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Price Discovery in NSE Spot and Futures Markets of India: Evidence from selected IT Industries

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Abstract

Johansen's Cointegration technique followed by the Vector Error Correction Model (VECM) was employed to examine the lead-lag relationship between NSE spot and futures markets of selected eight IT sector stocks of India. The empirical analysis was conducted for the daily data series from 20th April, 2005 to 15th September, 2008. The analysis reveals the bidirectional relationship between spot and futures markets in case of five selected IT stocks. This is followed by spot leads to futures and futures leads to spot markets in case of two and one selected IT stocks in India respectively. The present study suggests that depending on the relative proportions of informed to uninformed (noise) traders migrating from the spot market to the futures market, the lead-lag relationship between futures and spot market of selected IT sector stocks may differ.

Key words : *Stock Futures, Spot Market, Lead-lag Relationship, Cointegration, Vector Error Correction Model, Informational efficiency*

JEL Classification : *C32, G13, G14*

1. Introduction

The future market trading in Indian financial markets was introduced in June 2000 and options index was commenced from June 2001 and subsequently the options and futures on individual securities trading was commenced from July 2001 and November 2001, respectively. The future derivative trading on stock indexes has grown rapidly since inception and provides important economic functions such as price discovery, portfolio diversification and opportunity for market participants to hedge against the risk of adverse price movements. Hence, the movements of spot market price have been largely influenced by the speculation, hedging and arbitrage activity of futures markets. Thus, understanding the influence of one market on the other and role of each market segment in price discovery is the central question in market microstructure design and has become increasingly important research issue among academicians, regulators and practitioners alike as it provides an idea about the market efficiency, volatility, hedging effectiveness and arbitrage opportunities, if any. Price discovery is the process of revealing information about future spot prices through the future markets.

The essence of the price discovery function hinges on whether new information is reflected first in changes of future prices or changes of spot prices. Hence, there exists lead-lag relationship between spot and futures market by information dissemination. All the information available in the market place is immediately incorporated in the prices of assets in an efficient market. So, new information disseminating into the market should be reflected immediately in spot and futures prices simultaneously. This will lead to perfect positive contemporaneous comovement between the prices of those markets and there will be no systematic lagged response and therefore no arbitrage opportunity. This prediction arises directly from the Cost of Carry (COC) model of future pricing which postulates that

$$F_t = S_t e^{(r-y)(T-t)} \quad \ldots\ldots\ldots\ldots\ldots \textit{(1)}$$

where, Ft is the futures price of the index at time t, St is the spot price of the index at time t, r is the interest rate foregone while carrying the underlying stocks, y is the dividend yield on the stocks and T – t is the remaining life of the futures contract. Equation (1) is justified by a "no-arbitrage" assumption, since $F_t > S_t e^{(r-y)(T-t)}$ would enable investors to profit by selling futures and buying stocks, while $S_t e^{(r-y)(T-t)} > F_t$ would allow profits by buying futures and short selling stocks. The assumptions that underlie these arguments are that future and spot markets are perfectly efficient, and that transaction costs are zero. This simple version of the model also assumes that the interest rate and dividend yield are constant over the life of the futures contract, although in practice they will vary, as will $r - y$, the net cost of carry of the underlying stocks. Most importantly, in the real world, the existence of market frictions such as transaction costs, margin requirements, short-sale constraints, liquidity differences and non-synchronous trading effects may induce lead-lag relationship between the futures contract and its underlying spot market. In addition, if there are economic incentives for traders to use one market over the other, a price discovery process between the two markets is likely to happen (Zou and Pinfold, 2001). This implies that futures and spot market prices are inter-related and can be traced under different market frictions through price discovery mechanism.

Accordingly, there exist diversified theoretical arguments pertaining to the causal relationship between spot and futures markets by information dissemination and raises the major question that which market price reacts first (lead) whether (a) futures prices tend to influence spot prices or (b) spot prices tend to lead futures prices or (c) a bidirectional feedback relationship exists between spot and futures prices.

(a) Futures prices tend to influence spot prices

The main arguments in favour of futures market leads spot market are mainly due to the advantages provided by the futures market includes higher liquidity, lower transaction costs, lower margins, ease leverage positions, rapid execution and greater flexibility for short positions. Such advantages attract larger informed traders and make the futures market to react first when market- wide information or major stock-specific information arrives. Thus, the future prices lead the spot market prices.

