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Susan Thomas

Indira Gandhi Institute of Development Research, Mumbai
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Susan Thomas
Indira Gandhi Institute of Development Research (IGIDR)
General Arun Kumar Vaidya Marg
Goregaon (E), Mumbai- 400065, INDIA
Email (corresponding author): susant@igidr.ac.in

Abstract

The Indian financial system has been revolutionised by the application of a new market design: continuous trading with an anonymous limit order book at NSE and BSE. However, in certain situations, this market design has limitations. Call auctions represent an alternative strategy, where the order flow over a certain time period is pooled, and the market-clearing price obtained through an aggregated supply and demand curve. Call auctions trade off instantaneity of order execution in favour of elimination of impact cost, and can achieve a more trusted price. They can improve the functioning of the market on issues such as market opening, market close, extreme news events, and potentially for illiquid securities including bonds. Call auctions could usefully replace some existing market rules such as `circuit breakers\'. At the same time, there are many subtle elements in making a call auction market work, which require care in market design.

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Susan Thomas[*]
Indira Gandhi Institute of Development Research

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The Indian financial system has been revolutionised by the application of a new market design: continuous trading with an anonymous limit order book at NSE and BSE. However, in certain situations, this market design has limitations. Call auctions represent an alternative strategy, where the order flow over a certain time period is pooled, and the market-clearing price obtained through an aggregated supply and demand curve. Call auctions trade off instantaneity of order execution in favour of elimination of impact cost, and can achieve a more trusted price. They can improve the functioning of the market on issues such as market opening, market close, extreme news events, and potentially for illiquid securities including bonds. Call auctions could usefully replace some existing market rules such as 'circuit breakers'. At the same time, there are many subtle elements in making a call auction market work, which require care in market design.

[*]Email susant@igidr.ac.in, URL http://www.igidr.ac.in/~susant The views expressed in this paper belong to the author and not her employer. I am grateful to NSE for the data used in this paper and to the IGIDR Finance Research Group for research assistance.

Contents

1 Introduction

When exchanges in India shifted from open outcry to the anonymous electronic limit order book, a tremendous improvement in financial market outcomes was obtained. Price discovery became more efficient. Market volatility showed less persistence and liquidity became more resilient, even when faced with large news events. However, these improvements have not been symmetric across all securities and across all times. Many financial products are illiquid on the order book market, including in the equity spot market, several derivatives series and most bonds. Even for liquid stocks where continuous trading generally works well, good liquidity and low volatility are not consistent throughout the trading day.

The call auction is an alternative to continuous trading with an anonymous limit order book, which keeps the anonymous limit order book, but dispenses with continuous order matching. In a call auction, orders arrive continuously into the auction order book but remains unexecuted till the end of the auction period when the orders get matched into trades. Until then however, the system displays a market clearing "provisional price", and allows for orders to be revised or removed.

Why are call auctions interesting? The first issue is the improved price efficiency obtained through temporal aggregation of the order flow. In a continuous market, the price is made by moment-to-moment fluctuations in the order flow. In the call auction, a large number of orders are put together to yield a single market clearing price.

The second issue is that of risk from the viewpoint of traders with large orders that tend to have high price impact in continuous markets. When a large order is placed on a call auction, there is no immediate execution. Instead, the auction displays a different provisional price and gives time for responses from the other side. In an auction, there is a certainty of having no impact cost or being vulnerable to front-running. Large orders tend to be absorbed better using call auctions.

One example of where the aggregation of orderflow in a call auction can deliver better market outcomes is the problem of the start of trading. There is potentially a large change in the price from the previous days close to the opening price of the morning. In India, this opening price discovery takes as much as 35 minutes. If, instead, a call auction were held for (say) 10 minutes, it could create a more efficient opening price, after which continuous trading could commence.

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 was the Paris Stock Exchange. The Taiwan Stock Exchange uses periodic call auctions to trade stocks. India stands out, as a country with big exchanges, where call auctions are *not* used.

There are four important potential areas where call auctions could be applied in India. The first is the problem of discovering an opening price, so as to impound overnight news into the price more efficiently than with the existing continuous market. The second is for a closing price: it would be useful to get a sharp and well-trusted price, and to give all traders a zero-impact-cost mechanism to closeout positions for the day. The third is as a primary trading mechanism for illiquid securities, where periodic call auction (say every hour) could work better than illiquid continuous trading. Finally, call auctions could replace the existing system of 'circuit breakers'. Instead of *halting* the market when large price changes take place, the continuous market could be replaced briefly with a call auction, which would discover a new price, after which continuous trading could recommence.

The key constraint of call auctions lies in the free rider problem. Every trader likes to see the provisional price of a call auction, but traders do not have an incentive to reveal their own information until the very end, when the call auction is about to end. A series of design ideas have been found, which attack this problem. In this paper, we discuss five of these design parameters. Who can participate in the call auction? For how long should the call auction be kept open? What order types should be supported? How should the auction price be computed? What is the optimal level of transparency which should be used? These questions are now relatively well understood, with both conceptual ideas and empirical experience to guide thinking in market design.

In summary, call auctions could be used to yield important improvements in the Indian securities market in seven ways:

1. Reducing principal-agent problems for institutional investors,
2. By giving investors a choice of achieving a zero impact cost trade,
3. By reducing transaction costs and execution risk in derivatives arbitrage,
4. By increasing the informativeness of the official opening and closing price,
5. By reducing bid-offer spreads in the continuous market when news has broken,
6. By offering a market design that is more suited to illiquid products, and
7. By offering an alternative to market closure when faced with extreme events.

This paper examines the role of call auctions for trading at exchanges. Section 2 defines a call auction in comparison to continuous markets. Section 3 studies examples of call auctions used in international markets and its impact. Section 4 examine similar situations in India and whether the call auction might have a role to improve current market outcomes. Section 5 sets the framework within which to understand the link between design a call auction and its objective. We then apply this to suggest what parameters of the call auction design needs emphasis when being used in the Indian context. Section 6 concludes.

2 Call auctions – an alternative to continuous order-matching

Organised financial trading at exchanges is usefully seen as a double-auction where both buyers and sellers simultaneously participate in an auction. The fundamental function of any trading mechanism is to collect buy and sell orders, work out a market clearing price, and execute trades at this price.

2.1 The continuous market

The dominant market design at exchanges today is the electronic limit order book market. This involves continuous order matching in response to every order that comes into the market, and results in continuous trading.

This is a 'multiple price auction', for different trades can take place simultaneously at different prices, when a market order 'walks up the book' matching against limit orders placed at different prices.

2.2 The call auction

A call auction is an alternative mechanism through which electronic trading can be organised. It involves two critical differences. *First*, instead of a continous matching of orders, there is a period of time in which orders are accepted but no trades take place. *Second*, it is a 'single price auction'. At the end of the call auction, all orders which can be matched are traded at a single price.

A provisional market clearing price is computed as the intersection of supply and demand curves during the period of the call auction. It is the single price at which the maximal number of securities can be traded, given the orders present in the book at that point in time. It is displayed in real time on the computer screen. After a certain time period, the call auction is ended, and all orders which can be matched at this single price are executed. Call auctions can run for different periods, starting from as short as a minute.

Once single-price matching has been done for an order book, there could be orders left in it that cannot be matched. These order could be the natural starting point for continuous order matching.

The market clearing price in the call auction price comes from a demand and supply schedule comprising the consolidation of orders over a short period of time. In contrast, in the continuous market, the market clearing price is at the intersection between a potentially small number of orders present on the screen at an instant in time.

Table 1 Call Auction: Order book at start

Price	Quantity	
	Sell	Buy
345	150	50,000
349	25,000	10,000
350	250	10,000
351		2,000
355	15,000	

Table 2 Call Auction: From Order book to Demand–Supply Schedule

Price	Quantity			
	Sell	Buy	Supply	Demand
345	150	50,000	150	72,000
349	25,000	10,000	25,150	22,000
350	250	10,000	25,400	12,000
351		2,000	25,400	2,000
355	15,000		40,400	0

2.3 An example

Suppose the auction order book for "Epicure, Ltd.", consisted of the limit orders shown in Table 1. These orders would imply the *demand–supply schedule* shown in Table 2. The market clearing price would be decided by finding the price at which the maximum quantity would be transacted or "cleared". This is shown in Table 3. The market clearing price works out to be 349, at which a quantity of 22,000 shares are traded.[1]

However, seeing the total order imbalance on the buy side, suppose a new order came into the market to "Sell 30,000@345". The "auction book" would shift to that in Table 4. In this table, there would be a new demand–supply schedule, which would lead to a new market price of Rs. 345 to clear the maximum quantity in the market. The "auction clearing price" would shift to Rs. 345. The "auction ticker" would thus show a new provisional price of

[1] It need not always be the case that there is a unique price that clears the market. Part of the design of the auction process is how such conflicts are resolved. For instance, one of the more popularly used solutions is to use that price which is closest to the last traded price (LTP), or the price that minimises the order imbalance. In the example shown here, these considerations do not arise, for the turnover-maximising price is unique.

