Linkages Between Futures and Spot Prices: A Study of Bombay Stock Exchange Sensitive Index (BSE)

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Study aims at determining lead-lag relationship and price discovery mechanism between spot market and futures market based upon daily closing values of Sensex prices (SS) and Sensex based futures prices (FS) spanning June 12, 2000 to March 31, 2016. Spot and futures prices are cointegrated, confirming long-run relationship between the two series. VECM reveal that in short-run there exists bi-directional causality between futures market and spot market. However, same could not be traced within the spot market prices for their immediate past prices in the short-run. Further, error correction term has turned negative and significant for futures market while positive and significant for spot suggesting that both futures and spot prices respond to correct volatility shocks in the long-run. However, long-run causality is more pronounced from futures to spot, thus futures have greater contribution to price discovery and equilibrium correction in long run.

Keywords: Futures, Spot prices, Co integration, Error-correction, Equilibrium

JEL Classification Code: C22, C32, G14

Section I

Introduction

Trading in financial markets is both a need and cause behind the determination of rational prices for various financial instruments. The main purpose of trading in financial markets is to ascertain the accurate price of the financial assets. The level of efficiency of a stock market depends upon the degree of accuracy in forecasting the future prices of financial assets and whether this future price is contingent upon the past information, recent information or future events. A market is considered to be efficient only if it is able to forecast the future price with fair amount of accuracy by taking into account the current

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and future scenario. Several reforms have been introduced in the Indian capital market for improving the informational efficiency of the Indian stock market.

Futures trading will reduce the volatility by increasing the speed of flow of information between spot market and futures market. The derivative trading by means of futures contract and options has been launched to increase the avenues for risk transferability and enhanced liquidity. The average daily turnover for BSE's Sensitive index based Futures and Options segment had surged to Rs. 9358.5 millions in June 2014 from Rs 1419.1 millions in May 2014. By November 2014, it had gone up to Rs 17447.0 millions. Initially, to implement the programme various volume-based, quote-based and open interest-based cash incentives were announced. The exchange had also lowered transaction fees for all active trading members. Index futures based on the 30-share Sensex, alone account for 90 per cent of the total derivatives turnover on BSE, with index options and stock derivatives accounting for the rest 10 per cent of derivatives. Sensex futures turnover is just nine per cent of futures turnover on NSE Nifty, however, in terms of value Sensex based futures alone account for three times the value of futures based on Nifty. Hence, even with small percentage of futures trading volume of BSE Sensex futures in comparison to NSE Nifty futures, spot market of BSE may reveal significant information regarding existing interlinkages between spot market and cash market prices. Thus, major question which follows introduction of futures trading is the issue of price discovery mechanism based upon which market prices of the security are determined by considering the information available in the market. Whenever any information concerning an asset approaches the market, theoretically, it is assumed that both the spot and futures market share the same information and react simultaneously in similar manner. But, practically this might not happen. If both the markets do not react at the same time, then one market leads the other. The leading market is considered more dominant and thus, discovering the price of underlying asset or derivative instrument.

Available empirical evidence indicates that futures market reacts faster to the information and is expected to play a dominant role in price discovery due to its lower trading cost, higher liquidity and fewer restrictions in futures market in comparison to the spot market. Thus, futures market is expected to perform the function of price discovery which means futures prices should contain useful information about the subsequent spot prices. However, the contribution of each market in the price discovery with respect to an asset depends on several other factors like settlement mechanism, degree of transparency, etc. Determination of the relative contribution of futures and spot market in the price discovery is of great significance for investors, portfolio managers, brokerage houses, market regulators and other participants for their investment decisions, execution of orders and formulation of new rules to enhance stock market efficiency. The present study aims at estimation of relative contribution of spot and futures markets to the process of price discovery in the Indian stock market considering BSE Sensex based futures and spot prices.
Section II
Review of Literature

To be able to formulate problem precisely and pinpoint rationale for its undertaking it seems logical to present brief review of literature which is related directly or indirectly to the problem. Available literature on the price sharing between spot and futures market subsequent to derivatives listing provided mixed results. The estimation of price discovery mechanism continues to be one of the key areas of financial research. It provides significant information on the informational efficiency of spot and futures market. A lot of work has been done in this direction and much more still needs to be done.

