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Empirical Evidence of the Causative Association between Spot, Futures and Options Market: An ARDL Model Approach

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Abstract

Purpose: The purpose of this paper is to explore and provide evidence about the nature of short run causal relationship as well as the speed with which prices adjust towards achieving the long run equilibrium between cash and FAO markets in India as represented by National Stock Exchange. The study uses individual stocks for studying the underlying relationship.

Design/Methodology: The paper makes use of the auto regressive distributed lag model to study the causal relationship between spot, futures and options markets. The study makes use of the 15-minute interval trades data for the purpose of analysis.

Findings: The ARDL model shows a long run association between spot, futures & options (both call & put) prices but we do not have sufficient statistical evidence to conclude the short run causal association between the variable except for call and put options.

Practical Implications: The results indicate that derivative markets are not leading the spot market but spot market contributes towards price discovery in the FAO markets. Potential investors can take their positions and design their portfolio in the cash and FAO segments using the insights provided by this piece of work.

Originality/Value: This paper is an original piece of work towards evidencing the causative association between spot, futures and options markets using individual securities. Matters pertaining to price discovery process in Indian financial markets are issues of interest for financial thinkers, traders, investors and financial analysts.

Keywords: Futures and options markets, Autoregressive distributed lag (ARDL) model, NSE Nifty, stock market, derivatives

1. Introduction

"Price Discovery is the process through which asset markets reach equilibrium price levels. Increased information efficiency of a market allows for faster price discovery. This process in the stock market is aided by the presence of derivative markets, which allow for information to flow through another channel. Futures are one of the most commonly traded derivatives which support the spot markets in discovering the equilibrium price. As futures have inherent leverage and can be easily shorted, these markets tend to have higher liquidity than the underlying cash markets. Higher liquidity implies greater participation by various groups of investors and traders and hence faster information absorption. The addition of options market further improves the liquidity in the derivatives market which allows it to play a greater role in the price discovery process.

Research in the area of price discovery and information sharing amongst futures and cash markets is important from two main standpoints. Firstly, it has implications for market efficiency. Presence of arbitrage opportunities indicates an inefficient market. Secondly, the fundamental reason behind the introduction of derivatives markets is to increase liquidity and price discovery in the underlying cash markets through the trading linkages between these markets. This hypothesis assumes the importance of futures markets in absorbing and disseminating information to the cash market." (Jain & Biswal, 2012)

2. Overview of empirical literature

Some empirical studies in the past tried to analyze whether the spot prices are determined by the futures price. They found conflicting evidence and gave some questionable understandings. By applying the unidirectional econometrical technique, few papers found the lead of futures markets over the spot markets. It implies that the stock market has a mellow positive prescient capacity on returns of futures contracts. Kawaller et al. (1987) used the TSLS regression and evidenced that spot prices were led by S&P 500 futures prices to the extent of 20 minutes to 45 minutes and that the futures prices were influenced by the spot prices by 1 minute. Finnerty and Park (1987) found that evidence of association between the price changes in index futures and spot but they did not provide any evidence for a causative relationship. Stoll and Whaley (1990) applied time series analysis on the futures returns of the S&P 500 index and Major Market Index (MMI) to inquire about their connection with stock index returns. They envisaged that MMI index futures returns and S&P 500 index futures returns had a lead over stock index returns by more than 5 minutes. However, they also found that futures returns were led by spot returns during the early periods of futures trading. Nonetheless, they neglected to manage the issue of short and long run equipoise relationships in view of arbitrage exercises.

