**Japan’s High-Frequency Trading: The Product of a Unique Evolution**

**Section 1 The Merits and Deficiencies of High-Frequency Trading in Japan**

**Is High-Frequency Trading Fintech?**

High-frequency trading (HFT), which had been actively practiced in the United States since the early 2000s, began becoming more widespread in Japan around 2010. Today, after almost ten years, opinion is still divided regarding the impact of HFT on Japanese financial markets, and many aspects of this impact have yet to be fully evaluated. HFT defies straightforward judgement, due to a marked lack of clarity regarding matters such as the actual status of HFT activity, its effect on financial markets, and the possible existence of unfair trading.

Do AI-driven algorithmic trading, together with HFT as one of its subclasses, really constitute significant fields in fintech? If fintech is understood in the broadest sense as a fusion of finance and technology, then algorithmic trading and HFT are undoubtedly fintech fields.

　However, defining fintech more narrowly, as “innovations in financial fields that enhance the convenience of numerous users,” results in greater ambiguity as to whether or not HFT constitutes fintech.

Indeed, it is undeniable that many people have a negative impression of HFT, as “a way for only a few market participants to make money,” or believe that “advances in HFT technologies have not led to win-win situations that benefit more participants, but rather to zero-sum games,” or that “HFT manipulates the market and harms the interests of other investors, particularly individual investors.”

Professor Joseph E. Stiglitz of Colombia University has concluded that, while HFT firms profit from making trades faster than do other firms, this result leads to excessive investment and wasted costs in social terms.

Moreover, the involvement of HFT is suspected each time a “flash crash” occurs, where market prices fluctuate significantly over a short period of time. Consequently, HFT is often criticized as a destabilizing influence on financial markets.

**The Social Significance of HFT Should Not be Ignored**

At the same time, however, much empirical analysis in Japan and throughout the world indicates that HFT enhances market functioning, including increasing the liquidity and improving the efficiency of markets. There is a far greater volume of research demonstrating HFT’s positive impact than there is any empirical analysis showing that HFT destabilizes financial markets.

　It may therefore be reasonable to suggest that HFT has broad social significance, as it benefits society as a whole by enhancing market functioning. This importance of this issue should not be underestimated.

**The Movement Toward Greater Regulation of HFT around the World**

　Even if HFT clearly enhances market functioning under normal conditions, can the same be said in the case of an emergency? If markets become turbulent for some reason, it is possible that HFT may actually amplify this instability. To date however, there has not been sufficient evidence of this effect.

　In addition, it cannot be denied that HFT firms may, intentionally or otherwise, be engaged in unfair trading practices, such as market manipulation. It is also possible that trading by HFT firms may deprive other investors, particularly individual investors, of opportunities to gain profits. These issues too, still await thorough evaluation.

Countries around the world have proceeded to strengthen regulation and implement systems to respond to these risks potentially associated with HFT. In Japan, specifically, a registration system for HFT firms was instituted in April 2018.

　It is to be hoped that this increased regulation does not overly constrain those HFT activities that contribute to the public good, including its enhancement of market functioning, but rather mitigates risks that may lead to the potential problems described above.

The regulation of HFT requires sophisticated technology, and represents a new frontier for regulators. In fact, the level of technology used by regulators has been cited as one reason why, as yet, very few cases of unfair trading by HFT firms have been exposed in Japan. The future cooperation of private sector organizations is needed to improve the level of technology used by regulators.

**HFT May Play a Role in Shaping Business Models in Japan's Securities Industry**

　At the end of this paper, I present the latest trends in the activities of Japan’s securities companies and HFT firms. This includes an examination of the mechanism, already common in the United States, whereby a Japanese online securities broker may pass on share trading orders submitted by individual investors to a HFT firm in return for receiving a rebate (compensation) from the HFT firm. This practice has begun to be adopted by Japanese online securities brokers, leading to an increasingly strong relationship of mutual dependence between HFT firms and securities companies.

　Japan’s online securities brokers are confronted with an extremely fragile earnings base in the context of a persisting low interest rate environment. In the future, it is conceivable that these brokers may grow even more dependent than their United States counterparts on rebate income from HFT firms, obtained through mechanisms such as this.

Continued, strict monitoring will be necessary to ensure that these practices are not conducted out in a way that significantly damages the interests of individual investors.

**Section 2 What Are Algorithmic Trading and HFT?**

**What is Algorithmic Trading?**

　HFT is one form of algorithmic trading. What then, is algorithmic trading? In this section, I would like to discuss this question.

Algorithmic trading can be defined as “the repeated trading of securities where the timing and volume of orders placed is determined automatically by a computer system, according to a predesignated procedure.”

　Algorithmic trading itself has been around for a long time. In many cases, it is not particularly sophisticated, consisting of nothing more than the automation of conventional trading procedures. A significant amount of algorithmic trading is not actually high-frequency, high-speed trading. Recently however, there has been an increase in sophisticated algorithmic trading utilizing AI technologies such as machine learning.

　The main objective of algorithmic trading is to achieve stable profits. To this end, it aims to pursue returns while controlling risk, as well as reducing costs.

　Institutional investors, proprietary firms (investment companies that invest using only proprietary funds), proprietary trading and brokerage divisions of securities companies, and individual investors all engage in algorithmic trading. For all of these players, with the exception of the brokerage divisions of securities companies, the main objective of algorithmic trading is the pursuit of profits. For the brokerage divisions of securities companies, the main objective is the fulfillment of their duty of best execution; that is, their obligation to ensure that customer orders are executed under the best possible conditions.

**Types of Algorithmic Trading**

　Algorithmic trading can be classified into six types, according to its objective and procedure: trading using (1) execution algorithms, (2) benchmark execution algorithms, (3) market making algorithms, (4) arbitrage algorithms, (5) directional algorithms, and (6) market manipulation algorithms.

