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Determination of Opening Prices of Equities of the Day

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Abstract

Though past influences the present state, every day is a new day in the stock market. Hence, five forms of distributed lag model are used for analyzing data relating to opening prices of equities of 10 major companies for one year in BSE. This includes the analysis of day of the week effect. Equities of companies are not equally positioned in the market. So behavior of equity prices of no company can be generalized. Lags of daily opening prices explain the days of the influence of expectation built within the day. Influence of expectations of the day may be exhausted within a day or it lasts longer. It depends on the strengthening or weakening of expectations in subsequent days after the particular day. The paper focuses on differences, attributed to non-synchronous trading, between closing prices of preceding and opening prices of next days. Non-synchronous trading makes the market imperfect and oligopolistic in nature.

Results show the length of lags of opening prices of equities of 7 companies to be 2 and 1 for 3 companies. Closing price of preceding day decisively influences current day’s opening price but day of the week effect is not significant. Opening prices display stability and convergence to equilibrium; oft repeated thesis of volatility is refuted. The time taken by the opening prices of different companies to move back into their band of stability differs between the companies

JEL classification numbers: D630, G210
Keywords*:* Expectation, Opening Price, Equity, Non-synchronous trading,

1 Introduction

The paper examines the decisive determinants of current day’s opening prices of equities of ten selected companies of Bombay Stock Exchange (BSE). These ten companies together account for 30 % of total turnover of all companies included in BSE Index. It is postulated that opening prices embody the impact of closing price of the preceding day

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and are greatly affected by non-synchronous trading during the period intervening between the closing and opening of the market.

The study focuses on the following research questions:

(i) Is the opening price of the day determined mainly by closing price of preceding day and the returns associated with it?

(ii) Does the impact of non-synchronous trading during the period between closing on preceding day and opening of the market on current day mainly accounts for the observed differences between the closing and opening prices of equities of different companies?

(iii) Does the day of the week affect the opening price of current day?

(iv) Do opening prices of days explosively rise or fall within the day?

Exploration of answers to above research questions are the main objectives of the study. Cobweb like fluctuations of prices and flex-price theory constitute the base of models developed in the study for empirical analysis. Flex-price theory furnishes theoretical framework for the formulation of an appropriate econometric model(s) to determine opening price of the day.

1.1 Objectives of Study

The paper seeks to realize the following objectives**:**

(1) Determination of appropriate number of lags to be included in the analysis of data; this is despite the fact that auto-regression model and auto-correlation function have often been used for this purpose;

(2) Evaluation of impact of closing prices of preceding days, day of the week effect, and non-synchronous trading on opening prices of equities.

Realization of these objectives and exploration of answers to the research questions are linked to the following hypotheses.

Limited number of nested hypotheses is formulated as follows:

(i) There exists no *Day of the Week Effect* on opening prices of days because one day in the week is too restricted to influence opening prices of each day in view of the frequent changes in operational environment of the market even with a day. Each day is a a new day which may not be affected by *operations of one single day*;

(ii) Opening equity prices are not affected by preceding day’s closing prices, since the impact of closing prices and returns embodied therein is, by and large, nullified by the influence of non-synchronous trading on opening prices;

(iii) Influence of expectations of the day is not exhausted within a day; it is carried forward to influence the prices of subsequent days; it warrants the inclusion of lagged prices. This introduces lead- lag structure in the relationship, and hence, the opening prices of the day are assumed to change due partly to the lagged effect of past opening prices and expectations associated with the same;

(iv) Non-synchronous trading does not affect the market sentiment, and hence, opening prices remain unaffected by non-synchronous trading. It is assumed that the impact of non-synchronous trading is eliminated during the period of non-synchronous trading itself;

(v) Opening prices have long lags, but these prices never come back to initial equilibrium.

1.2 Broad Context of the Study

Stock market is treated as the barometer of health of a capitalist economy. Behavior of stock market reflects the macro fundamentals of an economy on the one hand, and it depicts financial status of the companies' stocks which are traded in the market on the other. Stock markets, however, develop in the process of economic growth both in terms of number of companies whose stocks are listed for trading, indigenous and foreign investment, brokerage companies, transactions and volumes involved in trading. *An interesting feature of stock market is that the size of all markets, including stock market of a dynamically growing economy, expands and no stock market returns back to its initial position even if the state of the market is disrupted by some big bang exogenous or endogenous event for a short while.* The stock markets continue to move upwards along with the growth of the economy.

Indices of opening, lowest, highest and closing prices of BSE from 2000 to 2012,, given in the Table 1, lend credence to this thesis:

Table1: Annual Indices of Equity Prices-BSE

Year/Index	Opening	Highest	Lowest	Closing
2000	5209.54	6150.67	3491.55	3972.92
2005	6626.49	9442.98	6069.33	9397.93
2008	20325.27	21206.7	7697.39	9647.39
2010	17470.45	21108.64	15651.99	20509.09
2011	20621.65	20664.80	15135.86	15454.90

Source: www.bseindia.com

The above table reveals that (i) indices of all four prices rose consistently from 2000 to 2008. But there was a reversal of trend after 2008 when world-wide economic slowdown adversely affected Indian economy also; (ii) Then, economic slowdown was succeeded by European debt crisis, which has affected Indian economy much more than economic slow-down of 2007-8. Decline in growth of the economy was accompanied by a decline in the indices of opening and the highest prices, while the indices of the lowest and closing prices have increased even during this period; (iii) Declining trend of indices continued from 2010 to 2011 except for the index of opening prices, which rose in 2011. These results amply support our thesis that the prices of equities tend to display long term growth, temporal trend reversals notwithstanding. Another inference deduced from above results is that economic growth conditions and guides the stock market, and hence, movements in equity prices, by and large. The hypothesis needs further investigation.***

1.3 Functions of Stock Market

Stock markets of capitalist economies perform several important functions some of which are highlighted hereunder. As the economy moves on its growth path, stock market mobilizes ever rising amounts of financial resources for investment for growth of the economy. Besides, stock markets differentiate between the companies through price differentials of their equities. Differences of equity prices of companies generally reflect market valuation of companies. Stock markets are also a conduit for the parking of financial resources, raised from different sources, by foreign institutional investors, insurance companies, mutual fund companies, corporate houses, market makers and individuals (Cf. Prakash, S. and Panigrahi, Ritisnigdha). Performance in stock market may also induce mergers and takeovers. Stock markets offer the platform to investors for disposing off unwanted securities and equities and for buying the desired securities/equities. Savers also find avenues other than the banks and insurance companies for investing their savings. Stock market also facilitates trading in the derivatives, including futures. It is not surprising that both policy makers and researchers have been paying much greater attention to the behavior of stock market in the globalised Indian economy since 1990-91, when New Economic Policy was adopted by government of India. This period has witnessed almost continual acceleration of growth till 2007-8. First world wide economic slow-down in 2007-08 and then current Euro-Zone debt crisis adversely affected growth of Indian economy, though slightly more than 6.2 % growth in 2011-12 is much higher than the earlier trend rate(s) growth during 1990s and 1980s. The economic slow-down has affected the Indian stock market also.

1.4 Past Studies of Behavioral Traits of Stock Markets

Day of the week effect on prices and volumes of trade has been the focus of several studies (See,French,K.R1980, Abraham, Abraham and Ikenberry, 1994, Barument and Kiymaz, 2001, Choudhury,T. 2000, Kumar, Hareesh, Madhusudhnan, and Deo, Malabika, 2006, Nagar, Singh and Mathura, 2009). Wednesday is postulated to be day of maximum volumes and high prices, while Friday is treated as the leanest day of the week. Some evidence has been garnered to support the thesis

Continuous oscillations, even if small but cumulative, make the equity prices volatile. It is, therefore, not surprising that many researchers focused on testing the hypothesis of efficient market (EMH) and volatility of both daily and weekly prices in stock market. Some studies used differences between opening and closing prices, or highest and lowest prices of the day for testing EMH/volatility by ARCH, GARCH and RWM models (Engle R 1982,Fama, 1965, 1970, Bhatacharya, Sarkar and Mukhopadhyay, 2003). Incidentally, such studies did not measure the degree of efficiency of the markets (For review of such studies, See, Prakash, S., Lamba, Manju, and Patel, G.N., 2012).