(b) Spot prices tend to lead futures prices

On the other hand, the low cost contingent strategies and high degree of leverage benefits in futures market attracts larger speculative traders from a spot market to a more regulated futures market segments. Hence, this ultimately reduces informational asymmetries of the spot market through reducing the amount of noise trading and helps in price discovery, improve the overall market depth, enhance market efficiency and increase market liquidity. This makes spot market to react first when market-wide information or major stock- specific information arrives. Hence, spot market leads the futures market.

(c) Bidirectional feedback relationship exists between spot and futures prices

Besides, there exists a bidirectional relationship between the futures and spot markets through price discovery process (see, Turkington and Walsh 1999; Chris, Alistar and Stuart 2001; Ryoo and Graham Smith 2004; Kenourgios 2004 and Chang and Lee 2008). This may be mainly due to future markets attracts larger informed traders to enjoy the advantages of higher liquidity, lower transaction costs, lower margins and greater flexibility for short positions. Hence, these advantages make futures markets to lead the spot markets around macroeconomic or major stock-specific information releases. Consequently, the spot markets will lead the futures market under the circumstances that these advantages of futures markets attracts larger speculative traders from a spot market and reduces informational asymmetries of the spot market through reducing the amount of noise trading and helps in price discovery, improve the overall market depth, enhance market efficiency and increase market liquidity. This makes spot market to react fast when market-wide information or major stock- specific information arrives. Thus, both the spot and futures markets are said to be informationally efficient and reacts more quickly to each other.

2. Review of Literature

An overwhelming number of studies have examined the price discovery process involving well established United States, European and Asian futures markets providing different results. Broadly speaking, Stock index futures contracts were first studied by Zeck Lauser and Niederoffer (1983) with reference to United States. The correlation technique was employed to examine the objective and the analysis reveals that future leads to spot market. A similar kind of correlation technique was employed by Finnerty and Park (1987) to examine the hypothesis that Major Market Index (MMI) futures price changes determine cash index changes. It was pointed out that correlation analysis provides only unidirectional results without any evidence for a causal relationship.

Further, Kawaller, Koch and Koch (1987) examined the intraday price relationship between the S&P 500 futures and index prices for the year 1984-1985. Three-stage-least-square regression analysis was employed to examine the objective. The analysis revealed that futures price movements consistently lead the spot index movements by up to 45 minutes. Herbst, McCormack and West (1987) employed cross correlation analysis to determine that futures lead the cash index for S&P 500 and value line futures contracts. They found that future index lead the spot index between 0 to 16 minutes. Similarly, Harris (1989) examined the relationship between S&P 500 index and futures during the October 1987 stock market crash using five-minute data. A correlation technique and weighted least squires (WLS) model have been employed to examine the objective. The analysis revealed that futures market leads the spot market. An ARMA (p, q) process has been employed by Stoll and Whaley (1990) to study the intraday price relationship between S&P 500 and the Major Market Index (MMI) futures for the year 1982-1987. They found a strong evidence of futures market leading the spot market. Similarly, other studies by Cheung and Ng (1990), Chan (1992), Tang, Mak and Choi (1992), Antoniou and Garrett (1993), Ghosh (1993), Fleming, Ostdiek and Whaley (1996), Pizzi, Economopoulos and O' Neal (1998), Shyy, Vijayraghavan and Scott-Quinn (1996), Yu (1997), Abhyankar (1998), Booth, So and Tse (1999), Min and Najand (1999), Roope and Zurbruegg (2002), Pattarin and Ferretti (2004) and Floros and Vougas (2007) supports the primacy of future markets in the price discovery process.

On the other hand, Wahab and Lashgari (1993) used daily data to examine the causal nexus between index and stock index futures for both S&P 500 and FTSE 100 Index for the period 1988-1992. Cointegration and Error Correction model were employed to examine the objective and the analysis reveals that spot leads to future markets appear to be more pronounced across days relative to the futures lead to spot. Similarly, Abhyankar, A. H. (1995) had investigated the lead–lag relationship between FT-SE 100 stock index futures and cash index using hourly data for the period 1986-1990. They employed an AR (2) and Exponential GARCH (1, 1) model to evaluate the lead-lag relations for periods of differential transactional costs, spot volumes and volatility, good and bad news (measured by the size of returns). The empirical results revealed that the futures lead the spot index reduced, when transaction costs for underlying asset declines. It also observed that futures market leads spot market returns during periods of high volatility.

