# Does the Pre-Open Auction Market Improve Efficiency of Price Discovery in Stock Markets ? Evidence from India

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## Abstract

**The paper analyzed the impact of opening call auction on the efficiency of price discovery at the National Stock Exchange (NSE), India by studying the returns and volatility behavior of one benchmark index (NSE's Nifty) and 10 Nifty component companies selected on random. The paper used the closing prices for the period 3 years before and 3 years after the introduction of the call auction market in 2010. Descriptive statistics, one-way ANOVA, augmented Dickey-Fuller unit-root Test, and ARCH-GARCH type methodology was employed for the analysis. The paper found no significant difference in the returns during the two periods, though a reduction in volatility was observed. The introduction of the pre-open auction market resulted in an improvement in the efficiency of price discovery of various stocks. The findings of the paper offer valuable inputs for stock market regulators as well as investors.**

***Keywords:*** **efficiency of price discovery, pre-open call auction, one-way ANOVA, augmented Dickey-Fuller unit-root test, ARCH-GARCH**

**JEL Classification: G11, G14, N25**

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In recent times, the call auction market has emerged as one of the prominent dimensions being added to the capital markets. Call auction is an alternative to continuous trading with anonymous limit order book. It keeps the anonymous limit order book, but dispenses with continuous order matching. In call auction, orders arrive continuously into the auction order book, but remain unexecuted till the time orders match. Until then, the orders can be revised or removed. Call auctions run in the forms of pre-open call auctions and post-close call auctions. There is a good deal of international experience with call auctions. At several exchanges, the NYSE being one of them, the opening price is computed using a call auction. At LSE, a call auction is used at the close of trading to discover the spot market closing price and to support closeout by derivatives arbitrageurs. Call auctions had long been used as the main market design in continental Europe, particularly for illiquid stocks, the best known example of which is the Paris Stock Exchange.

Trading at the NYSE begins with a call auction. A lot of research on the NYSE has been done, and research has revealed that the introduction of opening and closing call auctions has significantly reduced volatility and has improved efficiency in price discovery. Furthermore, the dissemination of indicated prices allows the uninformed traders to place appropriate orders that lead to more efficient prices and hence, there exists a price leadership among the market makers (Cao, Ghysels, & Hatheway, 2000 ; Dia & Pouget, 2005 ; Madhavan & Panchapagesan, 2000 ; Pagano, Peng, & Schwartz, 2008 ; Schwert, 1989).

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Call auctions are introduced with an aim to improve the price discovery mechanism, thereby increasing the efficiency of the markets (Pagano & Schwartz, 2003). Empirical research studies have pointed towards an improvement in the price discovery process and market quality through call auctions (Chan, Aitken, & Lepone, 2011 ; Lee, 2008). Furthermore, call auctions help smoothen the trading volume since traders select the strategies based on the information at hand and prefer auction markets to the dealer market (Brusco, Manzano, & Tapia, 2003 ; Reboredo, 2012; Snell & Tonks, 2003).

In India, the National Stock Exchange reintroduced the opening call auction in October 2010, 11 years after it was suspended in 1999. Researchers broadly found that the volatility, efficiency, and liquidity on the NSE improved after the suspension of the call auction market. However, market quality in terms of price synchronicity improved after the reintroduction of the call auction market (Agarwalla, Jacob, & Pandey, 2013 ; Camilleri & Green, 2009).

## Review of Literature

Call auctions act as a measure to control volatility in stock markets. Call auction, as an alternative to continuous order-matching for trading in the financial markets, has witnessed increased research interest in recent times. Studies have examined the introduction and the suspension of the call auction markets across the world, but largely in the developed nations. Financial markets in developing countries have seen a sharp surge in activity. Research efforts have not been able to match the surge in developing nations. The present study focuses on the Indian stock market and attempts to examine the impact of the pre-open call auction market on volatility in the stock markets. This section presents a detailed review of the studies focusing on the call auction market, mainly in the developing countries.

**(1) Focus Areas of Empirical Literature :** Research efforts to study the financial markets of developed nations have been made in plenty. Schwert (1989) ; Madhavan and Panchapagesan (2000) ; Cao et al. (2000) ; Snell and Tonks (2002), Moshirian, Nguyen, and Pham (2012) ; Pagano and Schwartz (2003) ; Brusco et al. (2003) ; Aitken, Comerton-Forde, and Frino (2005) ; Dia and Pouget (2005) ; Chang, Rhee, Stone, and Tang (2008) ; Kang and Lee (2007), Tian and Guo (2007) ; Comerton-Forde, Ting Lau, and McInish (2007) ; Ozenbas (2011) ; Pagano et al. (2008) ; Kelly (2008) ; Lee (2008), Reboredo (2012) ; Chan et al. (2011) ; Hinterleitner, Hornung, Leopold-Wildburger, Mestel, and Palan (2012) ; and Hagströmer and Nordén (2014) based their studies on the financial markets of developed countries. A few studies including the ones conducted by Harvey (1995), Batra (2004), Kaur (2004), Camilleri and Green (2009), Sharma and Bodla (2011), Sharma, Mahendru, and Singh (2013), and Agarwalla et al. (2013) focused on the stock markets of developing nations.

Empirical research studies have focused on various objectives while studying the pre-auction call trades. Ozenbas (2011) studied the stock markets of New York, Paris, Germany, and London collectively and investigated whether or not the patterns of volume changed across various market centers and market opening procedures while also taking into consideration the impact of the trading rule changes that occurred in the European market during the same time period. Pagano and Schwartz (2003) studied the impact of the closing call auction market on the Paris bourses. Hinterleitner et al. (2012) covered Austria's pre-open call auction market and made an effort to find out which market was ideal for market opening, that is, whether the call auction market or the continuous trading market was ideal, and also tested if there was a spillover effect from the opening call auction market on the continuous market.

Moshirian et al. (2012) and Aitken et al. (2005) focused on the Australian Stock Market, particularly on its call auction market. Moshirian et al. (2012) focused on the effect of the overnight corporate announcements on the order placement activities during the pre- opening period. The study also made a comparative analysis of the price discovery across the trading hours and the overnight non-trading hours based on the news announcements. Aitken

et al. (2005) attempted to find out if closing call auction resulted in the reduction in liquidity in the continuous market.

