Structural Changes in India's Stock Markets' Efficiency

Sasidharan, Anand

Centre for Development Studies (Jawaharlal Nehru University), India

June 2009

Structural Changes in India's Stock Markets' Efficiency

Anand Sasidharan

2009

Abstract

This paper finds evidence that the Indian stock market, of late, has become weak-form efficient. We proceed by, first, locating structural breaks in the index using Bai-Perron's method for endogenous multiple structural changes. Four strutural breaks are identified for the period 1991 to 2008 for the S&P CNX Nifty series – December 1994, July 1999, June 2003 and January 2006. For this period the behaviour of returns approximates a Stable Paretian distribution. This would mean that market risk will be beyond that can be predicted by measures build on the assumption of normality of returns. The property of infinite population variance of a stable paretian distribution makes variance based estimators redundant. Therefore, using non-parametric methods the paper tests the efficiency of the market across the periods of structural breaks. It is found that the market has become weak form efficient only since the second half of 2003, corresponding to the period of the third structural break.

1 Efficient Markets: A Discussion

The 2007-08 economic crises, which had its origin from the sub-prime lending in the US housing markets, not only left shaken the financial markets across the world, but also stirred the real sector and the labour markets as well. In this context of threatened jobs, lost savings, wealth and confidence, many questions were raised about the sanctity of market economies built on a world of speculative finance. In particular, the 'efficiency' of these markets is questioned.

In an efficient market the current price of a financial asset is said to reflect the expected present value of the underlying assets' future stream of earnings.

Since expectations are formed on information, in an informationaly efficient market prices discounts all available information quickly and correctly, in terms of its expected future impact. The agents in the market are expected to be rational in the sense that, they make use of all the currently available information to arrive at the asset value. Therefore, the interaction of 'rational agents' in the market make the current prices reflect the correct prices. This price will signal the movement of resources to the most productive activities, leading to the optimal utilization of available investable resources.

As has been shown by the global financial crisis, this need not be the case. Markets can be quite irrational in processing information. The global financial crisis was a result of the market's inability in processing information correctly. This is not the first time that the world 'herded' towards inefficient markets. East Asian Crisis is a classic example, with the world taking huge positions in Thai banks, Asian property and currencies, without regard to their inefficiencies.

The learning is that an inefficient market can create asset bubbles and crashes not backed by fundamentals, eroding the asset value and confidence in the markets. Inefficient markets run the danger of converting a currency crisis into a banking crisis. To illustrate, if competition in the banking sector is tough, the banks might engage in risky credit operations, but the competition might restrain them from charging risk premia. To augment their expected returns during bullish periods, banks leverage the financial position-taking of corporate borrowers. If the trend is not backed by fundamentals, then volatility of returns sweeps away their asset base since they will not be able to adequately collateralize the loan (Nachane, 2007). This was precisely how the sub-prime crisis swept away some of the largest financial institutions in the world.

Therefore the implications of world market inefficiencies are farfetched and have important macroeconomic and policy implications for India, at a time when the economies are increasingly getting integrated with one another, owing to the free mobility of both capital and information. For instance, the case of fuller convertibility in the capital account in India is crucially contingent not only on the efficiency of the Indian markets. The implications are apparent given the fact that current account deficit in India is increasingly financed with capital inflows from global financial markets.

The basic argument of efficient markets hypothesis is that, a market in which prices always fully reflect available information is efficient (Fama, 1970). Agents in the market form expectations based on the current information set ϕ_t, and if markets are sufficiently competitive then investors cannot expect to achieve superior profits from their investment strategies based on their information set. This is because "in competitive markets there is a buyer for every seller. If one could be sure that a price would rise, it would have already risen" (Samuelson, 1965).

The EMH model implies that all currently available information is embodied in the current prices (Fama, 1970; Bailey, 2005). This implies that[1]

$$E(p_{t+1}|\phi_t) = p_t \tag{1}$$

The above equation states that the expected price for the next period (p_{t+1}), based on the current information set (ϕ_t) will be equal to the current price. This is because the investors are assumed to be rational agents, who use all available information to arrive at their decision. And, the information that influences their decision gets reflected in the current prices. The wisdom contained in equation 1 can be best found in these words, which is from the man who first thought about it probably —"Past, present and even discounted future events are reflected in market price, but often shows no apparent relation to each other" (Bachelier, 1900).