Besides, Turkington and Walsh (1999) employed ARMA (p, q), Bivariate VEC, VAR models and impulse response functions to examine the high frequency causal relationship between Shares Prices Index (SPI) futures and the All-Ordinaries Index (AOI) for Australia. The analysis reveals bi-directional causality between the SPI futures and spot AOI index. Similarly, the study of Chris, Alistar and Stuart (2001) of UK finds feedback relationship between FTSE 100 stock index futures and the FTSE 100 index. Further, recent studies by H-J Ryoo and Graham Smith (2004) for Korea, Kenourgios (2004) for Athens and Chang and Lee (2008) for Taiwan finds bidirectional relationship between spot index and future prices.

At national level, an attempt has been made by Thenmozhi, M (2002) to investigate the empirical relationship between S&P CNX nifty futures and S&P CNX nifty index for the period 2000-2002. Ordinary least squares and two stage least squares regression methods were employed to examine the objective. The analysis reveals that futures returns lead the spot index returns. On the other hand, Raju and Karande (2003) examined the price discovery between the S&P CNX Nifty and its corresponding futures during the period 2000-2002. Cointegration technique and Error Correction models were employed for examining the objectives. The analysis revealed that price discovery occurs in the both futures and the spot market. Similarly, the study of Sah and Kumar (2006) had employed Cointegration and Error Correction models for the daily data series from June 2000 to March 2005 and finds a feedback mechanism between nifty spot and nifty futures in India. Further, Mukherjee and Mishra (2006) employed cross correlation and error correction model to investigate the intra day lead-lag relationship between nifty futures and spot index from April to September 2004. They found bidirectional relationship between future and spot markets. However, the study results reveals that spot market had a major role in price discovery and leads over the futures market. Kapil Gupta and Balwinder Singh (2006) investigate the hypothesis that the established Nifty Index Futures Market effectively serves the price discovery function in the underlying spot market. Johansen's Cointegration, Vector Error Correction Model and Generalized Impulse Response Analysis are applied to test the hypothesis on daily data from NSE. Bilateral causality is observed between Nifty Index and Nifty Index Futures. The evidence supports the hypothesis suggesting that the futures market in India is a useful price discovery vehicle. Recent study by Shalini Bhatia (2007) employed Cointegration and error correction model to examine the intra day lead-lag relationship between S&P CNX nifty futures and S&P CNX nifty index for the period April, 2005-March, 2006. The analysis reveals that nifty futures lead the spot index by 10 to 25 minutes.

The above existing literatures pertaining to lead-lag relationship between price changes in international futures and spot markets are well established by information dissemination. However, the results pertaining to price discovery process were seems to be mixed and reveal the following lacunae: Firstly, all of the studies have adopted index futures for the purpose of analysing the price discovery process between the spot and futures price. Therefore, there exists a scope for further analysis of employing the stock futures on individual securities. This can give the detail analysis of price discovery between the spot and futures on each individual security. Secondly, most of the studies employed Cointegration test and Vector Error Correction Model (VECM) to examine the causal nexus between futures and spot market. It revealed that Johansen's Cointegration test and Vector Error Correction Model are the superior techniques to investigate the issue because it indicates the possibility of long-run equilibrium between future and spot markets which gives the chance for equilibrium price for investors and traders after adjusting the short-run price fluctuations. Further, it is important for investors and traders for trading in the leading market in the short-run. So they can make arbitrage profit by trading in the leading market. The Error correction model estimates the leading market between spot and futures markets. Thus, the study can be done by employing Johansen's Cointegration test and Vector Error correction model to investigate the causality between spot and futures of the selected banking stocks and this will be immensely useful for the traders to hedge their market risk.

On the above background, the present article examines the lead-lag relationship between NSE spot and futures markets of the selected Information Technology (IT) sector stocks of India. The rest of the paper is organised as follows: Section–3 presents the methodology of the study. Section-4 gives empirical results and discussion. Finally, concluding remarks are presented in Section-5.

3. Methodology and Data

Johansen's (1988) Cointegration and Vector Error Correction Model (VECM) were employed to examine the lead-lag relationship between NSE spot and futures markets of the selected IT sector stocks. Augmented Dickey-Fuller (1979) and Phillips-Perron (1988) tests were employed to verify the stationarity of the data series. Further, the necessary lag length of the data series was selected on the basis of Schwarz Information Criterion (SC). Johansen's Cointegration test is employed to examine long-run relationship among the variables after they are integrated in an identical order. Then, Johansen's (1988) Vector Error Correction Model (VECM) is employed to investigate the price discovery and causal relationship between spot and future prices of selected IT industry stocks of India.

