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## Beyond Regulation

### A Cooperative Approach to High-Frequency Trading and Financial Market Monitoring

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#### EXECUTIVE SUMMARY

Some people are concerned that existing market structure regulation and liquidity incentives have skewed financial markets in favor of algorithmic and high-frequency trading (HFT). This type of market activity involves the use of computer programs to automatically trade securities in financial markets. This is a problem, critics say, because it creates unfair informational asymmetries between different types of market participants and because it increases the risk of a “flash crash”—a sudden market downturn driven by computer-automated trading.

According to these critics, additional regulation should be introduced to level the playing field. However, this approach neglects to recognize that problems with market fragmentation, price synchronization, information dissemination, and market technology long predate the advent of HFT. In fact, these problems have persisted for at least 40 years—despite repeated good-faith efforts to find regulatory solutions. What’s more, there is evi-

dence to suggest that HFT has led to increased liquidity, lower spreads and transaction costs, more efficient price discovery, and wider participation in financial markets.

That still leaves legitimate concerns about how to ensure market integrity and avoid flash crashes. Yet, further regulation may be counterproductive, since it risks creating an adversarial environment that gives market participants an incentive to hide errors associated with HFT. Instead, a cooperative solution should be pursued: firms could confidentially report human/automation interface errors to a neutral third party, which would anonymize, aggregate, and analyze such incidents in order to identify patterns that could help prevent a major market-disrupting event.

A successful model for such an approach already exists in the airline industry, where NASA’s Aviation Reporting System gathers and publishes data on human and technology errors—including those caused by automation—with the aim of preventing catastrophes and educating flight crews.

“Have we created an adversarial environment that pits regulators against market participants in an ongoing battle to shape market structure?”

## INTRODUCTION

Michael Lewis’s recent book *Flash Boys*<sup>1</sup> describes the evils of high-frequency trading and how Regulation National Market System (Reg NMS), which was designed to improve market competition and the dissemination of securities price information, has aggravated a market structure he deems inherently “rigged.” To remedy the situation, he suggests additional regulation designed to fix existing policy failures. But is a perpetual cycle of adding layer upon layer of regulation designed to control the ineffectiveness or unintended consequences of existing policies really the most efficient means of maximizing financial market integrity? Has growth in regulatory restrictions on the securities markets really improved the financial market environment for stakeholders? Or have we created an adversarial environment that pits regulators against market participants in an ongoing battle to shape market structure?

Beginning in the 1970s with the development of the national market system, which was designed to facilitate trading and post prices for securities simultaneously (price synchronization), through the Flash Crash of 1987 and the promulgation of Reg NMS in 2007, policymakers have sought to address a number of perceived market failures through regulation. These failures include market fragmentation and price synchronization across venues, information dissemination problems including market technology problems, and previous policy failures. Yet despite many good-faith efforts to regulate them out of existence, these issues persist.

The current regulatory target for these perceived issues is algorithmic and high-frequency trading (HFT). Algorithmic traders use computer programs—called algorithms—to automatically trade securities in financial markets. HFT is a form of algorithmic trading in which firms use high-speed market data and analytics to look for short-term supply-and-demand trading opportunities that are often the product of predictable behavioral or mechanical characteristics of financial markets.

However, if those perceived market failures existed prior to computer algorithms and HFT, what makes us think regulatory intervention will be any more effective this time? This policy analysis looks at how the current market structure and regulatory environment emerged and how securities market regulation has been largely ineffective in preventing these “failures.” It then considers whether the interface between humans and automation might be a greater risk than market structure and asks whether a cooperative solution designed to gather data, examine market integrity, and prevent major market events could be effective in reducing systemic risks.

## THE FLASH CRASH OF 1987

The U.S. Securities and Exchange Commission (SEC) began pursuing a national market system in the early 1970s, as increased market fragmentation had caused a lack of synchronization of prices across exchanges.<sup>2</sup> Implemented in 1975, regulators viewed the crash of 1987 as a failure of the national market system’s consolidated communication and data processing network designed to synchronize quotations. But in reality a complex mix of Federal Reserve and congressional policies, human failures, and technology problems led to the pricing difficulties that caused the crash.

