Intra-day Liquidity Provision in Stocks: Continuous Trading vs Frequent Batch Auctions

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Trading in U.S. Stock Market

- Electronic trading through open limit order book (ELOB) transactions has become the preferred avenue for trading, providing increased incentive to invest in speed.
  - About 2/3rd of all stocks traded in the US (https://www.bats.com/us/equities/market_share/)
- Speed - the ability to trade at high frequencies - has created several issues: Increased market making costs due to potential sniping by faster traders with information advantage from speed; potentially increased vulnerability to intra-day crashes

Frequent Batch Auctions (FBA)

- Budish, Cramton and Shim (2015) suggest Very Frequent periodic batch auctions (milliseconds apart) as a solution to the sniping problem and avoiding excessive speed trading infrastructure investment
  - Suppose sniping by HFT is the only behavior pattern that is affected in moving to Very FBA
  - Suppose we look at a period when there were no HFTs, and clear the orders using a hypothetical Very FBA:
  - We should expect the hypothetical prices, volumes, and traders' profits under Very FBA to be close to corresponding actuals even though time priority is lost under auctions.
  - I provide support for this view. Addresses one concern about moving from continous trading to Very FBA
- I argue that we may want to examine FBA as well, not just Very FBA

Overview of the talk

- Volume and prices – very frequent one second - batch auctions
  - I use data on a very liquid stock traded on the National Stock Exchange of India between April and June 2006, before HFTs entered the market.
  - The data has the identity of the traders; and time stamp is coarse (only seconds are separated) but the sequence of orders, cancellations/modifications, and trades are maintained.
  - Auctions and continuous trading: prices, volumes and profits are close, when traders place the same orders
  - Some empirical support for Budish et al recommendation

Overview of the talk

- Volume and prices – less frequent one minute - batch auctions
  - I show that under less frequent auctions, liquidity induced crashes can be less severe.
  - In the three crashes in the data, the price drop comes down by 20% to 80%.
  - While Volume comes down by 20%, average trader surplus goes up
  - However, short term (day) traders, who provide liquidity not only through limit orders, but also through market orders, and contribute to more than 60% of volume are adversely affected.
  - So, stock exchanges will have to be compensated not just based on volume.
  - And,
    - We need a better understanding of the role of short term traders
    - How trader behavior will change under auctions.

Very few papers in the literature on this. Baruch and Glosten (2013) is an exception.

Data for the Study

Data for the Study

- One stock, 56 trading days, NSE from April - June 2006.
- Two fast crashes May 19th, one May 22nd caused a market suspension.
  - More than 3% price drop in 15 minutes and recovery by more than 3% in 15 minutes

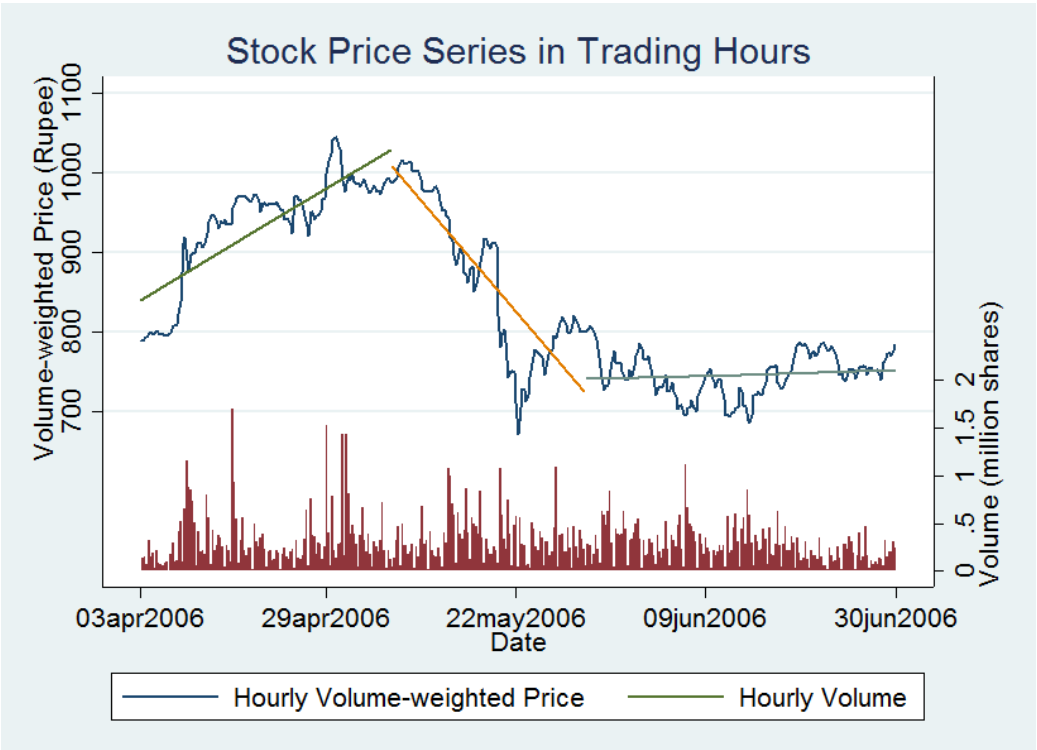
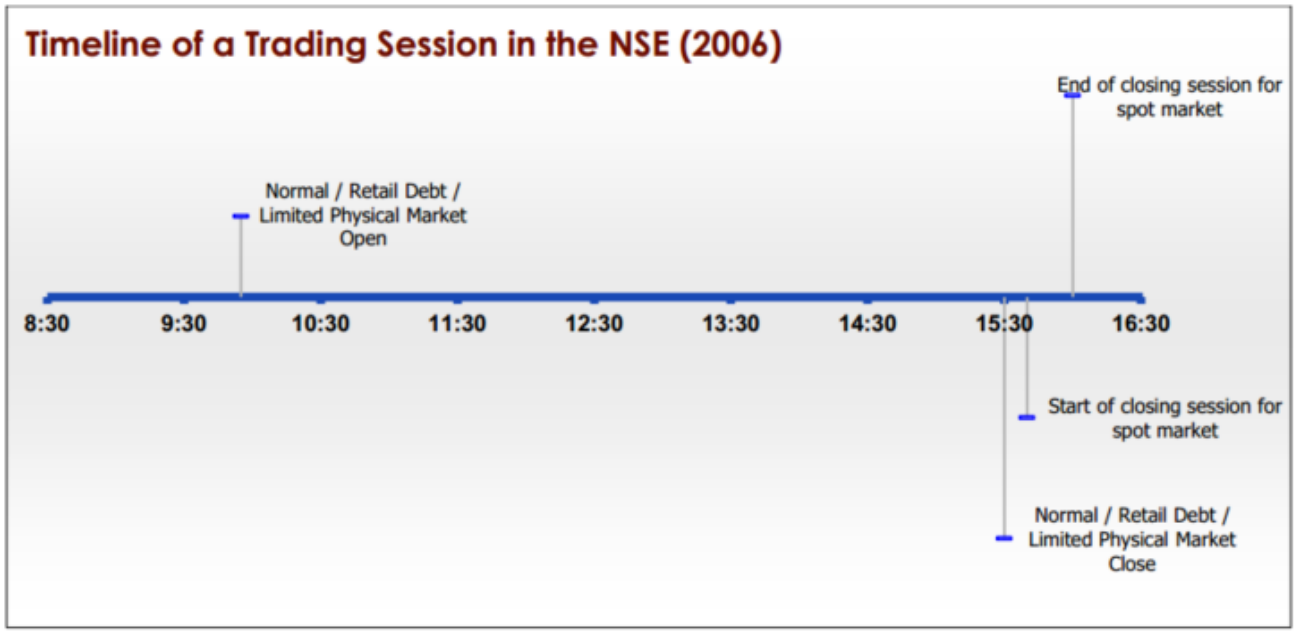