3.1 Johansen's Vector Error Correction Model (VECM)

Given the time-series nature of the data, the first step in the analysis is to determine the order of integration of each price series using Augmented Dickey-Fuller (ADF, 1981), and Phillips and Perron (PP, 1988) tests. Given a set of two I(1) series[1], Johansen (1988, 1991) tests are used to determine whether the series stand in a long-run relationship between them, i.e., they are cointegrated. The following VECM (Johansen, 1988) is estimated:

$$\Delta X_t = \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \varepsilon_t \quad ;$$

$$\varepsilon_t \mid \Omega_{t-1} \sim distr(0, H_t) \qquad (2)$$

where X_t is the 2x1 vector $(S_t, F_t)'$ of log-Spot and log-Futures prices, respectively, Δ denotes the first difference operator, ε_t is a 2x1 vector of residuals $(\varepsilon_{S,t}, \varepsilon_{F,t})'$ that follow an as-yet-unspecified conditional distribution with mean zero and time-varying covariance matrix, H_t. The VECM specification contains information on both the short- and long-run adjustment to changes in X_t, via the estimated parameters Γ_i and Π, respectively.

Johansen and Juselius (1990), show that the coefficient matrix Π contains the essential information about the relationship between S_t and F_t. Specifically, if rank (Π) = 0, then Π is 2x2 zero matrix implying that there is no cointegration relationship between S_t and $F_{t,t-n}$. In this case the VECM reduces to a VAR model in first differences. If Π has a full rank, that is rank (Π) = 2, then all variables in X_t are $I(0)$ and the appropriate modelling strategy is to estimate a VAR model in levels. If Π has a reduced rank, that is rank (Π) = 1, then there is a single cointegrating relationship between S_t and F_t, which is given by any row of matrix Π and the expression ΠX_{t-1} is the error correction term. In this case, Π can be factored into two separate matrices α and β, both of dimensions 2x1, where 1 represents the rank of Π, such as $\Pi = \alpha\beta'$, where β' represents the vector of cointegrating parameters and α is the vector of error-correction coefficients measuring the speed of convergence to the long-run steady state[2].

If Spot and Futures prices are cointegrated then causality must exist in at least one direction (Granger, 1988). Granger causality can identify whether two variables move one after the other or contemporaneously. When they move contemporaneously, one provides no information for characterising the other. If "X causes Y", then changes in X should precede changes in Y. Consider the VECM specification of Equation (2), which can be written as follows:

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[1] *I(1) stands for a price series which is integrated of order 1; that it is needed to be differenced once to become stationary.*

[2] *Since rank (Π) equals the number of characteristic roots (or eigenvalues) which are different from zero, the number of distinct cointegrating vectors can be obtained by estimating the number of these eigenvalues, which are significantly different from zero. The characteristic roots of the nxn matrix Π, are the values of λ which satisfy the following equation $|\Pi - \lambda I_n| = 0$, where I_n is a nxn identity matrix. Johansen (1988), proposes the following two statistics to test for the rank of Π:*

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln\left(1 - \hat{\lambda}_i\right), \quad \lambda_{max}(r, r+1) = -T \ln\left(1 - \hat{\lambda}_{r+i}\right)$$

where $\hat{\lambda}_i$ are the eigenvalues obtained from the estimate of the Π matrix and T is the number of usable observations. The λ_{trace} tests the null that there are at most r cointegrating vectors against the alternative that the number of cointe¬grating vectors is greater than r and the λ_{max} tests the null that the number of cointegrating vectors is r, against the alternative of r + 1. Critical values for the λ_{trace} and λ_{max} statistics are provided by Osterwald-Lenum (1992).

$$\Delta S_t = \sum_{i=1}^{p-1} a_{S,i}\Delta S_{t-i} + \sum_{i=1}^{p-1} b_{S,i}\Delta F_{t-i} + a_S z_{t-1} + \varepsilon_{S,t} \qquad (3)$$

$$\varepsilon_{i,t} \mid \Omega_{t-1} \sim distr(0, H_t)$$

$$\Delta F_t = \sum_{i=1}^{p-1} a_{F,i}\Delta S_{t-i} + \sum_{i=1}^{p-1} b_{F,i}\Delta F_{t-i} + a_F z_{t-1} + \varepsilon_{F,t} \qquad (4)$$

where $a_{S,i}$, $b_{S,i}$, $a_{F,i}$, $b_{F,i}$ are the short-run coefficients, $z_{t-1} = \beta' X_{t-1}$ is the error- correction term, and $\varepsilon_{S,t}$ and $\varepsilon_{F,t}$ are residuals.