Table 3 Call Auction: Finding the market clearing price

Price	Quantity				
	Sell	Buy	Supply	Demand	Cleared
345	150	50,000	150	72,000	150
349	**25,000**	10,000	**25,150**	**22,000**	**22,000**
350	250	10,000	25,400	12,000	12,000
351		2,000	25,400	2,000	2,000
355	15,000		40,400	0	0

Table 4 Call Auction: Finding the market clearing price with new orders

Price	Quantity				
	Sell	Buy	Supply	Demand	Cleared
345	**30,150**	**50,000**	**30,150**	**72,000**	**30,150**
349	25,000	10,000	55,150	22,000	22,000
350	250	10,000	55,400	12,000	12,000
351		2,000	55,400	2,000	2,000
355	15,000		70,400	0	0

"Rs. 345" when this new order came into the book.

At any point of time, if the auction ends, then all orders which can be matched at the prevailing provisional price are paired off (at the single provisional price), leaving an order book in which no orders are compatible with each other. As an example, if we start from conditions in Table 4, and if the auction ends, then all orders that can be matched at the single price of Rs.345 are matched.

2.4 Strengths of the call auction

1. **Greater liquidity through temporal aggregation** The 'temporal aggregation' of orders in the call auction, gives a relatively deep supply and demand curve. This foster better price discovery, in comparison with the relatively small number of orders from moment to moment determining prices in the continuous market.

2. **Reduced risk in the eyes of market participants** At every moment, there is uncertainty about the price in the continuous market. Traders

are concerned about placing limit orders, since these run the risk of being picked off by traders with better information. This is the risk of asymmetric information.

In a continuous market, when news breaks, it is efficient for many traders to draw back, remove limit orders, and wait and see what price is discovered by the market.

In a call auction, limit orders can be placed in a more secure environment, because no trades take place instantaneously. The trader can see the provisional price shown on the screen, and modify or cancel his order without fear of the risk of asymmetric information. When the order is matched, there is an assurance that all buyers and sellers walk away with one single price.

In both types of markets, limit orders faces the risk of non-execution if their prices are far away from the market price. However, the call auction is designed to give time to the trader to modify prices in an environment of a slower pace of price discovery compared to the pace of the continuous market.

3. **Reduced transactions costs** The continuous market imposes transactions costs: market orders pay *impact cost*. In contrast, if the order in a call auction is executed, the trade does not incur an impact cost. For traders who wish to avoid paying impact cost, on the limit order book market, the cost and complexity of 'working an order' – through limit order placement and multi-stage order revision – is avoided.

4. **Robustness to large orders** In a continuous market, a large order can "walk up the order book" and temporarily generate large price movements, potentially driving volatility in prices and of liquidity. In the call auction, large orders are part of the orderflow that determines the market clearing price. Therefore, call auctions are at least as robust to large orders compared to continuous markets.

5. **Easing agency problems** In the continuous market, when a customer places a large order with a broker, there is the danger of front-running. Since execution in the call auction is done at a single price, both the broker and the customer gets the execution at the single price announced after the call auction, the same as everyone else.

These features of call auctions make them an interesting alternative in situations when trading on the continuous market is daunting. While comparing the market outcomes of price immediacy and access to liquidity, these features mean the following differences between call auctions and continuous markets:

- **Immediacy of price.** Like the continuous market where a "traded price" is continuously disclosed, the call auction can also be designed to continuously disclose a provisional price at which the auction clears. Therefore, immediacy of prices can be generated in both markets.

  However, immediacy of *traded prices* in the call auction is lower than that in the continuous market. If the security is illiquid, with few trades during the trading day, there will effectively be little difference between the immediacy of disclosed and the trade price.

- **Price sensitivity to extreme values.** A new order will influence the market clearing price in both call and continuous markets.

  However, the "traded price" in call auction would be less sensitive to outliers compared to the continuous market price. A consequence of this is that intra-day volatility of traded prices from a continuous market would be higher than prices in a call auction.

- **Immediacy of liquidity.** Continuous markets offer immediacy in order execution. By construction, call markets do not: if a call auction is to last for 15 minutes, then for 14 minutes and 59 seconds, transactions have halted. Thus, continuous markets offer higher immediacy of liquidity than call auctions.

  In most situations, the loss of liquidity for a few minutes may not become a major constraint. However, there is one important task in modern finance – dynamic delta hedging of nonlinear exposures – where the continuous supply of liquidity is critically important. In such an instance, continuous markets are better placed to deliver liquidity than call auctions.

Table 5 summarises these differences in market quality, which comes down to a trade-off between quality of price of execution and immediacy of transaction. The table suggests that if immediacy of trade is *not* a priority, then call auctions offer an advantageous trading system with high price transparency,

Table 5 Call Auction vs. Continuous trading: A comparison

Feature	Call Auction	Continuous
Price discovery		
Disclosed price: immediacy	Yes	Yes
Disclosed price: sensitivity to extreme orders	Yes	Yes
Traded price: immediacy	No	Yes
Traded price: sensitivity to extreme orders	Low	High
Trade price: volatility	Low	Higher
Traded price: sensitivity to order size	Low	High
Liquidity		
Trade immediacy	No	Yes
Market impact cost and non-execution risk	Low	Present

lower impact costs and lower trade price volatility. For instance, a lot of financial institutions typically do not require immediacy of trades. Instead, they would prefer to be able to transact with (a) no price impact, (b) a single price irrespective of the size of the trade, (c) no concerns about the execution obtained by the brokerage firm and no possibility of front-running.

Market microstructure theory models the market as a combination of informed traders and uninformed traders. In the continuous market, uninformed traders have the choice of paying impact cost, or suffering non-execution by placing limit orders. When some of the uninformed order flow (e.g. institutional investors) moves off to call auctions, this would tend to exacerbate asymmetric information in the continuous market. If such adverse selection takes place, we would see *increased* impact cost in the continuous market, alongside the new alternative with zero impact cost being occassionally available to all. While such a shift is predicted by the theory, the empirical experience does not show such clear patterns.

3 International experience with call auctions

In this section, we examine the call auction designs used at some of the largest exchanges in the world: NYSE, the London Stock Exchange, Paris Stock Exchange/Euronext, Deutsche Bourse AG, Taiwan Stock Exchange and others in the Asia Pacific region. While call auction trading takes place at many other exchanges, these are important exchanges for which there exists a large base of research literature. However, it is important to keep in mind that some of these markets differ from India in having broker/dealers or market makers as key market participants. This influences the design and implications of call auctions in these markets in certain ways.

3.1 Price discovery at market open: NYSE

Trading at the NYSE begins with a call auction. Traditionally, this was not an electronic auction. Rather the auction was managed by "designated market makers" (DMM) who posted a price depending upon the limit orders they received during the opening period. The DMM was given some flexibility with respect to setting opening prices (first trade and first quotes). If there was an order imbalance at the market clearing price, the DMM was obliged to fill the imbalance out of their own inventory.

The DMM set a single opening price to clear the market-on-open. Under unusual circumstances, such as a "news pending" announcement or large imbalances, the DMM could delay the opening or temporarily halt trading. During this delay, non binding quote indications were usually issued on the tape to signal the source of the delay and to attract limit orders. The market power of the DMM was considerable, enhanced by privileged access to information about the limit order book. In return, the DMM had an "affirmative obligation" to provide price continuity and maintain liquidity.

