The Impact of Tick Constrained Securities on the U.S. Equity Market

Imagine you are buyside trader, striving to ensure best execution. You enter an order to buy a stock at $10.00, which is the National Best Bid (NBB) price. You see a number of trades execute at $10.005 and even some at $10.0001, while waiting for a fill. You decide to become more aggressive and enter a mid-point order. Once again, you see multiple fills at $10.005, some at $10.001 and others at $10.0099, but you still do not get a fill, as other market participants chose to execute at other venues besides the venue(s) with your midpoint order. If you think the stock price may rise, you may decide to cross the spread and buy the stock at $10.01. You've now paid 10 basis points more for the stock than if you had received a fill at your original $10.00 displayed price, and 9 basis points more than the $10.001 fills you observed.

The above example highlights "inaccessible liquidity," which generally refers to order flow available to only select market participants. Several factors contribute to inaccessible liquidity. Retail order flow is nearly always sent to market making firms, who can execute on a principal basis and can do so at prices inside of the best displayed prices, albeit often with de minimis price improvement; this flow has increased as a percentage of the market in recent months. Similarly, Single Dealer Platforms (SDPs) establish bilateral relationships with brokers and execute on a principal basis away from exchanges. The rising average price of stocks also contributes to inaccessible liquidity: Regulation NMS requires order protection status for round lot orders only, which are generally 100 shares. As stock prices rise, order sizes in shares tend to fall, leading to more orders below 100 shares and more potential fragmentation of available liquidity.

While there is some level of inaccessible liquidity in all stocks, some stocks are more affected than others due to another Reg NMS provision that restricts displayed quotes to $0.01 increments in all stocks above $1. There are many securities that may be considered "tick-constrained", as the $0.01 minimum tick increment is a wider tick than market forces would otherwise produce. These stocks tend to trade with high volume, relatively lower prices, and quoted spreads near $0.01. These tick constrained issues largely exhibit higher levels of inaccessible liquidity, hampering both market transparency and price discovery.

The theoretical example provided above illustrates how current US equity market structure can generate inaccessible liquidity. The sharp increase in retail trading since the start of the Covid-19 Pandemic has exacerbated the trend. This activity is mostly executed off exchange, and was recently estimated to be 25% of the market by Citadel Securities[i]. Brokers may also send orders to ATS's[ii] in an attempt to avoid certain trading interactions and minimize information dissemination, which creates further fragmentation and adds to the level of inaccessible liquidity. Total inaccessible liquidity is roughly represented by the amount of trading activity reported to the Trade Reporting Facility; this volume is at its highest levels since 2012, as shown in Chart 1 below.

Chart 1: Share of Dark Pool & Bilateral Intraday Volume

Dec-20, 48.3%
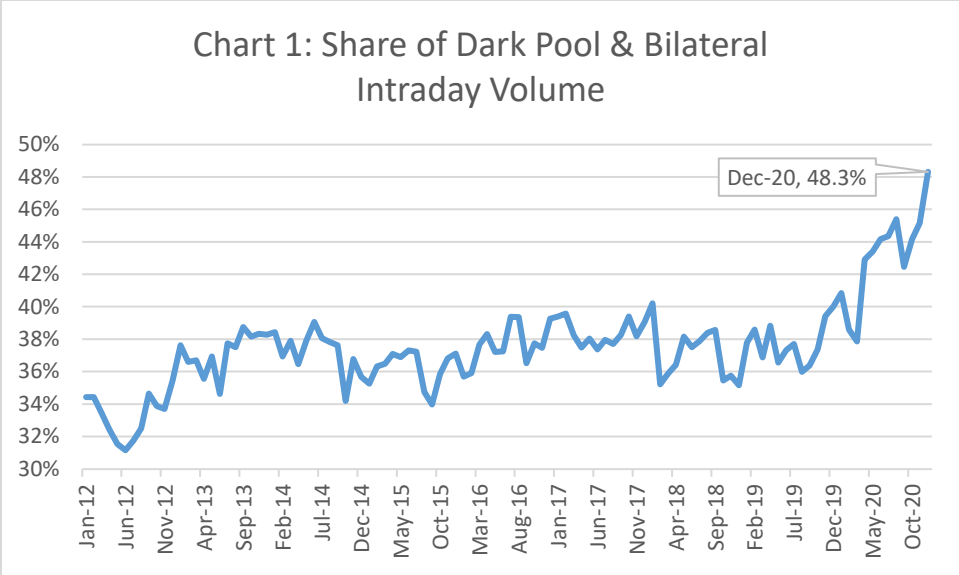
In this Whitepaper, we review our current market structure's contribution to the increasing levels of inaccessible liquidity. Much of U.S. equity market structure takes a "one size fits all" approach to the nearly 8,000 stocks which trade above $1. This paper focuses on the issue of having a single quoting increment (or "tick size') for all stocks above $1, showing that it increases disparate access to liquidity and therefore very different market experiences for different participants.