Chang et al. (2008) and Comerton-Forde et al. (2007) explored the introduction of the call auction market at the Singapore Stock Exchange. Chang et al. (2008) carried out the direct comparison between the call money market (CMM) and the continuous auction market (CAM) within the same order driven market using the open-to-open return volatility (subject to the CMM) and close-to-close return volatility (subject to the CAM) to highlight the differential effects of the two trading methods. Comerton-Forde et al. (2007) studied the impact of the introduction of the call auction markets on the price discovery at the open and the close. The authors also examined the change in the liquidity level in different stocks.

Studies by Schwert (1989), Madhavan and Panchapagesan (2000), Cao et al. (2000), Dia and Pouget (2005), and Pagano et al. (2008) are based particularly on the New York stock market. Schwert (1989) basically analyzed the relation between the stock return volatility with the volatility of inflation, money growth, and industrial production. Madhavan and Panchapagesan (2000) attempted to examine the process of price discovery at the New York Stock Exchange and also attempted to understand how the trading mechanism affected the process of price formation. Cao et al. (2000) studied the use of Nasdaq market makers pre-opening quotes as signals for price discovery. The study emphasized the combination of non-trading periods and non-binding signals in studying the informational content of the price quotation signals when there was no trading and also yielded the insights on the differences in close-to-open price reaction to overnight news announcements across markets. Dia and Pouget (2005) studied the presence or not of the pre-opening period and their welfare implications, and also investigated the role of pre - announcement in price determination and information revelation. Pagano et al. (2008) analyzed the impact of the call auction market on the informational efficiency of prices, and they also considered the efficacy of the call auction session as a price discovery mechanism.

Snell and Tonks (2003), Brusco et al. (2003), and Reboredo (2012) focused on the SSE (Spanish Stock Exchange) and the SIBE (Spain Stock Exchange). Snell and Tonks (2003) evaluated a call auction and a dealer market by examining the profits/costs to the institutional investors of trading on these two alternative trading platforms and identified the conditions under which one system was preferred to the other. Brusco et al. (2003) studied the impact of the pre-opening market in the Madrid Stock Exchange on information revelation and determination of opening price.

Kang and Lee's (2007) study was based on the Korea Exchange and that of Kelly (2008) was based on the Irish Stock Exchange (ISE). Kang and Lee (2007) studied how the price discovery efficiency was affected by changes in the pre-trade transparency level on the Korea Exchange (KRX). Covering the Shanghai Stock Exchange (SHSE), Tian and Guo (2007) examined both the interday and the intraday return volatility of the Shanghai Composite Stock Index. Hagströmer and Nordén (2014) based their research on the Stockholm Stock Exchange and studied the impact of the closing call auction market on the futures market. The study also investigated if the closing auction market had an influence on trader patience.

Lee (2008) and Chan et al. (2011) focused on the Hong Kong Stock Exchange. Sharma and Bodla (2011) studied the interlinkages among the stock markets of South Asia and attempted to find out if there existed the possibility of diversification among the stock exchanges under study.

Harvey (1995), Batra (2004), Kaur (2004), Camilleri and Green (2009), and Agarwalla et al. (2013) studied the volatility, volatility patterns, time varying volatility, impact of call auction on price discovery, and impact of the suspension of the opening and the closing call auction market, respectively on the Indian Stock Market.

Harvey (1995) explored the level of volatility across different emerging markets. Batra (2004) studied the pattern of the stock market volatility in India between 1979-2003, and the nature of the events that caused shifts in the stock price volatility. Kaur (2004) studied the existence of the 'calendar month effect' or the 'day of the weak effect' in the Indian stock market, and whether there was return and/or volatility spillover across the Indian and the U.S. stock markets. Camilleri and Green (2009) studied the impact of the suspension of the opening and closing

call auction markets on the Indian markets in 1999 and compared the volatility, efficiency, and liquidity of the securities before and after suspension, and estimated the value of the call auction to the traders with the help of an event study. Agarwalla et al. (2013) studied the impact of the call auction market on the Indian markets and how the trading mechanisms affected the process of price formation.

**(2) Statistical Tools Employed By Empirical Literature:** Researchers have employed different statistical measures to carry out the studies. Pagano and Schwartz (2003), Lee (2008), and Agarwalla et al. (2013) employed the market model regression approach (namely the single index market models regression technique given by Cohen, Hawawini, Maier, Schwartz and Whitcomb) to study the effect of closing call auction market on market quality. Lee (2008) further estimated multivariate regression to examine the relationship between trading volume and other factors like options and futures expiry days, daily trading volumes, and volatility. Agarwalla et al. (2013) further studied the impact of call auction market by comparing the pattern of intraday trade, volume, volatility, and return correlations before and after the introduction of the call auction market.

Comerton-Forde et al. (2007) studied the statistical differences, the standard matched paired *t*- test, and the non-parametric test on the rank assigned to the observations, which is equivalent to the Wilcoxon rank sum test. On similar lines, Pagano et al. (2008) computed the significance levels using *t*- test and Wilcoxon two-sided *t*- test. Camilleri and Green (2009) assessed the impact of suspension of the call auction market on market volatility by comparing the intra-day price differences and overnight returns reversals, before and after the call auctions. The study used GARCH model to check if auctions led to reduction in the volatility associated with "high-news". Camilleri and Green (2009) further employed the EGARCH model to test if the call auctions helped control the greater volatility on the days it was expected due to "high-news".

Schwert (1989) involved calculation of monthly standard deviation estimates and the Box-Pierce (1970) statistic as also, the PPI inflation volatility in a 12th - order vector autoregressive (VAR) system. To study the time variation in volatility, Batra (2004) employed the asymmetric GARCH model, and further augmented the model with dummy variables to examine volatility persistence. Kaur (2004) involved estimating TARCH (threshold ARCH) and EGARCH (exponential GARCH) models, where volatility clustering was modeled as an ARCH process. Tian and Guo (2007) employed parametric tests such as the mean equality test, and the non-parametric tests such as Kruskal-Wallis test, Levene test, modified Levene test, and the Brown - Forsythe test. Sharma and Bodla (2011) employed the Granger causality model, vector auto regression (VAR) model, and variance decomposition analysis to find out the linkages between the South Asian stock markets.