An analysis of price and spread characteristics around the opening, under this market structure, suggested that prices tended to be more efficient in information adjustment when a call auction was in place, compared to continuous trading (Madhavan, 1992; Schwartz, 2001b; Brooks and Moulton, 2003).[2]

In the recent past, the role of the DMM in price discovery at the call has been substantially reduced, with the call auction moving more towards being an electronic call auction, with a market clearing price being continuously

[2] After the 1987 crash, the settlement of the S&P 500 futures traded at the Chicago Mercantile Exchange (CME) was shifted to the NYSE open price. This enabled arbitrageurs to exit their positions at the NYSE opening call auction and ensure a more orderly market.

computed based on limit orders in an electronic order book. Relatively little research is available about the behaviour of the NYSE pre-opening call auction under this electronic environment.

3.2 Price discovery at the close: LSE

The London Stock Exchange (LSE) shifted to continuous electronic trading in 1997. While the exchange used a call auction to open the market from the beginning, a call auction for the closing was introduced only later in 2000.

The LSE continuous markets stops trading at 4:30 p.m, followed by a call auction, where both limit orders and market orders are accepted. At 4:35pm, the closing call algorithm runs to clear the market. The algorithm and price-setting rules are the same as that used in the opening call. If there is no price generated in the closing call auction, then the settlement price for a stock at the end of the day is calculated from the last ten minutes of continuous trading.

Since the introduction of a call auction at the close, there have been instances where the closing auction process has thrown up rogue prices which sparked a chorus of criticism from market players.[3] The design of the closing auction at the LSE was modified a few times, before settling at the following parameters:

1. Call auction for a period of 30 seconds.
2. Permit both market and limit orders.
3. Order entry and deletion are charged (1 pence).

LSE discloses the full order book in real time during the call phase.

Ellul *et al.* (2006) investigate the performance of call auctions at both the opening and closing at the LSE. They focus on the difference between the call auction and the "unofficial" dealer network that ran in parallel. They find the call auction market dominates the dealer market in terms of price discovery. However, they find that call auctions suffer from a high failure rate, when trading conditions are difficult. Trading costs in the call market increased whenever there was slow trading, order flow imbalances, and uncertainty.

[3] http://www.independent.co.uk/news/business/news/stock-exchange-forced-to-defend-closing-auction-procedure-711855.html

They conclude that the use of call auctions is negatively correlated to firm size. This implies that the call may not be the optimal method for opening and closing trading of medium and small sized stocks.

Battig and Chelley-Steeley (2010) examine the impact of the introduction of a closing call auction at the LSE. They find that market quality *improved* for (liquid) securities during "market close", as well as at "market open" the next day.

3.3 Trading low-liquidity stocks: Paris Bourse, Euronext, Deutsche Bourse

Before the merger with Euronext in 2000, the Paris Stock Exchange (PSE) ran a combination of continuous market and call auctions (Pagano and Schwartz, 2003), where electronic call auctions were used:

- In the opening price discovery for all stocks.
- In the closing price determination for all stocks.
- For less liquid stocks.

For illiquid stocks, two more call auctions were conducted to consolidate orders during the day in addition to the opening and closing auction. These were conducted at mid-morning (11:30am), and then in the late afternoon (at 4pm). PSE ran these auctions alongside with a dealer market, where dealers were considered the last source of liquidity provision.

Thomas and Demarchi (2001) found that price discovery at the PSE was enhanced during the call auction. They document a *drop* in market quality when the opening call market was removed for a while, despite the fact that the dealers were there to make market. Similarly, Pagano and Schwartz (2003) found an improvement in market quality at the closing call auction, *not just* at the close of market but also at the opening on the next day.

However, post-merger, Euronext retained the call auction process *only* for the opening and the closing sessions. Price discovery and liquidity provision for the illiquid stocks were handed over to the "liquidity providers" – market makers who provide liquidity by posting two-way quotes.

The Deutsche Borse (DB) AG, which was a key driver of innovation in the financial trading space in Europe, uses a pan European electronic system (called "Xetra") from November 1997. Along with continuous trading, DB AG uses call auctions to enhance price discovery. The call auction is used for trading liquid securities both before and after continuous trading. Less liquid stocks are traded using periodic call auctions. These call auctions are not electronic, but intermediated by "designated sponsors" who are mandated to provide liquidity, like on Euronext. DB AG conducts two additional call auctions, at mid-day and in the afternoon, for all stocks unlike Euronext.

The differences in the call auction at the two exchanges are:

1. The duration of the call phase has a random end at the DBorse AG. The auction at Euronext ends at a fixed time.
2. Call auctions at the DB AG has limited transparency. The order book remains closed. Only the indicative auction price or the best bid and/or ask limit is displayed. At Euronext, the order book is displayed.
3. While both systems use dealers to act as liquidity providers/designated sponsors, disclosure about the selection criteria of these on the DB AG is lower compared to the criteria on Euronext.
4. DB AG permits lower tick sizes compared to Euronext.

Kasch-Haroutounian and Theissen (2009) compares the quality of the overall market and find that, on average, spreads tend to be lower on the Deutsche system compared to the Euronext system. Hoffman and van Bommel (2010) focusses more on the effect of the auction system. They study the design of call auctions used at both exchanges in order to understand how differences in design might imply different market outcomes at both. They find:

- The size of the order flow coming into the opening auction is higher in Euronext than at DB AG.
- The quality of market in the post-auction period tends to be better at Euronext compared to DB AG.
- There is some evidence of attempts to manipulate prices of the illiquid stocks from the order cancellation during the closing call on Euronext.

3.4 Other evidence on call auctions in exchanges

The Taiwan Stock Exchange (TSE) offers an interesting case study of call auction as a trading mechanism for India because all stocks here trade in a series of periodic electronic call auctions without designated dealers. Each auction run between a minute to 1.5 minutes depending upon the liquidity of the stock. Chang *et al.* (1998) analyse the difference between the call auction and a simulated continuous market and find that:

1. Price discovery appears more efficient in the call compared to the continuous auction market.
2. Call auction volatility tends to be half the volatility in the continuous market.
3. Highly traded stocks demonstrate a larger drop in volatility under a call auction than stocks with poor trading.

Huang (2004) studies market quality at the open of the Taiwan Derivatives exchange (TAIFEX) which uses an electronic call auction and the Singapore Derivatives exchange (SGX-DT) which opens using a open outcry continuous market. He finds higher explicit transactions costs at the TAIFEX, but lower effective spreads. He also documents that trading volumes on SGX-DT to eventually migrated to TAIFEX.

Several exchanges in the Asia Pacific region[4] open the markets with call auctions (Comerton-Forde and Rydge, 2006a,b). They report that price discovery improves when call auctions are used at market open. Comerton-Forde and Rydge (2007) study the call auction used at the opening of the Stock Exchange at Hong Kong (SEHK). They document no benefits in market quality at the SEHK from the use of a call auction but also cite a flaw in the design of the call auction that led to this failure.[5]

Auctions at market close are particularly well-suited to the needs of institutional investors, who can face considerable impact costs associated with large transactions. Recent research show how the behaviour of market outcomes

[4] The exchanges covered are Australia, Malaysia, HongKong, Jakarta, Korea, Singapore, Shanghai, Taiwan, Thailand, Tokyo.

[5] The SEHK stopped using the call auction when it was used to manipulate the closing price in March 2009 (FinancialTimes, 2009).

of call auctions at Euronext are increasingly reflecting a greater participation by institutional investors (Hoffman and van Bommel, 2010).

An instance of the call auction at an exchange that is little considered is the call auction used during the NYSE Liquidity Replenishment Points (LRP). Single stocks which typically trade in the continuous market, automatically move into these LRP call auction if the stock price moved beyond a pre-determined range (called the "LRP range"). This range is based on the volatility of the stock, and was originally recalculated every 30 seconds as a function of the LTP. Traditionally, the DMM would take control of the order book and offer prices and adjust order imbalances. NYSE records show that on a normal day, there are 100 LRP triggers. But on certain days, many more LRPs have been triggered: e.g. on 6 May 2010, 1000 LRPs were triggered.

4 Potential application in India

In India, call auctions have been attempted in the past. BSE technical documentation on BOLT from 1993 includes a section on using a call auction for the "pre-opening" session. NSE implemented an call auction for both the opening and closing of the market in 1999 (Camilleri and Green, 2005). However, these are not in place today. Moreover, since these initial attempts, there have been no new efforts to implement call auctions for trading in the equity markets.

In this section, we examine some instances to use call auctions in the Indian equity market. These are auctions to

1. Decide the opening prices in the equity spot markets,
2. Decide the closing price for equity spot markets,
3. Use as the primary trading mechanism for illiquid products, and
4. Use as an alternative to circuit breakers/single security price bands.