1. Trading Using Execution Algorithms

Execution algorithms automate the splitting and timing of buy or sell orders placed by investors, choose optimal markets and make other adjustments, in order to achieve objectives such as cost reduction. Some of these algorithms are designed to conceal the execution of trades from other investors, thus mitigating market impact cost (the price change that occurs from the action of buying or selling a security). Others incorporate mechanisms to ensure compliance with market rules.

Splitting large orders into smaller ones, and placing these gradually over time, is an effective way of reducing market impact cost. On the other hand, the longer it takes to complete the execution of an order, the greater the risk of market price movements (timing cost). One important role of execution algorithms is thus to determine and implement the optimal timing that will minimize the sum of these two costs.

1. Trading Using Benchmark Execution Algorithms

　Benchmark execution algorithms aim to ensure that the results of order execution approximate some benchmark. They are used when executing large orders. For example, when splitting a large order into several smaller ones in order to limit market impact cost, a benchmark execution algorithm might be designed to ensure that the average price of each small order approximates a benchmark such as the market closing price.

1. Trading Using Market Making Algorithms

Like regular market makers, market making algorithmic traders place both buy and sell limit orders. By placing buy and sell orders simultaneously, at prices more favorable than the current market price (mid-price) then awaiting other market participants to trade with, they aim to profit from the difference between the market price and the bid or ask price. If buy and sell orders of the same size are both executed, then the trader will profit from the combined bid-ask spread.

This trading by market makers provides market liquidity, thus contributing the stability of markets. Investors utilizing market making algorithms must constantly adjust spreads and order sizes in accordance with the movements of markets and order books, repeatedly placing new orders, adjusting, and canceling orders.

1. Trading Using Arbitrage Algorithms

Where the prices of identical securities, or other equally-valued products or instruments, differ at the same point in time, arbitrage algorithms aim to generate profits by simultaneously selling at the higher price and buying at the lower price, then closing these positions after the prices converge. In this way, traders can make profits while limiting price change risk (market risk). In that the act of arbitrage mitigates or eliminates distortions in markets, it can be said to contribute to enhancing market efficiency.

Four processes must be completed before arbitrage trading can generate profits: the discovery of arbitrage opportunities, the opening of arbitrage positions, the total or partial resolution of price distortions, and the closing of the arbitrage positions. Because arbitrage works to eliminate price distortions, the first investor to utilize an arbitrage opportunity first can make the greatest profit. Therefore, speed is vital in the first and second arbitrage processes: the discovery of arbitrage opportunities, and the opening of arbitrage positions.

1. Trading Using Directional Algorithms

Directional algorithms aim to predict changes in market prices using market data such as prices and trading volumes, as well as news and other event data, and to generate profits from trading based on these predictions. The strategy is to profit from unidirectional changes in market prices. This style of trading is generally high-risk, high-return.

1. Trading Using Market Manipulation Algorithms

Market manipulation algorithms aim to move market prices in a favorable direction by issuing orders designed to mislead other market participants, regarding information such as the provision of liquidity or the intention to buy or sell. They enable the user to achieve considerable profits as a result. In some cases, they can work to reduce trading costs by attracting significant liquidity to the market. By repeatedly canceling large orders, they can also delay or prevent the execution of orders by other market participants.

**Using Machine Learning in Algorithm Construction**

　Two types of methods are used to construct the algorithms used in trading strategies such as those described above: a theoretical approach and an empirical approach.

Using the theoretical approach, the designer establishes certain assumptions regarding price movements and the mechanism that determines market conditions, and constructs a model based on this. In contrast, using the empirical approach, a computer is programmed to discover patterns in historical data using AI technologies such as machine learning, and then search for a model that matches these patterns.

The theoretical approach facilitates the validation of the assumptions made, and the correction of any problems, as the designer understands the mechanism of the algorithm. At the same time however, it is dependent on the designer’s individual experience. There is a limit to the number of theoretical causal relationships that any designer can recognize and understand. Constructing models based on more extensive and diverse case data, using the empirical approach, is anticipated to lead to better trading performance.

Therefore, a combination of theoretical and empirical approaches is often used in algorithm construction.

**A Struggle Between AI Technologies**

Among the forms of algorithmic trading described above, competition often arises between the AI technologies used by the brokerage divisions of securities companies in execution algorithms, and those used by HFT firms in market making algorithms.

The execution algorithms used by securities companies automatically determine a series of processes for the execution of large orders received from customers, such as order splitting, order timing adjustment, and the selection of optimal markets. In doing this, execution algorithms aim to prevent these large orders being detected by other investors, and execute them without giving rise to market price movements.

On the other hand, the aim of trading by HFT firms using market making algorithms is to profit from rapidly placing, altering, and canceling both buy and sell orders. By quickly detecting the existence of large orders in the market, these algorithms try to profit by anticipating their execution.

This leads to an intense struggle between the AI technologies designed to conceal the existence of large orders, and the AI technologies designed to uncover them.

**What is HFT?**

　High-frequency trading (HFT) refers to a type of algorithmic trading where securities are bought and sold at high speed and high frequency.

Because HFT enables many trades to be executed within a short period of time, it can generate large profits even when the return on each individual trade is comparatively small. In addition, because trades are executed rapidly, it allows the trader to capture and capitalize on profit opportunities that may exist for only an instant.

It is normal for HFT strategies to open and close positions within a brief interval. This is because holding a massive position for a long period of time exposes the trader to significant market risk.

Ferber, M. (2012) defines HFT as trading that satisfies at least four of the six conditions below.