The events that took place in the days leading up to the “Flash Crash” of October 19, 1987—a sudden market downturn driven by computer-automated trading—were an important precursor to understanding the informational problems that arose. Between Wednesday, October 14, and Friday, October 16, selling began to increase because of the announcement of a higher-than-expected federal budget deficit as well as new legislation filed by the House Ways and Means Committee designed to eliminate the tax benefits associated with corporate mergers. These led to additional dollar value declines and, combined with Federal Reserve Board action over the previous months, relatively rapidly rising interest rates. Those factors started to exert downward pres-

sure on equity prices, creating technical pricing problems, because of the high trading volumes. When markets re-opened on October 19, a day now known as Black Monday, sell pressure caused some specialists to postpone commencing trading for the first hour. Market indexes quickly became stale, and market participants had difficulty pricing securities accurately, which led to significantly impaired and disorderly trading. As Federal Reserve economist Mark Carlson described it, it was “the difficulty gathering information in the rapidly changing and chaotic [market] environment” that ultimately led to the market crash.<sup>3</sup>

## REGULATION NATIONAL MARKET SYSTEM (REG NMS)

The Flash Crash of 1987 resulted in calls from the public and legislators for additional regulation to ensure such a market event would never happen again. To this end, so-called “circuit breakers” were introduced and were installed as part of the market infrastructure. Circuit breakers are trading curbs meant to reduce the risk of crashes by halting trading in the event that market indices drop by more than a certain percentage. When the S&P 500 declines by 7 or 13 percent, trading is halted for 15 minutes; trading is stopped for the day if the decline reaches 20 percent. Following this, in 2007, Reg NMS was implemented to modernize and strengthen the existing national market system. Reg NMS was also aimed at improving the dissemination of market information, as high trading volumes created technical pricing problems during the flash crash and prices could not be synchronized across exchanges. Yet it is the very introduction of Reg NMS that critics like Michael Lewis, Sal Arnuk, and Joseph Saluzzi have blamed for the proliferation of HFT.

Reg NMS contains four main components:<sup>4</sup>

1. The Order Protection Rule (often called the Trade-Through Rule) requires trading centers to make price quotations im-

mediately and automatically accessible. This is designed to prevent the execution of an order in one trading venue that is inferior to a price displayed in another trading venue. The rule electronically links all exchanges and electronic communication networks—automated systems that match buy and sell orders—and allows trade orders to be executed at the best price regardless of which exchange they reside on.

2. The Access Rule requires fair and non-discriminatory access to quotations and reasonable limits for access fees.
3. The Sub-Penny Rule prohibits markets from displaying, ranking, or accepting quotations in prices involving fractions of a penny, except when the price of the equity is less than \$1 (in which case the minimum increment is one-hundredth of a penny). This minimum displayed price change is called the “tick size.” However, brokers/dealers are still allowed to use a sub-penny price internally for price improvements on their clients’ orders. A price improvement exists when your broker/dealer gives you an asking price that is higher than what the market is displaying when you are selling a stock, or gets you a slightly lower price when you are buying a stock. Since a client’s orders can only be displayed in penny increments, the displayed selling price would be \$52.34, but the broker/dealer could jump in front of the client’s order and buy the stock for \$52.34.
4. The Market Data Rules were designed to strengthen the market data system by rewarding market centers for trades and quotes. Three networks disseminate and consolidate market data for stocks that market centers use. The data include the national best bid and offer prices, trade size, and market center identifying information. The networks charge fees for these data and once expenses are paid, the revenues are distributed to the market centers. Previously, rewards

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had been heavily weighted toward number and size of trades, but under the new regulation, trade and quote information are weighted equally.<sup>5</sup> The total revenue split between market centers is estimated to be \$500 million per year.<sup>6</sup>

The second portion of the Market Data Rule establishes an advisory committee. The final section requires consolidation and distribution of all stock data through a single processor.

Concerns about price synchronization and the dissemination of market information because of market fragmentation were justifications for Reg NMS. Yet, at the time, the vast majority of trading was taking place on the New York Stock Exchange (NYSE) and the NASDAQ. This was primarily because the scale of their operations provided liquidity and created little incentive for trading firms to trade elsewhere. Since most buyers and sellers were operating on those exchanges, it meant they were the best places to get orders filled quickly. Once the Trade-Through Rule was implemented, however, price competition and liquidity across trading venues increased substantially, and there were incentives to trade across venues and for additional venues to enter the market, thereby further increasing market fragmentation and competition. The benefits of this increased competition have included improved liquidity, lower transaction costs, and narrower spreads.

