MARKET EFFICIENCY AND INTEGRATION: AN EXAMINATION OF INDIAN STOCK MARKET

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Abstract

This paper examines the efficiency and integration of the Indian stock market. The weak form of efficiency has been tested by studying the stationarity characteristics of the MSCI Stock Price Index of India. For testing the semi-strong form of efficiency and integration of the Indian Stock Market with the macro phenomenon of emerging stock markets of the world, the causality between the MSCI Stock Price Index of India and the MSCI EMF Index has been studied. The results point out that the Indian Stock Market is efficient in its weak sense. However, the same is not true for the semi-strong form of market efficiency. Therefore, the utility of a forecasting model having the macro phenomenon (MSCI EMF Index in the present case) as a forecasting variable cannot be ruled out.

1. Introduction

Transcending time is no longer the sole concern of people seeking spiritual progress. The 'time-transcendence' principle seems to have seeped into the more mundane. The more we read about the stock markets being efficient, the more convinced we become about the general consensus about efficiency that even in the weakest form of its efficiency the stock market leaves little room for analyzing the past to predict the future. Two out of three dimensions of time would be rendered quite futile if the current stock prices are supposed to reflect all the information that is contained in the history of prices and volumes. As such, the past would be utterly futile in predicting the future. In other words, even a weakly efficient stock market would be beyond time. Kendall (1953) has indeed, among others, notes that there is no predictable pattern in stock prices; stock prices behave randomly irrespective of what has happened in the past.

Stock market efficiency has remained an issue that raises continuous debate in financial literature as is evident from Fama (1970), Haugen (1997) and Huber (1997). For the sake of ease in comparison, stock market efficiency has been classified into three types, depending upon the type of information represented by each one of them: the set of historical price information, the remaining publicly available information and the 'inside' information. It is from these three information subsets, that the three degrees of efficiency have evolved namely; weak, semi-strong and strong. The weak form of market efficiency hypothesis postulates that present prices fully reflect information content of the price sequences in the past. The semi-strong form of the efficient market hypothesis contends that prices should reflect all the public information, and in its strongest form of efficiency, all the information, both public and non-public, is considered to be incorporated in the current prices. It follows that in order to be efficient in the semi-strong or strong form, the market must be efficient in its weak form.

The efficiency hypothesis rests on the presumption of a rapid information processing mechanism which would deny the market participants an opportunity of earning an abnormal return on a consistent basis because the changes in price would be serially uncorrelated and would follow a 'random walk'.

One way of testing the 'random walk model (RWM)' is through the application of the Augmented Dickey Fuller Test (ADF), which tests for the presence of unit root in a time series and the Autocorrelation functions (ACF), which determine whether the first differences of a series indicate white noise. For a purely white noise series, the autocorrelations at different lags would stay close to zero, indicating stationarity. Time series econometrics postulates that the presence of a unit root is indicative of non-stationarity in the series. The terms non-stationarity, unit root and random walk are treated synonymous.

Vaidyanathan and Gali (1994) have tested the weak form of market efficiency in the Indian Capital Market. They have computed 208 autocorrelation functions, out of which only 19 are found significant, providing support to the weak form of efficiency. Martin Laurence, Francis Cai and Sun Qian (1997) have examined the weak form efficiency and causality in Chinese stock markets by using Unit root test and autocorrelation functions. They conclude that market for "A" shares is weakly efficient but not the market for "B" shares. Ramasastri (1999) has used unit roots to test the market efficiency in India and finds that the hypothesis of random walk in the Indian stock market can not be rejected. Kleiman, Payne and Sahu (2002) have studied the random walk hypothesis by using stock market indices of real estate share prices for three geographical regions: Europe, Asia and North America. The Augmented Dickey-Fuller and Phillips-Perron unit root tests determine that each of these markets (as well as associated broader stock markets) exhibit random walk behavior. Similar findings have also been reported by Nassir (1991) in his results on the efficient market hypothesis in the Kuala Lumpur Stock Exchange.

It can be deduced, therefore, that unless the movements in a stock market were to respond to the movements in a more broadly defined market proxy and / or other informatory variables, there would exist no scope for earning super-normal profits and the market would be efficient. If, however, the causation is reverse, such integration would come at cross-roads with the tenets of market efficiency. Examining such integration would, in a way, investigate the semi-strong form of market efficiency. In the past, market integration has been studied by using correlation coefficients between two markets. A high coefficient of correlation has been used as a supporting proof for market integration. One such study in the context is that by Uri and Rifkin (1985) on geographic markets, causality and railroad deregulation. However, the presence of autocorrelation and /or non-stationarity may dilute the utility of using simple correlation coefficients as indicators of integration. Granger and Newbold (1974) point out that if two variables were integrated of the order 1 [I(1)], - that is, they become stationary after first differencing, the basic assumptions of the ordinary least square estimation would be violated and the correlation would be spurious. Johansen (1988) suggests a procedure for determining the number of co-integrating vectors that could accommodate more than two variables in the system.

The point regarding the market as a processor of information has been made earlier. The speed of such processing determines the efficiency of the market. This would, however be true only in case of a uni-directional causality, where the stock market explains the macro phenomenon. In case, the causality is the other way round, the ability of the market as a rational processor of information is questionable and the market would prove to be inefficient in that case because then it would be possible to derive meaningful forecasts for earning more than normal returns. The findings of Huang and Kracaw (1984) support this argument. The concept of causality is important as a mere relationship between two variables does not indicate the direction of influence. Something similar is emphasized by Gary Koop (2002). According to him, "*...time does not run backward. That is, if event A happens before event B, then it is possible that A is causing B. However, it is not possible that B is causing A. In other words, events in the past can cause events to happen today. Future events can not.*"

If the direction of causality indicates that the stock market is inefficient, the nature of cause-effect can be profitably studied to develop a forecast. Specifically, an attempt can be made to determine how the market is related to the explanatory factor; in a linear or non-linear fashion.

Here we examine the issue of efficiency in the Indian stock market. The data for this purpose constitute the Indian stock price index and the Emerging Markets Free Index (EMF index hereafter), both published by the Morgan Stanley Capital International (MSCI hereafter). The MSCI Price Index for India measures the market price performance. The index measures the sum of the free float-weighted market capitalization returns of all its constituents on a given day. The MSCI EMF Index is a free float-adjusted market capitalization index that is designed to measure equity market performance in the global emerging markets. As of April 2002 it consisted of the following 26 emerging market country indices: Argentina, Brazil, Chile, China, Colombia, Czech Republic, Egypt, Hungary, India, Indonesia, Israel, Jordan, Korea, Malaysia, Mexico, Morocco, Pakistan, Peru, Philippines, Poland, Russia, South Africa, Taiwan, Thailand, Turkey and Venezuela.

The paper is intended to address the issue of market efficiency in the emerging markets of South-East. Obaidullah (1994) in his work on Internationalization of Equity Portfolios observes that the benefits of including countries like India followed by Thailand and the Taiwanese markets are "too immense and clear cut to be ignored". The choice of the India as a market for this paper has been prompted by this finding. Also, only a few studies have been carried out on stock market integration in the Indian context. Amanulla and Kamaiah (1995) have studied the market integration in India as a possible alternative to test market efficiency. Jha and Nagaranjan (1999) have also made an attempt on similar lines but their focus is on short run dynamics. The emphasis has been largely the inter-exchange integration within the country or the high frequency data pertaining to some of the stocks traded on an exchange for a short period. In this paper, we intend to explore the efficiency of the Indian stock market taken in totality and to see if the market responds to a proxy with a broader gamut. Since India belongs to one of the major emerging markets of South-East Asia, the causal nature has to be examined against a larger entity. The EMF index provides the larger picture. The monthly data for both indices from February 1999 to May 2003 have been used for this paper.

The paper is arranged section wise. Section 2 presents the descriptive characteristics of the time series under study to see whether the data needs to be transformed for further analysis. Specifically, the series is examined for normality. Though the series should be checked for stationarity as well, this exercise has been been postponed till section 3, where the stationarity check also reveals the randomness of movement in the stock price index of India. In Section 3, the findings regarding the testing of weak form of market efficiency in India are reported. Section 4 determines the direction of causality between the Indian Stock Price Index and the EMF Index. Section 5 studies the co-integration between the Stock price index of India and the EMF index leading to the study of cause-effect relationship in section 6. Section 7 concludes the paper.