Most of these studies used weekly or even monthly prices to analyze volatility and/or EMH; weekly/monthly prices are average of averages of daily prices. Averages conceal more than what they reveal. Arithmetic average is sensitive to extreme values; and averages of daily prices are greatly affected both by the highest and lowest prices of the day and the range of their variation. Such studies peg rather than answer the question of volatility. Besides, the findings are mostly inconclusive (Among others, See,Dyl,E. and Maberly,E.1986, Fama, Pandey, Ajay, 2005, Prakash-Subramanian, 2006). Shri Prakash and Rama Subramanian (2006) approached volatility differently. They averred that *big bang change in stock markets occur only occasionally, while equity prices generally moved only in a narrow band*; *they delineated the bands of equity prices of eight companies over a period of seven years to support their thesis empirically.* But the use of weekly and monthly averages of equity prices, used in the study, constrained intra week and intra month volatility, empirical evidence furnished by authors notwithstanding.

All such studies miss the intra-day dynamics of change in prices and volumes, and hence, volatility of all prices that differ from opening and closing, or highest and lowest prices of the day. The intra-day price movements are outcomes of changing expectation profile. Understanding the behavior of equity prices remains a puzzle. There is still a vacuum, and hence, knowledge gap in understanding and explaining the behavior of equity prices, especially for the purpose of forecasting. No definitive theory has been propounded so far to explain the same. In this study, we attempt to capture the behavior of essential features of the opening prices of equity through appropriate econometric modeling.

However, study of Veysel, Hasan , and Serkan (2011) stands in contrast to the above; they analyzed intra-day volatility of equity prices in Istanbul stock market. Kendall and other analysts also highlighted the grave limitations of such studies. Then, a relevant question to ask in this context is whether expectations of different market players are amenable to averaging. If it were so, influence of bulls and bears on the behavior of market in different phases of business cycles would have not been important at all. The intra-day price movements are the outcomes of changing expectation profile. Understanding the behavior of equity prices therefore remains a puzzle. There is still a vacuum, and hence, knowledge gap in understanding and explaining the behavior of equity prices, especially for the purpose of forecasting. No definitive theory has been propounded so far to explain the same. In this study, we attempt to capture the behavior of essential features of the opening prices of equity through

In our view, assumption of stock market being competitive and efficient runs counter to observed facts, which have generally been overlooked in such studies. Efficient market implies that the market is competitive. If it were so, all information would have been equally shared among all stake holders, which would have eliminated all possibilities of insider trading. However, many instances of insider trading, which have come to light, contravene the assumption of free and equitable flow of all information among all stake holders in stock markets. What transpires during non-synchronous trading is hardly known to many.

Competitive markets are also characterized by homogenous products, irrespective of who is their producer/owner, so that one single price prevails in the market for all products. If stock markets were competitive, then equities of all companies would have been treated on par and all stocks would be sold at one single price during the entire day. This will rule out intra-day variation of prices. Consequently, opening, closing, highest and lowest prices of equities of all companies would be equal. Obviously, this is not the case. Besides, large number of buyers and sellers in a competitive market and tiny proportion of total sales or purchases made by each of them preclude any one player in the market to exercise any influence on price in the market. This is not the case with the stock markets where bulk purchases and sales of shares is common and big players swing demand or supply in a big way which does affect equity prices.

Free entry for all, absence of bias for or against any product or player in the market also prevails in a competitive market. But equities of companies, having better market positioning and brand image, is an inseparable facet of stock markets. Brand image of companies does make prices of equities vary between the companies. Thus, a priori reasoning on above lines will suffice to refute the efficient market hypothesis. Therefore, there is hardly any need to empirically test the efficient market hypothesis (Compare with Fama,1965, 1970, and Prakash, S. and Rama, Subramanian, 2006).

1.5 Rationale of Choice of the Topic of Study

Equity Prices, number of transactions, volume of trade, and returns (based on closing prices of the day) reflect the efficiency and productivity of stock market. However, equity prices, returns and volume of trade change many times or even instantaneously within the short span of a day. Equities of hundreds of companies are traded in the market. These features make it difficult to reckon every change in prices of equities, returns and volume of trade of all companies. Therefore, only opening, closing, highest, lowest, and averages of all above daily prices of equities of 30 companies are included in BSE index. These 30 companies account for a very high proportion of total trade in Bombay Stock Exchange. So, equities of ten of these 30 companies are selected for an in-depth analysis in this study.

1.6 Equity Prices and Changing Expectations

Continuous oscillations even small but cumulative, make equity prices volatile. Frequent intra-day price movements are outcomes of *swiftly* changing expectations. Expectations and resultant equity prices change even instantly and vary greatly amongst stake holders even within the short span of a day. This makes stock markets operate basically on expectations. Expectations are built and revised daily in the market. The influence of expectations can capture the essence of behavior of opening prices of the days. The opening price is the base for the day and it also reflects impact of non-synchronous trading. Distributed lag model may capture the effect of expectations and their modifications. This model can be used to explain or predict the day of the week effect and also expectations built on non-synchronous trading of the day on opening price of equity. The oscillations of equity prices in different phases of, the business cycles may, however, be captured by Cobweb model provided that the period of study is long enough. Cobweb model envisages the following three different states of price movement.

Understanding the behavior of daily equity prices, therefore, remains a puzzle despite numerous studies of different facets of equity prices. There is a vacuum and knowledge gap in understanding and explaining the behavior of daily opening, lowest, highest and closing prices of equities, especially for the purpose of forecasting. *Want of understanding or explaining becomes all the more difficult since* no definitive theory has been propounded so far *to explain the causes of movements of four core prices of the day*. Authors of this paper have made a modest attempt to study the determination of average prices of the day (Prakash-Bhatia Arora, 2011) and closing prices of the day (Prakash-Bhatia Arora, 2012). This study attempts to capture the essential features of behavior of opening prices of equities by Cobweb based distributed lag model. Stock markets operations are conditioned and guided by expectations of market players. Expectations are built and revised daily in the light of emerging state of the market. Distributed lag model, based on Cobweb like fluctuations in different phases of, the business cycles, can be used to explain or predict impact of (i) closing price of the preceding day; (ii) day of the week effect; and (ii) expectations built on non-synchronous trading during the period of closure on preceding day and opening of the market next day, on opening prices of equities of current day.

Price expectations of market players govern the demand for and supply of equities at different levels of prices at time of opening of the market for the day. Expectations of returns, based on closing prices of preceding day, may be modified under the influence of non-synchronous trading during the period of closure and opening of the market. *Opening price of the day reflects the impact of confluence of demand for and supply of equities at the time of opening of the market. Relative strengths of demand and supply determine the level of opening price and its price difference from the closing price of preceding day.* Closing price of preceding day may act as the bench mark for the opening price of next day, if non-synchronous trading does not alter expectations of returns in the direction opposite to that at the time of closure of the market last day (Prakash, S. and Bhatia Arora, Chitra, 2012). If, however, returns associated with the closing price of preceding day transform mind sets of market players, their expectations may be reformulated, which will impact the non-synchronous trading during the closure of the market. This will make the opening price of next day differ from the closing price of the preceding day. Besides, if the same business environment and expectations at the time of opening of the market persist during the day, opening price will positively affect the equity prices till the closing price of the day is settled. If, however, scaffolding of new business sentiment and expectations about prices materialize at any time during the day due to emergence of some new factor(s), equity prices will change in one or other direction and magnitude of change in prices will depend upon the strength of driver(s) of change. Investors may generally overlook the message conveyed by opening price of the day under such circumstances even within the day itself. Investors may also opt to wait for further scaffolding of the forces of the market to crystallize before they decide to buy particular equities during the day. Similarly, suppliers of equities may also play the waiting game; this will limit transactions and result in low volumes of trade These behavioral traits may explain the differentials between opening and closing prices on the one hand, and opening and highest/lowest prices of the day on the other.

