ESSAYS ON ISSUES
THE FEDERAL RESERVE BANK OF CHICAGO
2015 NUMBER 343

Chicago Fed Letter

A new approach to stock market execution

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The Federal Reserve Bank of Chicago has published extensively on the risks and effects of high-frequency trading (HFT) in U.S. financial markets and has in the past expressed an interest in the concept of batch auctions as a potential way to diminish the speed advantage of HFT traders.[1] The Chicago Stock Exchange (CHX) recently filed an application with the U.S. Securities and Exchange Commission (SEC) to inaugurate CHX SNAP, an on-demand batch auction service. If and when approved, SNAP auctions would deemphasize speed and allow institutional traders to place large orders, with a reduced risk that information leakage results in adverse price movements against them.

Some have argued that HFT is often not about market fundamentals, but "a game against order books and the market rules."

The proposed introduction of CHX SNAP is a response to changes in market technology that have provided an increasing advantage to the fastest market participants and led to the rise of HFT firms that often exploit their speed advantage to trade ahead of large orders placed by institutional traders. This has a tendency to make institutional traders more reluctant to display large orders to the marketplace, thus reducing liquidity. In this *Chicago Fed Letter*, we discuss the purpose and operation of SNAP auctions in the high-frequency trading environment.

HFT firms are market participants that have invested heavily in technology and algorithms that allow them to trade at high speeds and in large volumes. They typically make many small trades in a day and hold limited, if any, positions overnight.

HFT firms use a variety of strategies in pursuit of trading profits. *Co-location*, whereby their servers are placed near the servers of exchanges, allows these firms to gain access to and process information about trades ahead of the broader market. They are then able to trade ahead of large orders placed by traditional investment firms and money managers. "If a high-speed firm's computers detect a large buy order for a stock … the firm will instantly start snapping up the stock, expecting to quickly sell it back at a higher price as the investor keeps buying."[2]

Another strategy used by HFT firms is *spoofing*, "a form of market manipulation which involves placing certain non-bona-fide order(s) … with the intention of triggering another market participant to join or improve the NBBO [national best bid or offer], followed by canceling the non-bona-fide order, and entering an order on the opposite side of the market."[3]

Some have argued that HFT is often not about market fundamentals, but "a game against order books and the market rules."[4] This game has increased the gains accruing to the fastest market player, leading to an escalating arms race for speed.

The race for speed can lead to an inefficient allocation of resources; "one can certainly question how socially useful it is to build fiber optic or microwave networks just to trade at millionths or billionths of a second rather than

thousandths of a second."[5] This arms race can also increase market fragility by increasing "the pressure on the plumbing of the system to handle ever-increasing speeds and message traffic."[6]

In a market environment frequented by HFT firms, slower market participants, whose larger orders are vulnerable to front-running and other HFT strategies, face a competitive disadvantage and may "withdraw from markets or seek other venues, fracturing liquidity."[7] Budish, Cramton, and Shim (2013) show that the race for speed leads to wider spreads and thinner markets for institutional investors because of the risk that liquidity providers face of having stale quotes picked off by faster market participants.[8]

In a market environment frequented by HFT firms, slower market participants face a competitive disadvantage.

SNAP auctions occur with minimal information leakage to the market and force competition on price rather than speed, which should reduce the risk fundamental traders face of having HFT firms move prices against their orders and the need to engage in the race for speed.

SNAP cycle overview

Throughout the trading day, market participants will be able to place orders to start or participate in a SNAP cycle for a particular security. Upon the receipt of a valid start SNAP order, CHX will notify the market that a SNAP cycle has begun and accept orders for execution within the SNAP cycle. At the end of the order acceptance period, CHX will rank all SNAP-eligible orders on its books to determine the SNAP auction price, the price at which the most buy and sell orders can be executed. If protected bids or offers at better prices exist on other stock exchanges, CHX will route orders to those exchanges to execute. Remaining orders will execute within the CHX SNAP book at the SNAP auction price. After orders have been matched, the SNAP cycle will end and CHX will transition back to regular trading in the security. The entire auction cycle will take place in under one second.

