DEPENDENCE OF STOCK RETURNS AND TRADING VOLUME IN THE DELHI STOCK EXCHANGE

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CERTIFICATE

Certified that the dissertation entitled "*Dependence of Stock Returns and Trading Volume in the Delhi Stock Exchange*" submitted by *SOMSANKAR GHOSH*, in partial fulfilment of the requirements for the award of the degree of Master of Philosophy (M.Phil.) of this University, is a bonafide and original work to the best of our knowledge and may be placed before the examiners for evaluation. This dissertation has not been submitted for the award of any other degree of this University or any other University.

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DEDICATED TO MY

PARENTS

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The errors in, and failures of, the dissertation are entirely mine.

Som Sankar Ghosh

(SOMSANKAR GHOSH)

CONTENTS

INTRODUCTION

THE RATIONALE:

Till the end of the seventies, the role of the capital market in the financing of Indian industry remained marginal. Public sector banks and financial institutions played the dominant role in this field. The mid-seventies witnessed restrictions being imposed on the supply of bank finance to large scale industry. This was because of larger credit allocation to the priority sectors. The corporate sector, therefore, started looking more towards the capital market. In the face of gradual increase in demand for corporate finance through the capital market, several official committees were appointed to examine the changes needed to facilitate the same.

The role of the capital market in corporate financing underwent certain changes in the eighties and accelerated from 1989 onwards. A major thrust was provided to this process when in 1991, a new liberalised economic policy was adopted by the government.

Due to these developments taking place in the capital market, certain problems relating to investor protection, market regulation and technical upgradation of trading, clearing and settlement procedures have come to the fore.

The antiquated arrangements and rules of the Indian capital market have been found to be woefully wanting of major overhauling. There is mounting of investor complaints against issues of securities and market intermediataries on the one hand and increased market volatility on the other. The system seemed to be bursting at the seams and modernisation of the entire system appeared very urgent. Some developments, however, took place and more are required to make the capital market efficient in its operation.

The Securities and Exchange Board of India (SEBI) existed since 1988 but without any statutory authority. However, it was only in 1992 that it was given statutory powers. The SEBI was envisaged as the nodal authority for the securities market. Its main responsibilities are (i) investor protection and (ii) securities market development and regulation.

The statutory powers given to SEBI include the power to inspect those under its jurisdiction and the power to register and deregister. The SEBI framed regulations in the core areas of merchant banking, mutual funds, brokers, sub-brokers, insider trading and portfolio management. The inspection of stock exchanges also forms an important area of its activities. It also has two Advisory Committees one each for primary and secondary markets.

A policy of partial disinvestment of PSU shares was adopted. Shares of selected public sector undertakings were sold to investment institutions on the basis of competitive bids and have been listed on stock exchanges.

PSUs rely more on the capital market for raising money than on the government treasury. This is done generally by issuing bonds with no government guarantee. Interest rates on debentures of non-government companies were deregulated in 1991 and their credit rating made compulsory.

The private sector has been permitted to float mutual funds. SEBI is required to approve applications for the same and are then implemented.

Policy changes have also been made to encourage foreign direct investment and foreign portfolio investment. Moreover, selected companies have been allowed to float issues of shares and debentures in foreign markets and to get these listed on foreign stock exchanges. To this end, the limit of NRI portfolio investment in Indian companies has been raised from 5 per cent to 24 per cent. Reputed foreign financial institutions have been permitted to make portfolio investment in Indian shares and debentures. Permission has also been granted to Indian companies to issue shares and debentures in foreign markets. Such issues have been granted same concessions of tax as is given to offshore funds.

These developments in the Indian capital market that have taken place so far are only a part of the ongoing process aimed at making the secondary capital market efficient. Even these steps need to be scrutinized and implemented with vigour. Apart from these, other changes are also necessary to remove the market of its maladies and thus become efficient.

However, it is needless to say that Indian capital market with the recent developments have come a long way from the days preceding the liberalization. This provides us with a ground to study the relationship between price and volume transacted of shares in India and probe whether they have been effective in bringing about efficiency in the working of the capital market. The efforts of these aimed at developing the capital market can be said to bear fruit only if the benefits from it percolate down. The effect of these plans for modernization is easily felt on the bigger exchanges. The trickle-down effect becomes complete only when its pulse is felt on smaller stock exchanges where trading is thin.

This provides us with the rationale for our study based on grounds of Indian market-structure, market-efficiency and market rules and regulations.

The theoretical rationale for an investigation into the price-volume relationship is provided by Karpoff (1987). He enumerates four reasons as to why this relationship requires a closer look:

Firstly, the price-volume relationship provides an insight into the structure of financial markets. This takes into account the rate of information flow to the market, the way the information is disseminated, the extent to which market price conveys the information, the market size and the existence of short sales constraint.

Secondly, the price-volume relation is important for event studies that use a combination of price and volume data from which inferences can be drawn. When price changes and volume are jointly determined, incorporating the price-volume relation will increase the power of these tests. Changes in price and trading volumes are used by some to test for the existence of dividend clienteles. Price changes are also used to evaluate the arrival of new information into the market and the corresponding volume is considered an indication of the public's reaction to the meaning of the information.

Thirdly, the price-volume relation is critical to the debate over the empirical distribution of speculative prices. Rates of return appear kurtotic rather than nominal when sampled over fixed calendar intervals. Explanations to this observation is provided by (1) rates of return are characterized better by a member of a class of distributions with infinite variance, and (2) the distribution of rates of return appears kurtotic. This is because the data are sampled from a mixture of distributions that have different conditional variances.

Fourthly, price-volume relations have significant implications for research into the futures market. Price variability affects the volume of trade in futures contracts. This has bearing on the issue of whether speculation is a stabilizing or destabilising factor on futures prices. The time to delivery of a futures contract affects the volume of trading and through this effect, possibly also the variability of price. The price-volume relation can also indicate the importance of private versus public information in determining investors' demand.

However, these are only theoretical aspects which can be ventured into. In India, it is not possible to apply each of the above propositions because of either lack of availability of data or due to the fact that the Indian capital market is not all that developed (and so implications for research into the futures market should not be sought).

TECHNIQUE USED:

Our exercise here has been to investigate linear and non-linear dependence between change in share price and volume transacted in a small stock market, viz. Delhi Stock Exchange. For the purpose, we had used the daily closing price of the scrips of the 43 companies listed under group A of the Delhi Stock Exchange (DSE) and the volume transacted of these shares daily. Our period of study has been the post-structural adjustment programme initiated by the government of India in 1991. Due to irregularities in the Indian stock market coming to light in 1992, we concentrated on the period January 1993 to December 1994 in our study.

To test for the existence of linear dependence between change in share price and volume transacted, we have employed the technique of Granger causality. This, however, is the last of a three-step process. The first step involves testing for stationarity using the unit-root test. The next step checks whether the stationary series are cointegrated or not. If found cointegrated, only then does one go on to check for causality.

The Granger-causality tests concentrate on linear lead-lag relationships between stock price change and trading volume. The non-linear relationship is examined using Generalized Autoregressive Conditional Heteroskedasticity (GARCH) process. Attention has been restricted to a GARCH (1,1) specification since it has been shown to be a parsimonious representation of conditional variance that adequately fits many economic time series (Bollerslev [1986]).

However, before embarking upon the task of testing for dependence between stock price change and volume transacted, we attempt to review some of the previous and current research on the relation between price changes and trading volume in financial markets. This is done in chapter 1.

In chapter 2, we familiarise ourselves with the concept of cointegration and causality. Chapter 3 is concerned with the estimation, results and implications of the causality model. The concept of ARCH and GARCH is explained in chapter 4. It also deals with its estimation, results and implications. It is followed by the conclusion.

CHAPTER - 1

REVIEW OF THE LITERATURE

1.1 INTRODUCTION:

Academic treatment of price-volume relationship is not new to economic theory. Theoretical and empirical research into the field dates back to the early '50s. However, the simplicity of the earlier models - both in terms of methodology adopted and assumptions underlying the study, gave way to the use of sophisticated techniques and realistic assumptions with the passage of time.

An attempt to sketch the progress of academic research in the field is made in this chapter. Section 1.2 provides a brief overview of early research into the price-volume relationship. In subsequent research, two empirical relations emerge - (i) the correlation between volume and the absolute value of price change is found to be positive in both equity and futures market, and (ii) the correlation between volume and price change *per se* is found to be positive in equity markets.Section 1.3 has been organised to contain those research which supports the former while section 1.4 includes those which support the latter relation. Sections 1.3 and 1.4 have been further subdivided into subsections A and B. Subsection A looks into the empirical evidence supporting the relationship supported to in the section while subsection B takes care of the theoretical explanation of the relationship particular to the section. Section 1.5 reviews a model which shows the empirical relationships, mentioned above, to be mutually consistent.

1.2 Early Research:

Early research into the field can be traced back to Osborne (1959) wherein he attempted to model the stock price change as a diffusion process with variance dependent on the number of transactions. Later, he reexpressed the price process in terms of time intervals while assuming that transactions are uniformly distributed in time; the price-volume relationship was not directly addressed.

Empirical examination of price-volume relation was undertaken by many who could not find a correlation between prices or the absolute values of price differences and volume. Ying (1966) was motivated by these failures to apply a series of chi-squared tests, analyses of variance and cross-spectral methods to six years, daily series of price and volume. He measured price by the Standard & Poor's 500 composite index adjusted for dividend payments and volume was measured by the proportion of outstanding New York Stock Exchange shares traded. His findings can be listed as:

(1) A small volume is usually accompanied by a fall in price.

(2) A large volume is usually accompanied by a rise in price.

(3) A large increase for volume is usually accompanied by either a large rise in price or a large fall in price.

It is to be noted here that items (1) and (2) above suggest a positive correlation between volume and price change *per se*. The third item is consistent with a correlation between volume and absolute value of price change. Each of Ying's interpretations has been supported in subsequent tests and so we can rightly say that he was the first to document both price-volume correlations in the same data set.

However, Ying's methods are subject to certain criticisms because (1) his price series and volume series are not necessarily comparable and (2) his daily price series are adjusted by quarterly dividend data and the daily volume series was adjusted by monthly data on the number of outstanding shares, each using linear interpretation.

Among the early works are also those of Granger and Mergenstern (1963). They used spectral analysis of weekly data from 1839-1961. However, they did not find any relation between movements in a Securities and Exchange Commission composite price index and the aggregate level of volume on the New York Stock Exchange. Neither could they discern any relation between price and volume using data from two individual stocks. Godfrey, Granger and Morgenstern (1964) could not find any correlation between prices or between volume and absolute level of price differences. In this analysis, they used several data series including daily and transaction data for individual stock.

In our survey of the literature on the relation between price changes and trading volume, we divide the recent research in the field under two heads: (1) those which support that a positive correlation exists between volume and the absolute value of the price change, and (2) those which support that the correlation between volume and price change *per se* is positive in equity markets. These are, in turn, subdivided into (a) Empirical evidence and (b) Theoretical evidence.

1.3 Volume & the Absolute Value of the Price Change:

(A) Empirical Evidence:

Here we take a look at those empirical findings which supports what we call a "positive volume-absolute price change correlation"; however, the asserted causality can be called into question. Crouch (1970) found a positive correlation between the absolute values of daily price changes and daily volumes for both market indices and individual stocks. Using four-day interval and monthly data from a total of 51 stocks, Morgan (1976) noticed that the variance of price change was positively related to trading volume in all cases. The same relation was arrived at by Westerfield (1977) in a sample of daily price changes and volumes using 315 stocks as did Tauchen and Pitts (1983) using daily data from the Treasury bill futures market. A positive relation between the sample variances of price changes at given levels of volume and the volume levels using transaction data from 20 stocks was found by Epps and Epps (1976). Wood, McInsh and Ord (1985) also report a positive correlation between volume and the magnitude of the price change at the transactions level. Cornell (1981) found positive relations between changes in volume and changes in the variability of prices, each measured over two month intervals, for each of 17 futures contract. The relation was almost entirely contemporaneous, as most leading and lagged relations were statistically significant. Grammatikos and Saunders (1986) also found volume to be positively correlated with price variability. Comiskey, Walking and Weeks (1984) found a correlation between volume and absolute value of price change using yearly data on individual common stocks. Harris (1984) found a positive correlation between volume and the square of the price change using daily data from 479 common stocks. In subsequent articles, he showed that the strength of the correlation varied across securities. The correlation was found to be stronger for daily than for transaction data by him.

Smirlock and Starks (1988)[1] examine empirically the lagged relationship between volume and absolute value of price change in equity markets. Their study confirms a significant lagged relationship which is more prominent in short periods immediately preceding and immediately following quarterly earnings announcement. The results indicate that information arrival to investors tend to follow a sequential rather than a simultaneous process.

The results of the empirical studies put forth certain aspects which needed to be taken care of. Although there exists a positive correlation between volume and the absolute value of the price change, some of them indicate that the correlation is weak. Moreover, this correlation appears with price and volume data measured over all

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1 Simultaneous Information arrival hypothesis (SIH) is that when the complete information equilibrium (defined as the equilibrium when all traders have the information) is obtained in a single sound of trading. No intermediate equilibrium is assumed to exist. Sequential Information arrival hypothesis (SEQ) is the one concerning the lead-lag relationship between stock returns and trading volume. Here investors receive the information one at a time and trading occurs after each reception. Intermediate equilibria are assumed to exist under this hypothesis.

calendar intervals, but it appears weaker in transaction data.

(B) Theoretical Explanation:

Copeland (1976) had come up with the "sequential arrival of information" model where the information is passed on to one trader at a time and thus there exists a positive correlation between volume and absolute value of price change. The passing on of information causes an upward shift in each optimist's demand curve by a fixed amount δ and a downward shift of δ in each pessimist's demand curve. Trading occurs when the dissemination of information becomes complete and the uninformed traders do not infer the information from the activities of the informed traders. Moreover, short sales are prohibited.

Supposing a situation with N traders, of whom there are k optimists and r pessimists and N-k-r uninformed investors at any point of time. The values of k and r depends on the nature of information dissemination. Volume generated by a pessimist is generally less than that generated by an optimist because of prohibition of short sales. Thus the price change and trading volume when the next trader becomes informed depend upon (a) the previous pattern of who has been informed and (b) whether the next trader is an optimist or a pessimist. The total volume after all traders become informed depends on the way the equilibrium is reached. It is a random variable with an expected value equal to a weighted average of the total volumes under each possible path of information dispersion. It has been found under simulation tests that volume is higher when investors are either all optimists or all pessimists. The tests also indicate that the absolute value of price change is lowest at the same percentage of optimists at which the volume is lowest, and rises with volume. Thus we can say that it supports a positive correlation between volume and the absolute value of price change.

The model has been criticised on the ground that it assumes the uninformed traders to be naive since they cannot learn from activities of their informed counterparts. Secondly, the model's implication that volume is greatest when all investors agree on the meaning of the information, lends another point of weakness to it. Copeland explains that this is the result of the short sales constraint.

The "mixture of distribution hypothesis" (MDH) arose out of the need to explain a positive correlation between volume and absolute value of price changes in the speculative market. Epps and Epps (1976) derive a model wherein the variance of the price change on a single transaction is conditional upon the volume of that transaction. Transaction price changes are then mixtures of distributions with volume as the mixing variable. Their model is quite akin to the sequential information arrival model in that it places a particular structure on the way investors receive and act on the information. Apart from their own empirical study to supporting their contention, Wood, McIrish and Ord too confirm their results.

The other MDH model proposed by Clark (1973), Pitts and Tauchen (1985) and Harris (1983) separately, views the daily price change as the sum of a variable number m of independent within-day price changes. The central proposition of the models by Clark, Tauchen and Pitts and Harris is that transaction time intervals are variable. Clark's test use volume as a proxy variable for the number of transactions variable m and shows that the leptokurtosis in the empirical distribution of daily price changes largely disappear when the changes are grouped by volume classes. Empirical support to this is provided by Morgan (1976) and Westerfield (1977).

Harris assumes that the variation of m varies across securities and infers that sample measures of price change kurtosis, volume skewness and correlation of squared price change with volume should all be positively correlated across securities. Apart from his own empirical tests, the hypothesis was also supported by Upton and Shannon (1979).

The Tauchen and Pitts model says that the correlation between volume and absolute level of price change would increase with the variance of the daily rate of information flow. They also say that as the number of traders increase, the volume of trade increases and price variability decreases.

The MDH models in general imply no relation between volume and price change *per se* and this drawback may be due to short sales restrictions. However, it is not clear whether its inclusion would still imply a correlation between volume and price change *per se*.

Pfleiderer (1984) in his model provides another explanation of the positive correlation between volume and absolute level of price change by extending the information aggregation model. He establishes a rational expectations equilibrium in which speculators' private information is only partially aggregated by the market price because of noise introduced by life-cycle trading. The precision of private information increases speculative trading but the latter is uncorrelated with the absolute level of price change. Life-cycle trading, however, randomly affects the supply available to speculators. The volume of life-cycle trading thus has an effect on the magnitude of price changes. The model also implies that the strength of the correlation between volume and absolute level of price change increases with the relative importance of life-cycle trading in the market.

A glance over the models discussed highlights the fact that while the Epps and Epps model requires all investors to receive information simultaneously, the Clark, Tauchen and Pitts, Harris and Pfleiderer models can be mutually consistent with sequential information arrival. These models imply simultaneous dispersion of an information but they do not require it. The successive equilibria presumed by these models can result from a gradual dissemination of a single bit of information as in the sequential information arrival model or from a process in which investors receive information simultaneously. Generalised as these models are than sequential information arrival model because (i) they are consistent with either simultaneous or gradual information dissemination and (ii) they explain a greater number of phenomena. The MDH is consistent with the empirical distribution of price changes and the difference in the volume and absolute level of price changes, correlation over different frequencies.

1.4 Volume and The Price Change perse:

(A) Empirical Evidence:

Epps (1975, 1977) developed tests from the bond market and the stock market which indicate that the ratio of volume to the absolute level of price change is greater for transactions in which the price rises than for transactions when price falls. However, Wood, McIrish and Lord (1985) has conflicting evidence which says that the ratio of volume to absolute price change is higher when price faces a downswing. Smirlock and Starks (1985) found that this relationship holds only when the arrival of information, ex ante, could be distinguished. In other words, the ratio of volume to absolute level of price change is lower in upswings than for downswings; this is attributed to positive transaction costs and the lack of information arrival.

The findings of Epps, Hanna (1978) and parts of Smirlock and Starks may be said to imply a positive correlation between volume and price change *per se*. Such a correlation is found in the implications of Ying's results (i) and (ii). Rogalski (1978) found a correlation between volume and price change using the monthly data from 10 stocks and 10 warrants. Morgan (1976) and Harris (1986) each had found a positive correlation between price changes and volume as did Richardson, Sejeik and Thompson (1986) while trying to assess volume reaction to a change in dividend policy.

(B) Theoretical Explanation:

Attempts have been made by various authors to explain these findings. Morgan (1976) provides us with a suggestion that volume is associated with systematic risk, and through this to stock returns. Harris (1984 and 1986) indicates that the mixture of distributions hypothesis (MDH) implies a positive correlation between volume and price change *per se*, if the conditional mean of the stock-price process is proportional to the number of information arrivals. This in turn implies that the mean of the price change process is dependent on the same parameters as the mean of the volume process. However, he fails to clarify the way in which these implications would work to produce the desired results. On the contrary, the MDH with mean subordination is inconsistent with market equilibrium, since it implies the expected price change from an information arrival is positive.

Epps (1975) in his model implies that volume on transaction, where there exists a positive price change, is greater than for negative price changes. In order to explain his findings, Epps assumes two groups of investors - the 'bulls' and the 'bears'. The main point of distinction between a 'bull' and a 'bear' is that the 'bulls' are more optimistic about the value of the asset at the end of the trading period. They are assumed to react only to positive information about the asset's value. The 'bears' or the pessimists react only to negative information. The transactions demand curve in this market consists only of the demand prices of 'bulls', while the 'bears' comprise the transaction supply curve. Epps in his model shows that the relative optimism of the 'bulls' implies that the market demand curve is steeper than the supply curve. This however is conditional upon the appropriate assumptions about investors' utility function. As a result of this, the ratio of the volume to a positive price change (when the 'bulls' demands increase) is greater than the absolute value of the ratio of volume to a negative price change (when 'bears' demand decreases).