From equation 1 we can see that

$$E[(p_{t+1} - p_t)|\phi_t] = 0 \tag{2}$$

Instead it is safe to assume a sub–martingale model, where

$$E(p_{t+1}|\phi_t) \geq p_t \tag{3}$$

Or, we can think of this process as being generated by

$$E(p_{t+1}|\phi_t) = (1 + \mu)p_t \tag{4}$$

Rearranging the equation, we can see that

$$\mu = \frac{E(p_{t+1}|\phi_t) - p_t}{p_t} \tag{5}$$

Here, μ is a constant and can be interpreted as the *expected* rate of return. Now, we define rate of return as

$$r_{t+1} = \frac{p_{t+1} - p_t}{p_t} \tag{6}$$

By introducing the expectations operator, we get

$$E(r_{t+1}|\phi_t) = \frac{E(p_{t+1}|\phi_t) - p_t}{p_t} = \mu \tag{7}$$

[1]The discussion on martingales is based on Bailey (2005, p. 57)

Using the law of iterated expectations, we can write

$$E(r_{t+1}|\phi_t) = E(r_{t+1}) = \mu \tag{8}$$

The expected rate of return conditional on current information equals the unconditional expectations of the rate of return (Bailey, 2005). This implies that currently available information cannot be used in predicting future returns.

Since, $r_t \in \phi_t$

$$E(r_{t+1}|r_t) = \mu \tag{9}$$

Or,

$$E(r_{t+k}|r_t) = \mu; \forall k \geq 1 \tag{10}$$

More generally, since the information set can contain historical data i.e., current and past prices and returns

$$E(r_{t+k}|r_t, r_{t-1}...) = \mu \tag{11}$$

Therefore, we can have

$$r_{t+1} = \mu + \epsilon_{t+1} \tag{12}$$

Where,

$$E(\epsilon_{t+1}|\phi_t) = 0 \tag{13}$$

An issue of great interest in EMH is excess returns. Fama (1970) defines excess returns as

$$x_{t+1} = p_{t+1} - E(p_{t+1}|\phi_t), \tag{14}$$

then

$$E(x_{t+1}|\phi_t) = 0 \tag{15}$$

Excess return (x_{t+1}), is a fair game with respect to information sequence ϕ_t From the above discussion, we can derive the following inferences about the behavior of prices and returns. First, current return or prices provides no 'usable' or 'meaningful' information about its future. Second, from first it follows that, the current rate of return is uncorrelated with any of its past values. Third, it is not possible to make excess returns based on the current information set.

Studies in India primarily focused at examining weak-form efficiency. One of the first of these studies was by Sharma and Kennedy (1977). They examined Bombay, London and New York stock exchanges, testing for weak-form efficiency using runs test and spectral analysis. The results were in support of efficient markets. Barua (1981) studied 20 scrips listed in the Bombay Stock Exchange (BSE) as well as Financial Express index (FE). He examined serial dependence in price changes using both parametric and non–parametric techniques, which returned with mixed results. Similar was also the case with Gupta (1985) who examined Economic Times index (ET), FE and 39 scrips in BSE. Krishnarao (1988) examining a number of scrips, tried to see whether technical trading rules or filter rules can generate 'buy' or 'sell' signals which can give excess returns, as in Fama and Blume (1966). Yalawar (1988) also examined a number of scrips using correlation tests and runs test. Both studies supported the EMH paradigm. Whereas Choudhary (1991) conducting similar tests rejects the hypothesis that the markets are efficient. Barman and Madhusoodhan (1991) using unit root test and variance ratio test; Reddy (1998) and Ahmad et al. (2006) using runs test and ARCH, GARCH models, all provides evidence in rejection of the hypothesis of efficient markets. One of the latest study in this line by Ray (2007) examines evidence for cointegration and causality of macroeconomic variables with the stock market. Of all the macroeconomic variables he examined, only index of industrial production (IIP) seems to have a little, but negligible influence over the stock markets. He rejects the efficient markets hypothesis for the Indian markets.

Thomas and Shah (2002) and Agrawal (2007) examines the semi-strong efficiency of the market through event studies[2]. An event study, in this context, examines semi-strong or strong form efficiency by examining the market behaviour during a major event of interest. Semi-strong efficiency requires that markets react immediately to a new information and the prices capture the 'real' impact of the information on the expected future stream of earnings. A semi-strong efficient market will not continue to ride in the direction of a stale information.

Thomas and Shah (2002) examined the market behaviour for all the Union budgets from April 1979 to June 2001. The analysis was made possible by constructing a long time series data of a market price 'index' by concatenating five sets of indices for the period. Examining average cumulative returns they infer that substantial information processing takes place prior to the budget date, but with no overreaction or under-reaction prior to the budget date or immediately after it. In short, they find the market to be efficient in its semi-strong form for this information set. Agrawal (2007) conducted an event study on monetary policy announcements in India. He examines 6 announcements affecting CRR between April 2006 and July 2007. The study

[2]After Fama (1991), tests for weak-form efficiency falls within the larger framework of *tests for predictability of returns*. Examination for semi-strong-form efficiency is now known as *event studies* and examining strong-form efficiency falls within *tests for private information*

takes an event window of 31 days and examines the cumulative average abnormal returns (CAAR) of the fifty firms constituting the market price index 'Nifty' . He shows that CAARs does not normalize after the event, indicating that market is slow in incorporating the content of the monetary policy announcements. This, he argues, is evidence for semi-strong inefficiency.