2. Normality Check

The purpose of this section is to look into the descriptive statistics of both the stock price index for India and the EMF index. This is necessary to make sure that both time series can be used for classical normal linear regression (CNLRM), which is applied for determining the cause and effect relationship.

One of the prime assumptions of the CNLRM is that each disturbance term u_i is distributed normally with mean, E $(u_i) = 0$, variance E [$u_i - E(u_i)] = ó^2$ and $i \neq j$ the covariance $(u_i, u_j) = 0$ *and* $i \neq j$. This assumption has to hold good especially in the case of small samples in order to lend credibility to the *t* and *F tests*.

The normality of the series under consideration has been checked by computing the higher moments (along with their *z statistic*) of a normal distribution, namely the coefficient of skewness (s) and kurtosis (k). The condition of normality is satisfied if the coefficient of skewness is 0 (close to 0) and the coefficient of kurtosis is 3 (close to 3). The *z statistic* of skewness is given by;

$$Z_{skewness} = \frac{skewness}{\sqrt{\frac{6}{n}}} \quad \text{where, } n \text{ is the sample size} \qquad (1)$$

For kurtosis the *z statistic* is obtained by;

$$Z_{kurtosis} = \frac{kurtosis}{\sqrt{\frac{24}{n}}} \quad \text{where, } n \text{ is the sample size} \qquad (2)$$

For a distribution to be normal, the calculated value of the *z statistic* should exceed the critical value of *z*. For instance, calculated values of (+/-) 2.58 and (+/-) 1.96 indicate that we can reject the normality assumption at 1% and 5% probability levels.

The (JB) Jarque-Bera and the A^2 (Anderson-Darling) tests help solve the same purpose. The JB test of normality is a test of joint hypothesis that s = 0 and k = 3. In such a case, the value of JB statistic is expected to be zero.

The JB statistic is given by;

$$B = n\left[\frac{s^2}{6} + \frac{(k-3)^2}{24}\right] \tag{3}$$

If the p value of the JB statistic is sufficiently low (indicating that the value of the statistic is quite different from 0), the null hypothesis of normality can be rejected and vice-versa. The utility of the JB statistic may be slightly limited in small samples (fewer than 30 observations).The sample chosen for the present study contains 52 monthly observations, which is above that threshold level, but barely. As such, the results may be interpreted a bit conservatively. A visual inspection of the histogram of the series range may come in quite handy in such cases.

The A^2 statistic also tests the underlying null hypothesis of normality. A low p value for the computed A^2 statistic leads to the rejection of the null hypothesis and vice-versa.

From Exhibits 2.1 and 2.2, it is evident that the original time series for the stock price index of India does not fulfill the normality condition, whereas the series obtained after first differencing the original series almost satisfies the normality criterion except the *z statistic* value, which, though it declines from 6.60 to 4.96 does not fall enough to meet the recommended value of 3. However, on the whole, the first difference series is a fair evidence of a normal series. An almost similar picture emerges when we examine the histogram, the JB statistic, the A^2 statistic and the *z statistics* for skewness and kurtosis for the original and the first difference series of the EMF index (Exhibits 2.3 and 2.4 respectively).

The results for normality examination indicate that the first difference series are by and large normal in nature and can be used for further analysis.

Another condition that the data must satisfy is the stationarity of the series because if the time series is not stationary, it is not possible to generalize the findings of one time period to another period. In such a case, a forecast may be of little practical significance. Non-stationarity is also a condition for market efficiency in the weak form or random walk. The following section checks both time series under study for stationarity by testing for the presence of unit roots. Therefore, the unit root test serves two purposes in the context of this paper; i) to determine the sationarity of the time series and to transform a non-stationary series to make it stationary for subsequent analysis, and ii) to determine whether the Indian stock price index exhibits a random walk.

3. Is Past Relevant?

A stationary stochastic process means that its mean and variance are constant over time and the covariance between two time periods is dependent only on the lag between them.

If Y_t is a stochastic process, then it is considered to be stationary if:

Mean $E(Y_t) = \mu$

Variance $var(Y_t) = E(Y_t - \mu)^2 = \sigma^2$

Covariance $\gamma_k = E[(Y_t - \mu)(Y_{t+k} - \mu)]$

where, γ_k is the covariance at lag k between Y_t and Y_{t+k}

3.1. *The Autocorrelation Function*

If a time series does not show the above characteristics, it is said to be non-stationary. As mentioned earlier, the stationarity of the time series is important for the forecasts to have some pragmatic meaning. It follows that when a series is non-stationary and consequently, no meaningful forecasts can be drawn, the behavior of the series in question is considered random and it would then indicate market efficiency. The random walk model dries up all possibilities of a consistently superior return from the market.

We have tested the stationarity characteristics of both the Indian stock price index and the EMF index by *first* using the simple Autocorrelation function (ACF) for 24 lags. According to Gujarati (2003), "A rule of thumb is to compute up to one-third to one-quarter the length of the time series." The ACF has been plotted against these 24 lags to obtain a Correlogram. The ACF at lag k is obtained by;

$$\rho_k = \frac{\hat{\gamma}_k}{\hat{\gamma}_0} \quad (4)$$

where,

$\hat{\rho}_k$ = sample Autocorrelation function
$\hat{\gamma}_k$ = sample Covariance at lag k
$\hat{\gamma}_0$ = sample variance

A plot of the sample ACF against the lag k is the sample correlogram. E-views generates a correlogram the ACF and PACF (Partial autocorrelation function). The dotted line in the plot indicates two standard error limit, which is obtained by $\frac{\pm 2}{\sqrt{n}}$ where n is the sample size. An ACF lying within this limit is not statistically different from zero at 5% significance level. In order to test the *joint* hypothesis that all $\hat{\rho}_k$ up to a given lag are simultaneously not statistically different from zero, the Ljung-Box *Q statistic* is computed by E-views which is of considerable importance in small samples. *Q statistic* is defined as;

$$LB = n(n+2) \sum_{k=1}^{m} \left(\frac{\hat{\rho}_k^{\ 2}}{n-k} \right) \approx c^2 m \tag{5}$$

The LB *Q statistic* follows the chi-square distribution with m degrees of freedom. If the computed value of *Q statistic* exceeds the critical *Q* value from the chi-square distribution at the selected significance level, the null hypothesis of all $\hat{r}_k$ being zero can be rejected.

Table 3.1 shows the corrleogram of the Indian stock price index. It can be observed that the autocorrelation coefficients for lags closer to the present time period are very high and decline steadily till the 12th lag. From 13th lag onwards they start increasing on the negative side. The *Q statistic* for up to 24th lag is 220.3 but the probability of obtaining this value under the null hypothesis that the sum of 24 squared sample ACFs is zero, is zero. It can be inferred, therefore, that the Indian stock price index is a non-stationary time series. When we examine the correlogram of the first difference of the series in Table 3.2, it indicates the presence of only white noise as the autocorrelation coefficients never quite depart from zero significantly. The value of *Q statistic* is 26.29. The probability associated with this value is around 34% which, though not very high, indicates that the first difference of the time series are stationary when combined with the observation that only the autocorrelation coefficients at lags 6, 8 and 11 manage to cross the dotted line and that too, barely. Further, there is a clear visual evidence of absence of any pattern in their occurrence. It points out towards the series containing one unit root. This is typically true of a random walk series. Therefore, the Stock price index of India seems to follow a random walk and the stock market may be understood to be efficient in its weak sense.

The correlogram for the EMF index in Table 3.3 shows almost an identical pattern as that of the stock price index of India. The autocorrelation coefficients begin high and decline slowly till lag 12 after which they move over to the negative side. The *Q statistic* is 213 and the associated probability is zero, leading to the conclusion that the series is non-stationary. The correlogram obtained after first differencing the series for EMF index is shown in Table 3.4. When compared to the first difference series of the Indian stock price index, it provides much more forthcoming evidence that the series should be I (1) as the autocorrelation coefficients stay close to zero for all the 24 lags. Probability of achieving the *Q statistic* of 15.976 for up to 24 lags under the null hypothesis of zero simultaneous correlations at all lags is about 89%. In the market efficiency sense, therefore, the time series for EMF index also seems to follow a random walk and is non-stationary in nature.