Figure: Hourly Price and Volume Series

Timeline for Trading within a Day



Time	Event
9:55	Normal / Retail Debt / Limited Physical Market Open
15:30	Normal / Retail Debt / Limited Physical Market Close
15:40	Start of closing session for spot market
16:00	End of closing session for spot market

Figure: Trading Timeline

Source: Getmansky, Jagannathan, Pelizzon and Schaumburg 2015

Data Descriptive Statistics

Here we report the mean of some daily measures in the two crash days and other regular days.

Table: Descriptive Statistics of the Data

	May 19th	May 22nd	Other Days
N of Days	1	1	54
Daily Volume (K)	3457.9	2273.6	2037.4
Regular Session (K)	3457.2	2270.0	2035.7
Closing Session (K)	0.7	3.6	1.8
Daily N of Trades	48719	34671	31914
Daily N of Traders	8349	6957	5475
Trade Size	71.0	65.6	63.2
Order Size	204.2	171.9	198.4
log high-low-range	0.16	0.26	0.05
Daily Return	-17.3%	-3.3%	0.5%
Fill Rate	53.6%	58.7%	46.5%

Note: Log high-low-range is the natural logarithm of the highest price divided by the lowest price in a day. Fill rate is the quantity-weighted order-level traded volume divided by initial order size.

Trader Types (Based on Getmansky et al 2015)

Getmansky et al (2015) classify traders in this data set into seven types:

- Small: Traders who trade volumes less than or equal to 750 shares (1 contract) on a given day.
- STT Prop: Trading on own account and with day end inventory to traded volume ratio is less than 10%.
- STT Retail: Non-prop traders and whose day end inventory to traded volume ratio is less than 10%.
- OLTT Prop: Traders who trade on their own account, and whose day end inventory to traded volume ratio is greater than 10%
- OLTT Retail: Non-prop traders and whose day end inventory to traded volume ratio is greater than 10%.
- Mutual Funds: Traders who are classified as mutual funds.
- FIIs: Traders classified as Foreign Institutional Investors.

Trader Types (Based on Getmansky et al 2015) .

Given the classification of traders for each day:

- Compute the mode of the class for each trader across all trading days.
- If the mode is not *Small* then the modal category is assigned to that trader for the entire sample period (Apr, 2006 - Jun, 2006).
- If the modal category is *Small* and the "*Small*" days $>$ 67% active trading days, the trader is assigned to *Small*.
- When the modal category is *Small* but the "*Small*" days $\leq$ 67%, the trader is assigned the modal category for the days when the trader did not behave as *Small*.

Hypothetical 1-second Very FBA vs Actual

1-second Auction is Close to Continuous Trading

Volume-weighted prices in each second are close even during the most severe fast crash.

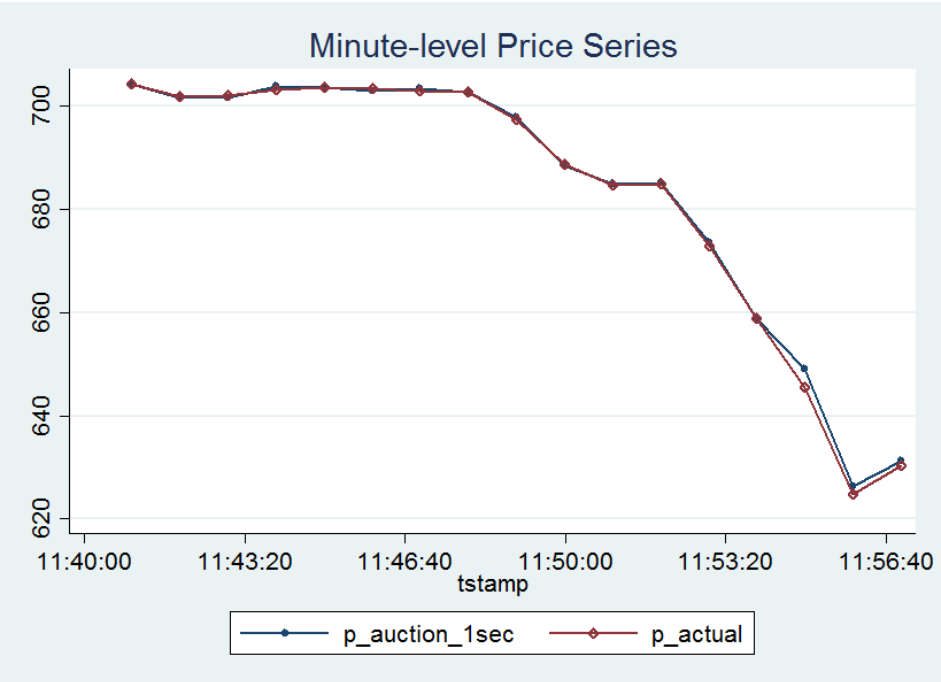


Figure: Minute-level Price Before the Market Suspension at May 22nd

1-second Auction is Close to Continuous Trading .

Volume by trader types in each second are close even during the most severe fast crash.