* Use of co-location services (services that allow trading participants to place servers and other devices that execute trades physically close to the trading system operated by the securities exchange)
* Daily trading value is at least 50% of the portfolio
* Order execution rate is less than 25%
* Order cancellation rate is more than 20%
* More than half of positions are offset by intraday positions
* Receives rebates on more than 50% of transactions or orders

**Trading Algorithms Used in HFT**

　Of the six forms of trading algorithms examined above, three in particular tend to be used in HFT: market making algorithms, arbitrage algorithms, and directional algorithms.

The most common of these are market making algorithms. High-frequency, high-speed trading is effective for market making, because of the requirement to constantly place, alter and cancel orders according to changes in market prices and liquidity.

　For arbitrage, the greatest profits can be generated by algorithms that are able to discover price distortions - arbitrage opportunities - and execute arbitrage trades the fastest. In this context too, the use of HFT is effective.

　This type of algorithmic trading - HFT - was described in *Flash Boys: A Wall Street Revolt* by Michael Lewis, published in 2014. In the United States, New York is the hub for trading individual stocks, while trading of equity index futures is centered in Chicago. A direct fiber-optic cable was laid between these two cities, with the aim of winning arbitrage trades between their two markets.

　Likewise, in the case of directional algorithms, the use of HFT is effective when the aim is to gain trading profits over a short period of time.

**Background to the Increase in the Use of HFT for Arbitrage in the United States**

　Regulatory reform in the United States provided the opportunity for more active use of HFT in arbitrage. The U.S. Securities and Exchange Commission (SEC), uncomfortable with the monopoly exercised over equities trading by the New York Stock Exchange (NYSE) and Nasdaq, promoted regulatory reform aimed at stimulating competition between securities exchanges.

As a result, markets became increasingly fragmented from the 1990s onward, with orders executed on a greater number of exchanges or alternative trading systems (ATS), or by market makers other than exchanges.

　The more places - markets - where a stock is traded, the greater the number of possible discrepancies between indicative prices, and therefore, the greater the opportunity for arbitrage. Investors progressively introduced high-speed trading systems capable of rapidly responding to changes in order book information. At the same time, markets (securities exchanges) themselves also increased the response speed of their order execution systems, in order to meet the needs of these investors.

　In Japan however, with the Tokyo Stock Exchange accounting for around 90% of the total value of trades, the use of HFT for arbitrage is relatively subdued. Rather, the use of HFT in Japan centers on market making algorithms.

**Will High-Speed Trading Approach the Speed of Light?**

　A relatively small number of emerging companies manufacture network switches that enable the processing of transactions at the equivalent of light speed. In 2016, *The Wall Street Journal* reported that network switches manufactured by Metamako, based in Sydney, Australia, and xCelor, based in Chicago, required just four nanoseconds (four billionths of a second) to relay information such as data sent from a securities exchange to an electronic trader.

　In this way, for some HFT processes, trading really is approaching the speed of light. Does this mean that the competition for greater speeds in HFT is coming to an end?

　As the speed of trading increases towards the speed of light, the amount of investment required to raise this speed even fractionally higher than that of competitors is increasing exponentially. If the marginal cost of greater speeds is increasing, then HFT firms can be expected to stop making additional investments in speed when the marginal cost of such investments matches the marginal expected return.

　As I will discuss later, the proportion of HFT among all equities trading in the United States has actually been decreasing since its peak in around 2009. Some have cited this as an indication that the investment in speed has reached just such a critical point.

Nevertheless, in the United States, firms still compete to achieve speeds even fractionally faster than their competitors, and approach even a little closer to light speed. The critical point has not yet been reached.

**Section 3 Reviewing the Historical Development of HFT around the World and in Japan**

**HFT First Thrived in the United States**

　It was the United States where HFT first became popular. By the mid-2000s, many HFT firms were already participating in markets. The percentage of HFT among all stock trades increased rapidly through the second half of that decade, and had reached 61.0% by 2009, according to an estimate by Valerie Bogard of the Tabb Group, a United States research firm.

　After this peak in around 2009 however, the percentage of HFT began to decrease. Excessive competition and declining profits were likely behind this decrease. In many ways, HFT is a zero-sum game, and an increase in HFT firms tends to decrease each firm’s profits. According to the Tabb Group’s estimates, in 2018, the HFT industry achieved a combined revenue of 1.8 billion dollars on United States stock markets. This represents a decrease of roughly 70% from the 5.7 billion dollars achieved in 2010.

It is also possible that the sudden drop in stock prices in May 2010 - the so-called flash crash - contributed to reduced participation in HFT. The HFT firm Eladian Partners was driven out of business in 2012, followed by Infinium Capital Management in 2014.

By 2014, the percentage of HFT as a proportion of the total value of all trades (as estimated by Bogard) had decreased to 48.5%. Since then, it appears to be relatively stable. The fact that this proportion is close to 50% implies the sort of scenario where each trade involves a HFT firm on one side, and a non-HFT counterparty on the other. If this proportion were to exceed 50%, then the struggle between HFT firms on both sides of trades to achieve profits would lead to the elimination of some. A proportion of around 50% is thus regarded by some observers as the upper limit of sustainability. Under this premise, the proportion of over 60% seen in 2009 is gone, never to return. Such a level is unsustainable.

HFT activities in Europe followed those in the United States, with a lag of several years. The percentage of HFT as a proportion of equities trading (based on the total value of all trades) was 29% in 2009, and reached 38% in 2010 (according to The World Federation of Exchanges). Subsequently however, it trended downwards, and is estimated to have sunk to 24% by 2014 (European Securities and Markets Authority).

**HFT Firms Move to Japan from Saturated Markets Such as the United States**

　The spread of HFT in Japan occurred later than in Europe or the United States, where its share of market trading peaked in around 2010. Its initial spread was driven by the launch by the Tokyo Stock Exchange of the equities trading system “arrowhead” in 2010. This trading system featured world-class speed, reliability, and extendibility, and enabled high-speed trading. Its introduction made way for full-fledged HFT.

