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# Multiple markets, algorithmic trading, and market liquidity[☆]

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ABSTRACT

Using a sample of NYSE firms from the first quarter of 2012, we show that the National Best Bid and Offer (NBBO) depth is negatively affected by quote competition between exchanges and by excess algorithmic trading (AT) activity, but positively impacted by volume fragmentation. Trade execution quality also decreases with higher quote competition and AT activity but is better with higher volume fragmentation. In addition, we find that the U-shaped pattern of spreads is an S-shape, with higher spreads at the open and lower spreads at the close. NBBO depth has an inverse pattern to that of spreads.

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## 1. Introduction

Variations and changes of market liquidity are of interest to practitioners and market regulators. Variations in market liquidity impact practitioners via execution costs, price impacts, and implementation shortfalls of desired stock positions. Regulators monitor and assess the impact of market structure and the regulatory environment on market liquidity.

Over the past few years, the role of liquidity supply in the stock market has changed with the growth of algorithmic trading (AT). However, informed traders are also likely to use algorithmic trading to fill positions. With the growth in AT, the replacement of NYSE specialists with designated market makers (DMMs), the implementation of the Regulation National Market System (Reg NMS), the adoption of high-speed intermarket communications systems, as well as other changes, we feel it is important to reexamine the liquidity of NYSE listed firms. We investigate NYSE liquidity using a sample of 656 NYSE listed firms in the first quarter of 2012, using Daily Trade and Quote (DTAQ) data.

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As a simple example of the changes in intraday market liquidity, we find that the most liquid time of the trading day is at the market close. National Best Bid and Offer (NBBO) percentage spreads are at their lowest at the market close, while the NBBO depth is at its peak. The U-shaped pattern of spreads for NYSE listed stocks is no longer present. These findings are robust across firm trading intensity. In addition, the findings are not driven by changes in the intraday pattern of volume or message traffic, both of which remain U-shaped.

Kaniel and Liu (2006) propose a model that shows informed traders will use passive limit orders to trade when the time until the release of the information is long. An increase in informed traders using passive limit orders can increase message traffic and signal that there is information in the market. Goettler et al. (2009) show that informed traders will submit the bulk of limit orders to the market when information quality is high and that competition between informed traders will reflect private information in the limit order book (LOB). As new limit orders are submitted and canceled in the LOB, price uncertainty will increase. Traditional liquidity providers and algorithmic traders who focus on supplying liquidity may reduce the amount of liquidity they provide while waiting for the price uncertainty to be resolved. Thus an increase in quote message traffic can indicate higher information asymmetries in the market and lead to a reduction in liquidity.[1] In addition, informed traders can adopt a cross-market strategy where limit orders are posted on multiple exchanges. The order protection rule of Reg NMS creates only a price priority execution rule, while within an exchange price and time priority governs the placement of an order in the execution queue. Both actions can indicate that informed traders are placing resting orders to fill desired positions and that the LOB is more informed than those demanding liquidity, resulting in a decrease in market liquidity as traditional liquidity suppliers and algorithmic traders who focus on supplying liquidity withdraw from the market until the information asymmetry is resolved. We refer to this as the informed LOB hypothesis.

Intermarket competition improves market liquidity (Bessembinder, 2003). Several studies focus on algorithmic traders and high-frequency traders (HFTs), a subset of algorithmic traders, and find that competition between algorithmic traders improves market liquidity (Hendershott et al., 2011; Brogaard et al., 2013; Hasbrouck and Saar, forthcoming; Menkveld, 2013, Jarnecic and Snape, 2014).[2] However, the adoption of algorithmic trading and the speed associated with computerized trading introduces a new risk into stock markets; algorithmic trading adverse selection risk (AT adverse selection risk). AT adverse selection risk reflects the increase in potential adverse selection costs that arise when algorithmic traders who supply liquidity attempt to manage resting orders in a multi-market center trading environment. Under the AT adverse selection risk hypothesis, when quoted depth becomes more fragmented (greater intermarket competition), AT adverse selection risk will increase and market liquidity will decrease as potential adverse selection increases. Quote fragmentation is a proxy for intermarket competition and is measured as the average time-weighted Herfindahl index of ask NBBO depth and bid NBBO depth.

The difference between the informed LOB hypothesis and the AT adverse selection risk hypothesis rests in the side of the market that informed traders are filling their positions. If informed traders are on the side of the LOB, then realized spreads will increase and demand trade execution quality will decrease as uninformed liquidity demanders' trade against the informed LOB. However, if the AT adverse selection risk hypothesis is correct, then realized spreads will decrease and trade execution quality will increase as informed traders pick off resting orders.

Our results indicate that as quote message traffic increases, both from a stock-specific and market-wide standpoint, market liquidity decreases. In addition, as quoted depth becomes more fragmented across exchanges, market liquidity decreases. Thus more competition may actually decrease market liquidity and increase transaction costs. We also find that as message traffic increases and as quoted depth fragments between the exchanges, realized spreads increase and trade execution quality decreases. These results are supportive of the informed LOB hypothesis. As uninformed liquidity demanders' trade with an informed LOB their execution quality is lower and their realized costs increase.

Execution volume may also fragment. We measure volume fragmentation as the Herfindahl Index of volume, which executes over all exchanges in the Daily Trade and Quote (DTAQ) database.[3] We find that the correlation of volume fragmentation and quote fragmentation is relatively low, with a maximum value of 0.264. Foucault and Menkveld (2008) propose a model which indicates that greater volume fragmentation will improve market liquidity. Regression results in this study support their model. As volume fragments at the stock level, percentage quoted spreads decrease and NBBO display depth increases. We also find that as volume fragmentation increases, realized spreads decrease and execution quality increases. Our results, taken together, indicate that the LOB is more informed when quoted depth fragments and when message traffic increases but liquidity demand is more informed when volume fragments.

The balance of the paper is organized as follows. In Section 2, a brief literature review is presented, while in Section 3 we develop the testable hypothesis of the research. In Section 4, we present details of the data and methods. We discuss the results in Section 5. The conclusion is in Section 6.

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[1] The Daily Trade and Quote (DTAQ) database only shows quote updates for the top of the book. This creates a negative bias to our results, likely underestimating the impact of message traffic on liquidity because we cannot see the message traffic away from the top of the book.

[2] See Goldstein et al. (2014) for a discussion on computer and high-frequency trading.

[3] The Finra Trade Reporting Facility, exchange D in the DTAQ database, is in the assessment of volume fragmentation. All so-called TRF trades are reported under this exchange code.

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