In another study Ghosh (1993), observed that the S&P 500 index prices were led by futures prices and the Commodity Research Bureau (CRB) futures index prices were led by spot prices. Tse (1995) estimated the leading and lagging relationship between futures and spot index prices of the Nikkei Stock Average (NSA). In his study, he used ECM on daily observations and found a long-run relationship between the two series. Shyy et al. (1996) explored the lead–lag association between the cash index and continuous assisted quotation (CAC) index futures. Applying the ECM on one-minute trading price they found that the cash index was led by the

CAC futures. However, it was also found that when the mid-quote points of bid–ask prices were used the CAC cash index led the futures. Gee and Karim (2005) analyzed the same lead–lag relationship in a study on the Malaysian markets using daily data of futures contracts over spot and index. The process of price discovery in the Hang Seng index market was investigated by So and Tse (2004) using the common-factor models of Hasbrouck (1995) and Gonzalo and Granger (1995) and the M-GARCH model. Using the 1-minute interval data from the Hang Seng index futures, Hang Seng index and the tracker fund (ETF) it was observed that the movements of these markets were interconnected. Fleming et al. (1996) investigated the US markets for the price discovery process in the spot and FAO markets in the presence of trading costs. They envisaged that the lead lag association between these markets was significantly influenced by the structure of trading costs.

Jong & Donders (1998) tested the lead lag association between the spot, options and futures contracts at the Amsterdam Exchange index and envisaged that the options market yields were led by the futures markets yields by 10 minutes. Gwilym & Buckle (2001) tested the lead-lag linkage among the spot index of Financial Times Stock Exchange 100 and its related FAO contracts, and found that both the futures and put options markets were led by the call options markets. Kang, Lee, & Lee (2006) used the returns of the Korea composite Stock Price Index spot, futures & options market to test the temporal associations and found the options market to be steering and trailing the futures market by 5 minutes only. Nam, Oh, Kim, & Kim (2006) studied financial markets in Korea to investigate the relationship among the Korea composite Stock Price Index spot, the index futures and options markets. The cross-sectional analysis as well as the time series analysis indicated a symmetric lead–lag association between the options and the futures markets with an exclusion for out of the money option contracts. Debasish & Mishra, (2008) tested the lead-lag linkage between the NSE Nifty index and its associated FAO contracts. They found a robust linkage between options and futures market where futures markets were led by the call options markets and put options markets were led by futures markets. Maniar (2011) studied the outcome of the existence of arbitrageurs on the contemporaneous relationship between the spot index, options & futures market and established that futures markets led the options markets by ten minutes. Ryu (2015) analyzed the informational content of futures and options transaction in KOSPI 200 index. They applied simple regression and studied the price influence of derivative trades over sequential time intervals. They concluded that not only the price discovery was greater in futures markets but they also led the options markets. (Lee, Kang, & Ryu, 2015) examined intraday data for KOSPI200 futures and options markets. They found a common deviation in the futures and options markets and the pattern of deviation was flat on the basis of intraday trades. They also envisaged that there was a strong linkage between the two markets with reference to dynamics of asset prices and trading volume. (Huang, Wang, & Wang, 2016), in their study on S&P 500 index options using the generalized spectrum method, found the statistical evidence of the options markets being inefficient. (Sim, Ryu, & Yang, 2016) tested the monotonicity characteristics of the options prices using the options trades on KOSPI 200 index and found that the options prices violated these properties and the increase/decrease in the prices of call and put options was concurrent. (Ryu & Yang, 2017) examined KOSPI200 futures and options markets to examine the mechanism through which prices of index futures and options contracts correct themselves to eliminate price disagreements. They found a strong association between index derivatives and stated that though both markets adjust to price disagreements but options markets were more likely to follow futures markets. (Yang, Choi, & Ryu, 2017) analyzed the monotonicity properties of options prices and found that they did not correlate with spot prices, rather the change in call and put options prices often takes place concurrently.

Apart from these, there are some studies that are conducted on low-frequency data on the measures of volume, returns and volatility and have reported a bidirectional relationship. To name a few are, in 1992 Malliaris & Urrutia (Malliaris & Urrutia, 1992), in 2001 Bhanupant (Bhanupant, 2001) and Chen et al. (Chen et al, 2001), in 2003 Mestel et al. (Mestel et al., 2003), in 2008 Floros (Floros, 2008) and Mahajan & Singh (Mahajan & Singh, 2008), in 2009 Kumar et al. (Kumar et al., 2009) and in 2013 Brüggemann et al. (Brüggemann et al., 2013) and Gurgul & Syrek (Gurgul & Syrek, 2013). Similarly, Granger et al. (1964) examined the association among the trading volume and prices and could not find proof of a linkage between the two.

