Proposal No. 155

Lead-Lag Relationship between Equities and Stock Index Futures Market and its Variation around Information Release: Empirical Evidence from India.

Introduction:
The Indian capital market has witnessed a major transformation and structural change from the past one decade as a result of ongoing financial sector reforms initiated by the Govt. Bringing the Indian capital market up to a certain international standard is one of the major objectives of these reforms. Due to such reforming process, one of the important step taken in the secondary market is the introduction of derivative products in two major Indian stock exchanges (viz. NSE and BSE) with a view to provide tools for risk management to investors and to improve the informational efficiency of the cash market. Though the onset of derivative trading has significantly altered the movement of stock prices in Indian spot market, it is yet to be proved whether the derivative products has served the purpose as claimed by the Indian regulators. In an efficient capital market where all available information is fully and instantaneously utilized to determine the market price of securities, prices in the futures and spot market should move simultaneously without any delay. However, due to market frictions such as transaction cost, capital market microstructure effects etc., significant lead-lag relationship between the two markets has been observed.

This study seeks to analyze the lead-lag relationship between return on a spot index and index futures contract in India and also the volatility spillover among those markets. Prior research has documented a considerable variation in the statistical significance of this relationship both through time and across the markets.

Review of Literature:
There is an extensive amount of literature examining the impact of derivative trading on the return as well as on the volatility of underlying spot market, giving special emphasis on the lead-lag relationship between the spot and the derivatives, viz., futures and options market all over the world. Since the proposed study is exclusively concerned with the lead-lag relationship and their variation over time, the review of existing literature has been restricted only to that specific aspect.

Several studies, attempted to examine the temporal relationship between the spot and the futures market both in terms of return and volatility [e.g., Ng. (1987); Kawaller, Koch, and Koch (1987); Harris (1989); Stoll & Whaley (1990); Chan, Chan and Karolyi (1991); Chan (1992); Abhyankar (1995); Shyy (1996); Iihara (1996); Pizzi (1998); Min (1999); Tse (1999); Frino (2000); Thenmozhi (2002); Anand babu (2003); Simpson (2004)], have concluded that there is a significant lead-lag relationship among the spot and the futures market, and also have tried to provide the possible explanation behind this.
Most of the studies have suggested that the leading role of the futures market varies from five to forty minutes, while the spot market rarely leads the futures market beyond one minute. While explaining the causes behind such relation, Kawaller et al. (1987) attribute the stronger leading role of the futures market to the infrequent trading of component stocks. Though, at the same time, Stoll & Whaley (1990), Chan (1992) etc. proved the existence of such relation even in case of highly traded stocks or after adjusting for infrequent trading of component stocks. Again, Chan (1992), Frino (2000), Simpson (2004) suggest that informed traders should trade in the futures market around the release of macroeconomic announcements; while, the leading role of futures market weakens through the discovery of stock specific information [Grunbicher, Longstaff and Schwartz (1994)]. Apart from this, while examining the volatility spillover, Abhyankar (1995), Tse (1999) and Min (1999) have documented that unlike a lead-lag relation, there is a bi-directional or contemporaneous relationship among the spot and the derivative markets, with bad news having a greater impact on volatility, and the relationship is entirely sample period dependent.

**Objective and Proposed Contribution:**

As far as developed markets, such as USA, UK, Japan etc., are concerned, a number of important and in-depth studies have been carried out to examine the lead-lag relationship between the spot and derivative, viz. futures market and also to provide the possible explanations behind such relation and its changes over time. But, as far as our knowledge is concerned, there is no relevant study either examining the lead-lag relationship between the derivative market and the underlying spot market in India by using high-frequency, i.e., intraday price data, or examining the variation in such relationship around the release of different types of information.

Therefore the present study is being contemplated with the following specific objectives:

i) Investigating the lead-lag relationship between the spot and futures market in India, both in terms of return and volatility; and

ii) Analyzing the possible explanations behind the variation in the above relationship over time. In this regard, the important propositions / hypothesis attempted to be tested are:

a) Futures market leads the spot market not because of infrequent trading of component stocks;

b) The leading role of futures market will be greater around macroeconomic information release;

and

c) The leading role of futures market weakens around the firm-specific announcements.

The proposed study seeks to contribute to the existing knowledge base and literature by not only examining the actual lead-lag relationship among the Indian spot and futures market in terms of return, but also in terms of volatility. Apart from this, the proposed study will try to provide some impact, on the above relation, of (i) infrequent trading of component stock in cash market, (ii) the release of market wide information and (iii) the exposure of firm-specific announcements.

