HIGH-FREQUENCY TRADING: A REGULATORY STRATEGY

Charles R. Korsmo *

INTRODUCTION

The events of May 6, 2010 took high-frequency trading from the edges of public consciousness to being front page news. American stock markets had opened that morning to unsettling rumblings from Europe. The previous day had seen violent protests in Greece against proposed austerity measures designed to avert a default on Greek government debt.[1] The ongoing riots seemed likely to scupper a proposed European Union bailout of Greece, potentially touching off a chain-reaction debt crisis with disastrous consequences for the entire euro zone.[2] Given these inauspicious augurs, it is hardly surprising that investor sentiment was somewhat jumpy and decidedly gloomy for much of the day.[3] Over the course of the morning, prices slid in increasingly volatile trading. By 1:00 p.m.,[4] the Standard & Poor's 500 ("S&P 500"), a well-known index of stock prices for 500 top American companies, had

* Assistant Professor, Case Western Reserve University School of Law. J.D., Yale Law School. I am grateful to Dean Lawrence Mitchell for research support. All errors are my own.

1. *See* STAFFS OF THE CFTC & SEC, FINDINGS REGARDING THE MARKET EVENTS OF MAY 6, 2010, at 1, 9 (2010), *available at* http://www.sec.gov/news/studies/2010/marketevents-report.pdf [hereinafter SEPTEMBER CFTC-SEC STAFF REPORT]; Dina Kyriakidou, Analysis: Greek Riots to Weaken Resolve for Measures, Reuters (May 6, 2010), http://www.reuters.com/article/2010/05/06/us-greece-violence-analysis-top-idustre6443ga20100506.

2. The increasing fear of a euro zone meltdown was evidenced by increased prices for credit default swaps offering protection against potential defaults on European government debt. *See* STAFFS OF THE CFTC & SEC, PRELIMINARY FINDINGS REGARDING THE MARKET EVENTS OF MAY 6, 2010, at 11 (2010), *available at* http://www.sec.gov/sec-cftc-prelimreport.pdf [hereinafter MAY CFTC-SEC STAFF REPORT].

3. *See* SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 1 ("May 6 started as an unusually turbulent day for the markets.").

4. All times are Eastern Standard Time.

fallen by about 1%[5]—a significant drop, to be sure, but not yet particularly alarming.

Around 1:00 p.m., the dollar value of the Euro started to decline precipitously, and the sell-off in the broader market began to accelerate.[6] The volatility of stock prices increased sharply, triggering automatic slowdowns in trading for numerous stocks traded on the New York Stock Exchange ("NYSE").[7] By 2:00 p.m., the S&P 500 had fallen a total of 2.9% for the day.[8] Such a large drop is unusual, and undoubtedly cause for consternation, but was nowhere near as severe as the multiple 5%+ daily swings seen at the height of the 2008 financial crisis.[9] Few would have guessed that the stage was now set for the most extraordinary hour in the history of the American stock market.

At 2:32 p.m., the fall in prices again began to pick up steam, with the broad markets dipping another 1% to 2% in less than ten minutes.[10] Then, at 2:41 p.m., the markets went careening entirely off the rails. In less time than it takes to soft-boil an egg, the markets took a sickening plunge of more than 5%, so that by 2:45 p.m. markets were down nearly 10% for the day.[11] One trillion dollars in wealth had apparently melted away over the course of the day, with more than $500 billion in market capitalization evaporating into thin air in less than five minutes.[12]

---

5. *See* MAY CFTC-SEC STAFF REPORT, *supra* note 2, at 11 & fig. 1.

6. SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 1.

7. As discussed more fully below, the NYSE employs automated "circuit breakers" that slow down trading for a given security when price volatility for that security exceeds certain thresholds. Kristina Peterson, *Programs, NYSE Circuit Breakers Contribute to Market Plunge*, WALL ST. J. MARKET WATCH (May 6, 2010), http://www.marketwatch.com/story/programs-nyse-circuit-breakers-contribute-to-market-plunge-2010-05-06-193500/. These slowdowns are intended to act as a "speed bump," preventing a stampede that might overwhelm available liquidity—the ready supply of buyers and/or sellers—and are thus known as "Liquidity Replenishment Points" ("LRPs"). *See* SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 68. Beginning at around 1:00 PM on May 6, 2010, the number of LRPs triggered began to increase dramatically, at first to several times larger than normal and ultimately reaching nearly 100 times the normal level. *See* MAY CFTC-SEC STAFF REPORT, *supra* note 2, at 22–23.

8. SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 11.

9. *Historical Index Data,* WALL ST. J., http://online.wsj.com/mdc/public/page/2_3047-djia_alltime.html (detailing the largest percent losses and largest point losses in one day on the Dow Jones Industrial Average).

10. SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 9.

11. *Id.*

12. *See* Edward E. Kaufman Jr. & Carl M. Levin, *Preventing the Next Flash Crash*,

What happened next was just as extraordinary. At 2:45 p.m., the broad market began to rebound almost as sharply as it had plummeted, and by 3:00 p.m. the S&P 500 had regained almost all of the ground lost over the past hour.[13] Over the same fifteen minutes, individual stocks traded wildly, with huge and evidently illogical price swings. Proctor & Gamble—a blue-chip component of the benchmark Dow Jones Industrial Average ("DJIA")—dropped by 36% in less than four minutes, and then fully recovered in less than a minute.[14] 3M experienced a similarly rapid collapse and recovery.[15] Accenture, a multi-billion dollar consultancy firm, saw its stock price fall from $40 per share to a penny in a matter of seconds, and then rocket back to $40 just as quickly.[16] Shares of Apple, which had been trading at around $250 per share, changed hands at the outlandish price of $100,000 per share.[17] Hundreds of other securities experienced similar chaos.[18] The markets shuddered up and down for the next hour, returning to orderly trading, and finally closing at 4:00 p.m. down 3%—back to about where they had been at 2:30 p.m.[19] The entire roller-coaster ride is shown in Figure 1.

N.Y. TIMES, May 6, 2011, at A27; SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 4.

13. SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 9.

14. *Id*. at 84.

15. *Id*. at 85.

16. *Id*. at 83.

17. *Id.* at 86; *Apple Inc. (AAPL) Historical Prices*, YAHOO! FINANCE, http://finance.yahoo.com/q/hp?s=AAPL.

18. *See* Henry T.C. Hu, *Too Complex to Depict? Innovation, "Pure Information," and the SEC Disclosure Paradigm*, 90 TEX. L. REV. 1601, 1703 (2012) ("Between 2:40 PM and 3:00 PM, over 20,000 trades across more than 300 securities were executed at prices 60% or more away from 2:40 PM prices.").

19. SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 1, 6.

Figure 1: The Flash Crash

After the markets closed, a single question was on everyone's lips: What just happened? Observing the general market collapse around 2:45 p.m., many professional traders simply assumed that something catastrophic, like a major terrorist attack, must have happened—but no cataclysm had occurred.[20] Nothing much at all had happened in the real world. Certainly nothing had happened that would make it reasonable to believe that American companies were worth $1 trillion less one minute, and then $1 trillion more fifteen minutes later.[21]

The markets had seen dramatic and unexplained declines before, but never before so rapid. Most notably, the "Black Monday" crash of October 19, 1987 saw markets fall more than 20% in a single day, with no obvious news "trigger" for the collapse.[22] But

20. *Id.* at 4–5 ("[A] number of [market] participants reported that because prices simultaneously fell across many types of securities, they feared the occurrence of a cataclysmic event of which they were not yet aware . . . .").

21. That great repository of human experience, YouTube, has preserved for posterity the live coverage from the day, which reveals an amusing mélange of uninformed speculation, blinking incomprehension, and stark terror. Jim Cramer, appearing on CNBC, seems almost relaxed throughout the episode—a sure sign that something is seriously amiss. *See* FLASH CRASH! *Dow Jones Drops 560 Points in 4 Minutes! May 6th 2010*, YOUTUBE, http://www.youtube.com/watch?v=86g4_w4j3jU (last visited Dec. 6, 2013).

22. Hu, *supra* note 18, at 1702–03; *see* Jerry W. Markham & Rita McCloy Stephanz,

the Black Monday crash and other smaller "market breaks" differed from the May 6, 2010 fiasco—which has come to be known as the "Flash Crash"—in that in previous crashes, the markets did not experience an immediate rebound.[23] Markets did not regain their previous highs until nearly two years after the 1987 crash.[24] The fact that markets had largely bounced back within twenty minutes of the 2:45 p.m. nadir made the Flash Crash all the more mysterious.[25]

Initial suspicions focused on the possibility of a "fat finger" trade—that a large investor might have mistakenly entered a "B" for "billion" instead of an "M" for million when entering a sell order, triggering a chain reaction of price declines.[26] However disconcerting the idea that a simple typo could cause such turmoil, the other alternatives were no less troubling. After the "fat finger" explanation was ruled out, suspicion turned to the new, highly computerized and heavily automated structure of the modern American markets. In particular, the Flash Crash cast a powerful spotlight upon the activities of so-called high-frequency traders ("HFTs").[27] Such traders use high-speed computers to execute rapid-fire trades, usually without real-time human involvement, and

The Stock Market Crash of 1987—The United States Looks at New Recommendations, 76 GEO. L.J. 1993, 1993 (1988) ("New York Stock Exchange (NYSE) stocks lost $1 trillion in value and the Dow Jones Industrial Average plunged 508 points in a day . . . known as Black Monday.") (citations omitted).

23. *See* Mark Carlson, *A Brief History of the 1987 Stock Market Crash with a Discussion of the Federal Reserve Response* 10 (Fin. And Econ. Discussion Series, Fed. Reserve Bd., Working Paper, 2006), *available at* http://www.federalreserve.gov/pubs/feds/2007/200713/200713pap.pdf (stating that trading on Tuesday, October 20, 1987 was "significantly impaired").

24. *See* Marsha Meyer & Prashanta Misra, *What, Me Worry About an All-Time Stock Market High?*, CNNMONEY (Oct. 1, 1989), http://money.cnn.com/magazines/moneymag/moneymag_archive/1989/10/01/85385/index.htm ("By the end of August [1989] it had begun to look just like the good old pre-crash days.").

25. Perhaps the closest parallel to the Flash Crash was May 28, 1962, when the market plummeted 5.7% in a single day, only to gain back 4.7% the very next day. H.R. DOC. NO. 88-95, pt. 4, at 832, 834 (1963).

26. David Easley et al., *The Microstructure of the "Flash Crash": Flow Toxicity, Liquidity Crashes and the Probability of Informed Trading*, 37 J. PORTFOLIO MGMT., no. 2, 2011, at 118; Matt Phillips, *SEC's Schapiro: Here's My Timeline of the Flash Crash*, WALL ST. J. (May 20, 2010), http://blogs.wsj.com/marketbeat/2010/05/20/secs-schapiro-heres-my-timeline-of-the-flash-crash/; see *Fat Finger Error*, INVESTOPEDIA, http://www.investopedia.com/terms/f/fat-finger-error.asp.

27. The abbreviation "HFTs" will be used throughout to refer to the high-frequency traders who engage in to the act of high-frequency trading. "HFT" will be used to refer to the general phenomenon of high-frequency trading.

have, in a matter of only a few years, gone from non-existent to conducting perhaps a majority of all trades on public securities markets.[28]

High-frequency trading ("HFT") is controversial. HFTs have largely driven out traditional market makers, disrupting longstanding methods of assuring liquidity on public securities markets.[29] HFT may involve manipulative or parasitic trading strategies.[30] The speed and technological sophistication of HFTs may give them advantages over other traders, generating an appearance of unfairness and leading less sophisticated parties to avoid investing in the markets. The sheer volume of trades entered by HFTs can overwhelm market systems, leading to slowdowns and imposing costs on other market participants.[31] The lack of direct human oversight raises the specter of "rogue" algorithms.[32] In many of these regards, however, HFT is not unique and does not pose fundamentally different risks than other market activities.[33]

The most troubling risk associated with HFT, which has generated widespread concern, is that HFTs will inadvertently—or even deliberately—cause extreme volatility events such as the Flash Crash. The evidence is surprisingly mixed as to whether HFT has, in fact, led to an increased incidence of extreme volatility,[34] but this suspicion or fear has led to a welter of proposed reforms and regulations.[35] Because of the relative novelty of HFT,

28. SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 45.

29. *See* Tom C.W. Lin, *The New Investor*, 60 U.C.L.A. L. REV. 678, 689–92 (2013); Scott S. Powell & Rui Gong, *Wall Street's New Race Toward Danger*, BARRON'S, March 8, 2010, at W45.

30. *See* Concept Release on Equity Market Structure, Exchange Act Release No. 34-61,358, 75 Fed. Reg. 3594, 3608–09 (Jan. 21, 2010) [hereinafter SEC Concept Release].

31. *See* Wallace Turbeville, *Reign of the High-Frequency Trading Robots*, U.S. NEWS & WORLD REPORT (Oct. 18, 2013), *available at* http://www.usnews.com/opinion/blogs/economic-intelligence/2013/10/18/how-high-frequency-trading-is-taking-over-markets.

32. *See* Alyse L. Gould, *Regulating High-Frequency Trading: Man v. Machine*, 12 J. HIGH TECH. L. 273, 280–81 (2011).

33. *See infra* Part III.

34. *See* SEC Concept Release, *supra* note 30, at 3603.

35. *See, e.g.*, Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010, Pub. L. No. 111-203, § 967(a)(2)(D), 124 Stat. 1376, 1913 (2010) [hereinafter Dodd-Frank Act] (requiring a study into the effect of HFT practices on the market); SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 7.

however, a consensus approach to dealing with the associated risks has yet to develop.

This article considers how to regulate the risks associated with HFT. This endeavor requires a thoughtful balancing of competing considerations.[36] The fact is often overlooked by critics, but HFT often benefits retail investors and markets as a whole.[37] Any regulatory scheme should be carefully designed so as not to jeopardize these benefits, which may be substantial. At the same time, regulation is necessary to ensure that HFT does not destabilize public markets, and that the public does not believe that HFT has destabilized the markets. While the benefits of HFT are vulnerable to regulatory overkill, widespread fear of HFT could lead retail investors to avoid public securities markets if regulation is seen to be insufficient. Maintaining the benefits of HFT, therefore, requires regulation that carefully addresses the real risks—reassuring the public without deterring socially beneficial trading activities.

The regulatory challenge is made all the more difficult by the fact that HFT is an inherently moving target. As explained below, there is seldom a clear line between HFT and other automated market activity. Furthermore, HFTs are protean in nature, introducing new trading strategies and algorithms on a continuous basis.[38] Consequently, regulatory responses must be dynamic, generating and responding to new information in real time, and stimulating market participants to minimize risks themselves. Aiding regulators in this last respect is that many of the most salient risks of HFT are borne, at least in the first instance, by the HFTs themselves or by other sophisticated market participants.[39]

36. This article seeks to do for HFT what Merrill and Schizer have recently done for hydraulic fracturing, or "fracking." *See generally* Thomas W. Merrill & David M. Schizer, *The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy*, 98 MINN. L. REV. 145, 149–50 (2013). Though the topics are, obviously, quite different, this article utilizes a structure and style of analysis quite similar to that employed by Merrill and Schizer.

