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ORIGINAL ARTICLE

High-frequency trading: Order-based innovation or manipulation?

Viktoria Dalko[1] · **Michael H. Wang**[2]

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Abstract
High-frequency trading (HFT) is a financial innovation that focuses on order flow and relies on quickly evolving information and communication technology. The innovation is successful, and HFT is highly and consistently profitable. However, the Flash Crash on 6 May 2010 exposed the unfamiliar side of HFT, thus illuminating the emergent need to unveil the negative impact that HFT has on other investors and the market. This paper examines data regarding quote-stuffing, spoofing, and market making provided by high-frequency (HF) traders, based on the increasing empirical literature. It first defines order-based manipulation (OBM) as the framework under which quote-stuffing, spoofing, and HF market making find common ground. It then provides details regarding how OBM is displayed in the three manipulation tactics. In essence, they all seek and exercise monopoly power in trading albeit through different ways of achieving it. The shared purpose is to gain monopolistic profit. The essence and common purpose explain why HF traders are not net liquidity providers, contrary to some proponents' conclusions. Rather, this paper points out the three consequences that HF traders have brought to the market, i.e. increased volatility, increased frequency of unfairness, and instability potential. Recent regulatory improvement and completed prosecutions against manipulative HFT strategies justify the analysis.

Keywords High-frequency trading · Order-based manipulation · Monopoly · Instability · Regulation

Introduction

Financial markets are full of uncertainty. One main source of uncertainty is the impact of price-sensitive information flowing constantly into the market. Corporate announcements, analysts' ratings, macroeconomic data, and breaking news are among the frequently encountered price-sensitive news events. However, some of those news events can be and have been manipulated for trading purposes. Numerous insider trading episodes have been recorded behind manipulation of earnings, spin of analysts' recommendations, and other publicly disseminated information for the past 50 years [1, 2]. Insider trading with or without the assistance of manipulated insider information adds substantial uncertainty to publicly available information. Thus, it is risky to make investment decisions by relying on information content only. Sophisticated investors invest heavily in technology in order to achieve consistent high performance by focusing on order flow while avoiding informational uncertainty. Information and communication technology is one area that plays an important role in the investment.

Since the 1980s, investors have used computer programs or algorithms to implement investment decisions and trading strategies. The application of information and communication technology in portfolio management is called program trading or algorithmic trading (AT). As the information and communication technology has grown, so has AT [3]. High-frequency trading (HFT) is considered as a subset of AT by several researchers, but the two have different purposes [4, 5]. While AT may be used for order management by institutional investors, HFT is used for trading profit only and relies on the processing power of fast computers to make good use of market data and trading transactions in as little time as microseconds. Some researchers attribute the birth

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✉ Viktoria Dalko
viktoria.dalko@faculty.hult.edu

[1] Department of Finance, Hult International Business School, 1 Education Street, Cambridge, MA 02141, USA

[2] Research Institute of Comprehensive Economics, 435 Hancock Street, Quincy, MA 02171, USA

of HFT to fragmented trading venues due to Regulation National Market System implementation by the Securities and Exchange Commission in 2005 [3, 6]. In addition, we believe that HF traders seek certainty by focusing on order flow and avoid uncertainty created by continuous, frequent, and globalized information flow of price-sensitive content. Another important factor is the decimalization of tick size due to regulatory improvement in 2001 [6]. This leads to more frequent turnover with thinner profit expectation per turnover. Thus, the main HFT strategies include market making, statistical arbitrage, liquidity detection, and momentum ignition [7]. In brief, HFT is an innovation based on fast advance in information and communication technology as well as regulatory evolution.

Innovation has awarded HFT large and persistent profits that are not commensurate with the risks they take [8, 9]. For example, Virtu Financial, a leading HF market-making firm, had 1237 days of positive returns but only 1 day in which it lost money for the period of 1 January 2009–31 December 2013 [10]. This consistency in a firm's high performance is superb according to the standard of traditional asset management firms.