Tick Size Impact

The shortcomings of today's tick size regime are most apparent in the liquidity profile of some high-volume, lower-priced securities. These stocks trade consistently with a spread of exactly $0.01, and maintain very deep order books at the national best price. This can make it difficult for liquidity providers to receive a fill, except at undesirable times such as when the price is about to change. This queue competition contributes to high-cost infrastructure deployments to help a firm be the fastest to a new price, and has encouraged the creation of inverted-fee venues, which allow, for a cost, liquidity providers to pay for better queue position. This shows the tick size regime's influence on the market technology "arms race" and venue fragmentation.

On a time-weighted basis, due to short periods of locked and crossed markets, *several of these stocks actually average - over a full day - a consolidated spread of less than one cent*. This suggests that many of these securities would likely trade at a spread of less than $0.01 if the rules so allowed. This would also allow orders that currently execute off exchange inside of the NBBO to potentially receive better prices. Today, there are limited opportunities for exchange-based market makers (without direct customers) to provide liquidity at prices better than the mandated $0.01 tick increment.

Overall, the academic evidence, as well as the evidence from the Tick Size Pilot Program discussed below, suggests that artificially wide tick sizes raise transaction costs and harm execution quality.

Previous Research & Tracking Tick Constrained Trading

NYSE

In the UK Government's analysis of tick size regulation[iii], researchers found that prior to decimalization, *"the tick size was binding for the large stocks and kept the bid-ask spread higher than it would have otherwise been. This high bid-ask spread, while enhancing the profits of the market makers and liquidity providers, increased the transaction costs for investors, especially small retail investors."*

Conversely, the Assessment of the Plan to Implement a Tick Size Pilot Program[iv] found little difference in total order book liquidity when aggregated to five and ten cents pre/post the pilot for stocks where the minimum tick size was increased (except for Group 3[v], which also had a trade-at constraint). It did, however, find smaller volume increases in the stocks in the test groups than the control groups (i.e., wider spreads relatively decreased volume) in both share volume and dollar terms. Importantly, effective spreads widened for the three test groups by 59%, 54% and 54% while they dropped for the control group by 5%. Quoted spreads increased by 14%, 14% and 24% for the three test groups respectively, and by 1% for the control stocks. Price improvement did increase for these stocks, but it did not make up for the wider effective and quoted spreads.

While this research informs the cost impact to spread size, it does not necessarily help describe or identify stocks with "incorrect" spreads. To identify stocks with artificially wide spreads and describe their impact on the market, we created a Tick Constrained Index, which is based on a Tick Constrained Score. The Tick Constrained Score includes:

- Consolidated Quoted Spread
  - Any security with a time-weighted spread between $0.01 and $0.0125 receives between 50 points and zero points.
- NBBO Coverage, determined from the average daily consolidated shares at the inside ratio to average intraday volume over a short-term time frame.
  - Fifty points are allocated to any symbol where the size at the inside averaged over a full day is greater than four times the average per-second intraday consolidated volume. Any symbol below a 2:1 ratio receives zero.

The Tick Constrained Score is the sum of the above two measures and is calculated each trading day. The resulting Tick Constrained Index includes all symbols that trade above $1.00 and had an average daily Tick Constrained Score during the prior six months of 95 or greater.[vi]

Table 1 below shows how many symbols would have been eligible for the Tick Constrained Index in each half-year using volumes from each six month period since the start of 2019. We also show the share of *intraday[vii]* volume these symbols represented. The final two columns show how these symbols traded in the following half year during which they would have been eligible to trade with a half-cent minimum tick increment[viii].

Table 1: Symbol Counts Eligible Based on Prior Half-Year Volumes

		During Half Year of Calculation		During Half Year of Implementation	
Half-year	Eligible Symbols	Average Intraday Volume per Symbol	Share of Intraday Volume	Average Intraday Volume per Symbol	Share of Intraday Volume
2019H1	539	3,990,774	34.2%		
2019H2	536	3,946,421	35.7%	3,861,716	34.9%
2020H1	182	6,565,994	11.6%	6,560,834	33.2%
2020H2	538	4,254,664	25.9%	5,527,544	11.2%

This substantial tick constrained volume means that investors are at times paying more in spread costs than true market forces would charge. We estimate that the Reg NMS arbitrary minimum spread of $0.01 cost investors over $1.7[ix] billion in the first half of 2020[x]. The estimate for the second half of 2020 is a somewhat lower $499 million, because wider spreads in the first half of 2020 resulted in far fewer symbols qualifying as tick constrained. However, if the markets stay the current course, 538 symbols could be considered tick constrained in the first half of 2021. Table 2 below shows estimated spread costs based on three different assumed improvements in effective spreads.