The time plots for the both time series are presented in Exhibit 3.1 and Exhibit 3.2. It can be observed that the first difference series for both the EMF index as well as the stock price index of India have a tendency to return back to their mean whenever there is an away movement from their mean values of 0.41 and *(0.029)* respectively indicating that stationarity is achieved after first differencing.

3.2 *The Unit Root Test*

Since the primary objective of this section is to test for randomness in the Indian stock market, the observations from section 3.1 are tested by a formal test for unit roots in the time series for the stock price index of India. One such formal test for stationarity is the Unit Root Test given by Dickey and Fuller (1979). To begin with, if we consider the simple random walk Model, which is an AR (1) process, it would look like;

$$Y_t = \rho Y_{t-1} + u_t \qquad -1 \leq r \leq 1 \qquad (6)$$

where, u_t is a white noise error term or a random shock which has zero mean, constant variance and is serially uncorrelated.

A unit root would be present if $\rho = 1$. This would be a model for random walk without drift. In a drift-less random walk model, the mean of Y is equal to its value in the beginning (that is, it is constant) but with the passage of time t, there is an indefinite increase in its variance, which violates a stationarity condition.

As has been noted earlier, u_t is a white noise error term. It is, therefore, stationary. It implies that the first difference of a random walk time series is stationary, which has already been observed in the correlograms and time plots of both the index series.

Unlike the random walk model without drift, if both the mean and variance of the series increase over time, it becomes a random walk with drift. It simply means that Y_t drifts upwards or downwards depending on the direction of change in the *drift parameter* represented as d. Thus, a random walk with drift would be;

$$Y_t = \delta + Y_{t-1} + u_t \tag{7}$$

It follows that depending on whether the time series are stationary or non-stationary, the trend in them would either be deterministic or stochastic. If a random walk model is considered having a drift around a trend, it would contain the time element *t* as well. In a random walk model with drift around a trend,

$$Y_t = \beta_1 + \beta_2 t + Y_{t-1} + u_t \tag{8}$$

In this paper, we have tested for unit roots by using the Augmented Dickey Fuller Test (ADF test). In the ADF test, the null hypothesis is that $\delta = 0$, where $\delta = (\tilde{n}-1)$. In other words, the hypothesis to be tested is that there exists a unit root and the time series is non-stationary. The alternative hypothesis is that $\delta < 0$ implying stationarity of the time series. The alternative hypothesis is kept one-tailed as a value of $\delta > 0$ would make a time series explosive. The ADF test considers all three possibilities of the random walk with and without drift and around a stochastic trend. In order to account for a higher order correlation, it adds lagged difference terms of the dependent variable *Y* to the right hand side of the following regression:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-1} + \varepsilon_i \tag{9}$$

A simple way of determining the lag length is to use the *Akaike information criterion* or the *Schwarz Bayesian criterion.*

The *Akaike information criterion* is defined by;

AIC = n [Log (residual sum of squares of equation 9)] + 2k,* (10)

The *Schwarz Bayesian criterion* is given by;

SBC = n [Log (residual sum of squares of equation 9)] + k log n* (11)

Both in *AIC and SBC*, *k* is the number of parameters estimated and *n** is the number of usable observations.

In the ADF test regression equation, $\mathring{a}_i$ is a pure white noise error term. In the present paper, the ADF test has been done by first taking only one lagged difference term. At lag 1, the *Akaike and Schwarz information criteria* are 7.60 and 7.75 for the level series of the Stock Price Index of India

(Table 3.5). For the first difference series, both information criteria rise slightly to 7.76 and 7.92 respectively (Table 3.6). Following the general rule of thumb to include lags up to one-quarter the series length, we conduct the ADF test on the first difference series for 13 lags. It is observed that both information criteria fall to 7.05 and 7.75 respectively (Table 3.7), thus showing that a lag length of 13 is a better choice than only a single lag.

The ADF test has not been applied on the EMF index series, as the objective is primarily to test for randomness in the Indian stock market only. However, the autocorrelation functions and the time plots for EMF index provide evidence that the series is non-stationary. Since it becomes stationary after first differencing, it has one unit root.

It can be seen from Table 3.5 that the computed value of the ADF test statistic for the level series of stock price index of India at lag 1 is -2.911624. This value is below the *critical value of MacKinnon's t (tau) statistic* at 1%, 5% and 10% levels of significance. As such, the times series contains a unit root. The fact is supported by the computed *F statistic* for the regression (3.385642). The 1% and 5% *critical F values* for the ADF test are 7.02 and 5.13 respectively for a sample size of 50. As the computed *F statistic* is less than the critical value, it points towards the presence of a unit root.

Table 3.6 presents the results of the ADF test for the first difference series of the stock price index of India. The computed value of the statistic is -4.74 which exceeds the *critical value of MacKinnon's τ (tau) statistic at 1% significance level*. It indicates the absence of unit root from the first difference series. The *F statistic* indicates the same. Therefore, stationarity is obtained after first differencing the level series and the series is integrated of the order 1. As noted earlier, the first difference of a random walk series is stationary. Table 3.5 points out a random walk in the behavior of the stock price index of India and Table 3.6 confirms that.

The test in Table 3.6 has been extended to include 13 lag terms to possibly adjust the effect of moving average component in the series and the results appear in Table 3.7. As expected, the test seems better, indicated by the fall in the value of the *Akaike and Schwarz information criteria* and a rise in the ADF statistic to -5.129.

It can be concluded therefore, that the Indian stock market appears to be efficient in its weak sense as indicated by the stationarity tests. As we mentioned in the introductory discussion, in order for the market to be efficient in the semi-strong and strong sense, it must be efficient in the weak sense. The weak form efficiency has just been established. To determine the market efficiency at higher levels, it must be known whether there is any causality between the stock price index of India and the more macro phenomenon, the EMF index in this case. Also, the direction of causality will matter in deciding the efficiency issue. In case of uni-directional causality from the EMF index to the Stock Price Index of India, the Indian stock market will not be considered as efficient in its semi-strong sense and forecasts could be developed profitably.

4. The Direction of Causation

In order to establish causation and its direction, we have used the Granger's causality test (1969). The test strives to answer the question whether *x* causes *y* and to determine how much of the current *y* can be explained by past values of *x*. It goes further to find out whether adding lagged values of *x* can improve the explanation. *y* is said to be 'Granger-caused' by *x* if *x* helps in the prediction of *y*. In other words, *x* would 'Granger cause' *y*, if the coefficients of the lagged *x values* are statistically significant. If the reverse is true, then *x* is 'Granger caused' by *y*. In case of bilateral causality, both *x* and *y* 'Granger cause' each other.

The phrase that *x* or *y* 'Granger cause' each other does not imply that they are the effects of each other. Granger causality only measures *precedence* but by itself it does not indicate causality in the more common use of the term.

For determining from *x to y*, two bivariate regressions are run as follows:

Unrestricted: $$y_t = \hat{a}_0 + \hat{a}_1 x_{t-1} + \hat{a}_2 x_{t-2} + \ldots\ldots + \hat{a}_n x_{t-n} \quad (12)$$

Restricted: $$y_t = \hat{a}_0 + \hat{a}_1 y_{t-1} + \hat{a}_2 y_{t-2} + \ldots\ldots + \hat{a}_n y_{t-n} \quad (13)$$

Similarly, reverse causation from *y to x* is determined by the following two bivariate regressions:

Unrestricted: $$x_t = \hat{a}_0 + \hat{a}_1 x_{t-1} + \hat{a}_2 x_{t-2} + \ldots\ldots + \hat{a}_n x_{t-n} \quad (14)$$

Restricted: $$x_t = \hat{a}_0 + \hat{a}_1 x_{t-1} + \hat{a}_2 x_{t-2} + \ldots\ldots + \hat{a}_n x_{t-n} \quad (15)$$

The null hypothesis is that *x* does not Granger cause *y* in the first regression and *y* does not cause *x* in the second regression, which is tested by the *F statistic*.

Since Granger causality test is very sensitive to lag length, it has been tested at varying lag lengths in this paper till some reasonably definite conclusion is reached. The errors in the original time series are autocorrelated as indicated by their stationarity characteristics. Therefore, the first difference series for the EMF index as well as the stock price index of India, have been used for the causality test.

