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High-frequency trading and dark pools: sharks never sleep

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The implications of massive high-frequency trading are becoming increasingly clear in equity markets and other financial markets. In recent years high-frequency trading has not only increased vastly in US equity trading, but in the last ten years has extended widely to other major international exchanges. High-frequency trading from its origins attracted the interest of regulators concerned about the impact on market integrity and stability. However, it was the publication of Michael Lewis's best-selling book Flash Boys *that alerted the world to the imminent dangers of this form of trading. Regulators are now confronted with the dilemmas of attempting to regulate an industry operating at the speed of light.*

A. Introduction

The dangers of massive high-frequency trading (HFT) are becoming increasingly clear in equity markets and other financial markets. HFT is a form of algorithmic trading performed by computers, to rapidly move into and out of trading positions in microseconds in order to capture fractions of a cent profit on every trade, which when magnified by millions of trades quickly yields a substantial return. In contrast to traditional buy-and-hold investment strategies, HFT firms do not need to employ large amounts of capital, do not accumulate positions, nor hold portfolios overnight. Trading on tiny margins, their large gains are through speed and frequency combined with fractionally earlier access to information.[1] The awesome power of this technologically driven approach to trading is hard to imagine: in a single day in October 2008 one HFT firm exchanged over 2 billion shares, amounting to 10% of US equities trading volume for the day.[2] Carol C Clarke of the Federal Reserve Bank of Chicago accurately captures the technical essence of this radical automation of trading:

> "A small group of high-frequency algorithmic trading firms have invested heavily in technology to leverage the nexus of high-speed communications, mathematical advances, trading, and high-speed computing. By doing so, they are able to complete trades at lightning speeds. High-frequency algorithmic trading strategies rely on computerized quantitative models that identify which type of financial instruments to buy or sell (eg, stocks, options, or futures), as well as the quantity, price, timing, and location of the trades. These so-called black boxes are capable of reading market data, transmitting thousands of order messages per second to an exchange, cancelling and replacing orders based on changing market conditions, and capturing price discrepancies with little or no human intervention."[3]

In recent years HFT has not only increased vastly in US equity trading, but in the last ten years has extended widely to other major international exchanges in Europe and the Asia Pacific, and is now spreading to emerging markets driven by the growth of proprietary trading firms and quantitative hedge fund strategies (Figures 1 and 2). As technology has developed, HFT has moved beyond equity markets to other asset classes including futures, options, bonds, and foreign exchange. For example, according to the Commodity and Futures Commission (CTFC) in July 2011, 95% of US crude

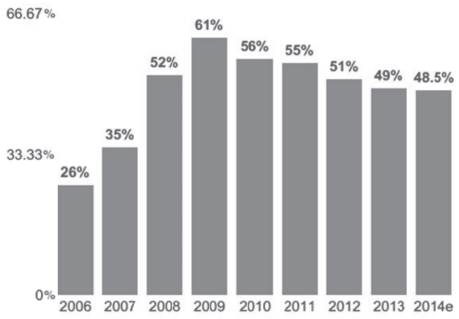

Figure 1. High-frequency percentage of volume of US equity shares traded, 2006–2014.
Source: Adapted from TABB Group (2014).

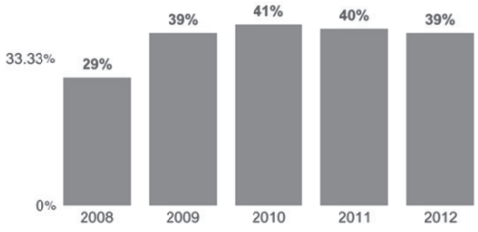

Figure 2. High-frequency percentage of value of European equity shares traded, 2008–2012.
Source: Adapted from TABB Group (2013)

oil futures trading volume is generated by day trading with a large proportion generated by HFT.[4]

HFT has from the outset attracted the interest of regulators concerned about the impact on market integrity and stability.[5] The "flash crash" on 6 May 2010 when the Dow Jones plunged $1 trillion in market value in the space of half an hour alerted regulators and the investing public to the imminent dangers of HFT. However, it was only with the publication of Michal Lewis's book *Flash Boys* on 31 March 2014 that the world realised suddenly that "Over the past decade, the financial markets have changed too rapidly for our mental picture of them to remain true to life."[6] Lewis, an investment bank insider, who had encapsulated the irrational behaviour at the root of the global financial crisis in *Liar's Poker*, begins his new Amazon bestseller with the mystery of why a network company should build an 827-mile cable between Chicago and New Jersey in order to reduce the journey time of the data from 17 to 13 milliseconds? As the work unfolds the enormous trading advantage of speed is revealed, and how opportunities are created to continuously intervene in the market ahead of other investors employing traditional strategies and technologies.