　2010 was also the year when the proportion of HFT in the United Stated reached its peak. Just as HFT peaked in the United States, it began to spread in earnest in Japan. It is possible that the spread of HFT in Japan was also boosted by HFT firms shifting their activities to Japan from the saturated United States markets, which were becoming less profitable.

　In *Analysis of High-Frequency Trading at Tokyo Stock Exchange*, as of 2014, the percentage of HFT as a proportion of equity trading (its share of trade value) in Japan is estimated to be 25.9%. This is roughly equivalent to the level in Europe at around the same time.

However, it is conjectured that the proportion of HFT in Japan has subsequently grown, given the renewal of “arrowhead” in 2015, and the quantum increases in trading speed and the number of transactions processed. Current levels of HFT, although falling short of the United States, are quite possibly higher than in Europe.

Incidentally, in other Asian markets, the percentage of HFT as a proportion of equity trading was estimated to be 27% in Australia, from January to March, 2015 (Australian Securities and Investments Commission). On the other hand, proportions of HFT in Hong Kong and Singapore are through to be very low (Wheatey: 2011).

Figure 1: International Comparison of the Proportion of HFT in Equity Markets

Source: Tooru, Fukuda, Japan Securities Research Institute, “Interim Report of ‘The Conference on the Impact of IT Innovation on Securities Markets’”

Notes: (1) Comparisons are based on the total value of all trades

(2) Measurement periods are as follows. Japan: September 2012, January and May 2013. United States: January 2008 – February 2010. Canada: August – November 2011. Australia: May – July 2012. All other countries: May 2013.

**Activities of HFT Firms in Japan, with Its High Market Concentration**

　Compared to markets in Europe and the United States, Japanese equity markets are highly concentrated. In other words, the level of market fragmentation is low. This is due to the Tokyo Stock Exchange’s overwhelming share of equity trading.

　As in the world of *Flash Boys*, in the United States, the dispersion of trading over multiple different markets provides an environment that enables HFT firms to profit from arbitrage. Moreover, a large number of markets translates to a large number of opportunities for HFT firms to engage in market making. In this sense, the greater the market fragmentation in a country, the more profit opportunities it provides for HFT, and the more attractive it is for HFT firms.

　From this perspective, Japan, where equities trading is largely concentrated on the Tokyo Stock Exchange, may not necessarily be an attractive a market for overseas HFT firms. The fact that, as discussed below, foreign HFT firms are nevertheless highly active in Japan, is perhaps due to the saturation of markets overseas. In Japan, they see a means of surviving and profiting.

**The Domination of the Japanese Market by Foreign HFT Firms**

　As I will examine below, Japan introduced a registration system for HFT firms in April 2018. As of October 15, 2020, 55 HFT firms (officially referred to as “those engaging in High Speed Trading”) were registered. The head offices of all the registrants, with the exception of one firm, are located in countries other than Japan. (See Figure 2.) HFT in Japan is dominated by foreign players. This seems to indicate that HFT firms from the saturated United States markets have now thronged to Japan seeking profit opportunities.

　It is therefore probable that much of the profit from HFT in Japan is flowing out of the country. It is possible that this scheme disadvantages trading by other domestic investors, particularly individual investors, with the profits that they should have received flowing offshore.

　And yet, as of today, there does not appear to be much criticism of this situation in Japan. Perhaps this is because there is a stronger awareness among market investors and others relevant parties of the positive roles of HFT, such as supplying the market with liquidity. At the same time, it may be because the very existence of HFT firms is little known among the general population in Japan.

In the future however, foreign HFT firms may one day be subject to the stern scrutiny of the Japanese population. The situation is reminiscent of the time when some overseas investment funds, referred to as “vulture funds,” beat down the prices of Japanese companies, resulting in a strongly cautious reaction from the Japanese population.

Figure 2: Location of the Head Offices of Registered HFT Firms in Japan

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| --- | --- |
| Hong Kong | 14 |
| United States | 13 |
| Singapore | 12 |
| Australia | 7 |
| United Kingdom | 2 |
| Israel | 2 |
| Netherlands | 2 |
| Germany | 1 |
| Ireland | 1 |
| Japan | 1 |

Note: As of October 15, 2020

Source: Financial Services Agency

**Section 4 Evaluation of the Impact of HFT on Financial Markets**

**HFT Effectively Enhances Market Function**

　Both positive and negative effects of algorithmic trading, and of HFT in particular, have been debated from a variety of perspectives.

　One of the most often cited positive effects of HFT is its function in supplying liquidity. The majority of HFT firms trade using market making algorithms.

In this context, HFT doubtless performs an important role, supplying markets with liquidity by placing both buy and sell orders. It could also be said to contribute to market stability in this way.

　In another of the main forms of trading algorithm used by HFT firms, arbitrage algorithms, HFT eliminates price divergence by rapidly placing orders whenever an arbitrage opportunity is discovered. In the sense that it swiftly eliminates these price differences - market distortions - HFT improves market efficiency in some respects.

In view of these two points, it cannot be denied that HFT-style algorithmic trading effectively enhances market function.

**Empirical Research Overseas on the Effect of HFT in Enhancing Market Function**

　There is a large quantity of evidence from empirical analysis overseas, on the supply of liquidity to the market by HFT, and its effect in enhancing market liquidity. Figure 3 shows some representative examples of this research.