Table 2: Estimated Annualized Investor Cost of Inaccessible Liquidity

	Eligible Symbols	Assumed Effective Spread Improvement per Share		
Half-Year		Cost @ $0.001	Cost at $0.002	Cost at $0.003
2019H2	539	$520,530,051	$1,041,060,102	$1,561,590,154
2020H1	536	$864,466,869	$1,728,933,738	$2,593,400,607
2020H2*	182	$249,401,737	$498,803,473	$748,205,210

To illustrate how a narrower tick increment can impact trading, we draw an example from actual trading in Ford (NYSE: F) stock on January 2, 2020.
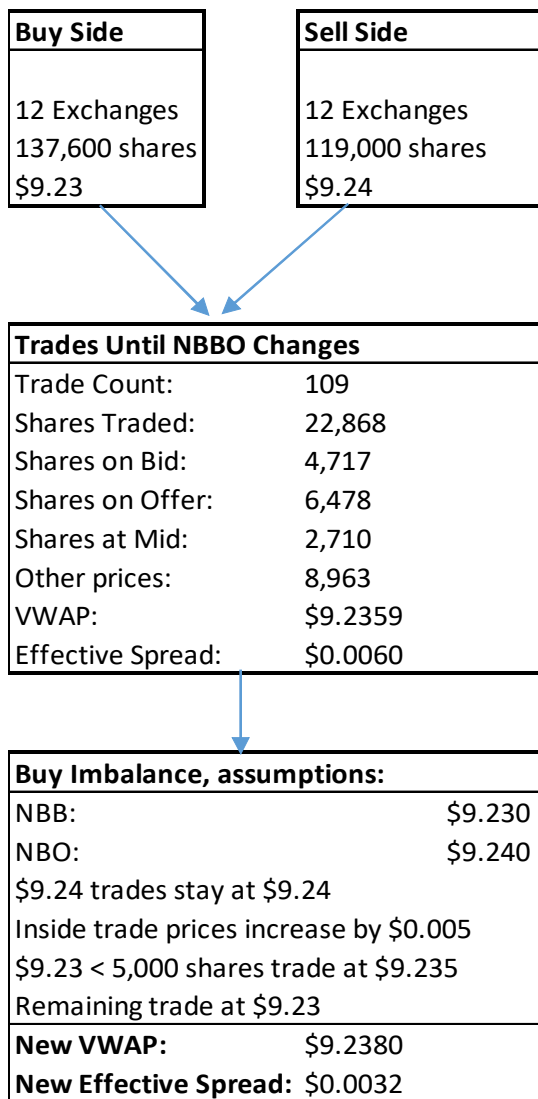
At 10:00 AM, Ford had 137,600 shares available to buy at $9.23 and 119,000 shares to sell at $9.24. The slightly larger share size on the bid implies a fair price closer to $9.24 than $9.23; if the allowable quoting increment was $0.005, for example, instead of $0.01 the National Best Bid price (NBB) would likely be $9.235 and the fair price implied by the market quotes would be higher than seen today.

We assume that all orders that received an execution at $9.24 still received that price. While we do not model an increase in midpoint activity here, it is reasonable to believe that with the lower cost of a mid-point execution (as a percentage of Ford's price), that there could have been more mid-point liquidity available, which would further improve effective spreads and the experience for investors.

We further assume that aggressive sellers sold at either $9.235 or, if the trade size was larger than 10,000 shares, executed partially at $9.235 and partially at $9.23, as such large orders may have moved through the $9.235 price level. This assumption could probably be relaxed, since there was more than 100,000 shares available to buy at $9.23, but large sales could have altered the quote. We assumed mid-point trades continued to execute at the new mid-point, and other trades maintained the same price improvement ratios.

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Our results show that the average price paid increases slightly, moving closer to the fair price, as sellers received higher prices. The effective spread in this example decreased by $0.0028.

Example: Ford on Jan. 2, 2020 at 10:00AM

Buy Side	Sell Side
12 Exchanges	12 Exchanges
137,600 shares	119,000 shares
$9.23	$9.24

Trades Until NBBO Changes	
Trade Count:	109
Shares Traded:	22,868
Shares on Bid:	4,717
Shares on Offer:	6,478
Shares at Mid:	2,710
Other prices:	8,963
VWAP:	$9.2359
Effective Spread:	$0.0060

Buy Imbalance, assumptions:	
NBB:	$9.230
NBO:	$9.240
$9.24 trades stay at $9.24	
Inside trade prices increase by $0.005	
$9.23 < 5,000 shares trade at $9.235	
Remaining trade at $9.23	
New VWAP:	$9.2380
New Effective Spread:	$0.0032