A major criticism that is often raised against this model, inspite of its widespread use and extension, is that it requires all investors to systematically and selectively ignore pertinent information. Investors are assumed to be irrational in their behaviour. The model makes a further irrational implication in that 'bulls' would acquire increasingly larger number of shares from 'bears' while the latter would increasingly hold negative quantities of shares.

Schneller puts forth two criticisms against Epps's model. He says that the assumption of the model is inconsistent with those of the mean variance approach. The mean variance portfolio selection model is valid only if (i) the distributions under consideration are normal or (ii) investors are characterised by quadratic utility functions. Epps, says Schneller, violates both these conditions.

The second criticism is that, even if one accepts the mean-variance framework as a working assumption, Epps' results do not follow.

Epps replies back that if the end of the period values (EPVs) are viewed as log-normal, then Schneller is formally correct in stating that the expected value of the utility of wealth function is inconsistent with the expected utility hypothesis.

To the second criticism, Epps says that while it is technical, it is quite important and is valid, although his arguments do not support it correctly.

Jennings, Starks and Fellingham (1983) provide an alternate theory consistent with the correlation between volume and price change per se. In fact, they were providing an extension of Copeland's sequential information arrival model to incorporate real world margin constraints and short selling. They put forth the idea that short positions are possible but are more costly than the long positions. Thus the quantity demanded of an investor with a short position is less responsive to price changes than the quantity demanded of an investor with a long holding. They showed that in many situations the resulting volume due to a pessimistic interpretation of a news by a previously uninformed trader, is less than when the trader is an optimist. Price is found to marginally decrease with a pessimistic seller and increases with an optimistic buyer and this is said to be the reason why volume is relatively high when the price increases and low when the price decreases.

Just like Copeland's model, this model of Jennings, Starks and Fellingham relies on a peculiar interpretation of heterogeneity across investors. They assume an economy with myopic investors; the model limits uninformed investors from learning from the trades of investors who are early in receiving the information. Moreover, it places emphasis on the behavioural distinction between groups of investors. The absence of documentation of a positive correlation between volume and price change *per se* in futures market where the costs of taking long and short positions are asymmetric, indicates that the differential cost of short sales is very likely one key.

Karpoff (1986) constructed a model that depends on asymmetries in the costs of going long and short. He finds that costly short sales restrict some investors from acting on their information when the effect is to decrease their demands. This decreases the variance of interperiod shifts in transaction supply relative to that for transaction demand, which in turn creates a positive covariance between volume and price change over the period. He substantiates his hypothesis with empirical tests that reveal the empirical relation between price change and volume found in stock and bond market data but is absent in futures market data.

1.5 A Synthesis of Previous Research:

A survey of the literature on the relation between price and volume reveals that (i) no volume-price correlation exists; (ii) a correlation exists between volume and absolute level of price change; (iii) the correlation is between volume and price change *per se*; (iv) volume is higher when prices increase than when prices decrease. Items (iii) and (iv) can be mutually consistent but it can be shown that (ii), (iii) and (iv) are all true (with a high degree of probability attached), at least in markets in which short positions are more costly than long positions. The reason for these seemingly inconsistent findings is that more tests are based on implicit assumptions that the price-volume relations are functional and/or monotonic, when it is likely that the volume, price change relation is not monotonic and volume - absolute level of price change relation is not a one-one function. Thus a researcher may find weak support for any one of the above hypotheses and stop looking for others.

*Define the sets of transformations

$W = \{w = w(\Delta p)/w'(|\Delta p|) > 0\}$

$X = \{x = x(\Delta p)/x'(|\Delta p|) > 0\}$

$Y = \{y = y(v)/y'(|v|) > 0\}$

Empirical tests have in general specified monotonic, linear relations between either $w \Sigma W$ or $y \Sigma Y$ or between $x \Sigma X$ and $y \Sigma Y$ (exceptions include the non-parametric tests of Epps, Smirlock and Starks or Harris). However, it is possible that volume (elements of the set Y) correlates positively with the elements of both sets W and X.

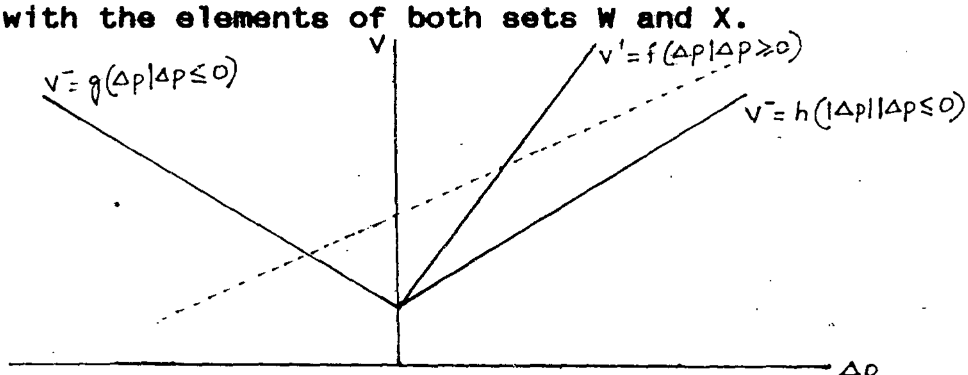

FIGURE 1
Illustration of an Assymetric Volume-Price Change Relation.

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* Contribution of Karpoff.

The figure assumes for simplicity that $w(\Delta p) = |\Delta p|$, $x(\Delta p) = \Delta p$, $y(v) = v$, and the expected volume is related linearly to the price change, but with a discontinuity at Δp

= 0 such that the relation is not monotonic. For positive price changes, the conditional expected volume-price relation is $V^{-} = f(\Delta p/\Delta p \geq 0)$, for negative price changes, it is $V^{-} = g(\Delta p/\Delta p \leq 0)$.

If $f' > /g'/$ is assumed, then for any given expected level of volume $E(V) = E(V^{+}) = E(V^{-})$, $E(V^{+}/\Delta p) > E(V^{-}/|\Delta p|)$. This is consistent with the findings of Epps, Hanna, Smirlock and Starks and Jain and Joh. Similarly, says Karpoff, a test for linear dependence between volume and price change *per se*, would discover a positive correlation. This is consistent with the findings of Ying, Morgan, Rogalski, Harris, Richardson, Sefeik and Thompson and Comiskey, Walking and Weeks. The assumption that $f' > /g'/$ also implies the relation between volume and absolute level of price change, is not a one-to-one function. This is demonstrated when the conditional expected volume on negative price changes is plotted in the first quadrant, $V^{-} = h(|\Delta p|/\Delta p \leq 0)$. A test for linear dependence between volume and the absolute level of price change, would yield positive results (as data would be generated along the solid and dotted lines in the first quadrant). This is specified with the studies enlisted in section 1.1 above. Karpoff, however, says that both the specified linear relations are 'misspecified' and so one would expect empirical tests that specify linear relations would yield statistically weak results.

Karpoff calls the figure a representation of an "asymmetric volume-price change hypothesis", indicating the relation to be fundamentally different for positive and negative price changes. It implies the following empirical propositions:

(1) The correlation between volume and positive price change is positive.

(2) The correlation between volume and negative price change is negative.

(3) Tests using data on volume and the absolute value of price changes will yield positive correlations and heteroskelastic error terms.

(4) Tests using data on volume and price change per se will yield positive correlations. When ranked by the price change, the residuals from a linear regression of volume on price changes will be autocorrelated.

With this background, we now turn to study the dependence between stock returns and trading volume in a thin market like the Delhi Stock Exchange (DSE). For this, we develop the concept of cointegration and causality in the next chapter.

CHAPTER - 2

CONCEPT OF CAUSALITY AND CO-INTEGRATION

2.1 Introduction:

Regularity might be observed amongst certain variables over time. Classical regression might also give a high R^2 for such variables providing a picture of apparent strong correlation between the concerned variables. However, such correlations might as well be spurious as a consistent upward or downward trend might be noticed amongst the variables. This calls into question the reliability of classical regression analysis and the resulting high value of R^2. It is worth remembering that a high value of R^2 does not necessarily mean that a causality runs between the variables or variation in one variable would lead to variations in the other. This can be explained by the fact that correlations between variables are likely to be symmetric in nature. In other words, the extent to which Y can be explained by X is exactly the same as the extent to which X can be explained by Y. In reality, causality is believed to be a non-symmetric relationship. This explains the spurious nature of classical regression in examining the causal relationship in time series data between explained and explanatory variables. This had necessitated the development of a technique to look into the long-run relationship between time-series variables. Causality and co-integration provide the answer to the search for a solution to the above problem.

The regular occurring of a particular value of certain variables implies that there must be some underlying mechanism which causes the variables to occur with such regularity. Such a phenomenon gives rise to the concept of causation. C.W.J. Granger was the first to formulate the idea of causality and thus the name Granger Causality Tests was given to these tests. Granger (1969), in his seminal article discussed the concepts of causality based on two main axioms:

1. the cause occurs before the effect - i.e., the present and the past can cause the future but the future cannot cause the past;
2. the cause contains some unique information about the effect.

In other words, what Granger said amounts to the fact that a variable X is said to cause Y, if Y is predicted better by using the entire relevant information including the past values of X, than by using the entire relevant information, except the past values of X.

As Singh & Sahni (1984) put it, a time-series X is said to cause Y relative to the universe U (where U is a vector time series including X and Y as components) if predictions of Y_t based on U_s, where $s < t$, are better than predictions of Y_t based on all components of U_s except X_s for all $s < t$. The Minimum Predictive Error Variance was used by Granger, as the criterion for comparing the two models. He defines predictive error variance as follows:

If $P_t(Y/X)$ is the optimum predictor of Y using past values of X, then the predictive error series would be defined as $\epsilon_t(Y/X) = Y_t - P_t\ (Y_t/X_t)$. Then $\sigma^2(Y_t/X_t)$ would be the predictive error variance of $\epsilon_t(Y_t/X_t)$.

In the bivariate case, Granger causality model is defined as follows:

$$Y_t = \beta_0 + \alpha_0 X_t + \sum_{j=1}^{m} \alpha_j X_{t-j} + \sum_{i=1}^{n} \beta_t Y_{t-i} + \mu_t \quad \ldots.(1)$$

$$X_t = \gamma_0 + \delta_0 y_t + \sum_{i=1}^{n} \gamma_i X_{t-i} + \sum_{j=1}^{m} \delta_j X_{t-j} + \nu_t \quad \ldots.(2)$$

where U_t and V_t are mutually uncorrelated white noise processes such that $E(U_t U_t') = E(V_t V_t') = 0$ for all t. Thus the test for causality involves regressing Y and X on all the relevant variables including the past and present values of X and Y. The next step involves testing the appropriate hypothesis; eg., in the above model the null hypothesis $\alpha_j = \delta_j = 0$ may be tested against the alternative hypothesis of $\alpha_j \neq 0$ and $\delta_j \neq 0$. Acceptance of the null hypothesis would imply that X does not cause Y and Y does not cause X.

However, it has to be borne in mind that causality of the Granger type is not considered between any randomly chosen variables. There must exist some a priori belief that causation, either way, is likely. If there exists some "degree of belief" that a causal relationship exists between two variables, then the objective of the causality analysis is to influence this "degree of belief", one way or the other (Granger, 1988).

Granger's proposition, however, has not been without its criticisms. Zellner (1984) for example argues that Granger's definition "is a special form of predictability and it does not mention of economic laws. So it is devoid of any subject matter consideration". He feels that the "degree of belief" that Granger talks about must be based on some generally acceptable theory but no such theory or law has been considered by Granger.

Granger has defined four types of causality (Granger, 1969):

(i) Simple Causality: If $\sigma^2(Y/U) < \sigma^2(Y/U-X)$, then X is said to cause Y. That is, X is said to cause Y if one is able to predict Y_t better using all information than if information on X_t is not used.

(ii) Instantaneous Causality: If $\sigma^2(Y/U_2X)<(Y/U)$ then there exists instantaneous causality from X_t to Y_t. This means that the current value of Y_t is better predicted if the present value of X_t is included in the 'prediction' than if it is not.

(iii) Causality Log: If X_t causes Y_t, then causality lag m is defined to be the last significant value K,. such that, $\sigma^2(Y/U-X_k) < \sigma^2 (Y/U-X_{k-1})$. Thus, if lag m is significant, then the knowledge of X_{t-j}, $j=0,1,\ldots,m-1$, will be of no help in improving the prediction of Y_t.

(iv) Feedback Causality: If $\sigma^2(Y/U) < \sigma^2(Y/U-X)$ and $\sigma^2(X/U)$ or $\sigma^2(X/U-Y)$, then feedback causality is said to be occurring with Y causing X and X causing Y.

The first three of the above mentioned four types of causality are unidirectional in nature while the fourth is a bi-directional model of causality. Singh and Sahni (1984) point out that the unidirectional models, in general, help to discern the exogeneity of one or more of the variables, while the bi-directional model helps to understand the joint dependence between variables.

In all practicability, availability of possible information on the universal set U is difficult and thus for operational purposes, Granger considers U to be set of all available information. This set of information may be assumed to contain information on X and Y alone.

Thus, given the causality equations (1) and (2), the hypothesis that need to be tested for the existence of the above mentioned different types of causality, may be summarized as follows:

Simple: $\alpha_o = \delta_j = 0$ but $\alpha_j \neq 0 \Rightarrow$ X causes Y

$\delta_o = \alpha_j = 0$ but $\delta_j \neq 0 \Rightarrow$ Y causes X.

Instantaneous: $\delta_j = 0$ but $\alpha_o = \alpha_j \neq 0 \Rightarrow$ X causes Y

$\delta_j = \alpha_j = 0$ but $\alpha_o \neq 0 \Rightarrow$ X causes Y.

$\alpha_j = 0$ but $\delta_o \neq 0$ & $\delta_j \neq 0 \Rightarrow$ Y causes X

$\alpha_j = \delta_j = 0$ but $\delta_o \neq 0 \Rightarrow$ Y causes X

Lag: $\alpha_o = \delta_j = \alpha_s = 0$ but $\alpha_{s+1} \neq 0 \Rightarrow$ X causes Y

$\delta_o = \alpha_j = \delta_s = 0$ but $\delta_{s+1} \neq 0 \Rightarrow$ Y causes X.

Granger causality test is based on a stochastic notion and hence it applies to only stationary time series. Thus before testing for causality, it is important to see that the series satisfies the property of stationarity.

2.2 The Concept of Stationarity:

An important feature of any time-series data is the direction of the flow of time. A time-series is required to be in a particular state of statistical equilibrium to be stationary. In fact, stationarity of a series is considered to be a precondition for Granger tests. The existence of any type of stochastic or deterministic trend in a series implies non-stationarity. Presence of non-stationarity in a time-series is likely to cause the moments of the distribution to change over time and so the existence of causality could also alter over time.

A stochastic process is said to be stationary if -

(i) $EY_t = \mu$ = constant; for all t

(ii) Var $Y_t = \sigma^2$ = constant; for all t = $E[(Y_t - \mu)]$

(iii) Cor (Y_t, Y_{t+s}) = constant; for all t = s.

Conditions (i) and (ii) implies that for a series to be stationary, it must have constant mean and variance. Condition (iii) says that correlation between any two values of Y belonging to different periods of time equals the difference apart in time of the two values of Y chosen and is independent of time itself. Thus Cor (Y_4, Y_8) would be different from Cor (Y_2, Y_5) but would be the same as Cor (Y_6, Y_{10}) or Cor (Y_{10}, Y_{14}) etc.

Granger Tests require a pre-condition that the series be stationary and that a time-series needs to be tested for stationarity. If non-stationarity is detected in a series, then it has to undergo suitable filtering or transformation to make it stationary. The properties of stationarity mentioned above would be satisfied only if the error term is the equation is white-noise (WN) or serially uncorrelated process.

2.3 Testing for Stationarity:

(a) <u>ACF and PACF</u>:

The visual inspection of the sample auto correlation function (SACF) and the sample partial auto correlation function (PACF) of a time-series provides an informal way of testing for stationarity. The auto correlation function (ACF) is auto correlation expressed as a function of time difference or the lag.

If, we consider a series Y_t; t=1,...k (say), then

Mean = $E(Y_1) = E(Y_2) = ... = (Y_t) = \mu$

Variance = $Var(Y_1) - Var(Y_2) = ... = VV(Y_t) = \sigma^2$

Auto co variances Cor $(Y_t, Y_{t-k}) = E[(Y_t-\mu)(Y_{t-k}-\mu)] = \Gamma_k$

$$\text{Auto correlations } \frac{\Gamma_k}{\Gamma_0} = \frac{\text{Cor }(Y_t, Y_{t-k})}{[\text{Var}(Y_t).\text{Var}(Y_{t-k})]^{1/2}} = \rho_k$$

then ρ_k as a function of K (time-difference) given the ACF. The ACF characterizes the stationary stochastic process that underlies the evolution of Y_t and thus it plays an important role in model ling the dependencies among observations. It indicates the length and strength of the "memory" of the process by measuring the extent to which one value of the process is correlated with previous values ρ_k = 0 for all K = 0 - for uncorrelated observations.

The different statistics mentioned above are all population measures and are unknown. Thus for operational purposes, the sample counterparts are taken into consideration. The sample statistics are consistent estimates of the population mean, variance, co variance and auto correlation. Standardizing the sample autocovariance by dividing it by sample variance gives the SACF.

In general, if a series is non-stationary, then it would exhibit a distinct trend and its ACF (or SACF) would not die down quickly. For a stationary series, however, it would exhibit a rapidly dying down ACF or correlagram over time. The visual inspection test for stationarity has its drawback in that there is no yardstick to measure whether the ACF is rapidly dying down or not. This leads one to make fake interpretations about the stationarity of the series. This problem is overcome by the use of more formal tests of stationarity.

The ACF and PACF also come in handy when it has to be ascertained whether a series follows an Auto Regressive (AR) process or a Moving Average (MA) one. To do so, the ACF and the PACF are examined together. The ACF takes into account the correlation between variables from two different periods with other intervening lags. It must be borne in mind that two variables may be correlated through both their correlation with some third variable. PACF takes account of the additional correlation between Y_t and Y_{t-k} after adjustments have been made for the intervening lags; e.g., $x_t-1, \ldots\ldots, x_{t-k+1}$.

In an AR (p) process,

(i) the extent of ACF is infinite and is a combination of damped exponentials and dampened sine-waves, and

(ii) the PACF becomes zero or very small for lags larger than p.

In a MA (q) process,

(i) the ACF cuts off after lag q and

(ii) the extent of PACF is infinite.

From an ARMA process, both the ACF and the PACF will be infinite in extent and tail off as k increases. The ACF is determined from the AR part of the model for k>q-p and for k>p-q, the PACF is determined from the MA part of the model.

(b) Unit-Root Test:

An important test of stationarity independent of visual inspection of ACF and PACF, is the UNITROOT test. Here the roots of the lag equation are tested to see whether they lie within the unit root. Nonstationarity is inferred if they do. If we have a first-order AR process, such as -

$$Y_t = \emptyset Y_{t-1} + \epsilon_t \qquad t = 1,2 \qquad .... \quad (3)$$

where $\emptyset$ is a real number and ϵ_t is a sequence of zero mean, independent normal random variables with variance equal to σ^2. Using the log notation, we can write it as,

$$(1-\emptyset L)\, Y_t = \epsilon_t \qquad .... \quad (4)$$

where $L\, Y_t = Y_{t-1}$.

If we consider $(1-\emptyset L) = 0$, then stationarity of the AR process given by equation (3) can be shown if the root of

$[1-\emptyset L = 0]$ is greater than unity in absolute value. The root is given by $L = 1/\emptyset$. If L has to be greater than 1, $\emptyset$ must be less than 1 or greater than -1. Hence equation (3) would be stationary if $-1 < \emptyset < 1$.

In an AR process of higher order, it is required that all the roots of the lag operator equation must be greater than unity in absolute value.