Today, HFT provides a significant portion of daily trading volumes in US equity markets. More recent estimates show that HFT made up 35 per cent of equity trades in the USA in 2005. This number increased to 56 per cent in 2010 and further to 70 per cent in 2012 [3]. The dominance of HFT in equity trading requires serious research on its impact to investors and the market as a whole. The Flash Crash on the New York Stock Exchange on 6 May 2010 and the Knight Capital's software glitch on 1 August 2012 forced regulators and market participants to assess the negative impact that HFT brings to the market [11, 12].

This paper first examines two HFT manipulative tactics centred on order submission and quick cancellation, quote-stuffing, and spoofing. They are all included under the same category: order-based manipulation (OBM). This type of market manipulation is de facto creating and exercising monopoly power in seeking trading profit [1, 13]. In addition, the paper investigates market making by high-frequency (HF) traders. The finance literature and practical experience show that market making carries unparalleled monopoly power. Since HF market makers are volunteers and have no contractual obligation to provide continuous liquidity, these HF traders seek monopoly power and make a certain trading profit. In essence, the three types of tactics used in certain HFT strategies share the same purpose. They are all used to obtain monopoly profits with exercising monopoly power in trading.

The rest of the paper is organized as follows. The next section presents the definition of OBM and analyses the major characteristics of OBM. The comparison between OBM and trade-based manipulation (TBM) exhibits different ways to create monopoly power in trading with the same purpose of gaining monopolistic profit in the two manipulation schemes. This paper then shows a detailed description and analysis devoted to two typical tactics used in OBM—quote-stuffing and spoofing. The authors use tables to demonstrate how these two tactics are applied in practice. Market making possesses monopoly power by nature. The volunteer market makers by HF traders seek monopolistic profit but provide no service of designated market makers. Thus, one understands why HFT is not a net liquidity provider as some researchers proposed. Rather, the manipulative part of HFT has brought negative impacts on other investors and the market. Increased volatility in both frequency and magnitude is one of them. Unfairness to competition regarding trading profits is another impact. The most disruptive is the instability potential which may lead to financial crisis and extraordinary unfairness. Thus, manipulative HFT should be and have been regulated in the developed markets. The final section concludes.

OBM creates monopoly power in trading

According to the manipulator's tactic to get share prices lifted, market manipulation is categorized as trade-based, information-based, and action-based [14]. There is a new type of market manipulation that does not belong to any of the above three types of market manipulation. It has neither public information dissemination nor corporate action involved. Thus, it is irrelevant to information-based or action-based manipulation. It does not use actual trading activities, such as self-dealing (wash trades) and cross-dealing (matched trades), to cause price changes to manipulate numerous investors' perception. Hence, it is not TBM. Rather, the manipulator has no intent to trade but relies on order submission and immediate cancellation to create the appearance of large and incoming liquidity in order to influence other investors' trading decision-making. If successful, the influenced investors will trade, or will have difficulty trading, to speed up or slow down price change, as desired by the manipulator. The key is the manipulation of order display or exchange's processing functionality [1, 15]. This type of market manipulation is called order-based manipulation (OBM).

The terminology OBM has been used previously but in situations in which HFT either did not exist or was not identified. One study selects pre-market hours to investigate the impact of submit-and-cancel activities by IPO firms on the reactions of investors [16]. Another study presents empirical high-frequency data of order cancellations to detect OBM [17]. However, they do not differentiate whether order cancellations in their sample are made by HF or non-HF traders. The third one provides a complete case study of

a convicted manipulator who conducted OBM in China in 2008 [18]. Apparently, the account-level data used by the authors show no HFT involvement. Furthermore, none of the above studies formally defines OBM.

Today, most equity markets worldwide are order driven, and HFT is an emerging dominance in developed markets. HFT focuses on order flow and frequently engages in manipulative schemes. Therefore, formally defining and analysing OBM in the HFT era is necessary. Thus, this paper presents a tentative definition of OBM in the following proposition.

