

High-Frequency Trade as a component of Algorithmic Trading: market consequences

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Abstract. The paper discusses about influence of algorithmic trading on the stock exchanges. Speculates about high-frequency trade as a component of algorithmic trading, chooses its advantages and disadvantages. Competently constructed methodology and technology of the game help to receive a profit without defeats. IT-technologies play one of the leading parts. The speed of any of the trading platforms and the wide spread of the Internet are essential and important factors in modern trade. Every second can become decisive in Internet-trading. Creating new, developing and improving existing Internet-technologies will surely lead to even greater mobilization of investors in the future. Traders should use server-based platforms to minimize technical failures. The biggest advantage of high-frequency trade and algorithmic trading is to cover weak sides of human, but it needs constant monitoring.

Keywords: high-frequency trading, algorithmic trade, stock exchange, securities information processor, alternative trading system, market pricing, stock exchange quotation.

1 Introduction

The frontier between algorithmic and high-frequency trade (HFT) is rather blurry, although this is not the same. Algorithmic trading is based on the programming of special systems, which, with the appearance of specific combinations, automatically open and close deals, while high-frequency trade performs these processes at maximum speed.

Algorithmic trade can be considered as a strategy for the rapid acceptance and implementation of investment decisions with the help of algorithms that trade without human intervention, and high-frequency trade – as a part of this strategy.

U.S. Commodity Futures Trading Commission (CFTC) offered a seven part test for what constitutes an HFT [1]:

- The use of extraordinarily high-speed order submission/cancellation/modification systems with speeds in excess of five milliseconds or generally very close to minimal latency of a trade;
- The use of computer programs or algorithms for automated decision making where order initiation, generating, routing, and execution are determined by the system without human direction for each individual trade or order;

- The use of co-location services, direct market access, or individual data feeds offered by exchanges and others to minimize network and other types of latencies;
- Very short time-frames for establishing and liquidating positions;
- High daily portfolio turnover and/or a high order-to-trade ratio intraday;
- The submission of numerous orders that are cancelled immediately or within milliseconds after submission;
- Ending the trading day in as close to a flat position as possible (not carrying significant, un-hedged positions overnight).

Companies have the opportunity to attract additional funding to increase the profitability of its activities in the stock market. Stock exchanges should have become a place where the demand and supply of securities are concentrated, agreements are concluded in accordance with the established rules and the exchange rate is formed. However, after the emergence of various intermediaries, the stock market has been broken into a large number of segments, and its structure has become much more complicated.

2 Theoretical and Methodological Backgrounds

Different aspects of algorithmic trading and peculiarities of high-frequency trade are represented in recent publications by prominent authors. A careful study of the world economists discussing IT technologies on the stock-exchange market shows that there are two main focuses in this field. The first one chooses advantages of high-frequency trade (Rishi K. Narang (2009), Jones C. (2013), Hendershott T., Riordan R. (2013), Boehmer E., Fong K., Wu J. (2015), Gerig A. (2015)). Scientists argue that using of IT technologies is a step for future of stock-exchange market because computers help to cover emotions and weakness of humans. Furthermore, scientists have proved that new technologies for transmission of information about stock-exchange market helps appearance new age of trade. The positive influence of algorithmic trading on the market is confirmed in the works of A. Gehrig and K. Jones. High-frequency traders due to the possibility of ultra-fast response to emerging news directly contribute to the growth of information efficiency of markets. As A. Gehrig has shown, the sequence of pricing of assets also improves, the prices become more synchronized, and that is, the change in the price of one instrument is more quickly reflected in changes of the prices of other assets [2]. The analysis of 42 markets conducted by E. Boehmer, K. Fong and J. Woo, demonstrated that the more casual the price change appear with the more intensive the algorithmic trading operations, which indicates the improvement of the parameters of market efficiency [3]. Confirmations of the positive influence of robot trade on liquidity are noted in the work of T. Henderschott and R. Riordan [4]. "Inside the Black Box" of Rishi K. Narang details the work of hedge funds in the field of quantitative trading. Initially, the book is aimed at investors who doubt whether to invest their finances in such a "black box" [5]. Despite of the seeming irrelevance for a private algorithmic trader, the paper presents full material on how the "right" trading system should work and how profitably it can be.