This is a basic example of the increased costs that can arise from a tick-constrained stock with many shares quoted on both the bid and offer. But what happens during periods of volatility, when in aggregate spreads widen and quoted size decreases? Does this issue persist? To study this, we show below how the stocks selected in the second half of 2019 performed during the extreme volatility in the first half of 2020.
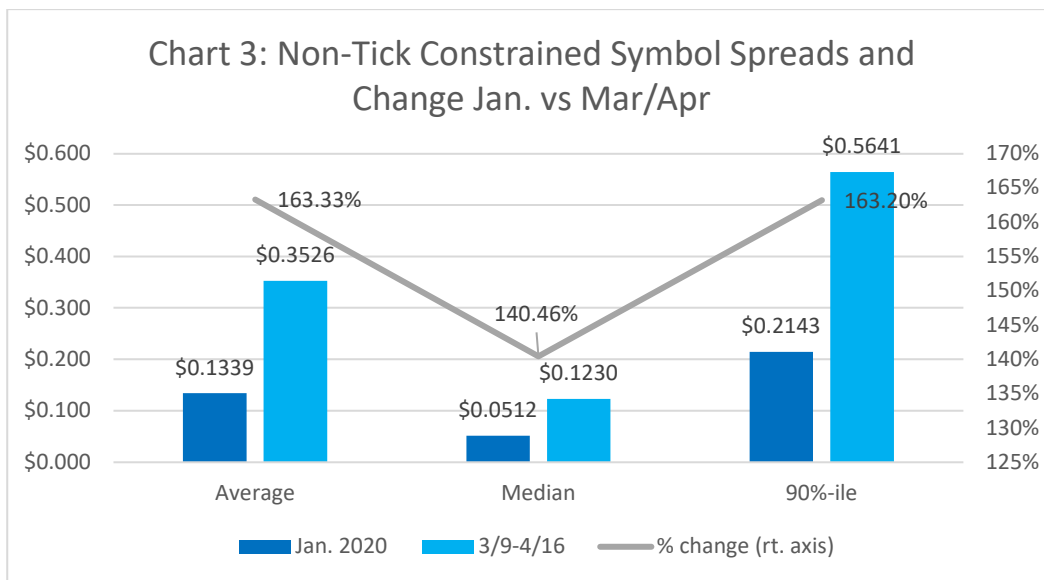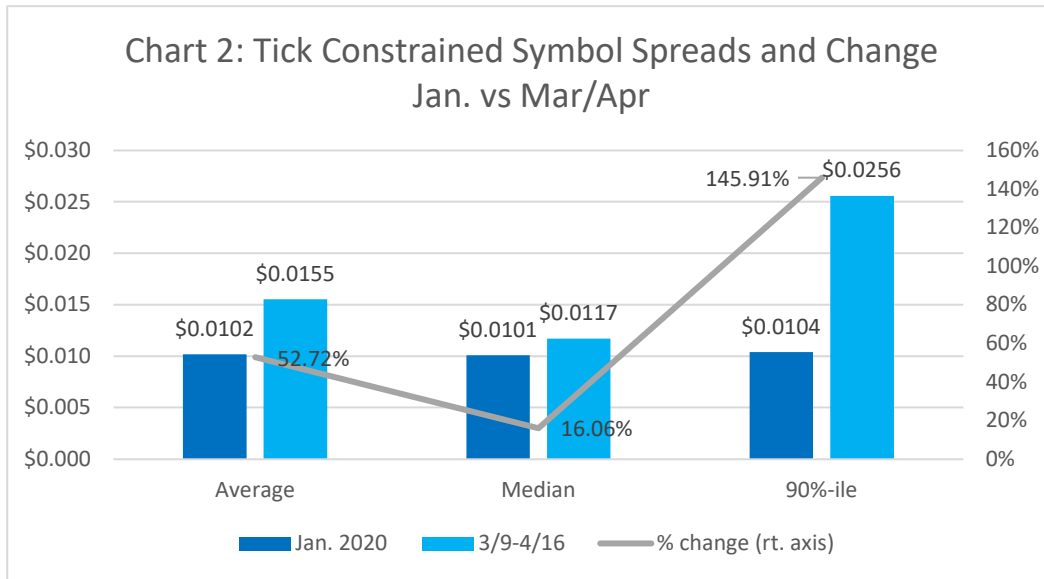
Testing the Approach

To determine whether our stock selections for the second half of 2019 remained tick constrained during the extreme volatility of 2020, we compared all symbols chosen that traded every day from January

![NYSE logo]