Proposition *Order-based manipulation is a type of market misconduct in which the manipulator creates illusive order display or artificial processing difficulty but with no bona fide intent to get submitted orders executed. The manipulator's purpose is to make monopolistic profit by inducing acceleration or deceleration of price changes in the targeted contract desired by the manipulator.*

OBM appeared during eras prior to HFT. The primary characteristic is that the fake orders—orders that are submitted and cancelled quickly before execution—are designed to be seen by other investors in order to create the false appearance of continuously increasing liquidity for the contract. Fake orders have to be large in order to facilitate numerous investors' perception that large volumes are entering the market. Fake orders are placed and cancelled in high frequency so as to induce high demand in the direction of fake orders in a short period of time. Thus, OBM is characterized by a short manipulation time period. This scheme bears no transaction cost and can be repeated with ease. Hence, it is the least risky among the known forms of manipulation used to accelerate or decelerate price changes within a short period of time. Several securities' litigation releases provide evidence in OBM prior to HFT era [1, 18]. Table 1 compares the key characteristics of OBM with those of TBM in the case of accelerating price changes.

A high ratio of order cancellation to execution is one primary characteristic of HFT [4, 19]. Apart from non-manipulative order cancellations, HFT has updated OBM with faster speed in placing and cancelling orders and larger numbers in submitted and cancelled orders. One innovation through HFT is to decelerate the price changes of a targeted stock or another contract in addition to the extant acceleration-oriented OBM. Another innovation is to simultaneously manipulate multiple targeted contracts and exchanges. Thus, HFT has created new manipulation tactics with microsecond or nanosecond frequency, which a human trader can hardly achieve.

Within the framework of OBM, the manipulator's purpose is either to accelerate or decelerate the price changes of a targeted contract. When accelerating price changes, the manipulator can profit at the increased price changes by closing an earlier accumulated shareholding position, or he can start a new position in a contrarian fashion. In such a case, he may or may not need another OBM cycle, so he can close the newly established position at a profit. When decelerating price changes of a targeted stock or contract, the manipulator usually creates cross-contract or cross-market arbitrage opportunities.

The next section will examine two more researched HFT tactics to determine how they create monopoly power. These tactics used by HF traders are quote-stuffing and spoofing. For the convenience of discussion without losing generality, the paper selects the stock market as a representative of financial markets.

Table 1 Comparison of OBM with TBM in accelerating price changes

Manipulation type	Manipulation tactics	Essence of manipulation	Profiting opportunity	Transaction cost	Legal risk
Order-based manipulation (OBM)	Submitting large orders and quickly cancelling them	Creating illusive order display to induce substantial trading by other investors desired by the manipulator	Accelerating price changes to distribute shares previously accumulated	No trading cost in the USA	Prohibited by Dodd–Frank Act (2010)
Comment	No intent to trade	Creating monopoly power in trading	Seeking monopolistic profit		
Trade-based manipulation (TBM)	Fictitious trading such as wash trades and matched trades	Creating actual price changes to induce substantial trading by other investors desired by the manipulator	Accelerating price changes to distribute shares previously accumulated	Limited trading cost	Prohibited by Securities Act (1933) and Securities Exchange Act (1934)
Comment	Genuine intent to trade with limited volume	Creating monopoly power in trading	Seeking monopolistic profit		

OBM tactics in the HFT strategies

Quote-stuffing

Quote-stuffing is a new manipulative tactic that certain HF traders bring to the stock market. It deserves serious attention, since it affects the majority of US listed stocks and operation of large exchanges [19]. Its practice is submitting an extraordinarily large number of orders followed by immediate cancellation. Subsequently, quote-stuffing generates order congestion. Its purpose is to slow down the processing of the exchange and lift the entry barrier to other traders [4, 15, 19, 20]. Thus, quote-stuffing is an OBM tactic in the category of causing processing difficulty and decelerating the price changes of the targeted stock.