Kawaller et.al. (1987) examined the intraday interlinkages between S&P 500 Index and the S&P 500 Index futures. They found that both S&P 500 spot and futures markets are simultaneously linked on a minute to minute basis throughout the trading day and confirmed the existence of lead lag relationship. Furthermore, the lead from futures to cash appears to be more pronounced.

Stoll and Whaley (1990) explored causal relationships between spot and futures markets using intraday data for both S&P 500 and the Major Market Index (MMI). Bi-directional causality was detected but the futures lead was held more pronounced than the cash index lead.

Booth et.al. (1999) study intraday price discovery process among stock Index, Index futures and Index options in Germany using DAX Index securities and intraday transactions data. It was observed that spot Index and Index futures share substantially more information than Index options.

Roope et.al. (2002) compared the informational efficiency between the Singapore Exchange and the Taiwan futures exchange for Taiwan Index futures which are listed in both markets. The study provided strong evidence to suggest that Singapore futures market leads the spot market.

Bose (2007) performed price discovery analysis on Indian stock market and observed that both cash market and futures market equally contribute to the price discovery process.

In India, there is a lack of robust evidence of the impact of derivatives trading on price discovery mechanism evidencing lead lag relationship between spot market and futures market. Trading in derivative contracts in India has been initiated for the last fifteen years. So, this length of period is quite adequate to empirically examine the impact of derivatives on underlying Indian indices and stocks to ascertain the resultant spot market efficiency level in terms of pricing interlinkages between cash market and futures market.
Section III  
**Objectives of the Study**

Study has been undertaken to achieve the following objectives:

(i) To study the existence of price discovery mechanism between futures market and spot market.

(ii) To explore the lead lag relationship between cash and futures market.

Section IV  
**Data Base**

**Return on Sensex (BSER):** Sensex has been considered as barometer of Indian capital market and constitutes 30 stocks of blue-chip companies. For the present study return on Sensex has been taken as benchmark of returns on Indian scrips. Returns have been proxied by the log difference in the current and previous day closing values of Sensex.

\[ \text{BSER}_t = \log P_t - \log P_{t-1} \]  

Where:

\( P_t \) = closing value of Sensex on time \( t \)

\( P_{t-1} \) = closing value of Sensex on time \( t-1 \)

Days when there is no trading have been omitted and the price change has been calculated from the last day the market was open.

**Return on Sensex Futures (FSER):**

\[ \text{FSER}_t = \log F_t - \log F_{t-1} \]  

Where:

\( F_t \) = closing value of Sensex based futures on time \( t \)

\( F_{t-1} \) = closing value of Sensex based futures on time \( t-1 \)

To determine lead lag relationship between spot market and futures market which will in turn determine price discovery mechanism is based upon daily closing values Sensex prices (SS) for spot market and daily closing values Sensex based futures prices (FS) for futures market covering a period from June 12, 2000 to March 31, 2016.
Section V
Methodology

To ascertain the order of integration is the prerequisite for almost all the econometric models and same has been determined for all the models using Augmented Dickey Fuller (1979) unit root test. A data series is stationary if its mean and variance are constant (not changing) over time and the value of covariance between two time periods depends only on the distance or lag between the two time periods and on the actual time at which the covariance is computed. The correlation between a series and its lagged values are assumed to depend only on the length of the lag and not the starting point of the series. A series observing these properties is called a stationary time series. It is also referred to as a series that is integrated of order zero I(0). The unit root test checks whether a series is stationary or not. For this the following types of Augmented Dickey Fuller (ADF) regression has been applied:

\[ \Delta Y_t = \alpha_1 Y_{t-1} + \sum_{m=1}^{n} \beta_m \Delta Y_{t-m} + \mu_t \] (3)

\[ \Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum_{m=1}^{n} \beta_m \Delta Y_{t-m} + \mu_t \] (4)