Perusal of Table 4.1 indicates uni-directional causality from EMF Index to the Stock Price Index of India. Though there are hints of such causality for smaller lags, the *F statistic* does not assume conclusive significance for either null hypothesis at lags 2 and 4. In fact, at lag 4, the significance of the *F statistic* seems to drop off from that at lag 2. However, at lags 8 and 16, the significance of the *F statistic* increases for the null hypothesis that EMF Index does not Granger cause the Stock Price Index of India.

In conclusion, a uni-directional causality is apparent since the null hypothesis that the Stock Price Index of India does not Granger cause the EMF Index can not be rejected. The second null hypothesis that EMF Index does not cause the Stock Price Index of India is rejected at higher lags. Therefore, the direction of causality is that EMF/Index Stock Price Index of India. This finding indicates towards the fact that perhaps, the Indian stock market is not very efficient in processing information in the semi-strong sense. The implication is that forecasting could be beneficial gainful, at least when the basis for forecasting is the EMF Index. Section 6 is devoted to a forecasting effort.

However, since the original series are both I(1), a regression forecast may be spurious unless their linear combination is I(0). In other words, the regression results of two non-stationary series would be meaningful only if they are co-integrated. Such a regression would be called the co-integrating regression. The following section evaluates this possibility.

5. Cointegration of Time Series Under Study

In order to test whether the time series of Stock Price Index of India is co-integrated with the time series of EMF Index, two simple methods have been used. They are; 1) The Augmented Engle-Granger Test (1987) and 2) The Co-integrating Regression Durbin-Watson Test .

5.1 *The Augmented Engle-Granger (AEG)Test*

The AEG test regresses the two non-stationary series and runs a unit root test on the residuals obtained from such regression. In case, there is no unit root, it can be concluded that the residuals from the regression are I(0) or stationary. The stationarity of residuals indicates that there is a co-integrating regression and that it is not spurious even if the individual series are non-stationary.

We have performed the AEG test by regressing the EMF Index series on the series for Stock Price Index of India. The results are presented in Table

5.1. The residuals (u_t) from this regression have been put to the Dickey-Fuller (DF) unit root test to check the stationarity of residuals. For the DF test, the following two test equations have been used:

u_t is a random walk: $\Delta u_t = \beta_1 + \beta_1 u_{t-1}$
u_t is a random walk with drift: $\Delta u_t = \beta_1 + \beta_2 t + \delta u_{t-1}$

The unit root results are shown in Table 5.2 and 5.3 respectively for each test equation. Since the *DF statistic* is significant at the 5% level, we conclude that the residuals do not have a unit root and are stationary implying thereby that the liner combination of the EMF Index and the Stock Price Index of India is stationary and the resulting regression is a co-integrating regression.

5.2 *The Co-Integrating Regression Durbin-Watson Test (CRDW)*
Under this method, the *d statistic* obtained from the regression in Table 5.1 is tested for the null hypothesis that *d=0* unlike the usual hypothesis of *d=2*. The 1%, 5% and 10% critical values for this purpose are 0.511, 0.386 and 0.322 respectively. These critical values are provided by Sargan and Bhargava (1983). Since the computed *d statistic* of 0.796 is above the 1% critical value, we conclude that the series for EMF Index and Stock Price Index of India are co-integrated.

Both the tests in sections 5.1 and 5.2 indicate that though the individual series show a random walk, there is perhaps a stable and long term relationship between them. This is a strong motivation for establishing a forecasting model for the Indian stock market. A few alternative forecasting models are compared in section 6.

6. The Nature of Cause and Effect: Alternative Forecasting Models

We begin with the simple linear regression model presented in Table 5.1. The model comes up with an encouraging R^2 of 0.82. However, the *d statistic* is 0.796 indicating that the results may be contaminated by positive serial correlation amongst the residuals. Therefore, correction methods are looked into.

6.1 *First Difference Model*
One way of correcting autocorrelation is the first-difference method, especially when $d < R^2$. It can be seen from Table 5.1 that this is actually the case. The simple linear regression between the first difference series of the EMF Index and the Stock Price Index of India is presented in Table 6.1. The prob-

lem of autocorrelation is solved as indicated by the *d statistic* of 2.22. However, since the R^2 goes down to 0.27, it prompts a search for a possibility of something better.

6.2 *The Cochrane-Orcutt Procedure*

The iterative technique called the Cochrane-Orcutt procedure is considered for an improved model, which consists of obtaining the residuals u_t from the OLS estimation. The residuals serve as the starting point. On the residuals thus obtained by the regression:

$$u_t = \rho u_{t-1} + \varepsilon_t \qquad (16)$$

The estimated ρ from the above regression is used to obtain:

$$y_t - \rho y_{t-1} = \beta_1 (1 - \rho) + \beta_2 (x_{2t} - \rho x_{2t-1}) + \ldots\ldots + \beta_k (x_{kt} - \rho x_{kt-1}) + (u_t - \rho u_{-1}) \qquad (17)$$

The parameter estimates obtained from the above regression are substituted in the OLS estimation equation, which yields a fresh set of residual terms. Another regression is run on the residuals and the procedure begins again to continue up to the n^{th} *iteration* if $\rho^n - \rho^{n-1} < \delta$, where δ is a small predetermined value.

Table 6.2 presents the results of the Cochrane-Orcutt estimation on the first difference of the EMF Index and the Stock Price Index of India, by retaining the first observation *a la Prais-Winsten*. The model improves slightly as compared to the simple linear regression presented in Table 6.1 in terms of a marginal increase in the R^2. The adjusted R^2 in fact falls slightly. The Root Mean square errors are almost identical and there does not seem much to choose from between the model in Table 6.1 and Table 6.2.

Therefore, we turn the attention back to the basic model in Table 5.1. Since the regression is not spurious due to co-integrating series (as noted earlier), the Cochrane-Orcutt procedure is applied on the original series of both variables to see if the model improves after tackling the autocorrelation. The results of the exercise are shown in Table 6.3 and *it seems* that the purpose is best served by keeping things simple and straightforward. The R^2 improves from 0.829 in Table 5.1 to 0.89 in Table 6.3. The serial correlation is accounted for too as the revised *d statistic* is 1.92 in Table 6.3 as compared to 0.796 in Table 5.1. The *standard error of regression* comes down from 10.65 to 8.61. The comparison between the actual and forecasted values of Stock Price Index of India is shown in Exhibit 6.1. Obviously, the forecast follows the actual quite closely. However, even if the regression is not spurious, the regressor and the regrass and do not satisfy the normality assumption, which is so essential in finite, small samples (Exhibits 2.1 and 2.2). Therefore, it is preferred to retain the forecasted results of Table 6.1 and Table 6.2. It must be noted, however, that the EMF Index is only one element in a larger information set which affect market behavior and therefore, a R^2 of around 30% may be considered of value. The visual comparison of actual and forecasted values (of first difference series) can be seen in Exhibit 6.2.

7. Conclusions

The study was undertaken to test the efficiency and integration of the Indian Stock market to find out the level of efficiency in the market and to see whether the Indian stock market is integrated with the emerging stock markets of the world. The proxy for the Indian market was the MSCI Price index and the emerging stock markets were considered by using the MSCI EMF Index. Specifically, the intention was to study whether any gainful forecasting can be done in the context of the Indian stock market. The conclusions drawn are: *First,* the Indian stock market is efficient in its weak sense as it seems to follow a random walk. *Second,* there exists causality between the MSCI Price Index of India and the MSCI EMF Index. *Third,* the direction of causality is uni-directional from the MSCI EMF Index to the MSCI Price Index of India, indicating that the Indian stock market is not efficient in the semi-strong sense. *Fourth,* due to the inefficiency of the Indian stock market in the semi-strong sense, publicly available information (the MSCI EMF index in this study), can be utilized to construct meaningful forecasts and there may be a possibility to earn superior returns. *Fifth,* the simple linear regression model seemed to yield a reasonable forecast after having been tested for normality and stationarity of the series and adjusting the autocorrelation.