through April 16. We then compared spreads for those symbols in January, and compared them to the high volatility period from March 9 - April 16.
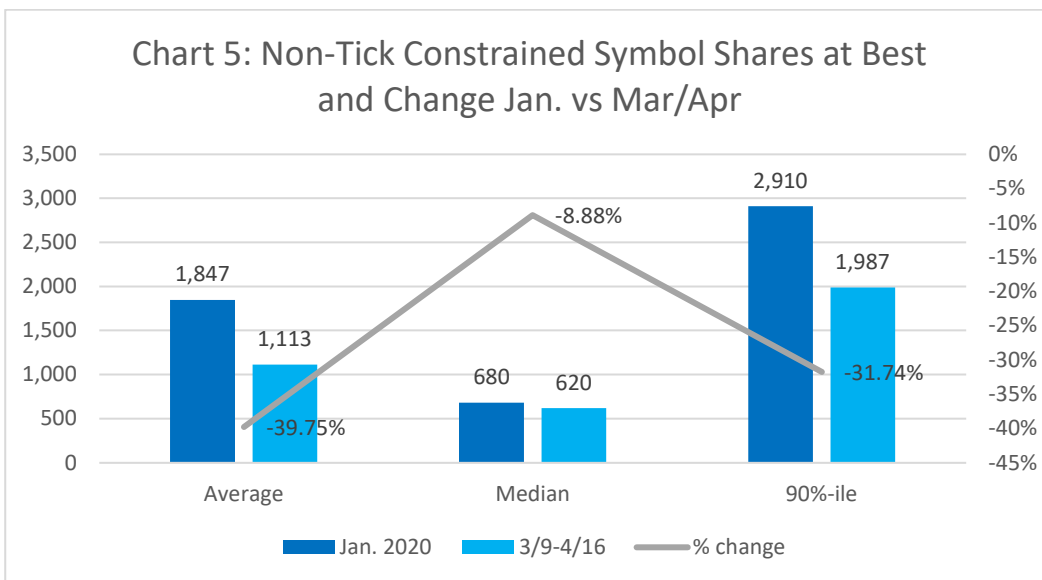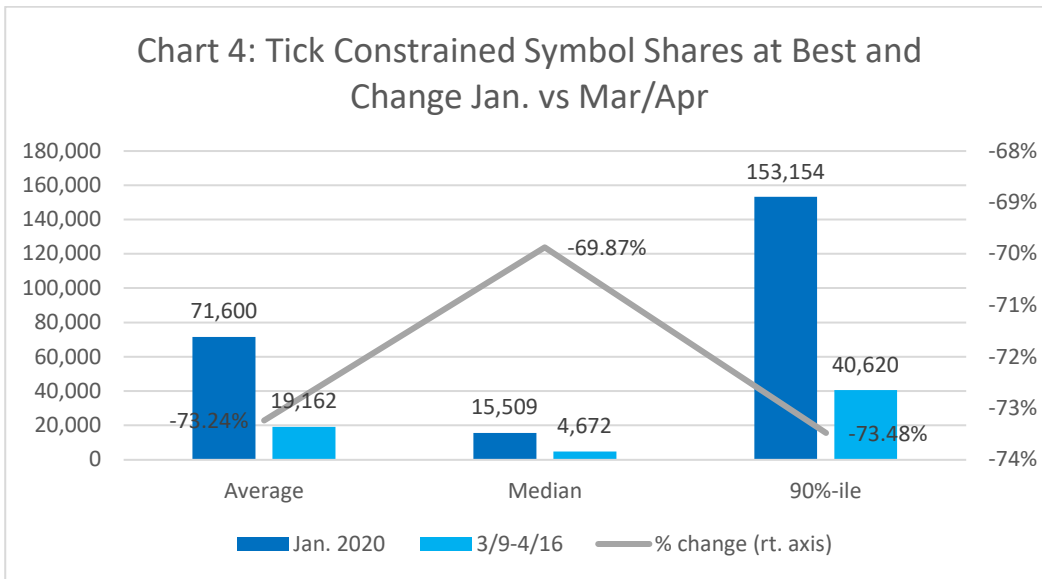
As Chart 2 shows, spreads remained very close to $0.01 despite the volatility surge. Compare this to Chart 3, which shows the same data, but for symbols that did not meet our tick-constrained criteria. These symbols saw their spreads in cents on average increase by 163%, despite generally falling prices.

Chart 2: Tick Constrained Symbol Spreads and Change Jan. vs Mar/Apr

Chart 3: Non-Tick Constrained Symbol Spreads and Change Jan. vs Mar/Apr

When markets turn volatile, market makers tend to decrease their risk appetite. As we saw from the above two charts, spreads widened more for the securities where their spread was not constrained by the $0.01 minimum tick increment, which likely reflects market makers becoming more risk-averse.

Another way to decrease risk is to keep price constant but decrease supply (i.e., provide less liquidity). Since the tick constrained stocks maintained near-$0.01 spreads, the only way to control risk was to decrease the shares provided at the best price. Since shares provided was market makers' risk lever in these stocks, we expect to see a larger drop in shares at the best price for tick constrained stocks when compared to our comparison group.

Charts 4 and 5 highlight the disparity. The tick-constrained stocks averaged 71,600 shares at the inside during January 2020. During March/April, this dropped by 73% on average, to 19,162 shares. The non-tick constrained stocks' size at the inside fell from 1,847 to 1,113 shares, or just 40%. Since prices dropped during this time period, the loss of dollar liquidity was even larger.

Chart 4: Tick Constrained Symbol Shares at Best and Change Jan. vs Mar/Apr

Chart 5: Non-Tick Constrained Symbol Shares at Best and Change Jan. vs Mar/Apr

The securities not meeting our Tick Constrained criteria tended to have higher prices and lower volumes. This helps explain a slightly higher off exchange share for the non-tick constrained stocks (and may highlight the impact of inaccessible odd-lot liquidity in high priced securities). Their overall lower volume, and in some cases high retail interest, produced strong off-exchange activity.

Trading Inside the Spread

Despite the increase in off-exchange trading in 2020, we do not see a substantial increase in price improvement. The share of volume executing with de minimis price improvement (prices that are less than 10% of the spread away from the bid or offer) has continued to rise throughout 2020 for all stocks off exchange[xi]. It remains lower for tick constrained securities, and fell further when volatility rose. Mid-point executions are lower off-exchange, but higher on-exchange for tick constrained securities compared to non-constrained stocks, as mid-point is the main avenue that on-exchange market makers can compete inside the spread versus off-exchange market makers. While there is little de minimis price improvement on exchange for securities with a $0.01 spread, the wider spread securities have more noticeable activity in this category, due largely to substantial on-exchange hidden liquidity inside these wider spreads.

Overall, Chart 6 shows that with more than half of all off-exchange volume and an even higher share of exchange volume executing without any price improvement, decreasing the minimum tick increment should help lower overall trading costs, as investors will be able to pocket much of the narrower spread.