Where \( \mu_t \) is white noise. The equation (3) is without intercept but equation (4) is with intercept. The additional lagged terms have been included to ensure that errors are uncorrelated. The following hypotheses have been tested by applying unit root tests:

\( H_0: Y_t \) is not I(0) i.e., \( Y_t \) is not integrated of order zero.

\( H_1: Y_t \) is I(0) i.e., \( Y_t \) is integrated of order zero.

If the calculated ADF statistics are insignificant then the null hypothesis (\( H_0 \)) is accepted and the series are taken as non-stationary or not integrated of order zero. Hence, unit root exists. Alternatively, if the calculated ADF statistics are significant then the alternate hypothesis (\( H_1 \)) is accepted and the series are taken as stationary or integrated of order zero. Hence, unit root does not exist.

Vector Error-correction Model (VECM)

To examine the second objective regarding price discovery mechanism between futures market and spot market vector error-correction model (VECM) has been applied to determine the expected lead lag relationship. VECM proceeds in three steps:
(i) VECM is applied if series are non-stationary at levels. Thus first step in estimation of VECM is to test the order of integration for the variables under study. The order of integration for the variables has been determined on the basis of Augmented Dickey Fuller unit root test both with and without trend and intercept.

(ii) Secondly, lag length for cointegration test and VECM has been determined following Akaike Information Criteria (AIC).

(iii) Thirdly, long-run relation among the variables has been determined on the basis of Johansen (1988) and Johansen and Juselius (1990) multivariate cointegration test. The techniques has been described briefly as below:

If the linear combination of variables is I (1) it implies the existence of long-run relationship between economic variables. Statistically, long-run relationship means cointegration for which non-stationarity at levels for the variables in the system is the pre-requisite test. Also, all the variables in the cointegrating equation must have the same order of the integration. To determine the existence of long-run relationship between spot market prices (SS) and futures market prices (FS) vector autoregressive (VAR) model developed by Johansen (1988) and further extended by Johansen and Jusiluis (1990) has been applied.

To formulate the model \(Z_t = (SS_t, FS_t)\) \(t = 1, \ldots, T\), represents a vector of the variables under study and the same is generated by a pth order vector autoregressive (VAR) model.

Johansen (1988) test states that the information regarding co-integration or long-run equilibrium relationship between the variables in the system. The rank of the matrix \(\Pi_k\) indicates the number of co-integrating relationships existing between the variables considered in the co-integrating equation. In the present study for two variables \(v\)iz., SS and FS, rank \((\Pi)\) should be \(\pi_k \leq 1\) since number of variables \((k) = 2\). In other words, the rank \(r\) must be at most equal to \(k-1\), so that \(r \leq k-1\) and there are \(k-r\) stochastic trends. If the \(r=0\), then there are no co-integrating vectors and \(k\) stochastic trends implying absence of long-run relationship.

The trace statistic has been computed to test the null hypothesis of \(r\) co-integrating relations against the alternative hypothesis of \(r+1\) co-integrating relations and is specified below:

\[
LR_{\text{trace}}(r / k) = -T \sum_{i=r+1}^{k} \log(1 - \lambda_i)
\]

Where \(\lambda_{r+1}, \ldots, \lambda_k\) are the smallest squared canonical correlation or eigen value. Further, maximum eigen value statistic has also been calculated to determine number of cointegrating vectors \(r\) in the following manner:
\[ LR_{\text{max}}(r / r + 1) = -T \log(1 - \lambda_{r+1}) \]

where: \( r = 0, 1, 2, \ldots, k-1 \)

Where \( \lambda_{r+1} \) is the \((r+t)\)th largest squared canonical correlation or eigenvalue. The null hypothesis is \( r \) co-integrating vectors against alternative hypothesis of \( r+1 \) co-integrating vectors.