A large number of order submissions may also cause the exchange receiving the quotes to lag other exchanges, thus creating arbitrage opportunities for the manipulator [8, 15, 21, 22]. Other investors can be misinformed as to which exchange has the most liquidity or best pricing. The HFT strategy that employs quote-stuffing is both manipulative and predatory. It generates more pollution and waste in message traffic. It reduces the probability and causes delays for other investors' orders to be filled. It is correlated with short-term volatility, decreased liquidity, and higher trading cost. It is detrimental to market quality [5, 15, 19]. In other words, cancelling orders in great numbers at a flash monopolizes resources. The trading profit gained in this regard is through OBM by slowing down victimized investors, particularly non-HF traders. Several researchers consider quote-stuffing to be a type of market manipulation [15, 19, 20]. To be more precise, quote-stuffing is the core tactic in the complete cycle of some OBM strategies. It is illegal, as Dodd–Frank Section 724 prohibits "bidding or offering with the intent to cancel the bid and offer before execution" [19].

Table 2 shows how quote-stuffing works on one stock on the targeted exchange that is also traded on another exchange.

In short, the purpose of quote-stuffing is essentially to slow down the trade processing of, and thus to decelerate the stock price changes in, the targeted exchange. This way, the manipulator has created monopoly power by opening up cross-stock or cross-exchange arbitrage opportunities. He can hence gain monopolistic profit.

Spoofing

Spoofing by an HF trader is essentially equivalent to engaging in fake orders or fake trading by human traders. The key to this tactic is to create the appearance of a great amount of liquidity coming into the market immediately. The HF trader has no genuine intent to trade and thus cancels all of the orders submitted. The main purpose of this tactic is to speed up the price changes of the targeted security by inducing other investors to trade in the direction desired by the HF trader. However, the fake orders and the lack of bona fide trading assemble manipulation of the order display in the limit order book. Research shows that some HF traders manipulate order display to speed up price changes with a high success rate [23]. The main reason spoofing works is that the display of the limit order book is incomplete. The display shows only submitted orders, but no cancelled or executed orders, which are seen instantly by numerous market participants.

The Flash Crash in the New York Stock Exchange on 6 May 2010 provides an excellent example of spoofing. Sarao, a London-based HF futures trader, entered thousands of E-mini futures contracts on the crash day to sell, which he planned to cancel later. These orders, amounting to about $200 million, were replaced or modified 19,000 times before they were cancelled at various times throughout that day. The spoof orders represented well over 20 per cent of all E-mini sell orders visible to the market and were sufficiently large to induce numerous genuine sell orders to follow

Table 2 Quote-stuffing on a stock traded on two exchanges

Manipulation stage	Normal trading on Exchange 1	Quote-stuffing by manipulator on Exchange 1	Deceleration of price changes on Exchange 1	Normal trading on Exchange 2
Action	Manipulator's buy orders executed	Large number of buy orders submitted and cancelled quickly	Numerous orders by other investors crowded out and stock prices increase slowed down	Manipulator's sell orders executed
Manipulator's intent	Genuine intent to trade	No intent to trade		Genuine intent to trade
Manipulation outcome	Shares bought at lower prices	Monopoly power created with order congestion		Shares sold at higher prices
Comment	Cross-exchange arbitrage initiated	Seeking monopolistic profit through arbitrage		Cross-exchange arbitrage completed

instantly. The resulting panic selling quickly caused both E-mini futures and the underlying stock market index to fall steeply after about 2:32 pm on the day. The Dow collapsed 998.5 points (about 9%), most within minutes, and recorded the largest intraday point drop by then. After a brief trading halt, the Dow rebounded as rapidly as it dropped. Within half an hour, nearly 90% of the loss was recovered [24, 25].

