PRICE DISCOVERY IN INDIAN STOCK MARKET – AN EMPIRICAL STUDY WITH THE S&P CNX NIFTY INDEX

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Abstract

This paper examines the relationship between the futures market and spot market of S&P CNX Nifty during the sample period January 2003 through September 2010 and quantifies the price discovery function of futures prices in relation to spot prices of the sample market. The Cointegration tests and Vector Error Correction Models (VECM) employed in the study proved certain long-run equilibrium relationship between the selected spot market and the futures market. From the results of the study it was also found that the futures price series had a greater speed of adjustment to the previous deviations and hence the price discovery was achieved first in the spot market.

Keywords: *Cointegration, Price Discovery, S&P CNX Nifty index, Vector Error Correction Models.*

Introduction

Several studies suggest that futures markets play a critical role in price discovery for the underlying spot market (Chatrath et al., 1999; Lien and Tse, 2000; Yang et al., 2001). Generally, Price discovery is the dynamic process by which market prices incorporate new information, and is arguably one of the most important functions of financial markets. This price discovery function implies that prices in the futures and spot markets are systematically related in the short run and/or in the long run. In the cointegration jargon, the price discovery function implies the presence of an equilibrium relation binding the two prices together. If a departure from equilibrium occurs, prices in one or both markets should adjust to correct the disparity.

One of the important issue that are related to price discovery are determining which market first incorporates new information about the underlying fundamental asset, and how the efficacy of price discovery depends on trading mechanisms. It has been argued that effective futures markets should generate prices that express consciously-formed opinions on cash prices in the future, and should transmit that information throughout the marketing system in a timely manner (Working, 1948)

Because of its importance, the effectiveness of futures markets in performing this function has been investigated extensively in the literature. The more recent studies have shown that futures prices play a dominant role in the discovery and transmission of price information. Whether this situation holds good for all markets is a question of debate for several years. For answering this question, this study makes an attempt taking into consideration the S&P CNX Nifty Index and its underlying futures prices.

Review Of Related Literature

Herbst (1987) studied S&P index futures and Value Line Index (VLI) futures from February 1982 to September 1991 and found that futures price led the spot price. They also found some evidence of feedback. They conclude that the spot index adjusted quickly so that knowledge of the lead lag relation could not be used for profitable trading opportunity. **Kawaller, Koch and Koch (1987)** examined the intraday price relation between S&P 500 futures and the S&P index using minute by minute data for the period 1984–85. Their results suggest that futures price movement led index movement by 20 to 45 minutes while movement in the index rarely affected futures beyond one minute. They attribute the stronger futures leading spot relation to infrequent trading in the stock market. **Cheung and Ng (1990)** studied S&P index futures using data over 15 minute intervals from April 1982 to June 1987. They found that futures led spot by 15 minutes with weak evidence of spot leading futures. Likewise **Stoll and Whaley (1990)** investigated the time series properties of five minute intra-day returns of stock index futures and stock index. They found that the S&P 500 and Major Market Index (MMI) futures returns led stock market returns by 15 to 20 minutes, even after purging effect of infrequent trading. However, the lead lag relation was not completely unidirectional, with lagged stock index returns having a mild positive predictive impact on futures returns in the inception period of futures trading. **Chan, Chan and Karolyi (1991)** studied S&P index futures and Major Market Index (MMI) futures using data over five minute interval from August 1984 to December 1989. They examined the intra-day pattern of lead lag relation using a bivariate GARCH framework and found strong intra-market dependence. They found much stronger bi-directional dependence between stock index and stock index futures price change when the volatility of price change was also considered. **Chan (1992)** investigated the stock index market on an intra-day basis using lead lag regression. He examined the effect of good and bad news, trading intensity and market wide price movement on dominance. The results showed weak dominance by futures market and no effect due to good or bad news. While the study found no compelling evidence that trading intensity affected lead lag relation, Chan suggests that response to market wide movement was supportive of dominance by futures market.

Thus numerous studies have been explored so far in the ascertainment of whether the price information reflects in the spot market or in its underlying futures market under various interval of time. This study adds to the existing literature in this field using some of the econometric tools like Co-integration and VEC models.