We see that, older studies more often tend to support the hypothesis that markets are efficient. Later studies increasingly reject the efficient markets hypothesis on account of observing serial dependence or unit root. But, Fama (1965, 1991) points out that simply dependence do not reject EMH. This is because, firstly, dependence that is important from a statistical point of view might not be important from an investment point of view and vice versa (Fama, 1965). Secondly, what is of concern is whether such dependence can facilitate profitable trading strategies. Finally, prices following a martingale[3] (Samuelson, 1965) may not have the independence property of a pure random walk (Fama and Blume, 1966). In this regard Campbell et al. (1997) points out that the concept of relative efficiency, i.e.,the efficiency of one market measured against another is a more useful concept than absolute efficiency[4]. Regarding the distributional properties of price changes, most studies do not go beyond the routine tests for normality and is often silent about its implications. Following Mandelbrot (1963), Fama (1965) shows that the return generating process is better approximated by stable Paretian distribution. This class of distribution has the property of infinite variance. Sample variance will show extremely erratic behaviour even for very large samples. Thus, statistic based on variance are meaningless or breaks-down.

2 Identifying Structural Breaks

EMH specifies return behaviour as $E(r_{t+1}|\phi_t^m) = \mu$. When we say μ is constant over time, it does not imply that the value of μ is same throughout the history and life of the scrip or the market. It is, indeed, more realistic to consider μ to adjust to changes in the structural features in the market or the economy. While the short-term fluctuations cancel-out each other, under the impact of a structural change it might move to a different level and remain there until the market undergoes another structural change. Therefore, one

[3]A *martingale* can be thought of as stochastic or random process (P_t) which satisfies the following condition $E[P_{t+1}|P_t, p_{t-1}, ...] = P_t$, or equivalently, $E[P_{t+1} - P_t|P_t, p_{t-1}, ...] = 0$. (Campbell et al., 1997).

[4]"Few engineers would ever consider performing a statistical test to determine whether or not a given engine is perfectly efficient–such an engine exists only in the idealized frictionless world of the imagination. But measuring relative efficiency–relative to the frictionless ideal–is commonplace" (Campbell et al., 1997, p. 24)

should be careful in defining the 'long-term' average returns of the market. It will be prudent to split the long-term series into different periods of structural changes and analyse them separately.

We make use of Bai and Perron (1998) method for estimating structural break in the nifty series. Conventional approach to structural breaks has been to perform Chow tests, which is to perform tests for statistically significant differences in parameters across the periods suspected of a break. The basis of a Chow–test, i.e., the break–dates that needs to be confirmed by a Chow–test, can come from two ways. One is to identify break–dates based on some known feature of the data such as an inflexion point or based on the occurance of an exogenous event (Balakrishnan and Parameswaran, 2007). The limitations pointed out for this method is that, for the first approach the choice of the date will be correlated with the data and the Chow–test is likely to validate a break-point when none exists. And, in the second approach it assumes that the event had an impact on the parameters of the model and it is the only causal factor at that point of time (Balakrishnan and Parameswaran, 2007). Another limitation is that it can be used to estimate only one break point at a time.

The Bai–Perron method allows for simultaneous estimation of unknown multiple breaks. The break–dates are estimated as global minimizers of the sum of squared residuals from on OLS regression of the multiple regression model using a dynamic programming algorithm (Balakrishnan and Parameswaran, 2007).[5]

[5]The *strucchange* package in the 'R' computing environment, provides a platform for undertaking tests for structural breaks. For details on performing it see Zeileis et al. (2005). The method in Bai and Perron (1998) is as follows: Consider the following multiple linear regression with m breaks (This gives us m+1 regimes).