1.7 Fragile Expectations and Cobweb-like Fluctuations in Equity Prices

Stock markets operate basically on expectations, which are built on past observations, experience of individual market players and their perceptions of changes in future prices. However, exogenous shocks and endogenous factors cause changes in business environment, which lead to frequent revisions/adaptations of expectations of market players daily in stock market. In fact, market players' perceptions, expectations and decisions and business environment of stock market are mutually related; they act and react to each other. The influence of expectations, based on returns furnished by closing prices of preceding day and non-synchronous trading may capture the essence of behavior of opening prices of the day. *Opening price is the base for all intra-day transactions and hence, prices that may come to prevail at different points during the day.*

1.8 Flex-Price Theory As Base of Equity Prices

J.R. Hicks (1939, 1965, 1973) distinguished between fix-price and flex-price markets in modern capitalist economies. Fix-prices are determined on the principle of cost plus. Markets of most of the manufactures approximate fix-price markets. Fix-prices change neither with every change in demand, nor such prices change in response to every change in cost. Fix-prices rise or fall in response to change in long run cost. If demand falls short of supply, intermediate traders, who are commission agents of producers, accumulate and hold the inventories; and if demand exceeds current supply, intermediate traders, who are takers of prices, absorb excess supply in inventories. Thus, intermediate traders' inventories are used to cover the supply demand gaps at prevailing prices in fix-price markets.

As against fix-prices, flex-prices prevail in agricultural, auction and stock markets. Independent intermediate traders (market makers in stock markets) are the makers of prices, and they accumulate or decrease their stocks in accordance with the expected rise or fall in future prices. Price expectations of market makers play a decisive role in their accumulation and inventory holdings, or release of inventories to the market from their holdings. In flex-price markets, the balancing of inflows and outflows and maintenance of balance between actual and desired holding of inventories' of market makers/intermediate traders represents the equilibrium state of the market (Prakash, Shri, 1986, Sharma, Shalini, 2004). Both the desired and actual holdings of stocks by market makers/traders crucially depend upon (i) current state of the market, and (ii) expected change in the state of the market. But expectations are characterized by fragility and variability. Expectations not only differ among different stake holders at any given point in time but the expectations of any stake holder tend to change quickly even at the drop of a hat. However, it is the expectations of dominant players, or the dominant expectation among all stake holders, which will make equity prices rise or fall. Magnitudes of rise/fall also depend on the quantum of expected change in price.

Naturally, stock markets, like other flex-price markets, do not operate in the same environment on all days and business drivers' expectations change even within the day. Expectations, the main determinant of all flex-prices, including equity prices, are fragile in nature. Changing psychology and perception of investors and traders in the market in response to both exogenous/external shocks or endogenous changes in business scenarios affect demand for and supply of equities even within the day. *These invisible and even imperceptible factors are the the dominant forces in stock markets.* Besides, *intermediaries constantly closely watch the market; they plays vital role of market makers in bringing market to equilibrium by bridging the gap between inflows and outflows of equities at given prices through their bids and asks*. *Demand-supply gaps are bridged at the prices chosen by market makers* (*Bids and Asks*). It is obvious that *Hicks' flex price theory closely approximates the 'expectation driven operations of market players'; and market makers' roles of 'price makers' and 'supply-demand gap fillers' is the pivot of equilibrium in stock market.* Stock market like all other flex price markets, are always in a state of stock equilibrium as against flow-stock equilibrium in fix-price markets. *Market Makers' 'Bids and Asks' and investors' expectations are the* dominant parameters to explain behavior of prices of equities. Certain expectations are built on closing price of the day, which prompts market makers to bid or ask, that is buy/sell the equities, if demand for and supply of equities diverge from each other.

Shares of different companies are viewed differently by stake holders. Hence, expectations of investors differ for shares of different companies. *On the opening of the market, opening equity prices may or may not be influenced by prices of the past*. If prices of stocks of some company *show considerable volatility even over short periods*, lagged prices will have no role in determination of current prices. Current equity prices will then be determined by current state of the market and status of the company. If, however, prices of equities of some companies depict either considerable stability in short run or move in a defined band with perceptible trend, investors' will expect the price movements of the past as guide posts for future, which will warrant the inclusion of lead-lag structure in the analysis of prices. Prices of equities of different companies may be expected to behave differently even in short periods of a day on this ground.

1.9 Models Based on Flex-Price Paradigm

This study uses basic elements of Hicks' flex-price theory for developing an appropriate econometric model for empirical analysis. Rudiments of flex-price theory are briefly described. Stocking behavior of independent intermediate traders (market makers in stock markets, who hold inventories of equities of different companies), based on their price expectations, constitutes the base of flex-price theory (See, Mathur, P.N. and Prakash, Shri, 1981, Prakash, S., 1986, Prakash, S., and Goel,V. 1994, Sharma, Shalini, 2004). Econometric model, based on Adaptive Expectation specification, may suit the objective of determination of equity prices in general and opening prices of the day in particular. *This model may approximate explosively divergent Cobweb model*, which will be appropriate to determine continuously upward moving daily equity prices from one equilibrium level to another in a dynamically growing scenario.

Distributed lag model may capture the effect of expectations and their modifications in the light of the changing state of the market during the operations in the day. This model may be used to explain and/or predict the influence of changing profile of expectations during the day till the highest/lowest price comes to prevail and also the impact of expectations built on non-synchronous trading on opening equity prices of the day.

Distributed lag multiple regression model has one dummy for non-synchronous trading, and second dummy for day of the week effect; and closing price of preceding day is also included as an additional explanatory variable. Closing price of the day is the base of expectations, which directly affects demand for and supply of shares during non-synchronous trading and at the time of opening of the market next day. However, expectations, based on returns associated with the closing prices, may be revised during non-synchronous trading. Then the question is to what extent preceding days' closing prices along with non-synchronous trading explain the changes in current day's opening prices.

If the day of the week continues to affect opening prices of all days, it warrants the inclusion of this variable also as an explanatory factor of opening prices of all days. But day of the week effect implies that maximum trading takes place on Wednesdays, while trading on other four days of the weak is relatively low. Low trade volume may also imply expectation of low volatility of opening prices of all days of the week. Volatility may be average out over the week to bring price stability if the day of the week effect is strong. But it does not totally preclude other possibilities.

So, all these three factors are included in the model as explanatory factors. The paper delineates the theoretical framework to explain the behavior of opening prices of the day with above variables as possible explanatory factors. It is postulated that opening price constitutes floor of the highest price and ceiling of the lowest price of the day. It is also hypothesized that the closing price of the day embodies some recovery after the price has touched its lowest level in the day. Thus, opening price of the day is assumed to delineate both the floor and ceiling of price movements during the day on *a priori reasoning.*

Shares of different companies are viewed differently by stake holders. Hence, expectations of investors differ for shares of different companies. *On the opening of the market, opening equity prices may or may not be influenced by prices of the past*. If prices of stocks of some company *show considerable volatility even over short periods*, lagged prices will have no role in determination of current prices. Current equity prices will then be determined by current state of the market and status of the company. If, however, prices of equities of some companies depict either considerable stability in short run or move in a defined band with perceptible trend, investors' will expect the price movements of the past as guide posts for future, which will warrant the inclusion of lead-lag structure in the analysis of prices. Prices of equities of different companies may be expected to behave differently even in short periods of a day on this ground.

The distributed lag model embodying Cobweb hypothesis with adaptive expectation specification may also be used to delineate the oscillations of equity prices in different phases of, the business cycles, provided that the period of study of daily prices is long enough.

2 Preliminary Notes

2.1 Cobweb Model Envisages the Following Three Different States of Price Movements

I. Static Cobweb Model incorporates price oscillations of constant amplitude. Amplitudes of oscillations in opposite directions are equal. Constant amplitudes of oscillations make the observed changes in prices in opposite directions perpetually move up and down round the base price. Initial price is never reached again but changes in prices always remain the same. These oscillations are stationary and no equity price will ever come back to its original level. This hypothesis is also not possible to substantiate with empirical evidence. In bearish phase each decline may be followed by a decline of greater magnitude till the trend is reversed in recovery phase in subsequent period. Recovery phase will experience the dominance of bullish operations. Thus, bullish and bearish phases alternate but the magnitudes of changes in prices are seldom equal. If unequal up and down changes continue to occur alternatively, this may capture the essence of actual changes in daily equity prices in the market.