The convicted HF trader admitted that, on the Flash Crash day, he was able to induce other market participants to sell E-minis by placing the downwardly layering spoof orders. The spoof orders were used to significantly but artificially depress the price of E-minis by creating the appearance of substantial false supply and to induce other market participants to sell E-minis at prices and quantities they normally would not have traded. Once the E-Mini prices were decreased to a very low point, the HF trader executed genuine orders to buy a large number of E-Mini contracts [25]. In this scenario, his real intention was to establish a new long position. He expected to buy shares at a price lower than the current price. By submitting and immediately cancelling a large number of downwardly layered spoof orders, he established a long position at a much lower price by trading against the panic selling investors [4]. The Flash Crash is an excellent example of the case in which the manipulator "shakes out" shares from selling investors before building a substantial long position [26].

Spoofing in the long direction is also called momentum ignition [4, 27]. The difference between this and spoofing in the short direction is that the manipulator holds a long shareholding position before manipulation in this case. He plans to close the position at a higher share price. His goal is to create the appearance of large buy orders entering the market so numerous investors will rush to buy and push up the share price. Depending on how much profit he expects, he can choose to spoof once and sell his holding position after the upward momentum has been ignited by his spoof orders. He can also choose to engage in consecutive upwardly layered spoofing multiple times, similar to the tactic used by Sarao on the Flash Crash day but in the opposite direction. Once the price inflates substantially higher, he sells his position completely by trading against the induced investors at a sure profit [4, 23, 28]. Herein the manipulator uses spoofing to increase the share price in his accumulation–lift–distribution scheme [1].

Table 3 shows the full cycle of OBM that features spoofing.

In sum, spoofing is a tactic of order display manipulation. Spoofing is successful because the stock market is set up to display only submitted orders but not cancelled or executed orders. The incomplete disclosure of order information by the exchange facilitates the OBM and enables some HF traders to use spoofing to make monopolistic profit by creating and exercising monopoly power in trading.

Market making by HF traders

Financial intermediaries include brokers and dealers or market makers. The literature shows that these entities have monopoly power based on the insider information of order flow [29–33]. Frequently they are engaged in price manipulation such as front running and pump-and-dump schemes. The brokers and market makers that conduct more manipulative trades earn significantly higher profits. The manipulation activity by intermediaries is prevalent among both developed and emerging markets [34–40]. A convicted Canadian manipulator confirms the above research findings [41]. Market makers have the last say than the investing public in both human and electronic markets. Thus, they are the winners of the trading game according to an old Wall Street adage, "he who trades last" [30].

Market makers or specialists are frequently criticized for the conflict inherent in their dual roles as brokers for the orders left with them to be entered in the book and to serve as dealers trading for their own accounts. They use the monopoly power based on access to the order book and the central role of trade processing for their own benefit at the expense of the investors who submit the orders into the book [29, 30, 42].

The literature of human market makers shows that they have both an execution advantage (buy at the bid and sell at the ask, which is higher than the bid in the bid–ask spread)

Table 3 Spoofing in a long manipulation strategy

Manipulation stage	Accumulation by manipulator	Spoofing by manipulator	Induced trades by other investors	Distribution by manipulator
Action	Buy orders executed	Buy orders submitted and cancelled quickly	Numerous buy orders executed and stock prices lifted	Sell orders executed
Manipulator's intent	Genuine intent to trade	No intent to trade		Genuine intent to trade
Manipulation outcome	Shares accumulated	Monopoly power created with appearance of incoming large buy volumes		Monopolistic profit gained

and a timing advantage (foresee the short-term price movement based on the order imbalance) relative to other market participants [43–48]. These two advantages give market makers monopoly power, which leads to predictable profit with little risk, i.e. monopolistic profit. Exchanges such as New York Stock Exchange give this monopolistic position to designated market makers (or specialists) in exchange for their service of continuously providing liquidity on both sides of the market. In other words, the designated market makers have contractual duty to facilitate smooth trading transactions during both tranquil and turbulent times of the market.