Finally, to examine the interlinkages between spot prices and futures prices Vector Error Correction Model (VECM) has been applied. VECM will help in determination of long-run relationship along with short-run dynamics between non-stationary variables under analysis. For this two variable system, VECM consisting of spot prices (SS) and futures prices (FS) has been constructed in following manner:

\[
\Delta FS_t = a_0 + \sum_{j=1}^{k} \alpha_j \Delta FS_{t-j} + \sum_{j=1}^{k} \alpha_j \Delta SS_{t-j} + \phi_t \text{ecm}_{t-1} + \epsilon_{\text{t}} 
\]  
(5)

\[
\Delta SS_t = a_0 + \sum_{j=1}^{k} \alpha_j \Delta SS_{t-j} + \sum_{j=1}^{k} \alpha_j \Delta FS_{t-j} + \phi_t \text{ecm}_{t-1} + \epsilon_{\text{t}} 
\]  
(6)

Where \( \text{ecm}_{t-1} \) is one time lagged residual from cointegration between SS and FS in levels.

In these equations (5, 6) \( \alpha' \)'s, \( \beta' \)'s, \( \gamma' \)'s & \( \delta' \)'s represent short-run causal impact while \( \phi' \) represent the long-run impact. Moreover, the significant error-correction term (ecm-1) implies existence of cointegration and negative values of \( \phi' \) signify that the model is stable and any disequilibrium will be corrected in the long-run.

Section VI

Analysis

VECM estimates using daily data from June 12, 2000 to March 31, 2016 are obtained for spot market prices based on Sensex (SS) and futures market prices based on sensitive futures index (FS) to analyse lead lag relationship between spot market and futures market which in turn will lead to trace price discovery mechanism between spot prices and futures prices.
Firstly, Augmented Dickey-Fuller (1979) unit root test has been performed on all the series to examine the order of integration. The results for unit root test are presented in Table 1. It is clear from Table that on the basis of trend and intercept both spot prices and futures prices are integrated of order I(1). Both the series turn out to be insignificant in unit root test equation with and without trend and intercept at levels whereas these variables are significant at their first differences and thus integrated of order I(1). Hence, these series fulfil the condition of 'same order of integration' to perform Johansen (1991) multivariate co-integration test.

Table 1
Augment Dickey Fuller Unit Root Test for FS (S&P Futures Sensitive Index) and SS (Spot Prices Sensex)

<table>
<thead>
<tr>
<th>Series</th>
<th>At Levels</th>
<th>First Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without Intercept and Trend</td>
<td>With Trend and Intercept</td>
</tr>
<tr>
<td>SS</td>
<td>1.21</td>
<td>-3.12</td>
</tr>
<tr>
<td>FS</td>
<td>1.21</td>
<td>-3.14</td>
</tr>
</tbody>
</table>

Note: * Significant at one per cent level.

To perform the co-integration test and obtain VECM estimates, a lag length of (4) has been selected on the basis of Likelihood Ratio (LR) test. The Johansen co-integration test results are obtained on the basis of this lag length (4) and 'with intercept' but 'no trend' and are presented in Table 2. Table 2 reveals that as per both trace statistic as well as Max-Eigen value statistic, there is one co-integrating equation normalising on futures prices (FS):

\[ FS = 0.79 + 0.85**SS \quad - CE1 \]

\[ (6.67) \]

Note: t-values are shown in parenthesis. ** Significant at five per cent level.