Nevertheless, this development has its critics. Since all prices were being synchronized through the Securities Information Processor (SIP), the speed of information processing became a new frontier of competition. As speeds across the market began to increase, it became apparent that the technology driving the SIP was too old and slow to keep up with the processing speeds of which traders were capable. In other words, technological price synchronization and information dissemination problems persisted even under Reg NMS. And so, the markets adapted.

The emerging high-frequency traders needed to be able to process information much

more quickly than they could via the SIP, so they began purchasing direct access to market data. In the same way data were received by the SIP, any market participant who wished to do so was allowed access to a direct feed for a fee. Using these purchased direct feeds, HFT firms were able to develop their own internal security information handlers that processed information much more quickly than those who relied on the SIP to capture, process, and disseminate the information.<sup>7</sup> It is this increased speed of market data processing that Michael Lewis believes gives HFT an advantage under the market structure created by Reg NMS.

Others believe the Sub-Penny Rule, which dictated a minimum tick size, has given HFT an advantage. A study by Mao Ye and Chen Yao found that when the minimum tick size (that is, one cent) is large relative to the price of the security being traded, price competition between traders is constrained in a way that favors HFT. The authors looked at the NASDAQ market, in which limit orders (that is, orders to buy or sell a certain number of shares at a specified price or better) are executed on the basis of a price/time priority rule. Price priority means that orders offering better terms of trade execute before orders at a worse price. However, the Sub-Penny Rule means that the cost of establishing price priority increases with relative tick size (one cent represents 20 basis points of a \$5 stock, compared with just one basis point of a \$100 stock). The result is that traders who might otherwise have differentiated themselves on price using increments of less than one cent, instead end up quoting the same price. In that case, time priority applies: orders at that same price execute in the order that they are submitted. Competition, in other words, is based on speed rather than price, and that clearly gives HFT an advantage.<sup>8</sup>

A study conducted by Australia's Capital Markets Cooperative Research Centre found that companies could affect the level of HFT present in their stock by changing the relative tick size to stock price through stock splits and consolidations. While Australia's tick size

structure is considerably different from that of the United States (which provides different advantages for Australian HFT), the study does demonstrate that relative tick size can affect HFT behavior.<sup>9</sup>

### THE MAKER-TAKER MODEL

The “maker-taker” model (MTM) has also been blamed for the rise of HFT and overall market “unfairness.” The MTM is a trading venue pricing system that gives a rebate to those traders who provide liquidity by posting buy and sell orders (market makers) and charges a transaction fee for those who “take” the buy or sell offer. Usually the “makers” received a slightly lower rebate than “takers” pay in fees. Some believe the MTM model has encouraged the emergence and growth of HFT.

In June 2014, in testimony before the U.S. Senate Homeland Security and Governmental Affairs Subcommittee on Investigations,<sup>10</sup> Brad Katsuyama, the hero of Michael Lewis’s anti-HFT book and president and chief executive of IEX Group, and Robert Battalio, professor of finance at the University of Notre Dame, focused their attention on the maker-taker model as a root market structure problem with responsibility for the proliferation of HFT. Katsuyama and others believe MTM gives an “unfair advantage” to HFTs because their frequent trading allows them to make money on the fees alone even when the price of a security remains unchanged.<sup>11</sup>

On a broader market level, there is concern that the lack of transparency associated with these fees can lead to violations of the broker’s fiduciary duty to obtain the best execution for their client. There is concern about a potential principal-agent problem in which traders will trade to get the lowest transaction cost versus the best share price for their client. In other words, the “best price” that the trader could get (including rebates and incentives) may not be the best share price for the client. The SEC is currently researching this broader market concern.<sup>12</sup>

### THE CHALLENGES OF A REGULATORY SOLUTION

Some critics of HFT have called for the elimination of Reg NMS and the MTM because the market structure they impose creates informational asymmetries they view as “unfair.” Yet since information dissemination and price synchronization problems existed before HFT and Reg NMS, we need to consider whether repealing or modifying Reg NMS and eliminating the MTM is any more “fair” to all market participants than the status quo.

Consider the Sub-Penny Rule as an example. The study by Ye and Yao (cited above) suggested that forcing trades to be executed in one-penny increments gives an advantage to HFTs. Raising the minimum tick size above a penny, as some have proposed, would then only increase the advantages realized by HFT and algorithmic traders more broadly. In contrast, reducing the minimum tick size to allow trades at sub-penny prices would give an advantage to retail investors who are more likely to trade in lower increments, according to the study.<sup>13</sup> So the question changes from, “How do we fairly level the playing field?” to “To whom shall we give the trading advantage through regulatory intervention?” There is no regulatory solution to make markets truly equal in terms of trading advantages or information distribution and processing. All regulatory intervention can do is move the advantage around. Someone will always be sitting in the catbird seat.