Figure 3: Empirical Research on the Supply of Liquidity by HFT

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| --- |
| ● Empirical analysis of equity markets in the United States: Zhang and Riordan (2011)  → Tendency to draw liquidity away from highly liquid stocks, and provide liquidity to less liquid stocks  ● Empirical analysis of equity markets in the United States: Brogaard et al. (2014)  → Institutional investors’ trading costs (the costs of correcting for market movements) have not increased, despite an increase in the proportion of HFT due to system renewal  ● Empirical analysis of equity markets in Canada: Brogaard et al. (2014)  → Observed reduction in HFT and shrink in the bid-ask spread after an increase in trade commissions |

Source: Prepared by the Nomura Research Institute from various materials

Empirical research in the United States and Canada indicates that HFT effectively enhances market liquidity. Empirical analysis in the United Kingdom also shows no evidence that an increase in HFT leads to an increase in trading costs for market participants by reducing market liquidity.

　Moreover, much empirical analysis overseas concludes that HFT has the effect of enhancing market efficiency. Figure 4 shows some representative examples of this research.

Figure 4: Empirical Research on HFT’s Enhancement of Market Efficiency

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| --- |
| ● Empirical analysis of equity markets in the United States: Zhang and Riordan (2011)  → HFT rectifies divergence from efficient price levels  ● Empirical analysis of equity markets in the United States: Benos and Sagade (2014)  → HFT actively promotes movement towards efficient price levels, and tends to anticipate orders that may cause price divergence |

Source: Prepared by the Nomura Research Institute from various materials

　The effect of the execution of orders placed using HFT to promote the determination of efficient price levels, has been confirmed through empirical analysis in the United States and United Kingdom.

**Results of Research in Japan**

　In Europe and the United States, there is quite an accumulation of academic research into the impact of HFT on markets. Much research presents a positive assessment of its impact on equity markets, where it contributes to enhancing the price discovery function and increasing liquidity.

　Meanwhile Japan, a relative newcomer to HFT, is notable for its large quantity of empirical analysis regarding the changes in markets that occurred due to the advent of full-fledged HFT, after the “arrowhead” trading system was launched in 2010.

Of these, the analysis conducted by the Tokyo Stock Exchange (Hosaka) is relatively orthodox. This analysis clarifies the characteristics of HFT firms through a classification of orders into those placed by HFT firms and those placed by others, based on attributes of HFT as defined by Ferber: an order execution rate of less than 25%, and an order cancellation rate of more than 20% (see Section 2).

According to the author, this analysis shows that (1) few orders were placed in after-hours trading, (2) market orders were extremely rare, and (3) many orders were limit orders, placed outside the best bid and ask prices, which therefore tended not to be filled immediately, but rather to remained in the order book, unfilled, for a long period of time. This suggests that the orders placed by HFT firms provide markets with liquidity, and contribute to market stability.

Below are the results of some representative examples of empirical research into the impact of HFT on market liquidity in Japan

Figure 5: Empirical Research on HFT’s Enhancement of Market Efficiency

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| --- |
| ● Uno & Shibata (2012)  → High-speed trading grew after the launch of “arrowhead,” and the supply of liquidity became more dynamic as a result  ● Arai (2012)  → The introduction of “arrowhead” made the supply of liquidity more dynamic for stocks subject to large price movements, and resulted in lower trading costs  ● Hosaka (2014)  → Many of the executed orders placed using HFT provided liquidity through this transaction. Many HFT limit orders are placed outside the best bid and ask prices, thus increasing the depth of the order book. Many HFT orders work to suppress price movement, softening the movement of stock prices  ● Ota (2015)  　→ Spreads shrank markedly after the introduction of “arrowhead” |

Source: Prepared by the Nomura Research Institute from various materials

**The Possibility that HFT May Destabilize Markets**

　In this way, much empirical research, both in Japan and overseas, indicates that HFT effectively increases market liquidity, and enhances market efficiency.

　On the other hand, it is often pointed out that HFT-style algorithmic trading destabilizes financial markets. The involvement of HFT is immediately suspected each time a ‘flash crash’ occurs, where prices in equities, bonds, or forex markets fluctuate significantly over a short space of time.

　It is possible that, should markets become unstable for some reason, algorithms may act in ways that their designers did not foresee, and that this may result in them amplifying market instability. Others have pointed out the possibility that a runaway algorithm, whether due to malfunction or other reason, might cause disruption in markets.

　In addition, it is possible that, because HFT firms place, alter and cancel orders swiftly and frequently, price formation may be dominated by a few HFT firms, with other investors unable to accurately grasp market conditions, thus resulting in distortions in price formation.

　In this way, compared to the results of empirical research indicating the positive effects of HFT on markets, there appears to be relatively little research on its negative effects. It cannot be concluded from this however, that the positive impact of HFT on markets outweighs its negative effects. It is possible that research on HFT’s negative effects is simply more difficult to carry out, due to data and technical limitations.

**Conflicting Opinions on Whether HFT Amplifies Market Disruptions**

As I indicated in Section 1, even if it is now clear that HFT effectively enhances market function under normal, peaceful conditions, uncertainty remains regarding the value of HFT in case of an emergency. Should markets become turbulent for some reason, then it is possible that HFT may amplify this turbulence. Today however, there is still insufficient validation of this possibility.

Regarding the relationship between HFT and the flash crash of 2010, Professor Kirilenko of MIT writes that when the flash crash occurred and price movements become accelerated, automated programmatic trading by HFT firms immediately withdrew the best bid and ask orders, which amplified price movements. He concludes that, when markets are under stress, biases in HFT order flows become more pronounced, leading to further price movements; in other words, HFT amplifies market disruptions.

Opinions are widely divided however. Professor Hendershott of UC Berkeley writes that no meaningful evidence exists that the algorithms used in HFT vary their volume of trading according to changes in volatility. He argues that algorithmic trading works not to heighten volatility, but rather to suppress it.