There are many studies conducted to find the causality for low frequency data but very few studies talk about the high frequency data, which is a phenomenon for intraday trade. This research paper tries to fill this literature gap especially regarding Indian Stock Market.

3. Data and Methodology

3.1 Data Description

The study uses 15-minute interval intraday data on prices of spot and near month futures and options contracts, sourced from Bloomberg, for the period of January 2017 to December 2017. For options contracts, contracts with highest strike price were selected. S, F, C and P represent the logarithmic value of prices in spot, futures, call and put options market respectively.

3.2 Cointegration

This paper makes use of the ARDL bounds testing methodology which was developed by Pesaran et al (Pesaran, Shin, & Smith, 2001) to test the long run equilibrium association between spot, options and futures markets. ARDL model provides a common dynamic measurement for approximating the long run and short run interactions between variables. This model makes use of the lagged values of dependent variables and lagged as well as concurrent values of the explanatory variables. With the help of these values, short run causality can be estimated directly while long run association can be estimated indirectly.

ARDL model comprises of estimating the following unrestricted ECM:

$$\Delta S_t = a_{0S} + \sum_{i=1}^{n} b_{iS}\Delta S_{t-i} + \sum_{i=1}^{n} c_{iF}\Delta F_{t-i} + \sum_{i=1}^{n} d_{iC}\Delta C_{t-i} + \sum_{i=1}^{n} e_{iP}\Delta P_{t-i} + \propto_{1S} S_{t-1} + \propto_{2S} F_{t-1} + \propto_{3S} C_{t-1} + \propto_{4S} P_{t-1} + \epsilon_{1t} \quad (1)$$

$$\Delta F_t = a_{0F} + \sum_{i=1}^{n} b_{iF}\Delta F_{t-i} + \sum_{i=1}^{n} c_{iS}\Delta S_{t-i} + \sum_{i=1}^{n} d_{iC}\Delta C_{t-i} + \sum_{i=1}^{n} e_{iP}\Delta P_{t-i} + \beta_{1F}F + \beta_{2F}S_{t-1} + \beta_{3F}C_{t-1} + \beta_{4F}P_{t-1} + \varepsilon_{1t} \quad (2)$$

$$\Delta C_t = a_{0C} + \sum_{i=1}^{n} b_{iC}\Delta C_{t-i} + \sum_{i=1}^{n} c_{iS}\Delta S_{t-i} + \sum_{i=1}^{n} d_{iF}\Delta F_{t-i} + \sum_{i=1}^{n} e_{iP}\Delta P_{t-i} + \gamma_{1C}C_{t-1} + \gamma_{2C}S_{t-1} + \gamma_{3C}F_{t-1} + \gamma_{4C}P_{t-1} + \varepsilon_{1t} \quad (3)$$

$$\Delta P_t = a_{0P} + \sum_{i=1}^{n} b_{iP}\Delta P_{t-i} + \sum_{i=1}^{n} c_{iS}\Delta S_{t-i} + \sum_{i=1}^{n} d_{iF}\Delta F_{t-i} + \sum_{i=1}^{n} e_{iC}\Delta C_{t-i} + \delta_{1P}P_{t-1} + \delta_{2P}S_{t-1} + \delta_{3P}F_{t-1} + \delta_{4P}C_{t-1} + \varepsilon_{1t} \quad (4)$$

The advantage with using ARDL model is that it can be used regardless of the order of integration of underlying variables i.e. whether the variables are I(0), I(1) or fractionally integrated, doesn't affects the methodology. F-test is used to study the cointegrating association among the variables.