Need Of The Study

The capital market in India has observed many changes in the new millennium. From June 2000 onwards, SEBI has introduced derivatives products such as Index futures, options, stock options and stock futures, in a phased manner in the securities market. These instruments have basically been used for risk management by many investors, including corporate, for the past several years. Besides the traditional role of risk sharing assigned to futures markets, these markets play an important role in the aggregation of information (for example, Grossman [1977], Bray [1981] and Brannen and Ulveling [1984]). The case of stock index futures is analyzed in Subrahmanyam [1991] and in Kumar and Seppi [1994]. Futures and cash markets contribute to the discovery of a unique and common unobservable price that is the efficient price. Price discovery thus refers to the use of futures prices for pricing cash market transactions (Working (1948), Wiese (1978, p. 87), and Lake (1978, p. 161)). The contribution of each market to the price discovery depends, at least in part, on the microstructure of these markets, including the level of transparency, the liquidity supply mechanism, the rules governing the priority of orders, the constraints on short sales and the settlement mechanism. The significance of both risk sharing and price discovery contributions depends upon a close relationship between the prices of futures contracts and cash markets. And this contributes for the study of the temporal relationship between the stock and the futures by many academicians, regulators and practitioners alike as it gives an idea about the efficiency of the market, its volatility and arbitrage opportunities, if any. Profitable arbitrage should not exist in perfectly efficient markets as prices should adjust instantaneously and fully to new information. Hence, new information disseminating into the market place should be immediately reflected in spot prices and the futures prices simultaneously. In other words, this suggests that there should be no lead-lag relationship between the cash and futures market. However, in reality, institutional factors such as liquidity, transaction costs, and other market restrictions may produce an empirical lead– lag relationship between price changes in the two markets. Futures markets could incorporate new information more quickly than do cash markets given their inherent leverage, low transaction costs, and lack of short-sale restrictions (Tse, 1999).

Supporting this, Pizzi et. al (1998) concluded in the study that the futures market performs an important function of price discovery to help improve efficiency of the market and is expected that price discovery would take place in the futures market first and subsequently percolate to the underlying cash market. From this argument, it can be said that the futures prices and their movements provide useful information about subsequent spot prices in the financial markets.

Objectives And Hypotheses

Every research must have some objectives. Setting research objectives helps the researcher to make others understand what the research is actually about and why such a kind of research has been done. This study has three key objectives which are given as follows:

1. To examine the relationship between the futures market and spot market for the sample market;
2. To quantify the price discovery function of futures prices in relation to spot prices of S&P CNX Nifty Index price series; and,
3. To analyze whether the price information reflects first in futures market or in the spot market.
4. Based on the above objectives,
   H_0: Futures prices do not play a major role in price discovery.
   H_1: Futures prices play a dominant role in price discovery.

Research Methodology

The data for this study was secondary in nature and it has been collected from the National Stock Exchange of India Limited. It consisted of daily closing prices of S&P CNX Nifty and the nearby Nifty Futures prices from January 2003 through 24th September 2010. In this study, S&P CNX Nifty has been specifically selected as our sample because they are well suited for bench-marking, index funds, and index-based derivatives. S&P CNX Nifty includes 50 of the approximately 1,300 companies listed on the NSE, captures approximately 60% of its equity market capitalization and is a true reflection of the Indian stock market.

Primarily, the stationarity of the data series was checked out by Augmented Dickey-Fuller (ADF), and Phillips-Perron (PP) tests. Since the price series of both the set of data were found to be integrated in an identical order, Johansen Multivariate Maximum likelihood cointegration test was employed to investigate the long-run relationship between spot and futures prices and it is presented below.

$$\Delta X_t = \sum_{i=1}^{p-1} \Gamma_i X_{t-i} + \prod X_{t-1} + \varepsilon_t;\ \varepsilon_t = \begin{pmatrix} \varepsilon_{s,t} \\ \varepsilon_{F,t} \end{pmatrix} \approx N(0,\Sigma) \quad (1)$$

Where $X_t = (S_t\ F_t)'$ is the vector of spot and futures prices, Δ denotes the first difference operator; Γ_i and Π are 2×2 coefficient matrices measuring the short-and long-run adjustment of the system to change in X_{ti} and ε_t is 2×1 vector of white noise error terms. The lag length P was selected using Akaike's Information Criteria (AIC Rule). The two likelihood ratio tests were employed to identify the co-integration between the two series. The first statistic λ_{trace} tests whether the number of cointegrating vectors is zero or one, and the other λ_{max} tests whether a single cointegrating equation was sufficient or if two were required.