**The Issue of Fairness in Trading, and Unfair Trading**

　Meanwhile, some observers point out that HFT creates unfairness between investors. HFT can capture trading opportunities that might exist for only a moment: something which is difficult for average investors. Some see this as unfair.

　Even if average investors make decisions and submit orders based on the current market order book, by the time these orders reach the exchange, the order book will often have changed due to high-speed trading by HFT firms.

　In addition, it is often pointed out that some HFT consists of market manipulation and other unfair trading practices. HFT entails the frequent placing, altering, and canceling of large orders. It is pointed out that these orders include some practices that are banned as market manipulation, such as “layering,” where traders place large orders that they never intend to execute, then cancel them when they are close to being filled. Indeed, there have been some cases in Japan, although not many, where trading has been conducted with the intent to manipulate markets, and HFT firms have been exposed as the perpetrators.

**Section 5 HFT Regulation as a Preventative Measure**

**HFT Regulation and System Response in the United States**

　The trading strategies used by HFT firms are black box strategies. Being the source of firms’ revenue, they are deliberately made difficult to discover. On the other hand, there is a growing movement to implement measures to prevent issues with HFT, in the context of a widespread perception of issues such as the possibility that HFT may lead to market disruption, and the possibility that some HFT firms may be involved in unfair trading such as market manipulation, even though these possibilities have not been clearly confirmed or proven. These measures consist of the introduction of various rules by self-regulating bodies, and the introduction of regulation by authorities.

　In Europe, regulators began by providing a clear definition of HFT for the purposes of the regulation. By contrast, no such clear definition of HFT exists in the United States. Even the definitions provided by the Commodity Futures Trading Commission (CFTC) and Securities and Exchange Commission (SEC) in 2010 are only very general. For this reason, no regulation directly targeting HFT has been introduced in the United States. On the other hand, The United States is notable for the progressive application of regulation targeting some forms of HFT-style trading.

　For example, naked trading is banned in the United States. Naked trading refers to the practice of granting traders direct access to securities exchanges, unfiltered by brokers’ order placement systems, and without any intervening system to check customer orders. (Where such a system is present, it is referred to as sponsored access.) This ban on naked access substantially reduces excessive competition between securities companies to acquire HFT customers.

　Stub quotes are also banned in the United States. Stub quotes are limit orders that are deliberately set far lower or higher than the prevailing market price. They are used by market makers who wish to fulfill their price quoting obligations without intending for their orders to be executed.

**HFT Regulation in Europe**

As I examined in Section 2, HFT is clearly defined in the European Union (EU), through MiFID II (Markets in Financial Instruments Directive II), a new, comprehensive regulative framework for financial and capital markets.

　Under this directive, all algorithmic trading firms, including HFT firms, have an obligation to report the details of their trading to the regulatory bodies. Additionally, securities exchanges have an obligation to ascertain whether or not each order originates from an algorithmic trading firm.

　Prior registration is also required for algorithmic trading firms that implement market making strategies, and they must supply the market with liquidity to a certain standard.

**HFT Regulation in Japan**

　In Japan, government and cabinet office ordinances containing HFT regulation came into force in April 2018, pursuant to amendments to the Financial Instruments and Exchange Act. HFT firms (“those engaging in High Speed Trading”) are required to register and provide prior notification of their trading strategies. Registration will be rejected if there are any shortcomings in the firm’s equipment or systems. As already noted, 55 HFT firms were registered as of October 2010.

　A definition of HFT firms has been established in Japan, although it is not as clear as the definition established in Europe. Japan defines HFT as trading “where methods are implemented to transmit orders, etc. in a shorter time than usual, and mechanisms are established to prevent competition with other orders.”

　In addition, HFT firms have an obligation to prepare and preserve trading records. The supervisory authority can demand and inspects reports, and issue business improvement orders.

　Regulation was not introduced in Japan with the intention of expelling HFT firms as necessarily malicious. Rather it aims to enable regulators and securities exchanges to obtain an accurate understanding of the actual status of HFT firms, which would be unclear otherwise, and to promote the establishment of an environment for enhancing their supervision of HFT firms. Many HFT firms are unlisted and disclose little information publicly. This makes it difficult for authorities to gain an understanding of their actual situation.

There were some initial concerns that the introduction of a registration system would inhibit HFT activities, but at present, there is no evidence to support these concerns.

The registration system was introduced because it was judged, with reasonable grounds, to be necessary for authorities to grasp the real situation regarding HFT. If the registration system did not exist, then it would be necessary for the Tokyo Stock Exchange and other private sector companies to monitor the situation autonomously. This would entail significant cost, and some aspects may be difficult to implement. By introducing a registration system, Japan has clearly indicated its stance, with the national administration responsible for, and paying for, the system, and clear exposure of any unfairness discovered.

**Few Cases of Unfair Trading Related to HFT Have Been Exposed in Japan**

　At present however, very few cases of unfair trading related to HFT have been exposed in Japan. Three reasons can be suggested for this.

Firstly, markets in Japan are not as fragmented as in the United States. As a result, there is relatively little market distortion, and HFT is not as active as in the United States or Europe. In addition, it is probable that the limits on information obtainable exclusively by HFT firms work to suppress unfair trading. Secondly, even if unfair trading by HFT firms is discovered, some aspects of exposing this trading may be difficult due to the limitations placed on regulatory controls in Japan. Thirdly, it is possible that regulators have not been able to trace unfair trading by HFT firms due to insufficient technology.

　Of these reasons, the third seems the probable with regard to past cases. Indeed, it seems that it was technically difficult for regulators to detect unfair trading by HFT firms. This was due to the extremely short time frames involved.