At the heart of this controversy could simply be the waste of human talent and effort employed in pursuing HFT which may be profitable but is simply unproductive:

> "The greatest tragedy of high-frequency trading may simply be the wasted capital, both physical and human, in the quest for arbitrage profit. The $300 million cable from Chicago to New York added no tangible societal benefit despite its price tag. Wall Street firms have accelerated their recruiting of the best academic and technological talent in the country in order to run HFT groups, often siphoning these employees from universities and productive businesses."[7]

Within a day of Lewis's book being released the FBI called for an investigation into HFT, focusing on whether this might involve front running, market manipulation and other insider trading strategies, and provoked a national debate on whether US financial markets are rigged.[8] The New York State Attorney General pursued an inquiry into "unseemly practices" in the HFT business, which ultimately led to legal action against Barclays Bank in June 2014, and further inquiries into a string of leading international investment banks' HFT and dark pools. (Dark pools, in contrast to public exchanges, are not displayed in an open book system, in order to conceal the scale and origin of trades, purportedly to protect them from high frequency traders.) The floodgates were open for a tsunami of private class actions against 27 financial service firms and 14 national securities exchanges, alleging that the defendants' HFT practices in the US equities markets violated the anti-fraud provisions of federal securities laws. Further actions were filed against the CME Group, and the Board of Trade of the City of Chicago, with similar allegations regarding trading in the US derivatives markets.[9]

Greg Medcraft, the chairman of IOSCO and of the corporate regulator ASIC, later confirmed to an Australian Federal parliamentary committee: "Regulators around the world are very concerned about the systemic risk on high frequency trading. We have already had the flash crash, we have had Knight Capital, but there have been incidents in other major markets as well." His colleague, ASIC deputy commissioner Belinda Gibson, suggested algorithmic and HFT is sometimes manipulative or illegal, but it is often simply predatory on other investors. In response, ASIC proposed mandatory computer "kill" switches that stop trades which appear to be out of control. In addition, regulators are increasingly concerned about the increase of trading taking place in "dark pools", and are encouraging trades back out on to open exchanges. As Mathew Rossi, a partner in Mayer Brown law firm, comments:

> "It is clear that trading firms, brokers and exchanges engaged in HFT are coming under increasing pressure in the US from private litigants, securities regulators and criminal law enforcement authorities. As HFT techniques are increasingly used in non-US markets, the strategies and tactics used by private litigants and regulators in the United States may soon be expected outside of the United States."[10]

B. The Evolution of Electronic Trading

The rapid adoption internationally of HFT is significantly changing the nature of capital markets, as traditional floor-based trading between identifiable buyers and sellers is replaced by massive amounts of automated trading.[11] This is the current stage of the historical evolution of the use of technology to make trading faster, smarter and more intense, and at each stage the stakes have been raised with the potential risk exponentially increasing from the fortunes of a few informed (or ill-informed) speculators, to the possible ruin of vast numbers of innocent people who have entrusted their wealth to others:

> "History repeats and informs in market technologies. From the days when front running involved actual running to the 'Victorian Internet era' brought on by telegraphy. … We think that the overwhelming influence of computers remaking the landscape around Wall Street today is something new, but … [i]n its day, telegraphy was seen as the same kind of overwhelming transformation that the Internet is today. In many ways, the telegraph was more dramatic since it was the first time in history that a message could be sent beyond the horizon instantaneously."[12]

The increasing dependence on computer technology commenced in 1971 with the National Association of Securities Dealers Automated Quotations (NASDAQ), which became the world's first electronic stock market with an electronic quotation system to trade securities. The introduction of NASDAQ prompted other stock exchanges internationally to allow the electronic transmission of orders to buy and sell securities. Program Trading followed in the 1980s, allowing computerised trading involving different portfolio strategies – for example, a program could automatically put in an order when there was a difference between equity and futures markets.[13]

Electronic trading was boosted in the 1990s with the introduction of electronic communications networks

(ECNs), allowing trading of financial securities outside of official exchanges. The greater speed and efficiency of ECNs, lower costs and fewer manual errors led to increased investment in algorithmic trading, and, unsettling the monopoly of the New York Stock Exchange (NYSE) and NASDAQ, the US Securities and Exchange Commission (SEC) passed the Regulation of Alternative Trading Systems, which facilitated the emergence of a range of alternative electronic trading platforms.[14] Further reforms encouraging algorithmic trading included the decimalisation of US stock exchanges with prices quoted in cents rather than fractions of a dollar which narrowed spreads:

> "Smaller tick sizes – the smallest increment by which the price of a financial instrument can move – caused an explosion in market data volumes. Processing such high volumes began to exceed the data assimilation capabilities of human traders, whereas machines were ideally suited to handling thousands of data points per second."[15]

Finally the 2005 SEC Regulation National Market System, which required orders to be posted nationally, not just at individual exchanges, allowed traders to leverage small price differences if they could take advantage of the momentary lag between them.[16]

This progressive digitisation of the trading process and of stock exchanges themselves set the scene for the frantic activities of high-frequency traders. The defence of HFT is that in the digital age they are the market-makers, providing liquidity which contributes to market quality and efficiency in the price formation process. However, there is a lingering sense by other market participants that they are unable to keep pace with the increasingly large investments in trading technology, and are vulnerable as a result. With the increasing scale of HFT, regulators are concerned particularly about potentially harmful effects in adverse market conditions, and are emphasising the need to subject HFT to prudential and organisational requirements and to the supervision by a competent authority.[17]

The juxtaposition of the frequent calls for a long-term view of investment in order to provide a stable investment platform for business, and the due returns to long-term beneficiaries in superannuation funds, insurance funds and mutual funds and the acute explanations of the increasing prevalence of HFT is deeply ironic, and starkly highlights the complexities and contradictions of contemporary finance markets.[18]

C. Digital myopia

HFT is an intense expression of the digital myopia that is sweeping the business world:

> "Is the world becoming short-sighted? As individuals, it sometimes feels that way. Information is streamed in ever greater volumes and at ever rising velocities. Timelines for decision-making appear to have been compressed. Pressures to deliver immediate results seem to have intensified. Tenure patterns for some of our most important life choices (marriage, jobs, money) are in secular decline.[19] Some have called this the era of 'quarterly capitalism'.[20] These forces may be altering not just the way we act, but also the way we think. Neurologically, our brains are adapting to increasing volumes and velocities of information by shortening attention spans. Technological innovation, such as the world wide web, may have caused a permanent neurological rewiring, as did previous technological revolutions such as the printing press and typewriter.[21] Like a transistor radio, our brains may be permanently retuning to a shorter wave-length."[22]

Advances in financial, computing and communications technologies have facilitated the dramatic reduction of the average holding period of equity: on the NYSE this has diminished from seven years in the 1950s to six months today. More worryingly as much as 60% of trading volume on the NYSE is measured now in milliseconds, and other exchanges are similarly overwhelmed. The more impact short-term traders have in the market, the more volatile prices will be as these become less rooted in the fundamentals of the value of corporations traded, as Andrew Haldane of the Bank of England has documented. Long-term innovation and investment performance requires attention to more than short-term financial metrics. As Lin recounts, automated programs responding to bad data or extraneous stimuli can potentially cause catastrophic harm to financial institutions before remedial measures can be implemented.[23] As Haldane highlights, HFT is moving beyond human control and becoming "too fast to save":

> "For the first time in human history, machines can execute trades far faster than humans can intervene. The gap is set to widen. In some respects the 2010 Flash Crash and the 1987 stock market crash have common genes – algorithmic amplification of stress. But they differ in one critical respect. Regulatory intervention could feasibly have forestalled the 1987 crash. By the time of the Flash Crash, regulators might have blinked – literally, blinked – and missed their chance."[24]

D. The US 'Flash Crash'

On 6 May 2010 the prices of many US-based equity products experienced an extraordinarily rapid decline and recovery, as major equity indices in the securities and futures markets plunged 6% in minutes, and then quickly rebounded:

> "The so-called 'Flash Crash' sent shocks waves through global equity markets. The Dow Jones experienced its largest ever intraday point fall, losing $1 trillion of market value in the space of half an hour. History is full of such fat-tailed falls in stocks. Was this just another to add to the list, perhaps compressed into a smaller time window? No. This one was different. For a time, equity prices of some of the world's biggest companies were in free-fall. They appeared to be in a race to zero. Peak to trough, Accenture shares fell by over 99%, from $40 to $0.01. At precisely the same time, shares in Sotheby's rose three thousand-fold, from $34 to $99,999.99."[25]

This near disaster resulted when a large fundamental trader, against a backdrop of unusually high volatility and thinning liquidity, initiated a sell programme to sell a total of 75,000

E-Mini contracts (valued at approximately $4.1 billion) as a hedge to an existing equity position. The trader executed the sell program via an automated execution algorithm (the "Sell Algorithm") that was programmed to feed orders into the June 2010 E-Mini market to target an execution rate set to 9% of the trading volume calculated over the previous minute, but without regard to price or time. With the Sell Algorithm only targeting trading volume, and neither price nor time, it executed the sell program in just 20 minutes, and chaos ensued.[26]