A p^{th} order auto regressive process, using the lag-operator notation, may be written as,

$$(1-\emptyset_1 L - \emptyset_2 L^2 - \emptyset_3 L^3 \ldots\ldots - \emptyset_p L^{t-p})Y_t = \epsilon_t \qquad \ldots. (5).$$

If we consider,

$$1-\emptyset_1 L - \emptyset_2 L^2 - \emptyset_3 L^3 \ldots\ldots - \emptyset_p L^{t-p}) = 0 \qquad \ldots. (6)$$

then we can say that the AR process associated with it would be stationary if and only if the absolute value of all the roots of the above equation (6) are greater than unity. The process will be stationary even if one root lies between 1 and -1 or is equal to 1 or -1.

For practical purposes, $\emptyset$ should lie between 0 and 1, i.e. $0 < \emptyset < 1$ to satisfy stationarity since it is unlikely that in an economic time-series $\emptyset$ would be negative. If the process is non-stationary (for $\emptyset = 1$), then the OLS estimator of $\emptyset$ can be shown to be biased downwards. Hence one may wrongly conclude a process to be stationary when it is not. Thus the reliability of the t-statistic to check the validity of the null hypothesis is called into question.

The Dicky-Fuller Test (DF) took care of the problem through a reformulation of the unit-root test. The AR process, in equation (3), may be rewritten as,

$$Y_t - Y_{t-1} = \emptyset\, Y_{t-1} - Y_{t-1} + \epsilon_t \qquad \text{.... (3A)}$$

or $$dY_t = (\emptyset-1)\, Y_{t-1} + \epsilon_t \qquad \text{.... (7)}$$

or $$dY_t = \emptyset^{*}\, Y_{t-1} + \epsilon_t \qquad \text{.... (8)}$$

where $\emptyset^{\times} = (\emptyset-1)$.

Thus, testing $\emptyset=1$, against $\emptyset < 1$ is the same as testing $\emptyset^{\times} = 0$ against $\emptyset^{\times} < 0$. Non-stationarity of the series is implied by $\emptyset^{\times} = 0$. Thus to test for unit root, OLS may be applied to equation (8) to obtain the optimum estimator of $\emptyset^{\times}$ and then to use the critical value of the DF t-statistic (τ) to test for its significance.

In order to generalise, when the DF test is extended to the p^{th} order AR process, it is called the Augmented DF Test.

Reparametrisation of equation (8) is needed when the data is not well approximated by a first order AR process. It is taken care of as follows:

$$dY_t = \emptyset^* Y_{t-1} + \emptyset_1^* dY_{t-1} + \emptyset_2^* dY_{t-2} +$$

$$\emptyset_{p-1}^* dY_{t-p+1} + \epsilon_t \qquad \text{.... (9)}$$

where $\emptyset^* = \emptyset_1 + \emptyset_2 + \emptyset_3 + \ldots\ldots + \emptyset_{p-1}$ and all the $\emptyset_j$'s are functions of the original Øs.

If $\emptyset^* = 0$ in equation (9), then it is called an equation in first difference.

To find out the order of AR process which best fits the given time-series, the ADF test is carried out in the following manner. Equation (9) is estimated adding as many terms of differenced variables as are necessary to achieve residuals that are non-auto correlated.

Augmented Dickey-Fuller Test is the name given to the final estimated version of equation (9). This equation may then be tested for stationarity. The null hypothesis to be tested is,

$$H_0 = \emptyset^* = 0 \qquad \text{against}$$

$$H_1 = \emptyset^* < 0.$$

Stationarity of the series implies rejection of H_0.

Thus, the steps involved in carrying out the ADF test is summarised in the following manner.

The ADF regression equation may be written as:

$$dY_t = C_1 + C_2 T + \emptyset^* Y_{t-1} + \sum_{i=1}^{n} \beta_i dY_{t-1} + \epsilon_t \qquad \text{.... (10)}$$

where a constant and a trend term have been included. The test is further carried on as

STEP 1: Equation (10) is tested initially for the absence of serial correlation, since the ADF test is applicable only to equations with while-noise residuals. Serial correlation is taken care of by the inclusion of the terms in first difference lagged dependent variables. In order to achieve WN residuals, as many of these terms should be included as are necessary.

STEP 2: Equation (10) is tested for unit-root once the WN residuals have been obtained. The DF test is used to test $\emptyset^{*} = 0$ against $\emptyset^{*} < 0$. The t-statistic of $\emptyset^{*}$ is termed τ_t in DF (1979). The critical values are available in Fuller (1976). If the calculated value of $\emptyset_{\tau}$ is greater than the critical value, the null hypothesis of non-stationarity can be rejected, i.e. as long as the tabulated value is less negative than the table value, the non-stationarity of the series is accepted.

If a series is accepted as non-stationary, it must be made stationary before undertaking the causality tests.

There are two ways of transforming a non-stationarity series to stationarity. They are

(A) detrending or removing the deterministic linear trend by prior regression on a time trend, and

(B) differencing the series to attain stationarity.

The model is called a Trend Stationary Process (TSP) if Y_t is expressed as a function of time called the trend and a zero mean error stationary process like

$$Y_t = \alpha + \beta_t + \mu_t.$$

Regressing Y_t on time helps in transforming to stationarity. TSP models are generally used when it is believed that the movements in the given time series are transitory in nature, driven by 'shocks' and that they would eventually revert back to their natural rate. Thus Y_t is subject to a deterministic trend, t, which can be removed by regressing Y_t on t.

In the next case, the model is called Difference Stationary Process (DSP) if the model is generated by (say)

$$Y_t - Y_{t-1} = \beta + e_t$$

or $$dY_t = \beta + e_t$$

where e_t is a stationary process with mean zero and variance σ_t^2. Successive differencing of the series generates stationarity. Y_t here is subject to a stochastic trend.

The lagic behind DSP is that a time series may be subject to both secular as well as cyclical components and hence such movements should be regarded as belonging to an integrated process. Both these types of fluctuations are taken care of by successive differencing and not by detrending.

Afextion (1984) provides an informal way of testing for TSP or DSP by inspecting the ACF for each series in both level and first difference. DSP is inferred if the ACFs for levels are large and fall slowly while for the difference they are found to be significant and positive.

The DF unit-root is applied at a more formal level. The ADF equation of equation (10) is used to test whether the equation is trend or difference stationary. For a series to be first-differenced stationary, the coefficient of time, C_2, must be zero. If the coefficient of time is significantly different from zero, then the series is trend stationary since it is dependent on time. If C_2 is not significantly different from zero, then it may be taken to be first-difference stationary.

Testing a series to be TSP or DSP involves simultaneous testing for $\emptyset^* = 0$ and $C_2 = 0$ in equation (10). If calculated $\emptyset_3$ is less than critical $\emptyset_3^*$, then the null hypothesis of the series being first difference stationary, is accepted.

Granger Causality Test is applicable only to stationary series. Thus if a series is found to be non-stationary then it is first converted to a stationary series through differencing of the required order and then Granger Causality is applied to it. Later, it was realized that this process leads to incorrect conclusions about the existence of causality. This is due to the loss of information arising out of differencing and these might have been important in explaining causality.

Cointegration is one process which takes care of the above problem. We take a look at what cointegration is all about.

2.4 Cointegration:

It is basically the test for the existence of an equilibrium relationship between two variables. If we consider an equilibrium relationship to exist between two variables X and Y which is of the form

$$Y_t = b\ X_t \qquad \text{.... (11)}$$

If at each point of time, the variables follow an equilibrium path, then,

$$Y_t - b\,X_t = 0 \qquad \text{.... (12)}$$

In reality, however, it is unlikely that the two series would follow an equilibrium path at every point of time. If the series is out of equilibrium, equation (12) takes the following form :

$$Y_t - b\,X_t = \epsilon_t \qquad \text{.... (13)}$$

where ϵ_t is the "equilibrium error".

Engle and Granger (1987) observed that the disturbance error tend to fluctuate around its mean value, or show some systematic tendency to become smaller over time, if an equilibrium relationship exists between Y_t and X_t. This implies that the variables would not drift too far apart from one another in the long run. Cointegration is the name given to the equilibrium behaviour between two series over time.

An "error equilibrium" model is generated, if two series are cointegrated, which takes the following form:

$$dX_t = r_1\,\epsilon_{t-1} + \text{lagged } dX_t,\ dY_t + U_{1t} \qquad \text{.... (14)}$$

and $$dX_t = r_2\,\epsilon_{t-1} + \text{lagged } dX_t,\ dY_t + U_{2t} \qquad \text{.... (15).}$$

The above equations imply that the amount and the direction of change in X_t and Y_t takes account of the previous equilibrium error. Either dX_t or dY_t or both must be caused by ϵ_{t-1} which itself is a function of x_{t-1} and

Y_{t-1}. Thus, for a series to have an attainable long-run equilibrium, there must be some causation between them.

In Granger's test of causality on a first-differenced series, the error correction term - ϵ_t, would not have been incorporated into the model. Information about the relationship between X_t and Y_t are included in ϵ_t and thus excluding it implies loss of some information.

Thus cointegration can be taken as a precondition for conducting the causality tests. Cointegration between two series implies some type of causation between them. Test of causality then is used to ascertain the extest and direction of causality.

2.5 Tests for Cointegration:

It is imperative that two series must be integrated of the same order if they are to be cointegrated. I(d) denotes a series integrated of order d, if it has to be differfenced d times to t\attain stationarity. And CI(d,b) denotes two series cointegrated of order d,b, if both the series are integrated of order d and there exists some linear combination of them which is integrated of the order b, $b < d$.

For a better explanation of the above, suppose two series are integrated of order one or I(1) (i.e. they are stationary and attain stationary on first differencing) but there exists some combination of the two which is integrated of order zero, I(0) (i.e. it is stationary), then the two series are said to be cointegrated.

The Augmented Dickey Fuller (ADF) test for unit-root may be used to test for I(1). If both series are I(1) then we test for cointegration as follows:

The hypothesized equilibrium relationship of the following form is first estimated by OLS:

$$Y_t = C_1 + C_2T + \alpha_1 x_t \qquad .... (16).$$

This is the cointegrating regression. The residuals of the above equation are retained such that

$$e_t = Y_t - C_1 - C_2T - \alpha_1 x_t \qquad .... (17).$$

The residuals may be now used to test the null hypothesis that $\rho = 1$ in

$$e_t = \rho\, e_{t-1} + \mu_t \qquad .... (18).$$

The null hypothesis of no cointegration is implied by $\rho = 1$. Thus for the series to be cointegrated, the alternative hypothesis implied by $\rho < 1$, is to be accepted.

It is the ADF test which is used to test for cointegration in practice. The test for cointegration is basically a test for stationarity applied to the residuals retained from the cointegrating regression. Here also, the number of lagged differenced terms included would depend upon obtaining White Noise residuals. The equation to be estimated is of the following form:

$$de_t = \theta^* 1\ell_{t-1} + \sum_{i=1}^{n} \theta_i^* \, d\ell_{t-i} + \nu_i \quad .... (19).$$

The null hypothesis of no cointegration, here, would imply testing for $\theta^* = 0$ as against $\theta^* < 0$. If the t-statistics on θ^* is less than the critical value of θ^*, then the null hypothesis is accepted.

Provided with the idea of cointegration and causality, we now move onto the task of estimation in the next chapter.

CHAPTER - 3

ESTIMATION , RESULTS AND IMPLICATIONS

3.1 Introduction:

In this chapter, we attempt to elucidate the data used in our analysis; the rationale for choosing the period of study and the need to work at the individual security level. The mode of estimation, the results of the study and their statistical interpretation have been provided. Thereafter, we ascertain the cause of the behaviour between price change and volume which has been revealed by our econometric exercise. Apart from the rules and regulations operative in our capital market, we also take a look at the individualistic level to substantiate our findings.

3.2 Data:

Daily data from the Delhi Stock Exchange (DSE) from January 1993 to December 1994 have been employed here. The data are those of the 43 companies enlisted in group-A of the DSE. Here daily closing prices and volume transacted of the shares of these 43 companies have been used with a view to search for a probable causality, running either way, between stock-returns and trading volume. The data were available from the Daily Official Quotation List of the DSE.

Stock prices and hence returns have always been an important element in the analysis of various facets of the stock market. Practitioners in investment decisions and researchers testing the theories in financial economics, have always used stock returns as an important source of information. In fact, the entire literature of Efficient Market Hypothesis (EMH) has pivoted around the notion of price reflecting all available information. In financial decision making whichever form of the EMH (weak, semi-strong or strong) is used, stock prices form the back-bone of it.

Trading volume, though reported daily in all financial media, has not been focused on properly. Little attention has been given to the information content of this data. Information on the volume transacted of stocks, however, are used as an important source of information by practitioners and theorists as well.

3.3 Why the individual security level?

The data on prices and volume transacted have been collected at the individual security level, as has already been mentioned. The rationale behind the choice of data at the individual security level is that: (i) the group-A companies, whose data have been used in our analysis, are the ones used in computing the DSE index. The DSE index represents an averaging over the underlying 43 companies. The averaging is done by assigning different weights to the quoted prices of the stocks of the companies.[1] It could well be the case that the individual securities have become jittery, the overall portfolio returns exhibit stability. This would be the case with the kind of day-to-day fluctuations caused by the markets - these would be uncorrelated across securities and the returns on the DSE index portfolio would diversify these fluctuations away.

Moreover, the market index measures the economy-wide news and a lowered fluctuation of the DSE index would suggest that there was less news affecting the macroeconomy during the period concerned.

Hence the need to work at the individual security level.

3.4 Period of Study:

1991 was the year when the Structural Adjustment Programme (SAP) was initiated by the government. The adoption of economic reforms was done primarily to effect a transition from a largely government-controlled system to a market based one. The transition was aimed at imposing allocative efficiency of the country's resources. For this, it is appreciated that financial markets and institutions

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1 The weights reflect the number of shares outstanding for an individual scrip and thus gives an idea of the value change in price rather than just price change.

must be expanded and liberalised to make them allocatively more efficient so that resources are directed to areas of highest economic rates of return. The purpose of the present study is to ascertain how far have we progressed towards the achievement of this allocative efficiency and thus also to the extent of the accuracy with which the market values reflect fundamentals and prices of financial assets send signals for resource allocation.

However, immediately after the initiation of the SAP, the securities scam was exposed in mid-1992. This, as is well known by now, involved an unholy nexus between certain bank officials and brokers resulting in illegal siphoning-off of a huge amount of bank funds to selected brokers which was used for share market speculation. This resulted in an unprecedented share boom with the market crashing after the irregularities were unearthed. It took long enough for the market to recover from the crash. Since no particular point of time could be pin-pointed as to when the market had recovered, for the sake of safety, we considered January 1993 as the starting point of our analysis.

3.5 Choice of a thin market like DSE:

The literature on the analyses of stock-return and trading volume shows that most of the studies were conducted using data from large stock markets. Studies conducted on thin markets are relatively few. The results from studies conducted on thin markets may be interesting for several reasons. Firstly, evidence from new markets reduces data snooping bias connected to financial models. The best methodological approach for this type of data snooping is through the use of an independent sample. Secondly, the integration of the world's capital markets and their development in recent years will have greater importance on the empirical results from smaller markets for people who are willing to operate in the international capital markets. Furthermore, in India, all empirical work related to the stock market have tended to focus on the Bombay Stock Exchange (BSE) and on the Calcutta Stock Exchange to some extent. With increase in the trading activity in the DSE and with the structural changes taking place in the economy, the analysis of the stock return-trading volume in context to the DSE promises to be interesting.

Since our aim had been to find causality between change in stock prices and volume (bidirectional), we calculated the change in stock prices for a particular company as $R_t = \log(P^i_t -) - \log(P^i_{t-1})$ where P^i_t is the time series of stock price of company i. All securities listed under group-A of the DSE has been used in our analysis.

For a day when no closing price was quoted and trading had taken place, for a particular scrip, the next days opening price was taken as a proxy for the closing price.

And when no transaction had taken place in a particular scrip and yet a price was quoted, the volume transacted was considered zero.

As is well known, share prices change abruptly when a company increases its paid-up capital either by (i) issue of bonus shares or (ii) by issue of rights shares. Prices and volume needs to be adjusted for comparability, immediately. For companies which had issued rights and/or bonus, during the period of study, in those cases the ex-bonus and ex-right prices were adjusted to make them comparable with cum-bonus and cum-right quotations.

3.6 Estimation Procedure:

To recapitulate, the entire estimation procedure involves three main steps:

1. The ADF unit root-test for stationarity,
2. Test for cointegration, and
3. Test for causality.

1. <u>ADF Unit-root Test:</u>

The unit-root test for stationarity has been conducted for both the series - the change in stock price and the volume transacted, for each of the 43 companies listed under group-A of the DSE. The equation estimated is of the following form:

$$dR_t = C_1 + C_2 T + \theta^* P_{t-1} + \beta_1 dR_{t-1} + \beta_2 dR_{t-2} + \beta_3 dR_{t-3} + \ldots + \epsilon_t \qquad \ldots (1A)$$

for price and

$$dV_t = K_1 + K_2 T + \emptyset^* V_{t-1} + \gamma_1 dV_{t-1} + \gamma_2 dV_{t-2} + \gamma_3 dV_{t-3} + \ldots + \epsilon'_t \qquad \ldots (1B)$$

for volume.

First the Lagrange Multiplier (LM) test was conducted to test for the absence of serial correlation in residuals. Those many lagged difference terms were included as required to obtain white noise (WN) residuals. Once the exact form of equation was determined, the following test was conducted:

Test:

Null: $H_0 : \theta^* = 0$ against the alternative

$H_A : \theta^* < 0$.

Acceptance of the Null hypothesis implies that the series is non-stationary.

Statistic:

The test statistic given by Dickey-Fuller (1979) is τ_τ, which is given by 't' ratio on θ^*.

Distribution:

The critical values for the test are given in Fuller (1976). If the estimated value of the statistic (absolute value) is greater than the critical value, then the null hypothesis of non-stationarity is rejected in favour of stationarity. However, if it is less than the critical value, then the series is accepted as non-stationary.

2. Test for Cointegration:

If, from the above test, it is found that the dependent variable series and the independent variable series are both I(1), then the above are tested for cointegration. This was done for both the price and the volume series of all the 43 companies. However, mis-specification would bias the results of the cointegration tests, each test is performed twice, with the designation (that of dependent and independent variable) reversed for the second test. The test is carried out in the following manner:

First, the hypothesized equilibrium relationship between price change (R_t) and volume transacted (v_t) is estimated by OLS. The regression equation takes the following form:

$$R_t = C_1 + \beta_1 V_t + \epsilon_1 \quad \text{....(2A)}$$

or

$$V_t = C_2 + \beta_2 R_t + \epsilon_2 \quad \text{....(2B)}$$

depending on whichever of the two series (that of R_t and V_t) is considered as the dependent variable and the independent variable.

The above are called the cointegrating regression equations or the static regression equations. The residuals from them are obtained, such that;

$$\hat{e}^1_t = R_t - \hat{C}_1 - \hat{\beta}_1 V_t \quad \ldots(3A)$$

$$\hat{e}^2_t = V_t - \hat{C}_2 - \hat{\beta}_2 R_t \quad \ldots(3B)$$

Now the ADF unit root test for stationarity is conducted on the residuals, which basically is the test for cointegration. The test equations become

$$de^1_t = \phi^*_1 e^1_{t-1} + \sum_{i=1}^{P} \phi^*_{1i} e^1_{t-1} + U^1_i \quad \ldots(4A)$$

$$de^2_t = \phi^*_2 e^2_{t-1} + \sum_{i=1}^{P} \phi^*_{2i} e^2_{t-1} + U^2_i \quad \ldots(4B)$$

and the null hypothesis $\phi^* = 0$ is tested against $\phi^* < 0$.

For cointegration of the two series, the null hypothesis of non-stationarity should be rejected. If the residuals are stationary, it would imply that there is some linear combination of the two series which is stationary. This in turn would imply that the two series are cointegrated.

Statistic:

The test statistic for cointegration is given in Engle and Yoo (1987). If the tabulated value of the Dickey-Fuller statistic is greater than the critical value, then the null hypothesis of no-cointegration is rejected.

3. Test for Causality

If the two series are found to be cointegrated, it implies that there is a long term equilibrium relationship between the two. The existence of causality between the two variables is very likely. Cointegration however reveals nothing about the direction of causality nor does it say for certain about the existence of causality. The Granger test for causality is conducted to test for the null hypothesis which is as follows:

Null: R_t is not caused by v_t and

v_t is not caused by R_t.