$$Y_t = x_t^{'}\beta + z_t^{'}\delta_j + u_t, \tag{16}$$

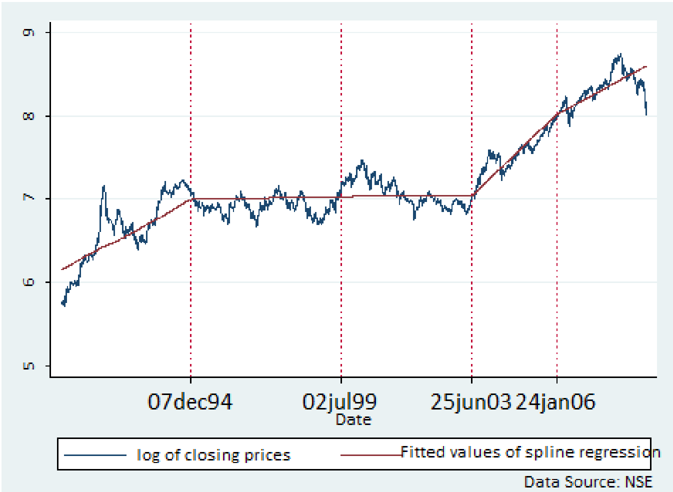
Where $t = T_{j-1} + 1, ..., T_j$. For $j = 1, ..., m + 1$. We denote $T_0 = 0$ and $T_{m+1} = T$. The indices $(T_1, ..., T_m)$ or the breakpoints are treated as unknowns. For each m-partition $(T_1, ..., T_m)$ denoted $\{T_j\}$, the associated least–squares estimates of β and δ_j are obtained by minimizing the sum of squared residuals.

$$\sum_{i=1}^{m+1} \sum_{t=T_{i-1}-1}^{T_i} [y_t - x_t^{'}\beta - z_t^{'}\delta_i]^2 \tag{17}$$

Let $\hat{\beta}(\{T_j\})$ and $\hat{\delta}(\{T_j\})$ denote the resulting estimates. Substituting them in the objective function and denoting the resulting sum of squared residuals as $S_T(T_1, ..., T_m)$, the estimated break–points $(\hat{T}_1, ..., \hat{T}_m)$ are such that

$$(\hat{T}_1, ..., \hat{T}_m) = argmin_{(T_1,...,T_m)} S_T(T_1, ..., T_m) \tag{18}$$

Figure 1: Structural Breaks in the Nifty series



This procedure returned 4 break–points in the Nifty series from 1991 to 2008 (see figure §1). With m breaks, there are m+1 regimes. So, there are 5 regimes to the series. They are

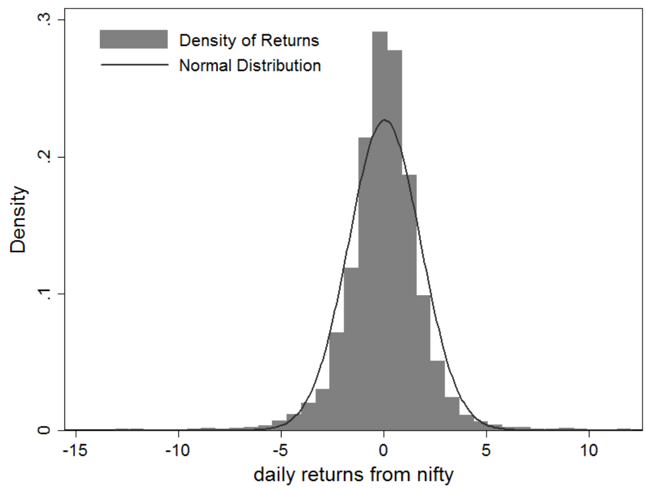
1. Regime 1: 02Jan91 to 07Dec94
2. Regime 2: 07Dec94 to 02Jul99
3. Regime 3: 02Jul99 to 25Jun03
4. Regime 4: 25Jun03 to 24Jan06
5. Regime 5: 24Jan06 to 23Oct08

3 Distribution of Returns

It is important to analyze the distribution of return as it has direct relationship with the riskiness of the investment and in the formation of expectations about returns itself. Besides, statistical inference is based on the assumptions about the distribution.

where the minimization is taken over all possible partitions $(T_1, ..., T_m)$ such that $T_i - T_{i-1} \geq q$. Note that q is the minimum length assigned to a segment and T_i is the break–point. The proceduer considers all possible combination of segments and selects the partition that minimizes the sum of squared residuals. The least–squares estimators of the break–points are the global minima of the sum of squared residuals of the objective function in §16. (Bai and Perron, 1998).