New order types and modifiers

As a part of the SNAP auction implementation, CHX is adopting two new limit-order types:

- *SNAP auction only order (AOO).* As soon as the trading day begins and until five minutes prior to the end of the regular trading session, CHX will accept SNAP AOO orders, subject to minimum size requirements. These orders will be queued until a SNAP cycle is initiated. As with dark pools, this queue is not visible to the market. SNAP AOO orders can be submitted with a "day" or "one-and-done" modifier, indicating that the order should stay in force for the entire trading day or one SNAP cycle only, respectively. If still unfilled, SNAP AOO day orders will be re-queued after a SNAP cycle based on the time the original order was received. A SNAP AOO order can be submitted with an explicit price or can be "pegged" to the national best bid (NBB), national best offer (NBO), or the NBBO midpoint at the start of a SNAP auction cycle. A SNAP AOO can also be pegged to an offset from the NBB or NBO, e.g., one penny better than the NBB. If pegged, the SNAP AOO order is not priced until the pricing and satisfaction period of a SNAP cycle, when a snapshot of the market is used to determine the NBB and NBO for the purpose of pricing pegged orders.
- *Start SNAP order.* These orders initiate a SNAP auction cycle, subject to minimum size and price requirements, including that the limit price of the start SNAP order must be priced at or through the NBBO. In order to make sure there is time for the market to establish itself before a SNAP auction takes place, start SNAP orders will be canceled if received within five minutes of when the first two-sided quote is received in the subject security. They will also be canceled if received within five minutes of the end of the regular trading session or within a minute of the completion of the previous SNAP cycle in the same security. If received during the order acceptance period of an ongoing SNAP cycle, they will be treated as SNAP AOO one-and-done orders unless explicitly marked otherwise. If received during any other portion of a SNAP cycle, a start SNAP order will be canceled.

Some orders will be ineligible for SNAP auctions. These will be canceled upon the start of a SNAP cycle in the subject security:

- Market participants will be able to submit orders with the modifier "cancel on SNAP," which marks them as SNAP ineligible.
- "Fill or kill" and immediate or cancel orders will also be SNAP ineligible.

Because the SNAP cycle requires routing and the suspension of information dissemination, the following order modifiers will be deactivated during a SNAP cycle: CHX only, post only, do not route, match trade prevention, always quote, and reserve size.

SNAP cycle operation

A SNAP cycle consists of: 1) initiation, 2) SNAP order acceptance, 3) pricing and satisfaction, 4) order matching, and 5) transition to the open trading state.

SNAP cycles only occur on demand, when a valid start SNAP order is received. This begins the initiation phase. In this first phase, CHX will suspend automatic execution of orders in the subject security, remove the exchange's protected quotations in the subject security, notify the market that a SNAP cycle has begun, and suspend dissemination of any order information concerning the subject security. The price, size, and side of the start SNAP order will not be revealed to the market. All non-SNAP-eligible orders on the CHX book will be canceled and order modifiers preventing routing and requiring quoting will be deactivated.

In initiating a SNAP cycle, market participants reveal that they have an order for the subject security that meets the

minimum size requirement for the security's price point. In order to compensate for this information leakage, they can attach a minimum size condition to their start SNAP order. If during the pricing and satisfaction period this condition is not met, the SNAP cycle transitions to the open state without any trade execution.

In the second phase of the cycle, order acceptance, the SNAP CHX book is established. This period lasts a random length of time, ranging from 475 to 525 milliseconds. All incoming orders during this period that are SNAP eligible will be added to the CHX SNAP book. Eligible orders that were already on the CHX book at the start of the SNAP cycle and nonpegged orders on the AOO queue will also be added to the SNAP book. Incoming AOO-pegged orders will be queued for addition to the book during the pricing and satisfaction period. Orders will receive priority in the CHX book in the following order (with priority within each category based upon how aggressively priced the order is, then display status and sequence number):

1) Existing orders on CHX book;
2) Start SNAP order that initiated SNAP cycle;
3) Existing orders in the AOO queue when the SNAP cycle began; and
4) SNAP-eligible orders and SNAP AOOs received during the order acceptance period.