In the above equations of Vector Error Correction Model, the unidirectional causality from Futures-to-Spot (F_t Granger causes S_t) requires: (i) that some of the bs, i coefficients, i = 1, 2, …, p-1, are non zero and/or (ii) aS, the error-correction coefficient in Equation (3), is significant at conventional levels. Similarly, unidirectional causality from Spot-to-Futures (S_t Granger causes F_t) requires: (i) that some of the $a_{F,i}$ coefficients, i = 1, 2, …, p-1, are non zero and/or (ii) a_F is significant at conventional levels. If both variables Granger cause each other, then it is said that there is a two-way feedback relationship between S_t and F_t (Granger, 1988)[3]. These hypotheses can be tested by applying Wald tests on the joint significance of the lagged estimated coefficients of ΔS_{t-i} and ΔF_{t-i}. When the residuals of the error-correction equations exhibit heteroskedasticity, the t-statistics are adjusted by White (1980) heteroskedasticity correction.

The vector error correction model (VECM) equation (2) and (3) provides a framework for valid inference in the presence of I(1) variable. Moreover, the Johansen (1988) procedure provides more efficient estimates of the cointegrating relationship than the Engle and Granger (1987) estimator (Gonzalo, 1994). Also Johansen (1988) tests are shown to be fairly robust to presence of non-normality (Cheung and Lai, 1993) and heteroscedasticity disturbances (Lee and Tse, 1996).

3.2 Research Hypotheses

Following hypotheses were taken for testing-

H_1: Futures markets provide an efficient price discovery mechanism, which supports the hypothesis that futures prices lead spot prices (futures prices contain useful information about cash prices of mature markets).

H_2: Spot markets provide an efficient price discovery mechanism, which supports the hypothesis that spot prices lead futures prices (spot prices contain useful information about future prices of mature markets).

H_3: Bidirectional causality exists between the two price series, then spot and futures have an important price discovery role.

3.3 Data

The data for the study consists of daily closing prices of spot and stock futures on eight IT stocks that traded in National Stock Exchange (NSE). The list of the selected IT sector stocks considered for the study had presented in Appendix-1. The data set has been comprised from 20th April, 2005 to 15th September, 2008. The near month contract of stock futures has been used for the study as they are mostly heavily traded as compared to next month and far month future contracts. All the required data information for the study has been retrieved from the National Stock Exchange (NSE) website.

4. Empirical Results and Discussions

As a preliminary investigation, Table -1 presents the result of summary statistics of spot and future market returns of selected IT stocks. The table result depicts that the mean returns of spot and futures markets of selected stocks are found to be positive and the standard deviations of both spot and future returns series of selected IT stocks were ranges between 0.169 and 0.339 which indicates

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3 The Johansen (1988) procedure is preferred because it provides more efficient estimates of the cointegration vector than the Engle and Granger (1987) two-step approach. Toda and Phillips (1993) argue that causality tests based on OLS estimators of unrestricted levels VAR's are not very useful in general because of uncertainties regarding the relevant asymptotic theory and potential nuisance parameters in the limit. However, maximum likelihood estimators based on Johansen's (1988, 1991) ML method (for large samples of more than 100 observations) are asymptotically median unbiased, have mixed normal limit distributions and they take into account the information on the presence of unit roots in the system. Therefore, they are much better suited to perform inference.

that the volatility nature of the stocks was found to be higher. Further, the table result reveals that the skewness statistics of selected stocks are significantly different from zero for both the market return series i.e. they are skewed either to the right or to the left. Also, the excess kurtosis values of spot and future market return series of selected stocks are fat-tailed or leptokurtic compared to the normal distribution. In addition, the Jarque-Bera test statistics indicate that the null hypothesis of normality of spot and future return series of selected IT stocks had been rejected at one per cent significance level except POLARIS. Hence, it can be concluded that both the market return series of selected stocks except POLARIS were significantly departures from normality. However, the Augmented Dickey Fuller and Phillips-Perron tests result of Table-2 reveals that the hypothesis of a unit root in the spot and future return series of each selected IT stocks is strongly rejected. Therefore, spot and future returns follow a stationary process even though they fail to be normally distributed. Besides, the unit root tests result reveals that both the data series of future and spot price of each selected stocks are found to be stationary at first order level and integrated at the order of I(1). Johansen's Cointegration test is performed to examine the long-run relationship between spot and future market prices of selected IT stocks and its results are presented in Table-3. The table result reveals the presence of one cointegrating vector between the two market prices at one percent significance level in case of each IT stocks. The Johansen's cointegration test confirms the existence of long-run relationship between the spot and future prices of each selected IT stocks.

