Hypothesized		**Trace**		
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None *	0.024322	135.8939	60.06141	0.0000
At most 1	0.017145	64.53726	40.17493	0.0000
At most 2	0.004557	14.41998	24.27596	0.5023
At most 3	3.39E-04	1.183505	12.3209	0.9919
At most 4	6.92E-05	0.200484	4.129906	0.7100
λ_{max}				
Hypothesized		**Max-Eigen**	**0.05**	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None *	0.024322	71.35667	30.43961	0.0000
At most 1 *	0.017145	50.11728	24.15921	0.0000
At most 2	0.004557	13.23647	17.7973	0.2130
At most 3	0.000339	0.983021	11.2248	0.9929
At most 4	6.92E-05	0.200484	4.129906	0.7100
Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Johansen Cointegration Equation[1] LNSE-3.42LIPC+2.96LBovespa+0.31LSSE-1.59LSP500=ε_t (8.21) (6.51) (1.42) (3.90)*				

*Figure in the parenthesis are t-statistics. [1]The cointegrating vector is normalized on the NSE stock index.

The model adequacy test of Johansen cointegration is tested using Portmanteau test for autocorrelations. The result of the test at lag length is tabulated as below:

Table 4 Portmanteau test for Autocorrelation

Lags	Q-test	Prob	Adj. Q test	Prob	Df
5	48.69340	0.3267	48.74364	0.3249	45

The result suggests no residual autocorrelation after the model is fit. It implies that the model is adequate to capture the cointegration among the stock markets. The cointegrating equation normalized on Indian stock price presented in the Table 3 suggests that there is a long-term tendency for NSE to converge with those markets.

The second phase involves estimation of five error correction equations, based on cointegrated model. Table 5 represents the results of VECM. It is used to examine the short run equilibrium dynamics of the stock indices.

Table 5 Results of VECM model

Error Correction:	D(LSP500)	D(LSSE)	D(NSE)	D(LBovespa)	D(LIPC)
ECM(-1)	-0.001823	-0.000898	0.002	-0.000458	-0.007313
	[-2.57889]*	[-0.81774]	[1.93062]	[-0.32163]	[-7.42545]

*Indicates t-statistics

The results suggest that the error correction terms or adjustment coefficients are statistically significant (coefficient of NSE is statistically significant at 90%) except for SSE and Bovespa. The speed of adjustment coefficients is low in magnitude. It can be seen from the Table 4 that the coefficients of error correction terms of all stock markets except NSE are negative. For instance, the positive coefficient of (0.002) of the cointegrating relation in the NSE equation means that the return of the underlying goes up when the cointegrating equation shows positive values (direct relationship). The negative coefficients (-0.001823) of SP 500 of USA and (-0.007313) of IPC of Maxico indicate that the returns of the stock markets go down when the cointegrating equation shows positive values (inverse relationship). The speed of adjustment of Indian stock market is marginally higher than rest of the stock markets. The results in the table 5 suggest that Indian stock market goes back to equilibrium faster.

4. Summary

The present stud endeavored to explore the dynamics of stock price co-movements of USA, Chinese, Brazil, Indian and Maxican stock markets. Cointegration model is used to examine the long-run equilibrium relationship among the time series. The results demonstrate that stock prices in those countries share a common trend. In general long-term relationship and short-term dynamics have been detected in this study.

The existence of market integration among the stock indices under investigations indicates that diversification among these five markets leads to little benefit to international portfolio investors. The results have several policy implications. If the markets are integrated, arbitrage opportunities would be very low. The absence of arbitrage opportunity may lead to low level of speculation leads to better market efficiency and the return would be proportionate to the risk.

The speed of adjustment of Indian stock market is higher implying it absorbs news faster than other stock markets and the it is considered to be more informationally efficient than other stock markets.

B. Speed of Adjustment Coefficient

1. Introduction

Studies of market efficiency focused on the question of how quickly information is reflected in prices. An efficient market is one in which information is expected to be quickly reflected in prices in an unbiased manner. It is well recognized that the inefficient resource allocation would occur if prices are not free to adjust to market conditions (Jackson III, 1997). The efficiency of price discovery process of a security market can be assessed through the analysis of speed of adjustment process (Rajesh, 2010). The structure of the market and the level of technology used influence the speed of adjustment. The changes in regulatory policy and procedures and more information dissemination result into faster processing of new information. Impact of changes in market microstructure on security speed of adjustment coefficient can be found by measuring whether there is underreaction or overreaction in security prices while adjusting to their intrinsic value. The security speed of adjustment gives us an idea about the degree of over or under reaction or full adjustment of prices to the arrival of new information. The speed of price reaction to the news is of interest not only to investors but also to stock exchanges. The transparency of prices in addition to the trading cost affects the competitive position of stock exchanges. Therefore, the subject is quite relevant to examine.

