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Market Lens

Has Market Structure Evolution Made Equities Less Liquid?

Episodes of stock market volatility have returned after a long period of relative calm, prompting a search for explanations and the emergence of false and misleading narratives. For example, some allege that volatility has increased because post-financial crisis regulatory reforms curtailed banks' market making capabilities – even though most banks exited principal market making in equities long before the financial crisis. Furthermore, according to our recent analysis of aggregate order book data from the direct data feeds of US exchanges, the full depth of displayed liquidity has remained remarkably stable over the past eight years, despite variations in market conditions and volatility. We hope that this research will prompt further discussion and analysis about the true causes of market volatility.

EXECUTIVE SUMMARY

The evolution of our equity markets – in terms of market structure, regulation and competitive dynamics – has been underway for the better part of two decades. This has yielded improvements in pricing and liquidity in our markets, making changes in market structure, regulation and competitive dynamics unlikely culprits for recent market swings.

- Our analysis shows that the full depth of displayed liquidity on US stock exchanges has remained remarkably stable over the past eight years.
- Our analyses of the depth-of-book data for individual stocks also yield important insights into the structural relationships between spreads, liquidity, and share price, and how each of these factors impact investors of different sizes.
- For example, for various liquid stocks we analyzed, though the cost of transacting large trades has remained relatively constant, spreads have decreased for medium-size trades and have decreased even further for small-size trades. The varying magnitudes of these improvements for different size trades has likely contributed to the misperception that liquidity has been decreasing – a flawed conclusion drawn when only observing displayed size at the national best bid and offer (NBBO).

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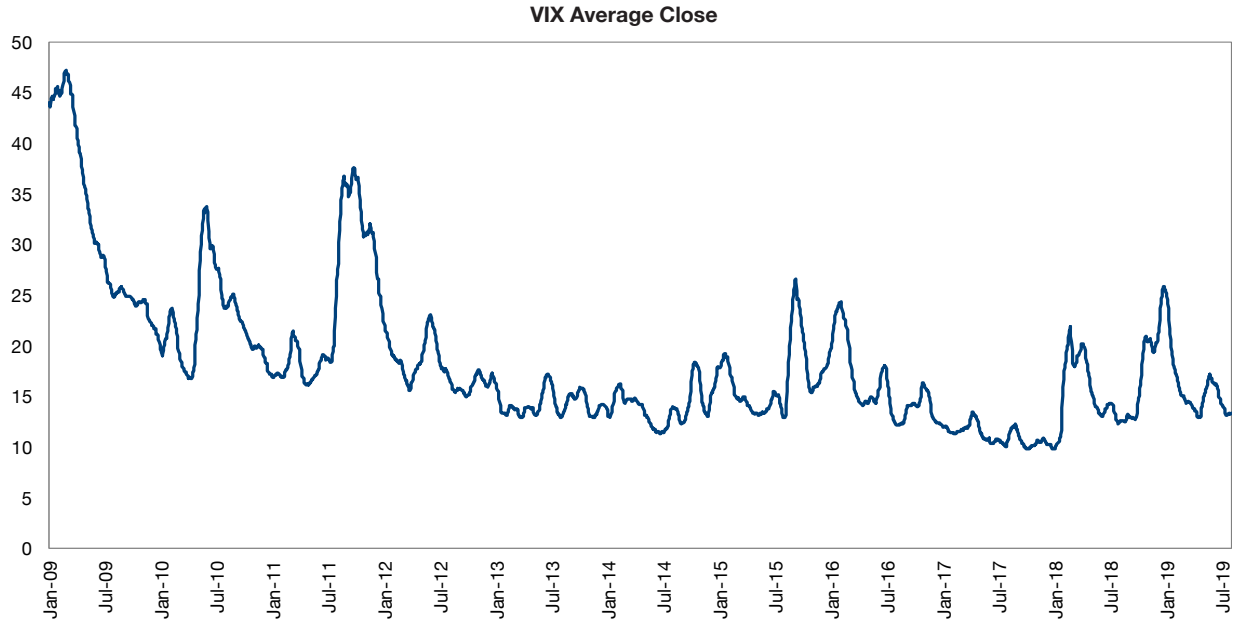


Source: Cboe Global Markets

The US equity market has recently weathered several episodes of heightened volatility, including swift share-price drops in October 2018, December 2018, and August 2019. These episodes stand out following a long period of relative calm. Indeed, implied equities volatility, measured by Cboe Global Markets' VIX index, fell to its lowest-ever level in 2017, nearly 10 years after hitting record highs during the 2008-09 financial crisis.

The contrast between that extended run of tranquility and more recent market swings has naturally prompted a search for explanations, and some observers have speculated that equity market liquidity has been impaired by changes in market structure, regulation and competitive dynamics, rendering markets more fragile and prone to dislocations. Such hypotheses identify several potential villains. In a nutshell, they argue that the growth of indexing, quantitative investment strategies and computer-driven trading have sapped markets of human judgment while post-crisis reforms like the Dodd-Frank Act have diminished banks' ability to commit capital to trading. Long-celebrated investors pursuing fundamentally driven strategies have blamed both their own underperformance and wider market ructions on these factors.[1]

There's no denying that our equity markets have evolved significantly in our generation. Over the past two decades, a wave of innovation has swept through the markets in response to new technologies and thoughtful regulation – benefiting all investors. While the basic function of the stock market – matching buyers and sellers – remains the same, the mechanisms through which buyers and sellers come together has been revolutionized. Whereas once much of the trading in a given stock happened on the trading floor of a single stock exchange in a single specialist post under the control of a single specialist, in recent years, regulatory changes combined with technological innovation have disrupted the old order.