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ANNEXURE 1:
LIST OF TABLES

TABLE No.	TABLE TITLE
3.1	Correlogram of the Indian Stock Price Index
3.2	Correlogram of the First difference of Indian Stock Price Index
3.3	Correlogram of the EMF index series
3.4	Correlogram of the First Difference of the EMF index series
3.5	Augmented Dickey-Fuller Test for stock price index of India at lag 1
3.6	Augmented Dickey-Fuller Test for First difference stock price index of India at lag 1
3.7	Augmented Dickey-Fuller Test for First difference stock price index of India at lag 13
4.1	Pair-wise Granger Causality Tests between the First Difference series of stock price of India and the EMF Index
5.1	Simple Linear Regression of EMF Index on Stock Price Index of India
5.2	DF Unit Root Test on the residuals of regression of EMF Index on the stock price index of India (constant)
5.3	DF Unit Root Test on the residuals of regression of EMF Index on the stock price index of India (constant and trend)
6.1	Simple Linear Regression between the first Difference series of EMF Index and the Stock Price Index of India
6.2	Cochrane-Orcutt estimation on the First Difference series of EMF Index and the Stock Price of India (singular value decomposition using Prais-Winsten)
6.3	Cochrane-Orcutt estimation between the EMF Index and the Stock Price of India (singular value decomposition using Prais-Winsten)

Table 3.1
Correlogram of the Indian Stock Price Index

Sample: 1999:02 2003:05
Included observations: 52

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th>k</th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Probability</th></tr>
<tr><td>. |*******|</td><td>. |*******|</td><td>1</td><td>0.895</td><td>0.895</td><td>44.104</td><td>0.000</td></tr>
<tr><td>. |****** |</td><td>.*| . |</td><td>2</td><td>0.773</td><td>-0.141</td><td>77.654</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. | . |</td><td>3</td><td>0.668</td><td>0.023</td><td>103.19</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>4</td><td>0.588</td><td>0.057</td><td>123.44</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. |*. |</td><td>5</td><td>0.542</td><td>0.104</td><td>141.01</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>.*| . |</td><td>6</td><td>0.481</td><td>-0.124</td><td>155.12</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>**| . |</td><td>7</td><td>0.362</td><td>-0.297</td><td>163.31</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>. | . |</td><td>8</td><td>0.257</td><td>0.056</td><td>167.53</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. |*. |</td><td>9</td><td>0.194</td><td>0.126</td><td>169.98</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>.*| . |</td><td>10</td><td>0.130</td><td>-0.165</td><td>171.10</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>11</td><td>0.092</td><td>0.040</td><td>171.68</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>.*| . |</td><td>12</td><td>0.019</td><td>-0.171</td><td>171.70</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. |*. |</td><td>13</td><td>-0.056</td><td>0.070</td><td>171.93</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>14</td><td>-0.095</td><td>0.062</td><td>172.60</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>15</td><td>-0.111</td><td>-0.044</td><td>173.54</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>16</td><td>-0.146</td><td>-0.151</td><td>175.20</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>17</td><td>-0.173</td><td>0.037</td><td>177.59</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>18</td><td>-0.206</td><td>0.039</td><td>181.11</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>.*| . |</td><td>19</td><td>-0.255</td><td>-0.168</td><td>186.63</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>20</td><td>-0.271</td><td>-0.047</td><td>193.08</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. |*. |</td><td>21</td><td>-0.274</td><td>0.093</td><td>199.88</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>22</td><td>-0.272</td><td>0.043</td><td>206.80</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>23</td><td>-0.263</td><td>-0.037</td><td>213.52</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>.*| . |</td><td>24</td><td>-0.259</td><td>-0.060</td><td>220.23</td><td>0.000</td></tr>
</table>

Table 3.2
Correlogram of the first difference of Indian Stock Price Index

Sample: 1999:02 2003:05
Included observations: 51

Autocorrelation	Partial Correlation	k	AC	PAC	Q-Stat	Probability
. |*. |	. |*. |	1	0.102	0.102	0.5668	0.452
. | . |	. | . |	2	-0.021	-0.032	0.5914	0.744
.*| . |	.*| . |	3	-0.188	-0.184	2.5743	0.462
.*| . |	.*| . |	4	-0.118	-0.085	3.3774	0.497
. |*. |	. |*. |	5	0.075	0.093	3.7112	0.592
. |** |	. |** |	6	0.312	0.278	9.5759	0.144
. | . |	.*| . |	7	-0.042	-0.144	9.6855	0.207
**| . |	**| . |	8	-0.214	-0.223	12.552	0.128
. | . |	. |*. |	9	-0.045	0.129	12.684	0.177
.*| . |	. | . |	10	-0.096	-0.050	13.291	0.208
. |** |	. |*. |	11	0.238	0.150	17.115	0.105
. |*. |	.*| . |	12	0.084	-0.085	17.599	0.128
.*| . |	.*| . |	13	-0.102	-0.088	18.337	0.145
.*| . |	. | . |	14	-0.178	-0.004	20.659	0.111
. | . |	. | . |	15	-0.008	0.032	20.664	0.148
.*| . |	.*| . |	16	-0.098	-0.151	21.412	0.163
. |*. |	.*| . |	17	0.073	-0.091	21.838	0.191
. | . |	. | . |	18	-0.001	0.002	21.838	0.239
.*| . |	.*| . |	19	-0.184	-0.073	24.703	0.171
.*| . |	. | . |	20	-0.063	-0.052	25.049	0.200
. | . |	.*| . |	21	-0.052	-0.092	25.292	0.235
. | . |	. | . |	22	0.003	-0.026	25.293	0.283
. | . |	. | . |	23	0.040	0.008	25.446	0.328
. |*. |	. |*. |	24	0.092	0.078	26.290	0.339

Table 3.3
Correlogram of the EMF index series

Sample: 1999:02 2003:05
Included observations: 52

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th>k</th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Probability</th></tr>
<tr><td>. |*******|</td><td>. |*******|</td><td>1</td><td>0.919</td><td>0.919</td><td>46.465</td><td>0.000</td></tr>
<tr><td>. |****** |</td><td>**| . |</td><td>2</td><td>0.806</td><td>-0.241</td><td>82.980</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. | . |</td><td>3</td><td>0.706</td><td>0.052</td><td>111.51</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. | . |</td><td>4</td><td>0.616</td><td>-0.020</td><td>133.71</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>5</td><td>0.539</td><td>0.014</td><td>151.05</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>6</td><td>0.477</td><td>0.031</td><td>164.92</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>**| . |</td><td>7</td><td>0.396</td><td>-0.194</td><td>174.69</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>.*| . |</td><td>8</td><td>0.301</td><td>-0.080</td><td>180.48</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>. | . |</td><td>9</td><td>0.214</td><td>-0.003</td><td>183.47</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>10</td><td>0.139</td><td>-0.019</td><td>184.77</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>11</td><td>0.072</td><td>-0.039</td><td>185.13</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>12</td><td>0.023</td><td>0.031</td><td>185.16</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>.*| . |</td><td>13</td><td>-0.028</td><td>-0.097</td><td>185.22</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. |*. |</td><td>14</td><td>-0.058</td><td>0.151</td><td>185.47</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>15</td><td>-0.095</td><td>-0.163</td><td>186.16</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>16</td><td>-0.125</td><td>0.056</td><td>187.37</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>17</td><td>-0.152</td><td>-0.064</td><td>189.23</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>18</td><td>-0.177</td><td>-0.040</td><td>191.83</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>19</td><td>-0.200</td><td>-0.003</td><td>195.24</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>20</td><td>-0.212</td><td>-0.014</td><td>199.19</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. |*. |</td><td>21</td><td>-0.198</td><td>0.150</td><td>202.73</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>22</td><td>-0.185</td><td>-0.111</td><td>205.94</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>.*| . |</td><td>23</td><td>-0.190</td><td>-0.083</td><td>209.45</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. |*. |</td><td>24</td><td>-0.188</td><td>0.071</td><td>213.00</td><td>0.000</td></tr>
</table>

