

Do Volatility Extensions Improve the Quality of Closing Call Auctions?

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A Volatility bands

The CCA extension is triggered when the auction equilibrium price deviates from the reference price by more than a prespecified threshold. For the opening call auction the reference price is the closing price of the previous trading day, whereas for the CCA it is the price of the last trade of the continuous trading session. The threshold depends on stock-specific characteristics (e.g., whether the stock is a penny share, the liquidity group it belongs to, or whether it is a First North stock). Exceptionally, NASDAQ Nordic may readjust the thresholds when required.

Table IA.1 reviews the volatility thresholds applied to the different stock categories at the opening and closing call auctions for the NASDAQ Nordic segments that are of interest for this study.

[Insert Table IA.1 Here]

Our data do not contain explicit information on the thresholds applied to each stock. We infer the thresholds from the prices of the stocks and additional information on the liquidity group, stock category, and segment found in documents published by NASDAQ Nordic.¹

As an example, we present the procedure we follow to determine the threshold to apply for each stock and whether the volatility extension should be triggered.

¹ We refer to the following documents: Auction Safeguards and Extension Period in Opening and Closing Auction Q&A. Available at: http://www.nasdaqomx.com/digitalAssets/95/95742_q-a-auction-safeguards-and-extension-nov-2014.pdf. Monthly Report – Equity Trading by Company and Instrument November 2014. Available at <https://www.globenewswire.com/news-release/2014/12/08/689480/0/en/Monthly-Report-Equity-Trading-by-Company-and-Instrument-November-2014.html>. Nasdaq Nordic Market Model 2015:03. Available at: http://www.nasdaqomx.com/digitalAssets/97/97551_nasdaq-omx-nordic-market-model-2015_03.pdf

Table IA.2 contains a snapshot of the last minutes of trading for two stocks: the mid-cap THULE.ST in Panel A and the small-cap RABTb.ST in Panel B. Both stocks have a default threshold of 5%. Since, according to NASDAQ documents, they do not fall in the penny share, First North, or liquidity group C categories, the default threshold applies to them. For THULE.ST, the price of the last trade is SEK 92 and the closing price is SEK 97. Since the difference in price is greater than the threshold of 5%, the auction extension is triggered. During the auction extension, new orders are submitted and the final price is set at SEK 94, which is below the threshold. For RABTb.ST, the price of the last trade is SEK 4.26 and the closing price is SEK 4.52. Since the difference in price is greater than the threshold of 5%, the auction extension is triggered. During the extension, traders do not submit new orders or modify existing ones. The auction is executed at the price of SEK 4.52.

[Insert Table IA.2 Here]

Table IA.1. Volatility Bands for NASDAQ Nordic Segments

This table summarizes, for different stock categories, the volatility thresholds determining when the call auction extension is triggered for NASDAQ Stockholm, Helsinki, and Copenhagen. Note that Copenhagen and Helsinki only have auction extensions implemented during the opening call auction. The technical details presented here are based on the NASDAQ Nordic market model (NASDAQ Nordic, 2015), which contains information on auction extensions in Appendix U.

<i>Stock Category</i>	<i>Threshold Opening Auction</i>	<i>Threshold Closing Auction</i>
Main index constituents ^a	±6%	±3%
Small-caps, mid-caps, and large-caps ^b	±10%	±5%
Illiquid shares ^c	±20%	±10%
Penny shares		
0.25 SEK/DKK < price < 5 SEK/DKK or 0.025 EUR < price < 0.5 EUR	±50%	±25%
0.1 SEK/DKK < price < 0.25 SEK/DKK or 0.01 EUR < price < 0.025 EUR	±80%	±40%
0.05 SEK/DKK < price < 0.1 SEK/DKK or 0.005 EUR < price < 0.01 EUR	±100%	±50%
0 SEK/DKK < price < 0.05 SEK/DKK or 0 EUR < price < 0.005 EUR	±200%	±100%

^a The main index constituents are OMXS30, OMXH25, and OMXC20 for Stockholm, Helsinki and Copenhagen, respectively.