The F-statistic given by the test is used to ascertain the direction of causation.

3.7 Results:

The results of the unit-root test, the cointegration test and the causality test have been tabulated and presented at the end of the chapter.

Table A gives the result of the unit-root test. For each company, the τ values have been given for each of the five lag periods for both the series of volume and change in price. The τ values give the Dickey-Fuller t-statistic for the unit-root test. The critical value of τ is also given at the bottom of the table. The tabulated values of τ are compared to its critical value to determine whether a series is stationary or not.

Table B gives the result of the cointegration test. The test has been conducted for those companies for which both the series were found to be non-stationary. It is, however, worth noting that only for one company - Vam Organics, it has been found that the series of volume transacted is non-stationary. The cointegration tests have been conducted twice for each company by changing the designation of the dependent variable. The critical value of the Dickey-Fuller statistic is given at the bottom of the table for comparison with the tabulated value. The calculations were carried out for each company for a lag of five periods. All these values have been reported in the table. Table C gives the result of the test of causality. The null hypothesis to be tested is that of (i) R_t, i.e., change in stock prices is not caused by v_t and (ii) v_t is not caused by R_t.

The test of cointegration has been carried out for all those companies whose series on change in stock prices and volume transacted have been found to be cointegrated. Here also five periods of lag has been considered. The F-statistic for each of these periods of lag have been calculated and the probability attached to the occurrence of the null hypothesis has also been given.

To have a better understanding of how the values of the calculated statistic are to be interpreted, we take the case of DCM-TOYOTA. The unit-root test for both R_t and v_t was conducted. The values of τ were found to be -1.08, -0.84, -0.816, -0.681 and -0.578 for lag periods ranging from one to five respectively. The critical value of τ is given to be 2.78 for a sample of size 250-500. The absolute values of the calculated τ are all smaller than the critical value and hence we accept the null hypothesis of non-stationarity.*[1] Moving on to the test of cointegration, we first consider the case of R_t being the dependent variable. The calculated values of the D-F-statistics is given in the table, which are -11.74, -9.12, -8.43, -7.03 and -5.65 for lag period of one to five respectively.

The critical value of D-F-statistic at the 5 per cent level is given by 3.37. The absolute value of the tabulated D-F are all greater than the critical value thus leading to the inference of cointegration. The test is repeated by taking v_t as the dependent variable.

The inference of cointegration, lets us move on to the next and final stage of causality testing. We consider the null hypothesis of "R_t is not Granger caused by v_t". The calculated F-statistics are 3.5014, 3.2391, 2.5866, 2.7466 and 1.8571 with associated probabilities of 0.0627, 0.0411, 0.0541, 0.0294 and 0.1043 respectively. They are arranged in order of lag period ranging from one to five. The results show the chance of the null occurring at only 6.27 %, 4.11 %, 5.41 %, 2.94 % and 10.43 % for lags of one to five respectively. This implies that causality runs from v_t to R_t with a chance of 94 %, 96 %, 95 %, 98 % and 90 % for lags of one to five respectively. The test is also carried out for the reverse causality. However, considering the case of Andhra Cement Company, a look at the causality test shows a

*1. Provided the value of the statistic is less than the critical value, the null is not rejected always. ⇒ The series has a unit root & is non-stationary but its first difference is stationary. or, it is a I(1) series. c.f. Perman, R. (1991).

lack of causality running in either direction (i.e. from R_t to v_t or from v_t to R_t) at the 1 %, 5 % or 10 % level of significance. In our exercise, we consider the existence of causality only at the 5 % level of significance.

3.8 Implications:

Among all the 43 companies tested for the existence of causality between R_t and v_t, only 11 companies exhibited the existence of causality between R_t and v_t. Only two companies showed the existence bi-directional causality between R_t and v_t. These companies are Gujarat Narmada Fertilizer Corporation (GNFC) and Hindusthan Development Corporation (HDC). Of the remaining, five companies showed the existence of causality from R_t to v_t. This was evident among the following companies; DCM-Toyota, Mahavir Spinning Mills, Shriram Industrial Enterprises, Shri Ram Fibres (SRF) and Tata Iron and Steel Company (TISCO). The causality running from v_t to R_t was exhibited by Asian Hotels, DCM, Escorts and LML. The remaining 32 companies, however, showed no causality running between R_t and v_t. It is worth noting, however, that even in those cases where causality has been detected, it has been done so at a very marginal level. Moreover, causality was found to exist at only one or two periods of lags, in some cases. Thus, there exists a probability of considering those cases where causality was found, as mere outliers. However, it has to be borne in mind that our period of study comes under the era of the Structural Adjustment Programme of the government. So there are chances that the causality between R_t and v_t noticed in our study might have been a result of the efforts aimed at making the capital market more efficient in the proper allocation of resources. The existence of causality between R_t and v_t contradicts the well documented fact about the inefficiency of Indian capital markets. This is consequent upon the recent developments in India's security markets resulting probably due to the adoption of economic reforms since 1991 and the deregulation and liberalisation which followed it.

The lack of causality between the two series of R_t and v_t could well be due to the imperfections present in the market, traditionally. Heavy government intervention is often thought to stand in the way of achieving the goals of proper allocation of resources thereby providing the distortionary effects of unchecked speculation leading to a number of imperfections. These include a messy market, asymmetric and incomplete information and various externalities not mediated by the market.

We now try to ascertain various reasons as to why causality might exist between R_t and v_t and also as to why it might not. First, we try enlisting the reasons which might be responsible for the existence of causality.

Following Copeland's (1976) model of sequential information arrival, a positive correlation between volume transacted and change in price is implied. Trading is assumed to occur after information percolates to each trader but the uninformed traders do not learn from the action of their informed counterpart. The market is assumed to consist of either 'optimists' or 'pessimists'. The price change and trading volume when the next trader becomes informed depend upon the previous pattern of who has been informed and whether the next trader is an optimist or pessimist. The total volume after all traders become informed depends on the path to final equilibrium. Tests showed that v is highest when investors are either all optimists or all pessimists and price change is lowest at the same percentage of optimists at which v is lowest and rises with v. This supports a positive correlation between volume and price change.

It can also be said that trading volume will be abnormally high during the periods in which the values of returns are serially correlated (Jennings, Stark and Fellinghan (1981)).

An explanation for the positive correlation can also be accounted for if the informed traders are allowed to take on speculative positions. Speculation causes price to adjust more quickly to new information. This implies a positive correlation between volume and price change for a given investor's trade (Jennings and Barry (1983)).

Research into the distribution of speculative prices provides another explanation into the causality between volume transacted and price change of a stock. Daily price changes are sampled from a set of distributions that are characterised by different variances. The volume-price change correlation results because volume is an increasing function of the number of within-day price changes (Epps and Epps (1976)).

The correlation between volume and price change increases with the variance of the daily rate of information flow. As the number of traders increase, the volume of trade increases and price-variability decreases. This follows from the hypothesis that transaction time differs from calendar time (Tauchen and Pitts (1983)).

Another explanation of the positive correlation between price and volume follows from information aggregation in markets. A rational expectations equilibrium is established in which speculators' private information is only partially aggregated by the market price because of noise introduced by life-cycle trading. Speculative trading increases with the precision of private information and is uncorrelated with price change. However, life-cycle trading randomly affects the supply available to speculators. The volume of life-cycle trading thus has an effect on the magnitude of price-changes. Here, the strength of the correlation between volume and price-change increases with the relative importance of life-cycle trading in the market (Pfleiderer (1984)).

Theoretically, if we consider a market with two groups of investors - the 'bulls', who react only to positive information about the asset's value and 'bears' who react only to negative information. Epps (1975) said that the volume on transactions in which the price change is positive is greater than for negative price changes. The transactions demand curve in the market consists only of the demand prices of 'bulls' while 'bears' comprise the transaction supply curve. The market demand curve is steeper than the supply curve and so the ratio of volume to a positive price change is greater than the absolute value of the ratio of volume to a negative price change.

The reasons for the existence of positive correlation between volume transacted and price change and hence the detection of causality stems from a market being efficient. The reasons of efficiency can be generalised for any market but the cause of lack of causality between volume transacted and price change are peculiar to markets operating under the same system of rules and regulations. We now attempt to identify the weaknesses of secondary securities market in India.

Speculative dominance of markets causes stock prices to be highly volatile and even divorced from the fundamentals. The prevailing trading practices in Indian stock exchanges causes such dominance. The practice of a long settlement system is thought to be the root cause behind the strong short period boom bust behaviour of the Indian stock market. The price behaviour is so erratic that there is a widespread belief among the broker community and investors that fundamental analysis does not pay and is of no importance in Indian conditions.

Control measures aimed at containing the boom has been found to be totally ineffective. This is because the root of the problem remains untouched by these measures. A complete overhauling of the trading system is called for.

At the root of the ever-present strong tendency towards speculative excesses in India is the fortnightly settlement system. This system really amounts to provision of automatic credit to speculations on low margins which are also frequently avoided. With credit flowing freely, a boom begins to build up on the slightest pretext and soon reaches great heights.

In spite of efforts made, manipulation remains uncontrolled. A strong tendency for speculation in India to degenerate into manipulation and the lack of checks on manipulative activities is quite clearly visible. A few large operators have been able to sway the market in the direction they want to without much hindrance. In economic terms, a speculator is seen as one possessing better foresight and judgement and thus contributing to the better functioning of the market. On the contrary, in Indian stock exchanges, the big speculators are found to depend more on their financial muscle and manoeuvering than on their superior knowledge. This was typified by the big bull Harshad Mehta. Insider trading rules might provide a way out of the impasse. Introduction of futures trading might also help.

The procedural risks and difficulties involved in the transfer of ownership of securities considerably hampers the development of the market. Apart from the enormous paperwork involved, there is a high incidence of real risk such as bad delivery for both investors and brokers. The problem has been present for a long time and has provided a serious point of weakness to the system. Introduction of a depository system might put an end to the problem. The problem regarding the settlement and transfer systems for securities is largely one of technological upgradation of the processes of trade matching, clearing, settlement and ownership transfer.

At present, India has about more than 20 stock exchanges and there is an increasing demand to open more from local interests in many places. A need is felt for the market's integration to make it a unified national market system. This would take care of the difficulty in inter-market dealing which involves high costs for investors, extreme delays in payments and deliveries in the case of inter-market deals, denial of best execution to investors and reduced market liquidity. The inter-market problems are probably due to the mismatch between primary market development and secondary market trading arrangements. The secondary market trading arrangements have remained localised and fragmented. Accumulation on a country wide basis of the buy/sell orders for each security helps to achieve economical and efficient order matching. However, this requires a high level of automation in the entire securities trading system.

Investors often have the feeling of being cheated by brokers regarding the market rate and this arises due to the lack of transparency in stock exchange trading in India. A belief runs among investors that they are charged with the highest rate of the day and while selling they are given the lowest. The growth of the stock market is hampered by such distrust in the trading mechanism. Moreover, the lack of transparency makes malpractices by some unscrupulous brokers easier and affects investors' confidence.

The policy of financial liberalisation implies a phasing out of direct lending to the large and established industrial firms and its replacement by public issue of debt securities. Public issue of pure debt instrument has been found to be unpopular among the investors. This is due to the fact that debt instruments have hardly any secondary market and are therefore illiquid. An improvement needed in the mechanism of the secondary market is the development of arrangements for active secondary market trading in pure debt instruments of companies. Changes like mandatory rating of debt instruments and removal of interest ceiling are desirable moves in the right direction but are not sufficient. Screen based trading on an all-India basis, computerised trading to facilitate order matching might be a way of improving liquidity of debt instruments. The present dilatory system of securities transfers and stamp-duty system pose a hurdle in the way of market making.

The other abnormality present in the Indian stock market is that trading carried on for the purpose of continuing to be enlisted on the stock exchange. The stock exchange lays down that trading must be continued without a gap of a stipulated time period exceeding which they would be delisted. Thus for the sake of being listed certain companies whose shares are generally held by a closed-knit group of people (mostly family members) have their share price quoted on the stock exchange through a very thin volume of transaction. This is made possible by an 'entente' between the major share owners (who are very few in number) and the jobbers of the concerned stock exchange.

Insider trading is also an important malady of the present system and regulations however strict, brought about to contain it would find it difficult to meet its end. This takes place when a cartel is formed between 'insiders' of the company and jobbers of the exchange. The 'insiders' makes a profit by passing on the information of a forthcoming event to a broker. This information revealed will have the potential of raising prices of the shares of the company and thus provide an avenue of making profits for individuals who own greater number of shares. Due to prior knowledge provided by the insider, the cartel works out to be a very profitable proposition. A closer look at the individual companies helps in the understanding of the results of our econometric exercise.

1. Companies whose shares are generally owned by the members of the families running the show, register very infrequent trading on the exchange and even then the volume transacted turns out to be very low. The major cause for the existence of such a phenomenon is that in order not to let outsiders into the functioning of the companies (through a large number of shares being changing hand in the stock market), trading takes place among the owners on a very negligible scale. This is exhibited by the companies owned by the big industrial families like the Birlas (Grasim, Hindustan Aluminium Company, Indian Rayon), the Singhanias (J.K. Industries, J.K. Synthetics), the Modis (Modi Rubber) etc.

2. Relatively higher volume as well as frequency of trading is observed for the shares of those companies which are

established in and around Delhi. The awareness and well-being of these companies are the concern of the people of the locality/region. Companies which can be listed in this category are Bindal Agro Industries, Oswal Agro Mills, J.P. Industries, J.C.T. etc.

3. Companies which are set up on a collaborative basis or comes under the purview of FERA have shown an increase in the volume transacted only during the period of announcement of their annual result like dividends, bonus, rights etc. Otherwise, during the remaining part of the year, they maintain a lower volume of transaction. Examples in point are Nestle, Kelvinator, LML etc.

4. Where a very high price has been quoted for a scrip, the volume transacted has been found to be relatively low. Companies like A.C.C., where a very high price has been quoted consistently over a period of time, the volume transacted has remained low and has not exhibited any seasonality in its data.

5. Speculative activity has been found to be prevalent in the case of those companies which are of very large magnitude measured in terms of paid-up capital. Trading in the shares of these bigger companies are affected by their trading all over the country due to their large number of share-holders being present everywhere. The volume transacted of these shares has been found to vary with slight variations in their

price. Generally, it has been noticed that the volume of trading in these shares has been quite high. The phenomenon has been noticed in the case of scrips of companies like Reliance, TISCO, L&T, Essar Shipping, LML etc.

6. Shares of UTI mastershare have been generally traded by the financial institutions and not by the individuals who own these shares. It is probably due to this that there has not been much of a variation in the price of the shares over the period of study and volume of transaction has also been kept at a high without any big variation in it.

7. Due to extremely long periods of no transaction, some companies have been delisted from the exchange. Vam Organics is a case in point. Trading in the shares of Vam Organics has been very infrequent and volume transacted is almost nil over the entire period of study. This has led to its delisting, in keeping with the stipulation of the stock exchange.

8. The volume transacted daily of the shares of the companies listed under group-A of the DSE has been largely made up by the volume of transaction of a few big companies. Of the 43 companies listed under group-A, only 15 companies (approximately) make up for about 80 per cent of the volume transacted in group-A. The proposition about the existence of a positive price-volume relationship cannot be expected to hold in a market where trading is thin and transaction occurs

in the shares of a few companies. Even then, the detection of a positive price-volume relationship, as is evident by standard literature, is not possible because of the reasons cited above.

NAMES OF COMPANIES .

1). ASSOCIATED CEMENT COMPANY (A.C.C.)
2). ANDHRA CEMENT COMPANY
3). APOLLO TYRES
4). ASIAN HOTELS LIMITED
5). BINDAL AGRO
6). D . C. M. LIMITED (D.C.M.)
7). D.C.M.– TOYOTA
8). D.C.M. SHRIRAM INDUSTRIAL ENTERPRISES
9). D.C.M. INDUSTRIES LIMITED
10). ESCORTS LIMITED
11). ESSAR SHIPPING.
12). GUJRAT NARMADA FERTILIZER CORPORATION. (G.N.F.C.)
13). GRASIM
14). HINDUSTAN ALUMINIUM COMPANY LIMITED (HINDAL)
15). HINDUSTAN DEVELOPMENT CORPORATION (H.D.C.)
16). HINDUSTAN LEVER LIMITED (H.L.L.)
17). HINDUSTAN MOTORS LIMITED
18). HERO-HONDA
19). INDO-GULF FERTILISERS CORPORATION (I.G.F.C.)
20). INDIAN RAYONS LIMITED
21). J.C.T. MILLS LTD. (J.C.T.)
22). J.K. INDUSTRIES LIMITED
23). J.K.SYNTHETICS LIMITED
24). J.P. INDUSTRIES LIMITED
25). KELVINATOR OF INDIA LIMITED
26). LARSEN & TOUBRO (L&T)
27). LML LIMITED (LML)
28). MALWA COTTON MILLS LIMITED
29). MOHAN MEAKINS
30). MODI RUBBER LIMITED
31). MAHAVIR SPINNING MILLS
32). NESTLES INDIA LIMITED
33). ORKAY SILK MILLS LIMITED
34). OSWAL AGRO MILLS
35). RELIANCE INDUSTRIES
36). SHRIRAM INDUSTRIAL ENTERPRISES
37). SMITHKLINE BEECHAM (S.K.B.)
38). SOUTHERN PETROCHEMICAL & INDUSTRIAL CORPORATION (S.P.I.C.)
39). SHRI RAM FIBRES (S.R.F.)
40). TATA ENGINEERING & LOCOMOTIVE COMPANY (T.E.L.C.O.)
41). TATA IRON & STEEL COMPAIANY (T.I.S.C.O.)
42). UNIT TRUST OF INDIA (U.T.I.)
43). VAM ORGANICS LIMITED

ALL THE ABOVE COMPANIES WERE LISTED UNDER GROUP - A OF THE DELHI STOCK EXCHANGE DURING THE PERIOD CONSIDERED IN OUR STUDY .

TABLE-A: TEST FOR STATIONARITY.

(GIVEN ARE THE CALCULATED VALUES OF THE D-F T-STATISTIC.)