Table 3.4
Correlogram of the first difference of the EMF index series

Sample: 1999:02 2003:05
Included observations: 51

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th>k</th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Probability</th></tr>
<tr><td>. |*. |</td><td>. |*. |</td><td>1</td><td>0.194</td><td>0.194</td><td>2.0444</td><td>0.153</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>2</td><td>0.007</td><td>-0.032</td><td>2.0468</td><td>0.359</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>3</td><td>0.015</td><td>0.021</td><td>2.0594</td><td>0.560</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>4</td><td>-0.096</td><td>-0.107</td><td>2.5943</td><td>0.628</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>5</td><td>-0.011</td><td>0.032</td><td>2.6008</td><td>0.761</td></tr>
<tr><td>. |*. |</td><td>. |*. |</td><td>6</td><td>0.079</td><td>0.075</td><td>2.9804</td><td>0.811</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>7</td><td>0.079</td><td>0.056</td><td>3.3626</td><td>0.850</td></tr>
<tr><td>. | . |</td><td>.*| . |</td><td>8</td><td>-0.024</td><td>-0.062</td><td>3.3973</td><td>0.907</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>9</td><td>-0.085</td><td>-0.075</td><td>3.8611</td><td>0.920</td></tr>
<tr><td>. | . |</td><td>. |*. |</td><td>10</td><td>0.063</td><td>0.113</td><td>4.1255</td><td>0.942</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>11</td><td>0.024</td><td>0.006</td><td>4.1638</td><td>0.965</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>12</td><td>0.034</td><td>0.021</td><td>4.2420</td><td>0.979</td></tr>
<tr><td>.*| . |</td><td>**| . |</td><td>13</td><td>-0.147</td><td>-0.210</td><td>5.7702</td><td>0.954</td></tr>
<tr><td>. | . |</td><td>. |*. |</td><td>14</td><td>0.016</td><td>0.120</td><td>5.7883</td><td>0.972</td></tr>
<tr><td>.*| . |</td><td>**| . |</td><td>15</td><td>-0.160</td><td>-0.192</td><td>7.7065</td><td>0.935</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>16</td><td>-0.076</td><td>0.033</td><td>8.1471</td><td>0.944</td></tr>
<tr><td>. | . |</td><td>.*| . |</td><td>17</td><td>-0.036</td><td>-0.126</td><td>8.2517</td><td>0.961</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>18</td><td>-0.117</td><td>-0.068</td><td>9.3688</td><td>0.951</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>19</td><td>-0.110</td><td>-0.086</td><td>10.390</td><td>0.943</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>20</td><td>-0.184</td><td>-0.167</td><td>13.335</td><td>0.863</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>21</td><td>-0.033</td><td>0.055</td><td>13.430</td><td>0.893</td></tr>
<tr><td>. |*. |</td><td>. |*. |</td><td>22</td><td>0.111</td><td>0.067</td><td>14.580</td><td>0.880</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>23</td><td>-0.026</td><td>-0.022</td><td>14.645</td><td>0.907</td></tr>
<tr><td>. |*. |</td><td>. |*. |</td><td>24</td><td>0.115</td><td>0.075</td><td>15.976</td><td>0.889</td></tr>
</table>

Table 3.5
Augmented Dickey-Fuller Test for stock price index of India at lag 1

ADF Test Statistic	-2.911624	1% Critical Value*		-4.1498
		5% Critical Value		-3.5005
		10% Critical Value		-3.1793
*MacKinnon's critical values for rejection of hypothesis of a unit root. *Augmented Dickey-Fuller Test Equation* *Dependent Variable: D(INDIA)* *Sample(adjusted): 1999:04 2003:05* *Included observations: 50 after adjusting endpoints*				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
INDIA(-1)	-0.210953	0.072452	-2.911624	0.0055
D(INDIA(-1))	0.156323	0.136913	1.141768	0.2595
C	31.37179	10.30530	3.044239	0.0039
@TREND(1999:02)	-0.321379	0.126663	-2.537273	0.0146
R-squared	0.180867	Mean dependent variable		-0.097620
Adjusted R-squared	0.127445	S.D. dependent variable		11.18234
S.E. of regression	10.44549	Akaike info criterion		7.606837
Sum squared residuals	5018.982	Schwarz criterion		7.759798
Log likelihood	-186.1709	F-statistic		3.385642
Durbin-Watson stat	1.999153	Probability (F-statistic)		0.025854

Table 3.6
Augmented Dickey-Fuller Test for first difference stock price index of India at lag 1

ADF Test Statistic	-4.741076	1% Critical Value*	-4.1540
		5% Critical Value	-3.5025
		10% Critical Value	-3.1804

*MacKinnon s critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INDIA,2)
Sample(adjusted): 1999:05 2003:05
Included observations: 49 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(INDIA(-1))	-0.942327	0.198758	-4.741076	0.0000
D(INDIA(-1),2)	0.042046	0.146772	0.286470	0.7758
C	1.731484	3.529988	0.490507	0.6262
@TREND(1999:02)	-0.078603	0.116180	-0.676561	0.5021

R-squared	0.459540	Mean dependent variable	-0.376592
Adjusted R-squared	0.423509	S.D. dependent variable	14.91556
S.E. of regression	11.32494	Akaike info criterion	7.769999
Sum squared residual	5771.438	Schwarz criterion	7.924433
Log likelihood	-186.3650	F-statistic	12.75413
Durbin-Watson stat	1.901157	Probability(F-statistic)	0.000004

Table 3.7
Augmented Dickey-Fuller Test for first difference stock price index of India at lag 13

ADF Test Statistic	-5.129179	1% Critical Value*	-4.2242
		5% Critical Value	-3.5348
		10% Critical Value	-3.1988

*MacKinnon's critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INDIA,2)
Sample(adjusted): 2000:05 2003:05
Included observations: 37 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(INDIA(-1))	-3.143317	0.612830	-5.129179	0.0000
D(INDIA(-1),2)	1.591580	0.494149	3.220851	0.0041
D(INDIA(-2),2)	1.215525	0.438828	2.769937	0.0115
D(INDIA(-3),2)	0.916158	0.404949	2.262402	0.0344
D(INDIA(-4),2)	0.677694	0.370682	1.828237	0.0818
D(INDIA(-5),2)	0.399431	0.345335	1.156647	0.2604
D(INDIA(-6),2)	0.382628	0.307662	1.243665	0.2273
D(INDIA(-7),2)	0.223382	0.288770	0.773563	0.4478
D(INDIA(-8),2)	-0.021415	0.272548	-0.078574	0.9381
D(INDIA(-9),2)	-0.155489	0.239432	-0.649410	0.5231
D(INDIA(-10),2)	-0.277739	0.210750	-1.317861	0.2017
D(INDIA(-11),2)	-0.131709	0.178734	-0.736897	0.4693
D(INDIA(-12),2)	-0.046775	0.152225	-0.307277	0.7617
D(INDIA(-13),2)	0.004537	0.112119	0.040466	0.9681
C	-22.67546	5.389756	-4.207140	0.0004
@TREND(1999:02)	0.494841	0.142803	3.465192	0.0023

R-squared	0.807997	Mean dependent variable	0.432351
Adjusted R-squared	0.670851	S.D. dependent variable	12.37835S.E.
of regression	7.101646	Akaike info criterion	7.057000
Sum squared residual	1059.101	Schwarz criterion	7.753613
Log likelihood	-114.5545	F-statistic	5.891537
Durbin-Watson stat	2.035707	Probability(F-statistic)	0.000137

Table 4.1
Pair-Wise Granger Causality Tests between the first difference series of stock price of India and the EMF Index

PAIR-WISE GRANGER CAUSALITY TEST Sample: 1999:02 2003:05 Lags: 2			
Null Hypothesis:	Observations	F-Statistic	Probability
EMF Index does not Granger Cause INDIA1	50	2.14296	0.12913
INDIA does not Granger Cause EMF Index		0.61262	0.54639

PAIR-WISE GRANGER CAUSALITY TEST Sample: 1999:02 2003:05 Lags: 4			
Null Hypothesis:	Observations	F-Statistic	Probability
EMF Index does not Granger Cause INDIA	48	1.48046	0.22677
INDIA does not Granger Cause EMF Index		0.33611	0.85195

PAIR-WISE GRANGER CAUSALITY TEST Sample: 1999:02 2003:05 Lags: 8			
Null Hypothesis:	Observations	F-Statistic	Probability
EMF Index does not Granger Cause INDIA	44	2.01120	0.08361
INDIA does not Granger Cause EMF Index		1.38718	0.24652

PAIR-WISE GRANGER CAUSALITY TEST Sample: 1999:02 2003:05 Lags: 16			
Null Hypothesis:	Observations	F-Statistic	Probability
EMF Index does not Granger Cause INDIA	36	7.97674	0.05628
INDIA does not Granger Cause EMF Index		0.86578	0.64256

Table 5.1
Simple linear regression of EMF index on stock price index of India

Dependent Variable: INDIA
Method: Least Squares
Sample: 1999:02 2003:05
Included observations: 52