In general, if r cointegrating vector is correct. The following test statistics can be constructed as:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} ln\left(1 - \hat{\lambda}_i\right) \quad (2)$$

$$\lambda_{Max}(r, r+1) = -T\ ln\left(1 - \hat{\lambda}_{r+1}\right) \quad (3)$$

Where, n is the number of separate series to be examined, T is the number of usable observations and ($\hat{\lambda}_i$) are the estimated Eigen values (also called characteristic roots) obtained from the (i+1) × (i+1) 'cointegrating matrix.'

The first test statistic (λ_{trace}) tests whether the number of distinct cointegrating vectors was less than or equal to r. The second test statistic (λ_{max}) tests the null that the number of cointegrating vectors is r against an r+1. MacKinnon-Haug-Michelis (1999) provide the critical values of these statistics. The rank of Π may be tested using the λ_{max} and λ_{trace}. If rank (Π) =1, then there was single cointegrating vector and Π can be factored as Π=αβ′, where α and β′ are 2×1 vectors. Using this factorization 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.

To test the causality, the following Vector Error Correction Model (VECM) is estimated by using Ordinary Least Square (OLS) in each equation.

$$\Delta S_t = a_{s,0} + \sum_{i=1}^{p-1} a_{s,i}\Delta S_{t-i} + \sum_{i=1}^{p-1} b_{s,i}\Delta F_{t-i} + \alpha_s Z_{t-1} + \varepsilon_{s,t} \qquad (4)$$

$$\Delta F_t = a_{F,0} + \sum_{i=1}^{p-1} a_{F,i}\Delta S_{t-i} + \sum_{i=1}^{p-1} b_{F,i}\Delta F_{t-i} + \alpha_F Z_{t-1} + \varepsilon_{F,t} \qquad (5)$$

where $a_{S,0}$, $a_{F,0}$ are intercept terms; $a_{S,i}$, $b_{S,i}$, $a_{F,i}$, $b_{F,i}$ are the short-run coefficients and $Z_{t-1}= \beta' X_{t-1}$ is the error correction term from equation 1.

In terms of the vector error correction model (VECM) of equation 4 & 5, F_t Granger Causes S_t if some of the $b_{S,i}$, coefficients, i =1,2,…., p-1 are not zero and α_S, the error correction coefficient in the equation for spot prices, is significant at conventional levels. Similarly, S_t Granger causes Ft if some of the $a_{F,t}$ coefficients, i =1,2,…., p-1 are not zero and α_F is significant at the conventional levels. These hypotheses can be tested by using either t-tests or F-tests on the joint significance of the lagged estimated coefficients. If both S_t and F_t Granger cause each other, then there is a feedback relationship between the two markets.

The Vector Error Correction Model (VECM) equation 4 & 5 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 Engel and Granger (1987) estimator (Gonzalo, 1994). Also, Johansen (1988) tests are shown to be fairly robust to presence of non normality and heteroscedasticity disturbances (Lee and Tse, 1996).

Since the futures prices series and the spot prices series of these set of data appeared to be non stationary, pair-wise granger causality tests had been ignored in this study.

Results And Discussions

A necessary condition to carry out a cointegration test in a time series data is that the data have to be non-stationary at the level, but stationary in the differences. The tests of stationary developed through Augmented Dickey Fuller have been performed for the selected series. The ADF test uses the existence of a unit root as the null hypothesis, that is:

H_0: $\alpha = 0$: H_1: $\alpha \neq 0$
The result of ADF was presented in Table 1.

To double check the robustness of the results, Phillips and Perron (1988) test of stationarity have also been performed for the series. The optimal lag numbers of each differenced series were tested by using the Akaike's Information Criteria (AIC). From the estimates of the Augmented Dickey Fuller (ADF) and Phillips Peron (PP) test results conducted for S&P CNX Nifty index and Nifty futures, it was found that the series were not stationary at their levels, but were stationary at their first difference.

Table 1 Unit Root Test Results

Constraint	Null Hypothesis	t-statistic		p-value*	
		Levels	**Difference**	**Levels**	**Difference**
Augmented Dickey and Fuller (ADF) test	S&P CNX Nifty prices series has a Unit Root	-1.450848	-31.30359	0.5585	0.0000
	Nifty Futures prices series has a Unit Root	-1.485134	-12.93220	0.5413	0.0000
Phillips-Perron test	S&P CNX Nifty prices series has a Unit Root	-1.422735	-40.48248	0.5725	0.0000
	Nifty Futures prices series has a Unit Root	-1.418131	-80.93809	0.5750	0.0001

Confidence Level A = 0.05

If two or more series were themselves non-stationary, but a linear combination of them was stationary, then the series were said to be co-integrated. The Engle–Granger two step methods (Engle & Granger, 1987) and the Johansen trace test (Johansen, 1988; 1991) were the two main approaches for testing cointegration.