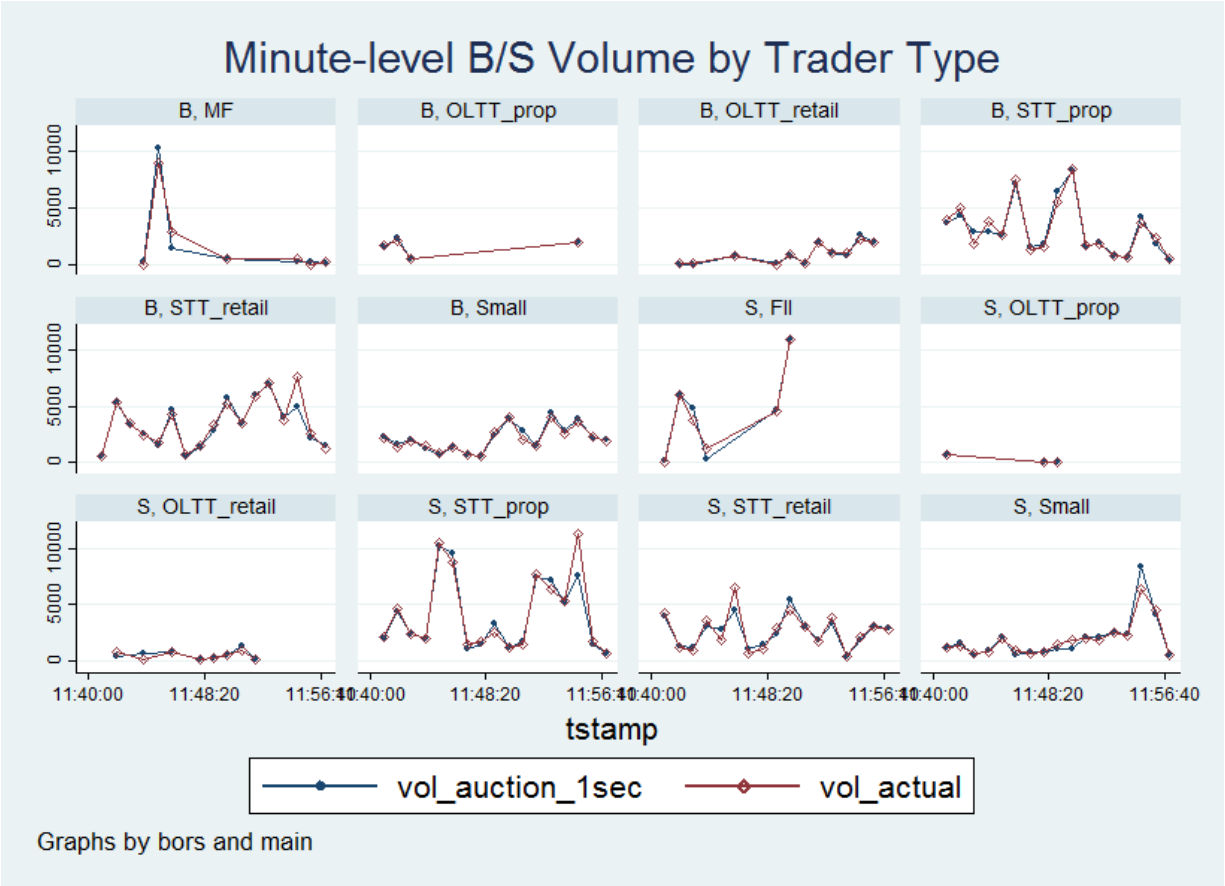


Figure: Minute-level Buy and Sell Volume by Trader Type Before the Market Suspension at May 22nd

1-second Auction is Close to Continuous Trading

Table: Average Daily Profit by Trader Type from May 17 to May 24

	Continuous Trading (Actual)			1-sec Auction			1-min Auction		
Daily Profit (M)	May 19	May 22	Other	May 19	May 22	Other	May 19	May 22	Other
FII	0.0	7.8	-0.8	0.0	8.0	-0.2	0.0	9.2	-9.2
MF	-0.3	-4.0	1.6	0.2	-3.8	1.3	-0.7	-4.1	4.7
OLTT_prop	9.5	1.6	-1.0	9.1	1.7	-0.9	7.9	2.6	-1.8
OLTT_retail	-4.1	0.7	-0.6	-2.4	0.7	-0.7	-0.2	-2.3	3.2
STT_prop	1.4	-2.6	-0.2	0.7	-2.2	-0.2	-2.3	-1.5	-0.8
STT_retail	-3.6	-1.1	0.1	-4.8	-2.0	0.2	-2.8	-0.6	-0.7
Small	-3.5	-2.4	0.6	-3.1	-2.4	0.6	-3.7	-3.2	1.4

Hypothetical Less Frequent 1-Minute Auctions vs Actual

1-min Auction: End of Day Inventories of STTs Increase

Table: End-of-the-Day Inventory to Trading Volume Ratio

	Continuous Trading (Actual)			1-min Auction		
Avg. EoD Inv. to Vol.	May 19th	May 22nd	Other Days	May 19th	May 22nd	Other Days
FII	100%	100%	100%	100%	100%	100%
MF	100%	99%	96%	100%	99%	96%
OLTT_prop	37%	76%	35%	38%	82%	39%
OLTT_retail	80%	79%	68%	85%	82%	72%
STT_prop	0%	1%	4%	9%	11%	14%
STT_retail	1%	2%	3%	14%	15%	17%
Small	18%	22%	13%	27%	33%	25%

Less Frequent Batch Auctions: Volume Declines

The ratio can be greater than 1 since we ignore the sequence in which order modifications arrive within a second for programming convenience.

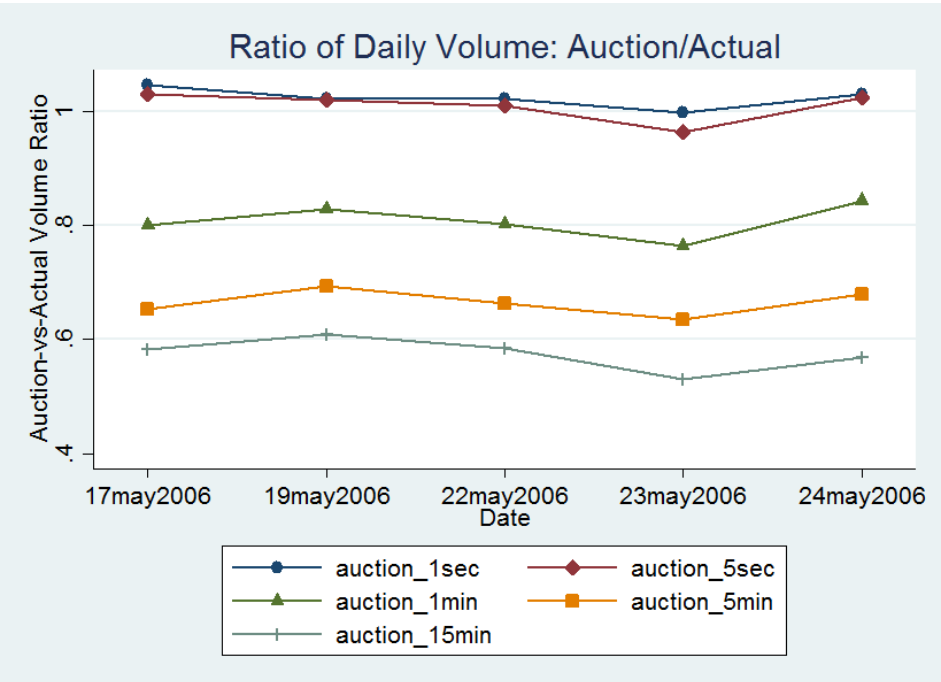


Figure: Ratio of Daily Volume from May 17th to May 24th

Volume Declines When Frequency Declines: An Example

Why Volume Declines: An Example

Four limit orders arrive.