During this period, the *first in, first out* (FIFO) queue is established for messages such as "cancel" orders that cannot be processed during the SNAP cycle. SNAP-eligible orders received after the end of the order acceptance period will also be added to the FIFO queue for processing during the transition to the open trading state. All SNAP-ineligible orders received throughout the SNAP cycle will be canceled upon receipt, unless they are cross orders, in which case they will be placed in the FIFO queue.[9]

At the conclusion of the order acceptance period, the matching system will take a snapshot of external market protected quotations and will determine if the CHX routing services are available.

If there is no two-sided NBBO, the NBBO is crossed, or the routing services are unavailable, the SNAP cycle will immediately begin the transition to the open trading state without any trade execution.

If there is an uncrossed, two-sided NBBO and routing services are available, the SNAP cycle will move into the third phase, pricing and satisfaction. First, AOO-pegged orders will be priced and ranked on the SNAP order book based upon the market snapshot taken at the end of the order acceptance period. Next, taking into account the protected quotations at other exchanges for the subject security, the matching system will establish the SNAP price, the price at which the greatest number of shares can be executed. If the number of shares meets the minimum execution requirement attached to the start SNAP order, then the auction moves to the pricing and satisfaction period. If the minimum execution requirement is not met, or if no orders could be matched, the SNAP cycle immediately moves to the transition to the open trading state.

In the pricing and satisfaction period, orders will be routed away to exchanges posting protected quotations (as of the market snapshot taken at the end of the order acceptance period) that improve on the SNAP price. This routing occurs in order to avoid trading through a protected price as prohibited under SEC Regulation NMS. The most aggressively priced orders will receive priority in being routed away and will be priced at the SNAP price, to maximize the chance of executions at multiple price points. The SNAP cycle will be delayed for 200 milliseconds or until the receipt of fulfillment/cancellation messages for all routed orders, whichever comes first. Any orders that are returned wholly or partially unfilled will be returned to the SNAP order book with their original priority. If at the end of 200 milliseconds there are still outstanding orders for which CHX has not received notification of fulfillment or cancellation, the SNAP cycle will move on to the order matching period. If routed orders are returned unexecuted outside of the 200-millisecond period, the returned order will be posted to the AOO queue or CHX book as applicable.

If external markets are displaying protected quotations at the SNAP price, CHX will also route away orders during this phase to address any order imbalance within the CHX SNAP book at the SNAP price.

In the fourth phase, order matching, remaining orders on the CHX SNAP book will be matched to one another to execute at the SNAP price, with execution priority awarded based on the ranking of orders within the CHX SNAP book.

At the conclusion of the order matching period, CHX begins the final phase of the SNAP cycle: transition to the open trading state. During this phase, CHX will rank unexecuted partial or whole orders from the SNAP book on the CHX book, return unexecuted SNAP AOO day orders to the AOO queue, and cancel applicable orders, like the unexecuted portions of SNAP AOO one-and-done orders. Order modifiers that were deactivated for the SNAP cycle will be reactivated for orders returned to the CHX book. CHX will then process the FIFO queue, adding and canceling orders on the CHX book and adding to the SNAP AOO queue as instructed. At the conclusion of this period, CHX will notify

ISSN 0895-0164

the market that the SNAP auction has ended and will restart automatic trade execution and dissemination of relevant market data.

Information dissemination during the SNAP cycle

When a valid start SNAP order is received, CHX notifies the market that a SNAP cycle has begun. It does not reveal the size, price, or side of the order. Participants in the SNAP cycle remain anonymous throughout the process. Orders on the AOO queue are also undetectable and are only eligible to be matched during a SNAP auction.

Given minimum size requirements associated with start SNAP orders, market participants have an idea of the minimum size of the order, though they have no information about the orders remaining on the AOO queue. Market participants also know that the start SNAP order was priced at or through the NBBO.

If a SNAP cycle does go through all five stages and execute trades, CHX sends execution reports to parties that executed orders during the SNAP auction or during the transition to the open trading state and sends trade reports to the national quotation system.

SNAP auction potential benefits

SNAP auctions may enhance market stability if they decrease opportunities for gaming the markets and encourage competition among traders on price rather than speed.