The second focus of recent publications is more concerning on disadvantages of algorithmic trading (Chernyak O. (2013), Johnston M. (2015), Picardo E. (2016)). Chernyak O. insists that modern trade technologies involve the risks, namely: in

stressful conditions, the interaction between automated trading programs (trading robots) and algorithmic trading strategies can quickly undermine liquidity and cause turmoil in the markets [6]. Johnston M. warns aside from being prepared for the emotional ups and downs that you might experience with algorithmic trading, there are a few technical issues that need to be addressed. These issues include selecting an appropriate broker, and implementing mechanisms to manage both market risks and operational risks such as potential hackers and technology downtime [7]. Picardo E. names HFT like algorithmic trading on steroids. Algorithmic HFT has a number of risks, the biggest of which is its potential to amplify systemic risk. Its propensity to intensify market volatility can ripple across to other markets and stoke investor uncertainty. Repeated bouts of unusual market volatility could wind up eroding many investors' confidence in market integrity [8].

The paper lights both sides of algorithmic trading. A significant influence on this process was made by information technology (IT) development. Appearance of new technologies helps to cover disadvantages of present, but this present should be clearly defined that was made next.

3 Research Findings

3.1 Influence of High-Frequency Trade and its Development

At the moment, trades in the United States are held by 11 public stock exchanges, about 50 alternative trading systems (ATS), also called "hidden pools", and about 200 outsiders (as a rule, these are broker dealers who can sell / buy securities, acting from one's or another's name). The New York Stock Exchange (NYSE) and the NASDAQ are considered the largest public stock exchanges. Public stock exchanges are being severely affected by regulators, while ATS systems, which are usually controlled by large banks and financial institutions, are less likely to be influenced by the authorities [9].

When you place an order on your online brokerage account, this order may be transferred to a specific stock exchange or to the ATS system. After you submit your application, you will almost immediately receive confirmation of the transaction's conclusion, but you will not be able to see through whose hands your order was able to pass in a few milliseconds.

Today, high-frequency trade is actively used with the help of robots at the stock exchanges. The share of such trade on different exchanges is from 30 to 70 percent of transactions [10].

High-frequency trade provides high liquidity of investors' deposits, the ability to quickly buy/sell a financial asset, and for high-frequency traders – to receive income. However, no matter how profitable the high-frequency trade appears, it also has some negative consequences for the market, such as:

1. The appearance of hidden pools and the growth of trade in it

As a result of the economic stimulation that arose due to imperfect legislation, hidden pools became even more relevant. More transparent public stock exchanges are usually considered like "legal markets," while less transparent alternative trading systems and hidden pools are commonly referred like "shadow markets."

Today, the part of hidden pools is about 15-18% and continues to grow. Approximately 40% of the total volume of transactions takes place through the Trade Reporting Facility (TRF), which covers the entire «over-the-counter trade», including the activities of alternative trading systems, upstairs trading – when stock exchange traders directly negotiate with each other and conclude a big deals.

The development of shadow trade has a negative influence on the market pricing process. Brokers-dealers and major investment banks, taking into account the consequences of new regulatory rules, hurried up to organize several hidden pools to capture the flow of orders from large organizations. Because large organizations can trade in hidden pools anonymously and can don't report about closing a big position.

Stock exchanges have become the last chance to receive liquidity for some institutions. Despite the fact that 60% of the trades are still held in the "legal markets", the stock exchanges have many problems because of orders which involved in the payment system of commission in the maker-taker model (and in the taker-maker model). Public stock exchanges today are sources of stable liquidity, but really its activity and reliability gradually decrease.

2. Unexpected consequences of securities information processing

In addition, the regulation of the national market system involves the creation of a securities information processor (SIP), which is the norm of regulation, allowing the implementation of arbitration strategies. These strategies are one of the main topics that concern the opponents of HFT.

SIP is a centralized processor, to which all stock exchanges send its market data in order to create a universal "internal market" for each security which is registered on the stock exchange. In total, there are two SIP processors: one works with registered securities of NASDAQ and takes place on its technology platforms, and the other works with securities of the New York Stock Exchange (NYSE) and other organizations which are trading with the help of NYSE technology platforms. In short, all 11 public stock exchanges are connected via a cable to SIP, which collects the data, analyzes it and issue the NBBO (National Best Bid and Offer) [11].