Table: A List of the Limit Orders

ord_no	b_or_s	p	q
1	S	100	100
2	S	200	500
3	B	100	100
4	B	200	500

Sinvle Batch Auction: Example

Market-clearing price is 200, trading volume is 500, and trader surplus $(\sum(P_{limit} - P_{auction}) \cdot \Delta Q)$ is $10,000$.

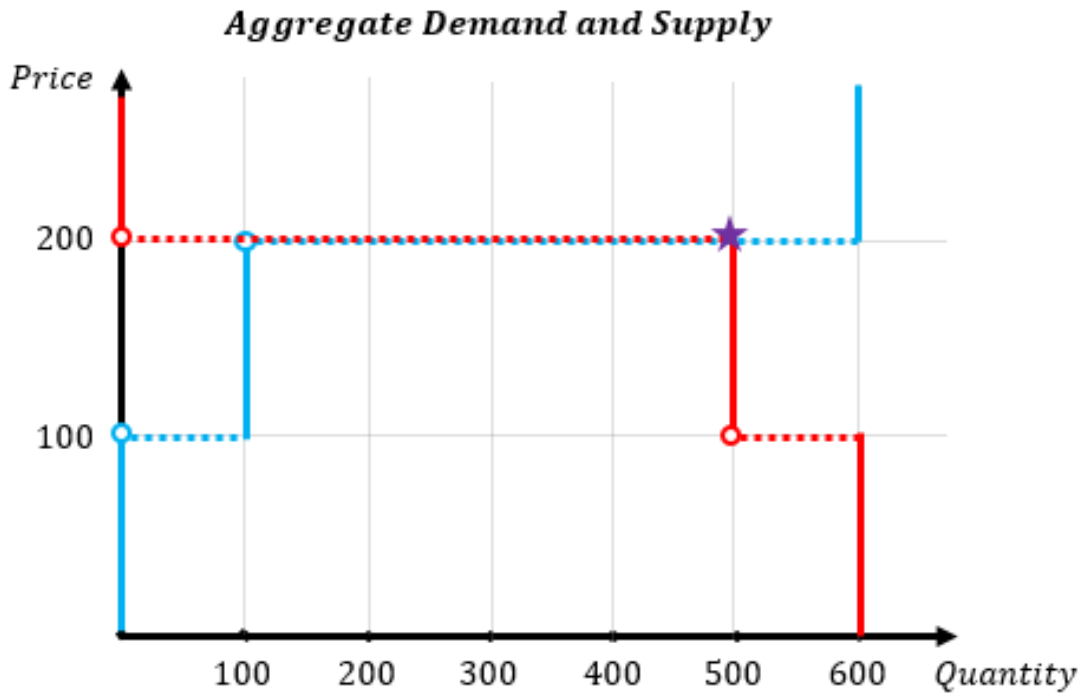


Figure: Aggregate Supply and Demand

Single Batch Auction: Example

After the auction, there will be two orders left in the limit order book.

Table: Left Orders of Batch Auction

ord_no	b_or_s	p	q
2	S	200	100
3	B	100	100

Continuous Auction (no time priority): Example

There are $4 * 3 * 2 * 1 = 24$ possible order arrival sequences. Under continuous auctions, an auction is conducted every time a new order arrives. The 24 possible order sequences can be classified into three categories.

Table: Market Dynamics of Different Sequences

category	# of cases	price	vw price	volume	trader surplus
1	8	200	200	500	10000
2	8	100→200	183.3	600	0
3	8	200→100	183.3	600	0

Volume $\mu = 566.7$, trader surplus $\mu = 3333.3$, vw price: $\mu = 188.9$ and $\sigma = 7.9$. Note: arrival sequence creates volatility

Liquidity Shock: Batch Auction

What happens next if the following two orders arrive at the end?

ord_no	b_or_s	p	q
1*	S	1	1
2*	B	1	1

In batch auction, price will drop from 200 to 100.

In continuous auctions, the order books are empty under category 2 and 3, so the price crashes to 1.

Table: Market Dynamics of Different Sequences

category	# of cases	price	vw price	volume	trader surplus
1	8	200→100	100	1	99
2	8	200→1	1	1	0
3	8	100→1	1	1	0

Single Batch Auction vs Continuous Auctions: Properties

To summarize:

- Trading volume is lower in Batch
- Trader surplus is higher in Batch

- Crashes can be less severe in Batch

Continuous trading will be similar to continuous auctions

Extension to Multiperiods: Batch vs Continuous Auctions

In each period, the same four orders as in the single-period example, arrive.

- Conclusions regarding properties of prices and volume continue to hold
- In periodic batch auctions, the buy and sell orders carried forward in the book will increase by 100 from one auction to the next.
- In continuous auctions, the buy and sell orders on the book will stabilize at 500.
- In both cases, the buys on the book will be at price of 100, and sells will be at price of 200 from one auction to the next.