Although there is a greater degree of price improvement off-exchange, rule restrictions prohibit on-exchange market-makers from fully competing with off-exchange providers to deliver the best price. Lessening the impact caused by tick-constrained securities might serve to lessen this disparity.

Chart 6: Tick Constrained Stocks
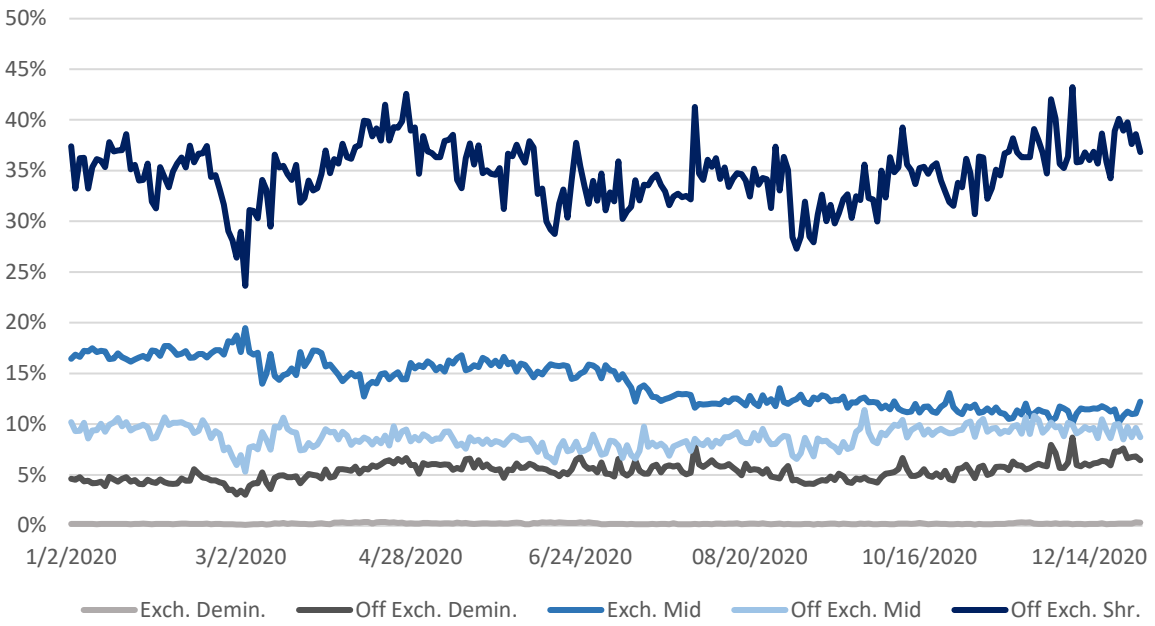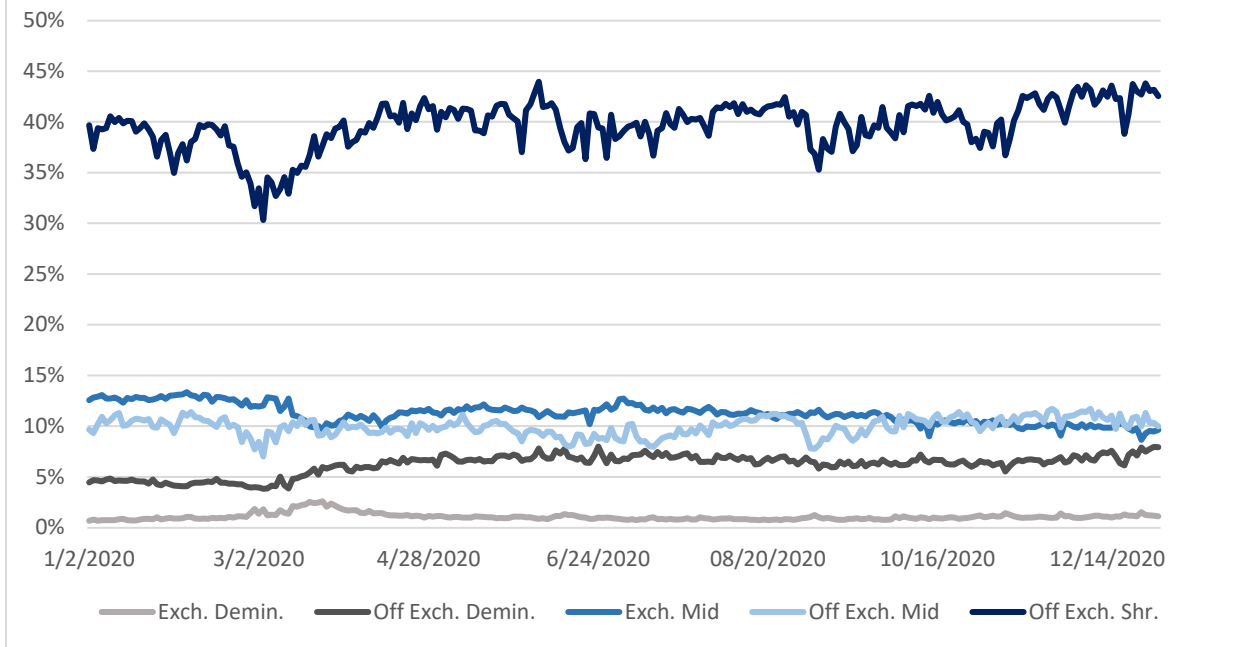Off Exchange Share and Price Improvement

Legend: Exch. Demin. | Off Exch. Demin. | Exch. Mid | Off Exch. Mid | Off Exch. Shr.