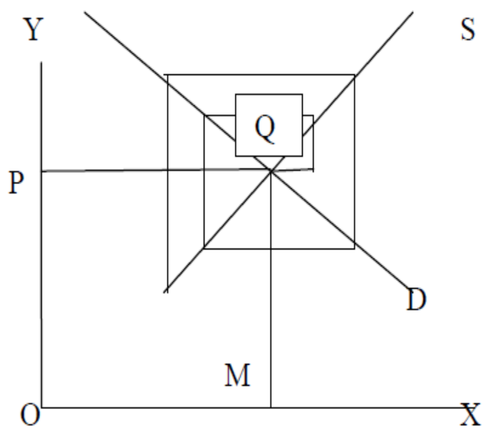
II. Convergent Cobweb model embodies damped price oscillations in so far as amplitudes of divergence from base price declines continuously with every change in price till the base price is reached again. This model is associated with the hypothesis of stable equilibrium price in the market. This hypothesis is difficult to replicate with the data of any stock market in a dynamic state of developmental flux, even though the oscillations may be cumulatively damped/explosively rising in the bearish/bullish phase. The magnitudes/amplitudes of cumulated downward/upward oscillations depend upon the duration of bearish/bullish phase.

II. Divergent Cobweb Model comprises explosive price oscillations and amplitudes of successive oscillations increase with every change in price, which moves the price farther and farther away from base price. In upward phase of the cycle, when bulls dominate, equity prices rise cumulatively, though there may be occasional decline Convergence towards the average of the week has a high probability. This hypothesis may be supported by empirical evidence from Indian Bombay Stock Exchange. This has, in fact, already been shown in preliminary part of the study. If similar expectations are cumulatively formed continuously over days, probability of prices moving up/down away from equilibrium will be very high; it will lend credence to Explosively Divergent Cobweb Model. This model incorporates downward as well as upward swings of increasing amplitudes. But *both troughs and peaks trace/map an ever increasing/decreasing trend of prices*. This model has great relevance for mapping the behavior of equity prices, including openings prices of the day. It is postulated that explosive cobweb model in different phases of cycles will capture the essence of the actual behavior of all equity prices, including opening prices of the day.

2.2 Determination of Equity Prices under Stable Demand/Supply Curves

The graph I given below depicts the behavior of prices in explosive Cobweb Model. The model underlying the graph assumes that both demand and supply respond to change in price, but neither conditions of demand, nor the conditions governing supply undergo any radical change. Consequently, quantities of demand and supply are depicted on curves D and S. Q is the point of Stable Equilibrium at OP price level. Q is the point of intersection of D and S under stable conditions of supply and demand. But Q is the point of intersection of demand curves D and S, to which prices never return due primarily to non-convergent expectations governing the respo nses of investors and supplier of shares.

Figure 1: Explosive Cobweb Model



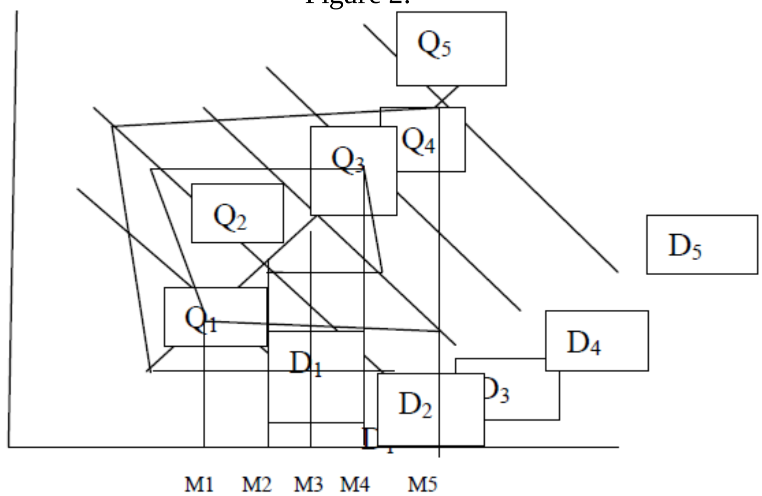
2.3 Determination of Equity Prices under Shifting Demand/Supply Curves

If, however, conditions of demand or supply of equities, especially expectations, change radically in a dynamic state of flux, then supply and/or demand curves will shift down or upwards and changing pattern of prices will present a picture different from the above**.** In the bullish phase, investors expect prices to rise in future which propels them to demand more equities at any given price(s) of equities; this leads demand to exceed supply, which pushes the price up. But the excess demand at earlier/lower price gets dissipated at higher price on the new demand curve.

Diagram-II depicts the changing states of the market, when supply conditions remain stable at its initial location, but the conditions of demand are altered substantially from one to another point of observation. The demand for equities shifts upwards from D_1 to D_2, from D_2 to D_3 and from D_3 to D_4, and from D_4 to D_5. Under the bullish conditions, demand at initial price rises to q_1 but the suppliers are not willing to supply, which pushes the price up. But at the higher price on new demand curve, excess of demand is dissipated with the result that the new price equates demand and supply again. Thus, every upward shift in demand curve leads to higher price. Naturally, prices are pushed up or pulled

down accordingly as demand rises or falls. Points $Q_{1,}$ $Q_{2,}$ Q_3, Q_4 and Q_4 depict shifting equilibrium at higher or lower prices than in the initial period. These points depict the fragile expectations being revised up or downward by investors in the bullish or bearish phase in the market.
Shifting equilibrium at higher/lower level of prices according to shifting demand curve with stable supply: Q_5-Q_4-Q_1-Q_2-Q_3

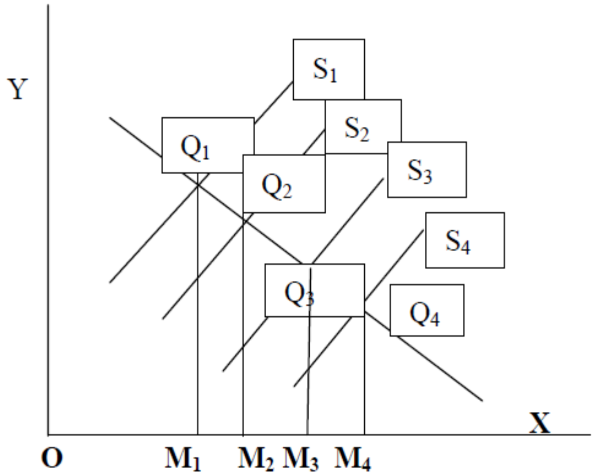
Figure 2:



2.4 Changing State of Supply in Market

It is also possible that the conditions governing demand remain stable but the conditions of supply change; consequently, supply curves shift up or down-wards in the process of change in expectations, which affect the equity prices of the day. In the bearish phase of the market, investors are not willing to raise their demand for equities at any given price due to want of buoyant price expectations. This keeps the demand curve stable. But the suppliers will be keen to offload their inventories of stocks at the given prices. This will result in the shifting of supply curve downward to the right. This leads to fall in equity prices with every downward shift in the supply curve. The prices change with every change in supply as the supply curve shifts up or down as is shown by the locations of S_1, S_2, S_3 $_{and}S_4$,. Equilibrium points Q_1, Q_2, Q_3, Q_3, Q_4 represent changing levels of equity prices. This is depicted by diagram three, given below.