**(3) Results Obtained By Previous Studies :** Varied results were arrived at in the studies under review. Pagano and Schwartz (2003) concluded that there was an improvement in the market quality, whereby the price discovery mechanism by the traders improved, which in turn, increased the efficiency of the derivatives market. Aitken et al. (2005) concluded that closing call auction provided a mechanism for consolidating liquidity and allowing investors to achieve the closing price without any adverse influence on the cost of trading during the continuous trading period. Chang et al. (2008) and Comerton-Forde et al. (2007) stated that an unambiguous improvement in the price discovery process occurred after introduction of the call money market. According to Comerton-Forde et al. (2007), this improvement was more pervasive in the more liquid stocks. The authors also found that the opening call auction improved the relative volume traded at the start of the day for the IPO without a significant change in the volume. The authors further observed that a reduced order aggressiveness on part of the traders near the closing time of the market resulted in a reduced manipulation level. Kang and Lee (2007) suggested that an increase in transparency in the pre-opening session improved price discovery. Lee (2008) concluded that the volume shifted from normal to closing auction, and the most liquid stocks traded most actively in the auction period. Lee (2008) also observed an improvement in the price discovery process.

Madhavan and Panchapagesan (2000) stated that there was large informational gain from observing the limit order book prior to the opening that lead to more efficient prices than a pure auction market using only public

orders. They stated that this happens as the dissemination of indicated prices allows relatively uninformed traders to place an appropriate order. Also, Chan et al. (2011) concluded that the pre - opening session enhanced the market quality under a fully automated 30 order-driven system. On similar lines, Hinterleitner et al. (2012) concluded that opening call auction increased the informational efficiency of opening prices and the market quality of the continuous double auction market.

Moshirian et al. (2002) stated that the information released before and during the pre-opening period was more quickly incorporated into the stock prices upon the commencement of trading, and this improved the price discovery process. Cao et al. (2000) concluded that the non-binding quotations of market makers uncovered different types of signals. The authors also established that there was a price leadership among the market makers. Brusco et al. (2003) suggested that rational expectation equilibrium existed with the active participation of the informed and uninformed traders, and traders selected the strategies based on the information in hand.

Dia and Pouget (2005) suggested that when there is a high cost of participation, the markets displayed a positive autocorrelation in the activity between the pre - opening period and the associated trading session. Dia and Pouget (2005) also stated that the pre - opening period leads to welfare improvements as the market organizers may provide information regarding the liquidity needs and asset valuation in the pre - opening session. The work of Snell and Tonks (2003) confirmed that the auction market was preferred over the dealer market, since the auction market yielded lower trading costs because of the ability to submit price contingent demands.

Camilleri and Green (2009) concluded that volatility, efficiency, and liquidity on the NSE improved after the suspension of the call auction market. The closing auctions helped to establish more efficient prices and reduced the overnight volatility, and the higher liquidity stocks benefited more from the call auction market. Agarwalla et al. (2013) stated that the Indian call auction market attracted insignificant volume, while it led to delay and a price reversal in the continuous market from the price discovered in the call auction market. On the other hand, the authors also concluded that market quality in terms of price synchronicity improved after the introduction of call auction market at the time of opening and closing of the market.

Chang et al. (2008) concluded that call money market (CMM) significantly reduced the volatility. Pagano et al. (2008) suggested that the introduction of opening and closing Nasdaq call auctions significantly reduced volatility and improved efficiency in price discovery. Reboredo (2012) suggested that the decrease in volatility following volatility auctions was greater than following the reference events, and the trading volume and the number of transactions was smoother around auctions than around reference events. Additionally, Hagströmer and Nordén (2014) stated that closing call auction reduced end of the day volatility and improved the price discovery mechanism while increasing the trader patience, and so, the liquidity also improved.

Schwert (1989) concluded that when stock prices fell relative to bond prices, then the stock volatility increased. The paper observed that volatility was higher in emerging markets and there was no evidence of effect of market liberalization on the stock return volatility. Harvey (1995) stated that variation in volatility across the emerging markets was more dependent on the asset and sector concentration. Batra (2004) stated that the shifts in volatility were more on account of the announcement effect of major economic policy shifts and reforms. Kaur (2004) concluded that the volatility spillover between the U.S. and the Indian markets exhibited a positive correlation but only in the 1999-2003 sub-period and not during 1993-1999. Hence, Kaur (2004) reported on the existence of market level sympathy between the U.S. and the Indian markets. Tian and Guo (2007) concluded that both auction and continuous trading had a much higher inter-day volatility, which was mainly due to both - the overnight trading halt and the accumulated information. Furthermore, it showed that Chinese insiders and manipulators intended to manipulate market prices by placing and withdrawing their orders during the call auction session and when the market opened.

**(4) Contribution of the Present Paper to Existing Literature :** Most of the research studies on call auction have been confined to the developed nations. The above review of literature reveals that the studies based on the call

auction market in the developing markets are very few. Introduction of the pre-open auction market in India is a rather new development. Not many studies have covered the impact of the pre-open auction market in India. The study focuses on the Indian stock market, which is highly under-researched in terms of the pre-open auction market and its impact on returns or risks. Secondly, most of the existing literature has studied the impact of call auction markets on either returns or risks. In order to have an applicable understanding, it is important to include both the aspects in the study. Hence, the present paper studies the impact of the call auction market on returns as well as risks, and through these, on price efficiency in India. Therefore, the paper is highly relevant for the players in the stock market as well as for the stock market regulators.

## Objectives of the Study

The present paper attempts to analyze whether opening call auction has been able to reduce the volatility and improve the efficiency of price discovery in NSE. The paper also explores if the opening call auction plays any role in improving investors' returns from NSE. The study aims at achieving the following research objectives:

**(1)** To establish if introduction of the pre-open auction market in India has led to higher returns to the investors;

**(2)** To observe if introduction of the pre-open auction market in India has helped to reduce the stock market volatility in India; and

**(3)** To find out whether introduction of the pre-open auction market in India has helped to improve the efficiency of price discovery.