Opportunities for gaming are likely to be decreased because:

- The side and exact size of the start SNAP order will not be disclosed, limiting the ability of market participants to place orders simply in reaction to the initiation of the SNAP cycle.
- No cancellations of orders in the subject security will be permitted during the SNAP cycle, encouraging market participants to submit only bona fide orders.
- SNAP AOOs already in the queue will take priority over orders submitted during the SNAP order acceptance period. This will allow those with bona fide orders that are not large enough to initiate a SNAP cycle to still put their orders in ahead of those submitting orders that are simply in reaction to the initiation of a SNAP cycle.

Competition on price rather than speed is likely to be encouraged because:

- The most aggressively priced orders will be routed away if there are better prices available on other exchanges during the pricing and satisfaction period.
- Through the SNAP AOO pegged order, market participants will be able to price their orders competitively based on market conditions at the moment of the SNAP cycle, while placing their order earlier in the day. These orders have a time priority based on the time of initial receipt, which can be hours before a SNAP auction begins. This will allow market participants to take advantage of market conditions current at the time of the SNAP auction without worrying about being front-run by faster market participants.

Conclusion

CHX SNAP is the proposed intraday, on-demand auction service of the Chicago Stock Exchange. It represents the first significant attempt to incorporate batch auctions into U.S. equity markets. Market participants would be able to place orders to start or participate in a SNAP cycle, a batch auction that will execute in under a second with minimal information leakage to the market. An analysis of the design and operation of SNAP auctions in equity markets suggests that they may have the potential to improve market stability and performance by facilitating large trades placed by institutional traders without having those trades "telegraphed" to the market before execution. Conceptually, this should deprive HFT traders of the price information leakage they often use to exploit large institutional orders. If effective, this should materially diminish the value of raw speed and cause more competition on price rather than speed.

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[1] See John McPartland, 2015, "Recommendations for equitable allocation of trades in high-frequency trading environments," *Journal of Trading*, Vol. 10, No. 2, Spring, pp. 81–100; Carol L. Clark, 2013, "Keeping markets safe in a high speed trading environment," in *Risk Management in Financial Institutions*, Shahin Shojai and George Feiger (eds.), London: Euromoney Books, pp. 72–92; and related policy discussion papers by the Chicago Fed's financial markets team at https://www.chicagofed.org/publications/publication-listing?filter_series=16.

[2] Scott Patterson, 2010, "Fast traders face off with big investors over 'gaming,'" *Wall Street Journal*, June 29, available at http://www.wsj.com/articles/SB10001424052748703374104575337270344199734.

[3] Financial Industry Regulatory Authority (FINRA), 2012, "FINRA joins exchanges and the SEC in fining Hold Brothers more than $5.9 million for manipulative trading, anti-money laundering, and other violations," news release, Washington, DC, September 25, available at http://www.finra.org/Newsroom/NewsReleases/2012/P178687.

[4] Jerome Powell, 2015, keynote address delivered at the Brookings Institution conference, Are There Structural Issues in U.S. Bond Markets?, Washington, DC, August 3, available at http://www.brookings.edu/~/media/events/2015/08/03-bond-markets/20150803_bond_markets_transcript.pdf.

[5] See Powell (2015).

[6] Antonio Weiss, 2015, keynote address delivered at the Brookings Institution conference, Are There Structural Issues in U.S. Bond Markets?, Washington, DC, August 3, available at http://www.brookings.edu/~/media/events/2015/08/03-bond-markets/20150803_bond_markets_transcript.pdf.

[7] See Powell (2015).

[8] Eric Budish, Peter Cramton, and John Shim, 2013, "The high-frequency trading arms race: Frequent batch auctions as a market design response," University of Chicago, Booth School of Business, research paper, No. 14-03, July.

[9] Cross orders (orders to buy and sell the same security at a specific price better than the working price) are placed in the FIFO queue instead of being canceled for handling at the conclusion of the SNAP cycle. This is because cross orders are often submitted as a part of a package of trades and canceling them would cause problems for market participants expecting multiple trades to be executed as a package.