37. *See* Lin, *supra* note 29, at 692–93, 725.

38. Gould, *supra* note 32, at 281; Michael J. McGowan, Note, *The Rise of Computerized High Frequency Trading: Use and Controversy*, 2010 DUKE L. & TECH. REV. 16, ¶18; Paul Springer, *HFT & Algo Get Tougher for Traders Large & Small*, TRADER DAILY (Mar. 23, 2011), http://www.traderdaily.com/03/hft-algo-get-tougher-for-traders-large-small/.

39. *See infra* Part III.A.

Accordingly, the regulatory strategy proposed here consists of four prongs. The first crucial step is to ensure that reliable information regarding HFT is generated in close to real time. In the wake of the Flash Crash, investigators required months to even partially reconstruct trades and orders that had occurred over the course of a few hours.[40] A consolidated audit trail would allow regulators to rapidly reconstruct all trading activity and identify the parties responsible for each order. Such a system would enable quick investigation of unusual market events and, if appropriate, the reliable assignment of liability to the responsible parties. It would also provide a valuable source of data for identifying emerging risks and designing new regulatory strategies to address those risks.

The second regulatory prong is an evolving body of best practices regulation designed to reduce the systemic risks posed by HFT. These regulations should be designed to ensure that both HFTs themselves and other large market participants—operators of securities exchanges such as the NYSE and NASDAQ, in particular—follow best practices. Best practices regulation has at least two advantages over other potential regulatory strategies. First, although it may not be entirely nonintrusive, best practices regulation provides market participants with a degree of stability and certainty. Given the large investments in technology and human capital required for HFT, a relatively stable and predictable regulatory regime is necessary. Second, even where it is not optimal, best practices regulation provides some reassurance to the public that regulators are focused on the relevant risks and are requiring the use of state-of-the-art safeguards.

Best practices regulation has, of course, some limitations. In a fast-changing field like HFT, where the risks are not yet fully understood, the body of regulations must necessarily remain incomplete for the foreseeable future. In addition, best practices regula-

40. *See* Jonathan Spicer et al., *Insight: SEC Tightens Leash on Exchange Post "Flash Crash,"* REUTERS, Jan. 12, 2012, *available at* http://www.reuters.com/article/2012/01/12/us-sec-exchanges-leash-idustre80b1ya20120112 (noting that regulators delayed a report on the crash almost five months to gather more data); Gregg E. Berman, Senior Advisor to the Div. Trad. & Mkts., SEC, Speech by SEC Staff at the Annual SIFMA Concept Conference (Oct. 13, 2010), *available at* http://www.sec.gov/news/speech/2010/spch101310geb.htm (describing the difficulty of obtaining trading data from May 6, 2010 in the months after the crash).

tion can be difficult to enforce. If oversight is ineffective and penalties are insufficient, best practices regulation can offer only limited protection. The information-gathering function of the first prong is thus crucial to the effective functioning of the second.

The third prong is to strengthen liability for HFTs and those who sponsor their access to their markets, in order to ensure that they are able to make good on the obligations they incur from their trading activities. Few things are more destructive to the functioning of public securities markets than the introduction of significant counterparty risk—that is, the risk that the party on the other side of the trade will be unable or unwilling to fulfill their contractual obligations to pay money or transfer securities.[41] HFTs and their facilitators must be required to demonstrate that they have the financial wherewithal to make good on any obligations their algorithms—even unintentionally—cause them to incur.

Finally, these regulatory measures should be backstopped by improved circuit breakers designed to temporarily halt trading in individual securities during periods of unusual volatility. Improved circuit breakers are already in the process of being implemented for most securities, and should help to limit the scope of any harm caused by rogue HFTs.[42]

To help ensure that regulation of HFT does not interfere with the move to a national market system, this article recommends that the regulatory center of gravity remain in the U.S. Securities & Exchange Commission ("SEC"), the only agency with the scope and expertise to oversee such activity. In order to help oversight remain dynamic and innovative, however, as much flexibility as possible should be given to the operators of securities exchanges. Exchange operators have a strong economic incentive to protect the integrity of the trading on their exchanges in order to attract trading volume and increase profits. This economic incentive should be preserved to the extent possible, such that competitive

41. Jeremy C. Kress, *Credit Default Swaps, Clearinghouses and Systemic Risk: Why Centralized Counterparties Must Have Access to Central Bank Liquidy*, 48 HARV. J. LEGIS. 49, 55–56 (2011).

42. Order Granting Accelerated Approval to Proposed Rule Changes Relating to Trading Pauses Due to Extraordinary Market Volatility, Exchange Act Release No. 34-62,252, 98 SEC Docket 2160 (June 10, 2010).

pressure will help to drive development of cost-effective safeguards. Private sector actors are likely to be more nimble in regulatory innovation, as well.

This article presents the first broad-view examination of HFT in the legal literature, and one of the first categorizations of the various potential dangers associated with such trading and with the modern electronic market structure in general.[43] The article proceeds in seven parts. Part I provides a brief introduction to HFT, and to the structure of the modern securities markets. Part II summarizes the economic benefits of HFT—including the substantial benefits to small investors. Part III identifies and categorizes a number of potentially regulation-justifying dangers and harms associated with HFT that are either not unique to HFT or that can be best addressed by private actors. Part IV considers the risks of increased volatility and public loss of confidence associated with HFT. Part V offers a general framework for choosing a regulatory strategy and uses it to critique regulatory proposals put forth by various academics and industry participants and suggests a superior regulatory approach to HFT. Part VI fleshes out the proposed regulatory strategy, including the use of liability and circuit breakers. Part VII discusses implementing this regulatory strategy, including the proper role of private sector actors such as exchange operators.

I. HIGH-FREQUENCY TRADING AND THE MODERN MARKET

A. *The Structure of the U.S. Securities Markets*

In order to understand the mechanics and strategies involved in HFT, it is necessary to have at least a rudimentary picture of the structure of the U.S. equity markets. Until the 1970s, trading stocks and other securities in the United States almost always involved, at the end of the day, a face-to-face transaction. Stocks

43. *See, e.g.*, Didier Sornette & Susanne Von der Becke, *Crashes and High Frequency Trading: An Evaluation of Risks Posed by High-Speed Algorithmic Trading* 5 (Swiss Finance Institute, Research Paper, No. 11-63, 2011), *available at* http://ssrn.com/abstract=1976249 ("Being a fairly new phenomenon, academic research on this subject is still limited in numbers and to some extent inconclusive with respect to potential risks posed by HFT."). Rather than an attempt at comprehensive evaluation, Sornette and Von der Becke focus primarily on the liquidity effects of HFT.

and related securities were listed and traded largely on a single exchange, and orders would be sent to a registered member of the exchange for execution through a dedicated individual—a specialist—who would manually book trades on the trading floor.[44] This began to change in 1971, when the National Association of Securities Dealers created the National Association of Securities Dealers Automated Quotations ("NASDAQ") system, the first securities market to use a computerized system for matching buyers and sellers.[45] From that point on, markets have seen increasing computer automation in the execution of trades and, more recently, on the investors' side in the placement of the orders themselves.[46]

Change has been especially rapid over the past decade. As late as 2006, stocks listed on the NYSE—which account for approximately three-fourths of the market capitalization of companies listed on U.S. exchanges—were still traded primarily manually on the NYSE's Wall Street trading floor.[47] In part due to changing technology, and in part due to new SEC regulations intended to foster greater competition between exchanges (known as "Regulation NMS" for "national market system"),[48] the NYSE instituted a fully automated quotation system in October 2006, which began to displace manual trading.[49] The result has been a dramatic shift in patterns of trading. In 2005, nearly 80% of trading volume in NYSE-listed stocks took place on the NYSE.[50] By 2009, as trading became fragmented among competing trading venues, that figure dropped to only 25%.[51] At the same time, the volume of trades skyrocketed, and the average speed with which orders could be

44. *See* SEC Concept Release, *supra* note 30, at 3594.

45. *See, e.g.*, Peter Gomber et al., High-Frequency Trading 8 (Mar. 2011) (unpublished manuscript), *available at* http://ssrn.com/abstract=1858626; *What is NASDAQ?*, NASDAQ, http://www.nasdaqomx.com/aboutus/company-information/whatisnasdaq.

46. *See* Gomber et al., *supra* note 45, at 6, 8.

47. SEC Concept Release, *supra* note 30, at 3594.

48. *See* Regulation NMS Release No. 34,51808, 70 Fed. Reg. 37,496, 37,496–98 (June 29, 2005) [hereinafter Regulation NMS Release].

49. SEC Concept Release, *supra* note 30, at 3594–95.

50. *See id*. at 3613; Peter Cohan, *Does It Matter That A German Exchange May Control the NYSE?*, DAILY FIN. (Feb. 10, 2011), http://www.dailyfinance.com /2011/02/10/nyse-deutsche-boerse-merger-stock-exchange-germany/; Aaron Lucchetti, *Niederaver's First Challenge: NYSE Floor Traders' Future*, WALL ST. J. (Nov. 21, 2007), http://online.wsj.com /news/articles/SB119561394296900182.html.

51. SEC Concept Release, *supra* note 30, at 3595.

executed fell from more than ten seconds to a fraction of a second.[52]

During this period, trading activity has spread across a number of dispersed trading venues, and the venues themselves have begun to function in an entirely automated fashion.[53] The majority of this trading occurs on a handful of official exchanges that are registered with the SEC and electronic communication networks ("ECNs") that function much like traditional exchanges but are regulated somewhat differently.[54] Both types of exchanges typically use what are called "central limit order books" which make available to all market participants a continually updated list, or "book," of outstanding offers to buy (bids) or sell (offers) at various prices.[55]

A substantial fraction of trades, however—in the neighborhood of a quarter—take place in somewhat less transparent forums.[56] When a large investor attempts to buy or sell a large block of shares, the mere fact that they are doing so—if revealed in the limit order book—can cause the price of those shares to move against them.[57] This can occur for a number of reasons. Other market participants might believe that the large trader has new information about the value of the security in question, and adjust their own estimates in response. Less innocently, the large trader might fall victim to other traders "front-running" the large order, a practice described below.[58] To minimize this risk, many institutional investors conduct at least some of their trading on

52. *Id*. at 3595–96. Trading on other exchanges can be even faster. Even three years ago, NASDAQ was reporting an average time to accept, process, and fill an order of only 294 microseconds. *Id*. at 3598 n.25.

53. *Id*. at 3594.

54. *Id*. at 3597–99.

55. *See* Gomber et al., *supra* note 45, at 8. For example, the limit order book for ABC stock might show that 100 shares had last changed hands at $10, and that there are 500 shares being offered at $10.01, 300 offered at $10.02, 800 offered at $10.03, and so on. Traders enter into trades in two basic ways. First, they can enter limit orders—resting offers to buy or sell a certain quantity of a security at a certain price, which remain in the limit order book until executed or cancelled—or they can enter market orders—an aggressive order to buy or sell a certain quantity of a security at whatever is the best price currently available in the limit order book. *See* David Kane, Andrew Liu & Khanh Nguyen, *Analyzing an Electronic Limit Order Book*, 3 R. J. 64, 64 (2011).

56. SEC Concept Release, *supra* note 30, at 3598.

57. *Id.* at 3599.

58. *See infra* note 126 and accompanying text.

one or more of several dozen so-called "dark pools" that "offer trading services to institutional investors and others that seek to execute [large trades] in a manner that will minimize the movement of prices against the trading interest and thereby reduce trading costs."[59] In particular, dark pools do not make publicly available their limit order books, thus rendering a large block trade invisible to other market participants until after it has already been executed.[60]

Another phenomenon that leads to somewhat less transparent trading is broker-dealer internalization. A broker-dealer is a person or firm who is "engaged in the business of effecting transactions in securities for the account of others" (brokering) and also "engaged in the business of buying and selling securities for his own account" as a principal (dealing).[61] A trade is said to be "internalized" when a broker-dealer receives an order from a client and executes it either against another client's offsetting order, or by buying or selling the shares directly on their own accounts.[62] In either case, internalized trades, like dark pool trading, can involve liquidity—a supply of willing buyers and sellers—that is not contemporaneously visible on publicly available limit order books.[63]

These dispersed trading venues are linked in several ways. First, Regulation National Market System ("NMS") created a consolidated market data system, designed to provide "a comprehensive, accurate, and reliable source of information for the prices and volumes of any NMS stock at any time during the trading day."[64] This data is "collected and distributed pursuant to a variety of Exchange Act rules and joint-industry plans."[65] In the interests of pre-trade transparency, this data includes "consolidated quotation data" consisting of the best bids and offers in the limit order books of the market players mentioned above, updated in

59. SEC Concept Release, *supra* note 30, at 3599.

60. *See id*.

61. *Guide to Broker-Dealer Registration*, U.S. SECS. & EXCH. COMM'N: DIVISION OF TRADING AND MARKETS (Apr. 2008), http://www.sec.gov/divisions/marketreg/bdguide.htm #II (citing Securities Exchange Act of 1934, 15 U.S.C. §§ 78c(a)(4)(A), (a)(5)(A) (2012)).

62. *See* SEC Concept Release, *supra* note 30, at 3599–3600.

63. *Id.* at 3612.

64. *Id.* at 3600.

65. *Id*.

real time.[66] If a customer does not want their order to be displayed prior to execution—for reasons suggested above—it need not be displayed. Thus, orders placed in dark pools or internalized by a broker-dealer may be kept from appearing in the consolidated quotation data.[67] But orders may not be selectively displayed: "[T]he display of orders to some market participants generally will require that the order be included in the consolidated quotation data that is widely available to the public."[68]

For post-trade transparency, Regulation NMS requires real-time (or close to it) reports of executed trades, or "consolidated trade data."[69] This reporting requirement applies to dark pools and internalized trades as well as to more traditional trades on exchanges.[70] The net result of these requirements, and the systems built to implement them, is that real time quotation and trade data is available to market participants with average latencies measured in milliseconds.[71]

The second major way markets are intertwined is via the SEC's "Order Protection Rule," which requires that any order must be executed at the best price available anywhere in the nation.[72] That is, when a trading center—whether a registered exchange or any of the other types of trading venues mentioned above—receives an order to buy or sell a security, it is required to execute that order at the best price currently listed in the consolidated quotation data.[73] If the trading center is unable or unwilling to

66. *Id.* ("With respect to pre-trade transparency . . . Regulation NMS requires exchange members and [certain other market participants] to provide their best-priced quotations . . . [and] make this information available to vendors.").

67. *Id*. at 3599.

68. *Id*. at 3600.

69. *Id.*

70. *Id*.

71. *Id*. at 3601.

72. *See* Regulation NMS Release, *supra* note 48, at 37,496–97 & n.2. As the SEC notes, the Order Protection Rule

> provides a baseline assurance that: (1) Marketable orders will receive at least the best displayed price, regardless of the particular trading center that executes the order or where the best price is displayed in the national market system; and (2) quotations that are displayed at one trading center will not be bypassed by trades with inferior prices at any trading center in the national market system.