Key regulatory changes over the past two decades accompanied this market evolution, including:

- New "order-handling" rules were introduced in the late 1990s that made customer orders more transparent.
- By 2001, the switch from quoting stock prices in fractions to decimals allowed competition to further compress spreads as the minimum "tick" went from 1/8 of a dollar (12.5 cents) to just one penny.
- Regulation NMS, adopted in 2005 and implemented during 2006 and 2007 provided a framework upon which the trends of the decade before would continue. For example, it protected exchanges' best price quotations against transactions occurring at inferior prices, which further incentivized competition.
- A range of reforms that were designed to improve market stability were implemented in the early 2010s, including "limit-up/limit-down" volatility protections and SEC Rule 15c3-5 (known as the "market-access" rule).

[1] Wigglesworth, Robin: "Volatility: How 'Algos' Changed the Rhythm of the Market." *Financial Times*, January 9, 2019

Today's markets are incredibly competitive. A new generation of analytically driven and technologically sophisticated market participants has emerged as the dominant liquidity providers, displacing the manual intermediaries that once controlled the markets. Legacy dealers, including many of the biggest banks, have not been able to compete in today's more efficient, transparent, and automated markets – and long ago largely abandoned principal market making. The trading firms that provide liquidity today employ cutting-edge communications and data-processing technology, along with sophisticated quantitative modeling, to successfully make markets on a large scale despite far more competitive markets and tighter profit margins. These firms have more than filled any liquidity gap left by the previous generation of manual dealers.

This new competitive landscape has been in place for the better part of the last decade, which again makes it an implausible cause of recent market swings. To the extent banks today face constraints in conducting certain trading activities, it is difficult to see how that explains stock market volatility, given the negligible role banks have played as liquidity providers in these markets for over a decade. In fact, the resilience of the equity markets during the financial crisis – which continued to function well, with record volume amid huge intraday price swings – compares favorably to many then bank-intermediated over-the-counter markets, such as for credit default swaps and other derivatives, which seized up entirely under that stress.

Given that the fundamental forces that have positively reshaped our equity markets have been at work for more than a decade, it seems unlikely that they are responsible for either impaired market liquidity or by extension, the episodes of volatility seen over the past year.

LOOKING FOR ANSWERS IN EXCHANGE DIRECT DATA FEEDS

But what does the data say? Are equity markets today actually less liquid than they were a decade ago?

To measure this, we analyzed aggregate order book messages from US exchanges' direct feeds, to which Citadel Securities subscribes as part of its market making activities. These direct feeds provide the full depth of bids and offers available to investors and other market participants— in other words, a complete picture of immediately available liquidity throughout each trading day.

We present our analyses at both the aggregate index level as well as at the individual security level for select stocks. We focus first on data aggregated across all stocks in the Standard & Poor's 500 index (S&P 500), a broad-market benchmark which currently accounts for 74% of total US equity market capitalization and 63% of value traded, excluding ETFs and other exchange-traded investment products. We also look at data aggregated across all stocks in the Russell 2000 index, a well-known benchmark of 2,000 small-cap companies. In all, we analyzed approximately 100 terabytes of order book data going back eight years on 13 exchanges.

Using this data, we constructed a series of scenarios to test how exchange liquidity changed over the years. These scenarios utilize a "size-adjusted" measure of spread, computed by observing how far into the depth of book (i.e. beyond the NBBO) orders of different sizes would need to reach to be fully executed immediately. This effectively measures the total amount of displayed liquidity available for investors to access when making various institutional-sized trades — $1 million, $10 million and $100 million — in these indexes. We also look at a range of trade sizes — $10,000, $100,000, $1 million and $10 million — for individual S&P 500 constituents. Any figures corresponding to an index, rather than the underlying securities, represent the size-adjusted spread of acquiring or shedding exposure to the basket of stocks underlying the index by buying or selling those stocks in proportion to their index weightings.

The size-adjusted spread measures the difference between the cost of buying and the cost of selling the same dollar amount by accessing all of the displayed liquidity required to fully execute the trade. Because we cannot recreate live trading situations with this historical data, the measurement assumes the liquidity consumer simply "walks" the exchange order books up or down, as necessary, until the desired quantity is satisfied. Although this is generally not how large orders are executed, it does provide a robust method of measuring liquidity depth and any changes in that depth over time.[2] We also note that this measurement is not purely hypothetical, as it is indeed possible to simultaneously access the full depth of book across multiple exchanges by using limit orders priced through the opposite side of the NBBO. An ISO limit order priced through the BBO of an exchange should execute against all resting quotes at and between the BBO and the limit price, thereby accessing the relevant depth of book.

[2] See Appendix for further details on our computation of size-adjusted spreads.

WHAT WE FOUND FOR MARKET INDEXES

Our analysis shows that, on the whole, the depth of displayed liquidity on US equity markets has been remarkably stable over the past eight years, despite ups and downs in implied volatility (based on the VIX index). Our size-adjusted spread measurement for a $1 million S&P 500 transaction, for example, has hovered at approximately two to four basis points (bps) for virtually all of the eight year period measured. Similar patterns hold for $10 million (3-6 bps) and $100 million trades (9-24 bps) in this broad-market benchmark (see Fig. 1).

Likewise, size-adjusted spreads for the Russell 2000 have remained remarkably consistent over time, with a $1 million trade carrying a spread of 14-31 bps during our time series (see Fig. 2). Size-adjusted spreads for a $10 million trade were not much higher, at approximately 18-35 bps, and the gap between the two narrowed markedly in recent years. Even the size-adjusted spread associated with a $100 million transaction in this small-cap benchmark has remained in a relatively tight band (62-154 bps) since 2011, illustrating steady depth of displayed liquidity in these arguably harder-to-trade names.