After identifying single cointegration vector between spot and future prices of the selected IT stocks, the Vector Error Correction Model (VECM) was employed to examine the causal nexus between future and spot market of selected IT stocks and its results are presented in Table-4. Besides, the vector error correction model is sensitive to the selection of optimal lag length and the necessary lag length of future and spot price series for the selected stocks is determined by the Schwarz Information Criterion (SC) and it reveals optimal lag of one and two in case of 3 and 5 IT stocks respectively.

By and large, the table results of vector error correction model reveal the bidirectional relationship between spot and futures markets in case of five individual IT stocks, viz. HCLTECH, I-FLEX, INFOSYSTCH, PATNI and POLARIS. This shows that both the spot and future markets are said to be informationally efficient and reacts more quickly to each other. The analysis also confirms the spot leads to futures followed by futures leads to spot markets in case of TCS and WIPRO and SATYAMCOMP respectively. The variation of price discovery mechanism of the selected IT stocks depends on the relative proportions of informed to uniformed (noise) traders migrating from the spot market to the futures market. Hence, the lead-lag relationship between NSE futures and spot markets of selected IT sector stocks may differ.

5. Concluding remarks

Johansen's Cointegration technique followed by the Vector Error Correction Model (VECM) was employed to examine the lead-lag relationship between NSE spot and futures markets of selected eight individual IT sector stocks of India. The empirical analysis was conducted for the daily data series from 27th May, 2005 to 29th May, 2008. The analysis reveals the bidirectional relationship between spot and futures markets in case of five individual IT stocks. This is followed by spot leads to futures and futures leads to spot markets in case of two and one selected IT stocks in India respectively. The present study suggests that depending on the relative proportions of informed to uninformed (noise) traders migrating from the spot market to the futures market, the lead-lag relationship between futures and spot market of selected IT sector stocks may differ.

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7. APPENDIX

Table-1: Summary statistics of spot and future markets return of the selected IT stocks

Name of the IT Stocks	Mean	Standard Deviation	Skewness	Kurtosis	Jarue-Bera Statistics
	Spot Market Returns				
HCLTECH	5.989	0.339	-0.025	1.648	64.94*
I-FLEX	7.194	0.336	-0.008	2.446	10.90*
INFOSYSTCH	7.646	0.215	0.299	2.231	33.72*
PATNI	5.907	0.253	-0.645	2.408	71.57*
POLARIS	4.773	0.258	0.189	3.144	3.825
SATYAMCOMP	6.256	0.234	0.760	2.198	104.8*
TCS	7.090	0.245	0.331	2.244	35.88*
WIPRO	6.221	0.169	0.346	2.873	17.65*
Futures Market Returns					
HCLTECH	5.986	0.337	-0.017	1.641	65.59*
I-FLEX	7.198	0.339	-0.009	2.449	10.77*
INFOSYSTCH	7.647	0.216	0.309	2.222	35.09*
PATNI	5.910	0.255	-0.653	2.409	73.03*
POLARIS	4.777	0.259	0.156	3.150	4.304
SATYAMCOMP	6.257	0.235	0.767	2.207	105.8*
TCS	7.091	0.244	0.325	2.240	35.56*
WIPRO	6.218	0.170	0.316	2.802	15.61*