Chart 7: Non-Tick Constrained Stocks
Off Exchange Share and Price Improvement

Legend: Exch. Demin. — Off Exch. Demin. — Exch. Mid — Off Exch. Mid — Off Exch. Shr.

Liquidity & Tick Constraint

We also measured NBBO Coverage as a component of our Tick Constrained Score. Chart 8 shows the average number of shares at the inside throughout the day for each symbol divided by the per-second intraday trading volume[xii]. It is not surprising that the tick constrained stocks have a far higher ratio[xiii]. As expected, however, the loss of liquidity for tick constrained stocks during high volatility was far more severe. The best to worst loss for the constrained stocks was approximately 97%, compared to 86% for the non-constrained stocks, where risk could be offset both by quoting fewer shares at the inside and/or widening the spread.

Using both the spread and NBBO coverage metrics, we find about 1/3rd of total market volume qualifies for our Tick Constrained Index during normal volatility periods (see Table 1 above). Our formula did result in a lower share of total market volume meeting our Tick Constrained Index requirements for the second half of 2020, showing that market conditions can sometimes outweigh the rules' influence on the tick constraint condition.

Chart 8: NBBO Coverage

Tick Constrained (left) — Not Tick Constrained (right)
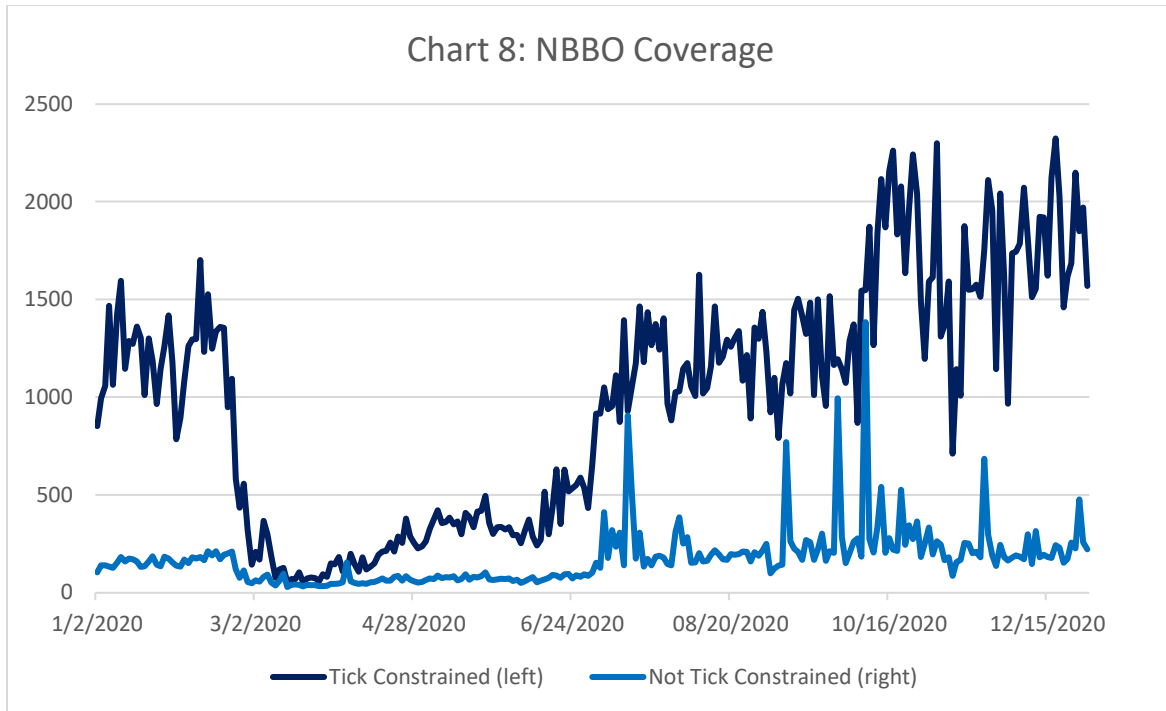
Conclusion

We find substantial evidence that an artificially wide minimum tick increment harms market quality and increases costs for investors. We identified how liquidity provision was severely hampered during the market volatility caused by the Covid-19 pandemic during the Winter and Spring of 2020, especially for stocks qualifying for our Tick Constrained Index. Securities that traded consistently with a $0.01 spread that typically had deep queues suffered much more severe drops in available displayed liquidity when compared to high-priced wider spreads issues.

Market activity - volatility and volume - do impact the share of activity that is tick constrained. Chart 9 below shows the percent of all symbols trading above $0.99 meeting our Tick Constrained Index criteria at any time (dark blue line). This result has been very close to 10% for most of the last two years, but dipped considerably during the Covid-19 pandemic peak and remains slightly below 2019 levels. The share of intra-day volume from Tick Constrained Index stocks remains below 2019 peaks, as market volatility remains higher vs. 2019 and spreads correspondingly wider.