Figure 3:



2.5 Length of the Lags and Auto-Correlation Function

Distributed lag model, like other auto-regression models, involves lags. The length of the lag needs determination for which auto-correlation function is generally used. Our experience shows that auto-correlation functions furnish extremely long lead-lag structure in the analysis of long time series data. Such functions also overlook multi-collinearity. Auto-regression performs this function better than auto-correlation function. It highlights multi-collinearity on the one hand, and yields fewer lags on the other. In view of multi-collinear auto-correlation functions, we have experimented with auto-correlation functions, based on partial rather than total regression coefficients in multiple regression analysis. Partial auto-correlation coefficients, derived from auto partial regression equations may furnish different results. Such results *will be experimental in nature in this study.*

If past prices influence current equity prices, length of lags reflects the time required for adjustment from actual to expected change, which is directly related to investors' expectations. Differences of sale and purchase decisions reflect the differences between expectations of owners of stocks and investors, which lead to oscillations in prices with these differentials. *Equilibrium of stock market is, in fact, the equilibrium of expectations of different market players/operators. This may be defined as expectation-al equilibrium. Oscillations of expectations result in oscillations in prices, while oscillations in prices lead to fluctuations in expectations, which increase with every rise or fall of prices in the market. The amplitude of upward and downward swings of prices depends on the stability of expectations and time lags involved in adjustment of expectations to given change in the market. Volatile expectations precede the volatility of prices in the market. Short term leads-lags structure of expectations leads to high degree of volatility in equity prices.* The distributed lag model used in the study captures the essence of these facets of market behavior along with impact of change in explanatory factors on opening prices of the day.

Changes in operations of the day influence formation or revisions of expectations during the the day in the light of unfolding of new scenarios in the market. This warrants

identification of lagged effect of expectations built up during preceding days. *We follow the well known dictum of Alfred Marshall (1891/1960) that force/strength of invisible, qualitative and non-measurable factors such as motivation, and expectation in our case, can be measured by the outcomes such factors lead to.* Besides, distributed lag models with partial adjustment or adaptive expectation specification are supposed to measure the impact of such factors on dependent variable of the function. *Underlying assumptions are that the adjustment to impact of change and adaptations of expectations is spread over several periods; and expectations are updated/adapted in the light of observed changes*.
For deriving an authentic and genuine rather than spurious regression model, data have been also been subjected to the test of stationary nature of the time series.

2.6 Dummy Variables in Distributed Regression Model

Identification of factors, associated with non-synchronous trading during the period of closure of market between two consecutive days, which account for differences between preceding day's closing prices and current day's opening prices, is needed for authentic analysis. If price is determined by the configuration of demand and supply, then why does demand and supply change after the closure of the market to make previous day's closing price different from current day's opening price? This paper attempts to explore the influence of such hidden facts of non-synchronous trading as affect opening price of the day and make it differ from the closing price of preceding day. As sufficient information about non-synchronous trading is not available, dummy variable is used as an explanatory variable in the distributed lag model.

2.7 Assumptions and Theoretical Thrust

Keynes General Theory of money, income and employment links investment in equities with money supply, demand for liquidity and interest rate. Investment depends on marginal efficiency of capital (MEC) and rate of interest (RI). MEC is the highest possible rate of return over cost from investment in an additional unit of capital asset. MEC =return- interest rate on additional capital asset. MEC is thus marginal productivity of capital. Cost refers to interest income foregone by investors. Interest rate, being largely an administered price, is relatively stable; it depends on money supply and demand for liquidity in money market. Keynes considers investment as an unstable factor. So MEC is also highly unstable since investors' psychology is centrally involved in investment decisions. Besides, MEC depends on prospective yield and supply price of the asset, which is based on current price and suppliers' price expectations. Prospective yields differ greatly according to investors' expectations. The positive gap between MEC and interest rate imparts inducement to investors.
Data Base: The study focuses on application of selected models to the data of Indian stock market. Period covered is from 1st January 2008 to December, 2008. Scripts of ten companies listed in BSE are analyzed in detail. These ten companies accounts for 30% of total volume of BSE Index.

2.8 Models and Methods

Alternative models for empirical application are outlined hereunder.

Model I: General Auto-Regression Model
Following is the general form of Auto-Regression Model of opening price of the day:

$$P_{ot}=\alpha_o+ \sum_j \alpha_j P_{ot-j} +U_t \tag{1}$$

P denotes equity prices, subscript t represents day/time, and j=1,2,3,…….t-1, shows the length of the lag involved in the relation of Y with its past values. In most of the cases, only a few lags will exhaust the influence of the past on the current value of the variable under consideration. This is especially true in case of stock market, where the sentiment may change almost instantaneously. We do not expect the value of j to go beyond 3/4 at the most in case of opening prices of the day.

II. Model of Auto-Correlation Function:
However, Auto-Correlation Functions (ACF) are estimated for 5 lags and the joint null hypothesis that there is no auto-correlation involved is tested by Box-Pierce Q and Ljung-Box Q* test statistics. These tests are applied both on total auto-correlation and partial correlation coefficients on an experimental basis to test the validity of our postulation that partial correlation coefficients are better guide to length of the lag than total correlation coefficients.

Auto-Correlation Function (ACF):
Auto-correlation function, a generalization and extension of the concept of correlation, is used if current value of variable, Y_t in time series analysis is related to its past value(s), Y_{t-s}**.** Concept *is extended to random errors of estimation being related to each other***.** Therefore, if Y_t is linearly dependent onY_{t-s}, coefficient of correlation of Y_t with Y_{t-s} is denoted by $\rho_{s.}$
For weak stationary time series**,** ρ_s is the function of s, length of the lag alone. ρ_s is calculated by as follows:

$$\rho_s=\{Cov(Y_t,Y_{t-s})\}/[\sqrt{\{Var\ (Y_t)\ Var(Y_{t-s})\}}]=Cov\ \{(Y_t,\ Y_{t-s})\}/\{Var\ (Y_{t},)\}=\boldsymbol{\gamma_s/\gamma_0} \tag{2}$$

Var (Y_t)=Var(Y_{t-s}) is a property of weak stationary time series.

It is inferred from relation 3 that $\boldsymbol{\rho_0=1}$ and $\boldsymbol{\rho_s= \rho_{-s}}$**.** Stationary time series is not auto-correlated, only if $\boldsymbol{\rho_s =0}$ for all s>0. Substitution of s=1,2,…,t-1 in relation 3 furnishes auto-correlation coefficients of desired length of the lag. If Y_t is distributed normally, auto-correlation coefficients will also be normally distributed so that $\rho_s^{\wedge}\sim$ approximates N(0, 1/T). T is sample size, $\rho_s^{\wedge}$ is the estimate of auto-correlation coefficient at lag s from the sample. This facilitates testing of significance of auto-correlation coefficient on the assumption of normality of distribution. Non-rejection rejection of null hypothesis, H_1 at 0.05 probability level is given below:

$$(+-)\{1.96x\ 1/(\sqrt{T})\} \tag{3}$$

for s=/=0.

If $\rho_s^{\wedge}$ falls outside the above range for lag s, then the *Null Hypothesis* that the coefficient in the population *is zero* is rejected. This is usual t test criterion. This test is a bit cumbersome as it is to be applied for each length of the lag. It is, therefore, preferable to set up the test for evaluation of joint hypothesis for given lengths of the lag: s=1,2,3,….

Box-Pierce Q Test of Joint Hypothesis

Generalized hypothesis, that m values out of s autocorrelation coefficients, $^\wedge\rho_m$ are zero, can be tested by Box-Pierce (1970) Q statistic, which is as follows:

$$Q=T^*\sum \rho_s^{\wedge 2} \tag{4}$$

T is sample size and m is the maximum length of lags for which joint hypothesis is tested. Q-test uses squared values of $\rho_s^{\wedge}$ for eliminating possible negative values cancelling out positive values of $\rho_s^{\wedge}$. Besides, Q, sum of squares of independent standard normal variable, $\rho_s^{\wedge}$, is asymptotically distributed like χ^2_m with degrees of freedom equal squared values of $\rho_s^{\wedge}$ in the sum under null hypothesis that all m autocorrelation coefficients are zero.

For joint hypothesis test, only out of m coefficients is required to be significantly different from zero statistically for the rejection of the hypothesis.