## Research Design

The study is performed on one benchmark index and 10 companies. In the benchmark index, the paper uses NSE's Nifty. The total number of companies included in the Nifty index is 50. It is broadly established that in order to gain an understanding of an index, around one-fifth of the index companies should be studied. Therefore, the paper uses a sample of 10 companies in addition to the benchmark index. These 10 companies were selected randomly from the companies indexed in NSE's Nifty. The randomly selected companies include Infosys, Reliance, TCS, ONGC, HUL, HDFC Bank, ITC, Sun Pharma, Tata Motors, and Wipro. The paper used closing prices for the period of 3 years before and 3 years after the introduction of the call auction market in 2010, that is, from October 18, 2007 to October 18, 2013. The period from October 18, 2007 to October 17, 2010 is termed as the pre-introduction period, while the period from October 18, 2010 to October 18, 2013 is termed as the post-introduction period for the purpose of the paper. In order to facilitate an easy comparison at the level of the readers, this classification remains intact under the analysis section of the paper.

The paper defines the return as dlog return, which may be put as :

$$return = dlog(cmp)$$

where,
*cmp* stands for current market price.

The study computed descriptive statistics with regard to the return, to begin with. Descriptive statistics including mean, standard deviation, skewness and kurtosis, and Jarque Bera were computed first. The descriptive statistics were followed-up by One-way analysis of variance (ANOVA). One-way Anova is the statistical technique used to compare means of two or more samples. This technique can be used only for numerical data as suggested by

Howell (2002). The ANOVA tests the null hypothesis that samples in two or more groups are drawn from populations with the same mean values. The ANOVA produces an F-statistic, the ratio of the variance calculated among the means to the variance within the samples. If the group means are same, then the variance between the group means should be lower than the variance of the samples. Furthermore, a higher ratio implies that the samples were drawn from populations with different mean values.

The paper moves on to apply the econometric methodology. The analysis of econometrics can be performed on a series of stationary nature. The study performs the augmented Dickey-Fuller unit-root test in order to confirm whether or not the series are stationary. For the basic understanding of the unit root testing, the following equation can be referred to :

$$y_t = \rho y_{t-1} + x_t'\delta + \varepsilon_t ,$$

where,
$x_t$ are optional exogenous repressors which may consist of constant, or a constant and trend, ρ and δ are parameters to be estimated, and $\varepsilon_t$ is assumed to be white noise. If $|\rho| \geq 1$, $y$ is a non stationary series and the variance of $y$ increases with time and approaches infinity. If $|\rho| \leq 1$, $y$ is a stationary series. Thus, we evaluate the hypothesis of stationarity by testing whether the absolute value of $|\rho|$ is strictly less than one.

The standard Dickey-Fuller test was carried out by estimating the following equation after subtracting $y_{t-1}$ from both the sides of the equation :

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \varepsilon_t ,$$

where, $\alpha = \rho - 1$. The null and alternate hypothesis may be written as :

$H_0 : \alpha = 0$
$H_1 : \alpha < 0$

If the probability value of the unit-root test is less than the 0.05 level of significance, then the null hypothesis is rejected, implying that the return series is stationary.
To check for the presence of ARCH effect in the return series, the heteroskedasticity test is also performed on the

**Table 1. Descriptive Statistics for Sample Companies**

| Company | Mean | | St. Deviation | | Skewness | | Kurtosis | | Jarque-Bera Probability | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-Phase | Post-Phase | Pre-Phase | Post-Phase | Pre-Phase | Post-Phase | Pre-Phase | Post-Phase | Pre-Phase | Post-Phase |
| **HDFC Bank** | -0.00073 | 0.001687 | 0.027204 | 0.060918 | -0.26914 | 24.37021 | 5.884552 | 642.2281 | 0.000 | 0.000 |
| **HUL** | -0.00047 | -0.00095 | 0.021221 | 0.01644 | 0.176958 | -1.72919 | 4.686801 | 16.69255 | 0.000 | 0.000 |
| **Infosys** | 0.000708 | 0.000148 | 0.024288 | 0.01967 | 0.099114 | -2.3164 | 5.851792 | 41.03122 | 0.000 | 0.000 |
| **ITC** | 0.001863 | 0.000997 | 0.033235 | 0.014858 | 10.91007 | -0.05806 | 224.0045 | 5.084628 | 0.000 | 0.000 |
| **Nifty** | 0.000169 | -0.0000066 | 0.021648 | 0.011548 | 0.146563 | 0.025454 | 9.765293 | 3.676794 | 0.000 | 0.000 |
| **ONGC** | 0.000651 | 0.000753 | 0.027072 | 0.029031 | -0.05811 | 13.59304 | 8.069196 | 297.5293 | 0.000 | 0.000 |
| **Reliance** | 0.000656 | -0.00015 | 0.038286 | 0.017682 | 6.321223 | 0.015566 | 114.9802 | 3.756227 | 0.000 | 0.000 |
| **Sun Pharma** | -0.00097 | 0.001568 | 0.024709 | 0.065884 | -0.30817 | 20.88474 | 11.61916 | 490.5243 | 0.000 | 0.000 |
| **Tata Motors** | -0.00051 | 0.001499 | 0.036413 | 0.065487 | 0.157352 | 21.44094 | 6.451383 | 541.808 | 0.000 | 0.000 |
| **TCS** | 0.001623 | 0.001047 | 0.038266 | 0.017133 | 8.278858 | 0.313167 | 155.852 | 6.913373 | 0.000 | 0.000 |
| **Wipro** | 0.0000057 | -0.00011 | 0.034175 | 0.017883 | 4.289111 | 0.816414 | 65.62522 | 8.186775 | 0.000 | 0.000 |