COMPANY	NUMBER OF LAGS 1 RT	VT	2 RT	3 RT	VT	4 RT	VT	5 RT	VT	RESULT
A.C.C.	-1.064	-0.723	-0.909	-0.779	-0.522	-0.711	-0.475	-0.619	-0.442	Stationary
ANDHRA CEMENT	-1.764	-0.821	-1.388	-1.209	-0.545	-1.101	-0.53	-0.998	-0.454	Stationary
APOLLO TYRES	-1.381	-0.793	-1.125	-0.991	-0.522	-0.874	-0.493	-0.739	-0.403	Stationary
ASIAN HOTELS	-0.965	-0.689	-0.872	-0.646	-0.474	-0.636	-0.487	0.611	-0.4	Stationary
BINDAL AGRO.	-2.388	-0.501	-1.349	-1.093	-0.402	-0.835	-0.368	-0.837	-0.333	Stationary
D.C.M.	-1.269	-0.969	-1.07	-0.991	-0.711	-0.906	-0.603	-0.754	-0.583	Stationary
D.C.M.-TOY	-1.087	-0.571	-0.842	-0.816	-0.454	-0.681	-0.435	-0.578	-0.451	Stationary
D.C.M. SRM.CONS.	-1.701	-0.875	-1.484	-1.285	-0.286	-1.128	-0.328	-0.989	-0.334	Stationary
D.C.M. IND.	-1.482	-0.941	-1.167	-1.028	-0.549	-0.895	-0.519	-0.855	-0.51	Stationary
ESCORTS	-1.147	-0.516	-1.02	-0.854	-0.411	-0.691	-0.386	-0.612	-0.296	Stationary
ESSAR SHIPPING	-1.436	-0.695	-1.165	-0.957	-0.475	-0.843	-0.464	-0.718	-0.459	Stationary
G.N.F.C.	-1.117	-0.682	-0.898	-0.724	-0.609	-0.536	-0.541	-0.642	-0.448	Stationary
GRASIM	-1.047	-0.718	-0.782	-0.731	-0.471	-0.74	-0.465	-0.6	-0.493	Stationary
HIND.ALUMINIUM	-1.211	-0.629	-0.973	-0.835	-0.478	-0.734	-0.464	-0.671	-0.43	Stationary
HIND.DEV.CO.	-0.876	-0.876	-0.713	-0.56	-0.522	-0.535	-0.431	-0.481	-0.408	Stationary
H.L.L.	-1.138	-0.626	-0.883	-0.876	-0.44	-0.844	-0.385	-0.713	-0.441	Stationary
HIND.MOTOR	-1.598	-0.657	-1.297	-1.147	-0.537	-0.981	-0.591	-0.877	-0.515	Stationary
HERO HONDA	-1.135	-0.772	-0.877	-0.69	-0.661	-0.705	-0.567	-0.677	-0.517	Stationary
I.G.F.C.	-1.774	-0.63	-1.388	-1.162	-0.827	-1.014	-0.704	-0.913	-0.674	Stationary
INDIAN RAYON	-0.824	-0.864	-0.669	-0.574	-0.626	-0.512	-0.566	-0.464	-0.512	Stationary
J.C.T.	-1.531	-0.622	-1.187	-0.972	-0.49	-0.819	-0.431	-0.745	-0.371	Stationary
J.K.INDUSTRIES	-1.581	-0.911	-1.225	-1.031	-0.642	-0.89	-0.582	-0.772	-0.534	Stationary
J.K.SYNTHETICS	-1.879	-0.797	-1.531	-1.172	-0.491	-0.983	-0.51	-0.885	-0.461	Stationary
J.P.INDUSTRIES	-1.677	-0.608	-1.355	-1.169	-0.444	-1.001	-0.476	-0.895	-0.394	Stationary
KELVINATOR	-1.622	-1.063	-0.904	-0.771	-0.792	-0.697	-0.712	-0.881	-0.644	Stationary
L & T	-1.091	-0.736	-0.944	-0.868	-0.445	-0.763	-0.367	-0.687	-0.394	Stationary
L M L	-0.936	-0.584	-0.844	-0.702	-0.439	-0.712	-0.468	-0.662	-0.473	Stationary
MALWA COTTON	-1.277	-0.867	-0.868	-0.837	-0.62	-0.706	-0.556	-0.585	-0.511	Stationary

TABLE–A: TEST FOR STATIONARITY.

(GIVEN ARE THE CALCULATED VALUES OF THE D-F T-STATISTIC.)

COMPANY	NUMBER OF LAGS								
	1		2	3		4		5	RESULT
	RT	VT	RT	RT	VT	RT	VT	RT	VT
MOHAN MEAKIN	-0.82	-0.822	-0.725	-0.761	-0.582	-0.638	-0.521	-0.593	-0.477 Stationary
MODI RUBBER	-0.906	-0.816	-1.157	-0.892	-0.501	-0.736	-0.46	-0.78	-0.422 Stationary
MAHAVIR SPG.MILL	-0.967	-0.513	-0.776	-0.647	-0.432	-0.578	-0.437	-0.517	-0.407 Stationary
NESTLE INDIA	-1.086	-0.672	-1.218	-1.079	-0.575	-0.862	-0.585	-0.857	-0.567 Stationary
ORKAY SILK MILLS	-1.399	-0.671	-1.087	-0.918	-0.342	-0.894	-0.465	-0.747	-0.596 Stationary
OSWAL AGRO MILL GR	-0.632	-0.599	-0.499	-0.413	-0.448	-0.345	-0.416	-0.297	-0.351 Stationary
RELIANCE IND.	-1.715	-0.756	-1.36	-1.067	-0.459	-0.863	-0.391	-0.705	-0.352 Stationary
SHRI RAM IND.ENT.	-0.987	-1.036	-0.826	-0.741	-0.755	-0.761	-0.692	-0.656	-0.645 Stationary
S.K.B.	-1.083	-0.958	-0.813	-0.632	-0.68	-0.71	-0.61	-0.66	-0.558 Stationary
SOUTHERN PETRO	-1.075	-0.922	-0.889	-0.863	-0.548	-0.799	-0.514	-0.771	-0.497 Stationary
S.R.F.	-1.043	-0.658	-0.944	-0.669	-0.527	-0.622	-0.488	-0.538	-0.44 Stationary
TELCO	-1.374	-1.002	-0.988	-0.805	-0.701	-0.685	-0.606	-0.653	-0.551 Stationary
TISCO	-1.014	-0.717	-0.904	-0.757	-0.427	-0.702	-0.389	-0.612	-0.36 Stationary
UTI MAST.SHARE	-1.779	-0.763	-1.428	-1.241	-0.484	-1.101	-0.446	-0.997	-0.451 Stationary
VAM ORGANICS	-2.795	-2.827	-3.636	-3.531	-3.511	-3.479	-3.468	-3.433	-3.442 Non-stat.

RT denotes the change in price & VT denotes the volume transacted of shares.

THE RESULTS COLUMN INDICATES WHETHER THE SERIES ARE STATIONARY OR NOT.

THE CRITICAL VALUE OF THE DICKEY-FULLER t-STATISTIC IS GIVEN TO BE 2.78.

TABLE-B: TEST FOR CO-INTEGRATION.

COMPANY	NUMBER OF LAGS										RESULT
	1		2		3		4		5		
	RT	VT	RT	VT	RT	VT	RT	VT	RT	VT	
A.C.C.	-10.69	-7.18	-9.05	-6.13	-7.65	-5.18	-6.91	-4.68	-6.21	-4.75	C
ANDHRA CEMENT	-17.42	-7.51	-13.68	-5.99	-11.89	-5.06	-10.76	-4.57	-19.09	-4.16	C
APOLLO TYRES	-13.12	-8.51	-10.66	-6.26	-9.25	-5.01	-8.16	-4.78	-7.12	-4.05	C
ASIAN HOTELS	-10.52	-7.57	-9.53	-5.5	-7.35	-4.81	-6.58	-5.04	-6.5	-4.01	C
BINDAL AGRO.	-15.71	-5.01	-13.25	-4.21	-10.57	-4.03	-7.89	-3.57	-7.64	-3.36	C
D.C.M.	-12.89	-9.86	-10.88	-8.69	-9.97	-7.17	-9.24	-6.12	-8.79	-6.14	C
D.C.M.-TOY	-11.74	-5.76	-9.12	-5.16	-8.43	-4.42	-7.03	-4.35	-5.65	-4.28	C
D.C.M. SR M CONS.	-16.96	-8.72	-14.68	-6.46	-12.54	-2.83	-10.84	-3.07	-9.31	3.09	C
D.C.M. IND.	-14.99	-9.46	-11.82	-6.81	-10.39	-5.37	-9.16	-5.14	-8.77	-5.01	C
ESCORTS	-11.93	-5.2	-11.18	-4.73	-8077	-4.06	-7.04	-3.68	-6.76	-2.81	C
ESSAR SHIPPING	-13.2	-7.97	-10.89	-5.74	-9.01	-5.48	-7.93	-4.95	-6.78	-5.19	C
G.N.F.C.	-11.19	-6.99	-9.38	-5.84	-7.53	-5.96	-5.86	-5.36	-7.05	-4.45	C
GRASIM	-10.84	-7.39	-8.11	-6.63	-7.57	-4.92	-6.83	-8.18	-5.19	-5.46	C
HIND.ALUMINIUM	-8.83	-7.48	-7.34	5.91	-5.82	-4.88	-5.56	-4.11	-5.62	-4.16	C
HIND.DEV.CO.	-12.39	-5.99	-9.82	-5.62	-8.31	-4.72	-7.46	-4.61	-6.72	-4.23	C
H.L.L.	-8.99	-5.47	-7.19	-5.03	-7.18	-4.38	-6.47	-4.94	-5.67	-4.69	C
HIND.MOTOR	-15.63	-5.54	-12.62	-5.29	-11.03	-5.34	-9.22	-5.15	-8.16	-2.95	C
HERO HONDA	-11.34	-7.98	-8.63	-6.81	-6.75	-6.63	-6.87	-5.48	-6.79	-4.94	C
I.G.F.C.	-17.62	-8.14	-13.67	-8.59	-11.36	-6.84	-9.77	-3.64	-8.7	-2.53	C
INDIAN RAYON	-8.3	-8.68	-6.73	-7.22	-5.76	-6.27	-5.12	-8.33	-4.62	-4.91	C
J.C.T.	-15.63	-6.2	-12.15	-5.67	-9.83	-4.74	-8.2	-4.07	-7.39	-3.44	C
J.K.INDUSTRIES	-15.06	-9.13	-11.07	-7.52	-9.75	-6.42	-8.55	-6.39	-7.53	-5.4	C
J.K.SYNTHETICS	-19.67	-7.55	-14.71	-5.33	-11.97	-5.18	-8.14	-4.47	-6.6	-3.99	C
J.P.INDUSTRIES	-16.69	-5.86	-13.46	-5.19	-11.56	-4.38	-9.83	-4.04	-8.87	-3.85	C
KELVINATOR	-16.3	-10.66	-9.08	-8.91	-7.74	-7.93	-6.95	-8.99	-8.97	-6.3	C
L & T	-10.87	-7.25	-9.59	-5.06	-9.05	-4.65	-7.98	-3.97	-6.98	3.71	C
L M L	-9.63	-5.46	-8.43	-4.91	-7.02	-4.24	-7.03	-4.24	-5.98	-4.39	C
MALWA COTTON	-9.15	-8.69	-5.63	-7.15	-7.22	-8.21	-5.76	-6.54	-5.96	-5.31	C
MOHAN MEAKIN	-8.32	-8.31	-7.35	-6.82	-7.67	-5.84	-6.42	-5.21	-5.95	-4.75	C
MODI RUBBER	-9.15	-8.18	-11.65	-6.39	-8.97	-5.04	-7.41	-4.6	-7.91	-4.31	C
MAHAVIR SPG.MILL	-10.26	-5.11	-8.22	-4.61	-6.79	-4.31	-6.16	-4.35	-5.45	-4.35	C
NESTLE INDIA	-10.81	-7.08	-11.92	-7.12	-11.04	-10.7	-8.64	-7.8	-8.49	-7.05	C
ORKAY SILK MILLS	-14.5	-6.81	-11.08	-4.06	-9.12	-6.18	-8.38	-4.42	-7.02	-3.25	C
OSWAL AGRO MILL	-6.46	-5.98	-5.01	-4.39	-4.05	-4.45	-3.36	-4.16	-2.92	-3.46	C
RELIANCE IND.	-17.21	-7.64	-13.64	-5.47	-10.88	-4.71	-8.63	-3.77	-7.17	-3.51	C

TABLE–B: TEST FOR CO-INTEGRATION.

COMPANY	NUMBER OF LAGS										RESULT
	1		2		3		4		5		
	RT	VT	RT	VT	RT	VT	RT	VT	RT	VT	
SHRI RAM IND.ENT.	-9.91	-10.38	-8.26	-8.56	-7.23	-7.47	-7.5	-9.76	-6.18	-6.56	C
S.K.B.	-10.87	-9.61	-8.35	-8.03	-7.88	-6.91	-6.67	-6.03	-6.16	-5.64	C
SOUTHERN PETRO	-10.6	-9.08	-9.13	-7.21	-8.32	-5.44	-7.64	-4.88	-7.42	-4.82	C
S.R.F.	-10.95	-7.03	-9.62	-5.97	-6.88	-5.22	-6.41	-4.85	-5.54	-4.47	C
TELCO	-13.7	-10.04	-9.76	-8.21	-7.21	-7.01	-6.46	-6.05	-5.92	-5.49	C
TISCO	-10.12	-7.08	-9.11	-5.35	-7.83	-4.3	-6.91	-3.53	-6.27	-3.41	C
UTI MAST.SHARE	-17.87	-7.61	-14.36	-5.68	-12.43	-5.45	-11.01	-4.91	-9.95	-4.7	C
VAM ORGANICS	-7.79	-7.37	-6.46	-5.78	-5.48	-5.16	-4.83	-4.68	-4.34	-4.39	C

RT denotes the change in price & VT denotes the volume transacted of shares .

" C " INDICATES THAT THE SERIES ARE CO-INTEGRATED.

THE CRITICAL VALUE OF THE DICKEY-FULLER TEST STATISTIC IS 3.37

TABLE–C: TEST FOR GRANGER-CAUSALITY.

COMPANY	NULL HYPO : R is not Granger caused by V.										NULL HYPO : V. is not Granger caused by R										Inference
	F	Pr	F	Pr	F	Pr	F	Pr	F	Pr	F	Pr	F	Pr	F	Pr	F	Pr	F	Pr	
Lags -->	1		2		3		4		5		1		2		3		4		5		
A.C.C.	0.11	0.73	1.22	0.29	0.79	0.49	0.96	0.42	0.8	0.54	1.99	0.15	2.03	0.13	2.4	0.06	2.72	0.03	2.12	0.06	N.C.
ANDHRA CEMENT	0.49	0.48	1.87	0.16	1.35	0.26	1.67	0.33	1.6	0.33	0.28	0.59	0.19	0.83	0.46	0.71	0.47	0.76	0.39	0.85	N.C.
APOLLO TYRES	0.62	0.43	0.43	0.65	0.48	0.69	0.92	0.45	0.77	0.58	1.66	0.2	0.51	0.61	0.85	0.47	0.97	0.42	1.2	0.29	N.C.
ASIAN HOTELS	15.5	0	10.1	0	7.3	0	5.33	0	3.48	0.05	1.8	0.18	2.63	0.07	0.99	0.4	1.11	0.35	1.39	0.23	$2
BINDAL AGRO.	2.03	0.16	1.88	0.15	1.98	0.12	1.65	0.16	1.8	0.11	2.6	0.11	2.34	0.09	1.58	0.19	1.23	0.3	1.24	0.29	N.C.
D.C.M.	17.3	0	13.6	0	8.9	0	6.4	0	5.2	0	1.06	0.31	0.04	0.96	0.59	0.62	0.86	0.49	0.62	0.68	$2
D.C.M.-TOY	3.5	0.06	3.24	0.04	2.59	0.05	2.75	0.03	1.85	0.1	8.27	0	5.11	0.01	3.54	0.02	2.85	0.03	2.3	0.05	$1
D.C.M. SR M CONS.	0.26	0.62	0.15	0.86	0.09	0.96	0.06	0.98	0.07	0.99	1.06	0.3	0.51	0.6	0.57	0.64	1.11	0.36	0.92	0.47	N.C.
D.C.M. IND.	0	0.97	0.74	0.48	1.75	0.16	1.94	0.11	1.75	0.13	1.42	0.23	0.87	0.42	0.97	0.41	0.98	0.42	0.78	0.57	N.C.
ESCORTS	7.5	0	3.59	0.03	3.74	0.01	2.66	0.03	3.58	0	0.07	0.8	0.11	0.89	0.24	0.87	0.37	0.83	0.37	0.87	$2
ESSAR SHIPPING	0.36	0.55	0.55	0.58	1.51	0.21	1.79	0.13	1.69	0.14	2.4	0.12	2.65	0.07	1.17	0.32	1.22	0.3	1.04	0.39	N.C.
G.N.F.C.	10.2	0	4.49	0.01	3.42	0.02	3.7	0.01	3.47	0.01	1.53	0.22	3.35	0.04	3.64	0.01	2.71	0.03	2.97	0.01	$3
GRASIM	0.94	0.33	1.66	0.19	1.24	0.3	1.33	0.26	0.53	0.75	0.03	0.88	0.44	0.64	1.96	0.12	1.45	0.22	1.32	0.26	N.C.
HIND.ALUMINIUM	0.4	0.53	0.24	0.79	0.57	0.64	1.18	0.32	1.27	0.28	1.29	0.26	0.74	0.48	1.55	0.21	1.12	0.35	1.05	0.39	N.C.
HIND.DEV.CO.	1.32	0.25	5.96	0	4.33	0.01	3.18	0.01	2.54	0.03	6.43	0.01	2.7	0.07	2.42	0.07	2.18	0.07	1.7	0.14	$3
H.L.L.	0.33	0.57	3.62	0.03	3.3	0.02	2.78	0.03	1.91	0.09	4.48	0.04	5.19	0.01	2.81	0.04	5.09	0	5.21	0	N.C.
HIND.MOTOR	0.04	0.85	0.64	0.53	0.72	0.54	0.57	0.68	0.53	0.75	0.18	0.67	0.27	0.76	0.07	0.98	0.1	0.98	0.28	0.92	N.C.
HERO HONDA	0.37	0.54	2.41	0.09	1.72	0.17	1.83	0.13	1.56	0.17	0.25	0.62	1.03	0.36	0.78	0.51	1.27	0.28	1.38	0.23	N.C.
I.G.F.C.	0.06	0.8	0.16	0.85	0.1	0.96	0.27	0.9	0.13	0.98	0.25	0.62	0.18	0.84	0.57	0.64	0.71	0.59	0.61	0.69	N.C.
INDIAN RAYON	0	0.97	0	1	0.27	0.85	0.2	0.94	0.16	0.98	0.02	0.88	0.01	0.99	0.02	1	0.03	1	0.02	1	N.C.
J.C.T.	1.61	0.25	1.4	0.25	1.32	0.27	2.03	0.09	1.58	0.17	0	0.96	0.33	0.72	0.33	0.8	0.35	0.84	0.29	0.92	N.C.
J.K.INDUSTRIES	0.12	0.73	0.39	0.68	0.44	0.72	0.39	0.82	0.3	0.91	0	0.96	0.03	0.97	0.01	1	0.05	1	0.07	1	N.C.
J.K.SYNTHETICS	1.48	0.23	0.72	0.49	0.81	0.49	0.89	0.47	1.11	0.36	0.07	0.8	0.04	0.96	0.02	1	0.02	0.96	0.23	0.95	N.C.
J.P.INDUSTRIES	0.11	0.74	0.05	0.95	0.22	0.88	0.27	0.9	0.24	0.94	0.76	0.38	0.53	0.59	0.34	0.8	0.2	0.94	0.33	0.9	N.C.
KELVINATOR	0.01	0.91	0.07	0.93	0.12	0.95	0.56	0.69	0.55	0.74	0.56	0.46	0.39	0.68	0.3	0.82	0.3	0.88	0.25	0.94	N.C.
L & T	1.94	0.17	1.42	0.25	2.33	0.08	2.06	0.09	1.62	0.06	0.05	0.81	0.71	0.49	1.91	0.13	1.85	0.12	2.68	0.02	N.C.
L M L	8.93	0	5.8	0	4.89	0	3.78	0.01	4.9	0	0.15	0.7	0.15	0.86	0.16	0.92	0.35	0.84	0.34	0.89	$2
MALWA COTTON	0.45	0.5	4.53	0.01	2.96	0.03	2.29	0.06	3.19	0.01	0.01	0.91	0.01	0.99	0.01	1	0.01	1	0.02	1	N.C.
MOHAN MEAKIN	0.01	0.98	2.14	0.12	1.43	0.24	1.01	0.41	0.8	0.55	0.03	0.86	0.14	0.87	0.12	0.95	0.09	0.99	0.08	1	N.C.
MODI RUBBER	0	0.98	0	1	0.09	0.97	0.12	0.97	0.09	0.99	0.21	0.65	0.2	0.81	0.54	0.65	0.42	0.79	0.46	0.81	N.C.
MAHAVIR SPG.MILL	1.53	0.22	1.21	0.3	0.94	0.42	0.83	0.51	0.74	0.59	7.51	0.01	5.69	0	3.76	0.01	3.03	0.02	2.41	0.04	$1
NESTLE INDIA	1.49	0.22	1.29	0.28	1.01	0.39	0.24	0.92	0.2	0.96	0	0.95	0.24	0.79	0.33	0.81	0.66	0.62	0.63	0.67	N.C.
ORKAY SILK MILLS	0.86	0.36	2.35	0.1	3.01	0.03	2.81	0.03	2.51	0.03	0.7	0.4	0.24	0.78	1.53	0.21	0.76	0.55	1.16	0.33	N.C.
OSWAL A(GRO MILL	0.04	0.85	0.13	0.87	0.09	0.97	0.17	0.95	0.23	0.95	0.03	0.87	0.06	0.94	0.13	0.94	0.77	0.55	0.58	0.72	N.C.
RELIANCE IND.	0.84	0.36	0.93	0.4	0.72	0.54	0.64	0.64	0.48	0.79	0.11	0.74	0.08	0.92	0.09	0.96	0.38	0.82	0.25	0.94	N.C.
SHRI RAM IND.ENT.	0	0.96	0.1	0.9	2.77	0.04	0.64	0.64	0.48	0.79	0.11	0.74	0.08	0.92	0.09	0.96	0.38	0.82	0.25	0.94	$1

TABLE–C: TEST FOR GRANGER-CAUSALITY.