The null hypothesis of no cointegration among the variables in Eq. (1) is H_0:$\propto_{1S}=\propto_{2S}=\propto_{3S}=\propto_{4S}=0$, against H_1: $\propto_{1S}\neq\propto_{2S}\neq\propto_{3S}\neq\propto_{4S}\neq 0$, which is denoted as F_S(S/F,C,P). Similarly, for Eq. (2), H_0: $\beta_{1F} = \beta_{2F} = \beta_{3F} = \beta_{4F} = 0$, against H_1:$\beta_{1F} \neq \beta_{2F} \neq \beta_{3F} \neq \beta_{4F} \neq 0$ which is denoted as F_F(F/S,C,P) and so on for Eq. (3) and (4).

Pesaran et al **(Pesaran, Shin, & Smith, 2001)** have proposed two sets of critical F values (upper bound and lower bound) for large samples, where one set supposes that all the variable are I (0) and the other set supposes all the variables to be I (1). If the calculated F values lie above the higher bound, we can reject the null hypothesis of no cointegration and conclude that the variables are Cointegrated implying a long run equilibrium relation. If the calculated F values lie below the lower bound, we cannot reject the null hypothesis and conclude that the variables are not Cointegrated. No inferences can be drawn if the F value lies between the upper and lower bounds.

3.3 Granger Causality

Engle and Granger (Engle & Granger, 1987) stated that if two series are I(1) individually and are Cointegrated, there would exist a contributory association at least in one direction, which can be detected using the vector error correction model. Causal association between a given set of variables can very conveniently detected using the Granger Causality test. A variable 'X' is said to Granger cause variable 'Y' if the prediction error of 'Y' reduces by using preceding values of 'X' and 'Y'. for the purpose of this study, Granger causality can be tested with the following equations:

$$\Delta S_t = \varphi_{10} + \sum_{i=1}^{p} \varphi_{11i}\Delta S_{t-i} + \sum_{i=1}^{p} \varphi_{12i}\Delta F_{t-i} + \sum_{i=1}^{p} \varphi_{13i}\Delta C_{t-i} + \sum_{i=1}^{p} \varphi_{14i}\Delta P_{t-i} + \varphi_{15}\varepsilon_{t-1} + u_{1t} \quad (5)$$

$$\Delta F_t = \varphi_{20} + \sum_{i=1}^{p} \varphi_{21i}\Delta F_{t-i} + \sum_{i=1}^{p} \varphi_{22}\ \Delta S_{t-i} + \sum_{i=1}^{p} \varphi_{23i}\Delta C_{t-i} + \sum_{i=1}^{p} \varphi_{24i}\Delta P_{t-i} + \varphi_{25}\varepsilon_{t-1} + u_{2t} \quad (6)$$

$$\Delta C_t = \varphi_{30} + \sum_{i=1}^{p} \varphi_{31i}\Delta C_{t-i} + \sum_{i=1}^{p} \varphi_{32i}\Delta S_{t-i} + \sum_{i=1}^{p} \varphi_{33i}\Delta F_{t-i} + \sum_{i=1}^{p} \varphi_{34i}\Delta P_{t-i} + \varphi_{35}\varepsilon_{t-1} + u_{3t} \quad (7)$$

$$\Delta P_t = \varphi_{40} + \sum_{i=1}^{p} \varphi_{41i}\Delta P_{t-i} + \sum_{i=1}^{p} \varphi_{42i}\Delta S_{t-i} + \sum_{i=1}^{p} \varphi_{43i}\Delta F_{t-i} + \sum_{i=1}^{p} \varphi_{44i}\Delta C_{t-i} + \varphi_{45}\varepsilon_{t-1} + u_{4t} \quad (8)$$

Where φ's are the parameters to be estimated, u_t's are the error terms and $\varepsilon_{t-1}$is the error correction term (ECT). Significance of short run causality is shown by the F-statistics on the lagged independent variables of error correction model. Similarly, significance of long run causality is shown by the t-statistics on the coefficients of lagged ECT. Lag length is selected using the AIC and/or SIC.