SEC Concept Release, *supra* note 30, at 3601.

73. Regulation NMS Release, *supra* note 48, at 37,504–05.

execute the order at the best price, then it must either cancel and return the order or route it to another trading center displaying the best price.[74] In essence, the Order Protection Rule imposes a mandatory "Home Depot-style" low price guarantee—trading venues are required to match or beat their competitors' prices.

A third way in which markets are linked is through the SEC's requirement of "fair access."[75] The SEC sets limits on fees for access to a trading center's quotation data, and prohibits trading centers from "imposing unfairly discriminatory terms that would prevent or inhibit any person from obtaining efficient access" to the securities being offered.[76]

To summarize, over the past forty years—and particularly over the past eight years—the structure and mechanics of the U.S. equity markets have undergone a radical sea-change. Less than a decade ago, the bulk of trading took place in a handful of venues, and most trades involved direct human intermediation at some stage of the process.[77] The average time to execute a trade was certainly fast by everyday standards, but was still measured on a relatively human scale, in terms of seconds.[78]

Today, trading is widely scattered across a large number of venues of varying characteristics, tied together by the consolidated market data system and the Order Protection Rule.[79] Virtually all trades are executed fully automatically, with no human intermediation on the execution side.[80] Even more remarkably, as discussed below, the majority of trades are now conducted without any human intermediation even on the *order* side—that is, most decisions to buy and sell are made by computer algorithm,

74. SEC Concept Release, *supra* note 30, at 3601.

75. *Id.* at 3602.

76. *Id.*

77. *See supra* note 44 and accompanying text.

78. *See supra* note 52 and accompanying text.

79. *See supra* note 72 and accompanying text.

80. *See* Hu, *supra* note 18, at 1702 ("In 1975, when Congress directed the SEC to facilitate the establishment of a national-market system to link together the multiple individual markets that trade securities, trading was dominated by exchanges with manual trading floors. Today, the market is dominated by automated trading. Moreover, trading volume is now dispersed—fragmented—among many highly automated trading centers that compete for order flow. By October 2009, the NYSE executed only 25.1% of the consolidated share volume in its listed stocks.").

and executed without prior human oversight.[81] Average execution times are now measured on an inhuman electronic scale, in terms of milliseconds and microseconds.[82]

B. *High-Frequency Trading*

Perhaps the most dramatic outgrowth of the changes described above has been the large-scale emergence of HFT. The phenomenon is new enough that it lacks an authoritative, uncontroversial definition. The first step to understanding what is meant by HFT is to recognize that it is a subset of the broader (and older) phenomenon of algorithmic trading—that is, "[c]omputerized trading controlled by algorithms."[83] In essence, algorithmic trading is simply the use of computers—running specialized software implementing pre-determined decision-making rules—to evaluate market conditions and other data to make trading decisions without the need for human involvement. More expansively:

> In algorithmic trading (AT), [traders'] computers directly interface with trading platforms, placing orders without immediate human intervention. The computers observe market data and possibly other information at very high frequency, and, based on a built-in algorithm, send back trading instructions, often within milliseconds. A variety of algorithms are used: for example, some look for arbitrage opportunities, including small discrepancies in the exchange rates between three currencies; some seek optimal execution of large orders at the minimum cost; and some seek to implement longer- term trading strategies . . . .[84]

One group of researchers has identified the following helpful "common characteristics" of algorithmic trading: (1) the use of pre-designed trading decisions; (2) implementation by professional traders; (3) automated observation of market data in real time; (4) automated order submission; (5) automated order management; (6) lack of pre-trade human intervention; and (7) use of direct market access (in other words, the trader's computer inter-

81. *See infra* Part I.B.

82. *See supra* note 52 and accompanying text.

83. Johannes Prix et al., *Algorithmic Trading Patterns in Xetra Orders*, 13 EUR. J. FIN. 717, 717 (2007).

84. Alain Chaboud et al., *Rise of the Machines: Algorithmic Trading in the Foreign Exchange Market* 1 (Fed. Reserve, Int'l Fin., Discussion Paper No. 980, 2009), *available at* http://www.federalreserve.gov/pubs/ifdp/2009/980/ifdp980.pdf.

faces directly with the exchange's computerized trading system).[85] U.S. regulators have not put forth an official definition of algorithmic trading, but in 2010 the European Commission defined it in broad terms as "the use of computer programmes to enter trading of orders where the computer algorithm decides on aspects of execution of the order such as the timing, quantity and price of the order."[86]

Algorithmic trading is not, in fact, anything new. It has been used for decades to manage orders and execute trading decisions made by actual humans in such a way as to minimize the market impact and cost of making a large trade.[87] Until recently this was probably the most common use for algorithmic trading, and many definitions of algorithmic trading allude to this function.[88] The SEC has referred to this use of algorithmic trading as well, noting that "[m]any brokers also offer sophisticated algorithms that will take the large orders of institutional investors and others, divide a large 'parent' order into many smaller 'child' orders, and route the child orders over time to different trading centers in accordance with the particular trading strategy chosen by the customer."[89] As discussed below, the SEC's favored explanation is that such an algorithm triggered the Flash Crash.

While algorithmic trading is nothing new—particularly algorithmic execution of orders involving human judgment—what is new is the rapid, computerized placement of orders that removes the human element from the decision-making process altogether. Such fully automated systems make possible true HFT, which is thus a subset of algorithmic trading. HFT is characterized by

85. Gomber et al., *supra* note 45, at 14. The authors provide a helpful appendix listing various academic and regulatory definitions of algorithmic trading. *Id.* at 74–75.

86. European Commission, *Public Consultation: Review of the Markets in Financial Instruments Directive (MiFID)* 14 (European Commission, Working Paper, 2010), *available at* http://ec.europa.eu/internal_market/consultations/docs/2010/mifid/consultation_paper_en.pdf.

87. *See* Chaboud et al., *supra* note 84, at 1; Gomber et al., *supra* note 45, at 13–14.

88. *See* Peter Gomber & Markus Gsell, *Catching Up with Technology—The Impact of Regulatory Changes on ECNs/MTFs and the Trading Venue Landscape in Europe*, 1 COMPETITION & REG. IN NETWORK INDUS. 535, 541 (2006) ("*Algorithmic Trading* emulates a broker's core competence of slicing a big order into a multiplicity of smaller orders and of timing these orders to minimize market impact via electronic means."); Gomber et al., *supra* note 45, at 21 ("Most non-HFT algorithmic strategies aim at minimizing the market impact of (large) orders.").

89. SEC Concept Release, *supra* note 30, at 3602.

very rapid trading at an extremely high volume.[90] While non-HFT users of algorithmic trading may have holding periods "that are minutes, days, weeks, or longer," HFTs "hold their position[s] for a very short horizon and try to close the trading day in a neutral position."[91] In general, HFTs attempt to profit from small, even transient, price moves compounded over huge numbers of trades, rather than seeking to profit from long-term price moves driven by fundamentals, like more traditional investors.[92]

While the SEC has not officially defined HFT, in 2010 they offered the following useful gloss:

> [HFT] is relatively new and is not yet clearly defined. It typically is used to refer to professional traders acting in a proprietary capacity that engage in strategies that generate a large number of trades on a daily basis. These traders could be organized in a variety of ways, including as a proprietary trading firm (which may or may not be a registered broker-dealer . . .), as the proprietary trading desk of a multi-service broker-dealer, or as a hedge fund . . . . Other characteristics often attributed to proprietary firms engaged in HFT are: (1) [t]he use of extraordinarily high-speed and sophisticated computer programs for generating, routing, and executing orders; (2) use of co-location services and individual data feeds offered by exchanges and others to minimize network and other types of latencies;[93] (3) very

90. *See* Jakvsa Cvitanić & Andrei Kirilenko, *High Frequency Traders and Asset Prices* 2 (Nat'l Sci. Found., Working Paper, 2010), *available at* http://ssrn.com/abstract=1569067 ("[HFT] typically refers to trading activity that employs extremely fast automated programs for generating routing, canceling, and executing orders in electronic markets.").

91. Jonathan A. Brogaard, High Frequency Trading and Its Impact on Market Quality 5 (July 6, 2010) (unpublished thesis, Northwestern University), *available at* http://www.futuresindustry.org/ptg/downloads/HFT_Trading.pdf; *see also* Cvitanić & Kirilenko, *supra* note 90, at 2 ("High frequency traders submit and cancel a massive number of orders and execute a large number of trades, trade in and out of positions very quickly, and finish each trading day without a significant open position."); John D'Antona, Jr., *HFTs Adapting to Stay Profitable*, TRADERS MAG. (Mar. 12, 2012), http://rblt.com/news_details.aspx?id=191 ("Rosenblatt defines HFT broadly as any strategy that requires very low latency/high capacity technology, makes very small profits per share and trades very large volumes.").

92. An analysis by Rosenblatt Securities, a brokerage firm, suggests that in 2011, HFTs made an average profit of between $0.0005 and $0.00075 per share traded. D'Antona, *supra* note 91.

93. As explained more fully below, "co-location services" refers to when an exchange allows HFTs to locate their computers on-site at the exchange, connecting directly to the exchange's computers. The speed of an electronic signal is limited by the finite speed of light, requiring approximately a nanosecond to travel each foot. The rapidity of HFT is such that the reduction of data-transmission time from co-location—even by a few microseconds, as compared to a computer located a block or more away from the exchange—can often confer an important competitive edge. *See infra* notes 196–200 and accompanying text.

> short time-frames for establishing and liquidating positions; (4) the submission of numerous orders that are cancelled shortly after submission; and (5) ending the trading day in as close to a flat position as possible (that is, not carrying significant, unhedged positions over-night).[94]

A number of different types of market players engage in HFT. Data assembled by the TABB Group—a financial research firm—suggests that a little under half of HFT volume comes from dedicated HFT shops, a little under half comes from the proprietary trading wings of major investment banks (most prominently, Goldman Sachs), and the remainder from a smattering of hedge funds.[95]

Authoritative numbers regarding HFT are hard to come by, but it is clear that in the grander scheme of things, HFT is actually a relatively small industry. All told, a few hundred out of the approximately 20,000 trading firms operating in the United States engage in HFT.[96] Estimates of the profits earned from HFT are likewise sketchy and divergent, with HFTs themselves hesitant to trumpet their results for fear of attracting regulatory attention. Various investigations, however, suggest that net profits from HFT increased from almost nothing ten years ago to a peak of around $5 billion in 2009, before declining sharply to less than $2 billion in 2011 and $1.5 billion in 2012 amid greater competition and changing market conditions.[97] By way of comparison, J.P.

94. SEC Concept Release, *supra* note 30, at 3606. Gomber and his colleagues offer a similar list of characteristics: (1) very high numbers of orders; (2) rapid placement cancellation of orders; (3) proprietary trading (using the trader's own capital, rather than acting as a broker); (4) an attempt to profit from buying and selling as a middleman; (5) no significant net position at the end of the trading day; (6) very short holding periods; (7) seeking low margins leveraged over many trades; (8) low latency requirements; (9) use of co-location services; and (10) a focus on highly liquid securities. Gomber et al., *supra* note 45, at 15. Again Gomber and his colleagues provide a helpful appendix listing various academic and regulatory definitions of HFT. *Id*. at 74–75 app. II.

95. *See* Gomber et al., *supra* note 45, at 24 ("While consolidated information on the major players in HFT is still scarce, the community of market participants leveraging HFT technologies to implement their trading strategies is highly diverse. Its members range from broker-dealer operated proprietary trading firms and broker-dealer market making operations to specialized HFT boutiques to quantitative hedge funds leveraging HFT technology in order to increase the profits from their investment and trading strategies.").

96. *See* Rob Iati, *The Real Story of Trading Software Espionage,* WALL ST. & TECH. (July 10, 2009), http://wallstreetandtech.com/trading-technology/the-real-story-of-trading-software-espio/218401501.

97. *See* Nathaniel Popper, *High-Speed Trading No Longer Hurtling Forward*, N.Y. TIMES, Oct. 14, 2012, at B1.

Morgan Chase & Co.—a prominent investment bank—earned profits of $11.6 billion in 2009 and $18.9 billion in 2011.[98] Apple, Inc., earned more profits in each quarter of 2011 than HFT earned all year.[99]

Despite the small number of HFTs and the (relatively) small profits earned from such activity, HFT has had an outsized impact on trading in U.S. equity markets. Again, starting from almost nothing only ten years ago, HFT now accounts for a majority of all shares traded in U.S. equities.[100] Thus, the small size of the HFT industry almost certainly understates the importance of HFT to the operation of U.S. equity markets.

The short holding periods and flat positions utilized by HFTs obviously preclude traditional long-term buy-and-hold value investing,[101] but most trading strategies used by HFTs are actually qualitatively similar to trading activities that have been around for decades. While the speed and volume of HFT is unlike anything that has come before, most of the investment strategies pursued using HFT are not particularly innovative.[102] The SEC

98. JPMorgan Chase & Co., Annual Report (Form 10-K), at 62 (Feb. 28, 2013).

99. *Compare* Apple Inc., Annual Report (Form 10-K), at 75 (Oct. 31, 2012), *with* Popper, *supra* note 97. To update that classic comparison for making large dollar amounts seem small, Americans spent more than $50 billion on their pets in 2011. *See* Press Release, American Pet Products Association, Pet Owners are Expected to Spend More than $52 Billion on Their Pets in 2012 (Mar. 1, 2012), *available at* http://media.americanpetproducts.org/press.php?include=143498.

100. *See* SEC Concept Release, *supra* note 30, at 3606 ("Estimates of HFT volume in the equity markets vary widely, though they typically are 50% of total volume or higher."); Hu, *supra* note 18, at 1702 ("HFT, a term referring loosely to professional traders acting in a proprietary capacity that engage in strategies generating a large number of trades on a daily basis, may account for at least 50% of equity trading."); Mi Hyun Yoon, Comment, *Trading in a Flash: Implication of High-Frequency Trading for Securities Regulators Worldwide*, 24 EMORY INT. L. REV. 913, 922 (2010) ("HFT is believed to have accounted for 50% to 70% of [the jump in trading volume] while also accounting for similar proportions of the trading volume increases in electronic futures and options markets."); Scott Patterson & Geoffrey Rogow, *What's Behind High-Frequency Trading*, WALL ST. J., Aug. 1, 2009, at B1 ("High-frequency trading now accounts for more than half of all stock-trading volume in the U.S."). The proportion of trading attributable to HFT appears to have lessened somewhat since the height of the financial crisis, when high market volatility made HFT especially profitable, for reasons that will become clear later. *See* Popper, *supra* note 97 (citing data by Tabb Group and Rosenblatt Securities showing HFT's share of trading volume declining from 61% in 2009 to 51% in 2012).

101. One of the most famous and successful "value" investors, Warren Buffett, is known for saying "our favorite holding period is forever." *See, e.g.*, Letter from Warren E. Buffet, Chairman of the Board, Berkshire Hathaway, to Shareholders (Feb. 28, 1989), *available at* http://berkshirehathaway.com/letters/1988.html.