2. Theoretical Background

The efficient market hypothesis states that asset prices in financial markets should reflect all available information; as a consequence, prices should always be consistent with ‘fundamentals’. Efficient Stock Markets provide the vehicle for mobilizing savings and investment resources for developmental purposes. They afford opportunities to investors to diversify their portfolios across a variety of assets. In general, ideal market is the one in which prices provide accurate signals for resource allocation so that firms can make productive investment decision and investors can choose among the securities under the assumption that securities prices at any time fully reflect all available information. A market in which prices fully reflect all available information is called efficient.

Fama classified stock market efficiency into three forms. They are namely 'weak form', 'semi-strong form' and 'strong form'. The classification depends upon the underlying assumptions relating to information set available to market participants. Each information set here is more comprehensive than the previous one. The more efficient capital market is more random which makes the market return more unpredictable.

Fama (1970 and 1991) renamed the market efficiency studies into three categories. The first category involves the tests of return predictability; the second group contains event studies and the third tests for private information. Later different frameworks have been developed to analyze the behaviour of stock prices to the arrival of new information.

De Bondt and Thaler(1984) examined the overreaction hypothesis using monthly data of Centre for Research in Security Prices (CRSP) for the period between January 1926 and December 1982. The findings discovered weak form of inefficiency. They found that portfolio of losers outperformed prior winners. The losing stocks earned about 25% more than winning stocks thirty six month after portfolio formation.

Grundy and McNichols(1989) analyzed price adjustment process to the release of new information using rational expectations model. When traders are heterogeneously informed, spot prices and volume contain private information and traders have rational expectations about the relationship between prices and signals.

Amihud and Mendelson (1987) examined the effects of trading mechanism on price behaviour of securities in NYSE stocks. They employed model in which prices followed a lagged partial adjustment process to intrinsic value with noise. The results suggested that the trading mechanism affected the price behaviour. The study did not measure the speed of security price adjustment.

Damodaran(1993) developed a simple approach that drew on attention in return processes to estimate price adjustment coefficients for the firm listed on NYSE and AMEX during 1977 to 1986. The study found evidence of lagged price adjustment coefficients to new information in shorter return intervals for firms.

As discussed earlier, a number of estimators have been developed (for example Amihud and Mendelson, 1989, Damodaran, 1993, Brisley ad Theobald, 1996; Theobald and Yallup, 1998). Recently, Thobald and Yallup(2004) addressed the problem of determining security speeds of adjustment towards their intrinsic values thereby providing the direct measures of the degree of price over and underreactions. They pointed out the limitations of earlier estimators. For example, Damodaran (1993) and Brisley and Theobald (1996) do not have readily available sampling distribution and therefore, significance testing is not possible. They will be also be subject to non-trading/non-synchronicity problems and require prices to fully adjust with available information at a specified return interval. It therefore prevents the possibility of testing for over or underreactions at longer differencing intervals. Further, they mentioned that the estimators do not provide estimates of the total speed of adjustment coefficient.

Few studies have examined information efficiency of stock exchanges with regard to Indian stock markets. Poshakwale and Theobald(2004) examined the lead-lag relationship between large and small market capitalization stocks using data of four stock market indices of BSE and NSE namely Nifty senior and junior Indices, SENSEX and BSENI indices. The studies found that large cap tend to lead small cap indices. The speed of adjustment of large capitalization stock was higher than small capitalization stock. Rajesh(2010) examined the impact of changes in market micro structure on market quality through security speed of adjustment coefficient using ARMA estimator. The study did not find significant difference in the speed of adjustment coefficient of small and large capitalization stocks.

Theobald and Yallup(2004) developed ARMA specification of the return process which overcome the deficiencies discussed in the previous paragraph. The estimator is a function of autocorrelation which is introduced by underreactions and overreactions. Underreactions induce positive autocorrelation while overreactions lead to negative autocorrelations in the return series. The ARMA estimator has a sampling distribution for significance testing. It provides total speed of adjustment coefficient. Thin trading effect can be expressed with higher order moving average terms. Finally, the estimator does not require prices to fully adjust to information at any specified intervals as in case of Damodaran (1993) estimator. Therefore, ARMA estimator can be applied in all potential adjustment scenarios to measure overreaction or underreaction.