For each instance, we start by examining the current market structure. We attempt to put together an empirical analysis of current market outcomes to see if the market could benefit from having a call auction as an alternative trading mechanism. Lastly, we suggest what aspects of the call auction design could be emphasised for a specific instance.

First, a detour into stylised empirical facts about intra-day market quality is called for.

4.1 Stylised facts about intra-day market behaviour

Market efficiency is often measured by the behaviour of traded prices and orders in the limit order book. Specifically, we examine patterns in the *volatility of traded prices*, and in *market liquidity* as measured by the *spread*. If a market is efficient at discovering prices, there should be no patterns of time dependence in both of these measures, since such patterns show a tendency for prices and orders to adjust to new information slowly, rather than adjusting rapidly.

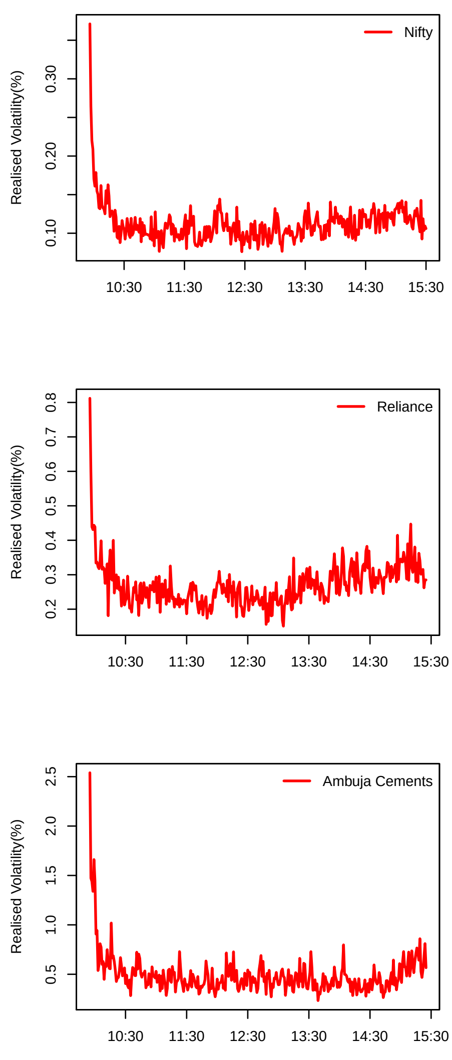
We focus on quantifying market performance within the trading day. The "Market-by-Price" (MBP) data from the NSE gives us access to: (a) Every single traded price for all securities, and (b) the best bid and ask prices in the limit order book (LOB). From the MBP data of October 2008, we use prices for the index ("Nifty"), as well as for the most liquid stock ("Reliance") and the least liquid index stock ("Ambuja Cements"). We use data at one-second intervals to calculate volatility in each minute, as the standard deviation of 60 observations of the percentage change of price within the minute. Liquidity is measured as the "relative spread" for individual stocks, calculated as $((\text{Bid} - \text{Ask})/\text{Midpoint quote})$ at every second.

Figure 1 illustrates this *intra-day volatility* in the Indian stock markets, averaged across all the trading days of October 2008. We can see the markets start with disproportionately high volatility at the very start of the market. Visual inspection appears to indicate that the higher volatility lives for an extremely short period. However, statistical tests show that the market remains in a period of high volatility for as long as half an hour after the start of the market.

Finance literature documents a strong link between the link between temporal patterns in volatility and liquidity, at the level of daily data. Here, we see that it holds for the behaviour of intra-day volatility and liquidity as well, as illustrated in Figure 2, which shows intra-day market volatility and liquidity

Figure 1 Intra-day volatility of Indian equity, Oct 2008

Each point on the graph is the standard deviation of returns within a minute, using price data that has been discretised to a frequency of one second. Realised volatility was averaged for all trading days of October 2008. Nifty has the lowest intra-day volatility at an average of 0.1% during the day, compared to 0.24% for Reliance, and 0.9% for Ambuja Cements. But the first half hour, index realised volatility is almost as high as that of Reliance.



for *Reliance* and *Ambuja Cements* on one day, 10^{th} October 2008. Here, the first "row" has the graphs of intra-day volatility, and the second "row" has the graphs of intra-day relative spreads, calculated as described above.

Statistical tests confirm that:

1. There are time dependencies in intra-day volatility of the current equity market, which implies that information is being incorporated slowly into prices and there is scope to improve market efficiency.
2. Intra-day spreads of the individual stocks display the same patterns. The higher the spread, the higher transaction cost. Any improvement in the market outcome of volatility could likely mean better liquidity, and lower transactions costs.
3. There is some regularity with which volatility shifts across different levels during a trading day. On average, volatility shifts down to a lower level *after 10:30am*, and then moves up again *after 2:30pm*.

4.2 Price at market open

Currently, equity exchanges start trading by opening the limit order book directly into the continuous market. At the start, the limit order book starts empty, flushed of all orders from the previous day.

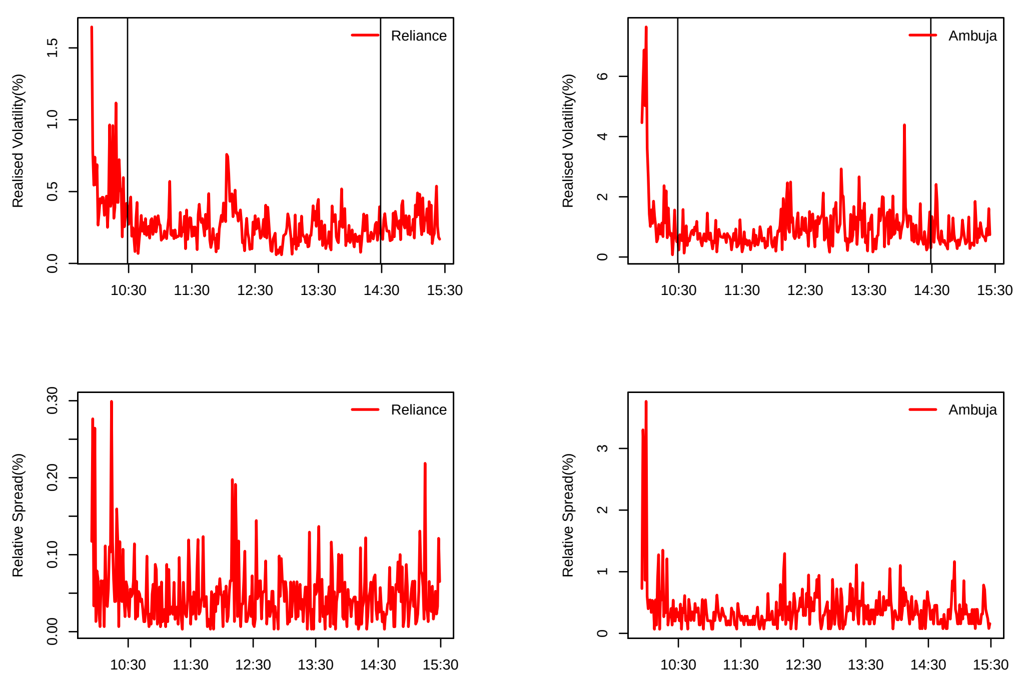
Figure 1, in the previous section, showed the clear presence of the higher volatility in traded prices as one of the outcomes of the current market structure. The stylised facts about the behaviour of intra-day volatility at the start of the day are:

1. Higher opening market volatility is persistent across all securities. Since this is driven by overnight news and information while the markets were closed, this is not unexpected.

   What is not expected is that it takes half an hour, on average, for prices to adjust. This high "persistence" of volatility is indicative of inefficiency in how slowly market prices adjust to new information.
2. Statistical tests show that the time taken for the prices to shift from the high "opening market" volatility to the normal "mid-market" volatility varies across (a) securities and (b) days. This seems to suggest that

Figure 2 Intra-day market outcomes for single stocks on 10^{th} October 2008

These graphs compare the patterns of intra-day volatility and liquidity for *Reliance* (high liquidity) and *Ambuja Cements* (lower liquidity) for a single day 10^{th} Oct 2008.
Realised volatility is the measured as the standard deviation of returns in a minute, using one-second returns data. *Relative spread* is measured as the (bid − ask/midpoint quote) using one-second order book data.
The vertical lines on the volatility graphs mark the time points where statistical tests show that prices typically shift from one level of volatility in the market to another. At 10:30am, the volatility shifts down from the high volatility of "market opening" to the lower "normal market". Between 2pm and 2:30pm, the securities typically shift from the "normal market" volatility to a slightly higher volatility of "market closing".
Reliance with higher liquidity (relative spread of 7 basis points on average) has lower levels of intra-day volatility compared to *Ambuja Cements* with weaker liquidity (average relative spread of 60 basis points).



different stocks require different periods to complete price discovery at the start of the day in the current market structure.[6]

3. Each security has a different "highest" level of intra-day volatility at the start of the day. The amount by which the "opening market" volatility is higher is correlated with the liquidity of the stock. For example, Reliance has lower opening market volatility Ambuja Cements.