COMPANY	NULL HYPO : R is not Granger caused by V .										NULL HYPO : I V is not Granger caused by R										Inference
	F	Pr	F	Pr	F	Pr	F	Pr	F	Pr	F	Pr	F	Pr	F	Pr	F	Pr	F	Pr	
Lags -->	1		2		3		4		5		1		2		3		4		5		
S.K.B.	0	0.95	0.01	0.99	6.17	0	4.87	0	5.84	0	0	0.99	0	0.99	0	1	0	1	0	1	N.C.
SOUTHERN PETRO	2.57	0.11	1.92	0.15	1.21	0.31	0.68	0.6	1	0.42	1.51	0.22	1.17	0.31	2.64	0.05	3.46	0.01	3.01	0.01	N.C.
S.R.F.	2.27	0.13	2.3	0.1	2.32	0.08	1.83	0.12	1.59	0.16	2.09	0.15	5.24	0.01	3.81	0.01	3.74	0.01	3.19	0.01	$1
TELCO	0	1	0.47	0.62	0.31	0.81	0.39	0.82	0.43	0.83	0.07	0.79	0.04	0.96	0.03	0.99	0.06	0.99	0.05	1	N.C.
TISCO	0.13	0.72	0.09	0.42	1.02	0.38	0.83	0.51	0.64	0.67	2.94	0.09	5.77	0	1.25	0.01	3.52	0.01	6.72	0	$1
UTI MAST.SHARE	0.09	0.77	0.11	0.9	0.11	0.95	0.1	0.98	0.08	1	0.01	0.91	0.06	0.94	0.04	0.99	0.04	1	0.05	1	N.C.
VAM ORGANICS	2.54	0.96	1.28	0.28	0.84	0.48	0.62	0.65	0.49	0.78	0.01	0.92	0.01	0.99	0	1	0	1	0	1	N.C.

RT denotes the change in price & VT denotes the volume transacted of shares .
** F denotes the F-Statistic of the concerned null-hypothesis .*
*** Pr denotes the probability of occurance of the null-hypothesis .*
****$1 denotes causality from R to V .*
*****$2 denotes causality from V to R .*
******$3 denotes causality both ways .*

CHAPTER - 4

GARCH MODELLING : CONCEPT , RESULTS & IMPLICATIONS

4.1 INTRODUCTION:

Modern finance theory pivots around uncertainty. Most asset pricing theories would have us believe that the risk premium is determined by the covariance between the future return on the asset and one or more benchmark portfolios like the market portfolio or the growth rate in consumption. In option pricing, the uncertainty associated with the future price of the underlying asset is the most important determinant in pricing function. Another example, where the conditional future variances and covariances among the different assets involved play an important role in the construction of hedge portfolios.

For long, it has been recognized that the uncertainty of speculative prices, as measured by the variances and covariances are changing through time. However, only recently applied researchers in financial and monetary economics have started implicitly modelling time variation in second or higher order moments. The Autoregressive Conditional Heteroskedasticity (ARCH) model of Engle (1982) and its various extensions has emerged as one of the prominent tools for characterizing such changing variances.

The ARCH process has been found to provide a good fit for many financial return time series. ARCH imposes an autoregressive structure on conditional variance, allowing volatility to persist over time. This persistence captures the propensity of returns of like magnitude to cluster in time and can explain the well documented non-normality and non-stability of empirical asset return distribution.

An appealing explanation for the presence of ARCH is based upon the hypothesis that daily returns are generated by a mixture of distributions, in which the rate of daily information arrival is the stochastic mixing variable. ARCH mixture captures the time series properties (e.g., serial correlation) of the mixing variable (Diebold [1986]).

4.2 ARCH:

The ARCH process which Engle (1982) introduced allows the conditional variance to change over time as a function of past errors leaving the unconditional variance constant.

Engle (1982) referred to all discrete time stochastic processes (ϵ_t) of the form

$$\epsilon_t = Z_t \sigma_t, \qquad \text{......(1)}$$

$$Z_t \text{ i.i.d, } E(Z_t) = 0, \text{ var } (Z_t) = 1, \text{......(2)}$$

with σ_t a time-varying, positive and measurable function of the time t-1 information set, as an ARCH model. ϵ_t is assumed to be a univariate process and is serially uncorrelated with mean zero, but the conditional variance of ϵ_t equals σ_t^2 , which may be changing through time. In most applications, ϵ_t will be found to correspond to the innovation in the mean for some other stochastic process, say (y_t) where

$$y_t = g(x_{t-1};b) + \epsilon_t \qquad \ldots.(3)$$

and $g(x_{t-1};b)$ denotes a function of x_{t-1} and the parameter vector b, where x_{t-1} is in the time t-1 information set. For simplification, ϵ_t is assumed to be observable.

Let $f(Z_t)$ denote the density function for Z_t, and let θ be the vector of all the unknown parameters in the model. By the prediction error decomposition, the log-likelihood function for the sample ϵ_t, $\epsilon_{t-1},\ldots,\epsilon_1$ becomes

$$L(\theta) = \sum_{t=1}^{T} [\log f(\epsilon_t \sigma_t^{-1}) - \log \sigma_t] \qquad \ldots.(4)$$

The second term in the summation is a Jacobian term arising from the transformation from Z_t to ϵ_t. Equation (4) above also defines the sample log-likelihood for y_t, $y_{t-1},\ldots, y_1$ as given by equation (3). Given a parametric representation for $f(Z_t)$, maximum likelihood estimates for the parameters of interest can be computed directly from equation (4) by a number of different numerical optimization techniques.

An extremely general set up is provided through equations (1) and (2) and it allows for a wide variety of models (Bollerslev et.al [1992]).

4.3 THE LINEAR ARCH (q) MODEL:

Engle (1982) in his seminal paper suggested one possible parameterization for σ_t^2 is to express σ_t^2 as a linear function of past squared values of the process,

$$\sigma_t^2 = w + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2 = w + \alpha(L)\epsilon_t^2 \qquad \ldots.(5)$$

where $w > 0$ and $\alpha_i \geq 0$ and L denotes the lag-operator. This model is known as the linear ARCH (q) model. With financial data, it captures the tendency for volatility clustering, i.e., for small (large) price changes to be followed by other small (large) price changes, but of unpredictable sign. In order to reduce the number of parameters and ensure a monotonic declining effect of more distant shocks, an ad-hoc linearly declining log structure was often imposed in many of the earlier applications of the model; i.e., $\alpha_i = \alpha(q+1-i)/(q(q+1))$ as in Engle (1982, 1983).

For Z_t normally distributed, the conditional density entering the likelihood function in equation (4) takes the form

$$\log f(\epsilon_t \sigma_t^{-1}) = 0.5 \log 2\pi - 0.5 \epsilon_t^2 \sigma_t^{-2} \qquad \ldots.(6)$$

Engle (1982) discussed the maximum likelihood (ML) based inference procedures for the ARCH class of models under this distributional assumption. An alternative to the ML mode of estimation of ARCH-type models, they can also be estimated directly with Generalized Method of Moments (GMM).

An observationally equivalent representation for the model in equations (1), (2) and (5) is given by the time-varying parameter MA(q) model,

$$\epsilon_t = w_t + \sum_{t=1}^{q} a_{ti} \epsilon_{t-i} ,$$

where w_t, a_{t-1}, ..., a_{tq} are i.i.d. with mean zero and variance $w, \alpha_1, \ldots, \alpha_q$, respectively. This is a relationship between the time-varying parameter class of models and the linear ARCH(q) model.

4.4 THE LINEAR GARCH (p,q) MODEL:

In many of the applications with the linear ARCH(q) model, a long lag length q is called for. An alternative and more flexible lag structure is often provided by the Generalized ARCH or GARCH(p,q) model of Bollerslev (1986). According to him, the extension of the ARCH process to the GARCH process bears much resemblance to the extension of the standard time series AR process to the general ARMA process and shows that it permits a more parsimonious description in many situations.

In empirical applications of the ARCH model a relatively long lag in the conditional variance equation is often called for, and to avoid problems with negative variance parameter estimates a fixed lag structure is typically imposed. Engle (1982, 1983). It is in this light that it seemed of immediate practical interest to Bollerslev (1986) to extend the ARCH class of models to allow for both a longer memory and a more flexible lag structure.

The GARCH model in Bollerslev (1986) can be seen to be of the form

$$\sigma_t^2 = w + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 = w + \alpha(L)\epsilon_t^2 + \beta(L)\sigma_t^2 \qquad \ldots.(7)$$

To ensure a well-defined process, all the parameters in the infinite-order AR representation $\sigma_t^2 = \emptyset(L)\epsilon_t^2 = (1-\beta(L))^{-1}\alpha(L)\epsilon_t^2$ must be non-negative, where it is assumed that the roots of the polynomial $\beta(\lambda) = 1$ lie outside the unit circle. For a GARCH(1,1) process, this amounts to ensuring that both α_1 and β_1 are non-negative. It follows also that ϵ_t is covariance stationary if and only if $\alpha(1) + \beta(1) < 1$. Surely, in that situation, the GARCH(p,q) model corresponds exactly to an infinite-order linear ARCH model with geometrically declining parameters.

The GARCH model has an appealing feature in that it concerns the time series dependence in ϵ_t^2 with autoregressive parameters $\alpha(L) + \beta(L)$, moving average parameter $-\beta(L)$ and serially uncorrelated innovation sequence $\{\epsilon_t^2 - \sigma_t^2\}$. According to Bollersler et.al (1992), this idea can be used in the identification of the orders (p+q) although in most applications, the specification p=q=1 is found to suffice.

Much of modern theory on finance is cast in terms of continuous time stochastic differential equations, while virtually all financial time series are available at discrete time intervals only. This apparent gap between the empirically motivated ARCH models and the underlying economic theory is done away with through the application of GARCH.

The GARCH(1,1) model has been shown to converge to a continuous time diffusion model as the sampling interval gets arbitrarily small. It has also been shown that if the true model is a diffusion model with no jumps, then the discrete time variances are consistently estimated by a weighted average of past residuals as in GARCH(1,1) formulation. Possibly another cause of success of the GARCH(p,q) model is that if ϵ_t^2 is linear, then the GARCH(p,q) representation may be seen as a parsimonious approximation to the possibly infinite Wold representation for ϵ_t^2.

4.5 THE ARCH EFFECT AND ECONOMIC INTERPRETATION:

The widespread existence of ARCH effects and the persistence of stock return volatility have led researchers to search for its origin. The GARCH(p,q) model can be viewed as a reduced form of a more complicated dynamic structure for the time-varying conditional second-order moments. Thus interpretations and explanatory variables for the observed ARCH effects have been proposed both on the micro and the macro level.

On the micro level, Lamoureux and Lastrapes (1990) argue that the ARCH effect is a manifestation of clustering in trading volumes. By introducing the contemporaneous trading volumes in the variance equation of a GARCH(1,1) model for individual firm's returns, they discover that lagged squared residuals are no longer significant. A simultaneity problem may seriously bias their results, as contemporaneous correlations between volume and price data have been documented by various authors like Karpoff (1987) etc. Indeed, using lagged volume as an instrument for the contemporaneous volume does not remove the standard ARCH effect. This joint relation of lagged volume and lagged returns to stock return volatility is explored using semi-nonparametric results for the value weighted New York Stock Exchange index by Gallant, Rossi and Tauchen. The results are reported in Bollerslev et.al (1992). In addition, they also found that large price movements are followed by high volume.

On the macro economic level, relevant economic variables driving stock volatilities have been proposed by various researchers. Some researchers have found that nominal rates of interest are significant determinants of volatility. It has also been shown that entering the interest rate into the GARCH formulation leads to a decrease in persistence as measured by the conventional linear GARCH. Studies have also revealed that dividend yields play a significant role in driving stock volatilities. Variance of stock returns have been found to depend on M1 money supply and an oil price index. Researchers have also established a linkage between business cycle and financial crises.

Issues also concern the impact of changes in margin requirements on stock volatilities. A significant negative relationship between return volatility and margin requirements in the U.S. and Japanese markets have been found. It has also been found that changes in margin requirements tend to follow increases in volatility but not vice-versa.

It is unlikely that the determinants of the ARCH effect, or more generally the duration of fluctuations, is exhausted by the variables suggested in the studies listed above. While exploring a larger set of variables is certainly a worthwhile exercise, a more fruitful strategy for future research in this area, as Bollerslev et.al (1992) suggests, might involve the construction of structural models that can explain the empirical findings.

4.6 The Heteroskedostic Mixture Model and ARCH:

The Generalized-ARCH (GARCH) model of Bollerslev (1986) restricts the conditional variance of a time series to depend upon past squared residuals of the process. Such a model for change in daily stock price to developed here following Lamoreux and Lastrapes (1990)

$$r_t = \mu_{t-1} + \epsilon_t \qquad \text{....(8)}$$

$$\epsilon_t/(\epsilon_{t-1}, \epsilon_{t-2} \text{ ....}) \sim N(0,h_t) \qquad \text{....(9)}$$

$$h_t = \alpha_0 + \alpha_1 (L)\epsilon_{t-1} + \alpha_2 (L)h_{t-1} \qquad \text{....(10)}$$

where r_t represents the daily stock price change, μ_{t-1} is the mean r_t conditional on past information, L is the lag operator and $\alpha_0 > 0$. If the parameters of the lag polynomials $\alpha_1(L)$ and $\alpha_1(L)$ are positive, then shocks to volatility persist over time. The degree of persistence is determined by the magnitude of these parameters.

To motivate the empirical tests, let δ_{it} denote the i^{th} intraday equilibrium price increment in day t, which implies

$$\epsilon_t = \sum_{i=1}^{n_t} \delta_{it} \qquad \text{....(11).}$$

The random variable n_t is the mixing variable, representing the stochastic rate at which information flows into the market. It is worth noting that ϵ_t is drawn from a mixture of distributions, where the variance of each distribution depends upon information arrival time. Equation (11) implies that daily price changes are generated by a subordinated stochastic process, in which ϵ_t is subordinate to δ_i and n_t is the directing process.

If δ_i is i.i.d. with mean zero and variance σ^2, and n_t is sufficiently large, then $\epsilon_t/n_t \sim N(0,\sigma^2 n_t)$. The normal law follows from the Central Limit Theorem (CLT).

GARCH may be explained as a manifestation of time dependence in the rate of evolution of intraday equilibrium price changes. To make arguments precise, we assume that the daily number of information arrivals is serially correlated which can be expressed as follows:

$$n_t = k + b(L)\, n_{t-1} + \mu_t \qquad \text{....(12)}$$

where k is a constant, b(L) is a lag polynomial of order q and μ_t is white noise. Innovations in the mixing variables persist according to the autoregressive structure of b(L). Define $\Omega_t = E(\epsilon_t^2 / n_t)$. As noted above, if the mixture model is valid, then $\Omega_t = \sigma^2 n_t$. Substituting the moving average representation of (12) into this expression of variance yields

$$\Omega_t = \sigma^2 k + b(L)\Omega_{t-1} + \sigma^2 \mu_t \qquad .....(13).$$

Equation (13) captures the type of persistence in conditional variance that can be picked up by estimating a GARCH model. In particular, innovations to the information process lead to a momentum in the squared residuals of daily returns.

The focus of our empirical test is on the variance of returns conditional on knowledge of the mixing variable. Because n_t is generally not observed, a proxy is required. Following Lastrapes and Lamoreux (1990), we choose daily trading volume as a measure of the amount of daily information that flows into the market. Tauchen and Pitts (1983) model volume and price change as being a joint (random) function of information flow. If this specification is correct, our estimation is subject to an unquantified specification bias. The sequential information models of Copeland (1976) and others and the mixture of Epps and Epps (1976) uses volume as the mixing variable. Though the precise role of volume in financial research is not clear, it is thought to contain information about the disequilibrium dynamics of asset markets.

The model to be estimated for each stock in the sample is given by equation (8) and the following generalized variance specification:

$$\epsilon_t | (v_t \ \epsilon_{t-1}, \epsilon_{t-2} \ \ldots.) \sim N(0,h_t) \qquad \ldots.(9')$$

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1} + \alpha_2 h_{t-1} + \alpha_3 v_t \qquad \ldots.(10')$$

Under the assumption that volume (v_t) is the mixing variable, volume is weakly exogenous. Attention here to restricted to the GARCH(1,1) specification as it has been shown to be a parsimonious representation of conditional variance that adequately fits many economic time series (Lamoreux and Lastrapes (1990)). A succinct measure of the persistence of variance as measured by GARCH is the sum ($\alpha_1 + \alpha_2$); as this sum approaches unity, the greater is the persistence of shocks to volatility.

4.7 DATA, ESTIMATION, RESULTS AND IMPLICATIONS:

The data used here are the daily closing prices and volume transacted for the shares of 43 companies listed under group-A of the Delhi Stock Exchange. The data, the rationale for working at the individual security level and also for that of working on a thin market like DSE has been provided in the previous chapter already.

To put it simply, we provide the equations which would help us to differentiate between GARCH(1,1), ARCH(2) and ARCH(3) models employed here. The model to be estimated is of the form

$$r_t = C_0 + \mu_{t-1} + \epsilon_t$$

and $$\epsilon_t/(v_t, \epsilon_{t-1}, \epsilon_{t-2} \ldots) \sim N(0,h_t).$$

For ARCH(1), the variance specification would be

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1}.$$

For ARCH(2), the variance specification would be

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1} + \alpha_2 \epsilon_{t-2}.$$

Similarly, for ARCH(3), the variance specification would be

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1} + \alpha_2 \epsilon_{t-2} + \alpha_3 \epsilon_{t-3}.$$

In case of GARCH(1,1), the variance takes the form of

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1} \; \beta \, h_{t-1}.$$

Since we have used volume as a "mixing variable" following Lamoreux and Lastrapes (1990), the volume enters each of the equations specifying the variance, i.e., for ARCH(2) (say), the variance specification would be

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1} + \alpha_2 \epsilon_{t-2} + \gamma v_t.$$

For GARCH(1,1), it would take the form

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1} \; \beta \, h_{t-1} + \gamma v_t \; .$$

In our exercise here with ARCH modelling, we have made an attempt to find out the efficiency of the capital market. The ϵ_{t-i} terms are used here as measures of the individuals' intuition of the working of the market based on the information of the previous periods with lags of 'i'. The information content of the ϵ_{t-i}s are, however, those of a particular scrip (viz., ACC or HLL etc.) since ours is an exercise at the individual security level. The information content of the ϵ_{t-i} term is, however, quite different from the information content of the h_{t-i} terms of the equations. The former, as has been said, contains information enough for an individual to make his own decisions for investment based on the signals emitted by the change in price of a scrip in the lag period 'i'. It can be inferred that the individual is myopic if the α_i's are significant for lower values of 'i'. More specifically, if ARCH(i) is found to hold for a particular scrip while ARCH(j) is present in another where $j > i$, then individuals trading in the former scrip are relatively more myopic than those trading in the latter.

The GARCH model incorporates another term - the one containing the h_{t-i}. The term h_{t-i}'s are the lagged variance of the error term present in the "mother" equation (number 8). It is considered to have an information content which has a broader base than that of the ϵ_{t-i}s. The h_{t-i}'s are considered to contain information about the market structure in general as well as those informations which play an active part in influencing the price of the scrip considered. It is the h_{t-i} whose incorporation into the variance of the error term h_t or the GARCH specification which helps us to bring the structure of the market into consideration while studying the factors which play a role in determining prices of scrips.

Following Engle, Hendry and Richard (1983); under the assumption that volume (v_t) is the mixing variable, volume is weakly exogenous. The term v_t provides us with the effect volume has on prices of scrips. Here volume is considered to be a "super-informative" source of price determination. In our effort to find out the change in price and volume relationship, we check for the significance of the term. If found significant, then volume is considered to be an important source of information in affecting the price of a scrip. If prices respond to volume traded of a particular scrip then it can be inferred that prices are sensitive to information arrival through volume. This reflects an efficient market structure where prices reflect available informations.