102. *See, e.g.*, Gomber et al., *supra* note 45, at 24 ("While the universe of HFT strate-

has divided the most prominent of these strategies into four categories: (1) market making; (2) arbitrage; (3) structural strategies; and (4) directional strategies.[103] Of these, the first two are long-standing—and generally beneficial—trading activities. The third and fourth are potentially more troubling, though also not exactly new. A brief examination of these potential strategies follows.

One of the most common uses of HFT is to conduct market making, providing liquidity to the markets.[104] Market making refers to the placement of limit orders to buy (sell) shares just below (above) the most recent market price.[105] The market maker seeks to profit from the difference between the price at which she will sell and the price at which she will buy (the "spread").[106] As its name implies, market making generally helps to ensure smooth functioning of markets, by providing liquidity in the form of a ready supply of shares to buy or sell.[107] Market making is not a new phenomenon. Traditionally, this market making function has been performed by "specialists" given privileged access to the trading venue in exchange for an affirmative obligation to maintain active quotes in the market.[108] With the advent of HFT, an increasing amount of this market making activity is performed by

gies is to [sic] diverse and opaque to name them all, some of these strategies are well known and not necessarily new to the markets. The notion of HFT often relates to traditional trading strategies that use the possibilities provided by state-of-the-art [information technology].").

103. *See* SEC Concept Release, *supra* note 30, at 3607–10. The Australian Securities and Investment Commission ("ASIC") set forth a similar categorization scheme. Report 215: Australian Equity Concept 47–48, Austl. Sec. & Inv. Comm'n 2010, *available at* http://www.asic.gov.au/asic/pdflib.nsf/LookupByFileName/rep-215.pdf/$file/rep-215.pdf. ASIC puts forth three categories—liquidity provision, statistical arbitrage, and liquidity detection—which largely overlaps with the four categories identified by the SEC. *Id.*; *see also* Gomber et al., *supra* note 45, at 24–31 (using a similar categorization scheme).

104. *See* Gomber et al., *supra* note 45, at 25 ("One of the most common HFT strategies is to act as a liquidity provider.").

105. *See id.* at 16.

106. *See* SEC Concept Release, *supra* note 30, at 3607 (describing how the market maker profits "from earning the spread by buying at the bid and selling at the offer").

107. In general, resting (limit) orders can be said to provide liquidity to the market, while orders seeking immediate execution at the best available price ("market" or "aggressive" orders) consume liquidity by executing against these resting orders. Peter N. Kolm & Lee Maclin, *Algorithmic Trading, Optimal Execution, and Dynamic Portfolios*, in THE OXFORD HANDBOOK OF QUANTITATIVE ASSET MANAGEMENT 371, 372–373 (Bernd Scherer & Kenneth Winston eds., 2012).

108. *See* SEC Concept Release, *supra* note 30, at 3607 ("Professional traders with a permanent presence in the marketplace, standing ready to buy and sell on an ongoing basis, are a perennial type of participant in financial markets.").

proprietary traders without any special access privileges—other than that provided by their superior technology—but also, notably, without any obligation to continue providing liquidity during periods of market turmoil.[109]

Because high liquidity makes an exchange more attractive to traders by reducing trading costs, trading venues compete for liquidity by offering rebates to traders who provide liquidity by supplying resting orders.[110] The NASDAQ, for example, paid market maker rebates of nearly $1.4 billion in 2009.[111] These incentives offer HFTs another way to profit from market making, by designing their algorithms in a way that seeks to capture these rebates.[112] As discussed more fully below, such rebate-hunting strategies are at least potentially of concern. If HFTs are able to design their algorithms to profitably capture rebates by offering liquidity when it is cheap to provide (and therefore least needed) and withdrawing liquidity when it is expensive to provide (and therefore needed most)—or by making and cancelling orders so quickly that no genuine liquidity is actually provided in the first place—then they would be driving up the cost of trading for long-term investors without providing any compensating benefits.[113]

109. *Id.* ("Proprietary firms largely have replaced more traditional types of liquidity providers in the equity markets, such as exchange specialists on manual trading floors and OTC market makers that trade directly with customers. In contrast, proprietary firms generally are not given special time and place privileges in exchange trading (nor are they subject to the affirmative and negative trading obligations that have accompanied such privileges)."); Gomber et al., *supra* note 45, at 25 ("While many HFTs provide the market with liquidity like registered market makers, they frequently do not face formal obligations to quote in the markets in which they are active.").

110. *See* SEC Concept Release, *supra* note 30, at 3608 ("One important aspect of passive market making is the liquidity rebates offered by many exchanges and ECNs when resting orders that add liquidity are accessed by those seeking to trade immediately by taking liquidity."); Gomber et al., *supra* note 45, at 25 ("[T]rading venues incentivize these liquidity provider[s] by granting rebates . . . in order to increase market quality and attractiveness."); Yoon, *supra* note 100, at 923 ("In competing for liquidity, exchanges reward rebates to members for non-marketableorders [sic] that merely *offer* liquidity at a particular price while charging an access fee to those who look for and execute against these limit orders, taking liquidity.").

111. NASDAQ OMX, Annual Report (Form 10-K), at 57 (Feb. 18, 2010), *available at* http://ir.nasdaqomx.com/secfiling.cfm?filingID=1193125-11-45348.

112. *See* Gomber et al., *supra* note 45, at 26 ("Other [HFT] liquidity provision strategies are built around particular incentive schemes of some markets."); Yoon, *supra* note 100, at 923–24.

113. *See* SEC Concept Release, *supra* note 30, at 3608 (asking whether "liquidity rebates reward proprietary firms for any particular types of trading that do not benefit long-term investors or market quality," and positing the existence of "risk-free trading strate-

Another long-standing market strategy brought into the electronic age by HFT is arbitrage. At its simplest, arbitrage is the attempt to profit from a situation where the same (or equivalent) goods are selling for different prices at the same time, by buying at the lower price and selling at the higher price.[114] When the same security trades in more than one venue, any price discrepancy between those venues presents an arbitrage opportunity, as does any discrepancy between the price of a derivative or index fund and the underlying securities.[115] With liquid, interconnected markets and large numbers of sophisticated traders, risk-free arbitrage opportunities in modern markets tend to be fleeting[116] and HFTs "leverage state of the art technology to profit from small and short-lived discrepancies between securities."[117]

gies driven solely by the ability to recoup a rebate that offer little or no utility to the marketplace"); Yoon, *supra* note 100, at 923–24.

114. *See* SEC Concept Release, *supra* note 30, at 3608 ("An arbitrage strategy seeks to capture pricing inefficiencies between related products or markets."). An everyday example of arbitrage is cigarette smuggling in New York City. Cigarettes sold in the city are subject to excise taxes totaling almost $7 per pack, driving the cost of a single pack of cigarettes to $12 or more. Meanwhile, untaxed cigarettes sold on Native American reservations on Long Island, or in nearby low-tax states like New Hampshire can cost less than $5 a pack. This enormous price differential creates a classic arbitrage opportunity, and has spawned an active smuggling trade seeking to take advantage of it. *See* Joseph Goldstein, *A Cigarette for 75 Cents, 2 for $1: The Brisk, Shady Sale of "Loosies,"* N.Y. TIMES, Apr. 4, 2011 at A1; Catherine Rampell, *Cigarette Taxes vs. Cigarette Smuggling*, N.Y. TIMES BLOG (ECONOMIX) (Jan. 10, 2013), http://economix.blogs.nytimes.com/2013/01/10/cigarettes-taxes-vs-cigarette-smuggling/?_r=0.

115. *See* SEC Concept Release, *supra* note 30, at 3608 ("For example, the [arbitrageur] may seek to identify discrepancies between the price of an ETF and the underlying basket of stocks and buy (sell) the ETF and simultaneously sell (buy) the underlying basket to capture the price difference."); Gomber et al., *supra* note 45, at 28 ("[I]f, e.g. an option is priced too high relative to its underlying; arbitrageurs can earn profits by selling the option and simultaneously buying the underlying. In a similar way, ETF arbitrageurs trade ETFs against their underlying and profit from respective pricing inefficiencies."). ETFs—exchange-traded funds—are simply investment funds that adjust their holdings in an attempt to track the returns of an index. Thor McLaughlin, *Eyes Wide Shut: Exchange Traded Funds, Index Arbitrage and the Need for Change*, 27 REV. BANK & FIN. L. 597, 599 (2008). Some of the largest and most liquid ETFs, for example, seek to track well-known indexes such as the S&P 500. Peter N. Hall, Note, *Bucking the Trend: The Unsupportability of Index Providers' Imposition of Licensing Fees for Unlisted Trading of Exchange Traded Funds*, 57 VAND. L. REV. 1125, 1126 n.2 (2004). Investors seeking to earn the same return as the S&P 500 can simply buy an ETF, rather than having to own all 500 component stocks. McLaughlin, *supra*, at 599–600. When the price of an ETF and the underlying index diverge, an arbitrage opportunity may arise.

116. Gomber et al., *supra* note 45, at 27 ("Opportunities to conduct arbitrage strategies frequently exist only for very brief periods (fractions of a second).").

117. *Id.*

HFTs may also use so-called "structural" strategies that attempt to "exploit structural vulnerabilities in the market or in certain market participants."[118] In particular, HFTs can potentially use their superior speed to take advantage of other market participants. When exchanges offer co-location arrangements and direct data feeds, HFTs can potentially process and react to market information more quickly than traditional traders relying on the consolidated market data, and "profit by identifying market participants who are offering executions at stale prices."[119] Such strategies are sometimes described as "latency arbitrage," in that they seek to profit from pricing discrepancies caused by brief delays in market data being conveyed to traders.[120]

The above three types of strategies are all "market neutral," in the sense that they do not involve taking an unhedged position in the belief that prices are going to move in a particular direction in a lasting fashion. The remaining HFT strategies—while still involving rapid trades and short holding periods—may be termed "directional" in that they do involve identifying potential price movements.[121] To the extent that such strategies are simply very fast efforts at determining that a security has strayed from its "true" value, they are uncontroversial and likely contribute to market efficiency.[122] HFTs may also seek to trend-follow, riding waves of market momentum just like classic day-traders during the dot-com boom.[123]

Two other types of "directional" strategy are potentially more problematic, though again not entirely novel. The first are so-called "order anticipation strategies."[124] As has been noted, when a trader seeks to execute a large order, it can cause prices to

118. SEC Concept Release, *supra* note 30, at 3608.

119. *Id.*; *see also* Yoon, *supra* note 100, at 924–25.

120. *See* Gomber et al., *supra* note 45, at 29.

121. SEC Concept Release, *supra* note 30, at 3608.

122. *See id.* ("Some 'directional' strategies may be as straightforward as concluding that a stock price temporarily has moved away from its 'fundamental value' and establishing a position in anticipation that the price will return to such value. These speculative strategies often may contribute to the quality of price discovery in a stock.").

123. *See* Gomber et al., *supra* note 45, at 30 ("Momentum based trading strategies are not new and have been implemented by traditional traders for a long time.").

124. Diego Leis, *High Frequency Trading: Market Manipulation and Systemic Risks from an EU Perspective* 23 (Feb. 29, 2012), *available at* http://ssrn.com/abstract=2108344.

move.[125] To prevent this, investors typically seek to disguise large trades by breaking them up into a number of smaller trades. Order anticipation strategies seek to identify such large, disguised trades, and trade ahead of them—a practice sometimes known as "front-running"—to take advantage of any resulting price movement.[126] Again, order anticipation long predates HFT,[127] though

125. Prices can move for at least two reasons. First, the fact that a trader is buying or selling a large amount of a given security conveys information about their belief as to the value of that security. To the extent that other market participants think the trader has new information about the security, they may rationally adjust their own beliefs as to the value of the security as a result. This phenomenon is sometimes known as the "information effects" of a trade. Second, a large trade might move prices directly by simply exhausting the available liquidity near the market price. This phenomenon is sometimes known as the "liquidity effects" of a trade. *See* Charles R. Korsmo, *Mismatch: The Misuse of Market Efficiency in Market Manipulation Class Actions*, 52 WM. & MARY L. REV. 1111, 1143–51 (2011) (discussing information effects and liquidity effects).

126. Leis, *supra* note 124, at 24. *See* LARRY HARRIS, TRADING AND EXCHANGES: MARKET MICROSTRUCTURE FOR PRACTITIONERS 245 (2003) ("Order anticipators are speculators who try to profit by trading before other traders trade. They make money when they correctly anticipate how other traders will affect prices or when they can extract option values from the orders that other traders offer to the market."); AUTH. FOR THE FIN. MKTS., HIGH FREQUENCY TRADING: THE APPLICATION OF ADVANCED TRADING TECHNOLOGY IN THE EUROPEAN MARKETPLACE 34 (2010), [hereinafter AFM] *available at* http://www.afm.nl/~/media/files/rapport/2010/hft-report-engels.ashx (defining "order anticipation strategies" as being when "a trader looks for the existence of large (for example) buyers, in the objective of buying before these orders, in order to benefit from their impact."). As suggested by Harris, order anticipators can make money in two basic ways. Most directly, they can

> Buy (sell) ahead of the large orders with the goal of capturing a price movement in the direction of the large trading interest (a price rise for buyers and a price decline for sellers). After a profitable price movement, the [order anticipator] then may attempt to sell to (buy from) the large buyer (seller) or be the counterparty to the large buyer's (seller's) trading.

SEC Concept Release, *supra* note 30, at 3609; *see also* Yoon, *supra* note 100, at 913–14 (describing an order anticipation strategy of this type).

Somewhat more subtly, the order anticipator can profit from an implied option created by the large trader. If, for example, the large trader is attempting to buy shares at $10, the order anticipator can swoop in and buy as many shares as possible at $10.01. If the price goes up, the order anticipator profits. If the price does not go up, the order anticipator can simply turn around and sell to the large trader at $10, thus capping their losses at a penny per share. *See* SEC Concept Release, *supra* note 30, at 3609 ("In addition, the [order anticipator] may view the trading interest of the large buyer (seller) as a free option to trade against if the price moves contrary to the [order anticipator's] position."); *see also* Gomber et al., *supra* note 45, at 29 ("Using this strategy, a trader who has detected a large order within the order book places his own order ahead of the large order. If he has detected for example a large buy order, he places his own buy order at a slightly higher limit. Should prices now move upwards, he profits from the rise. However, should prices fall, the large order resting in the book serves as an option/hedge against which the trader can sell his own shares, thereby limiting his possible losses as long as the large limit order rests within the book.").