Chart 9: Symbol and Volume Share Constrained
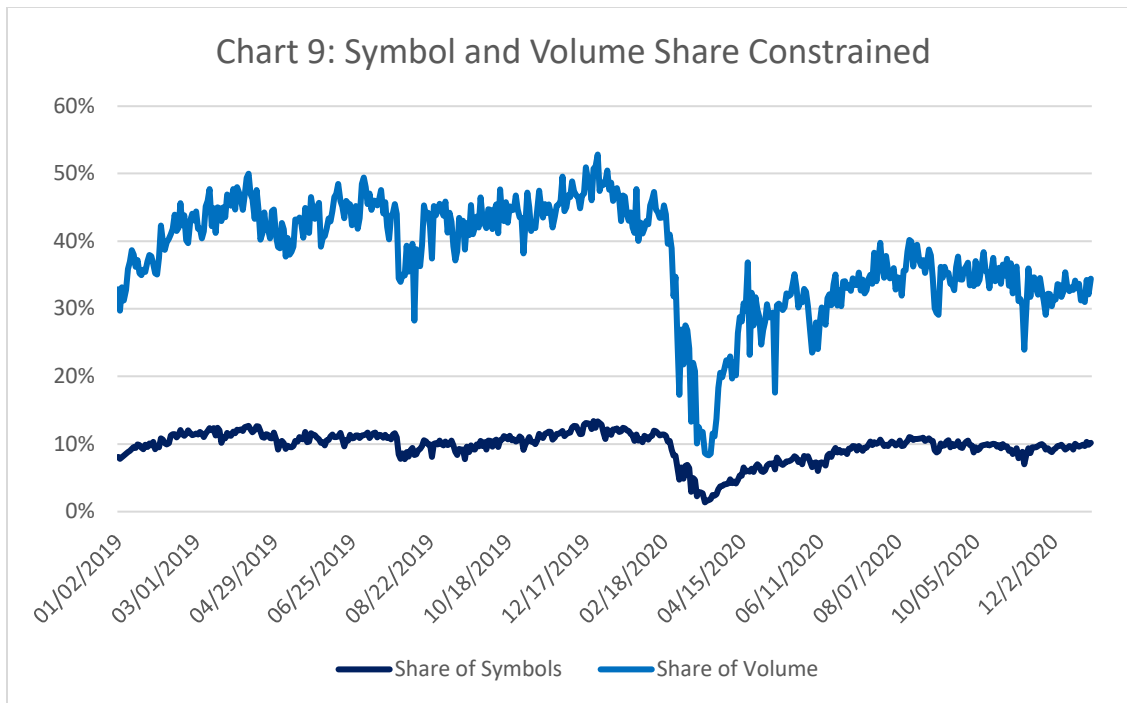
We estimate that trading in tick constrained securities typically increase transaction costs by about one billion dollars per year, based on a conservative estimate of $0.002 per share wider effective spreads in tick-constrained stocks. Should market conditions revert to previous levels the impact of Tick Constrained Index stocks will be even greater.

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[i] https://www.bloomberg.com/news/articles/2020-07-09/citadel-securities-says-retail-is-25-of-the-market-during-peaks

[ii] While ATSs are generally multilateral trading venues, access is highly variable and mostly dependent on the business model of each ATS, often resulting in highly selective segmentation and flow, often inaccessible to many market participants.

[iii] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/289035/12-1067-eia6-tick-size-regulation.pdf

[iv] https://www.nyse.com/publicdocs/nyse/Tick_Pilot_Assessment.pdf

[v] The tick-size pilot widened the minimum tick increment to $0.05 for low volume, small market cap stocks. There were three test groups and a control group. Group 1 (G1) only allowed quoting at nickel increments, but permitted execution at any price increment, G2 allowed trades at the mid-point or less for Retail Price Improvement and G3 added a Trade-at requirement.

vi Additional filters could require a closing price on the last day of the half-year below $50 and a closing price of at least $1.50 or $2.00, although there would be no change to the minimum increment if the stock drops below $1.00.

vii Intraday volume is calculated as total volume during core trading hours, excluding open and close auctions. Early closing days are excluded.

viii In practice, a more dynamic process may make sense, to allow for new securities or significant changes in volatility and liquidity.

ix Assumes $0.002 average improvement in effective spreads

x Based on an assumed effective spread improvement of $0.002 per share

xi We use 10% as our cutoff as that is the minimum price improvement required for resting orders in Retail Liquidity Provider programs on NYSE, Arca, and other exchanges

xii Symbols with a low price below $1.00 are excluded from all analysis. For NBBO coverage, we also excluded symbols that had CADV below 1,000. Some very low volume symbols have very high NBBO coverage. For example, a stock that trades 1000 shares per day, and averaged just 100 shares at the inside, would have a misleading ratio of 2,340. However, these symbols were included in the tick index calculation.

xiii Stocks with an average volume of 1,000 to 100,000 shares are included. A high NBBO coverage ratio may occur for stocks with wide spreads, especially higher priced higher volume securities.