An efficient market would testify the presence of GARCH effect thereby reflecting that all available market information plays an important role in influencing prices of scrips.

The coefficient of the volume term would also be significant indicating its importance in influencing prices of scrips.

And also it should show the presence of a higher-order ARCH process negating the fact that individuals are not myopic in using their intuition while forming their investment decisions regarding a particular scrip.

Here, we have followed the method of Lamoreux and Lastrapes (1991) by entering volume data into the GARCH variance equation and investigating whether the trading volumes contain significant information stock price change and volatility prediction in the Delhi Stock Exchange.

Our results have been provided in a tabular form at the end of the chapter in Table D. For every company, we have looked at the GARCH(1,1) model, the ARCH(2) and ARCH(3) models. The measure of persistence of volatility, as measured by Lamoreux and Lastrapes (1990) is carried out here too. The coefficient for ϵ_{t-1} and h_{t-1} i.e., α_1 and β in the GARCH(1,1) model is calculated. If the value of the sum is greater than unity, then we can testify the persistence of shocks to volatility. Here, in our results of GARCH(1,1) model we find that very few scrips exhibit the persistence of shocks to volatility. Only two companies exhibit the phenomenon.

The presence of GARCH is ascertained by using the t-statistic of the β-term. If the t-statistic is found to be significant, then we can conclude that GARCH effect is present for that particular scrip.

The presence of ARCH(2) is tested for by comparing the calculated and the tabulated value of the t-statistic of α_2. This implies that individuals take into their consideration the information for a particular scrip available to them from a lag of two periods. The presence of ARCH(2) implies that individuals are less myopic than they would have had ARCH(1) been present. ARCH(3) is similarly tested and explanation provided likewise.

A significant volume term would have one believe that volume has an influence on prices of scrips traded on the exchange.

To elucidate, the table shows that for Bindal Agro, the t-value of β is significant implying the presence of GARCH(1,1) effect. The coefficient of α_2 is significant while that of α_3 is not. This implies the presence of ARCH(2) and absence of ARCH(3) effect. The volume coefficient is found to be significant for GARCH(1,1) and ARCH(2) model. This implies that volume plays an important role in influencing prices of scrips for a maximum of two periods only.

The results of the GARCH and ARCH modelling show that 25 companies have been shown the presence of GARCH(1,1) or volume effect or both. 8 companies have exhibited the GARCH effect only. These are DCM Ltd., DCM-SRIRAM Industries Ltd., Hero Honda, J.K. Synthetics, Kelvinator, Larsen & Toubro, Malwa Cotton Mills Ltd. and TISCO. 13 companies had positive "volume" effect only. They are Andhra Cement, Apollo Tyres, Asian Hotels, DCM-Toyota, Escorts, Hindustan Development Corporation, Hindustan Motors, IGFC, J.K. Industries, LML, Nestle, SRF and UTI Master Share. 4 companies - Bindal Agro, SPIC, GNFC and Orkay Silk Mills.

Here, volume effect captures not the causality running to R_t as in the previous exercise, but acts as a source of super information. Volume is thought to be the source of such an information which affects prices of scrips. However, the GARCH effect captured through the h_{t-1} term in the variance equation, encompasses all possible market information and is thus stronger in itself.

Thus the GARCH modelling seems to be stronger than the causality test since the same data has been used here for a better result.

ARCH effect has also been tested here with p = 2 and 3. Asian Hotels, Bindal Agro, DCM-Toyota, Grasim Industries, Hero Honda, J.K. Synthetics, Malwa Cotton, Orkay Silk Mills and Reliance Industries have shown the presence of ARCH(2) effect. Only 5 companies - Andhra Cement, DCM Ltd., HLL, LML and UTI Master Share have shown less myopic nature in investors' decision by testing positive for ARCH(3) effect.

Thus, we can infer that the Structural Adjustment Programme initiated by the government has a long way to go before it can build up a capital market structure which is efficient. The efficiency of the capital market manifests itself in a pricing system where all information is reflected in the scrip's price. The probable causes for the presence/absence of an efficient market structure through causality between share price change and volume and hence GARCH and volume effects has been outlined in the previous chapter. The results of GARCH show little improvement from the results arrived at previously from the exercise on cointegration and causality.

Our result does not provide any empirical support for the hypothesis that ARCH is a manifestation of the daily time dependence in the rate of information arrival to the market for individual stocks. Thus, this form of heteroskedasticity is not an artifact of the arbitrary, at the same time natural, choice of observation frequency for conditions prevalent in the Indian capital market at present.

TABLE—D: RESULT FROM ARCH & GARCH MODELLING.

COMPANIES.	Constant	Alpha - 0	Alpha - 1	Alpha - 2	Alpha - 3	Beta	Gamma	Model Used
A.C.C.	0.20	0.00	0.04			0.07	0.00	GARCH(1,1)
	(0.00)	(0.20)	(0.17)			(0.02)	(1.15)	
	0.00	0.00	0.02	0.01			0.01	ARCH(2)
	(0.00)	(9.75)	(0.17)	(0.00)			(1.13)	
	0.006	0.00	0.09	0.05	0.18		0.00	ARCH(3)
	(0.00)	(9.42)	(0.17)	(0.88)	(0.30)		(1.13)	
ANDHRA CEMENT	0.20	0.10	1.17			0.24	0.20	GARCH(1,1)
	(7.77)	(6.97)	(2.36)			(0.34)	(-8.2599)	
	0.11	0.08	5.78	0.37			0.30	ARCH(2)
	(7.08)	(6.41)	(3.49)	(0.56)			(-8.824)	
	0.05	0.03	1.09	0.89			0.0087	ARCH(3)
	(2.76)	(6.86)	(3.42)	(0.97)			(-11.829)	
APOLLO TYRES	0.01	0.01	0.92				0.55	GARCH(1,1)
	(2.43)	(5.85)	(4.05)				(-.389)	
	0.68	0.11	1.06	0.10			0.72	ARCH(2)
	(2.49)	(6.61)	(4.02)	(1.41)			(-.4254)	
	0.63	0.15	0.44	0.25	0.61		0.33	ARCH(3)
	(1.96)	(7.81)	(2.86)	(0.65)	(2.75)		(-.1259)	
ASIAN HOTELS	4.51	0.40	0.02			0.03	3.71	GARCH(1,1)
	(21.81)	(2.50)	(0.09)			(1.25)	(3.19)	
	(0.23)	0.66	0.04	0.31			0.88	ARCH(2)
	(-.9760)	(7.66)	(0.85)	(2.77)			(2.32)	
	0.20	0.64	0.05	0.21	0.09		0.67	ARCH(3)
	(-.8785)	(6.88)	(0.90)	(2.21)	(1.33)		(3.20)	

contd.

TABLE—D: RESULT FROM ARCH & GARCH MODELLING.

COMPANIES.	Constant	Alpha - 0	Alpha - 1	Alpha - 2	Alpha - 3	Beta	Gamma	Model Used
BINDAL AGRO	4.45	0.43	0.92			0.22	2.32	GARCH(1,1)
	(2.09)	(4.09)	(5.37)			(3.49)	(2.23)	
	-0.02	0.01	0.32	8.76			0.00	ARCH(2)
	(-10.77)	(2.93)	(2.20)	(7.61)			(15.16)	
	0.02	0.05	0.42	0.42	0.20		0.00	ARCH(3)
	(0.716)	(9.520)	(1.353)	(0.625)	(1.063)		(0.711)	
D.C.M.	-0.0013	0.00019	0.14			0.55	0.00	GARCH(1,1)
	(-0.761)	(1.781)	(1.815)			(2.495)	(0.087)	
	-0.0014	0.00047	0.10	0.12			0.00	ARCH(2)
	(-0.80275)	(7.9018)	(1.3897)	(1.5026)			(0.30138)	
	-0.00134	0.000392	0.08	0.09	0.19		0.00	ARCH(3)
	(-0.7972)	(6.9373)	(1.1585)	(1.2872)	(1.9366)		(0.06614)	
D.C.M.-TOYOTA	-0.0092	0.0024	0.00			0.00	0.00	GARCH(1,1)
	(-0.138)	(0.160)	(0.00)			(0.00)	(0.001)	
	-0.00257	0.00204	0.00	0.26			0.00	ARCH(2)
	(-0.60183)	(7.3426)	(0.00)	(2.2054)			(3.3344)	
	-0.00296	0.00195	0.00	0.34	0.00		0.00	ARCH(3)
	(-0.7035)	(6.7823)	(0.00)	(2.5771)	(0.00)		(3.1097)	
D.C.M. INDUSTRIES	-0.0131	0.00019	0 1378			0.547	0.00315	GARCH(1,1)
	(-0.761)	(1.781)	(1.815)			(2.495)	(0.09)	
	-0.00140	0.00047	0.10351	0.12131			0.00651	ARCH(2)
	(-0.80275)	(709018)	(1.39)	(1.50)			(0.30)	
	-0.00134	0.0392	.07646	.0899	0.18890		0.00716	ARCH(3)
	(-.7972)	(6.94)	(1.16)	(1.29)	(1.94)		(0.66)	

contd.

TABLE—D: RESULT FROM ARCH & GARCH MODELLING.

COMPANIES.	Constant	Alpha - 0	Alpha - 1	Alpha - 2	Alpha - 3	Beta	Gamma	Model Used
D.C.M. SRIRAM	0.004	0.004	0.269			0.282	0.0032	GARCH(1,1)
	(-0.088)	(8.95)	(1.55)			(2.67)	(0.56)	
	-0.0578	0.00464	0.26146	0.00636			0.0038	ARCH(2)
	(-1.0805)	(9.92)	(1.48)	(0.00)			(0.42)	
	-0.00252	0.00352	0.13774	0.0065	0.00475		0.0069	ARCH(3)
	(-0.53934)	(9.96)	(1.40)	(0.00)	(0.33)		(0.82)	
ESCORTS	-0.0055	0.00212	0.0053			0.0096	0.0059	GARCH(1,1)
	(-1.4379)	(0.01)	(0.0031)			(0.096)	(2.65)	
	(0.00)	0.00137	0.01219	0.25814			0.0019	ARCH(2)
	(-1.3418)	(8.29)	(0.3514)	(2.33)			(2.85)	
	-0.0480	0.00127	0.00986	0.14412	0.10468		0.0097	ARCH(3)
	(-1.4811)	(7.80)	(0.28701)	(1.74)	(1.56)		(3.55)	
ESSAR	0.00105	0.22319	0.14162			0.0259	0.0062	GARCH(1,1)
	(0.25)	(5.93)	(1.49)			(0.00)	(-1.303)	
	0.00412	0.00228	0.13949	0.00931			0.00251	ARCH(2)
	(0.10)	(9.05)	(1.46)	(0.70)			(-1.033)	
	0.00142	0.00178	0.15562	0.08229	0.1381		0.00609	ARCH(3)
	(0.38)	(7.21)	(1.48)	(0.87)	(1.38)		(-0.747)	
GRASIM	-0.0028	0.039	0.0068			0.0069	0.0035	GARCH(1,1)
	(-0.066)	(0.06)	(0.01)			(0.00)	(0.0042)	
	0.0353	0.0240	0.00752	0.7703			0.0017	ARCH(2)
	(0.24)	(7.16)	(0.01)	(3.26)			(3.49)	
	0.00261	0.0295	0.0025	0.21415	0.0032		0.0029	ARCH(3)
	(1.74)	(7.06)	(0.00)	(1.96)	(0.00)		(2.98)	

contd.

TABLE—D: RESULT FROM ARCH & GARCH MODELLING.

COMPANIES.	Constant	Alpha - 0	Alpha - 1	Alpha - 2	Alpha - 3	Beta	Gamma	Model Used
G.N.F.C.	-0.00174	0.0026	0.03267			0.6445	0.00212	GARCH(1,1)
	(-0.752)	(2.26)	(1.16)			(4.27)	(2.17)	
	-0.00345	0.052	0.74432	0.01238			0.0015	ARCH(2)
	(-0.174)	(7.90)	(3.49)	(0.43)			(-2.341)	
	0.0722	0.0052	0.49267	0.0057	0.16002		0.006	ARCH(3)
	(-0.353)	(7.45)	(2.95)	(0.01)	(1.88)		(-2.286)	
HINDAL	0.0042	0.00105	0.0001			0.0061	0.0091	GARCH(1,1)
	(0.08)	(0.10)	(0.91)			(0.00)	(-0.003)	
	0.0042	0.0011	0.003	0.003			0.0083	ARCH(2)
	(0.08)	(0.10)	(0.00)	(0.00)			(-0.0299)	
	0.0052	0.00116	0.0061	0.005	0.003		0.0073	ARCH(3)
	(0.07)	(0.10)	(0.01)	(0.00)	(0.00)		(-0.0295)	
H.D.C.	-0.0997	0.0032	0.1281			0.00	0.01	GARCH(1,1)
	(-2.131)	(5.966)	(1.4155)			(0.00)	(2.707)	
	-0.00577	0.00366	0.12046	0.00			0.003	ARCH(2)
	(-1.1935)	(9.3209)	(1.3239)	(0.00)			(2.2032)	
	-0.00572	0.00304	0.0687	0.00	0.00		0.0095	ARCH(3)
	(-1.3059)	(9.4825)	(1.1482)	(0.00)	(0.00)		(2.0392)	
H.L.L.	-0.0128	0.02712	0.00083			0.0006	0.00083	GARCH(1,1)
	(-0.107)	(0.5321)	(0.00041)			(0.00019)	(0.00047)	
	-0.00965	0.0001	0.0009	49.738			0.00059	ARCH(2)
	(-23.037)	(2.2803)	(0.00056)	(9.3607)			(31.984)	
	-0.01071	0.0003	0.00039	40.563	2.1771		0.00051	ARCH(3)
	(-22.606)	(0.26952)	(0.00063)	(8.3953)	(3.0008)		(14.793)	

contd.

TABLE—D: RESULT FROM ARCH & GARCH MODELLING.

COMPANIES.	Constant	Alpha - 0	Alpha - 1	Alpha - 2	Alpha - 3	Beta	Gamma	Model Used
HIND. MOTOR	0.02031	0.00324	2.2870			0.00054	0.0008	GARCH(1,1)
	(4.597)	(6.5321)	(3.8741)			(0.00073)	(-3.045)	
	0.01490	0.000808	5.0393	0.0012			0.035	ARCH(2)
	(7.8267)	(4.7174)	(6.5108)	(0.00069)			(-9.5116)	
	0.03138	0.00334	1.4015	0.06792	0.00084		0.0057	ARCH(3)
	(6.2867)	(6.5149)	(3.4043)	(0.78938)	(0.00071)		(-6.1617)	
HERO HONDA	0.00183	0.00148	0.1454			0.75961	0.0006	GARCH(1,1)
	(0.809)	(1.952)	(2.2151)			(7.8389)	(-0.206)	
	-0.00130	0.00593	0.14013	0.80745			0.0009	ARCH(2)
	(-0.6491)	(7.5321)	(1.7610)	(3.4870)			(0.70996)	
	0.00152	0.00580	0.14688	0.77163	0.0055		0.00015	ARCH(3)
	(-0.7623)	(7.1327)	(1.8125)	(3.4410)	(0.0003)		(0.6177)	
I.G.F.C.	0.02415	0.0054	1.8686			0.00028	0.00091	GARCH(1,1)
	(4.7966)	(7.0894)	(2.9567)			(0.00053)	(-3.680)	
	0.01782	0.00882	4.7326	0.0003			0.00029	ARCH(2)
	(10.707)	(3.9264)	(6.4224)	(0.0008)			(1.9672)	
	0.00531	0.00723	0.43098	0.00023	0.13485		0.00031	ARCH(3)
	(0.79412)	(9.3638)	(1.5161)	(0.00016)	(1.0063)		(0.0196)	
INDIAN RAYON	0.00372	0.0302	0.00054			0.0003	0.0005	GARCH(1,1)
	(0.0036)	(0.504)	(0.00009)			(0.000012)	(0.00015)	
	0.00372	0.03088	0.00062	0.00054			0.00082	ARCH(2)
	(0.0034)	(0.51014)	(0.00042)	(0.00069)			(0.00153)	
	0.00237	0.03158	0.00058	0.00003	0.00041		0.00044	ARCH(3)
	(0.00302)	(0.51585)	(0.00036)	(0.00014)	(0.00002)		(0.000152)	

contd.

TABLE—D: RESULT FROM ARCH & GARCH MODELLING.

COMPANIES.	Constant	Alpha - 0	Alpha - 1	Alpha - 2	Alpha - 3	Beta	Gamma	Model Used
J.C.T.	0.01664	0.00175)	1.3664			0.00061	0.00050	GARCH(1,1)
	(4.509)	(6.2828)	(3.7651)			(0.00003)	(0.423)	
	0.02246	0.000728	4.4075	0.00031			0.00033	ARCH(2)
	(11.184)	(3.5461)	(6.5283)	(0.0006)			(-5.2373)	
	-0.00615	0.00224	0.74115	0.00008	0.23981		0.000017	ARCH(3)
	(-1.3539)	(7.5943)	(2.4115)	(0.00004)	(1.3964)		(1.8171)	
J.K.INDUSTRIES	-0.0341	0.00834	0.21454			0.00082	0.00002	GARCH(1,1)
	(-4.578)	(7.2968)	(1.2956)			(0.00006)	(-2.229)	
	0.01412	0.00185	4.6419	0.0002			0.000040	ARCH(2)
	(14.312)	(1.5334)	(6.0219)	(0.00009)			(3.8104)	
	0.005445	0.00387	0.60824	0.000008	0.030208		0.000072	ARCH(3)
	(1.0711)	(8.0574)	(1.6153)	(0.00005)	(1.0001)		(1.13885)	
J.K.SYNTHETICS	0.0148	0.01276	0.4076			0.2522	-0.00043	GARCH(1,1)
	(1.1695)	(4.9858)	(1.7182)			(2.9967)	(-0.313)	
	0.00331	0.00496	0.21625	10.965			0.000022	ARCH(2)
	(2.28281)	(2.7204)	(1.8676)	(7.7124)			(9.7154)	
	0.00514	0.02005	0.1257	0.00258	0.0204		0.00061	ARCH(3)
	(0.3800)	(9.9587)	(1.3744)	(0.0808)	(0.68316)		(0.21564)	
J.P.INDUSTRIES	0.0103	0.00820	0.1772			0.00081	0.000061	GARCH(1,1)
	(1.285)	(8.9677)	(1.0743)			(0.00003)	(-0.685)	
	0.00692	0.01028	0.20016	0.0006			0.00010	ARCH(2)
	(0.7707)	(9.9911)	(1.0562)	(0.0001)			(-0.5946)	
	0.00971	0.00776	0.10834	0.00051	0.8658		0.000038	ARCH(3)
	(1.2295)	(9.8202)	(0.90819)	(0.00002)	(0.80684)		(-0.50739)	

contd.

TABLE—D: RESULT FROM ARCH & GARCH MODELLING.