Variable	Coefficient	Std. Error	t-Statistic	Probability
EMF	0.307736	0.004119	74.70337	0.0000
R-squared	0.829402	Mean dependent variable		107.8734
Adjusted R-squared	0.829402	S.D. dependent variable		25.79040
S.E. of regression	10.65233	Akaike info criterion		7.588478
Sum squared residual	5787.077	Schwarz criterion		7.626001
Log likelihood	-196.3004	Durbin-Watson stat		0.796214

Table 5.2
DF Unit Root Test on the residuals of regression of EMF Index on the stock price index of India (constant)

	Coefficient	t-test
Constant	-.2802858	-.2301427
u_{t-1}	-.3931654	-3.439124

DF statistic = -3.439124 — 1% critical τ value -3.58

Test Equation: $u_t = \beta_1 + \delta u_{t-1}$ — 5% critical τ value -2.93

Table 5.3
DF Unit Root Test on the residuals of regression of EMF Index on the stock price index of India (constant and trend)

	Coefficient	t-test
Constant	-.2875105	-.2353663
u_{t-1}	-.40766	-3.515879
t	-7.056618E-02	-.8418369

DF statistic = -3.515879 — 1% critical τ value -4.15

Test Equation: $u_t = \beta_1 + \beta_2 t + \delta u_{t-1}$ — 5% critical τ value -3.50

Table 6.1
Simple linear regression between the first differenced series of EMF index and the stock price index of India

Dependent Variable: First Difference of Stock Price index of INDIA
Method: Least Squares
Sample: 1999:02 2003:05
Included observations: 52

Variable	Coefficient	Std. Error	t-Statistic	Prob.
First Difference of EMF Index	0.239455	0.054227	4.415800	0.0001
R-squared	0.276583	Mean dependent variable		-0.029077
Adjusted R-squared	0.276583	S.D. dependent variable		11.00571
S.E. of regression	9.360787	Akaike info criterion		7.329979
Sum squared residuals	4468.841	Schwarz criterion		7.367503
Log likelihood	-189.5795	Durbin-Watson stat		2.224178

Table 6.2
Cochrane-Orcutt Estimation On The First Difference Series Of Emf Index And The Stock Price Of India (Singular Value Decomposition Using Prais-Winsten)

MAXIMUM NUMBER OF DIGITS OF CONVERGENCE OF SUM OF SQUARED RESIDUALS:15.
ACTUAL NUMBER OF DIGITS OF CONVERGENCE OF SUM OF SQUARED RESIDUALS:14.
MAXIMUM NUMBER OF ITERATIONS: 20
ACTUAL NUMBER OF ITERATIONS: 11
DEPENDENT VARIABLE IS FIRST DIFFERENCE OF INDIA
NUMBER OF OBSERVATIONS 52 DEGREES OF FREEDOM 50

R^2	.2872051	R^2 ADJ	.2726583
UNCENTERED R^2	.2872102	MEAN OF DEP VAR	2.941176E-O2
F TEST	19.74348	PROB OF F TEST	5.058986E-O5
DURBIN-WATSON	2.009362	DURBIN'S H	0
VARIANCE OF ESTIMATE	89.72977		
SUM OF SQUARED RESID	4396.759	SEE OR RMSE	9.47258
SUM OF ABS(RES)	350.173	RHO	-7.335245E-03
LOG(LIKELIHOOD)	-186.0142	SCHWARZ CRITERION	-187.9801
AKAIKE CRITERION	-187.0142	STD DEV OF DEP VAR	11.10706

	COEFFICIENT	STD. ERROR.	T-RATIO	SIGNIF.
FIRST DIFFERENCE EMF	.2520103	5.326277E-02	4.731453	0.000019
AR-LAG-1	-.1187808	.1390367	-.8543125	0.397089

Table 6.3
Cochrane-Orcutt Estimation Between The Emf Index And The Stock Price Of India (Singular Value Decomposition Using Prais-Winsten)

MAXIMUM NUMBER OF DIGITS OF CONVERGENCE OF SUM OF SQUARED RESIDUALS:15.
ACTUAL NUMBER OF DIGITS OF CONVERGENCE OF SUM OF SQUARED RESIDUALS: 13.
MAXIMUM NUMBER OF ITERATIONS: 20
ACTUAL NUMBER OF ITERATIONS: 8

DEPENDENT VARIABLE IS STOCK PRICE INDEX OF INDIA
NUMBER OF OBSERVATIONS 52 DEGREES OF FREEDOM 50

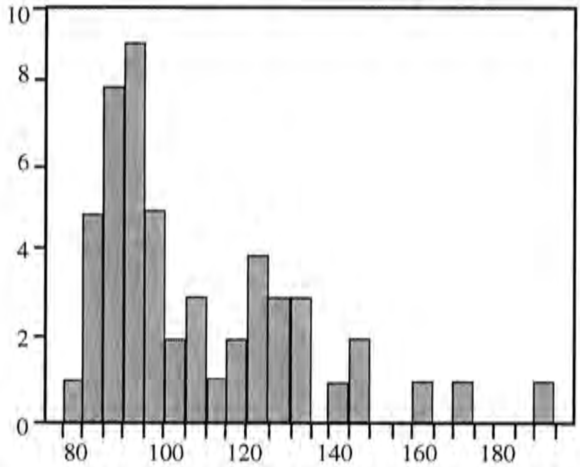
R^2	.8908372	R^2 ADJ	.8886539
UNCENTERED R^2	.9941931	MEAN OF DEP VAR	107.8443
F TEST	408.0315	PROB OF F TEST	1.062268E-25
DURBIN-WATSON	1.923278	DURBIN'S H	0
VARIANCE OF ESTIMATE	74.18438		
SUM OF SQUARED RESID	3709.219	SEE OR RMSE	8.613035
SUM OF ABS(RES)	303.6494	RHO	3.618E-02
LOG (LIKELIHOOD)	-184.7354	SCHWARZ CRITERION	-186.7111
AKAIKE CRITERION	-185.7354	STD DEV OF DEP VAR	25.81183

	COEFFICIENT	STD. ERROR.	T-RATIO	SIGNIF.
EMFINDEX	.305345	8.296425E-03	36.8044	0.000000
AR-LAG-1	.6107702	.109804	5.562368	0.000001

ANNEXURE 11:
LIST OF EXHIBITS

EXHIBIT NO.	TITLE
2.1	E-views output Descriptive Statistics for the stock price index of India
2.2	E-views output Descriptive Statistics for the First Differences of stock price index of India
2.3	E-views output Descriptive Statistics for the EMF Index
2.4	E-views output Descriptive Statistics for First Differences of EMF Index
3.1	Time Plot for the Stock Price Index of the EMF index
3.2	Time Plot for the Stock Price Index of India
6.1	Actual and Forecast values of Stock Price of India compared
6.2	Actual and Forecast values of Stock Price of India compared (Forecast based on first difference series)

Exhibit 2.1
E-views output descriptive statistics for the stock price index of India

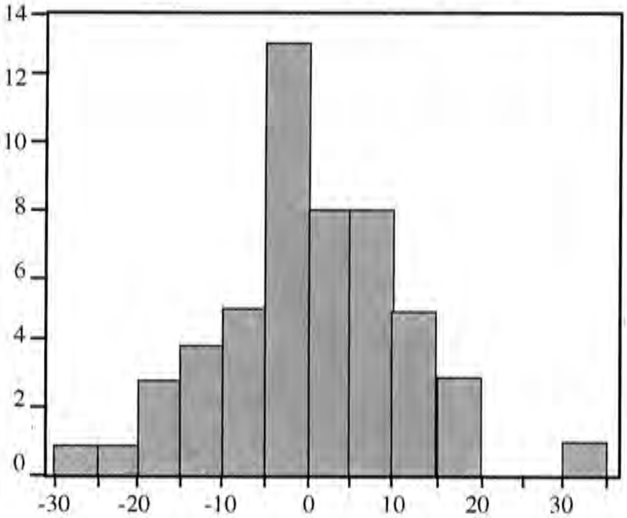


Series : INDIA
Sample 1999:02 2003:05
Observations 52

Mean	107.8734
Median	96.98600
Maximum	194.4840
Minimum	76.74100
Std. Dev.	25.79040
Skewness	1.320307
Kurtosis	4.487290
Jarque-Bera	19.90055
Probability	0.000048

$A^2 = 2.237236$ ($p = 0.0000$), $Z_{skewness} = 3.88$, $Z_{kurtosis} = 6.60$

Exhibit 2.2
E-views output descriptive statistics for the first differences of stock price index of India