A second example is the Order Protection (Trade-Through) Rule. Because the rule requires traders to find the best top-of-book price even if it means trading across multiple venues, there are incentives for competing venues to enter the market. Even if you believe this is a bad rule, removing it does not offer an obviously equitable solution. If the goal, as critics have suggested, is to remove the rule to make price discovery easier by minimizing market fragmentation, then you are essentially telling multiple trading venues that they will no longer be able to participate in the marketplace through no fault of their own. The same is true for the elimination of the MTM. Is it “fair”

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that companies who established firms to legally compete in the existing market structure should be driven out of business at the stroke of a regulatory pen? Those who support such a measure are often the same people who hope to regain market share by forcing out the competition, which would harm small brokers and give an advantage to large firms.<sup>14</sup> And remember, price discovery and information dissemination was problematic even with far fewer venues in the 1970s.

Another factor that deserves consideration is that while critics have pointed to Reg NMS and the MTM as creating an environment conducive to HFT—and thereby increasing systemic risk—there isn’t really much empirical evidence to support this claim. The chair of the SEC, Mary Jo White, in a speech before the Economic Club of New York on June 20, 2014,<sup>15</sup> clearly expressed doubt that these regulations are relevant to the appearance of HFT in U.S. financial markets.

To make her case, she first points to the fact that there are many countries that have seen the same levels of growth in HFT as the United States, even though they are not subject to Reg NMS or similar types of regulation. Second, she highlighted the problems with blaming the “trade-through” provision of Reg NMS for creating additional fragmentation and an emphasis on speed as the preferred means of competition. This argument is questionable because “E-Mini” S&P futures contracts—stock futures contracts that are one-fifth the size of standard stock futures contracts—are traded on a centralized single market—the Chicago Mercantile Exchange—and are not subject to Reg NMS, SEC oversight, or the MTM. Yet the proportion of HFT activity in E-Mini trading is 50 percent—the same level as equity markets that are fragmented, subject to Reg NMS, and the MTM.

## A COOPERATIVE SOLUTION

In the 1970s concerns about market fragmentation, information dissemination, and technology problems in financial markets

started rising. Recently, concerns have been raised about HFT—and algorithmic trading technologies more broadly—either creating or contributing to price synchronization and information dissemination problems. Furthermore, some worry that HFT “destabilizes” the market because of its high volumes and has the potential to bring down the entire market because of a technology anomaly.<sup>16</sup> On the other hand, increased liquidity, lower spreads and transaction costs, more efficient price discovery, and wider participation in markets provide evidence that HFT has contributed to an improvement in information dissemination and price synchronization under the existing market structure (see box). These improvements should be preserved.

While critics have pointed to the competitive market structure imposed by certain regulations implemented since the Flash Crash of 1987 as increasing market risk, there is no solid evidence to indicate that the current market structure, Reg NMS, or MTM is responsible for the emergence of HFT, algorithmic trading, or pricing- or information-dissemination problems. The regulation has certainly changed some aspects of the market, but it has been largely ineffective in solving the problems identified in the 1970s. While there may be some ways to continue to improve information dissemination by modernizing the SIP or increasing transparency, there is no reasonable or cost-effective regulatory intervention that could ensure complete equality of information among market participants. This being the case, the remaining concern associated with algorithmic trading is how to ensure market integrity and prevent a major market event like another Flash Crash. But how do we accomplish this without perpetually imposing regulations designed to fix the ineffectiveness or unintended consequences of previous regulations, especially when it is uncertain if the existing market structure is to blame?

## Insight from Airline Regulation

One option is to adopt a practice used by the airline industry. The United States has one