Figure 2: Histogram of Daily Returns



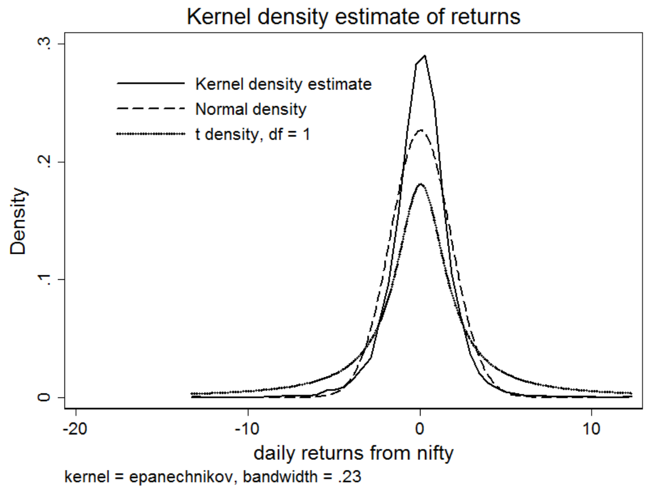
The Bachelior–Osborne model of the random walk of security prices assume that price changes are independent, identically distributed random variables; transactions are fairly uniformly spread over time; and the distribution of price changes from transaction to transaction has finite variance. If the number of transaction is very large, then the price changes will be sums of many independent variables. Under these conditions, according to the central limit theorem price changes will have normal distribution (Fama, 1965).

The easiest way to analyse the distribution of returns is to examine its frequency distribution. As can be seen from Fig §2 and Fig §3, the distribution is much peaked at the center than expected of a normal distribution.

Box–plot is also a convenient tool to analyse frquency distributions. Figure §4 is the box-plot of the distribution of returns. In a box plot, the 'box' is the size of the mid-spread or inter–quartile range. Therefore, the size of the box tells you the spread — the larger the box, the larger is the spread. The line inside the box is the median. The whiskers extend to at most 1.5 times the box width. The points outside the box are outliers or extreme observations. From figure §4 we can see that, the return distribution has a thin mid–spread, though symmetric. But, it is characterised by long tails at either ends, as can be seen from the size of the outliers.

An even more powerful method for examining the distribution is normal probability plots (Figure §5). It graphs the standardized random variable with the original random variable. If x is the random variable with mean μ

Figure 3: Density of Returns with Normal Distribution



and variance σ^2, then the standardised variable

$$z = \frac{x - \mu}{\sigma} \tag{19}$$

If x is Gaussian random variable, then a graph of its sample values with the values of z derived from the theoretical unit normal c.d.f should be a 45^0 straight line from the origin. When the tails of empirical frequency distributions are longer than expected of a normal distribution, the graph takes an elongated S form with the curvature at the top and bottom varying directly with the excess of relative frequency in the tails of empirical distribution (Fama, 1965). Such an observed shape is also accentuated by the fact that the center of the returns distribution are higher than the normal distribution, making the middle of empirical plot steeper than the one following strict normality.

We see that the empirical distribution of returns depart from normality. Fama (1965) argues that such departures from normality of the stock prices are in the direction predicted by Mandelbrot Hypothesis of a Stable Paretian distribution. Table §1 compares the empirical frequency distribution of returns from S&P CNX Nifty with that of unit normal and Fama's estimates. We can see that Nifty returns treads closer to Fama's estimates than that of unit normal.

Mandelbrot and Hudson (2009) gives an elegant illustration of the non-normality of financial data:

> "On one day, the dollar vaulted over the yen by 3.78 percent. That is a 5.1 standard deviations, or 5.1σ, from the average. If