Many of the US market's 8,000 individual equities and exchange-traded funds suffered price declines of between 5% and 15%, while over 20,000 trades across 300 securities were executed at prices more than 60% away from their values moments before. In the midst of this chaotic algorithmically programmed frantic buying and selling, the high-frequency traders were buyers of the initial batch of orders submitted by the Sell Algorithm; however, as conditions rapidly deteriorated

> "lacking sufficient demand from fundamental buyers or cross-market arbitrageurs, HFTs began to quickly buy and then resell contracts to each other – generating a 'hot-potato' volume effect as the same positions were rapidly passed back and forth. Between 2:45:13 pm and 2:45:27 pm, HFTs traded over 27,000 contracts, which accounted for about 49 per cent of the total trading volume, while buying only about 200 additional contracts net."[27]

The joint report from the US SEC and the US Commodity Futures Trading Commission (CFTC) concluded one key lesson is that under stressed market conditions, the automated execution of a large sell order can trigger extreme price movements, especially if the automated execution algorithm does not take prices into account. Moreover, the interaction between automated execution programs and algorithmic trading strategies can quickly erode liquidity and result in disorderly markets. As the events of May 6 demonstrate, especially in times of significant volatility, high trading volume is not necessarily a reliable indicator of market liquidity. [28]

The CFTC–SEC Report went on to comment that many market participants employed their own versions of a trading pause, whether generally or in particular software products, based on different combinations of market signals. If many market participants withdraw in this way a disorderly market can result. In contrast, having a general trading pause can be an effective way of providing time for market participants to reassess their strategies, for algorithms to reset their parameters and for an orderly market to be re-established. The SEC developed a circuit breaker to pause trading across US markets in a security that has experienced a 10% price change in the previous 5 minutes, and on 10 June 2010 approved the application of this circuit breaker to securities included in the S&P 500.[29] However, it is clear that neither financial markets nor regulators fully comprehend the potential impact of HFT, or regulate its activity in any meaningful way, powerfully illustrating that we still have got a lot to learn from the recent financial crisis.[30]

E. High-frequency trading

HFT employs sophisticated computer programming to execute stock transactions at extremely fast speeds in order to take advantage of small and often momentary changes in stock prices. With this new-found acceleration, the capacity of exchanges as measured by order messages per day has gone from one million in 1995 to hundreds of millions by 2009, and during the same period throughput as measured by messages per second has gone from 20 to over 100,000.[31]

High-frequency traders use different trading strategies but there are some common characteristics, including trading on their own account rather than on behalf of clients; utilising high-speed computer programs to generate, route and execute orders rapidly on multiple exchanges; maintaining unhedged positions for small fractions of a second; and submitting high rates of orders that are cancelled before the order is executed. In order for these trading strategies to work high-frequency traders need a speed advantage. To achieve such speeds, these traders pay to "co-locate" or "cross-connect" their trading computers in the buildings of public exchanges or "dark pools" in order to increase the speed with which they receive information, enabling the traders to rapidly place and cancel orders. High-frequency traders pay a premium for "direct data feeds" from public exchanges that are faster and have more information than data available to other investors. As the Attorney General of the State of New York has claimed:

> "Those speed and technology advantages allow high frequency traders to profile the pending orders on an exchange in order to detect the presence of large pending orders, usually from institutional investors. This 'information leakage,' allows high frequency traders to trade ahead of an anticipated stock purchase or otherwise have an impact on price. Speed and technology advantages also allow for strategies that seek to exploit the small, temporary pricing dislocations in a security that occur because of differential and/or delayed access to market data. This strategy is sometimes referred to as 'latency arbitrage,' because the trader is seeking to exploit the relative slowness, or 'latency,' in the transmission of market data experienced by other participants. Barclays itself commonly labelled these types of high frequency strategies as 'toxic,' 'predatory,' or 'aggressive.' Ordinary investors generally seek to avoid interactions with high frequency traders because of the effect those sorts of strategies can have on an investor's trading performance."[32]

"Latency" refers to the time it takes from sending an order to it being executed, the critical advantage of HFT:

> "A decade ago, execution times on some electronic trading platforms dipped decisively below the one second barrier. As recently as a few years ago, trade execution times reached "blink speed" – as fast as the blink of an eye. At the time that seemed eye-watering, at around 300–400 milli-seconds or less than a third of a second. But more recently the speed limit has shifted from milli-seconds to micro-seconds – millionths of a second. Several trading platforms now offer trade execution measured in micro-seconds. … The lower limit for trade execution appears to be around 10 micro-seconds. This means it would in

principle be possible to execute around 40,000 back-to-back trades in the blink of an eye. If supermarkets ran HFT programmes, the average household could complete its shopping for a lifetime in under a second. … It is clear from these trends that trading technologists are involved in an arms race. And it is far from over. The new trading frontier is nano-seconds – billionths of a second. And the twinkle in technologists' (unblinking) eye is pico-seconds – trillionths of a second. HFT firms talk of a "race to zero". This is the promised land of zero "latency" where trading converges on its natural (Planck's) limit, the speed of light."[33]

The SEC characterises HFT as typically involving:

1. Use of extraordinarily high-speed and sophisticated programs for generating, routing and executing orders.
2. Use of co-location services and individual data feeds offered by exchanges and others to minimise network and other latencies.
3. Very short time-frames for establishing and liquidating positions.
4. Submission of numerous orders that are cancelled shortly after submission.
5. Ending the trading day in as close to a flat position as possible (ie not carrying significant, unhedged positions overnight).[34]

F. High-frequency trading strategies and risks

Distinct types of HFT firms include (i) independent proprietary firms, which use private funds and specific strategies which remain secretive, and may act as market-makers, generating automatic buy and sell orders continuously throughout the day; (ii) broker-dealer proprietary desks, which are part of traditional broker-dealer firms but are not related to their client business, and are operated by the largest investment banks; and (iii) hedge funds, which focus on complex statistical arbitrage, taking advantage of pricing inefficiencies between asset classes and securities.[35]

Today strategies using algorithmic trading and HFT play a central role on financial exchanges, alternative markets and banks' internalised (over-the-counter) dealings. Agarwal distinguished high-frequency traders from the rest of the market, which generally employs algorithmic trading:

> "High frequency traders typically act in a proprietary capacity, making use of a number of strategies and generating a very large number of trades every single day. They leverage technology and algorithms from end-to-end of the investment chain – from market data analysis and the operation of a specific trading strategy to the generation, routing, and execution of orders and trades. What differentiates HFT from algorithmic trading is the high frequency turnover of positions as well as its implicit reliance on ultra-low latency connection and speed of the system."[36]

The use of algorithms in computerised exchange trading has experienced a long evolution with the increasing digitisation of exchanges:

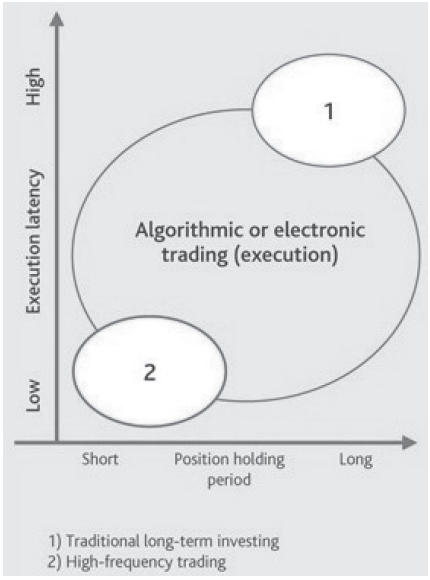

Figure 3. High-frequency trading versus algorithmic trading and traditional long-term investing.
Source: Adapted from Aldridge (2010).

> "Over time, algorithms have continuously evolved: while initial first-generation algorithms – fairly simple in their goals and logic – were pure trade execution algos, second-generation algorithms – strategy implementation algos – have become much more sophisticated and are typically used to produce own trading signals which are then executed by trade execution algos. Third-generation algorithms include intelligent logic that learns from market activity and adjusts the trading strategy of the order based on what the algorithm perceives is happening in the market. HFT is not a strategy per se but rather a technologically more advanced method of implementing particular trading strategies. The objective of HFT strategies is to seek to benefit from market liquidity imbalances or other short-term pricing inefficiencies."[37]

While algorithms are employed by most traders in contemporary markets[38] the intense focus on speed and the momentary holding periods are, as Aldridge indicates,[39] unique practices of the high-frequency traders (see Figure 3).

As noted, the defence of HFT is built around the principle that it increases liquidity, narrows spreads and improves market efficiency.[40] The high number of trades made by high-frequency traders results in greater liquidity in the market. Algorithmic trading has resulted in the prices of securities being updated more quickly with more competitive bid–ask prices, and narrowing spreads. Finally, HFT enables prices to reflect information more quickly and accurately, ensuring accurate pricing at smaller time intervals.[41] But there are critical differences between high-frequency traders and traditional market makers:

- High-frequency traders do not have an affirmative market-making obligation, ie they are not obliged to provide liquidity by constantly displaying two side quotes, which may translate into a lack of liquidity during volatile conditions.