COMPANIES.	Constant	Alpha - 0	Alpha - 1	Alpha - 2	Alpha - 3	Beta	Gamma	Model Used
KELVINATOR	0.00285	0.00031	0.2250			0.6979	0.000071	GARCH(1,1)
	(1.00870	(3.697)	(2.8684)			(12.152)	(0.1559)	
	0.001601	0.002110	0.29827	0.12939			0.000002	ARCH(2)
	(0.46166)	(8.4199)	(1.9037)	(1.3287)			(0.13596)	
	-0.00279	0.00178	0.29256	0.000008	0.17797		0.000004	ARCH(3)
	(-0.86264)	(8.0243)	(2.02220	(0.00002)	(1 6321)		(0.67602)	
L & T	-0.00147	0.000122	0.13835			0.6279	0.000013	GARCH(1,1)
	(-0.851)	(1.6747)	(1.8839)			(3.4371)	(1.940)	
	-0.001119	0.000397	0.1536	0.08688			0.000040	ARCH(2)
	-(0.63220)	(7.2851)	(1.6814)	(1.1192)			(1.6752)	
	-0.00128	0.000342	0.09006	0.07142	0.19022		0.000007	ARCH(3)
	(-0.74738)	(6.2919)	(1.1828)	(0.99581)	(1.9107)		(2.1598)	
L M L	-0.0130	0.00161	0.0334			0.000200	0.000045	GARCH(1,1)
	(-2.9515)	(0.679)	(0.5378)			(0.00003)	(4.876)	
	-0.01302	0.00167	0.03406	0.000061			0.000590	ARCH(2)
	(-2.9009)	(8.2982)	(0.53102)	(0.00004)			(4.7944)	
	-0.00981	0.0011	0.14134	0.000012	0.27596		0.000961	ARCH(3)
	(-2.4357)	(5.6814)	(1.5660)	(0.00003)	(2.3706)		(5.3463)	
MALWA COTTON	0.0170	8.9941	0.2692			0.2852	-0.00092	GARCH(1,1)
	(0.0580)	(0.0106)	(0.0025)			(3.0042)	(-0.0059)	
	0.05417	0.00001	62.163	43.429			0.00095	ARCH(2)
	(15.233)	(0.0000)	(3.8650)	(3.0174)			(3.5916)	
	0.13245	2.7332	66.246	48.787	43.403		-0.00088	ARCH(3)
	(8.0513)	(1.8330)	(1.1941)	(1.0633)	(1.2690)		(-3.5629)	

contd.

TABLE—D: RESULT FROM ARCH & GARCH MODELLING.

COMPANIES.	Constant	Alpha - 0	Alpha - 1	Alpha - 2	Alpha - 3	Beta	Gamma	Model Used
MAHAVIR SPNG.	-0.00644	0.00447	0.000023			0.000081	0.000067	GARCH(1,1)
	(-0.0837)	(0.20211)	(0.00001)			(0.00005)	(0.0033)	
	-0.00648	0.00450	0.000029	0.000051			0.000070	ARCH(2)
	(-0.0835)	(0.20297)	(0.00007)	(0.00001)			(0.0033)	
	-0.00651	0.00453	0.000003	0.000003	0.000071		0.000075	ARCH(3)
	(-0.0839)	(0.2036)	(0.00021)	(0.00063)	(0.00004)		(0.000332)	
MOHAN MEAKINS	0.00222	0.00135	0.00785			0.00691	0.000981	GARCH(1,1)
	(0.692)	(0.2715)	(0.233)			(0.00089)	(0.4587)	
	0.00222	0.0144	0.00794	0.00062			0.00076	ARCH(2)
	(0.67221)	(7.774)	(0.2212)	(0.00091)			(0.44531)	
	0.00221	0.00149	0.05671	0.00524	0.00608		0.00095	ARCH(3)
	(0.6571)	(7.5707)	(0.1645)	(0.00095)	(0.00079)		(0.4369)	
MODI RUBBER	0.00917	0.01109	0.00008			0.000051	0.00086	GARCH(1,1)
	(0.0098)	(0.31933)	(0.00061)			(0.00036)	(0.00149)	
	0.00917	0.01113	0.00078	0.00061			0.00092	ARCH(2)
	(0.00975)	(0.3224)	(0.00096)	(0.00009)			(0.00148)	
	-0.00907	0.00638	0.00059	0.00067	0.2518		0.00118	ARCH(3)
	(-1.3490)	(8.5008)	(0.00092)	(0.00033)	(1.1801)		(0.1738)	
NESTLE	0.01727	0.00330	0.2249			0.00091	-0.00051	GARCH(1,1)
	(4.0319)	(5.993)	(1.439)			(0.00667)	(-12.581)	
	0.01576)	0.00263	0.3114	0.03973			-0.6897	ARCH(2)
	(4.0708)	(9.2094)	(1.6825)	(0.72996)			(-14.054)	
	0.02135	0.00749	1.3575	0.000064	0.1447		-0.9786	ARCH(3)
	(10.505)	(5.4856)	(4.0301)	(0.00029)	(1.7711)		(-25.471)	

contd.

TABLE—D: RESULT FROM ARCH & GARCH MODELLING.

COMPANIES.	Constant	Alpha - 0	Alpha - 1	Alpha - 2	Alpha - 3	Beta	Gamma	Model Used
ORKAY SILK MILLS	-0.00364	0.0725	0.37859			0.373	0.0289	GARCH(1,1)
	(-1.1403)	(3.7002)	(3.0851)			(3.223)	(2.7228)	
	-0.00561	0.01004	0.32524	0.44951			0.9625	ARCH(2)
	(-1.9216)	(6.6409)	(2.5791)	(2.9956)			(3.1498)	
	0.00085	0.0160	0.26381	0.02883	0.00068		0.9778	ARCH(3)
	(-0.0192)	(8.0148)	(2.4427)	(0.60771)	(0.00391)		(1.1438)	
OSWAL AGRO.	0.0646	0.2469	0.48208			0.000057	0.00029	GARCH(1,1)
	(1.470)	(5.6396)	(0.90808)			(0.00072)	(0.61292)	
	0.074	0.24545	0.53900	0.000634			0.00402	ARCH(2)
	(1.685)	(10.172)	(0.9195)	(0.00298)			(0.4600)	
	0.08001	0.2375	0.63725	0.002	0.1065		0.00042	ARCH(3)
	(2.0200)	(9.9100)	(0.9253)	(0.00850)	(0.4981)		(0.5814)	
RELIANCE IND.	-0.0026	0.00265	0.16902			0.00059	0.00319	GARCH(1,1)
	(-0.50647)	(8.665)	(1.0371)			(0.00007)	(0.498)	
	-0.00380	0.0033	0.1955	0.00062			0.00051	ARCH(2)
	(-0.6570)	(9.89)	(1.0200)	(0.00002)			(0.00502)	
	0.0011	0.0003	0.018	2.3453	0.00058		0.000704	ARCH(3)
	(0.6200)	(5.429)	(0.6830)	(5.53)	(0.00091)		(1.04701)	
SHRIRAM IND.ENT.	0.0115	0.00738	0.00738			0.00061	0.00031	GARCH(1,1)
	(0.0261)	(0.0861)	(0.00006)			(0.00075)	(0.01920)	
	0.0012	0.00810	0.00031	0.00697			0.00068	ARCH(2)
	(0.0025)	(0.088)	(0.00045)	(0.00780			(0.00095)	
	0.0012	0.00971	0.00095	0.00063	0.005401		0.000051	ARCH(3)
	(0.026)	(0.0869)	(0.00875)	(0.00081)	(0.00061)		(0.00086)	

contd.

TABLE—D: RESULT FROM ARCH & GARCH MODELLING.

COMPANIES.	Constant	Alpha - 0	Alpha - 1	Alpha - 2	Alpha - 3	Beta	Gamma	Model Used
S.K.B.	0.00451	0.00738	0.000391			0.00068	0.00095	GARCH(1,1)
	(0.00988)	(0.0861)	(0.00561)			(0.00017)	(0.00879)	
	0.005061	0.001054	0.000981	0.00056			0.000495	ARCH(2)
	(0.01095)	(0.08970)	(0.00761)	(0.00033)			(0.00362)	
	0.00309	0.00748	0.005670	0.00016	0.06091		0.08543	ARCH(3)
	(1.4572)	(8.5621)	(0.00954)	(0.00002)	(1.06002)		(1.24901)	
S.P.I.C.	0.00580	0.00751	0.0797			0.8341	0.00609	GARCH(1,1)
	(2.8201)	(1.3912)	(1.8337)			(9.0123)	(4.684)	
	0.00601	0.00159	0.2331	0.07431			0.00582	ARCH(2)
	(2.7435)	(7.4102)	(2.8331)	(0.0789)			(5.6514)	
	0.00406	0.00702	0.09546	0.1564	0.00631		0.00051	ARCH(3)
	(2.0409)	(7.1944)	(1.2649)	(1.7802)	(0.00091)		(4.1799)	
S.R.F.	0.0032	0.010711	0.0323			0.00091	0.00841	GARCH(1,1)
	(1.0953)	(0.1714)	(0.1427)			(0.00074)	(2.9901)	
	0.0031	0.001251	0.00351	0.00058			0.000581	ARCH(2)
	(1.0809)	(10.0371)	(0.1421)	(0.00791)			(2.9604)	
	0.0039	0.001987)	0.003651	0.00027	0.00208		0.00042	ARCH(3)
	(1.0814)	(9.7091)	(0.1392)	(0.00048)	(0.10251)		(2.9511)	
T.E.L.C.O.	0.00162	0.0208	0.00091			0.000782	0.00023	GARCH(1,1)
	(0.0160)	(0.4561)	(0.00089)			(0.00068)	(0.00010)	
	0.00208	0.03095	0.00078	0.00058			0.00092	ARCH(2)
	(0.1381)	(0.6987)	(0.00096)	(0.00046)			(0.00562)	
	0.00064	0.04192	0.00009	0.00076	0.00095		0.00089	ARCH(3)
	(0.00651)	(0.60102)	(0.00064)	(0.00019)	(0.00815)		(0.00601)	

contd.

TABLE—D: RESULT FROM ARCH & GARCH MODELLING.

COMPANIES.	Constant	Alpha - 0	Alpha - 1	Alpha - 2	Alpha - 3	Beta	Gamma	Model Used
T.I.S.C.O.	0.00180	0.003710	0.11152			0.8440	0.00032	GARCH(1,1)
	(0.80460)	(1.52701)	(2.3643)			(13.3751)	(0.8767)	
	0.00101	0.005201	0.28901	0.1691			0.00077	ARCH(2)
	(0.04091)	(6.52010)	(2.5504)	(1.8401)			(0.36015)	
	0.00205	0.005491	3.4401	0.09018	0.50911		0.00281	ARCH(3)
	(0.09062)	(6.16081)	(2.7301)	(1.2109)	(0.78012)		(1.04006)	
UTI MAST SHARE	0.0723	0.02108	1.5885			0.00218	0.05654	GARCH(1,1)
	(5.5312)	(6.8359)	(1.7275)			(0.00091)	(3.020)	
	0.05026	0.03621	2.0305	0.00621			0.05943	ARCH(2)
	(3.9901)	(7.7801)	(1.4901)	(0.00325)			(2.4601)	
	0.01264	0.00019	2.9565	0.00258	3.3610		0.09621	ARCH(3)
	(7.2808)	(0.10529)	(6.0302)	(0.00121)	(6.19)		(3.1450)	
VAM ORGANICS	0.00807	0.0376	0.09625			0.000311	0.00672	GARCH(1,1)
	(0.0606)	(0.5445)	(0.00851)			(0.00061)	(0.02481)	
	0.0192	0.04012	0.08752	0.03691			0.00591	ARCH(2)
	(0.09621)	(0.5506)	(0.0691)	(0.00076)			(0.01979)	
	0.0361	0.6107	0.009118	0.02987	0.01581		0.00521	ARCH(3)
	(0.0285)	(0.5606)	(0.07141)	(0.00059)	(0.00585)		(0.0175)	

** The different parameters used in the ARCH & GARCH modelling has been explained in chapter four.*
** The figures in parentheses are the "t" values.*

CHAPTER - 5

CONCLUSION

To conclude in a few words seems a difficult proposition. This has been an endeavour to search for linear and non-linear dependence between change in share price and volume transacted of a share. Our study was motivated by the changing role of the capital market in financing of Indian industries in the face of a new liberalized economic policy adopted by the government under the Structural Adjustment Programme (SAP) initiated in 1991. Literatures provide evidence enough to have us believe that prior to the adoption of the New Economic Policy, the Indian capital market was inefficient and underdeveloped and its role in corporate financing remained marginal. It is, however, well documented from studies carried out on efficient capital markets elsewhere that a positive relationship between change in share price and volume transacted exists. Therefore, it remained to be seen, whether the Indian capital market made any considerable move towards an efficient and well-developed structure with the adoption of financial liberalization.

Writings of experts would have us believe that an efficient capital market is one where prices reflect all available market informations. Trading volume data has been used as a proxy for the dissemination of information.

Our aim had been to ascertain how far have we proceeded towards an efficient capital market structure since the adoption of the SAP in 1991. Irregularities in the capital market had come to light in 1992. No particular point of time can be fixed as to when the market had recovered from the crash, therefore, we consider January 1993 as the starting point of our two year period of study. Empirical study on thin markets like DSE promises to be of greater importance for people willing to operate in the international capital market in the present scenario of development and integration of the world's capital market.

A survey of some of the theoretical and empirical studies conducted on the relation between price change and volume transacted in capital markets has been made. This provides us with a firm ground to compare and contrast our findings and ascertain how far has the Indian capital market treaded towards its goal of attaining market efficiency. To meet this end, we have investigated the dynamic linkages between stock price change and trading volume in a small stock market, i.e., the Delhi Stock Exchange. Both linear and non-linear dependence is investigated.

For the former, we check for Granger causality between the change in stock price (R_t) and volume transacted (V_t). This, however, is the last of the three step procedure. The first step involves the unit-root test. This test is used to detect the stationarity of a series. Here, we have put to use the Dickey-Fuller unit-root test. The second step is the cointegration test. Two series, if found to be cointegrated, are then tested for causality. The seminal work of Engle and Granger (1987) throws light on the test for cointegration. Granger (1969, 1981) had provided us with the concept and tools for investigating causal relations. The null hypothesis of "R_t is not caused V_t" is tested against its alternative.

It is to be noted that in each of our test, we had chosen periods of lag from 1 to 5. Also each of the tests had been conducted by changing the designation of the dependent and independent variable. The results for stationarity, cointegration and causality have been reported in Tables A, B and C respectively.

Next, we go on to find out whether Autoregressive Conditional Heteroskedasticity (ARCH) provides a good fit for our data series. ARCH imposes an autoregressive structure on conditional variance, allowing volatility shock to persist over time. In our exercise here on ARCH and Generalized-ARCH (GARCH), we have followed the methodology of Lamareux and Lastrapes (1990). They found that an explanation for the presence of ARCH is based upon the hypothesis that daily price changes are generated by a mixture of distributions, in which the rate of daily information arrival is the stochastic mixing variable. ARCH is expected to capture the time series properties of the mixing variable. Volume is considered to be a good mixing variable. The objective of our exercise was to examine the validity of this explanation for daily stock price changes.

The basic difference between the ARCH and GARCH process is that the latter has an additional lagged variance term. Moreover, the apparent gap between the discrete time interval present in ARCH and the continuous time frame characterizing all economic theory is done away in GARCH. In our model, the mixing variable - volume transacted, acts as a source of super-information. The order of ARCH specifies the lag in the error term in the variance specification. This error term is used as a measure of the individual's intuition of the working of the market based on the information from the part of a particular scrip. Presence of a lower order ARCH implies myopic nature of the investor. The presence of GARCH effect implies an efficient market structure since all the information available from the past are used by individuals in decision making. Volume-effect is detected through a significant "mixing-variable" term.

The causality test showed existence of causal relation in 11 companies of which two had bidirectional causality, five had causality running from R_t to V_t and the rest had causality running from V_t to R_t. GNFC and HDC exhibited bidirectional causality. Causality from R_t to V_t was observed among DCM-Toyota, Mahavir Spinning Mills, Shriram Industrial Enterprises, SRF and TISCO. The remaining four companies, i.e., Asian Hotels, DCM, Escorts and LML showed causality running from V_t to R_t.

The results from ARCH and GARCH modelling reported in Table D provides a picture which is somewhat different from that of the Granger causality test. As compared to the results of the Granger test, where only 11 companies had exhibited the existence of causality, the results of our GARCH modelling shows that about 25 companies have showed the existence of either volume effect or GARCH effect or both. 17 companies have showed volume-effect. Among these, 5 had exhibited the presence of causality. They are LML, SRF, HDC, Escorts and Asian Hotels Ltd. Of the 12 companies where GARCH effect was found to be prominent, only two companies had previously tested positive for causality. They are DCM Ltd. and TISCO. Four companies had showed the existence of both GARCH and volume effects. From these, only GNFC had shown causality running both ways.

The GARCH effect is obviously stronger than the volume effect since the former is assumed to encompass all possible available market information within its ambit while the latter gives an idea of the role volume plays as a mixing variable and is thus a source of super-information. The information content of volume is also contained in the GARCH effect.

The ARCH effects have also been examined to search for myopic elements among decision making investors. ARCH(2) effects were noticed in 9 companies while ARCH(3) effect could be seen in only five companies.

Various reasons have been ascertained for the existence and non-existence of causality and also GARCH and volume effects. Theories of market efficiency show existence of the effects while the market structure which provides us with reasons for inefficiency proves the non-existence of causality. Theory provides us with some insight into probable causes for the existence of market efficiency. If sequential information arrival is assumed, then trading will occur only after it percolates to each trader sequentially. In a market comprising of optimists and pessimists, the total volume traded after all are informed, depends on the path to final equilibrium.

Trading volumes are high in periods when values of returns are serially correlated.

Speculation implies a positive correlation between volume and price change as it causes price to adjust quickly to new information.

The Mixture of Distribution Hypothesis (MDH) of Epps and Epps (1976) provides another theoretical setting for the existence of positive correlation between the two.

It is either due to information aggregation in markets; Pfleiderer (1984) or due to the variance of the daily rate of information flow; Tauchen & Pitts (1983), that a positive correlation between volume and price change results.

Epps (1975) considers the market to consist of only 'bulls' and 'bears' and in such a situation the market demand curve is steeper than the supply curve and so the ratio of volume to a positive price change is greater than the absolute value of the ratio of volume to a negative price change.

However, among the reasons identified as the weakness of secondary securities ranked in India, speculative dominance of markets causes stock prices to be highly volatile and divorced from fundamentals. Erratic price behaviour lends credence to the belief that fundamental analysis does not pay and is of no importance in Indian conditions.

Control measures for the above have not touched upon the much called for overhauling of the trading system.

Free-flowing credit causes a boom to be built up on the slightest pretext and reaches great heights.

Lack of control on manipulative activities of large operators and their financial muscle and manoeuvering have been identified as root causes of inefficiency.

Procedural risks and difficulties involved in ownership transfers hampers development of the market.

Market integration at the national level is called for. Though steps are taken to meet this end, they are still localised and fragmented.

Lack of transparency breeds in disbelief and a feeling of "being cheated" gains ground and hampers growth of the market.

Phasing out of direct lending in favour of public issue of debt instruments has turned out to be unpopular among the investors.

Insider trading - an entente between "insiders" of the company and jobbers of the exchange, provides an unscrupulous avenue of making profits.

To overcome these problems, various measures have been suggested. Some of these may have been adopted but proper implementation is called for.

A countrywide computerised trading network through the National Stock Exchange (NSE) is to be created. Coordination among existing stock exchanges is needed and improvement in the communication network is called for.

To do away with the inadequacy of the number of recognised retail brokerage houses, new brokerage houses should be enrolled using all possible means.

To enforce discipline among stock-brokers, their dominance from stock exchange governing bodies should be eliminated. Stricter supervision of stock exchanges, transparency of trade and trade reporting is required.

Settlement cycle should be on T+3 rather than the fortnightly settlement system. The prevailing practice of carrying forward trade should be done away with and proper systems of financial futures and options should be introduced.

Priority should be given to the creation of depository systems for traded securities.

Issues should provide adequate disclosure and for this it is necessary to tighten the audit and accounting standards observed by Indian companies.

Small and medium companies should be provided access to securities markets through specialised channels like the OTCEI etc.

Computerised trading and market making in debt instruments through specialised channels should be made.

The large number of listed equity shares with no reasonable degree of liquidity should be transferred to the computerised trading system of the OTCEI and supplement by appointment of market makers, supported by bank finance for their market making activity.

Immediate creation of securities market data base on regular basis so that data are available readily for review and research purposes.

Theoretically, several issues have been identified that merit indepth study.

(1) Is the price-volume relationship asymmetric?

(2) What would account for the asymmetric price-volume relation?

(3) Does the size of the market affect the price-volume relation?

(4) Do properties of the rate of information flow affect the price-volume relation?

(5) Can the price-volume relation be exploited to improve event study statistics?

(6) Is information arrival sequential or simultaneous, in general?

(7) Is the theory that guides empirical work in the area adequate?

With the adoption of measures aiming at the development of the Indian securities market, answer to the above questions would be pertinent in providing a solution to our query as to how far, if at all, have our financial liberalisation benefited us in gifting us a truly efficient capital market.

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