**Table 2. Augmented Dickey-Fuller Unit- Root Test**

| Company | Null Hypothesis | *p* - value | Decision | Implication |
|---|---|---|---|---|
| **HDFC Bank** | Return has a unit-root | 0.0000 | Null is rejected | Series is stationary |
| **HUL** | Return has a unit-root | 0.0000 | Null is rejected | Series is stationary |
| **Infosys** | Return has a unit-root | 0.0000 | Null is rejected | Series is stationary |
| **ITC** | Return has a unit-root | 0.0000 | Null is rejected | Series is stationary |
| **Nifty** | Return has a unit-root | 0.0000 | Null is rejected | Series is stationary |
| **ONGC** | Return has a unit-root | 0.0000 | Null is rejected | Series is stationary |
| **Reliance** | Return has a unit-root | 0.0000 | Null is rejected | Series is stationary |
| **Sun Pharma** | Return has a unit-root | 0.0000 | Null is rejected | Series is stationary |
| **Tata Motors** | Return has a unit-root | 0.0000 | Null is rejected | Series is stationary |
| **TCS** | Return has a unit-root | 0.0000 | Null is rejected | Series is stationary |
| **Wipro** | Return has a unit-root | 0.0000 | Null is rejected | Series is stationary |

residuals of log return series with 1 day lag. The null hypothesis, that is, "There is no ARCH effect on the residuals of log return series" is tested through the analysis.

The paper further attempts to arrive at the conditional variance equation. The general model of the ARCH *(q)* process is as follows (Engle, 1982):

$$\sigma_t^2 = \alpha_0 + \sum_{t=1}^{q} \alpha_i \in^2_{t-1}$$

where,

$\alpha_0$ is mean, $\sigma_t^2$ is conditional volatility, and $\varepsilon_t$ is white noise representing the residuals of the time series.

Bollerslev (1986) introduced the GARCH model, which has lagged squared residuals and lagged variances. The general model of GARCH *(p, q)* process is as follows (Bollerslev, 1986):

$$\sigma_t^2 = \alpha_0 + \sum_{t=1}^{q} \alpha_i \in^2_{t-1} + \sum_{j=1}^{p} \beta_i \sigma^2_{t-j}$$

where,

$i = 0, 1, 2, \ldots, p$, $\sigma_t^2$ is conditional volatility, $\varepsilon_t$ residuals and $\sigma^2_{t-j}$ is lagged conditional volatility that is the difference of GARCH from the ARCH. Then, $\alpha_i$ and $\in^2_{t-j}$ are known as ARCH components, $\beta_j$ and $\sigma^2_{t-j}$ are known as GARCH components and $\alpha_0$, $\alpha_i$ ,and $\beta_i$ are positive.

## Empirical Analysis and Results

The paper starts by computing the basic statistics for the 10 companies and the CNX Nifty index to get an insight into the data. Dlog of the series under reference are taken for the analysis under the study. The Table 1 presents the descriptive statistics of the return series of the reference stocks and the CNX Nifty index.

The Table 1 shows the average daily returns in the pre-introduction and the post-introduction phase. In the pre-phase, the average daily returns of ITC, TCS, Infosys, Reliance Industries Limited, ONGC, Nifty, Wipro, HUL, Tata Motors, HDFC Bank, and Sun Pharma are found to be 0.1863%, 0.1623%, 0.0708%, 0.0656%, 0.0651%, 0.0169%, 0.00057% , -0.047%, -0.051%, -0.073% and -0.097%, respectively. In the post-phase, the average daily returns of HDFC Bank, Sun Pharma, Tata Motors, TCS, ITC, ONGC, Infosys, Nifty, Wipro, Reliance Industries Limited, and HUL are 0.1687%, 0.1568%, 0.1499%, 0.1047%, 0.0997%, 0.0753%, 0.0148%, -0.000663%,

**Table 3. One-Way ANOVA**

| Company | Sum of squares | *df* | Mean square | *F* | Significance |
|---|---|---|---|---|---|
| **HDFC Bank** | .002 | 1 | .002 | .975 | .324 |
| **HUL** | .000 | 1 | .000 | .235 | .628 |
| **Infosys** | .000 | 1 | .000 | .234 | .629 |
| **ITC** | .000 | 1 | .000 | .443 | .506 |
| **Nifty** | .000 | 1 | .000 | .037 | .847 |
| **ONGC** | .000 | 1 | .000 | .007 | .931 |
| **Reliance** | .000 | 1 | .000 | .276 | .600 |
| **Sun Pharma** | .002 | 1 | .002 | .962 | .327 |
| **Tata Motors** | .002 | 1 | .002 | .535 | .465 |
| **TCS** | .000 | 1 | .000 | .126 | .722 |
| **Wipro** | .000 | 1 | .000 | .013 | .908 |

**Table 4. Hetroscedacticity Tests & ML-ARCH Model During the Pre-Introduction Phase**

| Companies | Hetroskedacticity Tests | | ML-ARCH Model | | | |
|---|---|---|---|---|---|---|
| | *F*-Statistic Probability | Chi-Square Probability | Residual Value | Residual Probablity | GARCH Value | GARCH Probablity |
| **HDFC Bank** | 0.0103 | 0.0103 | 0.054637 | 0.0000 | 0.940946 | 0.0000 |
| **HUL** | 0.0000 | 0.0000 | 0.239168 | 0.0000 | 0.597254 | 0.0000 |
| **Infosys** | 0.0000 | 0.0000 | 0.098925 | 0.0000 | 0.88633 | 0.0000 |
| **ITC** | 1.0000 | 1.0000 | - | - | - | - |
| **NIFTY** | 0.0000 | 0.0000 | 0.135633 | 0.0000 | 0.872447 | 0.0000 |
| **ONGC** | 0.0023 | 0.0024 | 0.105822 | 0.0000 | 0.882019 | 0.0000 |
| **Reliance** | 1.0000 | 1.0000 | - | - | - | - |
| **Sun Pharma** | 0.0000 | 0.0000 | 0.473574 | 0.0000 | 0.284103 | 0.0000 |
| **Tata Motors** | 0.0000 | 0.0000 | 0.088532 | 0.0000 | 0.893619 | 0.0000 |
| **TCS** | 1.0000 | 1.0000 | - | - | - | - |
| **Wipro** | 1.0000 | 1.0000 | - | - | - | - |

-0.011%, -0.015%, and -0.095%, respectively. Clearly, a sharp change in the average stock returns is witnessed with that of the HDFC Bank followed by Sun Pharma and Tata Motors, while the CNX Nifty index declines drastically and the stock HUL continues to decline even in the post phase. Stocks namely HDFC Bank, Sun Pharma, and Tata Motors give returns at the lowest level in the pre-phase, but in the post-phase, they become the stocks with the highest average returns.