In looking at our time series, it is interesting to examine the relationship between changes to our size-adjusted spread measurement and sharp increases in the level of the VIX (see Figs. 1 and 2). Here, we see that the VIX spikes in October 2018 and December 2018 coincided with increases in size-adjusted spreads (and, by inference, decreases in liquidity depth) for some of our index trade scenarios. But, with the potential exception of the very largest Russell 2000 transaction, none of these increases in size-adjusted spreads were outside of the range observed throughout the time series. Meanwhile, liquidity depth for the smaller Russell 2000 index trades appears to be almost entirely unaffected by the October 2018 episode. While recent and past decreases in liquidity depth (aka increases in size-adjusted spreads) have coincided with spikes in the VIX, this has not exclusively been the case and the data does not suggest that the depth or resiliency of liquidity is fundamentally different today than it has been over the past eight years.

Fig. 1 — Size-adjusted spreads for $1 million, $10 million and $100 million trades in the S&P 500, with VIX overlay

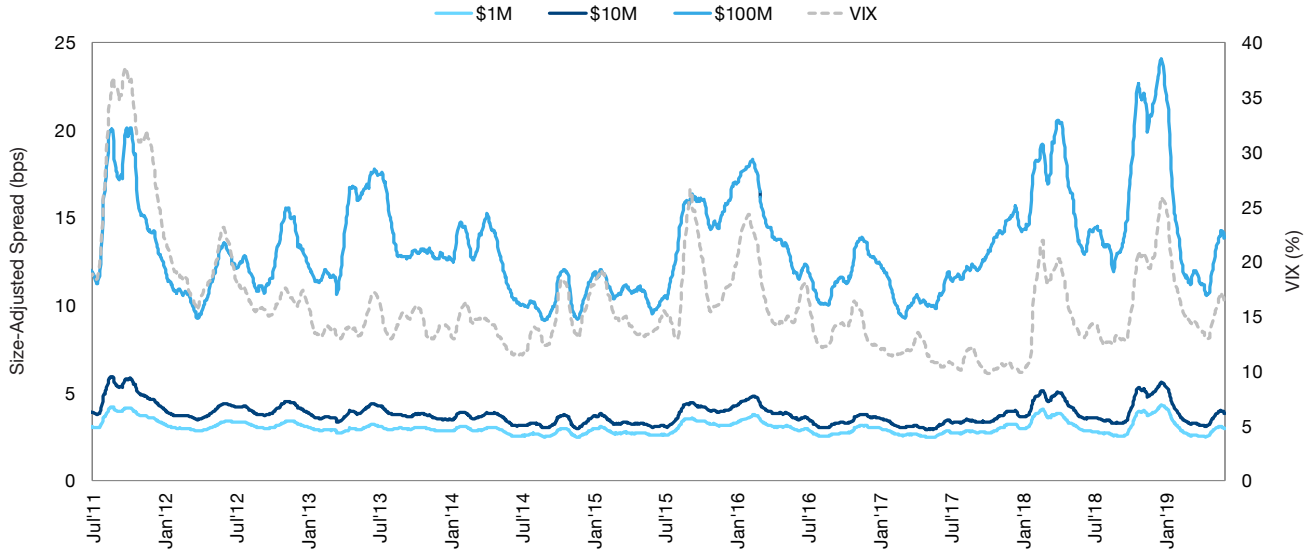
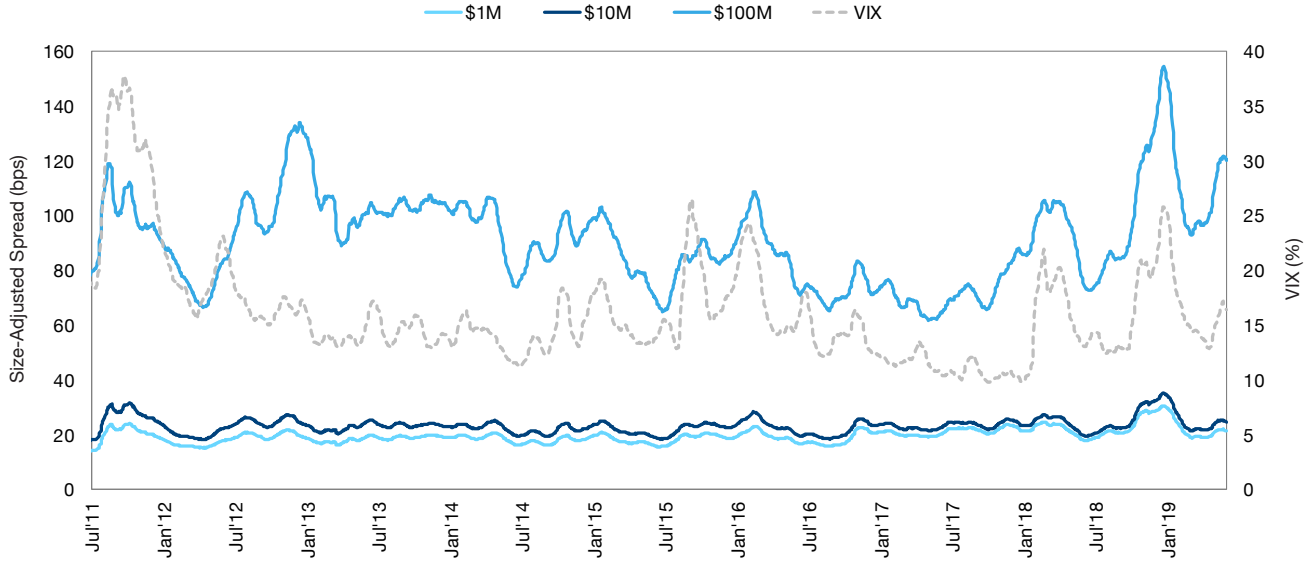


Fig. 2 — Size-adjusted spreads for $1 million, $10 million and $100 million trades in the Russell 2000, with VIX overlay.