Back to the Data

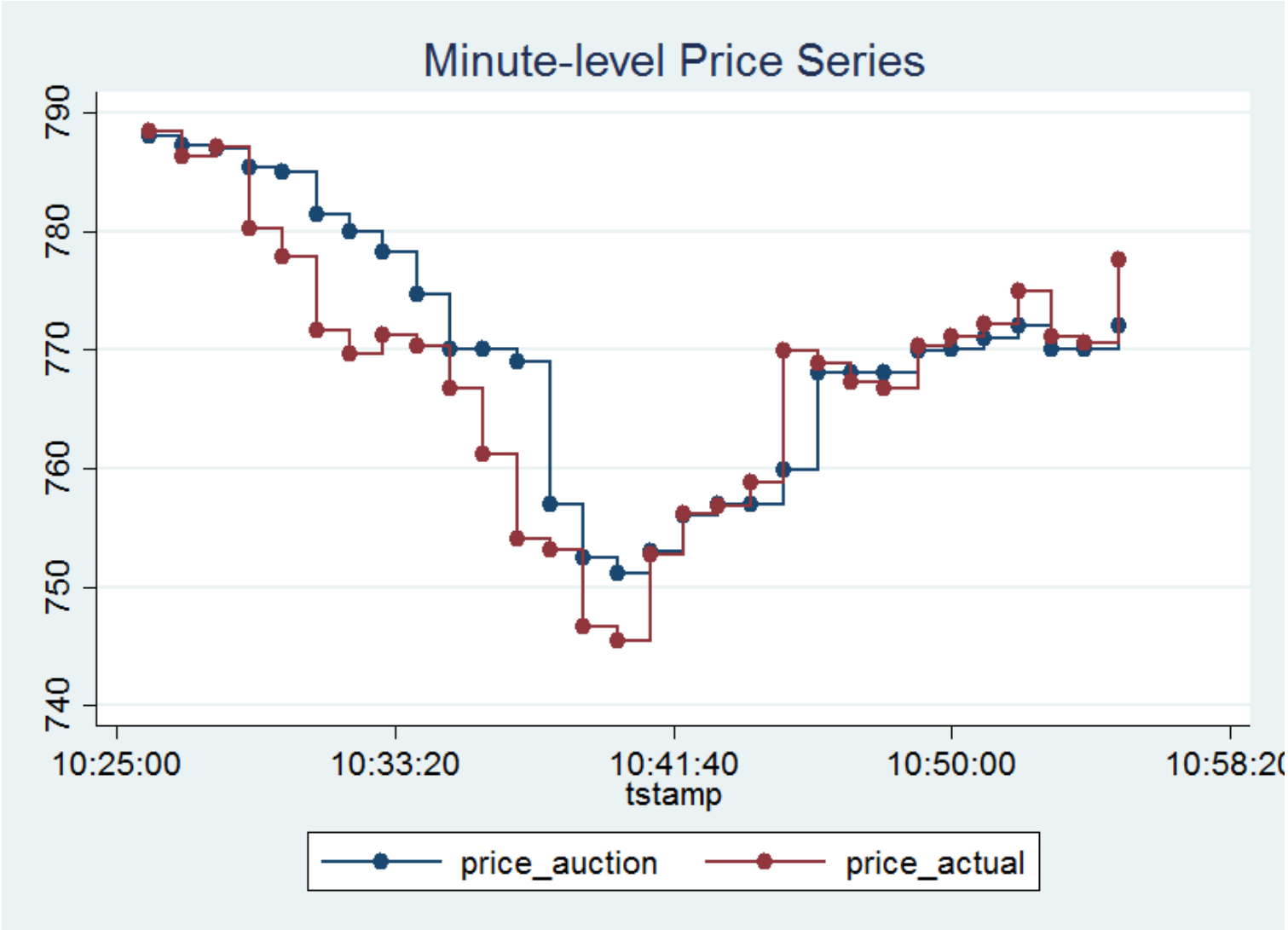
Change in Volume: Actual to 1-min Auctions

Table: Change in Volume Across Trader Types from Continuous to 1-min Auction

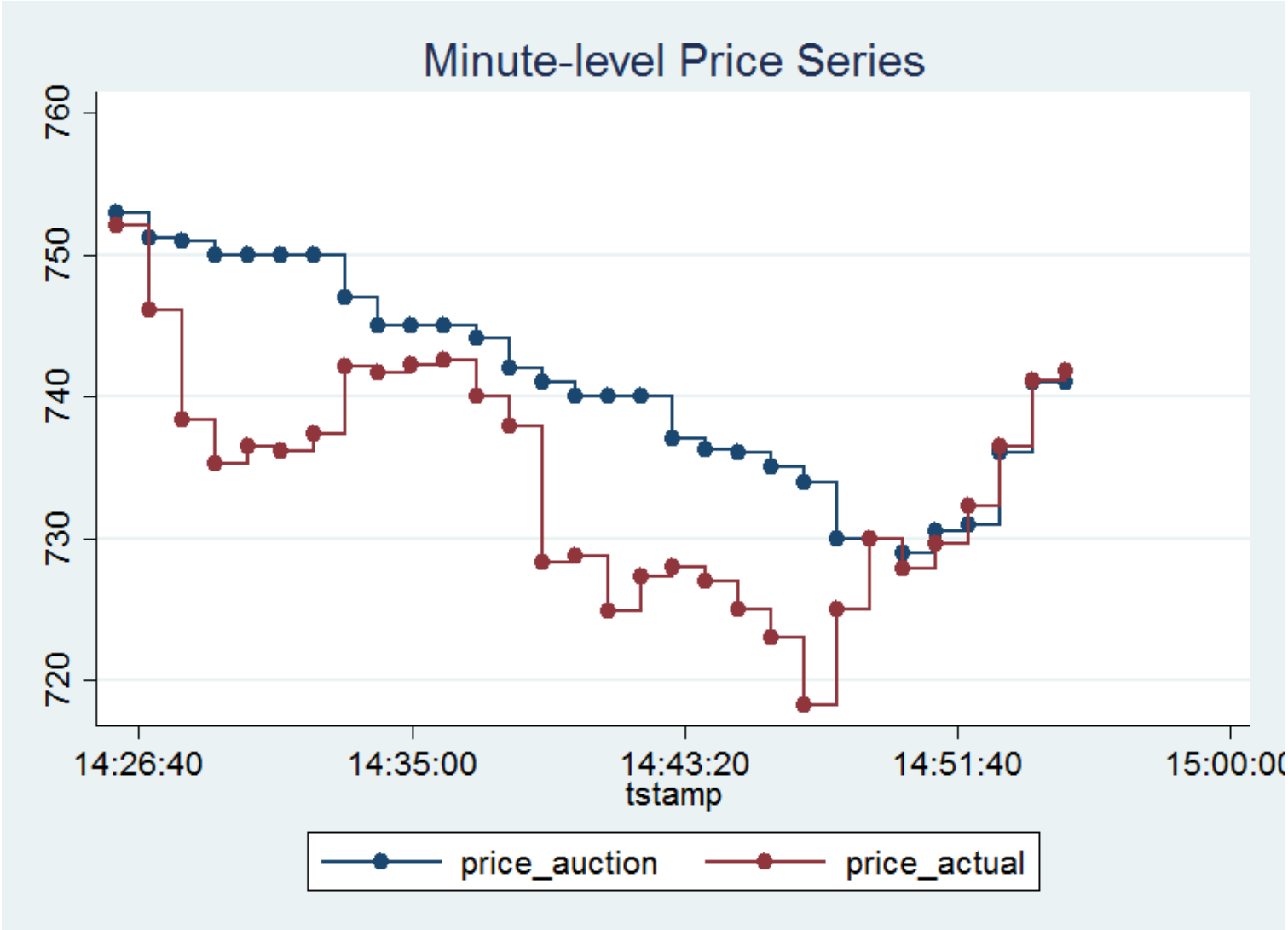
	Volume Change Ratio							
	Full Sample		Crash 1		Crash 2		Crash 3	
Category	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell
FII	-1%	-1%	0%	-7%	0%	-1%	0%	2%
MF	0%	-1%	-8%	0%	3%	0%	-3%	0%
OLTT_prop	-1%	-1%	0%	-1%	-1%	-2%	-1%	1%
OLTT_retail	-2%	-1%	-1%	-5%	-1%	-1%	0%	-1%
STT_prop	-8%	-8%	-10%	-4%	-6%	-6%	-3%	-9%
STT_retail	-4%	-4%	-3%	-3%	-6%	-1%	-5%	-3%
Small	-1%	-2%	0%	-1%	-1%	-2%	0%	-3%
Total	-18%	-18%	-21%	-21%	-12%	-12%	-13%	-13%

Note: For example, the buy volume change ratio of trader category i is calculated as $(BuyVolume^{i}_{auction} - BuyVolume^{i}_{actual}) / \sum_i BuyVolume^{i}_{actual}$.