*Note: * denote the significance at the one per cent level.*

Table 2 : Augmented Dickey-Fuller and Phillip-Perron Test Results

Name of the IT Stocks	Market	Augmented Dickey-Fuller Test Statistics			Phillips-Perron Test Statistics		
		Levels					
		Intercept	With Intercept and Trend	Without Intercept and Trend	Intercept	With Intercept and Trend	Without Intercept and Trend
HCLTECH	Spot	-0.94	-2.32	-0.58	-1.01	-2.44	-0.51
	Futures	-1.02	-2.45	-0.52	-1.04	-2.49	-0.50
I-FLEX	Spot	-2.40	-1.40	0.60	-2.52	-1.53	0.58
	Futures	-2.38	-1.54	0.50	-2.50	-1.56	0.57
INFOSYSTCH	Spot	-1.81	-3.38	-0.30	-1.87	-3.40	-0.28
	Futures	-1.96	-3.37	-0.29	-1.75	-3.36	-0.31
PATNI	Spot	-0.66	-1.71	-0.68	-0.77	-1.79	-0.64
	Futures	-0.64	-1.66	-0.69	-0.76	-1.80	-0.65
POLARIS	Spot	-2.05	-2.21	-0.35	-2.08	-2.24	-0.34
	Futures	-2.10	-2.26	-0.36	-2.13	-2.29	-0.33
SATYAMCOMP	Spot	-2.07	-3.19	-0.15	-1.96	-3.16	-0.09
	Futures	-1.74	-2.85	-0.16	-2.03	-3.21	-0.08
TCS	Spot	-1.52	-3.27	-0.45	-1.50	-3.26	-0.48
	Futures	-1.40	-3.10	-0.43	-1.27	-3.09	-0.46
WIPRO	Spot	-2.77	-2.94	-0.56	-2.80	-3.04	-0.48
	Futures	-2.82	-3.04	-0.49	-2.86	-3.13	-0.47
First Differences							
HCLTECH	Spot	-17.61*	-17.66*	-17.62*	-28.81*	-28.84*	-28.82*
	Futures	-21.26*	-21.30*	-21.26*	-29.27*	-29.31*	-29.28*
I-FLEX	Spot	-17.22*	-17.40*	-17.21*	-28.62*	-28.76*	-28.63*
	Futures	-20.39*	-20.53*	-20.39*	-28.23*	-28.38*	-28.24*
INFOSYSTCH	Spot	-18.61*	-18.60*	-18.62*	-30.89*	-30.90*	-30.91*
	Futures	-13.25*	-13.27*	-13.26*	-30.71*	-30.72*	-30.73*
PATNI	Spot	-11.97*	-12.06*	-11.96*	-26.70*	-26.73*	-26.71*
	Futures	-12.02*	-12.11*	-12.01*	-26.12*	-26.18*	-26.07*
POLARIS	Spot	-11.80*	-11.82*	-11.84*	-27.67*	-27.66*	-27.68*
	Futures	-14.68*	-14.69*	-14.65*	-28.12*	-28.11*	-28.13*
SATYAMCOMP	Spot	-21.72*	-21.75*	-21.73*	-28.66*	-28.69*	-28.68*
	Futures	-14.20*	-14.25*	-14.21*	-28.41*	-28.43*	-28.42*
TCS	Spot	-21.45*	-21.47*	-21.46*	-29.85*	-29.89*	-29.86*
	Futures	-16.36*	-16.40*	-16.37*	-29.93*	-29.95*	-29.94*
WIPRO	Spot	-12.96*	-12.95*	-12.18*	-29.64*	-29.63*	-29.66*
	Futures	-20.65*	-20.64*	-20.66*	-30.21*	-30.19*	-30.22*

Notes: * – indicates significance at one per cent level. Optimal lag length is determined by the Schwarz Information Criterion (SC) and Newey-West Criterion for the Augmented Dickey-Fuller Test and Phillips-Perron Test respectively.

Table 3 : Johansen's Cointegration Test Results

HCLTECH	r = 0	117.33*	116.23*	Cointegrated
	r ≤ 1	1.105	1.105	
I-FLEX	r = 0	118.08*	111.37*	Cointegrated
	r ≤ 1	6.715	6.715	
INFOSYSTCH	r = 0	248.43*	236.58*	Cointegrated
	r ≤ 1	11.84	11.84	
PATNI	r = 0	179.38*	174.09*	Cointegrated
	r ≤ 1	5.290	5.290	
POLARIS	r = 0	96.86*	91.87*	Cointegrated
	r ≤ 1	4.997	4.997	
SATYAMCOMP	r = 0	103.35*	92.87*	Cointegrated
	r ≤ 1	10.47	10.47	
TCS	r = 0	88.46*	86.44*	Cointegrated
	r ≤ 1	2.021	2.021	
WIPRO	r = 0	81.07*	71.26*	Cointegrated
	r ≤ 1	9.805	9.805	

Notes: *- denote the significance at the one per cent level.
r is the number of cointegrating vectors under the null hypothesis (Ho).