As quote-stuffing and spoofing display that some HF traders create monopoly power through OBM, some other HF traders gain endowed monopoly power by acting as market makers. This explains why a substantial portion of HF traders volunteer to act as market makers. Volunteer HF market makers have no contractual obligation. They are like other investors and are profit seekers only. They provide liquidity based on adverse selection [5, 49–51]. Thus, it is not surprising that HF market makers are profitable in general [21].

Aforementioned Virtu Financial implies that HF market makers earn consistent positive returns day in day out, at times of either quiet market or turbulence. The reason may be that they occupy the monopolistic position of market makers but do not provide the corresponding service. Often, they seek to accelerate price changes of the targeted stock through OBM, such as spoofing, or not, such as front running. Therefore, they profit more from buy-low-and-sell-high in the long direction or sell-high-and-buy-low in the short direction. Financial trading is a zero-sum game to the best, and HF market makers profit at investors' expense. When HF traders gain and exercise monopoly power in their trading strategies, they profit unfairly and sometimes illegally.

To summarize, some HF traders create monopoly power in trading by employing OBM tactics such as quote-stuffing or spoofing, and some other HF traders gain endowed monopoly power in trading by taking monopolistic positions such as market making. The common purpose of all of these HF traders is to seek monopolistic profit by exercising the created or endowed monopoly power in trading.

HFT is not a net liquidity provider

Research shows that HFT is mainly engaged in intraday speculation and finishes a trading day with no or negligible shareholding. Thus, HFT needs abundant liquidity to enter and exit the market with ease [4, 21]. A number of researchers argue that HFT provides substantial liquidity, reduces bid–ask spread, mitigates price volatility, and thus improves the market quality [8, 21, 52–55]. However, the data used by these researchers are provided by US exchanges. They do not include the broker identifications. Some of the aforementioned researchers use a proxy for the activity of HF traders by using data on submitted orders which may or may not be executed. Others use NSADAQ data that exclude brokers and dealers who are important HFT players [4]. These researchers used market quality metrics developed prior to the prevalence of HFT. Therefore, their conclusions that HFT improves market quality are questionable [5].

Research shows that HFT appears mainly in large liquid stocks, particularly in the stocks with the greatest capitalization yet the lowest price [8, 19, 21, 56]. A natural explanation is that HF traders are not net liquidity suppliers if not net liquidity takers. It has been shown that HF traders supply nearly the same amount of liquidity as the liquidity they take [8]. Worse, HFT does not supply liquidity but takes it when liquidity is in shortage. On the other end, HFT provides substantial liquidity when liquidity is not needed [5].

One must bear in mind that the ratio of order cancellation to order execution is very high among the submitted orders by HF traders. The liquidity generated by HFT may not be provided by the same HF trader but may be induced from other investors. This is true because, frequently, HFT strategies include spoofing and other OBM tactics that submit numerous large orders then quickly cancel them right before execution. The development is that very likely other investors, particularly slow traders, get spoofed and rush to trade in the direction desired by the spoofer. In this case, the liquidity provider is not the spoofing HF trader, but induced investors. They may be non-HF traders. They may be other HF traders [4, 22, 57].

During market tranquillity times, HFT seems to supply liquidity if induced liquidity counts as HFT liquidity provision as well. However, HF traders compete fiercely with other traders for liquidity during stressful times. The subsequence is that either HF traders compete to draw liquidity away from slower traders or the competition causes non-HFT liquidity providers to withdraw from the market [49–51]. This adverse selection in liquidity provision may be the more complete truth of HFT strategies.

To summarize, liquidity provision is the key argument that some researchers use to advocate for HFT. The above analysis shows that one needs to distinguish whether the liquidity generated by HFT is provided by honest HF traders or induced from other investors by HF traders who undertake OBM strategies. One should also consider the interplay between HFT and liquidity at both peaceful and stressful times of trading to gain a clear complete picture.