With the introduction of a registration system however, regulators’ grasp and assessment of unfair trading is becoming increasingly effective. Moreover, private sector initiatives are also enabling the enhancement of monitoring functions through the application of machine learning to vast quantities of market data using AI technologies, and these are becoming more adept at discovering suspicious activity.

Stronger relationships between the private sector and regulators, including the broad supply of information to regulators by private sector companies, should contribute to suppressing unfair trading.

　According to the Financial Services Agency, “in contrast with Europe and the United States, the amount of trading in Japan that unfairly exploits market fragmentation, etc. is limited. Even so, there have been cases of market manipulation using algorithmic trading, or working on algorithms, where corrective action has been required.” It goes on to describe cases where payment orders have been issued for monetary penalties concerning market manipulation activities, where the offenders placed trading orders that they never intended to execute.

**Section 6 HFT and the Securities Business in Japan Today**

**Japanese Securities Companies Delayed the Introduction of Practices from the United States**

Finally, I would like to focus on two recent trends in the activities of HFT firms in Japan. In both these cases, HFT firms are thought to gain benefits of some kind by obtaining information on stock orders placed by investors.

They have once again ignited the smoldering debate on whether, after all, HFT benefits or damages the interests of other investors.

The mechanism behind both these HFT activities was imported from the United States. In this sense Japan, a relative newcomer to HFT, is following in the footsteps of the U.S. model.

The first trend that I would like to examine concerns smart-order routing (SOR), a common practice in the securities business in the United States. Securities companies have an obligation to execute orders received from their customers at the best terms possible, based on publicly-available information on bid/ask quotes and trades, after considering factors such as price, cost, speed, and the possibility of order execution. This is referred to as their duty of best execution.

SOR is an automated system aimed at helping securities companies fulfill this duty of best execution, by using an algorithm to instantaneously select the market offering the best price.

**Smart-Order Routing (SOR) and Order Book Information**

According to a report published in *The Nikkei* in November 2019 (“Japan’s *Flash Boys*” 1 and 2), an online securities broker under the umbrella of one of Japan’s financial groups, on receiving orders from their customers (many of whom are individual investors) then placed these orders on the optimal market, selected using SOR from between the Tokyo Stock Exchange and the financial group’s own proprietary trading system (PTS). In Japan, the obligation to trade stocks only through exchanges was abolished in 1998, and the ban on PTS operation was lifted as a result.

After receiving a customer order, the online securities broker sent it first to the PTS, and then to the Tokyo Stock Exchange, if this was judged to be the optimal market. Even if the order eventually ended up on the Tokyo Stock Exchange, it would be exposed for a certain period of time on the PTS order book. This time was around 0.1-0.3 seconds. It may seem only an instant, but for HFT firms, 0.1-0.3 seconds is an extremely long time.

It seems that HFT firms were able to obtain information on customer orders, and swiftly place orders on the Tokyo Stock Exchange in anticipation of these orders arriving. When this happened, the HFT firm that anticipated the order may have been able to profit from the trade, and the individual investor whose order was anticipated may have been forced to trade at a less favorable price as a result. According to *The Nikkei,* this scheme was newly introduced in October 2019.

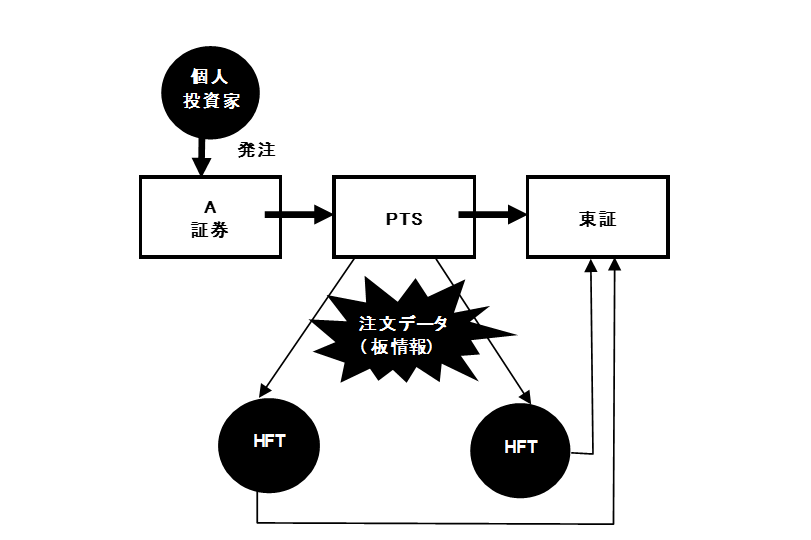
**The Emergence of Japan’s *Flash Boys*?**

The scheme described above closely resembles that described in *Flash Boys: A Wall Street Revolt* by Michael Lewis, published in 2014, where an HFT firm obtained information on orders placed by other investors from the order book, and profited by instantly placing, altering, and canceling orders accordingly. Their strategy was analogous to cheating at rock-paper-scissors, waiting to see their opponent’s move, then playing their hand an instant later. The scheme described above is sometimes referred to as Japan’s *Flash Boys*.

The aim of temporarily exposure of customer orders on a PTS is sometimes explained as an attempt to stimulate counter orders, thus enhancing trading activity and improving execution rates. Perhaps in view of criticism from some quarters, the financial group concerned revised its SOR execution method in November 2019, to prevent information on customer orders being temporarily visible from the outside.

However, it has been pointed out that even after this revision, in the case of customer orders that are sent by SOR to the PTS, but cannot be executed there and are thus transferred to the Tokyo Stock Exchange, there is still room for HFT firms to anticipate and profit from the arrival of these unexecuted orders.

(Figure 6) Are HFT Firms Anticipating Orders by Individual Investors?