Table 4 : Test Results of Vector Error Correction Model

Name of the IT Stocks	Regression Equation	C	$\Delta SPOT_{t-1}$	$\Delta SPOT_{t-2}$	ΔFUT_{t-1}	ΔFUT_{t-2}	ECM_{t-1}	Log Likelihood	Inference
HCLTECH	ΔS on ΔF	0.0001	-0.143		-0.335		0.625**	1442.74	F⟷S
		-0.1129	(-0.796)	-	(-1.864)	-	-2.129		
	ΔF on ΔS	0.0001	-0.315		-0.162		-0.945*	1443.04	
		-0.1128	(-1.753)	-	(-0.906)	-	(-3.219)		
I-FLEX	ΔS on ΔF	0.0001	0.5126*		-0.935*		2.158*	1632.42	F⟷S
		-0.1442	-3.096	-	(-5.865)	-	-8.73		
	ΔF on ΔS	0.0001	0.420**		-0.882*		0.884*	1584.82	
		-0.1406	-2.402	-	(-5.233)	-	-3.383		
INFOSYSTCH	ΔS on ΔF	0.0001	0.042		-0.572*		1.525*	1571.6	F⟷S
		-0.089	-0.347	-	(-4.571)	-	-7.311		
	ΔF on ΔS	0.0001	-0.282**		-0.255**		-0.392**	1555.09	
		-0.084	(-2.267)	-	(-2.001)	-	(-1.990)		
PATNI	ΔS on ΔF	0.0001	0.122*	-0.019	-0.644*	-0.152*	1.614*	2712.94	F⟷S
		-0.394	-3.136	(-1.758)	(-10.49)	(-4.219)	-25.3		
	ΔF on ΔS	0.0001	-0.522*	-0.225*	0.113	0.05	-0.769*		
		-0.135	(-4.281)	(-6.493)	-0.589	-0.444	(-3.847)	1744.43	
POLARIS	ΔS on ΔF	0.0001	-2.692*	-1.629*	2.057*	1.293*	-3.152*		F⟷S
		-0.115	(-4.048)	(-4.147)	-3.131	-3.379	(-3.661)	1458.6	
	ΔF on ΔS	0.0001	-3.119*	-1.807*	2.469*	1.469*	-4.986*		
		-0.113	(-4.492)	(-4.406)	-3.6	-3.678	(-5.549)	1422.25	
SATYAM-COMP	ΔS on ΔF	0.0002	0.875	0.372	-1.472**	-0.702**	2.202*		F⟷S
		-0.169	-1.371	-1.036	(-2.327)	(-1.984)	-2.593	1528.45	
	ΔF on ΔS	0.0002	0.4	0.221	-1.017	-0.556	0.214		
		-0.17	-0.632	-0.621	(-1.619)	(-1.567)	-0.254	1534.83	
TCS	ΔS on ΔF	0.0001	0.099	0.115	-0.745	-0.432	0.51	1559.87	S⟷F
		-0.0013	-0.17	-0.337	(-1.290)	(-0.432)	-0.671		
	ΔF on ΔS	0.0001	-0.293	-0.047	-0.358	-0.27	-1.392**	1556.68	
		-0.0013	(-0.503)	(-0.137)	(-0.617)	(-0.795)	(-1.994)		
WIPRO	ΔS on ΔF	0.0001	-0.438	-0.151	-0.223	-0.144	0.308	1526.42	S⟷F
		-0.092	(-1.154)	(-0.680)	(-0.593)	(-0.661)	-0.623		
	ΔF on ΔS	0.0001	-0.905**	-0.355	0.221	0.054	-1.578*	1540.51	
		-0.106	(-2.342)	(-1.571)	-0.579	-0.244	(-3.139)		

Notes: Parenthesis shows t-statistics, * (**) – indicates significance at one and five per cent level, respectively.

Appendix-1

List of selected IT Sector Stocks considered for the study		
S. No.	**NSE Code/Name of the Stocks**	**Name of the IT Industries**
1.	HCLTECH	HCL Technologies Ltd.
2.	I-FLEX	I-FLEX Solutions Ltd.
3.	INFOSYSTCH	Infosys Technologies Ltd.
4.	PATNI	Patni Computer Syst Ltd.
5.	POLARIS	Polaris Software Lab Ltd.
6.	SATYAMCOMP	Satyam Computer Services Ltd.
7.	TCS	Tata Consultancy Services Ltd.
8.	WIPRO	Wipro Ltd.