The process of transferring market data from the stock exchange to the SIP takes a share of a second. Given the fact that the signal is transmitted at different speeds which is depending on how close to the stock exchange the servers of its clients are placed, there is a small lag compared with the "direct data flow". The closer you are to the server of stock exchange (or use the extremely high frequency (EHF) connection), the faster you receive and transmit this data.

For example, the two largest trading centers of America, New York and Chicago are placed from each other on 720 miles distance that can be reached in 3.9 milliseconds if you move at a speed of light. However, the differences in modern data transmission technologies and how much time is needed to pass this distance, cost millions of dollars for high-frequency trades. Figure 1 shows an example of technologies that are used by different companies.

Table 1. Technologies that are used by different companies

Who use	Standard cable	Company SPREAD NETWORKS	Company MCKAY BROTHERS	Company TRADEWORK
Technology	Fiber optic	Fiber optic	EHF radiation	EHF radiation

	cable that laid under ground	cable that laid under ground	that spreads by the air	that spreads by the air
Date of implementation	Middle of 1980s	Summer, 2010	Summer, 2012	Winter, 2012
Length of way, miles	approximately 1000	825	744	approximately 731
Duration of data transmission, milliseconds	14,5	13,1	9	8,5

HFT companies are ready to pay a huge sum of money to place its servers near the stock exchange servers. So they can get data faster than a slower SIP. The stock exchange engine, which collects together purchase and sale orders, at one time was situated on the trading floor of the New York Stock Exchange, and a separate specialist worked with it. Today, such engines are placed in large rooms along with exchange servers.

Supporters of HFT argue that anyone can get direct access to the stock exchange and install their servers near it, but really only solid companies have the means to develop and implement HFT-strategies on a large scale. Services of hosting servers near the stock exchange bring a good profit for it, just should remember that the stock exchange is, first of all, a commercial organization. HFT companies pay millions of dollars to install their servers in the stock exchange building: demand for services of location, communication, speed and bandwidth is quite high [12].

As a result, HFT-firms are getting data faster with the help of direct access to the stock exchange, while the rest of market follows the quotes transmitted by the slower SIP. Due to this, HFT companies can use arbitration delays with the aim to outpace other orders and, thus, earn on a large number of transactions. Formally, this strategy differs from the "front-running" and is rather a loophole that appeared as a result of a conflict of interest and differences of stimulation mechanisms.

3. Layering and cancellation of orders

It seems that the current condition of the US stock market is the most liquid financial market in history, but it has a number of serious disadvantages.

Supporters of HFT believe that the stock market is in the most favorable for the ordinary individual investor condition. The volumes of transactions have increased, and it leads to more favorable execution of orders and low commission fees. At first glance, such situation should be appropriate for small individual investors who do not conclude large transactions on constant base. However, it is false idea.

The interaction between automated trading programs and algorithmic trading strategies can quickly undermine liquidity and cause chaos in markets under stress conditions, and high volumes of trading are not always a reliable indicator of market liquidity. One of the most striking examples of such a state is the famous "flash crash", which took place on May 6, 2010 in the US stock market - a sudden and serious drop in the price level by almost 10% in a matter of minutes [13].

The HFT arbitrage, which is based on delays, has negative effect for organizations, because of taking profits from large deals. Income from high-frequency trading is

distributed throughout the market, but much part of it is concentrated in the hands of several HFT-firms.

Aggressive HFT companies use arbitration strategies of delay: thus, they can manipulate with bunch of orders without allowing market participants to execute their bids at a better average price. Although this is just one of the possible scenarios, the market is really packed with orders that nobody and never intended to do: it is more like a lure for attraction of other players in the market and take possession of their money.

When HFT supporters are talking about the advantages of fast auto trading, they do not take into account the fact that most liquidity is just an illusion. Often it happens that we see a minimal spread of any stock, but the size of the order on the domestic market can be so small that traders will not be able to execute it.

4. Maker-taker model

With the development of shadow trade, commercial stock exchanges have to keep the flow of orders which bring income. Collocation services and additional fees represent a significant portion of its profits, but stock exchanges support a stable flow of orders to remain competitive [2].