The standard deviation in the pre-phase of Reliance is the highest with 0.038286, which shows the highest risk in this stock, but in the post-phase, it reduces down to 0.017682. Also, the standard deviation in the other stocks namely, HUL (0.021221), TCS (0.038266), ITC (0.033235), Wipro (0.034175), Infosys (0.024288) as well as the CNX Nifty (0.021648) index reduces drastically in the post-phase to 0.01644, 0.017133, 0.014858, 0.017883, 0.01967, and 0.011548, respectively.

In the pre-phase, stocks including HDFC Bank, ONGC, and Sun Pharma have negative skewness implying that the distribution has a long left tail. While, ITC, Reliance, TCS, and Wipro have a very high positive skewness, implying that their distribution has a long right tail. In the post-phase, the skewness has shifted from positive to negative as in case of HUL, Infosys, and ITC. In both the post and the pre phase, all these 11 series are leptokurtic

**Table 5. Hetroscedacticity Tests & ML-ARCH Model During the Post-Introduction Phase**

| Companies | Hetroskedacticity Tests | | ML-ARCH Model | | | |
|---|---|---|---|---|---|---|
| | *F*-Statistic Probability | Chi-Square Probability | Residual Value | Residual Probablity | GARCH Value | GARCH Probablity |
| **HDFC Bank** | 1.0000 | 1.0000 | - | - | - | - |
| **Hindustan Unilever Limited** | 0.0004 | 0.0005 | 0.455783 | 0.0000 | 0.031148 | 0.0000 |
| **Infosys** | 0.9899 | 0.9898 | - | - | - | - |
| **ITC** | 0.0022 | 0.0023 | 0.11831 | 0.0000 | 0.661038 | 0.0000 |
| **NIFTY** | 0.0050 | 0.0060 | 0.043601 | 0.0006 | 0.95177 | 0.0000 |
| **ONGC** | 1.0000 | 1.0000 | - | - | - | - |
| **Reliance** | 0.0000 | 0.0001 | 0.066744 | 0.0001 | 0.902081 | 0.0000 |
| **Sun Pharma** | 1.0000 | 1.0000 | - | - | - | - |
| **Tata Motors** | 1.0000 | 1.0000 | - | - | - | - |
| **TCS** | 0.0248 | 0.0251 | 0.147214 | 0.0000 | 0.759813 | 0.0000 |
| **Wipro** | 0.0995 | 0.0996 | - | - | - | - |

in nature as the kurtosis statistic for all the 10 stocks and the CNX Nifty index happens to be more than 3, while the kurtosis of normal distribution is 3. The Jarque - Bera probability value 0.00000 for all the 10 stocks and the index indicates that the null hypothesis (i.e. the series under reference is normal) is rejected, which means that the series are not normal. The return series are commonly found to be non-normal since they are leptokurtic in nature.

In order to check the stationarity of the series, the augmented Dickey-Fuller (ADF) test was applied on the dlog of the return series. The results in the Table 2 show that the probability value of the test for all the return series is less than 0.05 (level of significance), which indicates that the null hypothesis (i.e. the series under reference is not stationary) is rejected, and the return series of all the 10 stocks and the index are stationary in nature.

The Table 3 presents the results of one-way ANOVA, employed in order to observe if the returns in the pre-introduction period for a company are significantly different than those in the post-introduction phase of a company. If the significance value, as reported in the Table 3, is less than 0.05, the null hypothesis is rejected, which implies that the returns across the post and the pre - periods are significantly different. While from the findings, it is clear that (in) all the 10 stocks under study and the index present a high Sig. value, which is more than the 0.05 level. Hence, the returns from the 10 stocks and the index have not been different, even after the introduction of the pre-open market.

The paper further moves on to determine the existence of the ARCH effect in the return series, and for this purpose, the heteroscedasticity test is applied on the residuals of log return series with 1 day lag. ARCH type tests are applied firstly for the pre-introduction period and later for the post-introduction period. To check for the existence of the Arch effect, the probability of the *F*-statistic and the chi - square is examined. If any of these two probabilities is found to be less than 0.05, the null hypothesis (i.e. there is no ARCH effect on the residuals of log returns series) is rejected, implying that Arch exists.

The Table 4 reports the results with respect to ARCH in the pre-introduction period. From the Table 4, it is inferred that the probability of the *F*- statistic and the chi square is less than 0.05 in case of HDFC Bank, HUL, Infosys, ONGC, Sun Pharma, Tata Motors, and Nifty index, which indicates the presence of ARCH in these companies. Hence, we proceed further with the checking for the appropriate model of ARCH/ GARCH. On the other hand, in other stocks, including ITC, Reliance, TCS, and Wipro, the probability of *F*- statistic and chi square is more than 0.05, and hence, the null hypothesis of no ARCH is accepted. Therefore, no further tests are carried out to check the models in these stocks.

To further check for the most appropriate model of ARCH/ GARCH, the values of Akaike information criterion (AIC) and Schwarz information criterion (SIC) are examined, and the model in which these two values come out to be the lowest, is chosen. ARCH and GARCH (1, 1) models report the lowest AIC and SIC values, and are therefore, used to forecast volatility for this study. The values are also reported in the Table 4 in the ML-ARCH columns.

In the pre-introduction phase, in HDFC Bank, the value of RESID $(-1)^2$, 0.054637 is smaller in magnitude, and the GARCH (-1) value, 0.940946, is large enough in magnitude, implying that volatility is highly affected by the pre-open market. There exists a high percentage of volatility, while a lower residual value implies that a very small percentage of volatility is affected by the extraneous factors (other than the pre-open call auction market). In HUL, the value of RESID $(-1)^2$, 0.239168, is smaller in magnitude, and the GARCH (-1) value, 0.597254, is large enough, again implying that a high degree of volatility is highly affected by the introduction of the pre-open market. In case of Infosys, Nifty, ONGC, and Tata Motors, the values of RESID $(-1)^2$ are 0.098925, 0.135633, 0.105822, and 0.088532, while the GARCH (-1) values are 0.88633, 0.872447, 0.882019, and 0.893619, respectively. It shows that the GARCH values are higher in magnitude, implying that the pre-open market has highly affected the volatility in these stocks. While in case of Sun Pharma, the GARCH (-1) value, that is, 0.284103 implies that it is less affected by the pre-open market and more by the other extraneous factors.