Figure 4: Box plot of Daily Returns

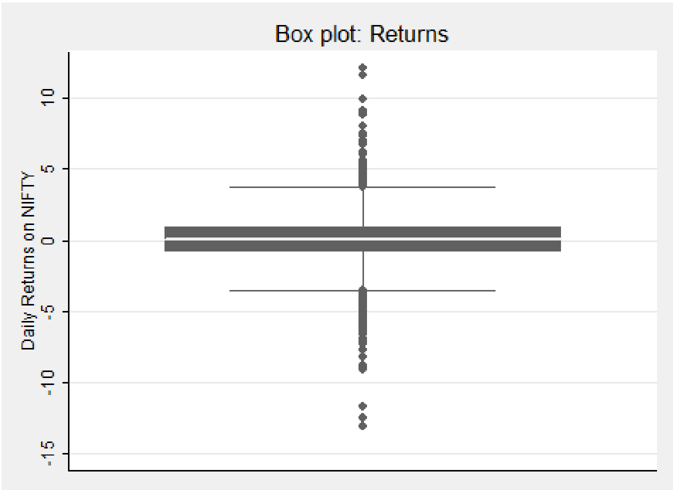


Figure 5: Normal Probability Plot of Daily Returns

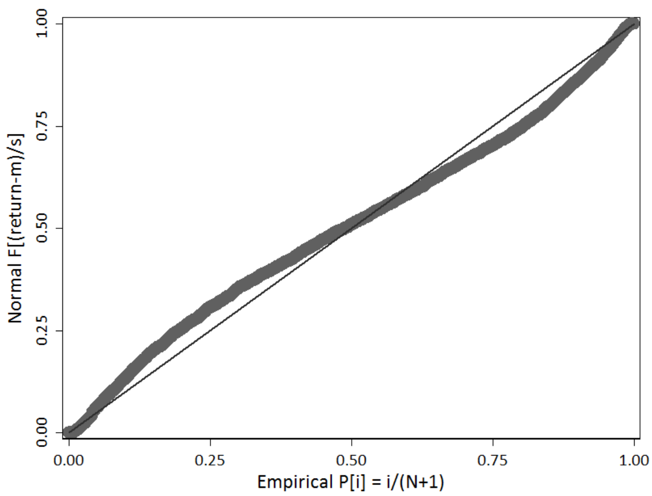


Table 1: Comparison of Empirical Frequency Distribution with Unit Normal

σ from mean	Unit Normal	Fama's Estimates	Nifty
0.005	38.3	46.7	5.4
1	68.3	75.7	76.6
1.5	86.6	88.5	89.9
2	95.5	94.8	95.1
2.5	98.8	97.6	97.5
3	99.7	98.9	98.4
4	99.99	99.7	99.5
5	100	99.9	99.7
+5	0.00	0.1	0.3

> exchange rates were Gaussian that would be expected to happen once in a century. But the biggest fall was a heart-stopping 7.92 percent, or 10.7σ. The normal odds of that: Not if Citigroup had been trading dollars and yen every day since the big bang 15 billion years ago should it have happened, not once."

During May 2004 alone we find 5 observations of daily return being above 4 standard deviations from the mean. The verdict of the General Elections and the unfolding drama on choosing the Prime Minister designate led to considerable volatility in the market. The day after the election verdict, the market nosedived with Nifty daily return falling by 8.19 percent. When the market reopened on Monday, it went even below. The 13.05 percent fall is the largest during the period 2001-08. That is approximately 7.5σ (for the entire period the average returns have been only 0.05 percent with a standard deviation of 1.75). The news that United Progressive Alliance forms government with the support of the left parties probably might have dented investor expectations on 'reforms' and dis-investment. On a surprise move, the very next day when the congress decided on Dr. Manmohan Singh as the Prime Minister, the Nifty registered an overnight comeback by 7.97 percent!

The implication of departure from normality or following a Stable Paretian distribution are many. First, the size of the total will be more than likely to be the result of a few very large changes that took place during much shorter sub–periods, unlike normal where individual price change is smaller compared to the total change. Second, the path of the price change is dis–continuous. Third, is the property of infinite variance. The implications of this last feature is that sample variance will show extremely erratic behaviour even for very large samples. Though sample variance is computable, population variance is infinite this makes measurements with sample variance meaningless (Fama, 1965).

4 Efficiency of the Market

Since Fama (1970) it is widely accepted that tests for market efficiency should be a test for Joint Hypothesis with an equilibrium asset pricing model. That is security markets are informationally efficient and returns follow a pre-specified equilibrium model (e.g. CAPM)

If the current prices fully reflect all available information then,

$$p_t^e = \varphi(\phi_t) \tag{20}$$

and

$$p_t^e = \varphi(\phi_t^m) \tag{21}$$

That is,

$$p_t^e = \varphi(\phi_t) = \varphi(\phi_t^m) \tag{22}$$

Where,

p_t^e = Equilibrium asset prices at time t

ϕ_t = Information set available to investors at time t

ϕ_t^m = Equilibrium prices actually used by the investors in the determination of asset prices at time t

$\varphi(.)$ is the model of equilibrium that links a particular information set with equilibrium prices

Equilibrium prices derived from the information set investors actually used are identical to the equilibrium prices implied by the set of all available information. If EMH is true in a world of certainty, no investor could earn supernormal profits by predicting prices from available information, since all relevant information will be reflected in asset prices. If EMH is true in a world of uncertainty, then no investor should expect to earn returns in excess of those normally associated with risky portfolios by predicting asset prices from the set of available information (Hess and Reinganum, 1979).

In this revised framework, market efficiency is tested with respect to an equilibrium asset pricing model. In which case it tests the joint hypothesis that security markets are informationally efficient and returns behave according to a pre–specified equilibrium model. But, this leads us to the joint hypothesis problem. That is, if the joint hypothesis is rejected we cannot attribute the rejection to either of it. Many economists (Schleifer, 2000) describe this as the ingenuity of Fama, because if joint hypothesis is the correct way of testing market efficiency then EMH can never be discarded!

Popular equilibrium models used for joint hypothesis testing are CAPM and its variants. It models cross–sectional returns as a function of market returns or risk and other firm–specific characteristics. But, the focus here is in modeling market returns itself, for which these models cannot be simply adopted as it is. Since a market index discounts economy wide information, a general equilibrium model might be a better predictor of its behaviour. This is, but, beyond the scope of this paper. If the concept of joint hypothesis has to be forced in, then we are testing the joint hypothesis that the market is efficient and the prices follow a random walk.