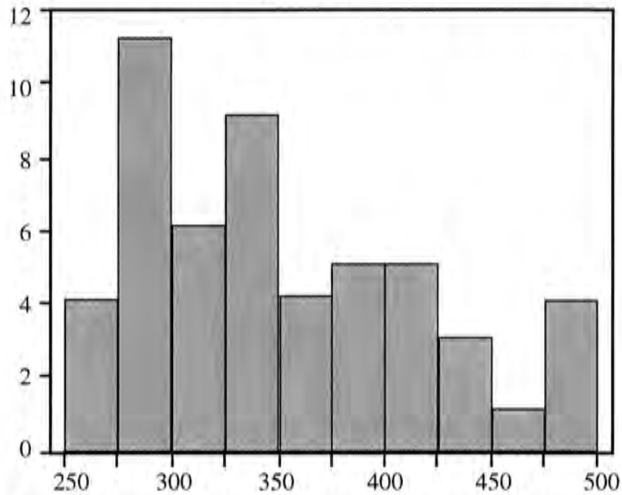


Series : INDIA1
Sample 1999:02 2003:05
Observations 52

Mean	-0.029077
Median	-0.221500
Maximum	30.10300
Minimum	-28.01300
Std. Dev.	11.00571
Skewness	-0.057344
Kurtosis	3.374301
Jarque-Bera	0.332052
Probability	0.847024

$A^2 = 0.194136$ ($p = 0.8884$), $Z_{skewness} = -0.17$, $Z_{kurtosis} = 4.96$

Exhibit 2.3
E-views output descriptive statistics for the EMF index

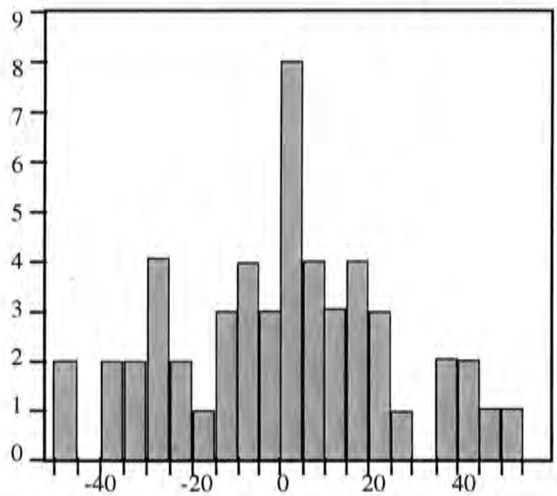


Series : EMF
Sample 1999:02 2003:05
Observations 52

Mean	352.5908
Median	333.2790
Maximum	499.4040
Minimum	251.3950
Std. Dev.	65.98490
Skewness	0.683970
Kurtosis	2.527907
Jarque-Bera	4.537281
Probability	0.103453

$A^2 = 1.178582$ ($p = 0.0040$), $Z_{skewness} = 2.01$, $Z_{kurtosis} = 3.72$

Exhibit 2.4
E-views output descriptive statistics for first differences of EMF index



Series : EMF1
Sample 1999:02 2003:05
Observations 52

Mean	0.413885
Median	1.818000
Maximum	54.72200
Minimum	-48.04500
Std. Dev.	24.16841
Skewness	0.061041
Kurtosis	2.538876
Jarque-Bera	0.493002
Probability	0.781531

$A^2 = 0.223470$ ($p = 0.8162$), $Z_{skewness} = 0.18$, $Z_{kurtosis} = 3.73$

Exhibit 3.1
Time plot for the EMF index

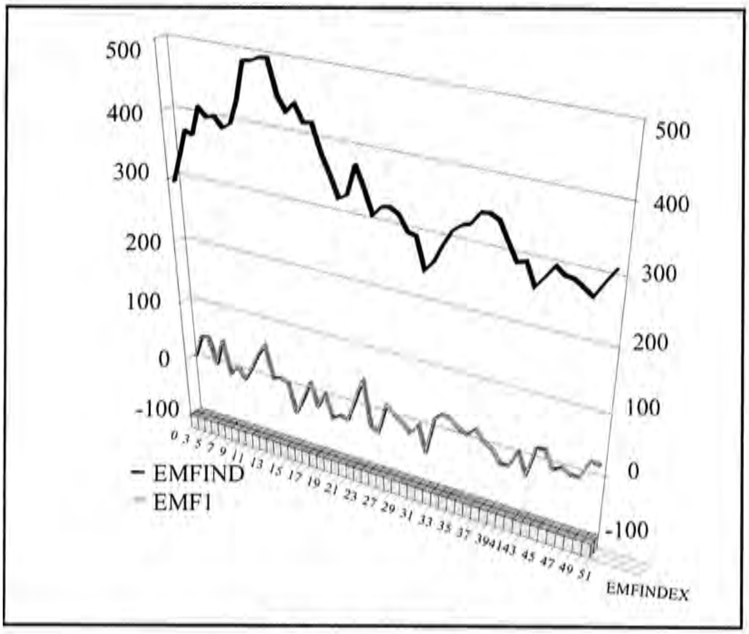


Exhibit 3.2
Time plot for the stock price index of India

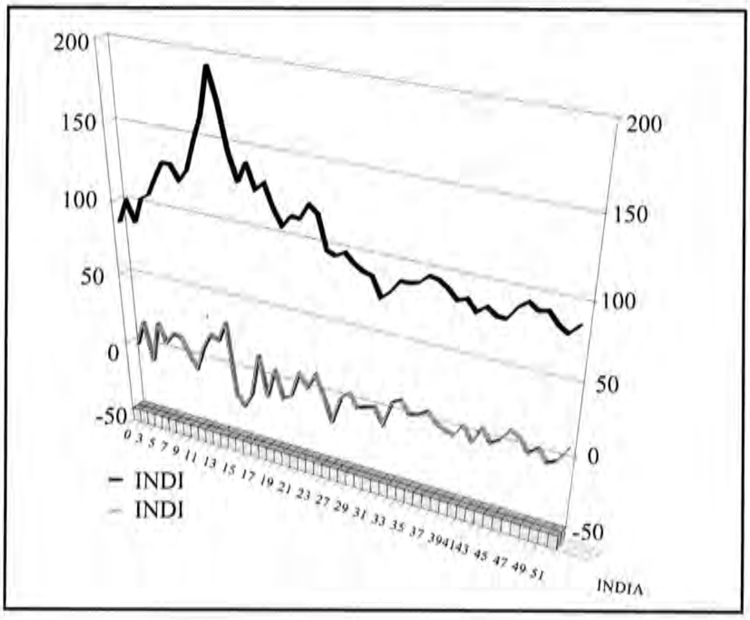


Exhibit 6.1
Actual and forecast values of stock price of India compared

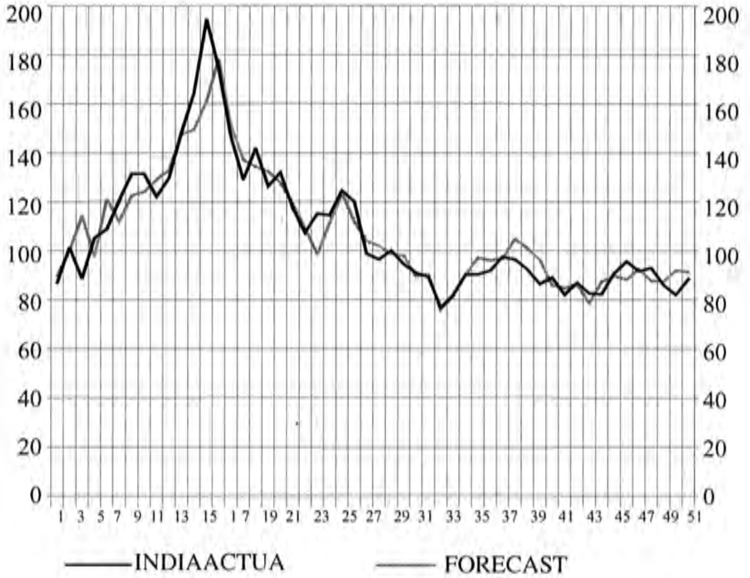


Exhibit 6.2
Actual and forecast values of stock price of India compared
(Forecast based on first difference series)