Table 2 Johansen Cointegration Test Results

Null Hypothesis	Hypothesized No. of CE (s)			
λ_{trace} Test		**Eigen value**	**λ_{trace} statistics**	**0.05 critical value**
r = 0	No cointegration*	0.002278	5.321570	15.49471
r ≤ 1	Atmost one Cointegration	0.000549	1.032189	3.841466
λ_{max} Test		**Eigen value**	**λ_{max} statistics**	**0.05 critical value**
r = 0	No cointegration*	0.002278	4.289381	14.26460
r = 1	Atmost one Cointegration	0.000549	1.032189	3.841466

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the null hypothesis at the 0.05 level

In this study, Johansen's cointegration test (1988) was performed for Nifty Index spot and the futures prices and results were presented in table 2. The test reveals that one cointegration relationship exists between spot and futures markets. As seen in the Table 2, the Johansen's λ_{max} and λ_{trace} statistics revealed that the Nifty Index and Nifty futures prices have one cointegration relationship and they shared a long-run relationship between them. Hence, vector error correction model (VECM) have been used which shows short run dynamics in the price series.

Table 3 Vector Error Correction Estimates Results

S & P CNX NIFTY		
Cointegrating Eq:	**CointEq1**	
FUTURES(-1)	1.000000	
SPOT(-1)	-0.654525	
	(0.20020)	
	[-3.26936]	
Z_{t-1}	-0.925740	
Error Correction:	**D(FUTURE)**	**D(SPOT)**
α_i	-0.001030	0.003648
	(0.00117)	(0.00210)
	[-0.87902]	[1.73700]
D(FUTURES(-1))	-0.113633	0.024083
	(0.02298)	(0.04117)
	[-4.94567]	[0.58490]
D(FUTURES(-2))	-0.099329	0.021344
	(0.02300)	(0.04122)

	[-4.31785]	[0.51775]
D(SPOT(-1))	-0.000747	0.071631
	(0.01285)	(0.02303)
	[-0.05815]	[3.10982]
D(SPOT(-2))	-0.002649	-0.054303
	(0.01285)	(0.02303)
	[-0.20610]	[-2.35745]
Z_{t-1}	0.245186	0.101358
	(0.00010)	(0.00018)
	[1.85407]	[1.99326]

The lag length of two in the vector error correction model (VECM) of equation 4 and 5 is chosen on basis of Akaike's information criteria (AIC) and Schwarz criteria (SC). From the VECM estimation results that were presented in table 3, it was noticed that α_f =0.245186. This indicates the futures price series *Ft* have a greater speed of adjustment to the previous period's deviation from long-run equilibrium than the spot price series. Thus, the results indicated that the price discovery was achieved in the spot market.

Conclusions And Implications

This paper has focused on the price discovery mechanism between futures and spot prices of the S&P CNX Nifty and its underlying futures price series. This empirical investigation has been conducted on the Nifty Index market in National Stock Exchange of India Ltd. through the years January 2003 to September 24, 2010. The results from unit root tests indicate that Nifty Index and Nifty futures are not stationary at their levels. But they are stationary at their first difference. The main result of the study is that there is a long run equilibrium relationship between spot and futures prices of CNX Nifty Index. Hence, a vector error correction model (VECM) was employed to investigate the short-run dynamics and price movements in the two markets. The Johansen's vector error correction model (VECM) results found that the futures price series had a greater speed of adjustment to the previous deviations and hence the price discovery was achieved first in the spot market. This draws up a conclusion that the spot prices lead the futures price series in the selected market.

This study can be useful to the investors, participants and academicians who are very keen in observing the trend of the selected market. Since the interests of the investors on the futures markets are comparatively low when compared to the spot markets, research contribution to the price discovery mechanisms on these markets can help them to predict in which markets they can invest for higher returns. At the same time, it is suggested that in future, the study can still be extended as the comparison between some of the other products or even single stocks so that a clear understanding on whether price discovery mechanisms act in a similar way for all financial products can be obtained.

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