Source: Prepared by the Nomura Research Institute from information published in *The Nikkei*

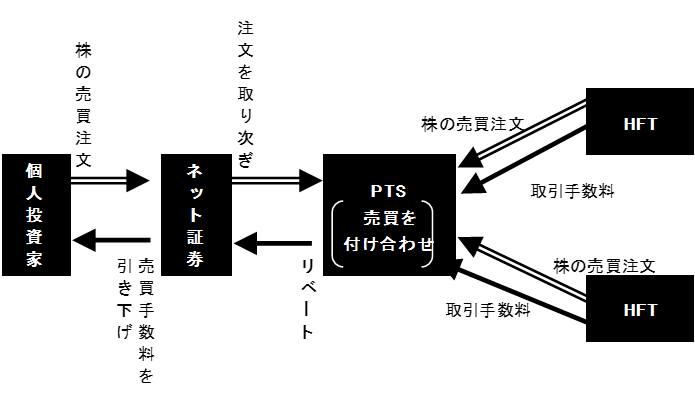
**The Movement to Introduce PFOF in Japan**

The other trend that I would like to focus on is the spread to Japan of PFOF, a practice common among securities companies in the United States. PFOF is an acronym of payment for order flow. It refers to a scheme whereby a securities company passes customer orders (transaction rights) on to market makers such as HFT firms, and receive a rebate (compensation) in return.

The setting for this scheme is, of course, the security company’s PTS. HFT firms pay commission to the PTS, and the PTS pays rebates to the online securities broker. In other words, rebates flow indirectly from HFT firms to the online securities broker, via the PTS.

It is thought that HFT firms are willing to pay rebates for information on orders issued by individual investors, because this allows them to enhance the precision of their proprietary algorithmic trading by analyzing this big data using AI, and utilizing it for purposes such as predicting the trading trends of individual investors in Japan.

Figure 7: Spread in the Receipt of Rebates from HFT Firms



Source: Prepared by the Nomura Research Institute from information published in *The Nikkei*

**Information on Orders by Individual Investors is Valuable for HFT Firms**

　It may seem that, unlike orders by large investors, which can cause significant movements in the market, the small-scale orders placed by individual investors provide HFT firms with few profit opportunities. However, the accumulation of many these small-scale orders by individual investors can have a substantial impact on the market.

　Moreover, large orders by institutional investors are sent to the market after being split into small portions by securities companies, to prevent them affecting market prices, or even to prevent them being detected by other market players. By analyzing orders by individual investors, HFT firms would likely be able to enhance the precision with which they can differentiate between small-scale orders and large orders that have been split into several portions. If the presence of a large-scale order is detected, then they will be able to anticipate the arrival of later portions of the split order on the market, thus achieving significant profits.

　It is conjectured that for these reasons, information on orders placed by individual investors is valuable for HFT firms, and they are thus willing to pay fees to obtain it.

**Against the Backdrop of Commission-Free Trading**

　In this way, the movement by Japanese online securities brokers to introduce U.S.-style practice of PFOF doubtless represents an effort to secure new sources of revenue. In recent years, there has been clear trend towards lower trade commissions (transaction fees) for share trading around the world. Japan is no exception.

　Securities companies require other sources of income to supplement the reduction in revenue from lower commissions.  
Generally speaking, these consist of sources such as interest revenue from money lent to customers for margin trading, and stock loan fees changed for lending customers’ shares to third party investors wishing to a take a short position in that stock.

In Japan however, with its extremely low interest rates, interest revenue from margin trading and stock loan fees from lending shares have both sunk to very low levels. It was in this context that Japan’s online securities brokers began to seek to secure a new source of revenue through the introduction of PFOF.

　Robinhood, an online (app-based) securities broker in the United States that offers almost entirely commission-free trading, passes almost all the orders that it receives from customers to HFT firms. It is estimated that, as of early 2018, it derived more than 40% of its revenue from rebates from HFT firms.

The possibility has emerged that Japan’s online securities brokers may also shift their business models progressively closer to Robinhood-style operations.

**Are the Interests of Individual Investors Being Protected?**

　Under PFOF systems, securities companies provide HFT firms with big data on orders, most of which were submitted by individual investors, and receives rebates in return. These rebates are used by securities companies to fund the provision of commission-free trading platforms to individual investors.

This scheme closely resembles the business models used by digital platformers, which provide users with free online services, funded by external income from targeted advertising, etc. utilizing personal data acquired through these online services.

　In this way, individual investors are effectively providing their order data to HFT firms in return for lower, or zero, trade commissions. It is possible however, that through this exchange, individual investors are being forced by HFT firms into a more disadvantageous trading environment. From this perspective, it is still not entirely clear whether, in fact, individual investors are receiving equivalent value in return. Further validation of this point is necessary in the future.

　Japan’s securities companies, operating under a persistent low interest rate regime, have a weaker earnings base than their U.S. counterparts. For online securities brokers in particular, the importance of rebates from HFT firms may eventually be even more important that in the United States. If this situation came about, then HFT firms active in Japan would play an even more important role than those in the United States or elsewhere, in supporting business models in the securities industry. Securities companies and HFT firms would be mutually dependent, bound together by a shared fate.

**Research on HFT is Still in Its Infancy**

　As I have shown above, despite a relatively clear consensus on the contribution made by HFT firms to enhancing market function, the jury is still out on issues such as whether it amplifies market disruptions, and whether it damages the interests of other investors, including individual investors. This uncertainty is no doubt partly due to a lack of clarity regarding the actual nature of HFT, conducted at speeds and frequencies that defy human comprehension. For both regulators and academics, research into HFT is still in its infancy.

As this research progresses however, and the merits and deficiencies of HFT become clearer, perhaps this will serve as an opportunity for HFT to evolve into a presence that contributes to further market development and new business models for the securities industry, of the kind described in the last section. In this context, I look forward to the further development of HFT research.

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