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1 In Indian context, the lead-lag relationship has been examined by using daily data [Thenmozhi (2002), Anand Babu (2003)], while in a real sense, one market can lead the other only for a few minutes, not for a whole day. So, actual or significant lead-lag relationship can be measured only by using intra-day data.
**Methodology:**

In examining the lead-lag relationship between cash and futures / option market, the first important thing is to determine the maximum length of leads or lags which are assumed to be significant in the present context.

Such a problem can be solved by running a cross-correlation test separately among the return and among the volatility measure in spot and futures markets in order to determine the extent to which the two markets are correlated to each other and the length of the lead / lag will be determine from the cross correlation coefficients [Stoll and Whaley (1990), Kalok Chan (1992), Abhyankar (1995), Min et al (1999)]. Now, based on the $t$-test$^2$, the length of lead / lags will be selected. After determining the lead-lag length, the next step is to examine the lead-lag behavior between the cash and futures markets by estimating the following equations:

The model proposed to investigate the lead-lag relation among the spot and the futures market in terms of returns is such that

$$ R_{s,t} = \alpha + \sum_{k=-n}^{n} \beta_k R_{f,t+k} + \delta Z_{t-1} + \varepsilon_t \quad (1) $$

where $R_{s,t}$ and $R_{f,t}$ are cash and futures index returns at time $t$ which are assumed to be collected at each one / five minutes interval. The coefficients with negative subscripts (i.e., $\beta_{-1}, \beta_{-2}, \ldots, \beta_{-n}$) are lag coefficients and those with positive subscripts (i.e., $\beta_1, \beta_2, \ldots, \beta_n$) are lead coefficients. If the lag coefficients become significant, then it can be inferred that the cash index lags futures, or in other words, futures lead the cash index. In the other way, if the lead coefficients will significant, then it can be proved that cash index leads futures index. If the contemporaneous $\beta$ coefficient (i.e., $\beta_0$) shows the highest value among all other lead-lag coefficients, then it can be concluded that the two markets react simultaneously to much of the information. $Z_{t-1}$ is an *Error Correction Term*\(^3\), taken to be as the first lag of the contemporaneous difference between the cash and futures price levels to account for the possibility that futures and cash return series may be cointegrated [Engel and Granger (1987)].

Now, while examining the lead-lag relations between the two markets, one important point that should be taken care off is to test whether such relation is induced by the infrequent trading of component stocks. Thus, the problem is how to eliminate the infrequent trading components from the price series of spot market index so as to examine the true lead-lag relation between stock index and futures index. Such a problem can be solved by estimating the above regression but based on return innovations instead of simple spot returns [Stoll & Whaley (1990), Chan (1992), Abhyankar(1995), Frino (2000)].

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2. Asymptotic standard error for the cross-correlation coefficients is proposed to be approximated as the square root of the reciprocal of the number of observations included in the sample [Chan Kolak (192)].

3. Since the spot and the futures market are cointegrated, the Error Correction Term has been included to account for the short run deviation of prices from their respective equilibrium values.
An Autoregressive process $\ AR(p)$ can be estimated for cash index returns in order to extract the serially uncorrelated return innovations. Apart from this, it is also proposed to examine such relation between futures and individual component stocks.

The purpose of examining the lead-lag relation at the component stock level is to compare the trading frequency and the non-trading probability [Chan (1992)] of each stock relative to the futures so that it is possible to determine whether the non-synchronous trading of futures and component stocks explain the lead-lag relation. If there is any effect of non-synchronous trading, then the futures should lead only those stocks showing lower trading frequency and higher non-trading probability.

Though there is mounting evidence for the time varying nature of stock return volatility, this model will not account for the variability of the disturbances while estimating the intraday relation between cash index and futures returns. However, since heteroskedasticity generally leads to inconsistent estimates of standard errors and invalidates inference, all of the t-ratios for the coefficients are proposed to be adjusted using the procedure outlined in White (1980).