Consequences of manipulative HFT strategies

Not all HFT strategies are detrimental to market quality. The HFT strategy that involves cross-market arbitrage is beneficial to other market participants because it helps to maintain the law of one price if no manipulative tactics such as quote-stuffing are used [58]. Some HFT strategies are manipulative, and they do have negative impact on other investors and the market.

Market manipulation is de facto creating and exercising monopoly power in trading [1, 13]. Consequences of OBM played by HF traders include increased frequency and magnitude of price volatility, unfair and monopolistic profit at manipulated investors' loss, and instability potential. Next, the three aspects will be explored in greater detail.

Volatility increase

In the end of the manipulation strategy that involves spoofing used by an HF trader, the induced traders, particularly slow investors, are not aware of a sudden and unexpected trend reversal because the spoofing HF trader will trade against them. This unpredictability of price trends results in uncertainty among induced investors. Since HFT generates a large number of trades within very short time periods [59], the frequency of price reversal and other volatility risks increases substantially [5]. That is, spoofing HFT causes more intraday price volatility. Research shows that short-term volatility systematically increases when AT and/or HFT intensity increases [55]; the responses of HF traders to the large selling pressure exacerbated market volatility substantially in a short time period [51]; and HFT activity increases long-term volatility [60]. HF traders' fierce competition for liquidity during market turbulence leads to liquidity dry-up and short-term volatility. Occasionally, the magnitude of volatility on a short timescale is relatively very high and negatively affects the functionality of the market. The Flash Crash in 2010 provides a convincing example to support the argument. Subsequently, the market quality deteriorates and instability emerges [19, 51, 61].

Increased frequency of unfairness

The set-up of the stock trading rule provided every investor the freedom to transact, enter a position, and exit from it, at least theoretically. The market maker provides immediacy by charging the bid–ask spread. If the investor enters the market at the ask price and immediately exits the market, he must close his round-trip trade by selling at the lower price of the bid. By so doing, he incurs a loss of the difference of the ask and bid. In this sense, trading is a sub-zero-sum game for the investor, if prices do not move. However, if one includes the market maker's gain, the game is zero-sum. In this case, the investor faces financial risk only.

However, the stock market evolves hand in hand with technology, particularly information and communication technology. The evolution of the technology has brought new risk to investors in addition to some benefits. Because stock exchanges place high priority on speed in order to display and process incoming orders at the same price, HF traders have an obvious advantage over slow traders. This creates unfairness if an HF trader competes with a slow trader for the same profit. Some may argue that slow traders should avoid competing with HF traders so there is no unfairness. The reality is that slow traders can hardly avoid being taken advantage of by HF traders, particularly when they place large orders [5]. The only solution slow traders may have is to hold over longer time horizons and reduce trading frequency. This way, slow traders lose some of their freedom, while HF traders can compete with any investor at will. This path seems to avoid financial unfairness but creates unfairness in freedom, which ultimately leads to financial unfairness [62].

As HFT increases order cancellations substantially, OBM becomes the dominant type of market manipulation relative to traditional action-based, trade-based, and information-based manipulation. OBM brings additional unfairness between HF traders and slow traders in addition to the existing sources of unfairness, such as insider trading and traditional types of market manipulation. This is because OBM incurs no transaction cost and can be repeated many times on any trading day. Therefore, manipulative HFT increases the frequency of unfairness. However, OBM dominance is due to the evolution of the stock market in tandem with information and communication technology. It is not overstated that the evolution of the stock market creates new dimensions of risk and subsequently new types of unfairness, which is characteristic of increased frequency.

Not all profits gained by HF traders are unfair simply because they have clear advantages in speed and processing capacity over other investors. However, some manipulative uses of HFT are unfair [63]. More accurately, if the HFT strategies exercise monopoly power, either created through OBM or endowed by monopolistic positions, in trading, the gained profits are monopolistic. Very likely they are unfair. Furthermore, they may be illegal.