Limitation of Box-Pierce Q-Test

Q test has poor small sample properties, which may lead to incorrect decision to accept/reject the null hypothesis in small samples. Ljung-Box Q* test (1978) is a modified version of Q test; it has better small sample properties than Box-Pierce test:

$$Q^*= T^*(T+2)^* \sum_{m=1} (\rho_s{}^2)/(T-m) \tag{5}$$

$$Q^*\sim \chi_m^2.$$

In relation 5, T-m out of T+2 terms will cancel out; this will make Q* equivalent to Box-Pierce test. Q/Q^* test is known as Portmanteau test of Joint Hypothesis**.**

Calculated values of Q/Q*:χ_m^2 are compared with table value for the given degrees of freedom for testing statistical significance.

The Q^* test is very useful in as a general test of the linear dependence of values in the time series.

Model II: Distributed Lag Model: Partial Adaptation of Expectations

It is assumed that the expected opening price of the day depends on day of the week effect and non-synchronous trading. This leads to the following model relation:

$$Y_t=\alpha_0+ \alpha_1DV_1 +\alpha_2DV_2+U_t \tag{6}$$

Due to frictions, imperfect foresight, inertia, and ignorance actual adaptation of expectation to a change in opening price of the day is only a fraction of the desired adaptation/adjustment so that the following relation holds:

$$(Y^*_t- Y_{t-1})=\lambda\ (Y_{t-}\ Y_{t-1}) \tag{7}$$

$$\mathbf{0}<\lambda< =1$$

Substituting for un-observed Y^*_t from 7 into 6 will yield the following relation:

$$Y_t = \alpha_0 + \alpha_0 Y_{t-1} + \alpha_2 DV_1 + \alpha_3 DV_2 + U_t \quad (8)$$

Left hand side of 7 shows the expected/desired/change to occur, while right hand side depicts the change that actually materialized from preceding day's opening price to the current day's opening price. This specification combines partial adjustment hypothesis with adaptive expectation model.

2.9 Assimilation of Models

The model given below assimilates all earlier models into a unified whole. Impact of day of the week effect and non-synchronous trading on opening price of the day is evaluated by dummy variables. Day of the week effect refers to Wednesday in Indian context. Wednesday falls in the middle of the trading week; equity prices are assumed to have recovered from the impact of Friday's 'wait for the next week' sentiment, and Monday follows lull after closure of the market for two consecutive days of the week. Existence of day of the week effect indicates that the current equity prices are influenced by the prices of the day of the week. Day of the week and non-synchronous trading are treated as binary variables: 1 is assigned for Wednesday to D_1 and 0 for all other days of the week, and if the opening price of the day is greater than preceding day's closing price, 1 is assigned to DV_2 otherwise it carries a zero value. The model is reported below:

$$P_{ot} = \alpha_o + \Sigma_j \alpha_j P_{ot-j} + \alpha_2 Pc_{t-1+} \alpha_2 DV_1 + \alpha_3 DV_2 + U_t \quad (9)$$

Step-wise regression (Klein,L.R., 1965) is used to retain or drop above variables from the model according to the test criterion. It also facilitates detection of presence, seriousness and pattern of multi-collinearity, if any. Opening price of the day is postulated to be closely related to closing price of the preceding day, if non-synchronous trading does not affect it. In fact, difference between opening and closing prices is assumed to reflect the influence of factors that affect non-synchronous trading from the time of closing to the time of opening next day.

As a part of distributed lag model, it is assumed that current opening price is affected by the preceding periods' opening prices.

Investors build expectation of next day's opening price on the basis of preceding day's closing price. It pertains to short duration of lag. As expectation exhaust within the day, it may be considered that higher closing price will carry positive sentiments for next day also unless some major disturbance does not occur. Further Engel-Granger test is applied to analyze the validity of preferred regression model.

An important aspect of opening price is that it reflects the influence of non-synchronous trading which creates a difference between previous day's closing price and current day's opening price. Opening price of the day may be the same or it may be higher than the preceding day's closing price, if market sentiment remains the same or becomes positive. If non-synchronous trading makes market sentiment negative, opening price may be lower than the closing price of preceding day. Length of the lag shall be determined on the basis of empirical results. Lags involve the process of adjustment of price to exogenous/endogenous shock. Market adjust itself in the short or long term; time involved in adjustment determines length of lags, thought lags are affected by by several factors (Gujarati and Sangeetha, 2006).

3 Empirical Results

Empirical results, derived from application of models outlined above, are reported sequentially company wise.

3.1 Results of Application of ACF

First we examine the results of application of ACF, which is required to determine the length of lags to be retained in final analysis. The fact that longer length of lags weakens the impact of lagged values on current value of the variable prompted us to examine only 5 lags. Choice of length 5 of lags is arbitrary, though it has been guided by past research experience. Results are reported in the Table 2.

Table 2: Auto-Correlation Coefficients of 5 Lags

Company	Lag1	Lag2	Lag3	Lag4	Lag5	Q	Q*
HUL	.907518	.862	.803	.742	.696	794.78	817.96
SUZLON	0.971	0.942	0.911	0.876	0.837	1010.5	254798.26
RelCom	0.990	0.983	0.975	0.966	0.960	1166.2	1198.19
DLF	0.993	0.987	0.979	0.9723	0.966	1175	1209
Rel Ind	0.988	0.975	0.963	0.952	0.9425	1144	1180
ICICI	0.991	0.983	0.975	0.966	0.957	1163	1192
Bharti	0.942	0.903	0.867	0.833	0.804	929.28	956
NTPC	0.967	0.947	0.928	0.905	0.882	1050.5	1077
GAIL	0.986	0.971	0.956	0.941	0.929	573	1149.78
ITC	0.872	0.776	0.676	0.548	0.469	794.8	586.9

The results lend credence to the hypothesis that as the length of the lag increases, impact of lagged values declines. Value of auto-correlation coefficients declines for each successive lag from first to last coefficient for all 10 companies. However, absolute values and magnitudes of decline in coefficients differ between the companies. Box-Pierce Q and Ljung-Box Q^* tests, based on χ^2 distribution for testing joint hypothesis, show that calculated values of χ^2, associated with Q and Q$*$ tests, for all companies are greater than the critical value of 160 for 224 degrees of freedom at .01 probability level. Therefore, the joint null hypothesis, that all five auto-correlation coefficients of ACF are statistically not significant, is rejected. This will justify inclusion of 5 lags in auto-regression model. So, j=5 may be the right choice in model 9 It may, therefore, be concluded that the opening prices of any day are influenced by 5 previous days' opening prices.

Table 3: Partial Correlation Coefficient

company	r12.3	T	r13.2	T	r23.1	T
Rel Com	0.653802	20.39994	0.148631	15.49988	0.653802	20.39994
DLF	0.605699	19.3337	-0.01926	15.26944	0.793007	25.39566
Suzlon	0.726859	22.07853	-0.08047	14.7222	0.725804	22.04839
HUL	0.590465	17.52418	0.21626	13.69841	0.589351	17.50357
ITC	0.496064	17.3003	0.488924	17.19939	0.492106	17.29792
Rel Ind	0.716478	22.06518	-0.036	15.10759	0.735444	22.71706
ICICI	0.689781	21.33455	0.044996	15.33069	0.689781	21.30483
Bharti	0.635541	18.93317	0.137824	14.17462	0.635541	18.93317
NTPC	0.624638	19.30851	0.179222	14.97685	0.631815	19.4596
GAIL	0.74205	22.93742	-0.073	15.15394	0.723624	22.19777

Table 4: Q and Q* of ACF of 3 Lags

Company	Q	Q*
Rel Com	214.8662	221.1331
DLF	244.0451	251.1631
Suzlon	260.0901	267.6761
HUL	181.9744	187.2819
ITC	178.1872	183.3843
Rel Ind	258.601	266.1436
ICICI	233.6371	240.4516
Bharti	202.571	208.4793
NTPC	201.2634	207.1336
GAIL	264.5019	272.2166
Companies	Q	Q*
HUL	539.1424	550.3279
SUZLON	648.7472	662.2067
RelCom	706.7948	721.4586
DLF	711.992	726.7636
Rel Ind	696.2784	710.724
ICICI	707.112	721.7824
Bharti	598.532	610.9497
NTPC	656.848	670.4756
GAIL	690.2272	704.5473
ITC	443.9092	453.1189