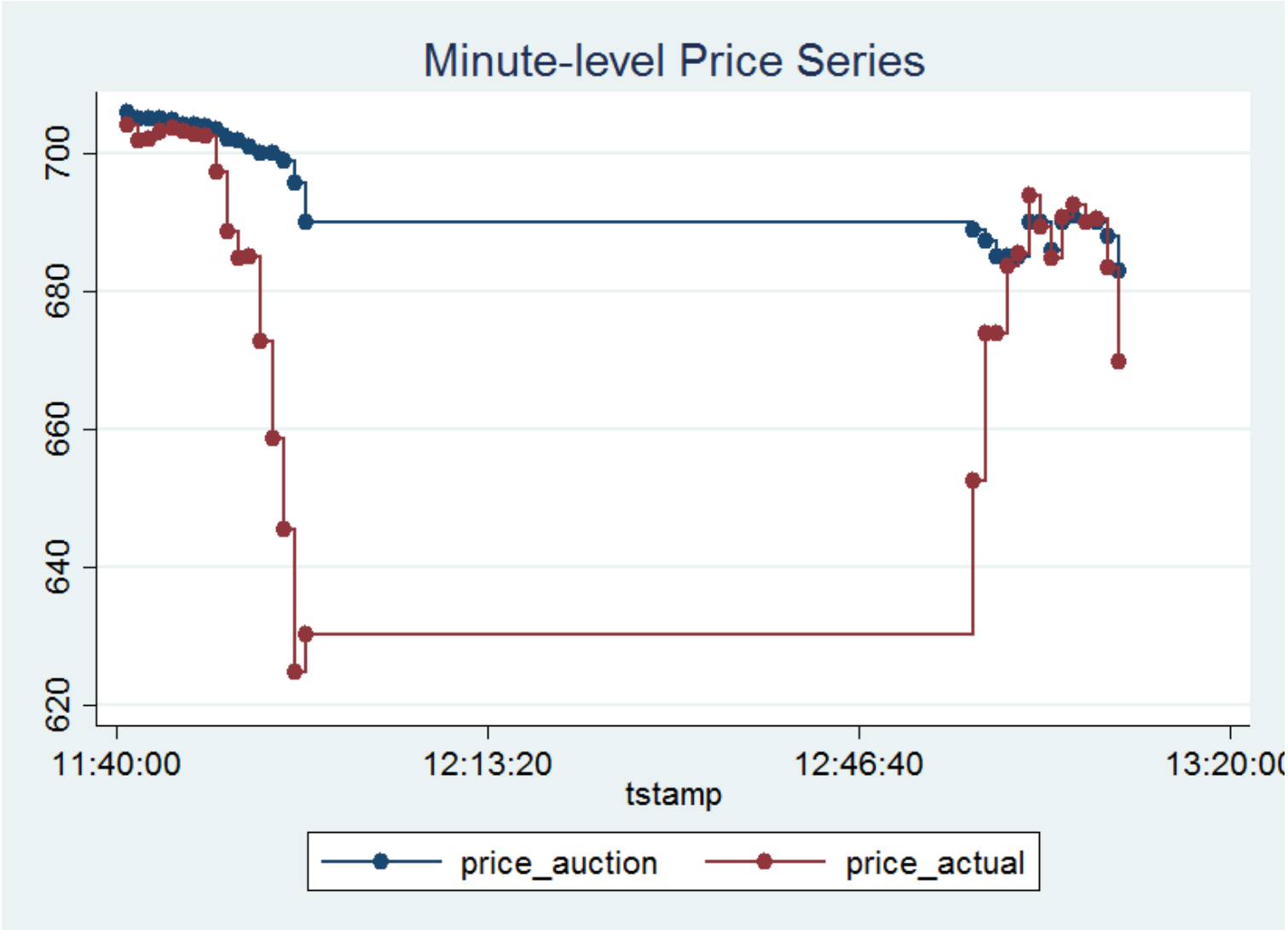
Prices in Crash 1, May 19: Actual vs 1-min Auctions



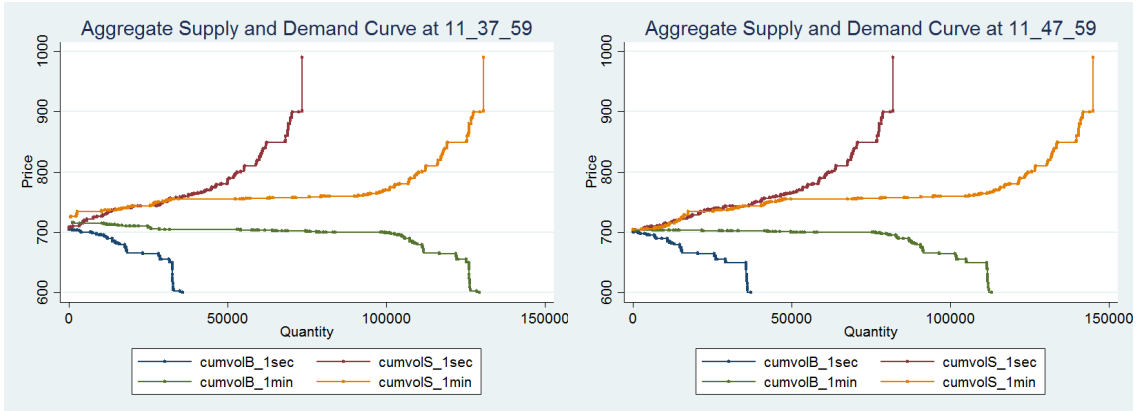
Prices in Crash 2, May 19: Actual vs 1-min Auctions



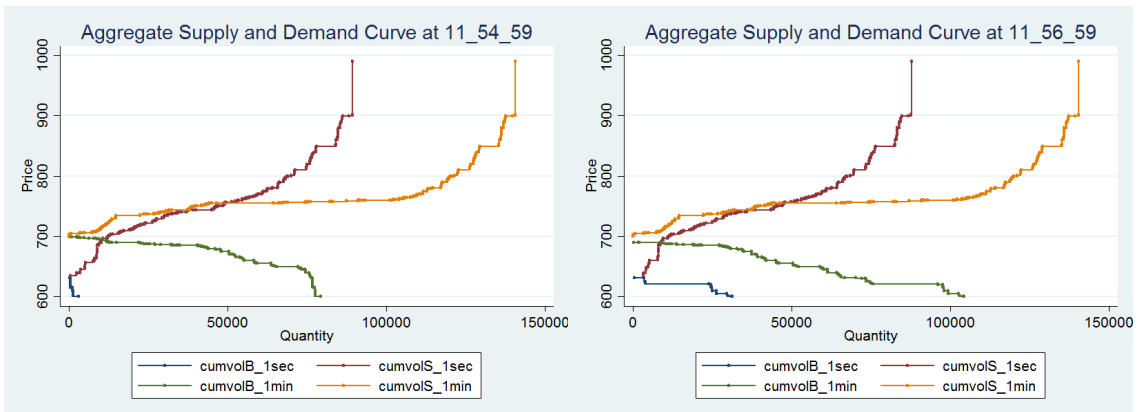
Prices in Crash 3, May 22: Continuous vs 1-min Auctions