WHAT WE FOUND FOR INDIVIDUAL STOCKS

Analyzing size-adjusted spreads for individual S&P 500 components provides additional insights about liquidity, as well as how changes in stock prices affect liquidity. Each of the names we examine in the rest of this paper — Bank of America (BAC), Microsoft (MSFT), Apple (AAPL), Google (GOOGL), Gap (GPS) and News Corp. (NWS) — tell a slightly different story that adds to our understanding of liquidity dynamics over time.

Bank of America (BAC)

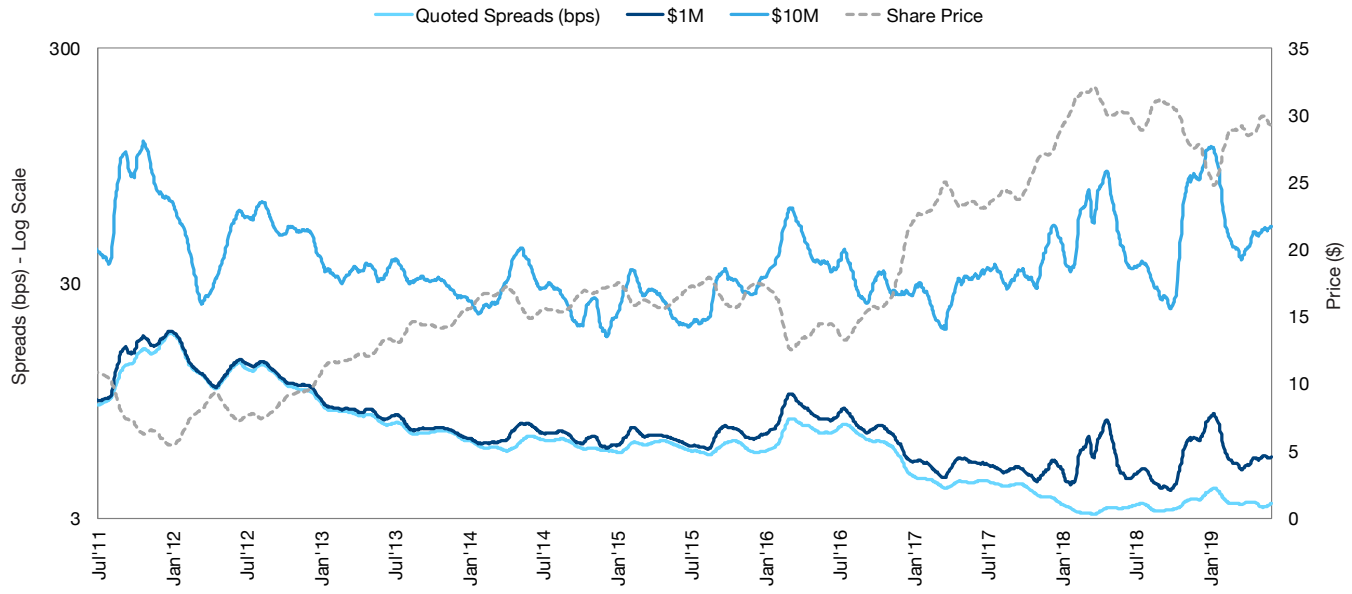
BAC is an interesting stock to analyze since its quoted spread (the spread at the NBBO) has been effectively locked at one penny during our entire time series even though the stock price has risen six-fold. In basis points (a more accurate measure of economic costs) this means the quoted spread has decreased by a factor of six in a relatively smooth and continuous fashion, providing us with an opportunity to evaluate the impact of decreasing spreads on depth of liquidity.

As shown, size-adjusted spreads for a $1 million transaction improved dramatically over time (see Fig. 3). This occurred even as size-adjusted spreads for the very largest size trades, $10 million, displayed a relatively stable pattern we observed for the S&P 500 as a whole. This suggests that while the depth of bids and offers required to fully execute the biggest trades changed little since 2011, displayed exchange liquidity has improved at those levels of the order book at or near the NBBO that are necessary to fill smaller, though still substantial, orders, including those of $1 million in size.

A notable divergence between the quoted spread and the size-adjusted spread for a $1 million transaction emerges throughout the time series. In 2012, it was possible to transact $1 million of BAC at the NBBO. Beginning in 2014 this was no longer the case, and by 2018, the divergence was even more pronounced. However, as the trends reveal, this was not due to a reduction in market liquidity for large transactions. Rather, it was the result of size-adjusted spreads compressing more for smaller transactions than for $1 million transactions. Thus, even though you can no longer transact $1 million of BAC at the quoted spread (i.e., the NBBO), *you can nevertheless transact $1 million of BAC against displayed liquidity in the depth of book at an overall lower economic cost than you could in 2012*. As a result, investors are now able to buy and sell greater dollar amounts at now lower size-adjusted spreads, which reduces their all-in trading costs.

