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High frequency trading and extreme price movements☆

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ABSTRACT

Are endogenous liquidity providers (ELPs) reliable in times of market stress? We examine the activity of a common ELP type—high frequency traders (HFTs)—around extreme price movements (EPMs). We find that on average HFTs provide liquidity during EPMs by absorbing imbalances created by non-high frequency traders (nHFTs). Yet HFT liquidity provision is limited to EPMs in single stocks. When several stocks experience simultaneous EPMs, HFT liquidity demand dominates their supply. There is little evidence of HFTs causing EPMs.

1. Introduction

In modern markets, high frequency traders (HFTs) play an important role in providing liquidity (Hasbrouck and Saar, 2013; Menkveld, 2013; Malinova et al., 2014; Conrad et al., 2015). Generally, the rise of HFT has been accompanied by a reduction in trading costs (Angel et al., 2011; Jones, 2013; Harris, 2013) and an increase in price efficiency (Carrion, 2013; Brogaard et al., 2014; Chaboud et al., 2014). Nevertheless, liquidity provision by HFTs is endogenous as they are typically not obligated to stabilize markets in periods of stress. A growing literature finds that endogenous liquidity providers (ELPs) often withdraw from the market during such periods (Raman et al., 2014; Bongaerts and Van Achter, 2015; Cespa and Vives, 2015; Korajczyk and Murphy, 2015; Anand and Venkataraman, 2016). The focus of this study is HFT behavior during stressful conditions.

We define stressful periods as unexpected and rapidly developing extreme price movements (EPMs) that belong

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to the 99.9th percentile of the return distribution. While a growing body of work examines HFT activity during normal conditions, less attention has been given to periods of market stress such as EPMs. Our main finding is that, on average, HFTs trade in the opposite direction of EPMs and supply liquidity to non-high frequency traders (nHFTs) by absorbing their trade imbalances. This result holds even during the largest EPMs and during the times when nHFTs demand substantial amounts of liquidity. Notably, HFTs supply liquidity both to the EPMs that eventually reverse and the EPMs that result in permanent price changes. This means that an average HFT trade during extreme price movements provides liquidity to aggressive, occasionally informed, nHFTs.

Even though EPMs occur quickly, they consist of multiple sequential trades. If HFT algorithms are designed to stop providing liquidity during EPMs, technology would allow them to withdraw limit orders as EPMs develop. Yet the results imply that the algorithms are designed to remain in the market, likely because doing so is profitable. Although revenue estimates are noisy, we find evidence that the revenues are greater on days when EPMs occur. Despite the enhanced revenue potential, the data show that HFTs do not cause EPMs. Our results complement those of Bessembinder et al., (2016), who show that liquidity provision increases around large uninformed predictable trades. In our setting EPMs are generally unpredictable and are occasionally informed, yet the incentive to provide liquidity remains. Our findings expand the understanding of resiliency of modern markets in stressful times.

Although HFTs stabilize prices during an average EPM, we find clear limits to HFT liquidity provision. HFT liquidity supply is outstripped by their liquidity demand when more than one stock simultaneously undergoes an EPM (we refer to these instances as co-EPMs). We show that during such periods, HFTs accumulate substantial position risk, which likely triggers risk controls, particularly for their liquidity-supplying strategies. Focusing on one exceptionally large co-EPM, the 2010 Flash Crash, Kirilenko et al., (2017) find that HFTs withdrew from liquidity provision. Reflecting on the Crash, the regulators have expressed concern that incentives to provide liquidity are deficient during market-wide periods of stress (Commodity Futures Trading Commission-Securities and Exchange Commission (CFTC-SEC), 2011). Our findings generalize these results and deepen our understanding of market-wide liquidity shortages and offer evidence in support of the regulators' view.

Theory suggests that ELPs may choose several ways of reacting to order imbalances. Traders described by Grossman and Miller (1988) choose to supply liquidity during order imbalances. On the contrary, the predatory traders of Brunnermeier and Pedersen (2005) opt to demand liquidity. The back-runners of Yang and Zhu (2015) supply liquidity until they recognize an institutional trading pattern and then switch to demanding liquidity. In our setting, HFT behavior during an average EPM is more consistent with that described by Grossman and Miller (1988), although the data point to net HFT liquidity demand during co-EPMs and occasional back-running for long EPM sequences.

2. Data, EPM detection, and summary statistics

2.1. HFT data

The HFT data come from Nasdaq and span two years: 2008 and 2009. These data have been previously used by Carrion (2013), Brogaard et al., (2014), and O'Hara et al., (2014), among others. For each trade the data set contains an indicator for whether an HFT or an nHFT participates on the liquidity-supplying or the liquidity-demanding side of the trade. When preparing the data Nasdaq identified 26 firms that act as independent HFT proprietary trading firms based on its knowledge of the firm's activity. A firm is identified by Nasdaq as an HFT if it trades frequently, holds small intraday inventory positions, and ends the day with a near zero inventory. HFTs on Nasdaq have no obligation to stabilize prices during stressful times (Bessembinder et al., 2011; Clark-Joseph et al., 2017) and so are ideal participants to study liquidity provision by ELPs.

The data allow us to directly observe HFT liquidity provision and demand. We are subject to the same limitations as the abovementioned studies, mainly that we cannot observe individual HFT activity and that we only observe trading on Nasdaq. Although trades on Nasdaq make up 30–40% of all trading activity in the sample stocks, it is possible that during EPMs HFTs provide liquidity on Nasdaq while taking it from the other markets. We are unable to refute this possibility. Nonetheless, we believe that such liquidity transfer is unlikely as liquidity provision on Nasdaq is not systematically more attractive than it is on other venues during the sample period.

2.2. EPM identification

We identify EPMs as extreme changes in the National Best Bid and Offer (NBBO) midquotes. The use of midquotes instead of trade prices allows us to reduce the effect of the bid-ask bounce. In untabulated results we find similar effects when using trade prices. We obtain the midquotes from the NYSE Trade and Quote database (TAQ) after adjusting the data according to the recommendations of Holden and Jacobsen (2014). Specifically, we (i) interpolate the times of trades and the times of NBBO quotes within a second, (ii) adjust for withdrawn quotes, (iii) delete locked and crossed NBBO quotes, and (iv) delete trades reported while the NBBO is locked or crossed. To avoid focusing on price dislocations that may be caused by market opening and closing procedures, we only consider trading activity between 9:35 a.m. and 3:55 p.m.

Using the filtered TAQ midquotes, we compute 10-second absolute midquote returns. The choice of the 10-second sampling frequency is based on two offsetting considerations. On the one hand, detecting EPMs that result from brief liquidity dislocations requires a relatively short sampling interval. On the other hand, a sampling interval that is too short may split an EPM into several price changes that are not large enough to be captured by the identification procedure. The choice of 10-second intervals is a compromise between these two considerations. As a robustness check, we repeat the main analyses for several