LOB Before Suspension: 1-min vs 1-sec Auctions



(a) 11:37:59 (b) 11:47:59



(c) 11:54:59 (d) 11:56:59

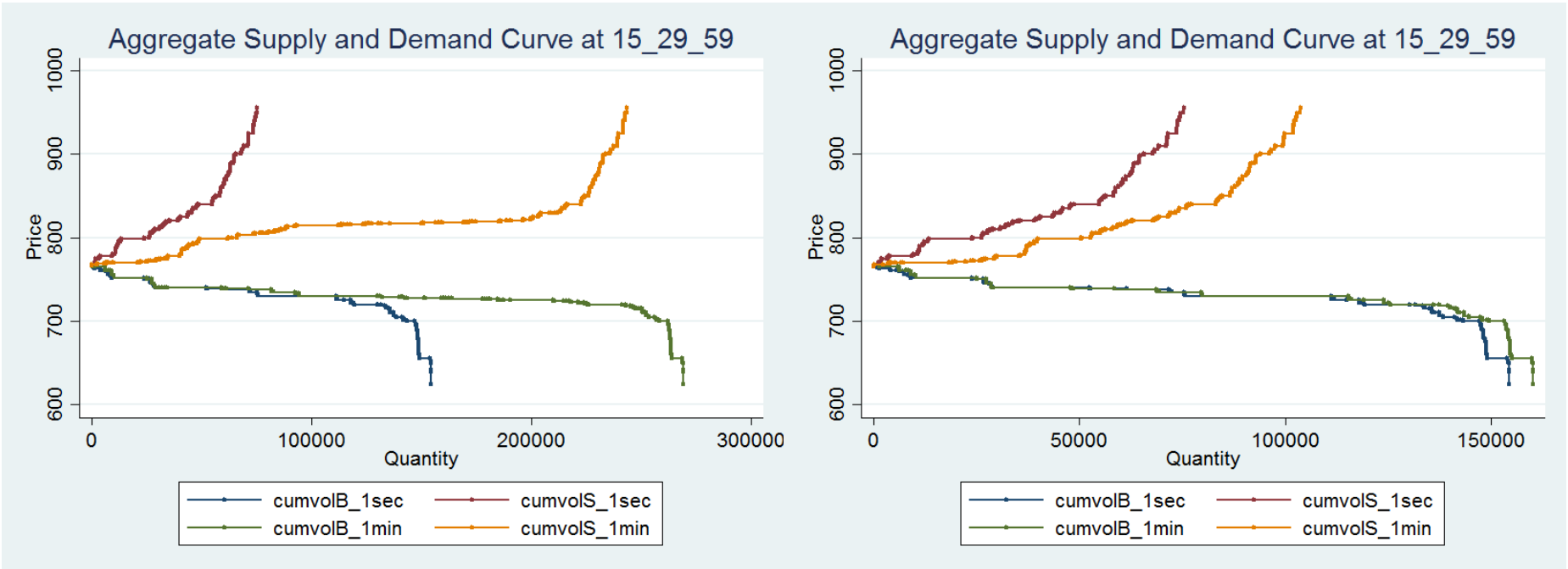
Figure: Supply and Demand Curves Before Market Suspension

Accounting for Order Cancellations

- Some orders that were executed under continuous trading may not be executed in the 1-min auction.
- We will carry such orders for a maximum of 15 future auctions
- Orders which remain unexecuted after participating in 15 1-min auctions are canceled.
- Denote this as "15-min Rule".

15-min Rule: Effect on End of Day LOB

With the cancellation rule, the residual orders are largely reduced.



(a) No rule on Cancellation (b) Cancel unexecuted after 15 min

Figure: End of the Day Supply and Demand: May 19th

15-min Rule: Effect on Order Duration

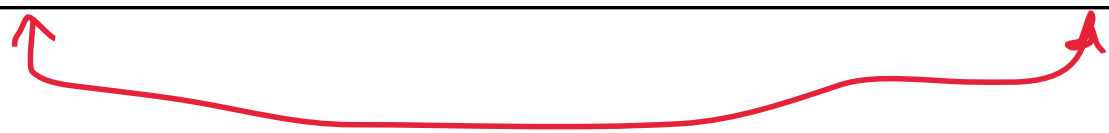
Table: VW Executed Order Duration by Trader Type from May 17 to May 24

	Continuous Trading (Actual)			1-min Auction			1-min Auction (15-min Rule)		
VW Dur. (min)	May 19	May 22	Other	May 19	May 22	Other	May 19	May 22	Other
FII	1.0	1.3	0.8	3.0	8.7	3.5	2.8	1.6	2.8
MF	3.5	5.6	1.5	2.9	8.6	2.4	3.1	7.4	1.9
OLTT_prop	0.6	4.6	2.2	3.6	7.8	2.2	1.9	7.1	1.2
OLTT_retail	5.6	14.0	11.8	13.6	22.0	21.0	7.2	16.4	8.3
STT_prop	1.0	0.8	1.0	9.6	4.9	4.6	2.9	2.5	2.6
STT_retail	2.6	3.3	5.1	8.8	6.9	7.6	4.4	3.8	5.4
Small	7.0	5.1	6.3	12.4	9.0	7.8	8.0	6.1	5.9