The plan of this part B is as follows. Section 3 discusses research design. Results are presented and discussed in Section 4. Conclusions are drawn in Section 5.

3. Research Design

3.1 Sample and Period of study

The study uses data on daily closing price of S&P CNX Nifty indices of India from 1st January 1996 to 31st December, 2007. The daily data are obtained from NSE web site(www.nseindia.com). The weekly and monthly data are accessed from Global Finance Data base. The study period is divided into two sub periods viz. 1996 to 2001 and 2002 to 2006. The first period represents the beginning years of NSE while the second period is most recent and many changes took place during the period like introduction of rolling settlement, transactions in futures and options, the bull run and the highs in the indices, increased FII inflows across the world stock markets, gradual lifting of restrictions on capital flows and relaxation of exchange controls in many countries etc. These changes might have influenced the speed of price adjustment.

3.2 Methodology

Daily returns are identified as the difference in the natural logarithm of the closing index value for the two consecutive trading days. It can be presented as:

$R_t = \log(P_t / P_{t-1})$ **or** $R_t = \log(P_t) - \log(P_{t-1})$ **Equation 9**

Where R_t is logarithmic daily return at time t. P_{t-1} and P_t are daily prices of an asset at two successive days, t-1 and t respectively.

The partial adjustment with noise model by Amihud and Mendelson(1987) specified the stochastic process for observed price series and intrinsic value series. The observed price series are assumed that it will incompletely adjust towards its intrinsic or fundamental values. The extent of adjustment is reflected in speed of adjustment coefficient. The intrinsic value series is assumed to follow a random walk process i.e. it fully adjusts to information shocks. The following two equations give us the specifications for observed price and intrinsic value series:

$\Delta P_t = \pi \{V_t - P_{t-1}\} + u_t$ **Equation 10**

$\Delta V_t = \mu + e_t$ **Equation 11**

Here ΔP_t is change in the logarithmic actual prices, π is the speed of adjustment coefficient which will be within the range of [0,2] for non explosive series. u_t is white noise error term. ΔV_t is the change in logarithmic intrinsic values, μ is mean of the intrinsic value random walk process and e_t is innovation in logarithmic intrinsic values which will be serially uncorrelated in efficient markets. The speed of adjustment coefficient, π =1, when prices fully and unbiasedly adjust whereas it will be greater than one, when there is overreaction and less than one, when there is underreaction.

3.3 ARMA Estimator

The study uses ARMA estimator to measure security speed of adjustment coefficient. ARMA estimator can be derived by re-expressing equation 2, after first differencing and rearranging as

$$R_t = (1-\pi)R_{t-1} + \pi\Delta V_t + \Delta u_t$$ **Equation 12**

By substituting for ΔV_t from equation 3, equation 4 becomes,

$$R_t = \pi\mu + (1-\pi)R_{t-1} + \pi e_t + u_t - u_{t-1}$$ **Equation 13**

The autocorrelations induced by underreactions or overreactions are reflected as an ARMA(1,1) process. The price adjustment effects will be contained in the AR(1) coefficient that will suggest estimates of the speed of adjustment coefficient. When adjustment is full, the process will be MA(1) process. It indicates that the 'noise' such as bid/ask bounces, drive the return process. If $|1-\pi| < 1$ i.e. 0< π <2, then AR component is stationary and prices are finite. MA component of high order will capture the effect of non-synchronicities.

4. Results

Present study uses ARMA(1,1) model to examine the security speed of adjustment. The order of one is selected based on Autocorrelation and Partial Autocorrelation Functions. Table 1 presents the results of security speed of adjustment coefficients as given by ARMA (1, 1) model. To assess the speed of adjustment coefficient, mean π is estimated and presented in the table. The results provide insight into the efficiency of the market and the extent to which reactions may depart from full adjustment.