Importantly, the divergence between the quoted spread and the size-adjusted spread for a $1 million transaction may also help explain the (mis)perception that liquidity for larger size trades has been negatively impacted by reduced quoted spreads. When benchmarked against just the NBBO (in basis points) there may be less posted size than in previous years, but when benchmarked against displayed quotes deeper in the order book, immediately available liquidity within a given number of basis points from the mid has actually increased, not decreased. Analyses of market depth that focus on just the NBBO unfortunately miss this critical point and often lead to incorrect conclusions about the robustness of our equity markets.

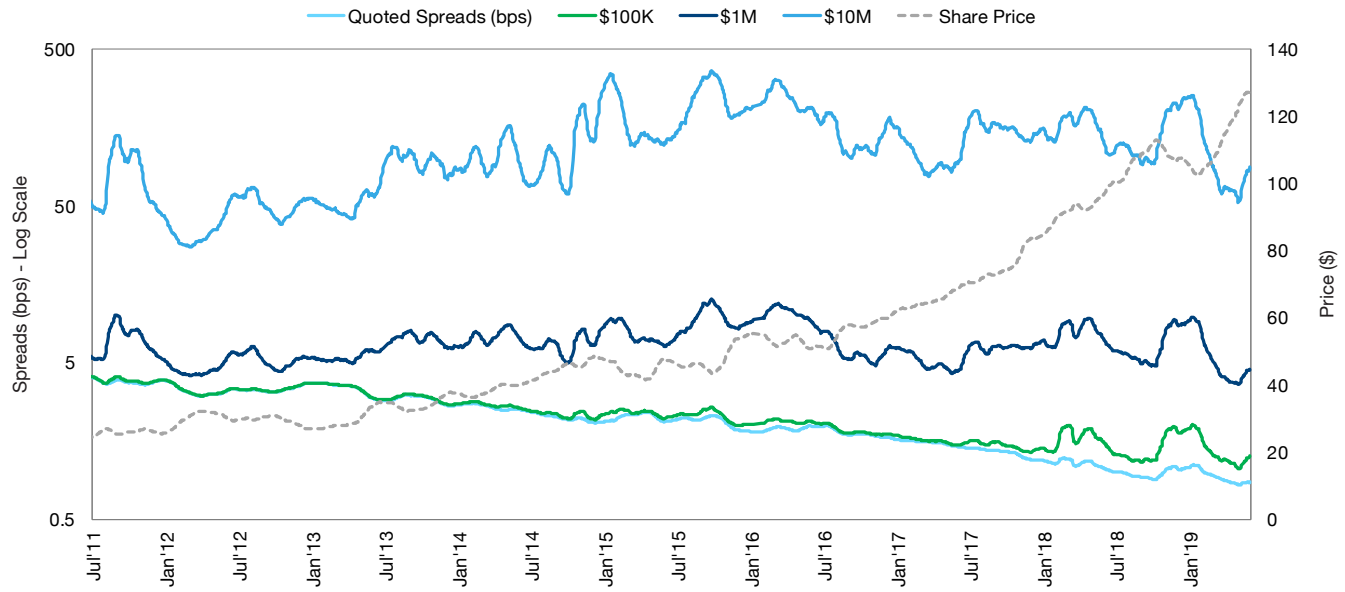
Fig. 3 — Quoted spread and size-adjusted spreads for $1 million and $10 million transactions in BAC with share price overlay



Microsoft (MSFT)

A somewhat similar pattern can be seen in MSFT (see Fig. 4). Here, the reductions in spreads are concentrated at the NBBO and for a $100,000 transaction, with larger trades displaying dynamics similar to the S&P 500 as a whole. MSFT's share price rose dramatically throughout the time series. However, unlike BAC, whose share price touched the single digits at the beginning of the time series, MSFT started off in the $20s before rising to current levels in excess of $100. Practically speaking, this means that the one penny tick size constraint, while still contributing to artificially wider spreads earlier on in the time series, was not as constraining for MSFT as it was for BAC. Consequently, the appreciation of MSFT shares appears to have not improved liquidity and size-adjusted spreads for larger transactions ($1 million or more) as much as it did for smaller ones ($100,000).

Fig. 4 — Quoted spread and size-adjusted spreads for $100,000, $1 million and $10 million transactions in MSFT with share price overlay