127. *See* SEC Concept Release, *supra* note 30, at 3609 ("Order anticipation is a [sic] not a new strategy."). The classic form of order anticipation is when a broker-dealer uses its

HFTs bring sophisticated new tools to the table. HFTs can "ping" or "snipe" trading venues[128] with small, rapid orders, and employ "sophisticated pattern recognition software" to sniff out hidden orders and attempt to trade ahead of them.[129]

The second type of directional strategy that is potentially troubling is a "momentum ignition" strategy.[130] Such a strategy seeks to "spoof" other traders—and perhaps most particularly, other HFTs seeking to exercise order anticipation strategies—into believing that large trading interest is present in the market.[131] If prices react to this phantom demand, HFTs can profit by trading into the reaction. Momentum ignition, again, closely resembles classic forms of market manipulation though HFT technology has allowed new levels of sophistication. A sophisticated manipulator will attempt to identify and reverse-engineer trading algorithms used by other traders, and then design his own algorithm so as to trick them by rapidly placing and cancelling orders to give the illusion of large buying or selling demand.[132] This type of manipulation has long been illegal, but the difficulty of discerning between

---

own capital to trade ahead of its customers' orders. Such misappropriation of order information is already clearly illegal and actively prosecuted. *Id.*

128. Gomber et al., *supra* note 45, at 28–29 (internal quotation marks omitted); Leis, *supra* note 124, at 23–24.

129. SEC Concept Release, *supra* note 30, at 3609; *see* Leis, *supra* note 124, at 23–24.

130. Leis, *supra* note 124, at 24.

131. *See* SEC Concept Release, *supra* note 30, at 3609 (internal quotation marks omitted); Leis, *supra* note 124, at 24.

132. *See* SEC Concept Release, *supra* note 30, at 3609. The SEC describes the process thus:

> For example, the trader may intend that the rapid submission and cancellation of many orders, along with the execution of some trades, will 'spoof' the algorithms of other traders into action and cause them to buy (sell) more aggressively. . . . By establishing a position earl[y], the [HFT] will attempt to profit by subsequently liquidating the position if successful in igniting a price movement.

Id. AFM defines "spoofing" and the related concept of "layering" as follows:

> "*Spoofing*: introducing an order (for example a buy order) to the order book, which is not meant to be executed, whose size and ranking in the order book results in a change in the spread to another (in this example: higher) level.
> *Layering*: a form of spoofing in which a trader on one side of the order book (for example the buy side) inserts a large quantity of orders with *different* price limits. This is designed to create the impression of increasing pressure on one side of the order book. The actual intention of this trader however is to trade opposite transactions to the orders originally inserted (in this example: to sell). The buy orders in question are then cancelled before they are executed."

AFM, *supra* note 126, at 34.

manipulative and legitimate patterns of trading—perhaps made even more challenging in a world of HFT—makes it hard to estimate the prevalence of illegal momentum ignition strategies.[133]

While other uses of HFT are possible, the four categories introduced above represent the dominant strategies, and most forms of HFT activity can be categorized under one or more of these headings.

II. THE BENEFITS OF HIGH-FREQUENCY TRADING

With so much of the focus on the *dangers* of HFT, it is easy to lose sight of the *benefits*, which are potentially substantial. Some of these benefits are relatively clear-cut and uncontroversial (even if they are often overlooked). For other seeming benefits, though, disagreement exists as to whether they are illusory.

On the one hand, it is clear that the emergence of HFT has resulted in dramatically reduced spreads and faster execution times, at least under ordinary conditions. The average time required to execute a trade on the major exchanges, which was once measured in minutes and was still measured in seconds as little as a decade ago, has fallen to a tiny fraction of a second.[134] As a result, investors are now able to execute trades almost instantaneously, without fear that prices or other information will grow stale before their orders go through.

At the same time, bid-ask spreads have narrowed considerably. Bid-ask spreads represent the cost of liquidity—the price an investor pays to have a market maker stand ready to trade with them at any time.[135] In the not so distant past, bid-ask spreads represented a significant cost for traders in all but the most heavily traded securities.[136] HFTs have brought intense competition

133. *See* SEC Concept Release, *supra* note 30, at 3609–10.

134. *See* TECHNICAL COMM. OF THE INT'L ORD. OF SEC. COMM'NS, REGULATORY ISSUES RAISED BY THE IMPACT OF TECHNOLOGICAL CHANGES ON MARKET INTEGRITY AND EFFICIENCY 26 (2011) ("Execution speed has fallen from seconds to as little as microseconds within ten years. Some measures of liquidity have improved with implicit trading costs (like quoted bid-ask spreads) and explicit costs (e.g., trading fees) declining.") [hereinafter IOSCO REPORT]; *see also* Jason Zweig, *Staying Calm in a World of Dark Pools, Dark Doings*, WALL ST. J., Oct. 24, 2009, at B1.

135. Leis, *supra* note 124, at 26.

136. *See, e.g.*, *Minimum Resting Time in Europe is "Going to be Awful," Warn Market Users*, MARKETS MEDIA (Oct. 17, 2012), http://marketsmedia.com/minimum-resting-time-

and superior technology to market making, reducing such costs dramatically.[137] HFTs ability to readjust orders at a very high speed in reaction to changing market conditions is one of the primary drivers of the narrowing of spreads in the past decade. By increasing the speed at which market makers are able to react, HFTs are able to reduce the risk of being wrong-footed by changing conditions, and thus need smaller spreads to compensate for such risk.[138] The effect has been large. In a 2009 interview, for example, Joe Gawronski of Rosenblatt Securities noted that "[f]ifteen years ago, some spreads between buying and selling prices could be at least a quarter; today, it often is a penny."[139] Similarly, high trading volume and intense competition have helped cause other trading costs to drop precipitously. By way of example, online brokerage fees from popular broker Charles Schwab were at least 2% in the late 1990s, prior to HFT becoming widespread.[140] In more recent years, such brokerage fees have totaled, at most, 0.3%.[141]

Long-term investors benefit from a lower cost of trading as a result of these developments. As such, HFT is often "render[ing] you a service as a buy-and-hold investor: On the very rare occasions when you do need to trade, you will be able to do so more efficiently than ever before."[142] These reduced costs benefit the broader economy as well. With lower trading costs, investors will demand less of a premium as compensation, and thus pay more for the same financial returns. The net result is a lowered cost of raising capital through the public markets.

---

in-europe-is-going-to-be-awful-warn-market-users/.

137. IOSCO REPORT, *supra* note 134, at 14.

138. *Id.* Owain Self, head of algorithmic trading at the investment bank UBS, explained the effect of this greater speed in the context of a proposal by European regulators to limit the speed at which HFTs can update their market quotes. He noted that

> if you're trading an ETF . . . where the underlying price of the constituents could change thousands of times a second and you are only allowed to update your quotes twice a second, you are going to have to have a wider spread to allow for that volatility on the underlying price. So spreads are bound to widen.

Minimum Resting Time, *supra* note 136.

139. Zweig, *supra* note 134.

140. *Id.*

141. *Id.*

142. *Id.*

III. FAMILIAR RISKS THAT ARE NOT UNIQUE TO HIGH-FREQUENCY TRADING

Balanced against these benefits are a large number of potential risks. The most important of these risks—and the one that is both serious and peculiar to HFT—is the risk of liquidity crunches leading to extreme volatility events like the Flash Crash, as described in Part IV. But before turning to the risk of volatility spikes, Part III reviews six other risks associated with HFT: (1) market manipulation by HFTs; (2) "parasitic" trading by HFTs; (3) unfairness to less technologically sophisticated investors; (4) negligently designed rogue algorithms; (5) reducing allocative efficiency by driving prices away from fundamental values; and (6) overburdening of market infrastructure.

These risks have two unifying themes. First, each of these risks has been singled out by proponents of new regulations for HFTs. Second, with the possible exception of the last risk, none of them are unique to HFT. Virtually all arose before HFT existed, and still exist as a result of non-HFT market activity. Because these risks are already familiar, they are already governed—at least to some extent—by existing regulatory regimes. While HFT might justify an increase in the scale of regulation aimed at these risks, or in the technique and intensity of enforcement, it is unlikely to require new HFT-specific regulatory regimes. Likewise, while the risk of overburdening of market infrastructure may be particular to HFT, it is a risk that is highly amenable to solution by private actors without the need for new public regulation.

A. *Market Manipulation*

As noted in Part I, one type of directional HFT strategy—momentum ignition—is simply a technologically augmented version of one of the classic forms of market manipulation. The concept of market manipulation has a long and checkered intellectual history.[143] Market manipulation was banned in 1934, and prevention of manipulation has been said to be at "the very heart" of the securities acts.[144] Nonetheless, the securities acts do not de-

143. *See* Daniel R. Fischel & David J. Ross, *Should the Law Prohibit "Manipulation" in Financial Markets?*, 105 HARV. L. REV. 503, 503–06 (1991); Korsmo, *supra* note 125, at 1135–43.

144. LOUIS LOSS, FUNDAMENTALS OF SECURITIES REGULATION 853 (2d ed. 1988) (quot-

fine "manipulation" beyond banning wash sales and matched orders,[145] "and courts have struggled to find a meaningful definition."[146] The term "manipulation" has also failed to acquire an agreed-upon meaning in the academic literature. In a well-known article, Daniel Fischel and David Ross spelled out the deficiencies in some of the most common definitions of "manipulation,"[147]

---

ing STAFF OF H. COMM. ON THE INTERSTATE & FOREIGN COMMERCE, 77th CONG., REP. OF THE SECURITIES AND EXCHANGE COMMISSION ON PROPOSALS FOR AMENDMENTS TO THE SECURITIES ACT OF 1933 AND THE SECURITIES EXCHANGE ACT OF 1934, at 50 (1941)) (internal quotation marks omitted). Section 2 of the 1934 Securities Exchange Act ("1934 Act") declares that "[n]ational emergencies . . . which burden interstate commerce and adversely affect the general welfare, are precipitated, intensified, and prolonged by manipulation and sudden and unreasonable fluctuations of security prices. . . ." 15 U.S.C. § 78b(4) (2012). In the wake of the market crash that marked the beginning of the Great Depression, popular imagination assigned a great deal of blame to so-called "stock pools"—insiders, bankers, and speculators who supposedly combined to manipulate the stock market. *See* Paul G. Mahoney, *The Stock Pools and the Securities Exchange Act*, 51 J. FIN. ECON. 343, 344 (1999) ("The purpose of the pools, the Senate[] concluded, was to manipulate the price of the chosen stock upward through the pool's purchases, then to sell the overpriced stock prior to the inevitable price decline.").

145. Wash sales are economically fictitious transactions in which there is no change in actual, beneficial ownership, while matched orders are offsetting purchases and sales entered into by a single party or members of a cooperating group of traders. Seth S. Gomm, *See No Evil, Speak No Evil*: Stoneridge Investment Partners, LLC v. Scientific-Atlanta, Inc. *and the Supreme Court's Attempt to Determine the Issue of Scheme Liability*, 61 ARK. L. REV. 453, 456 (2009).

146. Korsmo, *supra* note 125, at 1135; *see also* Fischel & Ross, *supra* note 143, at 506 (noting that "even though both have the prevention of manipulation as a primary goal," neither the Securities Exchange Act nor the Commodity Exchange Act provide a definition of "market manipulation"); LOSS, *supra* note 144, at 860 n.75 ("[T]he word 'manipulative' as used in §§ 10(b) and 15(c)(1) has never had any precise meaning . . . .").

147. Fischel & Ross, *supra* note 143, at 506. Specifically, Fischel and Ross reject attempts to define manipulation as conduct "designed to do one of three things: (1) interfere with the free play of supply and demand; (2) induce people to trade; or (3) force a security's price to an artificial level." *Id.* at 507. They reject the first formulation because the term "interfere" is "circular absent a definition of manipulation." *Id.* All trades and traders are a part of the "play of supply and demand." *Id.* A large investor who places a large order in the honest belief that the stock is a good investment will alter the supply and demand in the same fashion as one who places a large order for manipulative purposes. In attempting to define manipulation, the entire problem is to distinguish between demand that is in some sense "legitimate" and demand that is somehow "illegitimate." Without some definition of manipulation "that distinguishes between legitimate and illegitimate demand, the concept of interference with supply and demand does not advance the inquiry." *Id.*

Although acknowledging that "inducement of trading . . . is sometimes said to be the essence of manipulation," Fischel and Ross reject this second formulation as "hopelessly overbroad." *Id.* (quoting Steve Thel, *Regulation of Manipulation Under Section 10(b): Securities Prices and the Text of the Securities Exchange Act of 1934*, 1988 COLUM. BUS. L. REV. 359, 410 (1988)). At one extreme, of course, every bid or offer is intended to induce someone to trade—the counterparty to the trade. *Id.* at 507–08. Clearly this cannot be what is meant. There are also many perfectly legitimate situations in which firms or individuals may act to induce trades by people other than counterparties. Most obviously, any time a firm discloses new information about the "value or riskiness" of the firm's securi-

before settling on the following definition:

> (1) [T]he trading is intended to move prices in a certain direction; (2) the trader has no belief that the prices would move in this direction but for the trade; and (3) the resulting profit comes solely from the trader's ability to move prices and not from his possession of valuable information.[148]

To cover the HFT world, we need only expand this definition slightly to allow the possibility of strategies where it is the placement of a large number of orders that is intended to move prices, rather than any actual trading. With this minor addition, the definition is quite workable for our purposes. Without being overly broad, it aptly identifies trading strategies that are made profitable primarily as a result of effectively tricking other investors, and without providing any obvious benefits in terms of liquidity or price-discovery. It also focuses on the type of "trade-based" manipulation most likely to be characteristic of HFT—that is, manipulation that works by engaging in trading activity that,

---

ties, it is "likely [to] lead to increases in the volume of trading and thus can be said to have 'induced' trading." *Id.* at 508.

The third formulation—forcing security prices to an artificial level—"has intuitive appeal because creation of artificial prices, unlike trading, is socially undesirable." *Id*. The problem with this formulation as an attempt to craft an "objective" definition of manipulative conduct—not depending on the intent of the trader—is the inability to determine whether a price level is "artificial." *Id*. What is to distinguish between a manipulator and an investor who trades in the genuine belief that prices will move in a given direction, but who proves to be mistaken, with prices ultimately moving in the other direction? *Id*. at 509. "Trading based on a genuine belief that prices will ultimately move in the direction of the trades is the essence of nonmanipulative trading," but the third proposed formulation provides nothing to distinguish it from manipulation. *Id.*

More subtly, "[d]efining manipulation by reference to whether the trades move prices closer to their correct level" could threaten "property rights in information." *Id.* "[T]rades, as well as disclosures, can reveal information." *Id.* As noted previously, trades can signal the presence of new or superior information. Ronald J. Gilson & Reinier H. Kraakman, *The Mechanisms of Market Efficiency*, 70 VA. L. REV. 549, 572–79 (1984). If trades were perfectly informative, however, it would destroy the ability of investors to profit from generating new information, imperiling the very mechanisms on which market efficiency depends. *See id.* at 577; Sanford Grossman, *On the Efficiency of Competitive Stock Markets Where Trades Have Diverse Information*, 31 J. FIN. 573, 585 (1976) ("The price system can be maintained only when it is noisy enough so that traders who collect information can hide that information from other traders."). In order to preserve incentives for investors to acquire information in the first place—and thus fulfill the information-generating function of markets—"[t]raders must be allowed to disguise their trades to avoid disclosing the information they possess to other traders." Fischel & Ross, *supra* note 143, at 509–10. A definition of market manipulation built around forcing prices to an "artificial" level would threaten the ability of traders to disguise their trades. *Id*. at 510.