Table 6: Securities Speed of Adjustment Coefficients-ARMA(1,1) model-daily data

Differencing Interval in days	1996-2001	2002-2005
	Mean (π)	Mean (π)
1	0.9421*	0.9245*

2	1.4519*	1.4102*
3	1.0094	1.0258
4	0.8783	1.7026*
5	1.1546	1.2693
6	1.8352*	1.7761*
7	1.2222	1.2567
8	1.8495*	1.8348*
9	1.5158	1.4464*
10	1.2527	1.3764**
11	1.5806*	1.4473*
12	1.3184	1.8898*
13	1.0836	1.4125**
14	1.1017	1.4426**
15	1.6522*	1.4287*
16	1.1701	1.9149*
17	1.2395	1.3804*
18	0.1899*	1.4131*
19	1.5234*	1.3632*
20	0.1984*	1.4679*
21	1.6088*	1.3439**
22	0.1994*	1.3633*
23	1.6952*	1.5959*
24	0.2007*	1.3347*
25	1.6864*	1.4909*
* and **indicate statistically significantly different from 1 at 5% and 10% level		

Table 1 shows very high speed of adjustment to fundamental or intrinsic values. Results suggest neither continuous overreaction nor underreaction. Values of the coefficient of speed of security price adjustment are greater than one for most of the time implying overreactions in the market. During the 1996-2001 period, for the first day return difference interval, mean π is 0.9421. It indicates occurrence of underreaction in the market. On the second day, mean is about 1.4, which is statistically significantly different from one, showing overreaction in prices. For subsequent return differencing, most of the statistically significant values of π at larger differencing interval suggests the presence of overreactions in the market during 1995-2001. For other differencing intervals, the value of π is not statistically different from one, which is defined as full adjustment. During 2002-2007, speed of adjustment coefficients is greater than one for most of the time and is continuous during the period. The speed of adjustment coefficient has increased from the previous period of 1996-2001. It suggests overreactions in the market during the second period. The study finds consistent overreactions in the recent period.

We have also analysed the speed of adjustment coefficient at longer frequency of data i.e. weekly and monthly data during the same subperiods. The results of weekly and monthly data are reported in table 2 and table 3 respectively.

Table 7: Securities Speed of Adjustment Coefficients-ARMA(1,1) model-weekly data

Differencing Interval in days	1996-2001	2002-2005
	Mean (π)	Mean (π)
1	0.9102	0.9737
2	1.4216*	0.4599*
3	0.7871	0.9531
4	0.8297	1.7173*
5	1.0972	0.6776
6	1.7665*	0.6781
7	1.3178	0.5682
8	1.8338*	0.4772
9	1.5742	0.4352
10	1.8630*	0.5842

11	1.5787	0.8052
12	1.8720*	0.3977
13	0.7513	0.3102
14	0.8857	0.3744
15	0.8708	0.3280
16	1.6056*	1.9255*
17	1.6563*	0.4080*
18	1.5027**	0.4555
19	1.0048	0.5332
20	1.5499*	0.6254
21	0.6896	0.4218
22	0.7978	0.4407*
23	1.4592	0.4489*
24	1.9220*	0.3126*
25	1.0635	0.2265*
* and **indicate statistically significantly different from 1 at 5% and 10% level		

Results reported in table 2 suggest that overreactions are observed in the first period whereas in the second period, there are few instances of underreactions. In most of the return differencing interval, the values of speed of adjustment coefficients are not statistically different from one implying full adjustment.

Table 3 reports the results of speed of adjustment coefficients for monthly data. The numbers of return differencing intervals are chosen as 12 for monthly data. The values of π indicates overreactions during quite a few return differencing intervals in the first period whereas second period suggests that there are under and overreactions. There are overreactions in return differencing intervals at 3, 4 and 8 and underreactions are recorded at intervals 2 and 5. Other period values imply that the speeds of adjustment coefficients are not statistically different from one suggesting full adjustment.

Table 8: Securities Speed of Adjustment Coefficients-ARMA(1,1) model-monthly data

Differencing Interval in days	1996-2001	2002-2005
	Mean (π)	Mean (π)
1	1.0406	1.0158
2	1.5579*	0.4107*
3	1.9082*	1.9555*
4	0.2866*	1.7053*
5	1.9095*	0.2713*
6	0.4648	0.5714
7	0.6611	0.4968
8	0.7550	1.9183*
9	1.8882*	0.6367
10	1.4080	1.8595
11	1.8706*	1.0275
12	0.4455	1.0275
* and **indicate statistically significantly different from 1 at 5% and 10% level		

5. Conclusions

The main objective of the study is to analyse the speed of adjustment coefficients using daily, weekly and monthly data of NSE nifty. Based on empirical findings, the following conclusions can be drawn. Firstly, there are significant underreaction and overreaction alongwith full adjustment are observed at both shorter as well as longer differencing intervals during first period i.e. 1996-2001 using daily data. Second period is marked with significant overreactions with higher speed of adjustment coefficient. Second, results based on longer frequency data namely weekly and monthly data with regard to speed of adjustment coefficient indicate less instances of underreactions and overreactions in comparison with daily data, whereas more observations on full adjustment speed are detected.