Given that there will always be overnight news and information that has to be captured into a country's market price, it is perhaps inevitable that the opening market price will be far more "volatile" in any market compared to (say) the "closing" price. Our concern is that the market efficiency could be improved. Currently, the market takes half hour on average to adjust to the news.

The above suggests there is a strong case to support starting the market using a call auction. If the (uncertain) order flow at the start of the day is consolidated over a period, and participants allowed to see where the rest of the market stands, there is scope for the call auction to deliver better outcomes in terms of volatility, for each stock, and uniformity across all stocks. In addition, we expect that if a call auction can succeed in achieving lower volatility, this will also lower transaction costs of trading equity.

4.3 Prices at market close

Currently, the market continues trading using continuous order matching till 3:30pm. Closing prices are calculated as a weighted average of the last 30 minutes of traded prices (NSE), or the last 30 trades (BSE). After this, a post-close session runs where orders can be entered for trading at the closing price. There are two reasons why it might be useful to calculate the closing price out of a call auction instead of either approaches used currently.

First, theoretical arguments as well as empirical evidence in the published literature show that the weighted average methods of calculating the closing price are vulnerable to manipulation compared to the price from a call auction

[6] These are amongst the most liquid in the country. Further analysis is required to understand whether less liquid securities than the ones in the index take longer. This would imply that the call auction should be kept longer or shorter depending upon the liquidity of the stock.

(Hillion and Suominen, 2004). Further, Battig and Chelley-Steeley (2010) show that call auctions at the close improves pricing efficiency during the closing, as well as for the opening of the next day. Second, the stylised facts from Figure 1 about the close of the current market structures shows:

1. Volatility at the close of the market starts becoming higher between 2:00 and 2:30pm. This is more consistent time of shift in volatility, across stocks and across days, compared with the time that "open market" volatility comes down to "mid-market" volatility.
2. On average, "closing market" volatility is not much higher than normal "mid-day" volatility.
3. The higher "closing market" volatility persists over a longer period when compared to how long "open market" persists at the start of the day. "Closing market" volatility tends to last from around 2:00pm to 3:30pm.

The main concern of traders at the closing of the market is the need to exit their positions. The number of trades per minute goes up sharply as the market approaches closing time. Both the high concentration of trades and consistently higher volatility suggest the use of a call auction to close the market more efficiently.

At the close, there is an added emphasis to design the auction to discourage manipulation. There are significant economic gains to be had by influencing closing price compared influencing the opening price, since the closing price has implications for the mark-to-market valuation carried out at all financial institutions related to capital requirements, margin calls, profits for derivative positions, etc. This is reflected in the literature, which documents more problems at exchanges with a closing call auction than an opening call auction.

4.4 Large market moves

Currently, there are two market-controls on large price movements:

1. **Market wide circuit breakers:** When the stock market index moves outside of a fixed range of values (at $10\%, 15\%, 20\%$), the market halts

for trading (the period of the halt depends upon the time of day that the large movement took place).

2. **Specific to individual stocks:** Trading is permitted only within "price limits" or "price bands".

   The bands are calculated every day relative to the previous day closing price. The width of the band is derived from the previous volatility of the stock.

The first control slows down the price discovery process temporarily. The second one has the more damaging effect of censoring the prices in the market. The motivation for the controls on prices is to limit volatility when it is difficult to discern what drives the price change. The price change could be legitimate if there is news about the firm or the economy that justifies a large change in value. The alternative is that the prices are moving due to a manipulative attempt.

Price controls are considered beneficial because (a) they prevent overreaction by the market participants to uncertainty of information, and more importantly, (b) they bind price volatility and therefore, limit the risk in the market. This could help the market be more efficient and orderly. However, since neither of the controls listed above differentiates between these two possible causes of the price move, they can instead lead to weak price discovery and persistent market volatility.

Price controls are considered costly because (a) they curtail prices from quickly adjusting to their new level, (b) they interfere with liquidity since no trades can happen beyond the limit ranges, (c) they cause the high volatility due to information changes to persist in the marketplace. For large information shocks, that require the price to go beyond the stated band, price limits force information transmission to be spread out over a longer period. This implies that the market is not just disclosing a distorted price at every point, but it builds in a persistence of the distortion.

Evidence from several empirical studies that price limits have no impact, or lead to weaker price discovery in financial markets. There is more evidence to show effects of volatility spillover across periods when price limits are binding in the market. These studies span the effect of price limits across spot market as well as derivative markets, as well as across different market structures.

Since the call auction offers the benefit of better price discovery with asymmetric information, an alternative way of managing large price moves is to shift from continuous trading into a call auction, at the moment the "price band" is hit. With order consolidation and clearing price disclosure, the call auction could prove to be a more efficient method of discovering a trusted price while simultaneously managing systemic risk, compared with the two controls currently in place.

In the proposed scenario, when a large price move takes place, the market would switch from a continuous market into a call auction for a few minutes. The call auction would discover a single trusted price, and bequeath an order book for the recommencement of continuous trading.

4.5 Trading illiquid securities

Despite the great improvement in market quality that the market has gained since the reforms of the nineties, a glaring flaw is how heavily skewed liquidity is towards a small fraction of securities. Typically, these are securities of large listed firms, that have always had ready access to finance.

The most credible data for both market capitalisation and liquidity is of the firms that make up the CMIE Cospi index [7] (Shah *et al.*, 2008). Typically, there are around 2500-2700 firms in the COSPI set. Market capitalisation is captured as the average for the firm in March of the year. Liquidity is measured by the firms turnover ratio.[8]

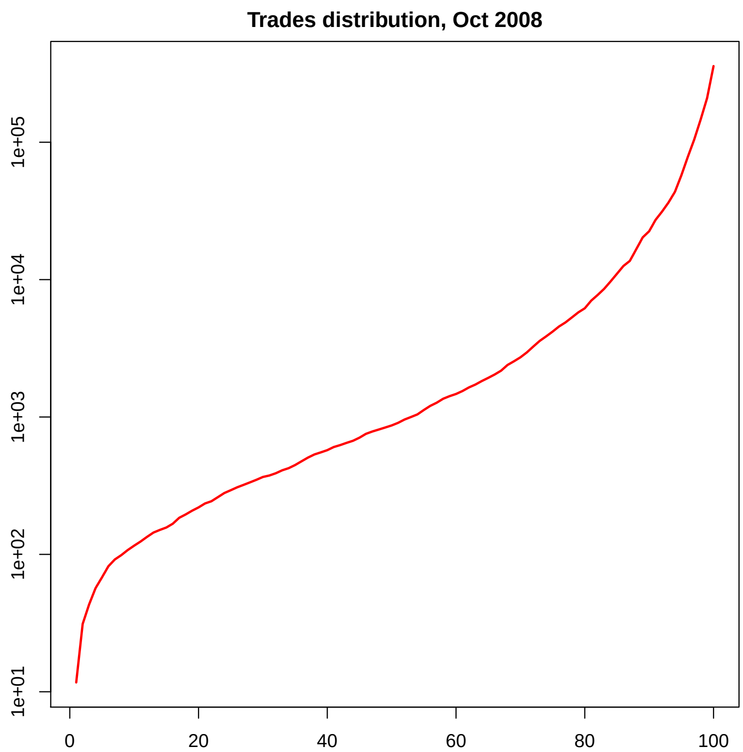
For the financial year 2009-2010, around 2000 of these firms had market capitalisations spanning a range from 200,000 USD upto 76 billion USD. Only 25% of the firms (under 500) had market capitalisations above 100 million USD. This skewness in their size was reflected in their liquidity. It is these top 500 largest companies that have turnover ratios of more than 100%

[7] Cospi is a portfolio with a large number of stocks, calculated at the Center for Monitoring Indian Economy (CMIE). The set of eligible stocks is recalculated every day, where eligibility is defined as having a historical trading frequency of above 66%. For all practical purposes, there is no meaningful equity market beyond the Cospi firms.