148. Fischel & Ross, *supra* note 143, at 510.

while perhaps conveying a false impression to other market players, does not involve making any actual false statements.[149]

It is useful to consider a few examples of trade-based manipulation. The so-called "Norwegian Robot Case" is illustrative of the types of strategies HFTs might use. Beginning in 2007, two Norwegian day traders managed to reverse-engineer an algorithm being used by Timber Hill Europe AG ("Timber Hill") to provide market making services for a number of securities.[150] They found that the algorithm—designed to allow Timber Hill to place limit orders at prices just above and just below the market price—looked at orders being executed, but did not take into account the size of those orders.[151] The day traders were able to take advantage of this ill-designed market making algorithm.[152] Over a period of several months, they repeatedly bought relatively large quantities of small stocks, and then executed a series of small purchases over the course of a minute or two, causing Timber Hill's algorithm to raise its prices.[153] The traders could then dump their larger positions at the elevated prices for a profit.[154]

Another example involves the type of momentum ignition strategy discussed above, and also led to actual sanctions for the

149. *See id*. at 510–11. "Trade-based" manipulations are to be distinguished from more straightforwardly fraud-like forms of manipulation, sometimes known as "action-based" manipulation or "information-based" manipulation. *See* Franklin Allen & Douglas Gale, *Stock-Price Manipulation*, 5 REV. FIN. STUD. 503, 505 (1992); Leis, *supra* note 124, at 31–32. The classic example of an action-based manipulation is where management announces a decision (such as a decision to close a profitable factory) that depresses the stock price, buys up as much of the stock as possible, and then reverses the decision. Allen & Gale, *supra*, at 503–05. Information-based manipulation involves the spreading of false rumors or information in an attempt to move the stock price, such as in a classic "pump-and-dump" scheme. Leis, *supra* note 124, at 32–33. Neither of these types of manipulation—which would perhaps be better analyzed as straightforward frauds—requires HFT technology, or is particularly characteristic of HFT activity.

150. *See* Leis, *supra* note 124, at 46–47.

151. *See id*. at 47; *see also* Chris V. Nicholson, *Oslo Court Sentences Traders for Beating Machine*, N.Y. TIMES DEALBOOK (Oct. 14, 2010), http://dealbook.nytimes.com/2010/10/14/oslo-court-sentences-traders-for-beating-machine/?-r=0.

152. *See* Leis, *supra* note 124, at 47.

153. *See id*.; Martin Sandbu, *How Norwegian Algo Traders Made Their Money*, FIN. TIMES (Oct. 17, 2010), http://www.ft.com/intl/cms/s/0/35d6244c-d9fa-11df-bdd7-00144feabdc0.html.

154. Leis, *supra* note 124, at 47; *see also* Nicholson, *supra* note 151; Sandbu, *supra* note 153. The unusual trading patterns were eventually noticed, and the two traders were ultimately "found guilty of market manipulation in violation of the Norwegian Securities Trading Act." Leis, *supra* note 124, at 47.

perpetrators.[155] While, again, the activity in question was not technically HFT,[156] the case provides a clear example of the types of strategies allegedly employed by HFTs. Trillium Brokerage Services ("Trillium"), a New York-based brokerage firm, together with a number of affiliated traders "engaged in a repeated pattern of layering conduct to take advantage of trading."[157] If, for example, Trillium wanted to buy stock ABC at $9.95, but the best (lowest) available offer was $10.00, Trillium would enter a limit order at $9.95, and then proceed to "layer the book" by entering large sell orders at just above the best available offer—at $10.01, $10.02, and so on.[158] Other traders would see these large sell orders in the book, and—Trillium hoped—interpret them as representing large, genuine selling interest.[159] As a result, these traders would lower their estimate of the value of the stock, and reduce their bid and offer prices accordingly.[160] Once the prices fell enough to hit Trillium's resting buy order at $9.95, the order would be executed.[161] Within seconds of executing its buy order, Trillium would cancel all of its sell orders, with the net result being that these "non-bona fide" sell orders enabled Trillium to obtain shares more cheaply than they otherwise could.[162]

While neither the Norwegian Robot Case nor the Trillium case technically involved HFT, they are excellent examples of the kind

155. *See* Leis, *supra* note 124, at 48. The firm involved, together with some of the responsible individuals, was ultimately fined more than $2 million by the Financial Industry Regulatory Authority ("FINRA"), a private regulatory organization that oversees the financial industry. Trillium Brokerage Servs., LLC, Letter of Acceptance, Waiver and Consent No. 20070076782-01, at 11–12 (FINRA, Sept. 13, 2010) [hereinafter Letter of Acceptance].

156. Press reports on the matter occasionally referred to the case involving a "high frequency trading firm"—likely keying off of FINRA's press release, which described the case as involving "an illicit high frequency trading strategy." *See* Jean Eagleshaw, *High-Frequency Trades Earn $2.3m Fine*, FIN. TIMES (Sept. 13, 2010), http://www.ft.com/intl/cms/s/0/488b7a66-beab-11df-a755-00144feab49a.html; Janet M. Angstadt, *FINRA Sanctions Trillium Brokerage Services, Director of Trading, Chief Compliance Officer and Nine Traders $2.26 Million for Illicit "Layering" Trading Strategy*, CORPORATE & FIN. WKLY. DIGEST (Sept. 17, 2010), http://www.jdsupra.com/legalnews/finra-sanctions-trillium-brokerage-servi-57752/. It appears, however, that the orders involved—while undoubtedly numerous and rapid by conventional standards—were entered manually, rather than as part of an HFT strategy.

157. Letter of Acceptance, *supra* note 155, at 5.

158. Leis, *supra* note 124, at 48–49.

159. *See id*.

160. *See id*. at 49; Angstadt, *supra* note 156.

161. Letter of Acceptance, *supra* note 155, at 5.

162. *Id*.

of trading in which HFTs are often suspected of engaging: designing their algorithms to sniff out and prey upon vulnerable strategies—often automated strategies—used by other traders.[163] The Norwegian day traders used actual orders to take advantage of a particularly lousy trading algorithm, but the Trillium case shows how more sophisticated HFTs can potentially exploit other traders entirely through the use of orders the HFTs never intend to execute.

These cases demonstrate two additional points. First, that manipulation—even manipulation using techniques similar to those that might be employed by HFTs—is not unique to HFTs. Second, in both of these cases, the perpetrators were identified and punished under existing regulations. These same long-standing regulations could easily be interpreted so as to encompass the types of manipulation HFTs might attempt.

This is not to say that manipulation by HFTs is not potentially problematic. HFT may increase the sheer amount of manipulation taking place. There is some reason to fear that HFTs may be able to solve the classic problem always faced by would-be manipulators—how to get out at a profit before the manipulative effect evaporates. Information effects from trading are "likely to be symmetrical—that is, any change in price caused by manipulative trades is likely to be offset when the manipulative trades are unwound."[164] The sheer speed of HFT could allow them to manipulate and exit the market before other traders are able to react.[165]

163. IOSCO REPORT, *supra* note 134, at 28 ("IOSCO was not presented with clear evidence of the systematic and widespread use of abusive practices by those engaging in HFT. Hence HFT and market manipulation should be kept as two distinct concepts and should not be automatically equated.").

164. *See* Korsmo, *supra* note 125, at 1145; *see also* Fischel & Ross, *supra* note 143, at 519 ("If purchases increase the demand and thus the price, sales will have the opposite effect."). Of course, the manipulator does not need to profit from actually re-selling (or buying) the stock at a manipulated price if she can profit from some contractual right tied to the market price of a security at a particular time. The most straightforward example would be a stock option expiring at the end of a trading day, giving the holder the contractual right to receive a payment tied to the closing price of the stock. HFTs (or other traders) could attempt to flood the market for the underlying stock with last-minute orders in an attempt to drive up the price—and the corresponding payment under the option contract—before the market closes, a practice known as "marking the close." *See* EMILIOS AVGOULEAS, THE MECHANICS AND REGULATION OF MARKET ABUSE: A LEGAL AND ECONOMIC ANALYSIS 131 (2005).

165. *See* IOSCO REPORT, *supra* note 134, at 28 ("[One] concern is whether technological advantage offers HFT firms the possibility of engaging in abusive practices on a larger scale than would have previously been possible.").

Furthermore, the huge order volumes generated by HFT could potentially mask illicit layering activity, making manipulative trading more difficult to detect.[166] As a result, greater investment in detection and enforcement—greatly assisted by the new consolidated audit trail discussed below[167]—may be required.

The danger of new forms of manipulation by HFTs is, however, somewhat limited by the nature of the parties potentially injured by HFT market manipulation. In a true HFT manipulation, only other highly sophisticated traders—most likely other HFTs—would even be able to respond quickly enough to detect the rapidly placed and cancelled orders in time to be fooled by them.[168] These sophisticated traders are likely well-positioned to take steps, such as redesigning their algorithms, to protect themselves against such manipulations.[169] It might be thought that other unknowing investors who just happen to buy or sell the manipulated security during the period of the manipulation could also be harmed. But so long as such trading is unrelated to the manipulation, it will be functionally random—the unknowing investor is as likely to benefit as to suffer from any given manipulation.[170]

B. *Parasitic Trading*

Closely related to manipulation is what I will call "parasitic" trading. By "parasitic" I mean strategies designed purely to prey upon other traders, without providing any obviously compensating benefits in terms of price discovery or liquidity. Many of the harms just considered could also be termed parasitic. Both the Norwegian Robot Case and the Trillium case involved trading schemes seeking to exploit the algorithms used by other traders.

166. *See* Leis, *supra* note 124, at 36 ("HFT use an elevated order-to-trade ratio, which implies the cancellation of most . . . submitted orders at a very high frequency. These orders are supposedly cancelled because of the continuous update of information, especially when used by market-makers. However, they could also be extremely effective in layering the market by simulating inexistent liquidity.").

167. *See infra* Part VI.A.

168. *See supra* Part I.B.

169. *See* Gomber et al., *supra* note 45, at 60 (stating that HFTs are "sophisticated market players").

170. *See* Fischel & Ross, *supra* note 143, at 516. Counterparties to contracts tied to the manipulated securities, such as the holders of options, could also be harmed if the manipulation causes them to suffer under the contract. This risk could also be protected against by using financial contract terms that are not overly sensitive to short-term price fluctuations—something that is already best practices in legal drafting.

Most generally, HFTs may deploy algorithms designed to "sniff[] out" and take advantage of vulnerable algorithms used by other traders (including other HFTs).[171]

The trading strategy most commonly referred to as "parasitic," however, is order-anticipation, or front-running.[172] Order anticipation is not a new phenomenon, and has long been regarded as parasitic in nature.[173] As with market manipulation, though front-running has long existed, HFT may enable somewhat new forms or more widespread use of such strategies. Order anticipation traditionally involved misappropriation or mishandling of order information by brokers.[174] The advent of HFT, however, has opened up the possibility of more sophisticated order-anticipation activity.[175] As described above, a high-frequency trader might place large numbers of small orders designed to "ping" or "snipe" order books, identifying patterns that suggest that another trader is seeking to execute a large purchase (sale), either all at once or disguised by being divided into a number of smaller chunks.[176] Anticipating that the large purchase (sale) will cause the price to rise (fall), the trader can quickly trade in front of the large buyer (seller), and either benefit from the subsequent price move or, at worst, turn around and reverse the trade by trading with the large buyer (seller), thus essentially obtaining a free option.[177]

In addition to the fact that parasitic trading is not novel, an important consideration to keep in mind is that parasites are not necessarily an entirely bad thing. They may have a crucial role to

171. Gomber et al., *supra* note 45, at 28–29 (internal quotation marks omitted).

172. *See supra* notes 124–29 and accompanying text.

173. *See* HARRIS, *supra* note 126, at 251.

174. *See id.* at 246–47 (stating that brokers must be careful with their order information so it is not exploited by front-runners).

175. *See* Leis, *supra* note 124, at 24 ("Up to a few years ago, [order anticipators] traded ahead on orders that were for example unwittingly or unintentionally exposed by brokers. Nowadays algorithms used by HF traders are much more efficient and allow a wide variety of techniques to extract a trading surplus.").

176. *See* SEC Concept Release, *supra* note 30, at 3609 (internal quotation marks omitted) ("The type of order anticipation strategy referred to in this release involves any means to ascertain the existence of a large buyer (seller) that does not involve violation of a duty, misappropriation of information, or other misconduct. Examples include the employment of sophisticated pattern recognition software to ascertain from publicly available information the existence of a large buyer (seller), or the sophisticated use of orders to 'ping' different market centers in an attempt to locate and trade in front of large buyers and sellers.").

177. *Id.*; *see also* Yoon, *supra* note 100, at 916–17 n.17.

play in the market ecosystem, just as they do in the actual ecosystem. In particular, they may drive the evolution of defensive mechanisms that make the market as a whole more robust and resilient against shock or exploitation.[178] A market with no parasitic traders may seem strong and healthy during placid times, but in reality may be catastrophically vulnerable to attack and exploitation should parasites arise.[179] In a market with a population of parasitic traders, market participants are forced to innovate in their own algorithms to avoid exploitation by the algorithms of others, leading to a rough equilibrium, robust against exploitation.[180] Even if imperfect, such a dynamic equilibrium may be preferable to the precarious stability that could arise from lack of parasitic pressure. To take only the most prominent example, the simplistic execution algorithm alleged to have set off the acute phase of the Flash Crash is one that could, and probably should, be punished out of existence by order anticipators.

It is also important to recall that the primary victims of parasitic trading are far from defenseless—they are themselves large, sophisticated traders making large transactions. Front-running, after all, depends on detecting orders large enough to move the market,[181] so we would expect institutional investors (and their customers) to be the parties most directly injured by widespread parasitic trading. Nor are resources spent by these institutional investors to parasite-proof their execution algorithms simply resources wasted. Large fundamental traders always have an incentive to reduce the information content of their trades, such

178. *See* Ilia Dichev et al., *The Dark Side of Trading* 8 (Emory Univ. Law Sch. Pub. Law & Legal Theory Research Paper Series, Paper No. 11-143, 2011), *available at* http://papers.ssrn.com/S013/papers.cfm?abstract_id=1754215.

179. Examples of this phenomenon in biology abound. During the American Civil War, the apparently hale and hearty Midwestern farm-boys of the Union armies—lacking immunity against many childhood diseases common in cities—died in droves when they came into contact with the apparently weak and sickly Northeasterners. *See* JAMES M. MCPHERSON, THIS MIGHTY SCOURGE: PERSPECTIVES ON THE CIVIL WAR 120 (2007) ("Midwestern states in Union armies suffered a disease mortality rate 43 percent higher than those from the more urban states of the Northeast."). An even starker example is the vulnerability of the Native American population to diseases such as smallpox and bubonic plague that had long been endemic in Eurasia. *See* JARED DIAMOND, GUNS, GERMS, AND STEEL: THE FATES OF HUMAN SOCIETIES 77–78 (1997). A colorful example from literature is the vulnerability of the H.G. Wells's Martians to the common cold in his "War of the Worlds." *See* H.G. WELLS, THE WAR OF THE WORLDS 171 (David Y. Hughes ed., 1995).