3.2 Step wise Regression Modeling

We subject the determination of length of the lag to further testing by inclusion of lagged opening prices for all these ten companies in auto-regression model. Results are grouped on the basis of length of the lag for the companies. Seven out of 10 companies have two significant lags, while other three companies have only one significant lag in the auto-regression model. Company wise results are reported hereunder:

Table 5: Dependent variable Opening Price

Company	Intercept	P_{ot-1}	P_{ot-2}	P_{ot-3}	R^2	F
NTPC	7.67071	0.9561			0.9373	3485.76
(t)	(2.554)	(59.04)				
	7.5211	0.7801	0.17631		0.9378	1742.7
(t)	(2.50)	(12.09)	(2.77)			
	7.5197	0.7716	0.1442	0.0404	0.9361	1118.08
(t)	(2.46)	(11.69)	(1.74)	(0.62)		
ITC	8.8524	0.9533			0.9084	2311.69
(t)	(2.30)	(2.30)				
	7.776	0.8006	0.1579		0.911	1183.27
(t)	(2.50)	(12.09)	(2.77)			
	7.40	0.788	0.113	0.058	0.9106	777.6
(t)	(1.89)	(11.96)	(1.35)	(0.89)		
HUL	21.85	0.906			0.8235	1087.78
(t)	(3.43)	(3.4)				
	17.297	0.873	0.653		0.831	1087.78
(t)	(2.700)	(11.021)	(3.395)			
	17.73	0.7152	0.2411	-0.032	0.8307	374.79
(t)	(2.7)	(10.82)	(3.027)	(-0.492)		
Rel.Com	3.57	0.987			0.980	11821.216
(t)	(0.801)	(108.72)				
	2.79	0.834	0.154		0.980	5919.004
(t)	(0.625)	(12.81)	(2.382)			
	3.185	0.845	0.217	-0.074	0.980	3877.214
(t)	(0.707)	(12.81)	(2.54)	(-1.132)		
GAIL	6.39	0.97			0.96	5695.8
(t)	(1.29)	(75.470)				
	5.21	0.84	0.141		0.96	2895.47
(t)	(1.05)	(12.81)	(2.153)			
	4.10	0.821	0.026	0.136	0.96	1959.7
(t)	(0.83)	(12.48)	(0.31)	(2.074)		
Bharti	54.391	0.930			0.887	1833.84
(t)	(3.124)	(42.823)				
	46.539	0.7957	0.1443		0.887	914.63
(t)	(2.635)	(12.24)	(2.247)			
	45.57	0.7893	0.1043	0.0474	0.887	914.63
(t)	(2.529)	(11.959)	(1.246)	(0.72816)		
DLF	4.124	0.986			0.9857	16086.12
(t)	(0.868)	(126.8)				
	3.980	0.8925	0.0938		0.985	7902.915
(t)	(0.8338)	(13.633)	(1.441)			
	4.995	0.899	0.1831	-0.0971	0.985	5198.48
(t)	(1.0438)	(13.720)	(2.086)	(-1.487)		

All regression coefficients of first two functions with two lags for these 7 companies are highly significant; it may, therefore, be inferred that lagged opening prices of two preceding days positively and significantly affect opening price of the current day. Regression coefficients, attached to second and third preceding days opening prices are not significant. Presence of third lag makes the coefficient of second lag not-significant; transformation of significant into not significant coefficient in this function is accounted by multi-collinearity. These results validate our thesis that ACF is not a full-proof criterion for the determination of the length of the lag; auto-regression model performs this function better. Subjective choice of 5 lags in ACF also turns out to be logical on this count.
Length of the lag is different for the remaining 3 companies. Their results are reported hereunder:

Table 6: Dependent variable Opening Price

Company	**Intercept**	P_{ot-1}	P_{ot-2}	R^2	**F**
Suzlon	9.68	9.68		0.946	4100.917
(t)	(1.1705)	(64.03)			
	10.88	1.008	-0.0657	0.943	1922.38
(t)	(1.30)	(15.389)	(-1.031)		
ICICI	5.7563	0.9878		0.982	12659.01
(t)	(0.8087)	(112.512)			
	5.6562	0.9342	0.0534		
(t)	(0.79)	(14.23)	(0.82)		
Reliance India	18.9007	0.9879		0.975	9295.68
(t)	(0.84)	(96.41)			
	18.3128	1.0147	-0.0262	0.975	4581.35
(t)	(0.80)	(15.44)	(-0.40)		

Only two rather than three functions for these companies are reported above, since the coefficient attached to the second lag is not significant. It means that the length of the lag for these three companies is only 1. It implies that the behavior of opening prices of the day for these three companies differs from the behavior of other 7 companies. It may therefore, be generalized that for capturing the essence of structural differences in the behavior of equity prices, company wise analysis of data is warranted.

3.3 Auto-Regression Model with Closing Price of Preceding Day and Day of the Week Effect

As a part of experimental design, the following model, which is a truncated part of model 9 was applied first on the data of 10 companies. For 7 companies two and for 3 companies only one lag was included in the model with day of the week effect dummy and closing price of preceding day as explanatory factors. The coefficients attached to the lagged values of opening price of the day and closing prices of the preceding day are significant. But the coefficient attached to the day of the week effect dummy is not significant in any of the ten functions. For the sake of economy, results are not reported here, which are available with the authors.

3.4 Auto-Regression Model with Closing Price of Preceding Day

Preceding day's closing price is a significant determinant and day of the week effect is found superfluous in the earlier model. Therefore, dummy for the day of the week effect is dropped from the model. The results are reported in table 7.

Table 7: Auto Regression Model with Closing Price as Determinant

Company		Intercept	Lag1	Lag2	Pc_{t-1}	R^2	F
NTPC		-2.056	-0.114	0.052	1.074	0.99	8812.81
	t	(-1.789)	(-3.37*	2.20*	(37.78)*		
ITC		0.235	-0.0387	--	1.0381	0.979	5492.956
	t	(0.126)	(-1.06)	--	28.25*		
HUL		9.268	-0.103	0.070	0.993	0.97	2613.566
	t	(3.50)	(-2.89)*	(2.62)*	33.68*)		
Suzlon		-0.074	0.066		0.940	0.998	64985.72
	t	(-0.049)	(6.06)*		(82.27*		
Rel Com		-1.22	-0.165	0.095	1.074	0.99	30397.75
	t	(-0.75)	(-4.74)*	4.03*	38.98*		
GAIL		0.540	-0.174	0.034	1.141	0.985	5184.7
	t	(0.17)	(-2.5)*	(0.814)	(18.47 *		
Bharti		-5.215	-0.0616	0.0185	1.0508	0.975	3105.103
	t	(-0.62)	(-1.45)	(0.615)	(28.98)*		
ICICI		-3.89	-0.0718		1.0768	0.99	28755.72
	t	(-1.152)	(-1.92)*		28.488*)		
Rel Ind		1.457	-0.056		1.05	0.99	26359.96
	t	(0.1516)	(-1.738)		(32.6)*		
DLF		-3.106	-0.05		1.0603	0.997	49106.28
	t	-1.597	-1.759		34.25 *		

Following conclusions flow from the above results (1) regression function with preceding day's closing price along with lags explains opening price of the day satisfactorily; (2) coefficient attached to the preceding day's closing price is statistically significant in all functions; (3) Coefficient of first lagged value of the opening price is statistically significant in 6 out of 10 functions. Coefficient of first lagged value is significant in all 10 cases in the model used to determine the length of lags. Hence, the non-significance of these 4 coefficients may be attributed to multi-collinearity with which one has to live. The presence of serious multicollinearity is further established by the negative sign of 9 out of 10 of these coefficients; (4) second lag was used only in 5 selected functions in view of previous results. Only 3 of these five coefficients are significant. But the non-significance may again be attributed to multicollinearity.