^b Excluding the main index constituents, Liquidity Group C shares, and penny shares.

^c As defined by NASDAQ Nordic (2014b) Liquidity Group C shares. A stock is listed in this category when, the previous month, it traded less than 50% of the days, its average daily turnover was below SEK/DKK 200,000 (or EUR 20,000), or its average spread was greater than 5%.

Table IA.2. Example of auction extension

This table shows two examples of auction extensions for the mid-cap stock THULE.ST in Panel A and the small-cap stock RABTb.ST in Panel B. Both stocks fall within the threshold category of 5%. The table is a snapshot of the last minutes of trading for the two stocks. The data are obtained from the Tick History database, maintained by Refinitiv.

Panel A: THULE.ST (13 February 2015)

<i>Period</i>	<i>Timestamp</i>	<i>Action</i>	<i>Price</i>	<i>Volume</i>	<i>Bid Price</i>	<i>Bid Size</i>	<i>Ask Price</i>	<i>Ask Size</i>
LOB	5:21:56 PM	Trade	92	492				
	5:21:57 PM	Quote			91.5	734	92	500
	5:24:16 PM	Quote				500		
Auction	5:25:50 PM	Quote			105	30,000	105	29,404
	5:25:00 PM	Indicative price	105	29,404				
	...							
	5:27:59 PM	Quote			104.5		104.5	34,377
	5:27:59 PM	Indicative price	104.5	30,032				
	5:28:24 PM	Quote			99		99	33,792
	5:28:24 PM	Indicative price	99	30,032				
	5:29:34 PM	Quote			97		97	34,920
Extension	5:29:34 PM	Indicative price	97	30,032				
	5:32:48 PM	Quote			94	30,232	94	14,129
	5:32:51 PM	Trade	94	14,129				

Panel B: RABTb.ST (17 December 2014)

<i>Period</i>	<i>Timestamp</i>	<i>Action</i>	<i>Price</i>	<i>Volume</i>	<i>Bid Price</i>	<i>Bid Size</i>	<i>Ask Price</i>	<i>Ask Size</i>
LOB	17:21:04	Trade	4.26	3,540				
	17:21:04	Quote			4.26	124		
Auction	17:25:00	Quote				8,540		
	17:26:53	Quote			4.52	50		
	17:26:53	Indicative price	4.52	50				
Extension	17:32:41	Trade	4.52	50				

B Clustering of Extraordinary Closing Price Volatility

In this Appendix we address the potential concern that the instances of extraordinary closing price volatility are clustered on a specific stock or day. Figure IA.1 is a bar chart of the number of *Extraordinary Closing Price Volatility* instances on each day of the sample period for both the treatment and the control group. The chart provides evidence that the instances of *Extraordinary Closing Price Volatility* are dispersed across time rather than being clustered on specific days, at the end of the quarter or at year-end.

[Insert Figure IA.1 Here]