[8] Turnover ratio is measured as the fraction between the annual traded volume of the security to their market capitalisation. A liquid security can trade many times more than its size in the markets over the year.

Figure 3 Distribution of trades at the NSE across firm centiles, Oct 2008

Each point on the graph is the average number of trades per centile. The graph shows that there is a steadily growing trading activity from the bottom centile to 80% of the firms. It is around 15% – under 150 firms out of 1215 firms – account for more than half the trading activity on the NSE.



on average. The bottom 500 among these liquid companies have turnover ratios of under 50% on average.

We look at trading activity of these firms in the day as an alternative measure of their liquidity as seen in Table 3. In Oct 2008, there were around 1215 firms that traded on NSE. The smallest number of trades was once a day, while the largest number was more than half a million trades in 5.5 hours of trading. Of these firms, 50% traded under 1000 trades.

Thus, a large fraction of the listed companies in the country suffer extremely varied levels of liquidity using continuous trading. The greatest benefit of continuous trading is the immediacy of liquidity. For a very large fraction of listed stocks, the liquidity is too sparse to justify the need for continuous access to liquidity. Call auctions that consolidate orders over a period of time and results in a trade at a predefined time naturally recommends itself as the alternative trading mechanism. In fact, trading such stocks on the call auction rather than continuous markets could likely benefit for two reasons:

1. A single call auction with advance intimation about the time of the call could be much more successful in attracting orders, by offering the trade off of no immediacy during the day to a competitive market equilibrium price at a fixed time in the day.
2. Continuous markets, where the time of trade is uncertain, leaves the buyer/seller vulnerable to take prices that are far from fair-value. This results in a "liquidity premium" that the buyer/seller is willing to suffer as cost of transaction. For illiquid stocks, this cost tends to be very high.

In an auction that is held at a clearly specified time that is universally disclosed, there is a higher chance of obtaining the order flow required to build a more accurate demand–supply to determine a price closer to the fair value of the security.

Going beyond the equity spot market, there are important pockets of illiquidity in India with certain equity derivatives series (e.g. a deep in the money option on Nifty with 3 month maturity, or a INR/JPY futures with six month maturity), and with the bond market.

4.5.1 Bond market liquidity

One set of illiquid securities that deserve mention here are bonds. Corporate bonds are already among the securities listed for trade on the exchanges, and trade very infrequently on the continuous market even in comparison to the least traded stocks. The reasoning outlined above for using call auctions to improve market quality of illiquid equity apply equally for the corporate bond market.

However, the outcome of improved price efficiency and liquidity using a call auction has more significant ramifications for the government bond market.

While the primary market for these bonds are done using the auction process by default, secondary market trading is not. In fact, secondary market trading has always been a dealer-brokered market in the past. Only in the last decade has there been a development of electronic markets for secondary market trading of treasuries (Mizrach and Neely, 2006).

In India, the current market structure for trading (say) central government bonds are two: a continuous market called the Negotiated Dealing System (NDS) that is operated by the Reserve Bank of India (RBI) and has been in place since 2000, and a dealer market. However, some characteristics of the government bond market in India makes it a candidate to use electronic call auctions for trading. These characteristics are common to most treasury bond markets, and are:

Pattern of market participants

Unlike in the Indian equity markets where the participant base is a mixture of retail investors (generating around 80% of the traded volume) and institutions, the participants in these markets are restricted to the set of all financial institutions. These include banks, primary dealers, insurance firms, mutual funds, pension funds, trust funds. The continuous order matching NDS market is accessed by the large financial institutions such as the primary dealers and banks, while the rest of the bond market participants trade in the dealer market.

While this number of participants is smaller compared to that of the equity markets, there is a large size heterogeniety amongst these ranging from the very large (banks, insurance firms, pension funds) to the very small (trust funds). In such a heterogenous mix, there is a higher problem of asymmetric information, where the larger participants have the power to set the prices ("leaders") and the smaller participants follow ("followers"). In the continuous market, such an organisation can lead to a large heterogeniety in prices available to different participants. In some situations, this characater of the market also makes the "followers" vulnerable to price distortions away from the true market value.[9]

[9] An example of the "leaders" profitting at the cost of "followers" was the case of Citigroup's controversial euro area government bond trades in August 2004. Citigroup traders initiated concerted sell orders in the bond market that caused a disruption in market prices, before the traders bought the bonds back at a profit of nearly ten million

In addition, each of the financial institutions listed above are likely to trade different sizes, thereby paying varying levels of impact costs, resulting in significantly different prices of transaction for what ought to be the least risk security in the country.

Unlike in a continuous market, or a dealer-intermediated market, the call auctions process that delivers a single market clearing price to all participants at a given point in time would be optimal compared to the highly differential prices that different participants are likely to access in a continuous market.

Current liquidity patterns

Most of the liquidity in the treasury bond market is concentrated in the "on–the–run" bonds – those bonds that have been issued recently. Typically, bonds have some secondary market liquidity in the six months after their issuance, and practically none after. This is evident in the patterns of trading intensity on this market.

The readiest access to liquidity of the government bond market is from trades on the RBI-NDS market. This data shows that typically there are less than 30 securities that trade in the market at any given point in time. These include: "on–the–run" Treasury bonds (long dated bonds issued by the Central Govt.), Treasury bills (short dated Central Govt. securities), call money, non-standard repo, dated state government and public sector unit bonds. There are very few trades in state government bonds.

Of these, the number of trades on any given day tends to be between 25-50 trades for the highest traded bond. Trading intensity tends to be highest in March, where the number can cross 75-100 trades in a day. What is important is that there tends to be a significant variation in the prices for the same security within the day by time and by size of trade.[10] With call auctions, there would be one price. Thus, if the

GBP. While the UK Financial Services Authority took away the profits and fined Citigroup an additional four million GBP (Euroweek, 2009), the trade was not classified as market abuse.

[10]For instance, on 10^{th} June 2010, NDS trade data show the "8.24% GOVT.STOCK 2018" as the most traded security. The prices show large variation as large as INR. 5, over

market closed with a call auction used to determine the closing price of the bonds, the “followers” would be able to trade market orders without any impact cost.

An auction to determine the closing price in the treasury bond market has deep economic ramifications, going beyond closing prices in the equity market. Traded prices of bonds today are used in the calculation of the daily “zero coupon yield curve” which is the estimated term structure of interest rates for India.

Currently, the estimation is sensitive to market prices that carry varying degrees of the “liquidity premium” depending upon the liquidity premium of a specific bond. If these prices are instead taken from a closing call auction, the estimated term structure would be less distorted by the varying degrees of “liquidity premium” from the different bond prices.

5 Design of call auctions

The dominant reason cited in the literature for the use electronic call auction is that they are better designed to handle price discovery in the face of asymmetric information in the market (Madhavan, 1992; Schwartz, 2001a). If the impact of asymmetric information can be reduced, it would effectively lower the cost of trading, result in a lower volatility in the traded price and a greater efficiency in the price discovery process.

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a small period of time:

TradeTime	Deal Price (Rs.) (Rs)	TradeFaceValue (Million Rs.)
2:49pm	101.1299	100
2:50	100.8499	100
3:07	101.0000	250
3:19	100.9499	100
3:26	100.7500	100
3:27	95.5999	50
3:42	101.0000	5
3:55	101.0800	100

With the access to technology available today, electronic call auctions can be readily deployed as alternative trading systems, along with continuous trading. Electronic call auctions can be designed to disclose the market clearing price as immediately as orders are added to, or drop off, from the demand–supply schedule.

5.1 Principles for call auction design

A call auction is successful if significant order flow comes to the auction book during the consolidation period. The auction must be designed and run to always attract as comprehensive a coverage of the demand and supply schedule as is possible. When the full demand and supply for a security clears, the prices comes closest to the equilibrium price. There are two key bottlenecks that stand in the way of attracting all trading interest into a call auction. These are:

- Any individual participant will be interested in entering orders in a call auction once they believe that everyone else will participate as well. If the participants think that they will be disadvantaged in terms of their access to all relevant information, they would be wary to enter the trading process without seeing that others have placed their orders. Thus, their incentive to participate in a call auction tends to be the participation of others.