@ We have applied Harvey model to test the stationarity of opening price which has provided that opening price is non-stationary. Hence we have moved to Enger –Granger test

3.5 Engel-Granger Test of Unit Root of Residuals

Engel-Granger test is applied on the results of above model to test whether regression function is genuine. Results are reported hereunder:

Table 8: Dependent variable Δu_t

Company	U_{t-1}	R^2	F
NTPC	-1.06827	0.5343	267.30
T	(-16.5)		
ITC	-1.00016	0.99	1210424.77
T	-1100.19		
HUL	-1.004	0.99	457131.14
T	(-676.114)		
Suzlon	-1.0008	0.998	185941.52
T	(-431.20)		
Rel Com	-0.96	0.480	214.6103
T	(-14.64)		
GAIL	-0.95	0.47	211.037
T	(-14.527)		
Bharti	-0.845	0.0442	10.779
T	(-3.283)		
ICICI	-1.0501	0.242	74.75
T	(-8.646)		
Reliance India	-1.0287	0.515	247.731
T	-15.73		
DLF	-1.036	0.52	253.85
T	-15.93		

As sign of all coefficients of U_{t-1} is negative and τ indicates their significance, the root of all above regression functions is less than unit. Hence, these functions are genuine.

3.6 Effect of Non-synchronous Trading on Opening Prices

We have experimented with the following two models of non-synchronous trading. In view of strong multi-collinearity due to the inclusion of lagged values of opening prices in the model, lagged values of opening prices of the day is not a part of this experiment.

$P_{ot}=\alpha_o+\alpha_1 P_{ct-1+}\alpha_2 DV_2+U_t$

Results of application of above model are reported in table 9; dummy variable, DV_2 depicts non-synchronous trading:

Table 9: Closing Price and Non-Synchronous Trading

Companies		Intercept	Pct-1	DV2	R^2	F
Gail		-9.02622	0.99004	22.532	0.96	3178.785
	T	-1.8293	79.59	10.7642		
DLF:		-11.2405	1.00407	16.1084	0.99	90714.21
	T	-7.286	(424.05)	(14.21)		
Rel Com		-6.4402	1.00216	11.2447	0.99	81299.42
	T	(-5.08142)	(402.27)	(14.91)		
Suzlon		-11.1518	1.00725	20.1447	0.9984	74215.69
	T	(-5.70095)	(384.4673)	(8.65157)		
HUL:		3.3541	0.9764	3.63459	0.9923	7455.075
	T	(1.783)	(122.07)	(14.735)		
ITC:		-0.6418	0.9923	3.8565	0.989	11099.68
	T	(-0.4901)	(146.59)	(15.239)		
Reliance India:		-33.909	1.0072	44.831	0.997	41240.13
	T	(-4.129)	(282.57)	(11.6237)		
ICICI		-16.0624	1.00394	25.804	0.9981	61194.46
	T	(-6.596)	(349.135)	(16.385)		
BHARTI:		-6.907	0.996	18.2966	0.987	9318.62
	T	(-1.1637)	(133.361)	(14.77511)		
NTPC:		-3.9129	1.009	3.973	0.995	27005.58
	T	(-4.80675)	(231.3401)	(231.3401)		

The above results show that (i) Model fit the data well. Proportion of total change in opening price of the day which is explained by this model ranges from 96 to 99.8 per cent. This model appears a bit more satisfactory than auto-regression model with closing price of preceding day as explanatory variables on this count. Besides, coefficients of both the explanatory variables are positive and significant The results of this model suggest that the one or two significant lags in previous model usurp the influence of non-synchronous trading on the opening price of the day when this dummy is not included in the model.

These results reflect not only the existence of Non-Synchronous trading in the market but its significant influence on opening price of the day. Besides, our approach to treat the difference between closing price of preceding day and opening price of current day as an indicator of influence of non-synchronous trading is validated by the results. Results also validate the criterion of assigning zero and unit values to the dummy. Non-synchronous trading alters the expectation built on closing price of the day and it brings new expectation almost daily into operation. Influence of non-synchronous trading also lends credence to the use of Cobweb model to analyze variations of opening equity prices.

3.7 Cobweb Model

Above results of ten companies have common observation that opening prices have maximum two lags. Short lead and lag structure indicates explosive or damped fluctuations in the market and provides an indication of swiftly changing expectations among investors and sellers in the market. Explosive or damped fluctuations in prices have no fixed amplitude; it depends on change. Such changes lead prices far away from initial equilibrium as these may generally be *cumulatively* explosive in nature. Cobweb model is appropriate to capture amplitudes of such changes in the opening prices.
The following Cobweb model is estimated by OLS:

$\Delta Yt=\alpha_o+\alpha_1 T$,

Where ΔYt shows difference between the highest and lowest prices of the week (Amplitude) and T depicts time. Each value of the amplitude indicates change in the movement of prices. Results are reported in table 10.

Table 10: Cobweb Model of Change with Time

companies		Intercept	T	R^2	F
Suzlon:		65.5	-1.39	0.231	14.44951
	(t)	(6.1)	(-3.8)		
HUL:		11.476	-0.0118	0.000648	F0.030472
	(t)	(5.861)	(-0.174)		
DLF:		79.052	-1.2706	0.27825	18.50563
	(t)	(9.1339)	(-4.3018)		
Rel Com		54.038	-0.708	0.173	10.069
	(t)	(8.2578)	(-3.173)		
GAIL:		23.151	0.0508	0.001	0.05468
	(t)	(3.6328)	(0.2338)		
ITC		4.3904	0.4837	0.024	1.1805
	(t)	(0.336)	(1.0865)		
NTPC		15.248	-0.1695	0.0906	4.782289
	(t)	(6.71)	(-2.186)		
Bharti:		41.067	0.2319	0.0149	0.728
	(t)	(5.154)	(0.853)		
ICICI:		96.632	-1.1413	0.219	13.7636
	(t)	(10.513)	(-3.7099)		
Rel Ind:		138.617	-0.2178	0.001705	0.08028
	(t)	(6.275)	(-0.2833)		

The above table highlights the following important features of fluctuation of prices in BSE: (i) Three coefficients of time are positive but not significant statistically. It implies the amplitude of change to be as good as zero; (ii) eight coefficients of time are negative which indicates that the fluctuations in the market are damped, and hence, equity prices tend to return back to the bench mark equilibrium in the market. This inference runs counter to the findings of studies which conclude that the equity prices behave in a volatile manner; (iii) However, two of these coefficients are not significant statistically. It means that prices of equities of 6 out of ten companies tend to be converging towards the stable equilibrium level. As against this, the equity prices of 4 companies do not diverge much from the equilibrium band.

The next important question is the period that the prices will take to come back to the stable level. This is calculated as follows from the model:

$\Delta Y_t=\alpha_o+\alpha_1 T,$

The convergence will be complete if change in price converges to zero->$\Delta Y_t=0$, so that we have the following relation:

$\alpha_o+\alpha_1 T,=0$
$T=-(\alpha_{o\,/}\,\alpha_1)$

Since the negative sign indicates convergence, it may be overlooked in calculation. The estimated periods of convergence are reported in the Table 11.

Table 11: Time of Convergence

Companies	T (Weeks)
Suzlon	47
HUL	965
DLF	62.24
RelCom	76.32
NTPC	90.22
Reliance India	636.4
ICICI	84.7
Bharti	177
ITC	9
GAIL	455.72

The maximum differences in the observed price from week to week will be reduced to zero over a period of more than 47 weeks. The period is too long relative to 48 observations of difference between highest and lowest price of the week , this will hold over a period more than one year only if the operational conditions of the market remain similar if not the same.

It is obvious that the Cobweb model captures the long term trend of the prices in the market by assuming that market conditions remain the same, this is taken as the norm as such markets do not exist. But it furnishes the standard for comparison.

4 Main Findings

1. Length of lags of the opening prices of equity of 7 companies is two, and it is one for 3 companies.
2. Closing price of the day plays a decisive role in explaining current day's opening prices of equities.
3. Day of the week effect is not significant.
4. Non-synchronous trading jointly with the closing price of the preceding day emerges as the main determinant of the opening prices of equities in BSE\
5. Results derived from Cobweb model show the opening prices of equities to display stability and convergence which refutes the oft repeated thesis of volatility.
6. The time taken by the opening prices of different companies to move back into their band of stability differs between the companies.

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