In section 3 we saw that the distribution of returns is not normal, instead it follows a Stable Paretian distribution. In the discussion which ensued, we showed that the property of infinite population for this class of distribution makes variance based measurements meaningless. This implies that we are not in a position to continue to use parametric estimators.

Non-parametric tests do not make restrictive assumptions about the shape of the population distribution. Though this advantage is important, it also faces the limitation that they loose information while converting values to non-parametric ranks. Also, they are not as sharp as parametric tests. This is the trade-off a researcher has to make. Here, we test for random order of the return distribution using 'runs-test'.

A run is a sequence of identical occurrences preceded and followed by different occurrences or by none at all(Levin and Rubin, 1997). Suppose, a sample of the returns behave as follows:

$$-1.6, +1.3, +1.1, +1.5, -0.9, -1.2, -2.3, -1.9, +2.6, +3.1 \tag{23}$$

If a positive change is denoted by P and a negative change by N, then the sequence will contain 4 runs:

$$\underbrace{N}_{1st}, \underbrace{P, P, P}_{2nd}, \underbrace{N, N, N, N}_{3rd}, \underbrace{P, P}_{4th} \tag{24}$$

Let us denote n_1 as the number of occurrences of P and n_2 that of N. Both occur 5 times in the series. And, we denote r as the number of runs, which is 4. A one-sample runs test is based on the idea that too few or too many runs show that the sequence was not drawn random.

The mean and standard error of the r-statistic is computed as follows:

$$\mu_r = \frac{2n_1n_2}{n_1 + n_2} + 1 \tag{25}$$

$$\sigma_r = \sqrt{\frac{2n_1n_2(2n_1n_2 - n_1 - n_2)}{(n_1 + n_2)^2(n_1 + n_2 - 1)}} \tag{26}$$

Table 2: Runs Test

	Test Value	No. of runs	Z	Sig.(2-tailed)
p	7.0479	54	-63.817	0
r	0.09	1887	-7.78	0
r0	0.1231	331	-5.779	0
r1	-0.0484	480	-4.815	0
r2	0.0428	443	-3.581	0
r3	0.2518*	321	-0.548	0.584
r4	0.1269*	330	-1.032	0.302

The sampling distribution of r can be closely approximated by the normal distribution, in a one-sample runs-test, if n_1 or n_2 is larger than 20. We test the null hypothesis of random order against the alternative hypothesis of no random order, using the test statistic

$$z = \frac{r - \mu_r}{\sigma_r} \tag{27}$$

Instead of positive and negative changes (i.e., zero as the cut-off) we take median as the cut-off value. That is, cases are defined as values above and below the median. The test of random order of returns is conducted seperately for returns falling within each structural breaks which corresponds to December 1994, July 1999, June 2003 and January 2006. The results of the runs-test are given in figure 2.

In the figure 2 variable p corresponds to log closing prices for the period 1991 to 2008 and the variable r denote the returns during this entire period. $r1$ corresponds the sample returns during the first regime; $r2$ denotes the second regime and so on. The last column of the table provides the significance or the p-value of the test statistic. Except for variables r3 and r4, p-values are significant for all the other variables, implying that we do not reject the null hypothesis of random for r3 and r4.

Runs-test rejects the null hypothesis of random order for the entire return series for the period 1991 to 2008. Which is rejection of weak-form efficiency. But, different sub-periods have behaved differently. While, the returns for the first three regimes do not comply with random order or independence, regimes 4 and 5 fit the EMH view of randomly distributed returns. This implies that lately market is moving towards the EMH view of weak-form efficiency.

5 Conclusion

Presence of structural breaks in the price series and the evidence of the returns following a stable paretian distribution made us perform tests based on nonparametric methods across the periods of structural breaks. The test rejected the hypothesis of price changes being randomly ordered. One can argue that the runs-tests' rejection of the random ordering of the returns series is a direct rejection of the Bacelior-Osborne hypothesis of the stock market behaviour; and that, there is more to the market than the theoretically bounded realms of rationality. In this context it is important to understand and better appreciate the market from a behavioural perspective.

As Shiller had pointed out, as long as human beings form the market, their instincts will be built into it and therefore the market will be always and everywhere inefficient. But, one need not take such an extreme stand. Efficient markets provides us with a comfortable litmus test to see the sophistication of the market – is there enough players in the market who has exploited all the available information such that, outside noise, only new information can 'move' the market? With regard to weak-from efficiency, it is not the simple presence of serial correlation that is of interest - but, the ability to exploit this information in a trading strategy. But, a closer examination across the periods of structural breaks showed that the market has become weak-form efficient since the structural break in June 2003. That is, lately market has begun to tend towards the theoretical ideal of weak form efficiency as evidenced by the returns being independently distributed. Identifying factors responsible for improving efficiency is a research in itself. The reasons can range from improvement in operational efficiency affecting the market microstructure; increased integration with world markets; role of foreign institutional investors; or changing patterns in market participation – about which we do not wish to speculate here.