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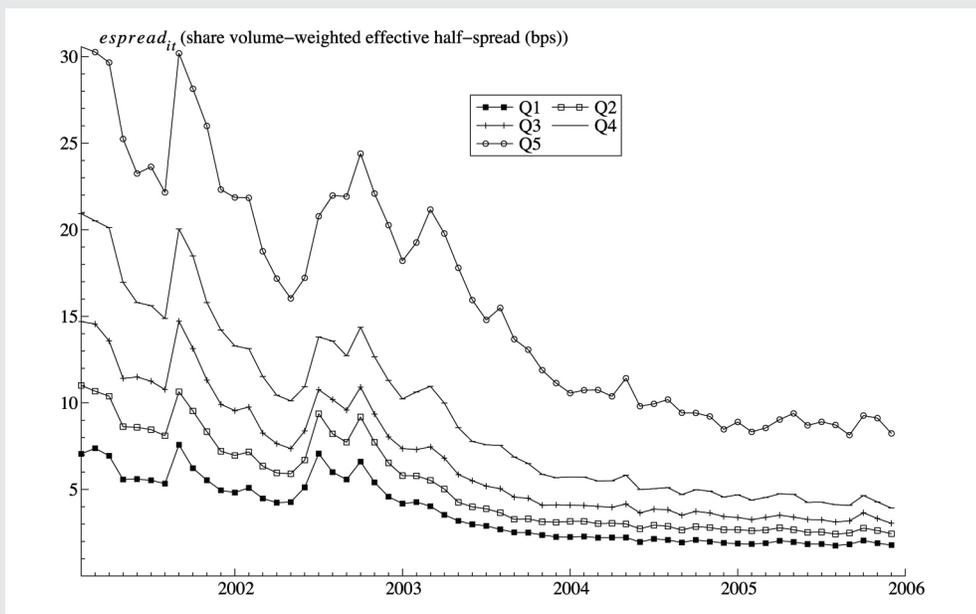
## BOX 1 THE BENEFITS OF HIGH-FREQUENCY TRADING

The main benefit of HFT is that it improves liquidity in financial markets. In other words, it increases the ease with which financial assets can be bought and sold on demand, without this affecting the asset’s price. Participants in HFT achieve this through “market making”—that is, they are always ready to buy and sell particular securities at a publicly quoted price, on a continuous basis throughout the trading day.

This is important because buy and sell orders are not always placed simultaneously. This means that even if an investor wants to sell immediately at a specified price, there won’t always be a buyer available. As a result, the seller might be forced to hold the security longer than he wants to while he waits for a buyer. In such a scenario, there is less liquidity in the market, *and* the seller’s asset is less liquid (that is, less easily converted into cash). It is precisely in these circumstances that HFT adds value: its participants will buy the security when the seller wishes to sell, and then sell that same security to another buyer when he or she enters the market. HFT “makes the market” and increases its liquidity for investors.

Increased liquidity is reflected in lower “bid-ask spreads”—that is, smaller differences between the price bid by buyers, and the price asked for by sellers. Evidence of this can be seen in Figure 1, which is taken from a paper by Terrence Hendershott, Charles M. Jones, and Albert J. Menkveld.<sup>a</sup> It shows that effective spreads decreased across market-cap quintiles as HFT increased from 2001 onward. The narrower the effective spread, the more liquidity is present in the stock.

**Figure 1**  
Effective Spread by Market-Cap Quintile (Q1 is the largest-cap quintile)



Source: Terrence Hendershott, Charles M. Jones, and Albert J. Menkveld, “Does Algorithmic Trading Improve Liquidity?” *Journal of Finance* 66, no. 1 (2011), <http://faculty.haas.berkeley.edu/hender/algo.pdf>.

HFT’s role in reducing bid-ask spreads has also reduced trading costs. According to data from the Financial Information Forum, the average cost of trading one share of stock was

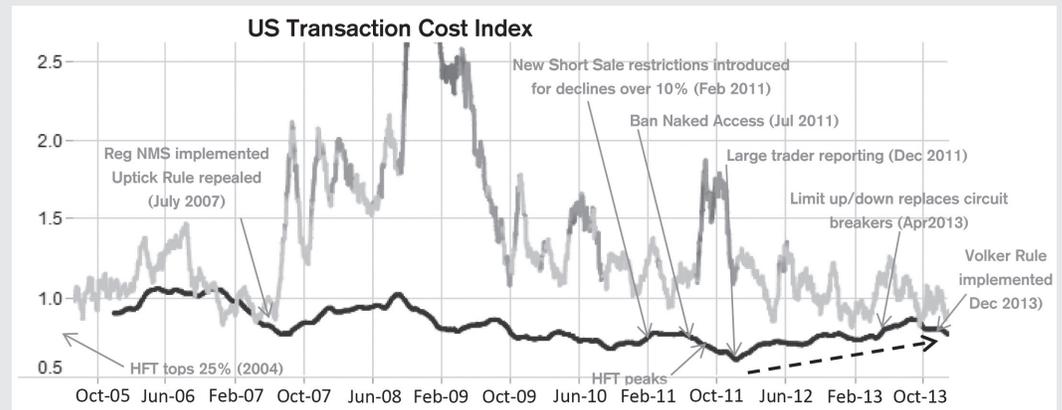
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“High-frequency trading assists in stabilizing short-term prices by eliminating gaps that would otherwise exist when buyers and sellers are not active in the market at the same time.”