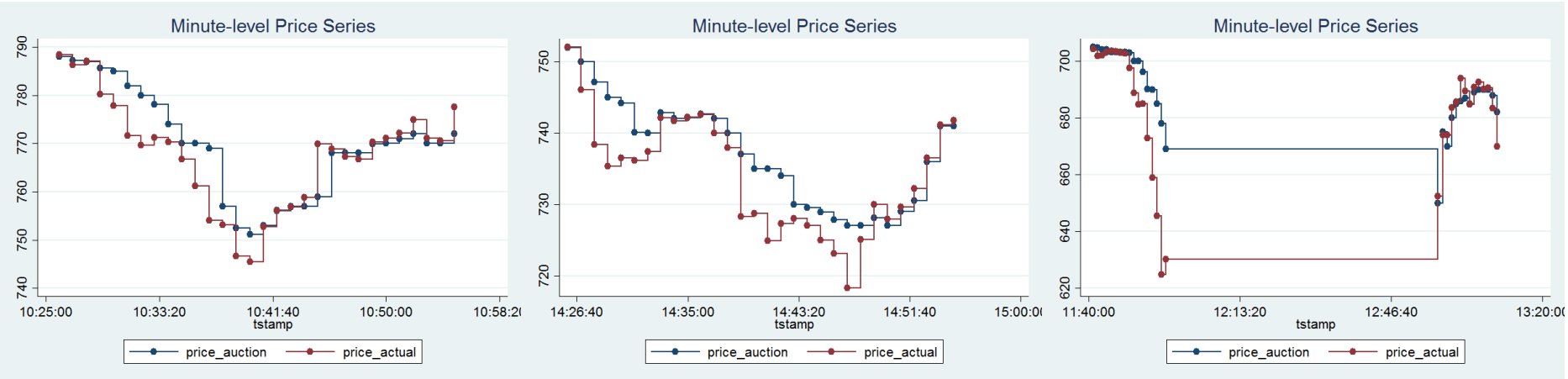
15-min Rule: Effect on Order Duration

Table: VW Canceled Order Duration by Trader Type from May 17 to May 24

	Continuous Trading (Actual)			1-min Auction			1-min Auction (15-min Rule)		
VW Dur. (min)	May 19	May 22	Other	May 19	May 22	Other	May 19	May 22	Other
FII	0.3	33.0	112.9	157.8	137.1	206.5	10.3	32.3	118.0
MF	33.9	23.9	221.6	119.9	82.0	244.1	25.6	21.6	199.6
OLTT_prop	4.9	7.0	4.3	71.8	115.0	25.3	6.6	17.0	10.0
OLTT_retail	43.8	43.6	129.5	73.5	96.2	129.1	33.1	35.8	100.6
STT_prop	1.0	2.9	10.3	13.1	24.0	29.8	2.1	3.8	11.1
STT_retail	12.0	11.1	34.7	36.8	51.4	68.5	10.0	11.6	28.2
Small	66.0	51.3	146.4	98.8	92.7	175.5	44.2	38.4	104.4



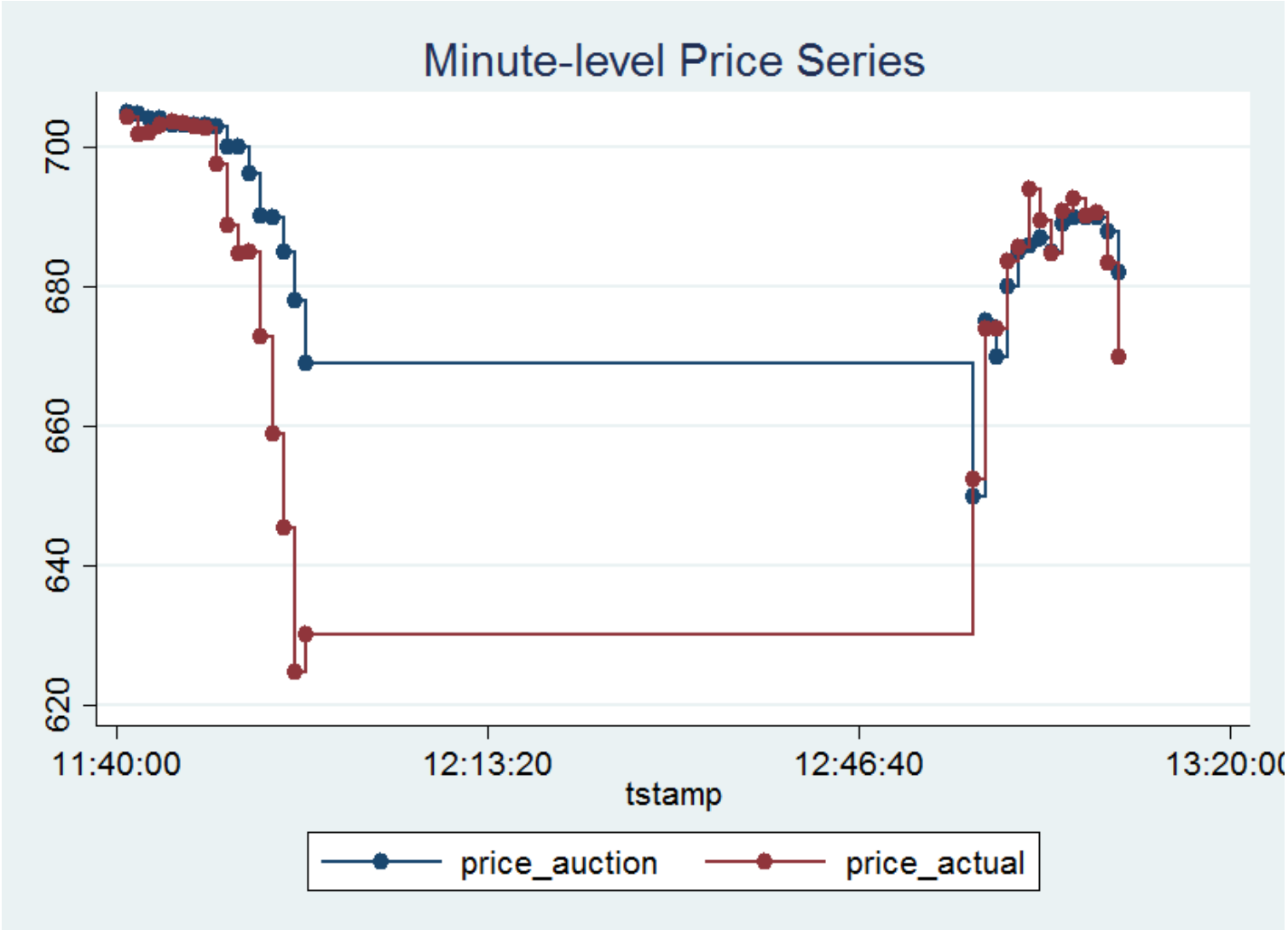
15-min Rule: Effect on Prices in Crashes



(a) May 19th Crash 1 (b) May 19th Crash 2 (c) May 22nd Crash 1

Figure: Prices during Crashes with 15-min Cancellation Rule

15-min Rule: Effect on Prices in Crashes



Summary & Conclusion

- Continuous trading vs. very frequent – 1-second batch auctions:
  - Price and volume patterns are very close
- Continuous trading vs. less frequent – 1-minute batch auctions:
  - Prices are less volatile, crashes are less severe
  - Trading volume falls significantly
  - Average Trader surplus goes up
- Need for theory that will lead to a better understanding of:
  - The behavior of short term traders who carry very little inventory overnight but contribute significantly to intra day liquidity provision and trading volume.
  - How trader behavior will change when moving from continuous trading to frequent batch auctions