The Table 5 reveals that in the post-introduction phase, in HDFC Bank, Infosys, ONGC, Sun Pharma, Tata Motors, and Wipro, the probability of the *F* - statistic and chi - square are more than 0.05, and hence, the null hypothesis is accepted, implying that ARCH does not exist. Therefore, further tests are not carried out in these cases.

The combined value of both the RESID $(-1)^2$ and GARCH (-1) imply the degree of volatility, that is, higher the combined value, the higher is the degree of volatility. In HUL, GARCH (-1) value, 0.031148 carries a low level of volatility. In ITC, the GARCH (-1) value, 0.661038 and RESID $(-1)^2$ value, 0.11831, imply that the volatility has increased after the introduction of the pre-open market. Also, is case of HDFC Bank, Reliance, and TCS, the volatility increased to 0.99, 0.97, and 0.89, respectively. While in case of Nifty, Reliance, and TCS, the GARCH (-1) values are : 0.95177, 0.902081, and 0.759813, respectively, implying the effect of the pre-open market on volatility. This further proves that the introduction of the pre-open market has highly affected the volatility in the market. The highest reduction in volatility has been observed in case of ONGC followed by Tata Motors, Infosys, Sun Pharma, and HUL.

## Discussion and Conclusion

This paper discusses the impact of introduction of the pre-open call auction market introduced on October 18, 2010 on the continuous market. The main purpose behind this introduction was to improve the efficiency of price discovery, reduce the price volatility, and ultimately increase the returns to the investors. Other targeted advantages included greater liquidity, minimized impact cost, and a much fairer market.

The major reason behind this study is the limitation that most of the research studies on the pre-open call auction market are confined to the developed nations, and particularly, very few research papers have examined the Indian stock exchange in this context. Additionally, since the introduction of the pre-open auction market in India, very few studies have covered its impact on returns and risks, and for that matter, on price discovery.

The paper examines if the introduction of the pre-open market has led to increased returns and decreased volatility in the Indian markets, and ultimately, attempts to find out if it has improved the efficiency of price discovery.

The tools and the methodology employed in this paper are descriptive statistics, namely skewness and kurtosis, the Jarque - Bera test, followed by one-way ANOVA, unit root test (ADF), and ARCH-GARCH type models. In all the return series, excess kurtosis and skewness is observed, which ultimately leads to a higher

Jaurque - Bera value, which indicates that the distribution is not normal. This is also because all the 11 series are leptokurtic in nature as the kurtosis statistic for all is more than 3 (i.e., the kurtosis of normal distribution). Also, the probability value of the Jarque - Bera test is 0.00000, which further proves that the series is not normal. Furthermore, the augmented Dickey-Fuller test was carried out to confirm that the log return series under consideration are stationary. One way - ANOVA was carried out, which shows that the returns in all the stocks under reference and the CNX Nifty index is not significantly different in the pre and the post phase periods. Hence, the null hypothesis ($H_0$), that is, returns of the period before introduction of the pre-open auction market are not significantly different than the returns of the period after introduction of the pre-open auction market is accepted.

Finally, with the help of the Akaike information criterion (AIC) and the Schwarz information criterion (SIC), the two best fitted models are chosen namely, ARCH and GARCH (1, 1). The heteroscedasticity test is applied on the log return series to further check for the existence of Arch, and where the probability values of F statistic and chi square are less than 0.05, further tests were applied. On employing the GARCH model, a vast reduction in the volatility has been witnessed in all the stocks except for HDFC Bank, ITC, Reliance, and TCS, which implies that the introduction of the pre-open market has brought about a reduction in the stock market volatility. Hence, the null hypothesis ($H_0$), that is, volatility of the period before introduction of the pre-open auction market is not significantly different than the volatility of the period after introduction of the pre-open auction market is *rejected*, *as the volatility has reduced after the introduction of the pre-open market.*

## Research Implications, Limitations of the Study, and Scope for Further Research

With no difference in the returns from the reference stocks and the CNX Nifty index, and with the reduction in the volatility of the stocks as well as the index, we can infer that there has also been an improvement in the efficiency of price discovery of the various stocks. Additionally, an improvement in the price discovery and reduction in the volatility also leads to more participation on the part of investors and increases liquidity in the market. The findings of this paper are in agreement with the findings of Agarwalla et al. (2013), who investigated the impact of the re-introduction of the opening call auction market by NSE, and concluded that the market quality in terms of price synchronicity improved after the re- introduction of the call auction market. On the other hand, the findings of Camilleri and Green (2009) stated that volatility, efficiency, and liquidity improved after the suspension of the call auction market, a result which is completely contradictory to the findings of this paper.

The following are the limitations of the study : (a) the paper focuses on the empirical analysis of the Indian stock markets. Therefore, the findings of the paper may not be generalized to the stock markets of other countries ; (b) the study performs the analysis on 10 Nifty companies. The results may not be replicated to mid-cap and small-cap companies ; (c) the period of the study ranges from 2007 to 2013. Therefore, the study does not take into account the changes in financial markets taking place after 2013.

The findings of the study are important for stock market regulators across the globe, since they may like to use the pre-open auction market as a tool to control volatility in the markets. On the other hand, these findings also serve as a valuable input for the investors. Risk-averse investors may like to invest in the markets that do not have an active pre-open auction market, and vice-versa. Further research activities may be undertaken to comparatively explore the improvement in price discovery across various sectors after the introduction of the pre-open auction market.

## References


Agarwalla, S. K., Jacob, J., & Pandey, A. (2013). *Impact of the introduction of call auction on price discovery: Evidence from the Indian stock market using high-frequency data* (IIM Ahmedabad Working Paper). Ahmedabad : Indian Institute of Management Ahmedabad.