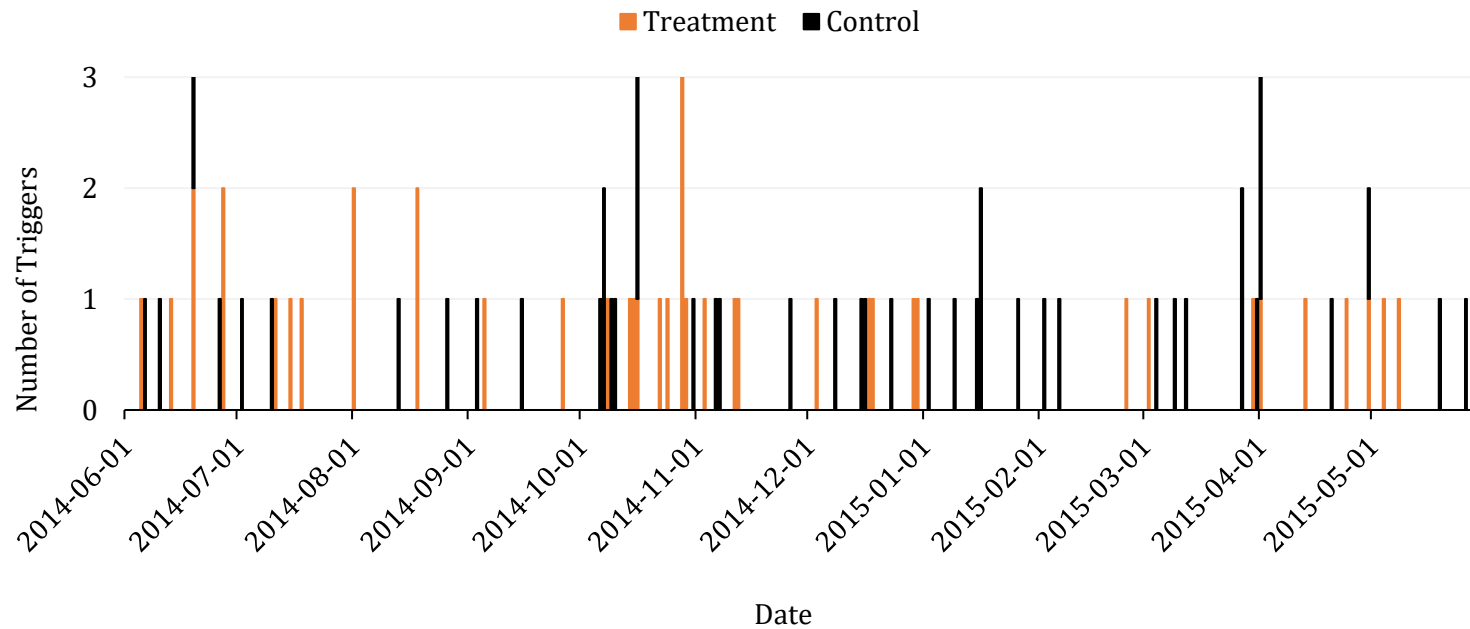
Next, we perform statistical tests to examine whether there is a day of the week effect. To this end, we conduct a chi-square test to examine whether the observed frequencies of each day of the week in our sample are consistent with the expected frequencies. The X^2 and p-value of the test are 2.37 and 0.67 respectively, and hence we do not reject the null hypothesis that the observed frequencies for each day of the week are the same as the expected frequencies (i.e., that each day of the week has an equal probability of experiencing a CCA extension) except for chance variation. Similarly, we perform a chi-square test to investigate whether there is a quarter effect. The corresponding p-value of the test is 0.71 and hence we can conclude that end of the quarter months have an equal probability of experiencing a CCA extension than the other months.

We further investigate whether a majority of the triggers of the CCA extensions happen on days where derivative contracts expire, and whether the instances of *Extraordinary Closing Price Volatility* are caused by only a handful of stocks. We do not find support for any of these claims. For both treatment and control, only one incidence

happens on a witching day for each group, ruling out the argument that CCA extensions are clustered on those days when derivative contracts expire. In a similar way, the instances of *Extraordinary Closing Price Volatility* are not caused by only a few stocks but by several. A total of 56 stocks experienced *Extraordinary Closing Price Volatility* during the sample period. Of these 56 stocks, 28 belong to the treatment group and 28 to the control group.

Figure IA.1. Instances of extraordinary closing price volatility

This figure shows the number of instances of *Extraordinary Closing Price Volatility* for each day of the sample period. For each day, the bar chart reports the number of stocks where the price change from the end of the continuous session to the end of the CCA is large enough to fulfill the conditions for a volatility extension. The results are reported for both the treatment group (NASDAQ Stockholm) and the control group (NASDAQ Copenhagen and Helsinki). The sample period contains all trading days from 1 June 2014 to 31 May 2015.