### BOX 1 Continued

reduced from 7.6 cents in 2000 to 3.8 cents by the second quarter of 2012.<sup>b</sup> Further evidence comes from Credit Suisse’s Transaction Cost Index, shown in Figure 2, which suggests that transaction costs in the United States decreased as HFT increased and have subsequently started to rise as HFT activity has declined.<sup>c</sup> In the Credit Suisse graph below, transaction costs (bottom line) are charted with volatility (top line).

**Figure 2**  
U.S. Transaction Cost Index and Volatility (Index on bottom, volatility on top)



Source: Phil Mackintosh and Liesbeth Baudewyn, “Market Structure: Beware, Transaction Costs are Trending Up,” *Credit Suisse Trading Strategy*, 2014.

Finally, HFT’s market-making function has an additional benefit: it assists in stabilizing short-term prices by eliminating gaps that would otherwise exist when buyers and sellers are not active in the market at the same time.<sup>d</sup> This runs contrary to accusations that HFT creates market volatility.

<sup>a</sup> Terrence Hendershott, Charles M. Jones, and Albert J. Menkveld, “Does Algorithmic Trading Improve Liquidity?” *Journal of Finance* 66, no. 1 (2011), <http://faculty.haas.berkeley.edu/hender/algo.pdf>.

<sup>b</sup> N. Popper, “On Wall Street, the Rising Cost of Faster Trades,” *New York Times*, August 13, 2012, [www.nytimes.com/2012/08/14/business/on-wall-street-the-rising-cost-of-high-speed-trading.html](http://www.nytimes.com/2012/08/14/business/on-wall-street-the-rising-cost-of-high-speed-trading.html).

<sup>c</sup> Phil Mackintosh and Liesbeth Baudewyn, “Market Structure: Beware, Transaction Costs Are Trending Up,” *Credit Suisse Trading Strategy*, 2014.

<sup>d</sup> J. J. Angel and D. McCabe, “Fairness in Financial Markets: The Case of High-Frequency Trading,” *Journal of Business Ethics* 112, no. 4 (2013): 585–95.

of the best records for commercial aviation safety in the world, even though the use of automation by jet aviators versus “hand flying” has been increasing steadily since the 1970s.<sup>17</sup> Thomas Schnell, a researcher with the Operator Performance Laboratory at the University of Iowa, estimates pilots spend approximately 90 percent of their time in the cockpit monitoring automation systems rather than manu-

ally flying.<sup>18</sup> Automation has helped the airline industry improve safety and on-time performance. By 1992 automation was commonplace in the industry and a passenger’s risk of being killed in a crash was reduced from 1 in 100,000 in the early 1960s to 1 in 500,000.<sup>19</sup>

Yet, between June 2009 and July 2014 there were 4,311 incidents in which the interface between pilots and cockpit automation failed.<sup>20</sup>

Those incidents did not necessarily lead to a catastrophic event, but taken together they could provide clues as to how to prevent a crash or other major event in the future. For example, if a pilot is using automation to execute a landing, and at 100 feet the autopilot suddenly decides to veer left rather than continue its straight path to the runway, the pilot is supposed to quickly shut off the automation and recover the plane by hand, do a go-around, and hand fly the aircraft to the ground. To the flight crew, this event is an anomaly and no one in the cockpit will probably ever experience it again. But what if three other crews at three different airlines have experienced the same problem one time each? Collectively it is no longer an anomaly, but a potential problem that requires some root cause analysis. The problem is that unless everyone knows the event has occurred a total of four times, people will continue to think it was a one-time event.

To solve this problem, both human and technology errors are reported confidentially via the Aviation Reporting System<sup>21</sup> at NASA, where identifying information is removed and data are compiled, analyzed, and reported on. The database is also made public, so anyone interested in the data is able to analyze it. In the scenario described here, NASA would be aware that the technology problem occurred a total of four times and could report on it, thereby triggering airlines and technology manufacturers to work together to determine the root cause of the problem and fix it before there is a major incident. Problems are reported to NASA as a neutral third party rather than to the Federal Aviation Administration, which regulates and investigates air transportation, to encourage reporting and to ensure that punitive measures are not taken unless a criminal act was involved or an airplane accident occurred. The goal is to gather data on human and technology errors to prevent major catastrophes and better educate flight crews, not to look for reasons to “punish” recovered errors. In fact, failure to report an error that is later discovered may result in punitive action, so the incentive is clearly to report incidents.