- High-frequency traders contribute little market depth due to the marginal size of their quotes, which may result in larger orders having to transact with many small orders, and this may impact on overall transaction costs.
- High-frequency trader quotes are barely accessible due to the extremely short duration for which the liquidity is available when orders are cancelled within milliseconds.[42]

In addition to the shallowness of the HFT contribution to liquidity, there are real fears of how HFT can compound and magnify risk through the rapidity of its actions:

> "There is evidence that high-frequency algorithmic trading also has some positive benefits for investors by narrowing spreads – the difference between the price at which a buyer is willing to purchase a financial instrument and the price at which a seller is willing to sell it – and by increasing liquidity at each decimal point. However, a major issue for regulators and policymakers is the extent to which high-frequency trading, unfiltered sponsored access, and co-location amplify risks, including systemic risk, by increasing the speed at which trading errors or fraudulent trades can occur."[43]

Although there have always been occasional trading errors and episodic volatility spikes in markets, the speed, automation and interconnectedness of today's markets create a different scale of risk. These risks demand that exchanges and market participants employ effective quality management systems and sophisticated risk mitigation controls adapted to these new dynamics in order to protect against potential threats to market stability arising from technology malfunctions or episodic illiquidity.

However, there are more deliberate aspects of HFT strategies which may present serious problems for market structure and functioning, and where conduct may be illegal, eg order anticipation seeks to ascertain the existence of large buyers or sellers in the marketplace and then to trade ahead of those buyers and sellers in anticipation that their large orders will move market prices. A momentum strategy involves initiating a series of orders and trades in an attempt to ignite a rapid price move.[44]

HFT strategies can resemble traditional forms of market manipulation that violate the Exchange Act according to the SEC:

1. *Spoofing and layering* occurs when traders create a false appearance of market activity by entering multiple non-*bona fide* orders on one side of the market at increasing or decreasing prices in order to induce others to buy or sell the stock at a price altered by the bogus orders.
2. *Painting the tape* involves placing successive small numbers of buy orders at increasing prices in order to stimulate increased demand.
3. *Quote stuffing and price fade* are additional HFT dubious practices: quote stuffing is a practice that floods the market with huge numbers of orders and cancellations in rapid succession which may generate buying or selling interest, or compromise the trading position of other market participants. Order or price fade involves the rapid cancellation of orders in response to other trades.[45]

The World Federation of Exchanges insists: "Exchanges are committed to protecting market stability and promoting orderly markets, and understand that a robust and resilient risk control framework adapted to today's high speed markets, is a cornerstone of enhancing investor confidence."[46] However, this "robust and resilient risk control framework" seems lacking, including in the dark pools now established for trading that were initially proposed as safer than the open market.

G. Dark pools

In addition to the 11 public stock exchanges in the United States there are dozens of privately owned and operated trading venues, including venues known as "dark pools".[47] Public stock exchanges match tens of millions of orders to buyers and sellers each day, and these are generally visible to participants, and executions of orders are posted immediately. Public exchanges immediately display to the market the submission of pending stock orders; dark pools do not.

> "Dark pools, defined in contrast to 'lit' trading venues where trading intentions and activity are visible, provide access to non-displayed liquidity. A dark pool is an OTC (over-the-counter) venue for reporting purposes, which has the practical value that unmatched trade orders are not displayed on an open order book. The use of dark pools is typically found where disclosure of trading intent might prove injurious to price efficiency. For example, moving a large block of shares onto the market might impact counterparty pricing; feeding the same block through a dark pool (in smaller lots) will conceal the size of the overall trade."[48]

This has attracted an estimated 40% of all US equity trades to dark pools, where it is believed there is greater protection from predatory trading by high-frequency traders or other aggressive trading strategies. An explanation for the retreat into dark pools is provided by Thomas Caldwell, CEO of Caldwell Securities Ltd:

> "Large institutional investors know that if they start trying to push through a large block of shares at a certain price – even if the block is broken into many small trades on several ATSs and markets – they can trigger a flood of high-frequency orders that immediately move market prices to the institution's disadvantage. … That's why institutions have flocked to so-called dark pools operated by ATSs such as Instinet, and individual dealers like Goldman Sachs. The pools allow traders to offer prices without publicly revealing their identities and tipping their hand."[49]

Because these large, dark pools are opaque to other investors and to regulators, they inhibit the free trade that depends on open and transparent auction markets to work, but are considered by institutional investors as a safer place to trade than the open market. The existence and extensive use of dark pools is an indication of how markets have become fragmented and eroded by the activities of HFT and other aggressive predatory strategies:

> "Risks to market integrity and efficiency do not have to arise solely from a major shock such as the flash crash. Regulators are cognisant of the possibility that the confidence of some investors in the efficiency and integrity of the market (and possibly their willingness to trade) by the ongoing development of algorithmic trading and HFT, may lower investors' confidence and, possibly, reduce traditional market participants' willingness to trade."[50]

H. Sharks in dark pools

On 25 June 2014 the Attorney General of the State of New York, Eric T Schneiderman, took action against Barclays Capital Inc and Barclays plc, claiming "fraud and deceit by one of the world's largest banks".[51] Schneiderman alleged that:

> "The facts in this case concern a major business division in Barclays' New York office, the Equities Electronic Trading division. In that division, Barclays operates a private securities trading venue known as a 'dark pool.' From 2011 to the present, Barclays embarked on a business strategy to dramatically increase the market share of its dark pool, with the goal of making it the largest dark pool in the United States. Barclays accomplished this through a series of false statements to clients and the investing public about how, and for whose benefit, Barclays operates its dark pool. In short, contrary to Barclays' representations that it implemented special safeguards to protect clients from 'aggressive,' 'predatory,' or 'toxic' high frequency traders, Barclays has operated its dark pool to favor high frequency traders. Barclays has actively sought to attract such traders to its dark pool, and it has given them advantages over others trading in the pool."[52]

It was further alleged that Barclays' wrongdoing included:

1. Falsifying marketing materials purporting to show the extent and type of HFT in its dark pool, which intentionally excluded the dark pool's then largest participant, a HFT firm Barclays knew engaged in predatory behaviour in the dark pool.
2. Falsely marketed the percentage of aggressive HFT activity in its dark pool, asserting to clients and the investing public that it was less than 10%, while secretly indicating to one HFT firm that the level of such activity was at least 25%.
3. Falsely representing to clients that its Liquidity Profiling tool analysed each interaction in the dark pool to "protect clients from predatory trading" when in reality Barclays failed to remove or profile predatory traders in its dark pool, and granted overrides to HFT firms, and to Barclays' own internal trading desks which employed aggressive trading strategies, in order to make them appear less toxic than they really were.
4. Falsely represented to clients that it routed clients orders for securities to trading venues in a manner that did not favour Barclays' own dark pool, when a detailed analysis by one major institutional investor showed it was routing and executing the vast bulk of the client's orders to Barclays' own dark pool.
5. While marketing its dark pool to institutional investors as offering protection from high-frequency traders, Barclays secretly gave HFT firms informational and other advantages over other clients trading in the dark pool, allowing high-frequency traders to maximise the effectiveness of their aggressive trading strategies in the dark pool.[53]

The detailed analysis contained in the Attorney General's summons provokes stark images of unseen sharks preying on unsuspecting victims in dark pools of intense unseen trading. "Barclays grew its dark pool by telling investors they were diving into safe waters," said Schneiderman. "According to the lawsuit, Barclays' dark pool was full of predators – there at Barclays' invitation."[54] The Attorney General went on to allege that:

> "On January 16, 2014, senior leaders in the (Barclays') Equities Electronic Trading division were provided an analysis identifying over a dozen major high frequency trading firms engaged in significant trading activity in Barclays' dark pool. That analysis discussed those firms' history of sending 'toxic' order flow. One high frequency trading firm was described in the analysis as 'historically …very toxic.' Another firm was described as having '[trading activity that] is very toxic, and the client is upfront about this.' Another firm was described as having '[k]nown latency arbitrage flow' in the dark pool. Barclays has not denied any of those firms (or others) access to its dark pool, despite its representations that it will identify 'aggressive behavior, [and] take corrective action' to 'refuse a client access' to the dark pool if such aggressive or toxic high frequency trading strategies are discovered."[55]

The Attorney-General further alleged that Barclays had impeded efforts by its own executives to inform investors of what was occurring:

> "In October, 2013, Barclays prepared a trading analysis for a major institutional investor that services millions of individual accounts both inside the United States and abroad ('Institutional Investor'). The analysis determined that:
>
> - Approximately 88% of this Institutional Investor's sampled trades in dark venues were executing in Barclays' dark pool;
> - Approximately 60% of the trading counterparties for the Institutional Investor's sampled orders were high frequency trading firms."
>
> In preparation for a meeting with the Institutional Investor to explain these findings, two senior Directors prepared a PowerPoint presentation that included the results of the trading analysis. Two days before the scheduled meeting, one of those Directors was called into a meeting with senior leadership in the Equities Electronic Trading division, who instructed him not to disclose the findings to the client. According to this Director, '[t]here was no suggestion at that meeting, or at any other point, that the analysis was wrong,' merely that it should not be shared with the client because it reflected poorly on Barclays. Despite the pressure from senior leadership, this Director declined to withhold the findings from Institutional Inves-

tor. The next day, and prior to the scheduled meeting with the Institutional Investor, this Director was fired."[56]