Aitken, M., Comerton- Forde, C., & Frino, A. (2005). Closing call auctions and liquidity. *Accounting & Finance, 45* (4), 501-518.

Batra, A. (2004). *Stock return volatility patterns in India* (Working Paper No. 124). New Delhi : Indian Council for Research on International Economic Relations.

Bollerslev, T. (1986). Generalized autoregressive conditional heteroscedasticity. *Journal of Econometrics, 31* (3), 307 - 327.

Brusco, S., Manzano, C., & Tapia, M. (2003). *Price discovery in the pre-opening period: Theory and evidence from the Madrid stock exchange* (Working Paper 03-58). Madrid : Universidad Carlos III de Madrid.

Camilleri, S. J., & Green, C. J. (2009). The impact of the suspension of opening and closing call auctions: Evidence from the National Stock Exchange of India. *International Journal of Banking, Accounting and Finance, 1* (3), 257-284.

Cao, C., Ghysels, E., & Hatheway, F. (2000). Price discovery without trading: Evidence from the Nasdaq preopening. *The Journal of Finance, 55* (3), 1339-1365.

Chan, K. N., Aitken, M. J., & Lepone, A. (2011). *The impact of closing call auction on liquidity and price discovery process: An analysis on the stock exchange of Hong Kong*. DOI : http://dx.doi.org/10.2139/ssrn.1908626

Chang, R. P., Rhee, S. G., Stone, G. R., & Tang, N. (2008). How does the call market method affect price efficiency? Evidence from the Singapore Stock Market. *Journal of Banking & Finance, 32* (10), 2205-2219. doi:10.1016/j.jbankfin.2007.12.036

Comerton-Forde, C., Ting Lau, S., & McInish, T. (2007). Opening and closing behavior following the introduction of call auctions in Singapore. *Pacific-Basin Finance Journal, 15*(1), 18-35. doi:10.1016/j.pacfin.2006.04.002

Dia, M., & Pouget, S. (2005). *Liquidity formation and preopening periods in financial markets* (Unpublished Working Paper). France : University of Toulouse.

Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica, 50* (4), 987 - 1007.

Hagströmer, B., & Nordén, L. (2014). Closing call auctions at the index futures market. *Journal of Futures Markets, 34* (4), 299-319. DOI: 10.1002/fut.21603

Harvey, C. R. (1995). The cross-section of volatility and autocorrelation in emerging markets. *Finanzmarkt und Portfolio Management, 9* (1), 12-34.

Hinterleitner, G., Hornung, P., Leopold-Wildburger, U., Mestel, R., & Palan, S. (2012). *A good beginning makes a good market: The effect of different market opening structures on market quality* (No. 2012-01). Faculty of Social and Economic Sciences, Karl-Franzens-University Graz. Retrieved from http://static.uni-graz.at/fileadmin/sowi/Working_Paper/2012-01_Hinterleitner_Hornung_Leopold-Wildburger_Mestel_Palan.pdf

Howell, D. (2002). *Statistical methods for psychology.* Duxbury : Wadsworth Cengage Learning.

Kang, J., & Lee, D. (2007). The effects of a transparency change in the preopening session on price discovery. *Proceedings of KSA, Korean Securities Association*, Korea.

Kaur, H. (2004). Time varying volatility in the Indian stock market. *Vikalpa: The Journal for Decision Makers, 29* (4), 25-42.

Kelly, R. J. (2008). Opening and closing asymmetry: Empirical analysis from ISE Xetra. *Economic & Social Review, 39* (1), 55-78.

Lee, H. W. (2008). Implementation of pre-opening session and market quality: An empirical study on the Hong Kong Stock Market. *International Journal of Finance, 20* (3), 4884-4909.

Madhavan, A., & Panchapagesan, V. (2000). Price discovery in auction markets: A look inside the black box. *Review of Financial Studies, 13* (3), 627-658. doi: 10.1093/rfs/13.3.627

Moshirian, F., Nguyen, H. G. L., & Pham, P. K. (2012). Overnight public information, order placement, and price discovery during the pre-opening period. *Journal of Banking & Finance, 36* (10), 2837-2851. doi:10.1016/j.jbankfin.2012.06.012

Ozenbas, D. (2011). Intra-day trading volume patterns of equity markets: A study of US and European stock markets. *International Business & Economics Research Journal, 7* (8), 79-94.

Pagano, M. S., & Schwartz, R. A. (2003). A closing call's impact on market quality at Euronext Paris. *Journal of Financial Economics, 68* (3), 439-484. DOI: 10.1016/S0304-405X(03)00073-4

Pagano, M. S., Peng, L., & Schwartz, R. A. (2008). *Market structure and price formation at market openings and closings: Evidence from Nasdaq's calls* (Unpublished Working Paper, 31). Retrieved from http://www90.homepage.villanova.edu/michael.pagano/LP%20Nasdaq%20Cross%20Feb%206.pdf

Reboredo, J. C. (2012). The switch from continuous to call auction trading in response to a large intraday price movement. *Applied Economics, 44* (8), 945-967. DOI:10.1080/00036846.2010.526584

Schwert, G. W. (1989). Why does stock market volatility change over time? *The Journal of Finance, 44* (5), 1115-1153. DOI: 10.1111/j.1540-6261.1989.tb02647.x

Sharma, G. D., & Bodla, B. S. (2011). Inter-linkages among stock markets of South Asia. *Asia-Pacific Journal of Business Administration, 3* (2), 132-148. DOI : http://dx.doi.org/10.1108/17574321111169821

Sharma, G. D., Mahendru, M., & Singh, S. (2013). Are the stock exchanges of emerging economies inter-linked: Evidence from BRICS. *Indian Journal of Finance, 7* (1), 26-37.

Snell, A., & Tonks, I. (2003). A theoretical analysis of institutional investors' trading costs in auction and dealer markets. *The Economic Journal, 113* (489), 576-597. DOI: 10.1111/1468-0297.t01-1-00146

Tian, G. G., & Guo, M. (2007). Interday and intraday volatility: Additional evidence from the Shanghai Stock Exchange. *Review of Quantitative Finance and Accounting, 28* (3), 287-306. DOI : 10.1007/s11156-006-0011-x