There is some evidence that the cooperative approach to airline safety has helped keep the growth of regulatory restrictions much lower than in the adversarial financial sector. While both industries are highly regulated, data obtained from the Mercatus Center’s regulation database indicate growth in regulatory restrictions from all regulators on the air transportation sector (Figure 3, bottom line) has only increased by 2.46 percent since 1997, compared to 22.94 percent on the securities, commodity contracts, and other financial investments and related activities sector (Figure 3, top line).<sup>22</sup>

### The Flash Crash of 2010

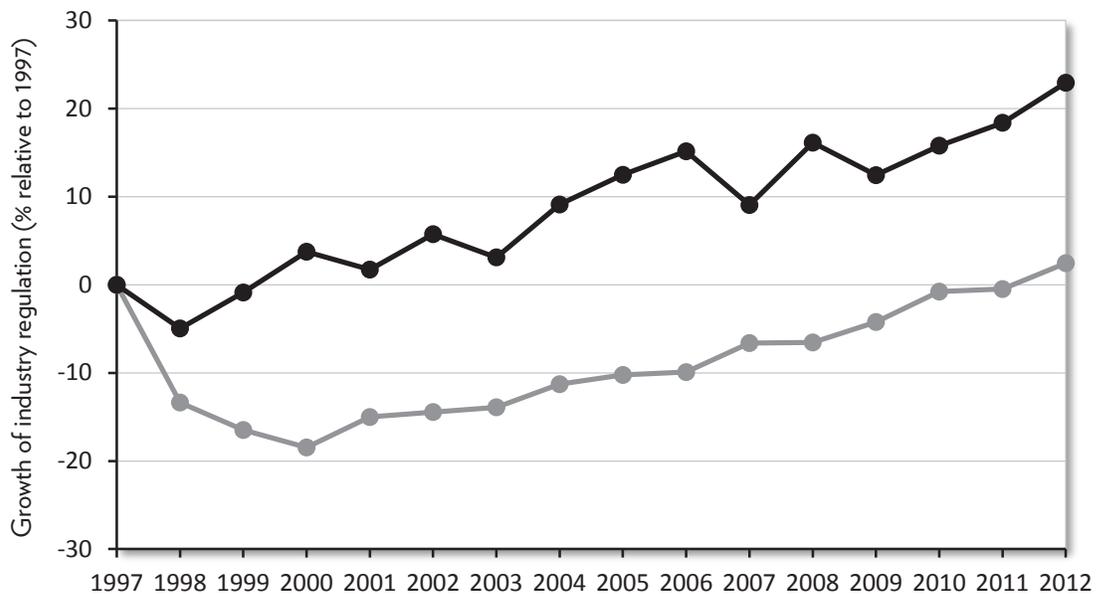
The Flash Crash of May 6, 2010, during which the market fell 6 percent in a matter of minutes and then rebounded almost as quickly, provides some evidence that the interaction between humans and automation is a systemic risk factor in financial markets. On the day of the crash, negative political and economic news about the European debt crisis led to sharp declines in the Euro against both the U.S. dollar and Japanese yen and caused market price volatility in some securities to rise. In addition, there had been an approximately 55 percent decrease in buying activity (buy-side liquidity) in E-Mini contracts and the S&P 500 SPDR, an exchange-traded fund designed to mirror the return on the S&P 500 Index. In this already stressed and relatively volatile market, a mistake was made that triggered the Flash Crash.

A large trader executed an unusually large sell order of 75,000 E-Mini contracts using an automated execution algorithm. What was unusual about this sell algorithm was that it was designed to sell on the basis of a percentage of trading volume over the previous minute, but was not to consider price or time. The HFT firms and other intermediaries initially absorbed the volume, but when the intermediaries also started to sell, the automatic execution algorithm—which was only responding to volume—began to sell more rapidly. The result was an extremely rapid sell-off within 20 minutes. In the past, orders of this size considered

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“When and how often do algorithms not work as intended or have to be stopped during their operation because of a problem?”