To capture the flow of orders that are flowing into hidden pools, which can usually make a better deal, the stock exchanges resort to such controversial practices as payment for the flow of orders. Its essence lies in the fact that stock exchanges and wholesale companies pay each individual broker-dealer for the direction of his order on a particular route. As a compensation for the sent flow of orders, the stock exchange pays the broker-dealer a reward for the limit orders per each share. This reward is usually insignificant, but when it comes to several million shares, the total amount is quite significant.

One variant of such scheme is used when large organizations send flow of orders: this model is called maker-taker. Not so long ago, it caused the true anger of the HFT opponents.

The introduction of payment for orders flows and the very fact of using the maker-taker model are far from the real purpose of the stock exchange, which is appeared like platform for meeting of buyers and sellers and market pricing under the influence of the law of supply and demand. If the situation had not been distorted because of improper stimulation, which contributed to the development of shadow markets, the introduction of rewards would be superfluous.

The high-speed race for profit has led to the over-saturation and consolidation of the HFT-industry. Big fish eat smaller. Today only the fastest HFT companies with the largest volume of resources survive. Any HFT-strategy can be transformed into itself, which means that if a HFT company knows about strategy of other, then it can develop a high-speed algorithm on its basis and take over an advantage.

If the revenue, which consist of potential revenues from arbitrage delays, is still high, then as time goes on, many players of HFT industry will get smaller parts.

5. Significant overload on stock infrastructure

The development of high-frequency trade transforms the quality of market transactions into its quantity. This leads to a significant overload of the trading infrastructure, as the representatives of the stock exchanges and experts have repeatedly repeated.

Stock exchanges should use certain mechanism of protection to avoid the negative effects of high-frequency trade on the "transparency" of the stock market, stock ex-

change quotations of prices on market principles, trading infrastructure, etc [14]. These include: the creation of regulatory norms and restrictions through the taxation of a large number of applications or increasing of tariffs for customers with a large volume of applications; introduction of a minimum time interval for the life cycle of the application; introduction of limit on the number of transactions; introduction of equal conditions for all users of stock information, etc.

In general, the development of the HFT is cyclic and is characterized by the following scheme (Fig. 1):

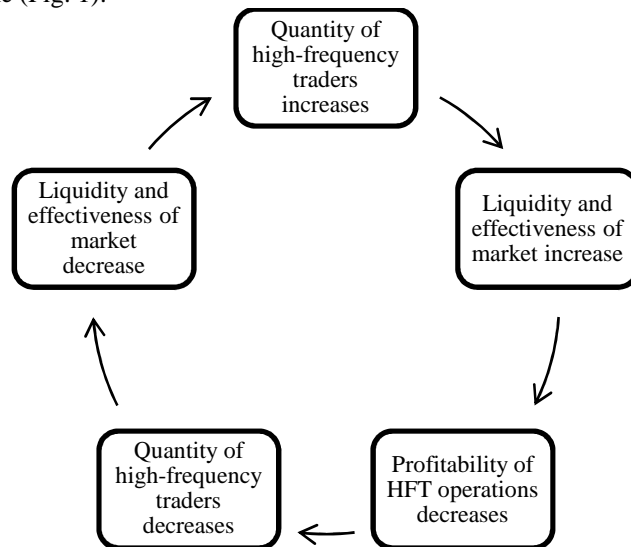


Fig. 1. Cycle of HFT development

Incorrect motivation has led to the emergence of entire groups of different mediators (Fig. 2), who exist due to transactions that do not correspond to the ultimate goal of stock exchange activities – the execution of transactions in a free market.

Some categories of representatives of the stock market, who compete for profit between themselves, fall into the area of algorithmic trading:

- First of all, it is investors who execute long-term operations – they buy shares of certain enterprises, based on a deep analysis of their activities, and whose goal may not be to sell these securities at all.
- Speculators and day-traders who execute securities transactions precisely in order to earn a difference in prices between buying / selling.
- Scalpers are type of merchants who execute a lot of deals in a very short time started from a few seconds. The profit from each such transaction, as a rule, is not very large, and the income consists of a huge quantity of transactions.
- Actually, high-frequency traders, who create trading robots which operate according to certain algorithms.