Table 2
Johansen's Co-integration Test for FS (S&P Futures Sensitive Index) and SS (Spot Prices Sensex)

<table>
<thead>
<tr>
<th>( r )</th>
<th>( H_0 )</th>
<th>( H_a )</th>
<th>Trace statistics</th>
<th>5% critical value of trace statistics</th>
<th>P-values for trace statistics</th>
<th>Max. Eigen Value</th>
<th>5% critical value of Max-Eigen Value</th>
<th>P-values for Max-Eigen Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>( r \geq 1 )</td>
<td></td>
<td>271.94**</td>
<td>15.49</td>
<td>0.0001</td>
<td>271.86**</td>
<td>14.26</td>
<td>0.0001</td>
</tr>
<tr>
<td>( r \leq 1 )</td>
<td>( r \geq 2 )</td>
<td></td>
<td>2.12E-05</td>
<td>0.084</td>
<td>0.3996</td>
<td>0.084</td>
<td>3.841</td>
<td>0.7716</td>
</tr>
</tbody>
</table>

Note: ** Significant at five per cent level.
The Co-integrating Equation (CE1) normalised on FS shows that in the long-term, spot prices (SS) have positive and significant impact on futures prices (FS) of underlying stocks. This leads to conclude that spot and futures prices are cointegrated and hence there is a long-run relationship between the two series and equilibrium exists in the long run. Spot and futures prices share common information of long-run relevance.

Since cointegration is confirmed between the spot and futures price series, VECM model has been applied to determine the interlinkages and lead-lag relationship between the spot and futures price series. The number of co-integrating vectors results in corresponding number of residual series and hence Error-Correction Terms (ECTs), which can be embodied, as exogenous variables appearing in their lagged levels, in VECM. The results of VECM are presented in Table 3. The results of causality based on VECM reveal that in short-run there exists bi-directional causality between futures market and spot market since coefficients of lagged values of independent variable $\Delta SS_{t1}$ and $\Delta SS_{t2}$ (spot prices) on dependent variable $\Delta FS_t$ (future prices) and independent variable $\Delta FS_{t1}$ and $\Delta FS_{t2}$ (future prices) on dependent variable $\Delta SS_t$ (spot prices) are significant. However, causality could not be traced within the spot market prices for their immediate past prices since coefficients of lagged values of independent variable $\Delta SS_{t1}$ and $\Delta SS_{t2}$ (spot prices) on dependent variable $\Delta SS_t$ (spot prices) are insignificant. This is due to the fact that Indian stock market (BSE) is efficient in its weak form since random walk hypothesis for Sensex has already been confirmed (Kaur and Dhillon, 2011). This VECM analysis further supports the existence of random walk hypothesis, that is, weak form of informational efficiency of Indian spot prices (Sensex) but higher level of efficiency which is semi-strong form and strong form of efficiency is yet to be attained. Indian spot prices are sensitive to all kinds of information other than yesterdays’ prices. Thus, spot prices and futures prices are being caused by each other and share common information in short-run also.

<table>
<thead>
<tr>
<th>Variables ↓</th>
<th>Sensex (Future Prices) $\Delta FS_t$</th>
<th>Sensex (Spot Prices) $\Delta SS_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta ECT_{t1}$</td>
<td>-1.85* [-25.82]</td>
<td>0.67* [7.55]</td>
</tr>
<tr>
<td>$\Delta FS_{t1}$</td>
<td>0.25* [5.02]</td>
<td>-0.55* [-8.79]</td>
</tr>
<tr>
<td>$\Delta FS_{t2}$</td>
<td>-0.04*** [-1.86]</td>
<td>-0.33* [-10.98]</td>
</tr>
<tr>
<td>$\Delta SS_{t1}$</td>
<td>-0.85* [-14.52]</td>
<td>-0.01 [-0.13]</td>
</tr>
<tr>
<td>$\Delta SS_{t2}$</td>
<td>-0.28* [-9.16]</td>
<td>0.03 [0.91]</td>
</tr>
<tr>
<td>C</td>
<td>0.03 [0.02]</td>
<td>0.05 [0.02]</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>735.96*</td>
<td>343.14*</td>
</tr>
</tbody>
</table>