In response to the summons Barclays Bank fired back a 42-page motion to dismiss the Attorney General's complaint, insisting the bank planned "to mount a firm defence against the allegations, which have hobbled its dark-pool operation and damaged Barclays's reputation on Wall Street. The London bank asked the court to dismiss the case, which it said is 'based on clear and substantial factual errors'."[57] Barclays claimed that its customers are:

> "Highly sophisticated traders and asset managers responsible for investing millions or billions of dollars of assets, who execute trades across multiple markets and ATSs, are capable of closely monitoring the quality of execution they receive based on extensive data, and can select from multiples platforms on which to execute their trades based on detailed execution data, not on the glossy marketing brochures or quotes from magazine articles the New York Attorney General cites."[58]

Moreover, Barclay's claimed its clients were aware that its dark pool allowed trading by high-speed firms:

> "The materials cited in the Complaint demonstrates that they were intended only for sophisticated clients and that they transparently disclosed the volume of HFT and 'aggressive' trading on LX. Contrary to the Complaint's allegations, the very Barclays marketing materials on which the NYAG relies made clear that HFTs were a substantial part of LX traders and transparently marketed LX as a platform on which clients could benefit from the liquidity provided by HFTs, while having the option of reducing exposure to 'aggressive' order flow."[59]

Barclay's concluded that the Attorney General's complaint "fails to identify any fraud, establishing no material misstatements, no identified victims and no actual harm".[60] Meanwhile the Attorney General's office has extended its scrutiny to other large dark pools at Goldman Sachs, Morgan Stanley, Credit Suisse, Deutsche Bank and UBS, and the US SEC has launched an inquiry into dark pool trading.

I. Conclusions: regulating high-frequency trading and dark pools

On the 22 September 2010 the SEC chair Mary Schapiro signalled that US authorities were considering the introduction of regulations targeted at HFT:

> "High frequency trading firms have a tremendous capacity to affect the stability and integrity of the equity markets. Currently, however, high frequency trading firms are subject to very little in the way of obligations either to protect that stability by promoting reasonable price continuity in tough times, or to refrain from exacerbating price volatility."[61]

However, regulating an industry working towards moving as fast as the speed of light is no ordinary administrative task:

> "Modern finance is undergoing a fundamental transformation. Artificial intelligence, mathematical models, and supercomputers have replaced human intelligence, human deliberation, and human execution. … Modern finance is becoming cyborg finance – an industry that is faster, larger, more complex, more global, more interconnected, and less human."[62]

Lin proposes a number of principles for regulating this cyber finance industry:

- Update antiquated paradigms of reasonable investors and compartmentalised institutions, and confront the emerging institutional realities, and realise the old paradigms of governance of markets may be ill-suited for the new finance industry.
- Enhance disclosure which recognises the complexity and technological capacities of the new finance industry.
- Adopt regulations to moderate the velocities of finance realising that as these approach the speed of light they may contain more risks than rewards for the new financial industry.
- Introduce smarter coordination harmonising financial regulation beyond traditional spaces of jurisdiction.[63]

Electronic markets will require international coordination, surveillance and regulation.

> "The high-frequency trading environment has the potential to generate errors and losses at a speed and magnitude far greater than that in a floor or screen-based trading environment. … Moreover, issues related to risk management of these technology-dependent trading systems are numerous and complex and cannot be addressed in isolation within domestic financial markets. For example, placing limits on high-frequency algorithmic trading or restricting un-filtered sponsored access and co-location within one jurisdiction might only drive trading firms to another jurisdiction where controls are less stringent."[64]

In these regulatory endeavours it will be vital to remember that all innovation is not intrinsically good and might be inherently dangerous, and the objective is to make a more efficient and equitable financial system, not simply a faster system: "Despite its fast computers and credit derivatives, the current financial system does not seem better at transferring funds from savers to borrowers than the financial system of 1910."[65] The tragedy is that under the guise of technological advance and sophistication we could be destroying the capacity of financial markets to fulfil their essential purpose, as Haldane eloquently notes:

> "An efficient capital market transfers savings today into investment tomorrow and growth the day after. In that way, it boosts welfare. Short-termism in capital markets could interrupt this transfer. If promised returns the day after tomorrow fail to induce saving today, there will be no investment tomorrow. If so, long-term growth and welfare would be the casualty."[66] ■

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