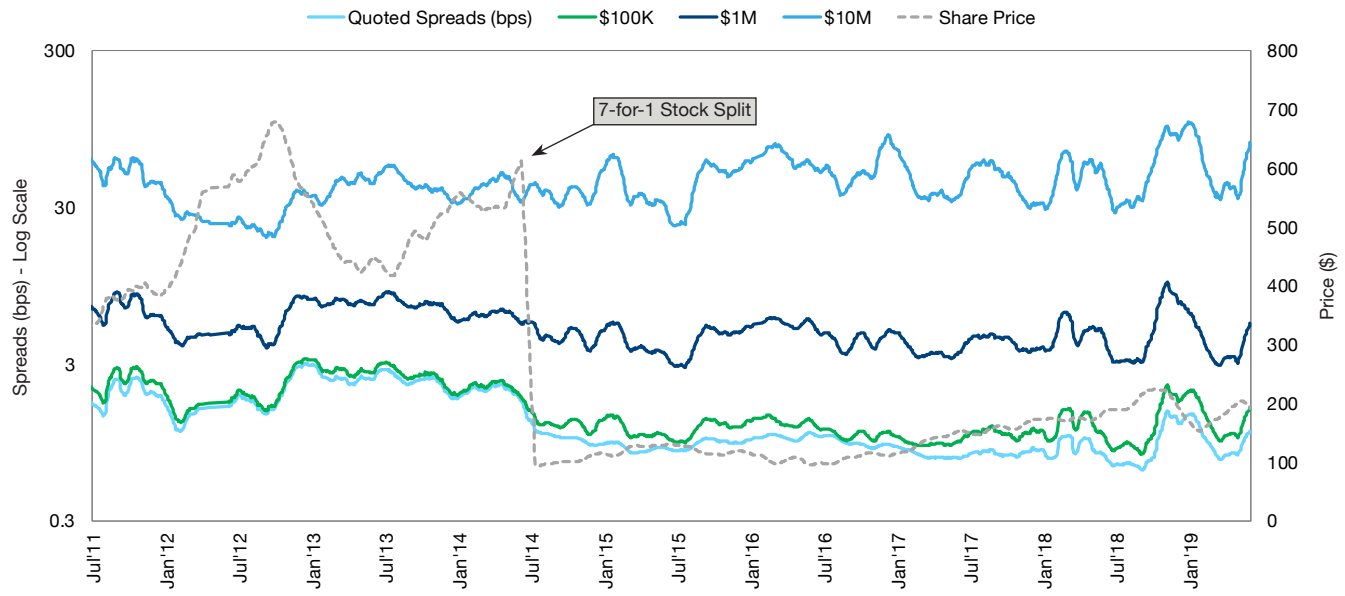


Apple (AAPL)

Perhaps the most interesting example among the individual names we examined is AAPL, where the depth of liquidity, as measured by size-adjusted spreads, remained basically unchanged for $10 million transactions, but improved for $1 million and $100,000 transactions (and markedly for the latter; see Fig. 5). A key factor here appears to be the company's 7-for-1 stock split on June 9, 2014, which took AAPL's share price down from about $700 to approximately $100. Immediately following the split, the quoted spread in AAPL fell from 10 cents to the regulatory minimum of one cent (more than compensating for the 7-to-1 split). This appears to also have improved size-adjusted spreads for all but the largest trades requiring the deepest levels of displayed liquidity.

One reason why the dramatic reduction in share price associated with the split may have reduced spreads is that the dollar value of a 100 share round lot transaction in AAPL dropped from ~$70,000 to ~$10,000. Quoted spreads are impacted by the risk market participants face in providing liquidity at a given price level and size. Put simply, the more risk one takes, the more one generally wishes to be compensated for taking that risk. Especially for market makers, this often means that bidding or offering in larger sizes comes with less-aggressive pricing than it would for smaller sizes. A market maker might make a two-sided market for $100,000 trade in a given stock at ten cents wide, for instance, while quoting a penny-wide market for a $10,000 trade, simply as a matter of risk management. The reduction in the round lot size for AAPL, then, may have brought risk levels down for market makers to the point where they were willing to quote at tighter spreads. Although the full depth of liquidity as seen in the $10 million scenario appears unaffected, supporting our broader thesis, the fact that liquidity improved for smaller transactions may be one reason why, in a market structure built on the display of round lots of 100 shares, issuers of high-priced securities may want to consider stock splits.

Fig. 5 — Quoted spread and size-adjusted spreads for $100,000, $1 million and $10 million transactions in AAPL with share price overlay

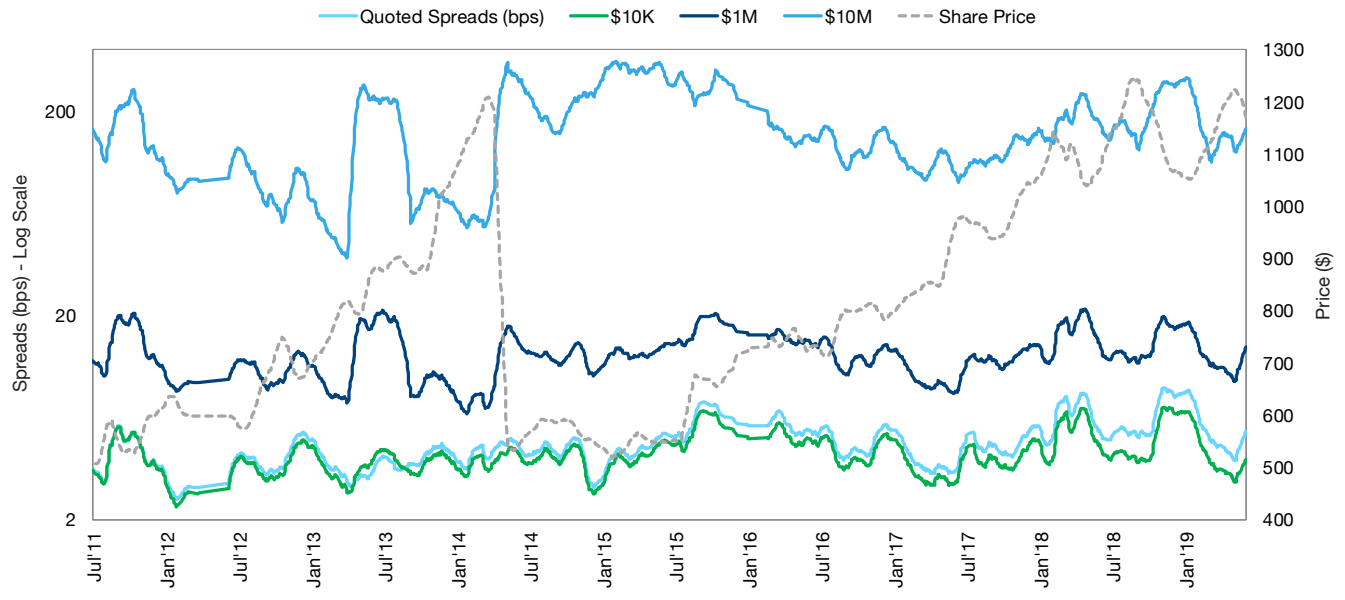


Google (GOOGL)