**Figure 3**  
Growth of Regulation: Airline Industry vs. Financial Sector  
(Finance top line, airline bottom line)



Source: Mercatus Center, “Historical Regulation Data: Securities, Commodity Contracts, and Other Financial Investments and Related Activities Regulated by All Regulators vs. Air Transportation Regulated by All Regulators,” self-initiated database query, *RegData*, [http://www.regdata.org/?type=regulatory\\_restrictions&regulator\[\]=0](http://www.regdata.org/?type=regulatory_restrictions&regulator[]=0).

volume, price, and time and took more than five hours to execute.<sup>23</sup>

As with the Flash Crash of 1987, there were a series of events that created the environment that led to the Flash Crash of 2010. However, the automated execution algorithm used by the large trader—whether intentional or unintentional—appears to have been a poor choice for the market environment that existed at the time, suggesting a human/automation interface breakdown. What remains unclear is how often such less-than-optimal algorithms are executed. Are errors made in selecting which algorithm to execute (a “fat finger” error), or is it more common for an intentionally selected algorithm to prove inappropriate for market conditions? When and how often do algorithms not work as intended or have to be stopped during their operation because of a problem?

When these issues occur on a much smaller scale, or are caught internally and disrupted, they may go relatively undetected by the larger market and only be known to the traders

themselves. The punitive environment that exists between traders and regulators provides incentives to keep these errors internal to avoid penalties. However, if these occurrences are aggregated, they might provide clues about patterns of human/automation interface issues that could help prevent a major market event like a flash crash.

News about Knight Capital’s error—which involved the use of an outdated, defunct algorithm to trade on August 1, 2012—has been widely reported by the media, but there are other errors that never see the light of day. The sheer size of Knight’s loss—\$440 million within 45 minutes, resulting in the demise of the company—is difficult to hide. However, Donald MacKenzie recounts a story told by a former high-frequency trader about an error he observed in which one of his colleagues interchanged a plus and a minus sign, causing the program to act much like the Knight program did. They realized what was happening within 52 seconds, but by then they had already lost \$3 million. Their after-incident analysis indi-

cated that if it had continued they could have bankrupted both the firm and their clearing broker, a major Wall Street investment bank.<sup>24</sup> It is precisely this type of incident that needs to be reported.

Following the example set by the airline industry, a new system of reporting errors to a neutral third party could be developed for financial markets. Giving market participants an opportunity to confidentially report their own or others' human or technology errors might help identify the root causes of real—rather than perceived—risks, encourage cooperative solutions between stakeholders, and establish a baseline of problems under the existing market structure. Market participants could also report when existing policies or regulations impede their ability to “do the right thing” for their customers.

A neutral third party could collect, analyze, and disseminate information. Trading firms and venues could use the reports to internally audit their own organizations for the identified problems, develop monitoring systems, and implement training when appropriate. Regulators could create advisory committees to work with trading firms and venues to establish action plans, develop performance improvement reporting, and, when cooperative solutions are inadequate or unsuccessful, propose regulatory solutions to improve the human/automation interface and prevent market-disrupting events. Making the database public would provide opportunities for self-regulating authorities, academics, and others to analyze the data, look for patterns, explain market behavior, and propose solutions.

## CONCLUSION

In the 1970s, regulators began trying to solve financial market problems involving market fragmentation and price synchronization across venues, information dissemination issues including market technology problems, and previous policy failures. These problems persist to this day, despite numerous regulatory efforts to solve them. One challenge is that

as regulatory intervention modifies market structure, markets are often evolving at a faster pace, creating an ongoing battle between regulators and market participants.

Ongoing regulatory modifications to market structure may not be any more successful than previous attempts. Regulators need to ensure an orderly, efficient, and secure marketplace and—in this context—working toward cooperative rather than adversarial solutions is preferable. Creating a self-reporting system that allows for aggregation of events across firms and venues will give regulators and market participants better information about patterns of specific technology and human errors that will help improve market integrity and minimize the need for regulation. Making this database public would create increased transparency and opportunities for others to apply and analyze the data to gain a more holistic perspective on root causes of existing and potential market problems and events.

This strategy does not meet the desire of many for a quick, one-size-fits-all solution to perceived market problems. Yet price, information dissemination, and technology problems have existed for at least 40 years, which suggests that a quick regulatory fix is more fantasy than reality. These issues should not be addressed in the knee-jerk reactionary court of public opinion, but through careful analysis that works toward prevention, seeking root causes, and developing cooperative solutions to minimize the potential effects of policy failures on markets.

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