180. McGowan, *supra* note 38, at ¶¶ 19, 42.

181. *See* Jerry W. Markham, *"Front-Running"—Insider Trading Under the Commodity Exchange Act*, 38 CATH. U. L. REV. 69, 70–71 (1988).

that they can capture more of the benefits of uncovering new information in the first place.

On the flip-side, the so-called parasites are simply using publicly available information—orders in the market—to make trading decisions, and in doing so making sure that information is fully reflected in the market price. As one CEO of a HFT firm has argued, this "is what the market is supposed to do."[182] As such, any regulatory steps to curb order anticipation not involving a violation of some exogenous duty would likely be misguided. They would, in effect, command market participants to trade without reference to one of the most salient pieces of public information regarding a security's value—what other sophisticated market participants think, as evidenced by their trading activity. Regulatory intervention would also arguably protect market participants who are fully capable of protecting themselves, and in so doing encourage the proliferation of poorly designed execution algorithms.[183]

C. *Unfairness*

A somewhat less precise but nonetheless widespread fear is that HFT is simply unfair. At its most basic, this fear is that the small retail investor is not able to compete with the heavy artillery of HFTs, and that even traditional large non-HFT institutional investors are, or soon will be, unable to keep up.[184] Several more specific market practices are often singled out as systematically unfair. I will address three of these practices: flash orders, co-location, and direct data feed access.

182. Richard Gorelick, CEO of RGM Advisors, TABB Group's SEC Roundtable, *available at* http://tabbforum.com/opinions/tbd-3.

183. Gomber et al., *supra* note 45, at 60–61; Matt Prewitt, Note, *High-Frequency Trading: Should Regulators Do More?*, 19 MICH. TELECOMM. & TECH. L. REV. 131, 151 & n.137 (2012).

184. Richard Gorelick, CEO of the prominent HFT firm RGM Advisors, has sarcastically noted that HFT is typically portrayed in the press as "unfair, highly profitable and socially useless." Nina Mehta, *High-Frequency Traders Strike Back*, TRADERS MAG. (Sept. 22, 2009), http://www.tradersmagazine.com/news/hft-firms-strike-back-104398-1.html?pg=1.

Flash orders are a somewhat unusual procedure.[185] Consider the following example. A trader places an order to buy 1,000 shares of a certain stock. The order is routed to an exchange, and the exchange determines that there are no sellers available on the exchange at the best price available nationwide. As explained above, the exchange traditionally has had the option of either routing the order to another exchange or canceling the order.[186] Flash orders, however, provide a third option. With a flash order, instead of immediately re-routing or canceling the order, the exchange "flashes" the order to its customers, making it available for a fraction of a second.[187] Anyone who sees the order and desires to sell to the buyer at the best-quoted price can do so during that split second.[188]

The purpose of this procedure is to allow market participants—the seller in this example—to trade without first placing an order that will be visible in the limit order book.[189] As noted above,

185. *Cf.* Austin J. Sandler, *The Invisible Power of Machines: Revisiting the Proposed Flash Order Ban in the Wake of the Flash Crash*, 2011 DUKE L. & TECH. REV. 003, ¶ 4 ("These trading methods are obscure, the technology behind them is highly-sought after, their details are kept secret, and the implications for the market are uncertain.").

186. *See* Lawrence Harris, *The Economics of Flash Orders*, U.S.C. MARSHALL SCHOOL OF BUSINESS 1 (Dec. 4, 2009), *available at* http://www.sec.gov/comments/s7-21-09/s72109-97.pdf (describing the process of a flash order).

187. *Fact Sheet: Banning Marketable Flash Orders*, U.S. SECS. AND EXCH. COMM'N (Sept. 17, 2004), http://www.sec.gov/news/press/2009/2009-201-factsheet.htm.

188. The SEC has described the mechanics of a flash order as follows:

> An order to buy is "flashed" by the exchange that received the order when the exchange has determined it has no willing seller at the best quoted price. Rather than seeking out a seller in a competing exchange or market, the exchange 'flashes' the order to certain of its participants. By doing this, the exchange is able to seek out willing sellers on its market who may have decided not to publicly display their sell price.
>
> Using high-speed technology, potential sellers that receive the flash can see the buy order and, within a fraction of a second, respond with their own order to execute against the flashed order. The time periods vary in length, but generally are one second or less.
>
> If there is no response to the flashed order, the exchange generally will route orders away to execute against the best-priced quotations on other markets.

Id.

189. The trader whose order is "flashed" may also benefit from getting a liquidity rebate for technically being the liquidity-supplying resting order. *See* SEC Concept Release, *supra* note 30, at 3608. In addition, the exchange itself benefits from being able to fulfill the order itself, rather than having to reroute it to a competitor for execution. *See* Nina Mehta, *Flash Order Debate Moves to Options After Direct Edge Bows Out*, BLOOMBERG (Mar. 1, 2011) [hereinafter Mehta, *Flash Order*], http://www.bloomberg.com/news/print/2011-03-01/flash-order-debate-moves-to-options-after-direct-edge-bows-out.html ("Flashing allows venues to match orders by soliciting trading responses from users instead of

merely placing an order can cause the price to move against a large trader.[190] Front-running is, in part, designed to exploit this tendency. Flash trading helps to alleviate this problem. The seller is able to participate in the market without first revealing her selling interest to the world.[191]

Whatever their advantages, flash orders also contribute to at least an appearance of unfairness. The basic problem is easy to see. In order to take advantage of a flash order, one needs to be able to observe, evaluate, and respond to the flash order in the fraction of a second it is in existence.[192] Doing so requires the expensive technology utilized by HFTs—a small investor sitting at home with a laptop and an E-Trade account will not take advantage of any flash orders.[193] The SEC, in proposing a never-implemented ban on flash trading, suggested that flash orders "could lead to a two-tiered market in which the public does not have access, through the consolidated quotation data streams, to information about the best available prices for U.S.-listed securities that is available to some market participants through proprietary data feeds."[194] At root, this concern simply boils down to a

sending buy or sell requests that they can't fill to rivals quoting better prices.").

190. Yoon gives a simplified example involving a wine expert who desires to keep her trading interest in a certain wine secret, because revealing her buying interest would cause other market participants to revise their estimates of the wine's value, causing the market price to rise even before she is able to buy the wine. Flash orders would potentially enable her to make a purchase without first revealing her trading interest. Yoon, *supra* note 100, at 930–31. Comparably, the mere fact that Warren Buffett is interested in buying stock in a particular company can cause the company's stock to go up significantly, raising the price he himself would have to pay if he is unable to buy before his interest is discovered.

191. At the same time, flash orders also create a new opportunity for front-running on the flashed order. The buyer in our example got the best-quoted price available nationally, as required. At least potentially, however, HFTs could spot the flash order and trade in front of it before the flash order expires and is rerouted to another exchange. Thus, flash orders could conceivably contribute to the parasitic trading discussed earlier. *See supra* Part III.B. While concluding that the risk is overblown, a December 2009 article noted that "several commentators and pundits have complained bitterly that flashes expose information that may allow traders to 'front-run' orders." Michelle Price, *So Who is Afraid of the Flash Trade?*, THE BANKER (Dec. 1, 2009), http://www.thebanker.com/tech-trading/trading/trading-so-who-is-afraid-of-the-flash-trade?ct=true; *see also* Cristina McEachern Gibbs, *Laying Down the Law*, WALL ST. & TECH., Nov. 1, 2009, at 20 (stating that flashing an order "gives the recipient the ability to front-run the customer whose order has been flashed").

192. *Fact Sheet: Banning Marketable Flash Orders*, *supra* note 187.

193. *Id.*

194. Elimination of Flash Order Exception from Rule 602 of Regulation NMS, Exchange Act Release No. 34,60684, 74 Fed. Reg. 48,632, 48,633 (Sept. 23, 2009). Direct

question of whether it is "fair" to effectively give first crack at an order to those with the resources and sophistication to obtain and utilize the necessary technology.[195]

A second HFT-related market practice that has come under fire as "unfair" is co-location. In seeking to reduce latency, HFTs will often seek to place their computers as physically close to an exchange's data center as possible.[196] Doing so minimizes the distance data needs to travel between computers, and thus—due to the finite speed of electronic signals—the communications delay.[197] Many trading centers rent "rack space" on-site, so that HFTs and other proprietary traders can locate their computers at the exchange, right next to the exchange's own servers.[198] Exchanges must receive SEC approval for offering co-location services,[199] and the SEC requires that "terms of co-location services

Edge, an exchange that was a leader in flash trading, has vigorously disputed this characterization, arguing that flash orders actually democratize access to liquidity that is not publicly displayed. Letter from Eric W. Hess. Gen. Counsel, Direct Edge, LLC, to Elizabeth Murphy, Sec'y, U.S. Sec. and Exch. Comm'n (Nov. 20, 2009), *available at* http://www.sec.gov/comments/s7-21-09/s72109-82.pdf ("[W]e do not view technology that instantaneously aggregates passive and aggressive liquidity as creating a two-tier market. Rather, flash technology democratizes access to the non-displayed market and in this regard, *removes* different 'tiers' in market access.").

195. Flash orders could also potentially have liquidity and efficiency effects. In short, flash orders allow traders to avoid having to place publicly visible orders in the limit order book, potentially reducing liquidity and the public availability of full supply and demand information. *See infra* notes 217–23, 264–65 and accompanying text.

196. Gomber et al., *supra* note 45, at 10 n.9 (stating that market participants use co-location services "for the purpose of locating their network and computing hardware closer to the matching engines" in order to control latency issues).

197. *See* Charles M. Jones, *What Do We Know About High-Frequency Trading*? 10 (Columbia Business School, Research Paper), *available at* http://online.wsj.com/public/resources/documents/HFT0324.pdf. At the speed of light, each additional foot of wire down which an electronic signal must travel increases the delay by approximately 1 nanosecond (one billionth of a second). While this might not sound like much, HFTs whose computers are even one Manhattan crosstown block further away from the exchange than their rivals will suffer a speed disadvantage of at least 2 microseconds (~1000 feet each way).

198. *See* SEC Concept Release, *supra* note 30, at 3598 ("To further reduce latency in transmitting market data and order messages, many exchanges also offer co-location services that enable exchange customers to place their servers in close proximity to the exchange's matching engine."); *see also* Gomber et al., *supra* note 45, at 10 ("In order to reduce latency, automated traders make use of co-location or proximity services that are provided by a multitude of market operators. By co-locating their servers, market participants can place their trading machines directly adjacent to the market operator's infrastructure.").

199. SEC Concept Release, *supra* note 30, at 3610 (citing 15 U.S.C. § 78c(a)(27) (2012)) ("Exchanges that intend to offer co-location services must file proposed rule changes and receive approval of such rule changes in advance of offering the services to customers."). The NASDAQ received SEC approval for co-location in 2009. *See* Vince Veneziani, *SEC*

must not be unfairly discriminatory, and the fees must be equitably allocated and reasonable."[200]

Like any kind of preferential access, co-location services can be seen as inherently unfair. Co-location raises the possibility of special treatment for preferred customers, but even where it is offered in a facially non-discriminatory fashion, co-location will naturally favor those with the resources and sophistication to take advantage of it.[201]

A third, related fairness concern is the availability of direct data feeds from exchanges. Many exchanges offer customers the ability to receive data feeds directly from the exchange at the same time the data is provided to the consolidated quotation system.[202] Under the applicable regulations, exchanges can transmit data to their customers at the same time they transmit the data to the consolidated system.[203] To the extent these customers can process the data more quickly than the time it takes for the data to be routed through the consolidated quotation system, they can gain a crucial speed advantage.[204]

Gives Kiss of Approval to NASDAQ Co-Location, BUS. INSIDER (Oct. 23, 2009), http://www.businessinsider.com/nasdaq-co-location-business-to-be-regulated-by-the-sec-2009-10.

200. SEC Concept Release, *supra* note 30, at 3610 (citing 15 U.S.C. §§ 78f(b)(4), (5) (2012)).

201. *Id*.

202. *See id*. at 3601 ("In addition to providing quotation and trade information . . . for distribution in consolidated data, many exchanges and ECNs offer individual data feeds directly to customers that include information that is provided in consolidated data."); SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 36 ("Most of the firms we interviewed are concerned with data latency in the milliseconds (such as market makers, internalizers, and HFTs) subscribe directly to the proprietary feeds offered by the exchanges.").

203. *See* SEC Concept Release, *supra* note 30, at 3611 (citing Regulation NMS Release, *supra* note 48, at 37,567) ("When it adopted Regulation NMS in 2005, the Commission did not require exchanges . . . to delay their individual data feeds to synchronize with the distribution of consolidated data, but prohibited them from independently transmitting their own data any sooner than they transmitted the data to the plan processors.").

204. *Id.* at 3611 ("Given the extra step required . . . to transmit market data to plan processors, and for plan processors to consolidate the information and distribute it [to] the public, the information in the individual data feeds . . . generally reaches market participants faster than the same information in the consolidated data feeds."); Yoon, *supra* note 100, at 925 n.74 (noting that it takes approximately five to ten milliseconds for the consolidated quotation system to process and distribute information from the exchanges, and noting that "with the help of their super-fast computers and close location to the plan processors, high-frequency traders can receive the information in their individual data feeds provided by exchanges and ATSs before the rest of the market.").

As with co-location services, the SEC requires exchanges "that offer individual data feeds to make the data available on terms that are fair and reasonable and not unreasonably discriminatory."[205] The practice is nonetheless arguably unfair to retail investors. Again, only market participants with the wealth and sophistication required to pay for, receive, and process the data feeds in real time will be able to take advantage of such feeds. These traders—HFTs in particular—can gain still more of a speed advantage, receiving information, in a practical manner, before that information is available to the public. During the critical period of the Flash Crash, this problem became especially acute. Due to the flood of trading activity, average delays for NYSE stocks on the consolidated quotation system stretched to more than ten seconds, while proprietary data feeds containing the same information maintained delays of only eight milliseconds (0.008 seconds).[206] To the extent this speed advantage is also accompanied by disparities in the information provided—with the direct data feeds including additional information—the potential unfairness is even greater.[207]

The necessarily imprecise notion of unfairness makes it somewhat difficult to say who might be "injured" by these practices. The principal worry is that they will, over time, result in a transfer of resources away from long-term and retail investors to short-term and technologically sophisticated investors, without any compensating benefit to such investors or to market efficiency in general.[208] To the extent that these transfers result in long-term retail investors avoiding the equity markets, more systemically negative consequences are possible.

In some sense, however, the broadest fears that the sheer speed or sophistication of HFTs, in and of themselves, renders HFT uniquely "unfair" are misguided, if not entirely unfounded. In many ways, HFTs operate on a playing field that is, if any-

205. SEC Concept Release, *supra* note 30, at 3601; *see also* Regulation NMS Release, *supra* note 48, at 37,567.

206. SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 77.

207. SEC Concept Release, *supra* note 30, at 3611 ("[T]he consolidated data feeds include the best-priced quotations of all exchanges and certain ATSs and all reported trades. The individual data feeds of exchanges . . . generally will include their own best-priced quotations and trades, as well as other information, such as inferior-priced orders included in their depth-of-book.").