We see a variation on our theme in the data for GOOGL (see Fig. 6). On March 27, 2014, the company also executed a stock split. However, there were some key differences from AAPL's split that likely account for GOOGL's depth of liquidity not improving as AAPL's did. First, GOOGL's split was only 2-for-1, as opposed to AAPL's 7-for-1. Additionally, GOOGL shares were trading at approximately twice the share price of AAPL's before the split. As a result, from the perspective of market makers, the risk involved in making a two-sided market in a round lot in GOOGL (~$120,000 to~$60,000) did not decrease nearly as much as it did for AAPL (~$70,000 to ~$10,000 per round lot). The share price reduction for GOOGL, then, may not have been significant enough to encourage market makers to quote narrower spreads. Furthermore, GOOGL shares regained pre-split levels by 2018. AAPL shares, on the other hand, remain far below pre-split levels despite also appreciating markedly since, largely because of the greater magnitude of its split. Indeed, this may have prompted a slight decrease in liquidity depth for smaller-sized trades of $10,000 in GOOGL.

Also notable in the graph is that the size-adjusted spread for a $10,000 transaction is actually smaller than the quoted spread. This is because the high absolute price of GOOGL leads to significant odd lot quoting at spreads tighter than the NBBO.

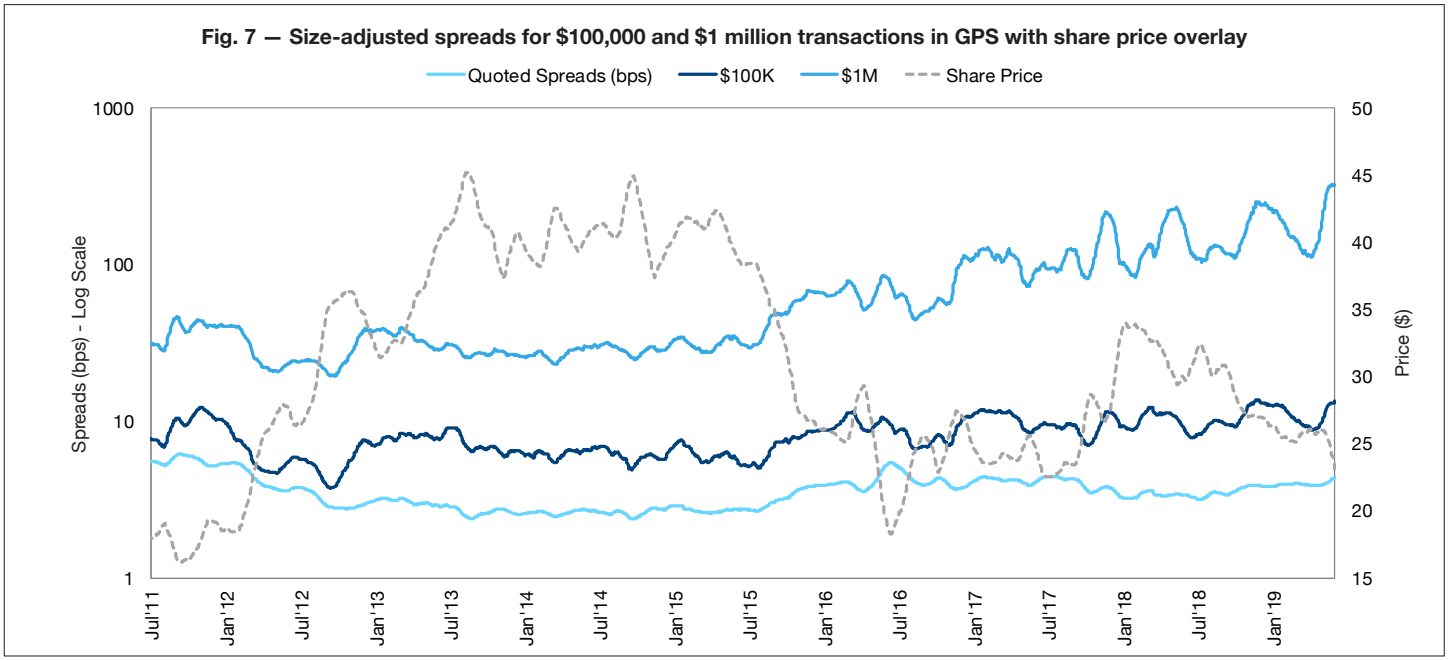
Fig. 6 — Quoted spread and size-adjusted spreads for $10,000, $1 million and $10 million transactions in GOOGL with share price overlay



Gap (GPS)

One outlier to the overall trend of stable liquidity among the individual stocks we analyzed appears to be GPS, which sees size-adjusted spreads increase for much of our time series. This is especially pronounced at larger trade sizes and during the past four years, as the share price has declined. GPS's market capitalization (currently about $7 billion) puts it among the smallest S&P 500 constituents, which may account for some of the differences seen.