Note: *implies that values are significant at one per cent level of significance (critical Value: 2.58). ** implies that values are significant at five per cent level of significance (Critical Value: 1.96). *** implies that values are significant at 10 per cent level of significance (Critical Value: 1.65).
Error correction coefficient has been used to trace the lead lag relationship between spot and futures price series. Results of VECM reveal that error correction term is negative and significant for futures market while positive and significant for spot market. It implies that both futures and spot prices respond to correct volatility shocks in order to attain the long-run equilibrium. This causality also exists in the long run between futures and spot market since the error correction coefficients are significant. However, long run causality is more pronounced from futures to spot market since error correction coefficient is negative and more significant and thus has greater contribution to price discovery and equilibrium correction in long run.

Estimated VECM for SS and FS passes through the diagnostic tests no serial correlation, no heteroscedasticity and normality of errors since $\chi^2$ is insignificant for all the three diagnostic tests. Further, on the basis of VECM the results of temporal causality are presented in Table 4.

<table>
<thead>
<tr>
<th>Desired Test</th>
<th>$\chi^2$ (Lag) -Values</th>
<th>P-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial correlation Test</td>
<td>$\chi^2(5) = 6.12$</td>
<td>P = .19</td>
</tr>
<tr>
<td>Heteroscedasticity Test</td>
<td>$\chi^2(1) = 69.07$</td>
<td>P = .25</td>
</tr>
<tr>
<td>Normality Test</td>
<td>$\chi^2(2) = 4.54$</td>
<td>P = .10</td>
</tr>
</tbody>
</table>

**Section VII**

**Conclusion**

Co-integrating results lead to conclude that spot and futures prices are cointegrated and hence there exists a long-run equilibrium between the two series. Spot prices (SS) have positive and significant impact on futures prices (FS) of underlying stocks which implies that a bearish trend in cash (spot prices) of stocks will cause a surge in underlying futures prices and vice-versa.

The results of causality based on VECM reveal that in short-run there exists bi-directional causality between futures market and spot market in the short-run. However, causality could not be traced within the spot market prices for their immediate past prices in the short-run. This is due to the fact that Indian stock market (BSE) is efficient in its weak form since random walk hypothesis for Sensex has already been confirmed (Kaur and Dhillon, 2011). This VECM analysis further supports the existence of random walk hypothesis, that is, weak form of informational efficiency of Indian spot prices (Sensex). Study further highlights that Indian spot prices are sensitive to all kinds of information.
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other than past prices. The results of VECM confirmed the existence of bi-directional causality between futures market and spot market since coefficients of lagged values of independent variable $\Delta S_{St-1}$ and $\Delta S_{St-2}$ (spot prices) on dependent variable $\Delta F_{St}$ (future prices) and independent variable $\Delta F_{St-1}$ and $\Delta F_{St-2}$ (future prices) on dependent variable $\Delta S_{St}$ (spot prices) are significant. This finding of VECM clearly implies that Indian stock market is quite inefficient in semi-strong form level.

Error correction coefficient has been used to trace the lead lag relationship in the long-run between spot and futures price series. Error correction term incorporated in VECM is negative and significant for futures market while positive and significant for spot. This suggests that both futures and spot prices respond to correct volatility shocks in order to reach the long-run equilibrium. Thus, causality also exists in the long run between futures and spot market. However, long run causality is more pronounced from futures to spot market since error correction coefficient is negative and more significant and thus has greater contribution to price discovery and equilibrium correction in long run.

In nutshell, study contributed that in short run spot and futures prices both are being caused by each other and semi strong efficiency hypothesis for Indian stock market failed. It further implies that in short-run spot and future prices are sensitive to every piece of information except past prices. It demands greater degree of transparency in stock market transactions to attain semi-strong form of efficiency level. Also, long run causality is more pronounced from futures to spot prices since error correction coefficient is negative and more significant and thus future prices has greater contribution to price discovery and equilibrium correction in long run.

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