  A standard observation about call auctions is that participants tend to wait till the last moment before placing their orders. In such a situation, while the auction price will be the result of a consolidated order flow, the price discovery benefit over the period of the auction will be lost.

- Orders might be placed with the deliberate intent to manipulate disclosed prices.

  As in a continuous market, the provisional price is calculated to maximise the order. Unlike in the continuous market, an order in a call auction market does not immediately result in a trade. With the ability enter, modify and cancel orders, manipulating the disclosed price so as to influence price discovery can be done at a lower cost in the call auction than in the continuous market.

These become the following specific set of objectives for any call auction:

1. How to incentivise participants to place limit orders to buy and sell as early on in the auction period as possible to encourage price discovery?
2. How to actively discourage orders placed with the intention of falsely influencing the disclosed price?
3. Should one design of the auction be uniformly applied to all instances of use of the call auction in the trading system? Or should different auction designs be used for different purposes, for different audiences, and for different securities markets?

5.2 Parameters of a call auction

The most important parameters defining a call auction are:

- Q: What are the entry barriers to participating in the call auction?
- Q: How long the auction will be kept open to receive orders?
- Q: What kind of orders are permitted – market orders, or only limit orders? What is the prioritisation of matching between market and limit orders at the end of the auction?
- Q: How is the auction price calculated?
- Q: What is the "optimal" level of transparency of the auction? Should the market clearing price be continuously disclosed, or just the price at the time of close of the auction? Should the entire demand–supply schedule is disclosed to the participants during the auction, or just the best price to buy and sell?

In the following section, we examine some answers to these questions. In many cases, there is no one answer, and there is a role for identifying the design most suited to the question at hand.

5.2.1 What entry barriers?

Recommendation: The call auction should be considered part of the trading process of the market. All the normal entry criteria that apply to buy/sell a security will apply here.

Argument: In India, anyone can trade in the continuous market as long as they post some initial margin with the exchange. Once a position is taken, the clearing corporation marks the position to market, calculates a loss or a profit and ensures that the margin is sufficient to cover any loss. Similar requirements ought to be applied for participants of the call auction.

5.2.2 For how long?

Recommendation: The length of the auction can differ depending upon where it is being applied. The key idea is that the auction should be kept open as long as it takes to gather the best possible demand–supply schedules for the security.

In order to encourage early order placement in the book, and discourage last-moment order cancellation/modification, the auction might adopt the following features:

1. The actual close of the auction could be at a *random time point*, defined relatively close to the officially stated closing time of the auction.

2. There could be a charge for order placement into the call auction. The charges could follow a graded scale where the charges increases as the auction comes toward a close.

3. Time priorities of orders that are modified should be reset to reflect the time of the modification.

Argument: The auction period is the length of time that the auction is open for collection and consolidation of orders. We know that:

- The longer the period of the auction, the lower the immediacy of liquidity available to participants.

- The longer the period of the auction, the more vulnerable the disclosed price could be to being manipulated.

Call auctions that are successful at exchanges in the world run over a short period, stemming from the observation that most of the order flow enter the book close to the end of the auction. In addition, various exchanges find evidence that vulnerability to manipulation goes down when there is uncertainty about the exact time that the market stops taking in orders and calculates the market clearing price.

Solutions that aim to encourage participants towards early order placement and discourage malicious orders that mislead price discovery are:

Randomised time of auction closure What emerges from the experience of various call auction implementations is that auctions with a fixed time of closure are vulnerable to manipulation. One mechanism commonly used to deter manipulation is to declare that the auction will close at a random time. Prior to the auctions, participants are only informed of the range of time within which the auction could close.

For example, if there is a call auction for the opening price calculation which starts at 9:30am, and the continuous market starts at 10am, the auction could close anywhere between 5 to 10 seconds before 10am. We discuss this in more detail in the Section 4.3.

Graded charges for orders placed [11] The charges for orders placed in the system should be to encourage early placement and limit order placement. Therefore:

1. Charges for any orders placed in the call auction ought to be lower than the fees charged for orders in the continuous market.
2. Orders that are entered at the start of the auction ought to be charged the least. The charges could start at as low as 0 and go up to a maximum for entry at closest to the close of auction.
3. Charges for order modification/cancellation should exponentially increase closer to the time of auction close.

   If orders are placed with intent to distort the disclosed price during the price discovery, then high charges for order modification would increase the cost of mischief making.

Charges for order modification/cancellation **must be** sensitive to the kind of information asymmetry that the auction is being used to overcome. Around periods of high flow of information, market participants will need to modify/cancel orders. Therefore, fixed or no charges for

[11] Economides and Schwartz (1995) suggests this as an incentive for early order entry.

order modification/cancellation automatically with time may result in efficient market participation. This is unlike the market closing session where price volatility is driven largely because of changes in liquidity. Here, charges that increase as the auction comes to a close might motivate more orderly participation in the call auction.

It must be noted that there appears to be no exchange that uses a time-graded charge on order placement. Most report fixed charges for orders.

5.2.3 What order types?

Recommendation: Both limit orders as well as market orders ought to be permitted. However, the design of the auction should include:

1. The priority with which each type of order will be matched at the end of the auction. Here, time priority is an obvious choice since it replicates what happens in the "normal continuous" market.
2. If there is order imbalance at the end of the auction, there should be clear rules of how the imbalance is to be resolved.

Argument: It is optimal to permit all orders into the book, if the auction objective is to achieve as comprehensive a demand–supply curve as possible. Limit orders bring information about liquidity and prices to the market, while market orders consume liquidity – they contribute to the size of the transaction but not the price discovery. Particularly in a call auction, it is important to have limit orders since an auction with only market orders cannot contribute to price discovery.[12]

The problem arises when there is a possibility of an order imbalance, and there is a trade-off between matching market versus limit orders in the book. One approach is to match all orders based on time priority. Another approach is to execute all the "winning" orders on a pro-rata basis. For examples, if a limit order in the auction had 200 shares, a market order had 300, and the counter party has only 400 shares, the

[12]When the LSE first started a call auction on market open in 1997, the call allowed only limit orders. However, that was modified in 1999 to include market orders (Ellul *et al.*, 2006).

limit order will get a trade for 160 shares, and the market order trades 240.

Another question is: what happens to the unfilled orders at the end of the call auction? While the unfilled limit orders can go into the continuous market order book, a market order can either be traded against the best available prices or move as limit orders with the auction clearing price into the continuous market.

These are part of the choices that exchanges will have to clarify as part of the design of the auction.

5.2.4 How to compute the auction price?

Recommendation: The auction price is the one that maximises the quantity traded. The clearing price maximises the trade quantity.
If there are multiple prices at which the same quantity can trade, the auction price is that which minimises order imbalance. If there are multiple prices at which both conditions about the quantity are satisfied, the auction price could likely be picked at random among the choices.
If there are no orders, the auction price should be set to the a weighted average of a set of the last traded price. If the auction is for the opening of the market, the auction price could be the closing price of the previous day.
There is little justification for price bands on the call auction price.

Argument: The market clearing price is calculated to maximise the quantity that will get traded at that price. A well designed call auction will have rules on how to deal with the situation when there is more than one price that maximises the same traded quantity.

Most call auctions have a set of well-defined rules when this situation arises, which falls back upon a notion of a "benchmark/reference" price. In the "older" structure of exchanges like the NYSE/Euronext/DB AG, the fall back was on the system of specialists who typically provide liquidity in parallel with the continuous system. On electronic limit order book markets like Indian equity markets, the reference price could be the last traded price.

Henke and Voronkova (2005) show how price limits result in delaying price adjustment and cause spillover of volatility across days at the call auction at the Warsaw Stock Exchange.

5.2.5 How much transparency?

Recommendation: In order to aid the price discovery process, there ought to be high disclosure of the provisional price. This could be disclosed whenever it is calculated, or at regular intervals during the period of the call.
The extent of order book transparency could differ depending upon what the call auction is being used for.
There should be full anonymity of the counter party identities to enable consolidation at the highest level.

Argument: Transparency of the electronic call auction should be considered from twin dimensions of what information to disclose and a trade-off.

"What information to disclose" includes (a) price and (b) the set of orders that form the demand–supply schedule.