Fig. 7 — Size-adjusted spreads for $100,000 and $1 million transactions in GPS with share price overlay

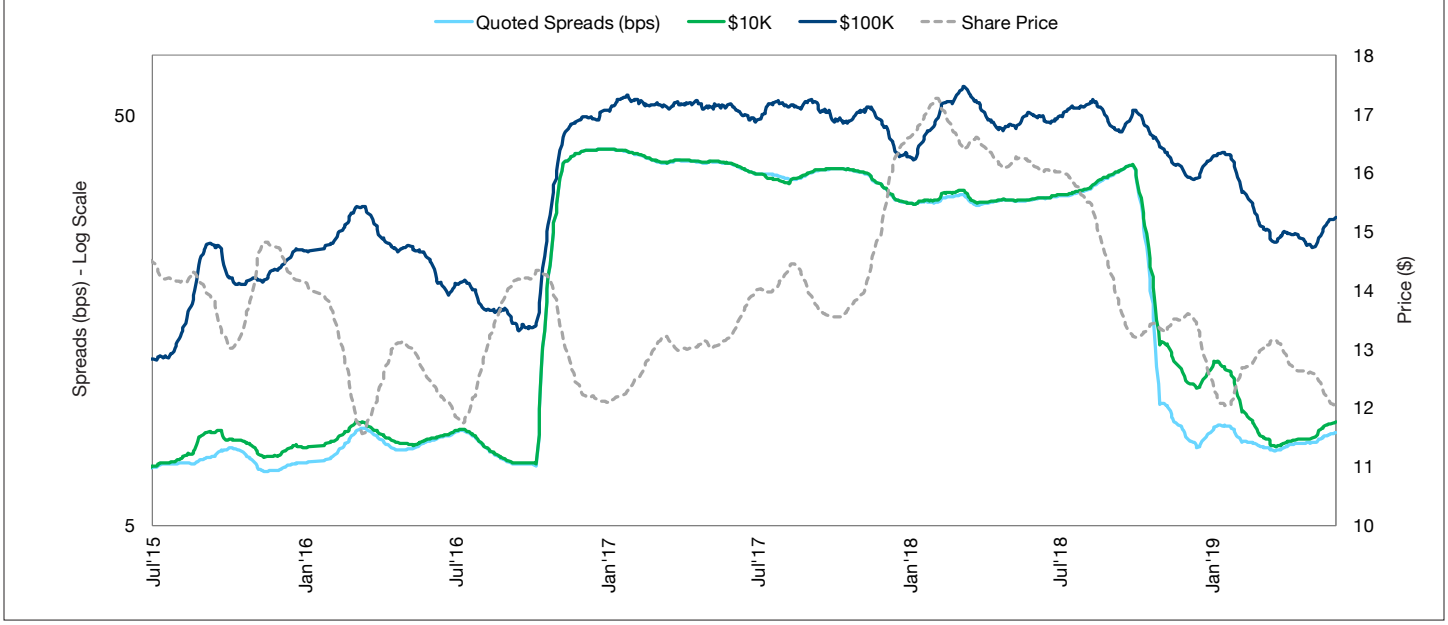


News Corp (NWS)

The most unique individual case in our data, however, is NWS. Also among the lowest market cap S&P 500 components (currently about $8 billion), NWS was included in the tick size pilot that ran from October 2016 to October 2018. During the pilot, NWS's minimum tick size jumped from $0.01 to $0.05 per share. Our data shows that depth of liquidity suffered while the pilot treatment was applied, significantly increasing size-adjusted spreads for $10,000 and $100,000 transactions, regardless of share price fluctuations (see Fig. 8).

The pre-pilot size-adjusted spread for a $100,000 transaction notably increased from below the tick size pilot minimum to well beyond what was required by the tick size pilot. In this example, the pilot not only failed to create more liquidity to counterbalance the cost of forcing a greater spread, but actually led to less overall liquidity at that greater spread. This observation is consistent with some of the more general results found by the exchanges in their analyses of the tick-size pilot.[3]

Fig. 8 — Size-adjusted spreads for $10,000 and $100,000 transactions in NWS with share price overlay



[3] See Joint Assessment of the Plan to Implement a Tick Size Pilot Program, July 3, 2018.

CONCLUSION

After a long period of benign market conditions and record-low VIX levels in the period since the financial crisis, it is only natural that recent volatility spikes in October 2018, December 2018, and August 2019 have prompted a search for explanations.

It is also understandable that some market participants would wonder whether recent structural changes have adversely affected liquidity and made markets more fragile.

Upon closer inspection, however, it is clear that the fundamental characteristics of today's trading landscape — including the rise of electronic market makers — predate the financial crisis and subsequent regulatory reforms. They also were in place before the recent explosion of passive investment strategies that are sometimes blamed for market fragility. Furthermore, our analysis of all displayed price quotations in the US equity market during the time period in question shows that liquidity has been remarkably stable for both large-capitalization and small-capitalization stocks.

Episodes of volatility are rarely enjoyable for market participants, but they do occur from time to time. The facts of how US equity trading has evolved and our analysis of liquidity data over time strongly suggest that such episodes occur because of factors other than changes in market structure, regulatory and competitive dynamics. We hope that our work here sparks further discussion among interested parties.

APPENDIX (METHODOLOGY)

Depth-of-book data was calculated by processing and aggregating individual order messages and price-level data, using the direct market data feeds from each of the 13 public stock exchanges. For each day, size-adjusted spreads were sampled at ten-second intervals from 9:45 through 15:45 ET. Size-adjusted spreads represent the price to clear the purchase of $X of a stock (or index) minus the price to clear the sale of a stock (or index), divided by the average of those two prices. Size-adjusted spreads for indexes represent the cumulative spread for the pro-rata purchase or sale of each of the underlying stocks in the index, in proportion to their index weightings. Quoted spreads were sampled directly from the SIP. Data in the charts represent a 22-day moving average of the daily observations.