C. Efficiency Using Event Study Methodology

1. Introduction

Event studies are used in tests of EMH to ask whether prices incorporate information fully on the day that the information is revealed. If EMH holds, the information about the event should be incorporated into prices before or on the day of the event itself. There should be no impact on returns after the event. Typical event studies analyze the impact of a specific event on returns behaviour. Sometimes it is a macro-economic or institutional event at fixed periods or at a given point in time for which we want to understand the impact on returns e.g. the start of electronic trading in India, or the depository; the introduction of derivatives etc.

Charest(1978) assessed NYSE efficiency with respect to selected dividend information from 1947-67 period using event study. The results indicated the persistent inefficiencies in the market. Agrawal and Singh(2002) examined the stock price effects and trading volume patterns for the possible existence of informed trading prior to merger announcement. Event study analysis of forty companies suggested the evidence of insider trading. Using Event study analysis, Susan and Ajay Shah(2001) found that the stock market appeared to be fairly efficient at information processing about the Union Budget.

Subramani and Walden(1999) examined the issue of e-commerce announcements on the market value of firms using event study methodology and assessed the cumulative abnormal returns(CARs) for 305 e-commerce announcements between October and December 1998. The results suggested that e-commerce initiatives announced in this period led to positive CARs for firms.

Green et al(2010) investigated the impact of screen based trading on Mumbai Stock Exchange(BSE) using samples of most liquid shares (A) and less liquid share(B). Using event window of 56 days, the study found the substantial impact of screen based trading on cumulative abnormal return and the BOLT improved BSE’s market micro structure for both A and B shares.

Event study methodology has been used with enormous success in understanding stock market response to events about firms. Event study reveals valuable facts about the bevaiour and decisions of firms under the premise that markets efficiently process information. Most of the studies focused on the information efficiency of stock market by analyzing impact of firm level announcement like earnings and dividends, mergers and acquisitions etc. on firm specific returns. In our case, we are not dealing with firm level data. Our study tries to analyze the impact of potential initiatives and regulations undertaken by NSE(National Stock Exchange) and SEBI(Securities and Exchange Board of India) on the efficiency of S&P CNX Nifty. The Part C is organized as follows. Section 2 discusses research methodology used in the analysis. Results are presented in section 3. Conclusions are drawn in section 4.

2. Research Methodology

2.1 Sample and Period of study

The study uses data on daily closing price of S&P CNX Nifty indices of India from 1st January 1996 to 31st December, 2007. The daily data are obtained from NSE web site(www.nseindia.com). We also referred the web site of SEBI (www.sebi.gov.in) to identify guidelines and regulatory measures taken by it to make stock market efficient.

2.2 Methodology

Daily returns are identified as the difference in the natural logarithm of the closing index value for the two consecutive trading days. It can be presented as:

$$R_t = \log(P_t / P_{t-1}) \text{ or } R_t = \log(P_t) - \log(P_{t-1}) \qquad \textbf{Equation 14}$$

Where R_t is logarithmic daily return at time t. P_{t-1} and P_t are daily prices of an asset at two successive days, t-1 and t respectively. We consider daily mean square returns of index as a measure of volatility.

Since we are not using firm level data, standard event study methodology using market model is not relevant. However, we do use the key insight of the event study methodology-that of defining t=0 as the event data, and focusing on mean behavior (across all events) before and after event.

In a perfectly efficient market, markets process information very fast. New information only generates volatility. We try to test following hypothesis using event study methodology.

H_1: If markets are strong form efficient, most information will be incorporated in prices prior to respective regulatory measures and initiatives.

If this hypothesis is valid, it will suggest that the substantial information processing will take place prior to event. The stock return will be statistically significant before the event but not after the event.

3. Results

We considered following important initiatives and regulatory measures taken by NSE and SEBI to make market efficient. They are presented in Table 1 below.