Now, the lead-lag relation among the two markets, in terms of volatility, or in other words, volatility spillover, is proposed to be examined through a VAR methodology such that

$$
\sigma_{s,t} = c_1 + \sum_{k=1}^{p} \alpha_{sk} \sigma_{s,t-k} + \sum_{k=1}^{q} \beta_{sk} \sigma_{f,t-k} + \nu_{st} \tag{2}
$$

$$
\sigma_{f,t} = c_2 + \sum_{k=1}^{p} \alpha_{fk} \sigma_{f,t-k} + \sum_{k=1}^{q} \beta_{fk} \sigma_{s,t-k} + \nu_{ft} \tag{3}
$$

where $\sigma_{z,t} = (\pi/2)^{1/2} \times |\epsilon_{z,t}|$; $z =$ Spot (s), Futures (f) markets] (Schwert (1989), Min (1999)) has been considered as the proxies for return volatilities and $\epsilon_{z,t}$ is the return innovation obtained from the Granger causality test among the return series of the spot and the futures market.

Now, the impact of macroeconomic or firm-specific information on the lead-lag relation among the spot and the futures markets can be tested through the same equation [Eq.(1)] but including a dummy variable representing the release of information, such that

$$
R_{s,t} = \alpha_0 + \sum_{i-n}^{i} \alpha_i R_{f,t+i} + \sum_{i-n}^{i} \alpha_i' D_{w,s} R_{f,t+i} + \delta Z_{t-1} + \epsilon_t \tag{4}
$$

$$
R_{s,t} = \alpha_0 + \sum_{j-n}^{j} \alpha_j R_{f,t+j} + \sum_{j-n}^{j} \alpha_j' D_{w,f} R_{f,t+j} + \delta Z_{t-1} + \epsilon_t \tag{5}
$$

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4. P, the lag length, to adjust for the auto-correlation problem, will be selected through the Akaike Information Criterion.
5. Trading frequency is the average number of trades in a specified (e.g., one / five minute) interval; Non-trading probability is the proportion of intervals showing no trades and therefore no price change.
6. White’s (1980) procedure allows estimating the regression using least squares, but then computes a consistent estimate of the covariance matrix allowing for heteroscedasticity that will lead to change the standard errors, not the coefficients themselves.
where Eq. (4) and Eq. (5) estimate the lead-lag relation around the release of market-wide and firm specific information respectively. The dummy variables \( D_{m,t} \) and \( D_{s,t} \) represent the market wide and stock specific information release respectively and will take on a value of 1 if observation \( t \) lies within a half hour time period either side of a major macroeconomic or firm-specific information release, otherwise 0 [Frino (2000)]. In order to standardize the information, the macroeconomic and stock-specific announcements are proposed to be prefiltered through a method suggested by Ederington and Lee\(^8\) (1993) and also applied by Frino (2000). In order to assess the impact of information release on the volatility spillover among the spot and the futures market, the same equations (Eq. 4 and 5) can be used but using the volatility measure instead of the return series.

**Data Type and its Sources:**

In order to examine the lead-lag relation between the underlying spot market and the futures market, the basic data proposed to be used in this study consist of intraday price histories for the nearby contract of nifty index futures, nifty cash index and also the prices of some specific component stocks, recorded in each second but picked up with a frequency of one / five minute, during April 2004 to September 2004.

In order to carry out the study at the stock/script level, some stocks having high trading frequency and some stocks traded very infrequently in the cash market will be taken into consideration. Each day trading hour will be partitioned into one / five- minute intervals. In each interval, the last price observations for the futures and the cash index will be identified. If no price will be observed within that specific interval in any of those markets, then the last price in the previous interval will be taken as the proxy for this interval.

Return on market indices will be defined as usual, i.e., the first difference in the log of price indices, such that

\[
R_t = \ln(P_t) - \ln(P_{t-1})
\]

Above all, all the relevant data relating to the spot as well as the futures market in India will be collected from the NSE website (www.nse-india.com) and also from the CD-ROM supposed to be collected from the NSE, Mumbai. A list of macroeconomic and firm specific announcements which came into effect during the proposed study period will be short listed from some reliable sources (e.g., www.indiainfoline.com)

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\(^7\) The Granger Causality test on the spot and futures index return is proposed to be done through a VAR approach and the estimation will be based on the Seemingly Unrelated Regression technique [Zellner (1962)].

\(^8\) According to Edrington and Lee (1993), the macroeconomic and stock-specific information can be pre-filtered by regressing a measure of volatility on dummy variables corresponding to the different categories of information. Then the information represented by a significant dummy coefficient will be taken into consideration
Reference:

- Iihara et al. (1996), Intraday Return Dynamics between the Cash and the Futures Markets in Japan, *Journal of Futures Markets* 16 (2, Apr), 147-162.