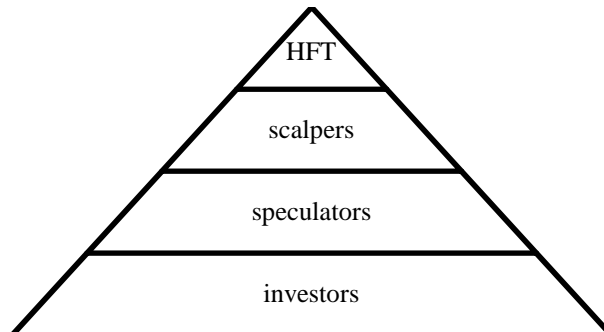


Fig. 2. Types of traders

This pyramid is a "feed chain", that is, long-term investors become a source of profit for short-term investors, and short-term investors – a source of profit for speculators and day-traders, and so on. But this is true in the case if the market is arranged correctly and has correct proportions of all listed groups of traders.

3.2 Advantages of Algorithmic Trading

Automated algorithmic trading allows trader to set special rules for trade orders to execute actions that they have been programmed to automatically execution with the help of computer. Entry and exit rules can be based on simple conditions such as moving the middle run or complex strategies that require a complete understanding of the programming language which is specific for the user's trading platform and the experience of a skilled programmer. Automated trading systems usually require the use of software that is associated with mediator of direct access, and any special rules must be written in their own language platforms. For example, the TradeStation platform uses the EasyLanguage programming language; The NinjaTrader platform uses the NinjaScript programming language [5].

Many traders, however, decide to program their own indicators and strategies or work closely with a system development programmer. Although it usually requires more effort than using the platform master, it provides much more flexibility and results can be higher. Unfortunately, perfect investment strategy which guarantees success doesn't exist.

The computer can control the markets to find options for buying or selling based on the specification of the trading strategy after setting the rules. Depending on the specific rules, as soon as trade is entered, any orders will be automatically created with the use of protective "footsteps", one of the most important functions which help to save profit. In fast-growing markets, instant enter of order can mean the difference between small losses and catastrophic losses in the case of "the market goes against the trader."

There is a significant list of advantages from using an automated algorithm in the markets, including:

1) Reduce emotions. Automated trading systems minimize emotions during the trading process. It is usually easier for traders to follow the plan if emotions are kept

under control. Since sales orders are executed automatically after the system conditions are met, traders will no doubt in the trading process.

2) Possibility of Back test. Back testing applies trade rules according to historical market data to define the viability of the idea. In designing of system for automated trading, all rules must be absolute, have no place for interpretation (the computer is not able to guess – precisely need to set the exact algorithm). Traders can take these exact sets of rules and check it according to historical data before taking risks with real money.

3) Save the discipline. Since the rules of trade are established and trade is executed automatically, the discipline is safe even in unstable markets. Discipline is often lost due to emotional factors such as fear of loss or desire to get a little more profit. Automated trading helps to ensure discipline and strictly follow trade plan.

4) Improved entry-to-order speed. Because computers respond immediately to changes in market conditions, automatic systems are able to generate orders as soon as the trading criteria are met. Entering or exit the position for a few seconds earlier can greatly change the result of the trade.

5) Diversify trade. Automated trading systems allow the user to trade with a few accounts or different strategies at one time.

Generally, the biggest advantage of high-frequency trade and algorithmic trade is to cover weak sides of human. Despite of it, automated trading system cannot be seemed like substitute of human, because possible mechanic failures and data of system need constant monitoring.

3.3 Disadvantages of Algorithmic Trading

Automated trading systems can have many advantages, but should to know about some problems and disadvantages too:

1) Technical errors. The theory of automated trading describes everything simply: install the software, program the algorithm and look after it. Really, however, automated trading is a complicated way of trading, but not without errors. Depending on the trading platform, the order may be on a computer, not on a server. This means that if an internet connection disappears, the order may not be sent to the market. There may also be a discrepancy between the theoretical requirements generated by the strategy and the component of the platform, which transforms it into a real algorithm [15].

2) Monitoring. Although it would be great to turn on the computer and leave the auto trade for a day, but automated trading systems require monitoring. This is due to the possibility of mechanical failures such as connection problems, power loss or system faults.