Also the models are tested for serial correlation using the Breusch-Godfrey Serial Correlation LM Test and for stability using the recursive estimates of CUSUM test. All the models were free from serial correlation and were found to be stable at 5 percent level of significance.

4. Empirical results

The results of Bounds Testing are presented in table 1. Results indicate that cointegration is not present when spot prices are the dependent variable because F_S (S/F, C, P) is lower than the lower bound critical value at 5 percent level. However, when futures, call and put options prices are dependent variables F_F (F/S, C, P), Fc(C/S, F, P) and F_P(P/S, F, C) are higher than the upper bound critical value at 5 percent level. Therefore, we can say that there is a long run relationship when they are treated as a dependent variable.

Table 1. Results of Bounds Testing

F-statistics	F-value
F_S(S/F, C, P)	1.383215 (0.2370)
F_F(F/S, C, P)	423.2759 (0.0000)
F_C(C/S, F, P)	31.99496 (0.0000)
F_P(P/S, F, C)	30.30069 (0.0000)
F-critical at 5% level	I(0) 3.23 I(1) 4.35

The results of granger causality test are presented in table 2. Results indicate that when spot prices are dependent variable, there is no short run causality found i.e. futures, call and put options are not granger causing spot prices. Also the error correction term is not significant. When futures price is dependent variable, though we have a long run association coupled with a negative and significant error correction term, there is no short run causality among the variables implying spot, call and put options prices are not granger causing futures prices. The error correction term shows that the system achieves its equilibrium at a speed of 99.27 percent. When call options price is the dependent variable, there is a short run causality with put options prices but not with spot and futures prices i.e. put options prices do granger cause call options prices in short run but the same is not true for spot and futures prices. Also we have a significant negative error correction term implying the speed of adjustment towards achieving equilibrium in long run is 25.91 percent. When put options price is the dependent variable, though we have a long run relationship with a negative and significant error correction term, there is no short run causality among the variables implying spot, futures and call options prices are not granger causing put options prices. The error correction term shows that the system achieves its long run equilibrium at a speed of 19.5 percent.

Table 2. Results of Granger Causality Test

Dependent Variable	ΔS	ΔF	ΔC	ΔP	ECT_{t-1}
ΔS	-	0.066753 (0.9354)	1.07122 (0.3427)	1.733595 (0.1767)	-0.001470 (0.8554)
ΔF	0.009469 (0.9906)	-	0.273945 (0.7604)	0.187493 (0.8290)	**-0.992741** **(0.0000)**
ΔC	1.493275 (0.0923)	0.969910 (0.4872)	-	**1.698347** **(0.0399)**	**-0.259197** **(0.0000)**
ΔP	0.851604 (0.5967)	0.541120 (0.8891)	1.473722 (0.1260)	-	**-0.195083** **(0.0000)**

5. Conclusion

Contrary to previous studies, this study establishes a long run association between spot, futures & options (both call & put) prices but we do not have sufficient statistical evidence to conclude the short run causal association between the variable except for call and put options. This implies that in long run, prices of futures and options together as well as individually, fail to influence the prices in spot market i.e. they do not aid the price discovery process in spot markets. On the contrary, prices in spot and options market, collectively as well as individually, affect the prices in futures market. Similarly, prices in spot and futures market, collectively as well as individually, affect the prices in options market. In short, we can say that while spot prices aid the price discovery process in both futures and options markets, neither futures nor options markets affect the price discovery in spot markets in long run. This is also evident in futures prices converging with spot prices at the time of maturity but not the other way round. Also, the speed of adjustment towards achieving equilibrium is greater in futures markets as compared to options markets implying greater arbitrage opportunities in options as compared to futures markets. Finally, these findings can be used by investors and hedgers to take their positions. Also they can be useful for understanding the price discovery process in Indian financial markets, which are issues of interest for financial thinkers, traders, investors and financial analysts.

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