The "trade-off" is how much of this information contributes to true price discovery versus how much it can be used to manipulate price discovery. While the principle of full disclosure stands behind the idea that the cost of price manipulation is high in liquid and competitive markets, the same principle may not deliver the best results when the market is illiquid, or has imperfect competition.

Price disclosure Prices in an electronic call auction can be disclosed in varying degrees from

- "least transparency": where only the clearing price is disclosed to the market, to
- "maximum transparency": where the market clearing price calculated for every fresh order that enters the auction order book, is disclosed.

The rationale for more disclosure of the market clearing price is that when there is asymmetric information leading to market volatility, participants can use the disclosed price to update their understanding about the value of the security in the face of new information. If there is no transparency in the market clearing price, there is no clear signal about the impact of the information for the value of the security.

Order book disclosure Similar to prices, the orders that make up the demand and supply schedule can disclosed in varying degrees from

- "least transparency": where only the quantity that would clear at the current market clearing price is disclosed.

  For example, this is the level of disclosure in call auctions run at the NYSE and the Deutsche Bourse.

- "maximum transparency": where the full set of orders in the demand and supply schedule are constantly made available to the market participants.

  For example, at Euronext, the best five orders around the market clearing price are displayed to the market participants in real time.

Higher order book transparency could either be a signal to participants about the entire demand–supply which could incentivise better participation. It could be a deterrent to institutional traders whose order sizes that are large compared to the auction order book, and who do not wish to be known to be trading in the market. Exchanges could choose the level of order book disclosure to suit the purpose and the target audience for the auction.

For example, while auctions at Euronext have high disclosure in terms of displaying the best orders to participants, they also permit hidden orders in the auction book.

The literature on call auctions supports more disclosure of the orders in the book than less. Participants prefer to place orders in markets where they are confident that others will too. This derives from the co-ordination motive" for trading (Ellul *et al.*, 2006). If a trader is incentivised to place order in the auction by seeing the number and size of the orders already in the book, then the auction should be designed to disclose more about the demand–supply in the market. The studies on the comparison between Euronext and DB AG in Section 3.3 supports higher order transparency of Euronext, especially if the target market has a significant presence of institutional investors (Hoffman and van Bommel, 2010). On the flip side, they also document evidence of more attempts to manipulate the closing price of illiquid securities "swiping" orders in the auction.

5.3 Towards a call auction design for India

Finally, we use the framework outlined above to examine a set of possible parameters for the auctions that we proposed to be implemented in Indian equity markets in Section 4. The stylised facts presented in Section 4.1 on intra-day volatility and liquiditiy indicate the following choices may be optimal in the design of the these call auctions.

Price at market open

- Since it is critical to have maximum participation in the opening auction, the opening call ought to benefit from the continuous disclosure of the clearing price. Similar benefits are likely to accrue with more disclosure of the auction order book than not, as is done in the Euronext/LSE opening call auctions.
- Order modifications/cancellations are more likely to be motivated by genuine reasons to discover the price. Thus, the charges for these should be relaxed compared to (say) when the probability of manipulation is higher.
- A wider range of prices ought permitted in the opening price call auction because of genuine news and information at the start of trade. It would be optimal to have no price bands at all, particularly for the liquid securities (Henke and Voronkova, 2005).

Prices at market close

- There is less dependence on the auction for price discovery since the closing call auction comes immediately after continuous trading.

  Therefore, the price range permitted for a closing call auction ought to be much tighter than those used in an open call auction, particularly for liquid stocks.
- The auction period can be short to reduce the time between the continuous market and the closing of the market.

- The random time of closing the auction could be an effective mechanism to discourage placement of frivolous orders to mislead the clearing price.
- The amount of order book disclosure can be more restricted as compared to the opening call auction, more in line with the order disclosure adopted by the Deutsche Bourse.
- Larger orders could be charged less than smaller orders.

Large market moves

For extreme market movements, the likely auction design parameters are:

- The auction could be automatically triggered when the LTP reaches 95% of the "price band" that the exchanges internally sets for each security at the start of the day.
- A short and fixed auction period is likely to be sufficient for price discovery on individual securities. A longer period could be used for a large market-wide movement.
- There ought to be continuous disclosure of the market clearing price. The extent of disclosure of the order books ought to be left to the exchanges to set, as a function of the type of movement that triggered the price fluctuation.
- At the end of the auction period, if the price exceeds the earlier "price band" by more than 50% (say at 25% rather than at 20%, the auction will not close.

  Instead, it should roll over into another call (same duration and rules as the previous one). This has the benefit of giving the market some more time to discover the price.
- If a second auction is triggered, it ought to have a random close.[13]

Trading illiquid securities

[13] The time of the second auction should be a random number between 20% to 80% of the time of the first auction.

If the first auction runs for 5 minutes, then the second auction should run for anywhere between 1 and 4 minutes.

A call auction held to trade illiquid securities may benefit from the following design parameters:

- The time at which the call auction should be widely disclosed to the public, and well in advance of the actual auction itself.
- The frequency of the auction should be a function of the current trading frequency.

  For example, if the stock trades a few trades every day, it could have one auction. If the stock trades a few trades every hour, there can be several call auctions.
- In order to maximise the probability of participation, auctions for very illiquid stocks can be held in the middle of the trading day when the trading for liquid stocks is at the lowest.[14] Auctions for illiquid stocks can run after market opening and before market closing.
- The auction close can be a fixed time so as to encourage more order placement. However, it should be well publicised that there will be higher charges for order cancellation close to the end of the auction.

Secondary market trading for treasury, state government and public sector bonds

The bond market would most likely benefit using the call auction in all the areas that have listed above for the equity markets. The price volatility in prices observed in the NDS data suggest that there could be significant benefits from using a call auction to:

1. Open the market for trading
2. Close the market to calculate the "closing price" based on which mark-to-market valuations of bond portfolios can be done, as well as a more robust estimation of the term structure of interest rates.
3. The design of the auction can be more specifically structured to suit the needs of institutional traders. This will particularly be

[14] Currently, intra-day price and liquidity information suggest that the market sees lowest activity on average between 12 and 1.

important when deciding the desired disclosure of the auction order book.

5.4 Operationalising the call auction

In the above section, we looked at four instances when call auctions could be used to improve the quality of the equity markets in India. Each of these instances have different motivations for why a call auction might succeed in delivering better market outcomes than the continuous market in place now. This requires that different aspects of the auction design needs emphasis in each instance.

However, as described in Section 5, each of the design parameters have multiples choices, each of which might have different implications depending upon what the primary factor dominating the market, or who the dominant participants might be in the market at that time.

International experience guides us that even after careful thought is given to the selection of the parameter choice, exchanges could go through multiple iterations before they find the optimal value. The process of operationalisation of call auction in the market should include (a) constant evaluation of the market outcomes once the auction is in place, and (b) the flexiblity to conduct the auction under changed parameter values if market outcomes do not improve as expected with the parameter values that are in place.

6 Conclusion

The call auction is an alternative price-discovery mechanism that is being increasingly considered for trading on exchanges. Exchanges use call auctions to improve price discovery where continuous trading have not delivered desirable market outcomes. Call auctions are used to discover prices at market open, market close, as a trading mechanism for illiquid stocks, as well as during periods of information shocks.

However, their role is relatively small at exchanges today, compared to either continuous trading or dealer-market/specialist trading system. Part of the reason is that call auctions can improve market outcomes only when it can attract sufficient order flow to create a demand-supply schedule, well populated with information rich orders. This has proved difficult. Furthermore, the auction price-discovery process is vulnerable to manipulation, since it is less costly to place orders with misleading price information in the auction compared to placing orders on the continuous market.

Thus, call auctions need the “right design” to ensure optimal auction participation. Key parameters that the design depends upon are:

- The period of the auction.
- The flexibility of the auction to accommodate all kinds of orders, that contribute directly to price discovery or to maximising traded volumes.
- How the auction price is calculated.
- Frequency and quantity of price and order disclosure to reduce information asymmetry for participants.

Stylised facts about the behaviour of intra-day equity volatility and liquidity in India suggests that the call auction could prove beneficial here as well. Call auctions could reduce the excessive levels of volatility and high spreads that Indian equity currently goes through at market open. Auctions may enable better price discovery during a market disruption compared to a market half. Lastly, they are likely to be more effective for price discovery of the large number of illiquid stocks in India. In each case, we also identify what parameters of the auction needs emphasis to enable a successful implementation of the call auction.

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