Instability potential

HFT makes spoofing and other manipulative practices much more frequent and pervasive today [5]. HFT strategies involving spoofing or other OBM tactics may ignite herding by other investors. The herding can be fast and

more frequent if HF traders are among the induced crowd. Because HFT can ignite and maintain superfast downward herding or that would also be measured as serial correlation, it could increase the risk of a sharp price swing with or without the arrival of any fundamental news. Therefore, HFT has more potential to create a systemic risk [8, 10, 22, 64]. The Flash Crash on the New York Stock Exchange in 2010 is one of the most severe events that disrupted the market stability. Such events were caused or exacerbated by HFT [25].

Instability has a more potent detrimental effect on market participants than volatility and unfairness. Serious market instability incidents such as short-term crashes and sharp return reversals catch numerous investors off guard and may result in steep losses. Thus, market instability is frequently linked to unexpected victimization of some market participants. The rates of unexpected and large losses may be higher than those of losses due to unfairness in trading. The extreme of market instability, marketwide crisis, may lead to global financial crisis. The 2007–2008 global panic has caused more consequences in unfair losses, unhappiness, and mental and physical health problems than any economic event since World War II [1].

In summary, it is not the trading technology itself but how to use the technology that impacts the fairness and stability of the market [63]. Furthermore, it is not how fast HFT processes information or executes trades but the HFT strategy that creates and carries monopoly power that is of concern [5]. In response to the Flash Crash of 6 May 2010, regulators in major economies have proposed or enacted new regulations to curb HFT and mitigate OBM consequences. The Limit Up–Limit Down enacted by the SEC as well as the maximum order-to-trade ratio and minimum resting time of displayed orders proposed by the European Commission are good examples of such regulations [65, 66]. A number of prosecutions against spoofing and other manipulative HFT tactics have been completed [6, 25, 67]. These enforcement actions provide evidence supporting the findings of the above analysis.

Conclusions

This conceptual paper investigates the essence of quote-stuffing, spoofing, and market making by HF traders based on a review of the empirical literature on HFT. By formally defining OBM and analysing its characteristics, as well as examining the complete picture of market making volunteered by certain HF traders, this paper points out three different paths towards achieving monopoly power in trading and one common purpose of gaining monopolistic profit by the HF traders using the three manipulative tactics. Thus, it adds to the debate that HFT is not a net liquidity provider. It then analyses the consequences that the three tactics have caused to other investors and the market. Increased volatility is one concern, while increased frequency of unfairness is another. The most worrisome is the instability potential that HFT can bring to the market. The recent regulatory improvement includes new regulations and completed prosecution cases against manipulative HFT tactics. They have implied the securities regulators' concern for the sake of maintenance of fair and orderly market.

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Viktoria Dalko is a Professor of Finance at Hult International Business School and an Instructor at Harvard Extension School. She obtained a PhD in Economics from the University of Pennsylvania. She taught at the University of Illinois at Urbana-Champaign, Thunderbird, The Garvin School of International Management, and Zicklin School of Business, City University of New York. Prof. Dalko was the special advisor to the National Bank of Hungary and consulted numerous corporations internationally and is a frequent speaker at international conferences.

Michael H. Wang is a Senior Researcher at the Research Institute of Comprehensive Economics, a think tank in Boston, MA. He received a PhD in Mechanical Engineering from the University of Illinois at Urbana-Champaign. His recent research focuses on uncovering systemic risks to financial markets and preventing financial crisis. In addition to numerous journal articles, together with other co-authors, Dr. Wang published *Regulating Competition in Stock Markets* (2012) by John Wiley. The recently enacted securities regulations, in the US, UK, Germany, France, Italy, China and India, bear a close similarity to several of the proposed measures in the book.