References

Agrawal, G. (2007). Monetary policy announcements and stock price behavior: Empirical evidence from cnx nifty. *Decision 34*(2), 133.

Ahmad, K. M., S. Ashraf, and S. Ahmed (2006, January7). Testing weak form efficiency for indian stock markets. *Economic and Political Weekly*, 49–56.

Bachelier, L. J. B. A. (1900). Theorie de la speculation. Paris: Gauthier-

Villar. Reprinted in Paul H. Cootner (ed.) 'The Random Character of Stock Market Prices'. Cambridge: M.I.T. Press, 1964.

Bai, J. and P. Perron (1998, January). Estimating and testing linear models with multiple structural changes. *Econometrica 66*(1), 47–78.

Bailey, R. E. (2005). *The Economics of Financial Markets*. Cambridge.

Balakrishnan, P. and M. Parameswaran (2007, July 14). Understanding economic growth in india: A prerequisite. *Economic and Political Weekly*, 2915–2922.

Barman, R. and T. Madhusoodhan (1991). Inefficiency and speculation in the indian securities market. *Vikalpa 16*(4), 17–21.

Barua, S. (1981). Short run price behaviour of securities: Some evidence of indian capital market. *Vikalpa 6*(2), 93–100.

Campbell, J. Y., A. W. Lo, and A. C. MacKinlay (1997). *The Econometrics of Financial Markets*. Princeton University Press.

Choudhary, S. K. (1991). Short-run price behaviour : New evidence on weak form of market efficiency. *Vikalpa 16*(4), 17–21.

Fama, E. F. (1965, January). The behavior of stock-market prices. *The Journal of Business 38*(1), 34–105.

Fama, E. F. (1970, May). Efficient capital markets: A review of theory and empirical work. *The Journal of Finance 25*(2), 383–417.

Fama, E. F. (1991, December). Efficient capital markets: Ii. *The Journal of Finance 46*(5), 1575–1617.

Fama, E. F. and M. E. Blume (1966, January). Filter rules and stock-market trading. *The Journal of Business 39*(1), 226–241.

Gupta, O. (1985). *Behavior of share prices in India: A test of market efficiency*. National Publishing House.

Hess, P. and M. Reinganum (1979). *Efficient Capital Markets*, Chapter 1, pp. 3–12. North Holland.

Krishnarao, N. (1988, March). Market efficiency: Indian experience. In *Proceedings of National Seminar on Indian Securities Markets: Thrust and Challenges*. University of Delhi.

Levin, R. I. and D. S. Rubin (1997). *Statistics for Management.* Printice Hall.

Mandelbrot, B. (1963, October). The variation of certain speculative prices. *Journal of Business XXXVI*, 517–43.

Mandelbrot, B. B. and R. L. Hudson (2009). *The (Mis)Behaviour of Markets: A Fractal view of risk, ruin and reward.* Basic Books, U.S.

Nachane (2007, September). Liberalisation of the capital account: Perils and possible safeguards. *Economic and Political Weekly.*

Ray, H. (2007). Macroeconomic variables and stock market behaviour: An indian experience. *Arthavijnana XLIX*(3), 255–274.

Reddy, Y. S. (1998). *Indian Capital Markets: Theories and Empirical Evidence*, Chapter Efficiency of the Indian Stock Markets: An Empirical Analysis of Weak-Form EMH of the BSE, pp. 91–115. UTI Institute of Capital Markets and Quest Publications.

Samuelson, P. A. (1965, Spring). Proof that properly aniticipated prices fluctuate randomly. *Industrial Management Review 6*(2), 41–49.

Schleifer, A. (2000). *Inefficient Markets.* Oxford University Press.

Sharma, J. and R. Kennedy (1977, September). A comparative analysis of stock price behaviour on the bombay, london and new york exchanges. *Journal of Financial and Quantitative Analysis 12*, 319–414.

Thomas, S. and A. Shah (2002, February2). Stock market response to union budget. *Economic and Political Weekly*, 455–458.

Yalawar, Y. B. (1988). Bombay stock exchange: Rates of return and efficiency. *Indian Economic Journal 35*(4), 68–121.

Zeileis, A., F. Leisch, K. Hornik, and C. Kleiber (2005). strucchange: An r package for structural change in linear regression models. available from http://www.R-project.org/.