Table 9: Important Initiatives and Regulatory Measures

Sr. No	Measure	Date
1	Setting up of National Securities Depository Limited, first depository in India, co-promoted by NSE	Nov, 1996
2	Commencement of trading/settlement in dematerialized securities	Dec, 1996
3	Commencement of trading/settlement in dematerialized securities	Dec, 1996
4	Commencement of Internet Trading	Feb, 2000
5	Launch of NSE's electronic interface for listed companies	August, 2004
6	Securities and Exchange Board of India (Depositories and Participants) Regulations, 1996	May 16, 1996
7	SEBI (Mutual Funds) Regulations, 1996	December 09, 1996
8	Buy back of securities Regulations	Nov 14,1998
9	SEBI (Credit Rating Agencies) Regulations, 1999	Jul 07, 1999
10	Disclosure and investor protection guidelines 2000	Feb 14, 2000
11	Securities And Exchange Board Of India (Depositories And Participants)(Amendment) Regulations 2004	Sep 2, 2003
12	SEBI(Prohibition of Fraudulent and Unfair Trade Practices relating to Securities market) Regulations, 2003	July, 17, 2003

Event study requires the exact date to specify the event window. This will help to analyze correctly the impact of those initiatives on efficiency of the stock market. Since for the first six measures, no record with respect to specific dates are available.

Milestone on NSE web site does not mention the date on which the respective measures were implemented. We cannot proceed to apply event window analysis for the first six measures. We, therefore, endeavor to analyze the impact of remaining five measures taken by SEBI on the efficiency of NSE.

The most important issue is the length of the event window used in the event study. Many management studies used long event window. Brown and Warner(1990, 1985) mentioned that long event window reduced the power of the test statistics which led to false inference about the significance of an event. Second problem with long event window is that it is much more difficult to control for confounding effect. Therefore, Mcwilliams and Siegel(1997) suggested that the length should be as short as possible in event window analysis. Most of the studies used market model in event window analysis. There are no specific guidelines on the length of event window. We focus on the behavior of the equity index for a window of 45 trading days as considered by Susan and Shan(2002).

Table 10: Return of index time series

Sr.	Event	Date	All days	45 days	
			Mean Return	Before the event	After the event
1	Securities and Exchange Board of India (Depositories and Participants) Regulations, 1996	May 16, 1996	0.0606*	0.39	0.01
2	SEBI (Mutual Funds) Regulations, 1996	Dec 09, 1996	0.0606*	-0.5*	0.49
3	Buy back of securities Regulations	Nov 14,1998	0.0606*	-0.15	0.06
4	SEBI (Credit Rating Agencies) Regulations, 1999	Jul 07, 1999	0.0606*	0.46	-0.10
5	Disclosure and investor protection guidelines 2000	Feb 14, 2000	0.0606*	0.32	-0.46
6	SEBI(Prohibition of fraudulent and Unfair	July, 17,	0.0606*	0.46*	0.33

	Trade Practices relating to Securities market) Regulations, 2003	2003			
7	Securities And Exchange Board Of India (Depositories And Participants)(Amendment) Regulations 2004	Sep 2, 2003	0.0606*	0.45*	0.47

We can see from Table 1 that there is no significant difference in mean returns before and after the events before year 2000 consisting of various regulatory measures taken by SEBI. It suggests that market has not processed the information and the information has not been reflected in stock prices prior to the events. The results of the other two measures initiated by SEBI in recent times after year 2000 indicate that there is an increase in stock returns from day -45 till the date for the last two regulatory measures. From date 0 to date +45, the stock returns are not statistically significantly different from zero. This suggests that substantial information processing is taking place prior to the measures. This is in line with our hypothesis H_1.

4. Conclusion

Efficiency of Indian stock market is fairly important amidst the various regulatory measures and initiatives taken by SEBI and NSE respectively. Our results find that the NSE nifty appears to be efficient at information processing about the regulatory measures initiated by SEBI in recent times. The stock returns are statistically significant before the regulatory measures of SEBI suggesting that information are impounded into stock prices while returns are not statistically different from zero after the measures. This indicates stock markets during recent times becomes fairly faster in processing information. The statistically insignificant returns during the regulatory measures on or before year 2000 may be due to the fact that the stock market was in the beginning phase. It has started the process of modernization and development thereafter. It, therefore, may not be able to process information faster. While in recent period, the market witnessed major development in terms of the introduction of internet trading, derivatives etc. These make the information processing faster and are reflected in prices.

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