C Robustness Tests

As discussed in Section 5.3, manipulators have economic incentives to concentrate their activities to the last few seconds of the auction. This motivates us to focus on the very end of the CCA when proxying market integrity. If the measurement horizon is set too short, however, we risk overlooking part of the manipulative order flow. Based on these considerations, we believe that a 10-second horizon strikes a good balance. However, in this appendix we consider two alternative horizons: 20 and 30 seconds.

Table IA.3 follows the structure of Table 5. The only difference is the horizon used for the dependent variables. For the *Late Cancellation Rate*, the conclusions from the robustness test are in line with those from the baseline analysis. That is, the statistically significant drop in the *Late Cancellation Rate* is consistent with the idea of an improvement in market integrity. The results are also in line with Figure 2, Panel A, where after the introduction of the extensions, it is visually noticeable a decrease in the number of cancellations during the last 45 to 30 seconds of the auction. We caution, however, that such long horizons are difficult to reconcile with the economic incentives of manipulative strategies.

[Insert Table IA.3 Here]

For the *Late Order Imbalance*, which is significantly negative in the baseline analysis, the coefficients of interest are negative but not statistically significant when considering the longer horizons. This is consistent with the view that manipulative strategies are concentrated to the very end of the order entry phase. The results are also consistent with Figure 2, Panel B, where it is visible that the decrease in order imbalances

is concentrated at the last few seconds of the auction. The figure instead motivates a shorter horizon. In Column (5), we thus consider the *Late Order Imbalance* measured at a 5-second horizon. This yields a significantly negative estimate of greater magnitude than for the 10-second specification.

Table IA.3. Difference-in-differences analysis of market integrity

This table repeats the analyses of Table 5, with the only difference being the time horizons used for the dependent variables. *Late Cancellation Rate* is the ratio between the EUR volume cancellations occurring in the last 30 seconds (Column 1) and in the last 20 seconds (Column 2) of the auction and the EUR *Closing Volume*. *Late Order Imbalance* is the ratio between the average bid-ask EUR *Order Imbalance* of the last 30 seconds (Column 3), of the last 20 seconds (Column 4) and of the last 5 seconds (Column 5) of the batching period and the overall average *Order Imbalance* of the batching period (excluding the last 30, 20 and 5 seconds, respectively). All other definitions are the same as in Table 5.

	<i>Late Cancellation Rate (30 sec) (1)</i>	<i>Late Cancellation Rate (20 sec) (2)</i>	<i>Late Order Imbalance (30 sec) (3)</i>	<i>Late Order Imbalance (20 sec) (4)</i>	<i>Late Order Imbalance (5 sec) (5)</i>
Intercept	0.945*** (0.005)	0.932*** (0.005)	0.936*** (0.004)	0.929*** (0.005)	0.924*** (0.007)
<i>Treatment</i> _{<i>i,t</i>}	0.134*** (0.028)	0.148*** (0.042)	0.029*** (0.007)	0.039*** (0.010)	0.068*** (0.013)
<i>Post</i> _{<i>i,t</i>}	0.009** (0.005)	0.000 (0.005)	-0.008 (0.011)	-0.008 (0.016)	0.000 (0.011)
<i>Treatment</i> _{<i>i,t</i>} <i>Post</i> _{<i>i,t</i>}	-0.084*** (0.026)	-0.102** (0.046)	-0.001 (0.013)	-0.010 (0.018)	-0.043* (0.023)
<i>Volatility</i> _{<i>i,t</i>}	-0.001 (0.002)	0.001 (0.005)	0.005 (0.003)	0.008 (0.005)	0.011*** (0.003)
<i>Volume</i> _{<i>i,t</i>}	0.000** (0.000)	0.000* (0.000)	0.000*** (0.000)	0.000 (0.000)	0.000 (0.000)
Observations	11895	7942	10907	6566	2493
Adjusted R-Squared	0.01	0.01	0.01	0.01	0.01