3) Excessive optimization. Despite the specifics of automated trading systems, traders who use tracking techniques can create systems that look great on paper but work weakly on real markets. Traders sometimes misunderstand that a trading plan should have about 100% profitable trades, or never have to be reduced to be viable. Thus, the parameters can be configured to create an "almost perfect" plan – which is not possible as soon as it is applied to the real market.

Traders have opportunity to run their automated trading systems through a server trading platform such as Strategy Runner. For an additional fee, an automated trading system can scan, execute and control bids – with all orders placed on its server.

4 Conclusions

Competently constructed methodology and technology of the game help to receive a profit without defeats. IT-technologies play one of the leading parts. The speed of any of the trading platforms and the wide spread of the Internet are essential and important factors in modern trade. Every second can become decisive in Internet-trading. Creating new, developing and improving existing Internet-technologies will surely lead to even greater mobilization of investors in the future. Traders should use server-based platforms to minimize technical failures.

The high-frequency trade has not the best influence on market pricing, since, in pursuit of its own benefit, the interests of investors are offset. In addition, the share of shadow trade increases, stock exchanges suffer because of overload of trading infrastructure. Rich companies became more rich because have the ability to use the latest technological advances to instantly capture stock fluctuations with its large capitals. Thus, ordinary traders who monitor quotes with the help of standard SIP, have just crumbs. Using the maker-taker model destroys the natural purpose of the stock market and negatively affects on the market pricing. Stock exchange activity quietly began its adaptation to the cyclicity of high-frequency trade, which generated segments of traders, each of whom feeds at the expense of long-term investors.

In order to update justice in the financial market, it is necessary to improve its regulation by market methods and maximize the use of free trade opportunities. Changing the landmarks of stock exchanges for investors' interests will improve the situation on the stock market. Increasing of mechanism of protection against negative consequences of high-frequency trade can do it too. Norms of regulation should always be as simple and effective as possible to meet the original purpose of the stock market, namely, to be the place where the pair of buyers and sellers will be organized.

References

1. Brush, S.: CFTC Panel Urges Broad Definition of High-Frequency Trading, <http://www.cftc.gov/idc/groups/public/@aboutcftc/documents/file/hftdefinitionletter111711.pdf>, last accessed 2018/03/10.
2. Gerig, A.: High-Frequency Trading Synchronizes Prices in Financial Markets, <https://arxiv.org/abs/1211.1919>, last accessed 2018/05/1.
3. Boehmer, E., Fong, K., Wu, J.: International Evidence on Algorithmic Trading, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2022034, last accessed 2018/04/17.
4. Hendershott, T., Riordan, R.: Algorithmic Trading and the Market for Liquidity, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2001912, last accessed 2018/04/17.
5. Rishi, K. N.: Inside the Black Box: The Simple Truth About Quantitative Trading. 1st ed. John Wiley & Sons, New Jersey (2009).
6. Chernyak, O.: High-frequency trade as the latest technology of financial markets. Bulletin of the University of Banking of the National Bank of Ukraine 2(17), 91-95 (2013).

7. Johnston, M.: How to Code Your Own Algo Trading Robot, <http://www.investopedia.com>, last accessed 2017/12/10.
8. Picardo, E.: Four Big Risks of Algorithmic High-Frequency Trading, <http://www.investopedia.com>, last accessed 2017/12/10.
9. Mancino, M., Sanfelici, S.: Estimation of quarticity with high frequency data. *Quantitative Finance* 4 (12), 607–622 (2012).
10. Hong, H., Wang, J.: Trading and returns under periodic market closures. *Finance vol. LV (NO. 1)*, 297–354 (2000).
11. Wilson, T.: How Online Trading Works, <https://money.howstuffworks.com>, last accessed 2017/12/10.
12. Jones, C.: What Do We Know About High-Frequency Trading, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2236201, last accessed 2018/04/17.
13. Agapova, A.: Conventional Mutual Index Funds Versus Exchange Traded Funds. *Journal of Financial Markets* 14 (2), 323–343 (2014).
14. Andersen, T., Dobrev, D., Schaumburg, E.: Integrated quarticity estimation: Theory and practical implementation. John Wiley & Sons, New Jersey (2012).
Mikhailov, S., Noegel, U.: Heston’s stochastic volatility model implementation, calibration and some extensions. *Wilmott Magazine* 1, 74–79 (2005).