208. *See id*. at 3605.

thing, far more level than what previously existed. There have always been market participants with speed or other advantages. Traditionally, market "specialists" with special trading floor privileges would have physical speed and proximity advantages over ordinary traders.[209] Unlike specialists, HFTs are not granted any "special time and place privileges in exchange trading (nor are they subject to the affirmative and negative trading obligations that have accompanied such privileges)."[210] Arguably, the open access to co-location, data feeds, and flash orders to anyone willing and able to pay for them is far more "democratic" than what came before.[211]

Of course, "it could be worse . . . and was" is not necessarily a winning argument. But it is worth noting the essential strangeness of the argument that trading capabilities available to the well-financed and technically capable are somehow intrinsically unfair. It is not entirely unlike complaining that Boeing and Lockheed-Martin have an "unfair" advantage vis-à-vis a garage-workshop tinkerer in bidding on aircraft contracts.[212] Furthermore, retail investors who invest via large funds, or even trade through a major broker, can often piggyback on the sophistication of these larger entities. As the CFTC-SEC Initial Report emphasized, "[i]t is important to note that retail order flow is generally handled by [broker-dealers] who are also among those participants that use proprietary exchange feeds to make trading and routing decisions."[213]

It also bears repeating that total profits from HFT are likely in the single-digit billions, and apparently falling as markets adapt.[214] While these profits are large in everyday terms, they pale in comparison to the profits of even a single large investment

209. *See* Yoon, *supra* note 100, at 926–27.

210. SEC Concept Release, *supra* note 30, at 3607.

211. *See* Gibbs, *supra* note 191 (noting that "[a]nyone who wants to invest the resources can compete").

212. As Yoon puts it:

> This notion of the free market applies to other industries. For example, in the computer chip industry, a computer chip manufacturing company can invest a massive amount of capital in research and development, while ordinary people are also free to start their own research as long as they can obtain funding.

Yoon, *supra* note 100, at 937.

213. SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 77.

214. *See* Popper, *supra* note 97.

bank, and cannot plausibly be said to represent an enormous or unprecedented transfer of wealth from the weak and slow to the strong and fast.[215]

Finally, as will be discussed further in Part V, the specific "unfair" practices mentioned here are all amenable to regulation by the exchanges themselves. If non-HFTs find it disadvantageous to trade on exchanges offering flash orders, co-location, and direct data feeds, competitive pressure should force exchanges to curtail these practices. Indeed, a regulatory ban on flash orders would, at this point, be largely redundant, as trading venues have been backing away from them ever since they began to attract negative publicity.[216]

D. *Negligent or "Rogue" Algorithms*

The dangers surveyed thus far have primarily been intentional, in that they are the result of deliberately undertaken trading strategies, whether those strategies should be considered legitimate or not. Similar dangers, however, can arise from inadvertence on the part of HFTs and other algorithmic traders. In particular, poorly designed or buggy "rogue" algorithms can cause, and often have caused, extreme dislocations in security prices.

The Flash Crash itself is perhaps the most dramatic example of the chaos a poorly designed algorithm can cause, even if the faulty algorithm in question was not being used by HFTs. Though the conclusion remains controversial,[217] the joint CFTC-SEC report on the Flash Crash identifies a single large, algorithmically executed trade as providing the catalyst for the crisis portion of the Flash Crash.[218] A large long-term trader decided to sell ap-

215. *See supra* Part I.B.

216. *See* Mehta, *Flash Order*, *supra* note 189.

217. *See, e.g.*, Hu, *supra* note 18, at 1704 ("Outsiders reject this CFTC-SEC narrative."); Easley et al., *supra* note 26, at 122–24, (arguing that order "toxicity," in the sense of the probability that market makers were being taken advantage of by informed traders, reached historic highs just before the crash, causing market makers to withdraw liquidity and flee the market); Ananth Madhavan, *Exchange-Traded Funds, Market Structure and the Flash Crash* 20 (Jan. 13, 2012), *available at* http://ssrn.com/abstract=1932925; Press Release, CME Group, CME Group Statement on the Joint CFTC-SEC Report Regarding the Events of May 6 (Oct. 1, 2010), *available at* http://investor.cmegroup.com/investor-relations/releasedetail.cfm?ReleaseID=513388 (arguing CME Group Markets "functioned property" and "operated as designed").

218. *See* SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 2.

proximately $4.1 billion in E-Mini S&P 500 ("E-Mini") futures contracts[219] using an algorithm designed to break up the trade into many smaller trades, in part to disguise the large change in position, and in part to avoid simply swamping available liquidity in the market.[220]

The algorithm was designed to target a rate of execution equal to 9% of the total E-Mini trading volume over the previous minute, but—disastrously—did not take price or total time into account.[221] Volume is a traditional proxy for liquidity, and "volume-targeting" is a time-honored method of executing large orders, but times have changed.[222] In a world of HFT, volume is not always a particularly good proxy for liquidity.[223] Especially under highly volatile market conditions—such as those that prevailed on the day of the Flash Crash—HFTs may engage in very large numbers of quick trades in an attempt to capture price movements. This large volume can mask the fact that this apparent liquidity is actually very shallow, as the HFTs typically have no appetite for accumulating any significant position.

In any event, under the volatile conditions of the early afternoon of May 6, 2010, the $4.1 billion sale, targeted at 9% of volume, was executed in only twenty minutes.[224] In the face of this selling, liquidity quickly dried up, driving the price of the E-Mini down by 3% in approximately four minutes, and setting off a chain of liquidity crises as traders sought to arbitrage this sudden price differential between the E-Mini and the S&P 500 itself.[225]

219. The holder of an E-Mini contract is entitled to a payment of 50 times the value of the S&P 500 index at the time the contract expires. The E-Mini is one of the most widely traded stock market index futures contract, allowing both speculation and hedging of other positions. *See Equity Index Products: E-Mini: S&P 500 Futures*, CME GROUP, http://www.cmegroup.com/trading/equity-index/us-index/e-mini-sandp500_contract_specifications.html (last visited Dec. 6, 2013).

220. *See* SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 1–2.

221. *Id.* at 2.

222. *See, e.g.*, X. Frank Zhang, *High-Frequency Trading, Stock Volatility, and Price Discovery* 8 (2010), *available at* http://ssrn.com/abstract=1691679.

223. *See id.* ("[A]s illustrated in the flash crash on May 6th, 2010, high trading volume generated by HFT is not necessarily a reliable indicator of market liquidity, especially in times of significant volatility. The automated execution of large orders by fundamental investors, which typically use trading volume as the proxy for liquidity, could trigger excessive price movement, especially if the automated program does not take prices into account."); *see also* Sornette & Von der Becke, *supra* note 43, at 4 ("[L]iquidity is not equal to volume. HFT arguably increases the volume of transactions.").

224. *See* SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 2.

225. *Id.* at 3–4.

Thus, if you believe the CFTC-SEC version of events, the Flash Crash is largely attributable to an outdated algorithm run amok under unusual market circumstances.

Even more stark examples of rogue algorithms exist—though none with such dramatic consequences. On February 3, 2010, just minutes before the close of trading, Infinium Capital Management—a respected Chicago-based HFT boutique—began "live-testing" a new oil-futures trading algorithm.[226] The algorithm immediately began flooding the market with uncontrolled orders, which Infinium's order control systems failed to stop.[227] In a matter of five seconds, the algorithm placed orders equivalent to nearly 4% of average daily volume, before the order router "choked" and crashed.[228] Infinium rapidly unwound the inadvertent trades in the minutes before the market closed, losing more than $1 million in the process.[229] The flood of orders caused the price of oil to spike by 1.3% in a matter of seconds, before mysteriously slumping by about 5% over the next few days.[230] In addition to the million dollar trading loss, Infinium was fined $850,000 by the Chicago Mercantile Exchange Group, which manages the Chicago and New York Mercantile Exchanges, for "acts detrimental" to the market.[231]

Perhaps the most public HFT debacle was the August 1, 2012, near-implosion of Knight Capital Group, a large HFT group engaged in market making that constituted, at its peak, approximately 10% of all volume on the NYSE and NASDAQ.[232] On the

226. *See* Jonathan Spicer, *Firm Faces Civil Charges for Oil Trading Mayhem*, REUTERS, Aug. 25, 2010 [hereinafter Spicer, *Oil Trading Mayhem*], *available at* http://www.reuters.com/article/2010/08/25/us-trading-oil-probe-idustre67o2qq20100825.

227. *See id.*

228. *Id.*; *see also* Sornette & Von der Becke, *supra* note 43, at 13 (internal quotation marks omitted).

229. *See* Spicer, *Oil Trading Mayhem*, *supra* note 226.

230. *Id.*

231. *See CME Fines Infinium $850K for Trading Glitches*, FUTURESMAG (Nov. 29, 2011) (internal quotation marks omitted), http://www.futuresmag.com/2011/11/29/cme-fines-infinium-850k-for-trading-glitches. In addition to the fine levied against Infinium itself, the trader responsible for entering the orders was personally fined $50,000 and issued a temporary ban against trading on the Mercantile Exchanges. *See High-Frequency Oil Trader Fined for Runaway Trades*, REUTERS, Dec. 23, 2011, *available at* http://www.reuters.com/article/2011/12/23/us-cme-infinium-trader-idUSTRE7BM1BF20111223.

232. *See* Stephanie Ruhle et al., *Knight Trading Loss Said to Be Linked to Dormant Software*, BLOOMBERG (Aug. 14, 2012), http://www.bloomberg.com/news/2012-08-14/knight-software.html.

morning of August 1, a new market making algorithm installed overnight went berserk, entering huge numbers of market orders, and causing prices in nearly 150 companies to be disrupted, with some rising by several hundred percent.[233] The broken algorithm caused Knight to lose approximately $440 million—three times its annual earnings—in the first thirty minutes of trading.[234] The NYSE stepped in and cancelled trades in a handful of securities as "clearly erroneous," but left Knight to take the vast bulk of its losses.[235] Within two days, Knight—which is itself a publicly traded company—saw its stock price fall by 75%, and was forced to seek an emergency injection of capital.[236] Despite the injection of funds, Knight was unable to survive as an independent firm, and was ultimately bought by a rival market making firm.[237]

As is clear from the examples above, regulatory processes already exist for identifying and punishing users of rogue algorithms. More broadly, however, there is an inherent tension in trying to prevent harms from negligence, in that the greatest harm tends to fall on the negligent party itself. That is, the consequences of a shoddy or glitchy algorithm are likely to be most dire for the party responsible for the algorithm in the first place.

233. *See* Maureen Farrell, *Knight's Bizarre Trades Rattle Markets*, CNN (Aug. 1, 2012), http://buzz.money.cnn.com/2012/08/01/trading-glitch/?iid=H_MKT_News; Caroline Valetkevitch & Chuck Mikolajczak, *Error by Knight Capital Rips Through Stock Market*, REUTERS, Aug. 1, 2012, *available at* http://www.reuters.com/article/2012/08/01/us-usa-nyse-tradinghalts-idusbre8701bn20120801.

234. *See* Matthew Heusser, *Software Testing Lessons Learned From Knight Capital Fiasco*, CIO (Aug. 14, 2012), http://www.cio.com/article/713628/software_testing_lessons_learned_from_Knight_capital_fiasco.

235. *See* Pallavi Gogoi, *Knight Capital Blames Software For Computer Trading Glitch*, USA TODAY (Aug. 2, 2012), http://usatoday30.usatoday.com/money/economy/trade/story/2012-08-02/Knight-Capital-trading-glitch/56692822/1; Bob Pisani, *The Knight Fiasco: How Did it Lose $440 Million?*, CNBC.COM (Aug. 2, 2012), http://www.cnbc.com/id/48458289.

236. Pallavi Gogoi & Christina Rexrode, *Cost of Glitch for Knight Capital: $440 Million*, ASSOCIATED PRESS WORLDSTREAM (Aug. 5, 2012), http://bigstory.ap.org/article/cost-glitch-knight-capital-440-million.

237. Halah Touryalai, *Knight Capital's Trading Disaster Ends In Merger With Getco, Joyce Named Chairman*, FORBES (Dec. 19, 2012), http://www.forbes.com/sites/halahtouryalai/2012/12/19/knight-capitals-trading-disaster-ends-in-merger-with-getco-joyce-named-chairman/. Other high-profile examples include the March 23, 2012 system problems that caused BATS Global Markets—a stock exchange—to withdraw its own initial public offering ("IPO") on the first day of trading following a glitch that caused its stock to fall from $16 to four cents, and the system problems that plagued the NASDAQ during Facebook's May 18, 2012 IPO. Ben Rooney, *BATS: Well, This is Awkward*, CNN MONEY (Mar. 23, 2012), http://money.cnn.com/2012/03/23/markets/bats-ipo/; *see* Henry T.C. Hu, *Efficient Markets and the Law: A Predictable Past and an Uncertain Future*, 4 ANNUAL REV. FIN. ECON. 1, 19–20 (2012); Hu, *supra* note 18, at 1705–06.

While no figure has been made public, the user of the execution algorithm that allegedly precipitated the Flash Crash undoubtedly lost tens or even hundreds of millions of dollars as a result of the botched execution of the $4 billion sell order. Similarly, it is difficult to see what sanction a regulator could have imposed on Knight for its half-hour adventure in rogue trading that would be more consequential than the instant $400 million loss, which effectively ended Knight's life as an independent firm. While others were undoubtedly hurt in these episodes (and still others undoubtedly benefited), from a deterrence standpoint it is hard to see that the market itself systematically under-deters such negligence. The main goal with regard to negligence-type harms, then, as elaborated below, is simply to ensure that a responsible party is appropriately on the hook when mistakes are made.

E. *Efficiency Harms*

It is sometimes speculated that HFT could reduce allocative efficiency by driving prices away from fundamental values.[238] Perhaps the most basic function of capital markets is to generate accurate prices so that resources can be allocated to their most productive uses.[239] If HFT reduces efficient price discovery and causes departures from accurate pricing, it could result in distortions and inefficiencies throughout the economy.

On the one hand, to the extent that HFT is at least partly responsible for the types of extreme market movements observed in the Flash Crash and the various mini-flash crashes, it is patently obvious that HFT leads to substantial departures from fundamental value. Nothing happened during the Flash Crash that justified believing U.S. equities were fundamentally worth nearly $1 trillion less at 2:45 p.m. than they were at 2:30 p.m. or 3:00 p.m. Nor can the other dramatic spikes and crashes described above be explained by reference to changing expectations for the given firm's prospects.

238. Zhang, *supra* note 222, at 1–2, 11. The notion of "fundamental value" is notoriously sticky. For our purposes, it is not necessary to be too precise, and we can simply take it to mean "prices justified by reference to future expected cash flows." *See* Kenneth Ferris & Barbara Petitt, *Valuation for Mergers and Acquisitions: An Overview*, FIN. TIMES PRESS (Aug. 5, 2013), http://www.ftpress.com/articles/article.aspx?p=2109325.

239. Zhang, *supra* note 222, at 3 n.2 (describing efficiently allocating "scarce capital resources to their most productive use" as "the key objective of the capital market").

More broadly, if HFT has led to greater volatility in stock prices, those prices will, by definition, stray further from fundamental value on average, assuming the real economy itself has not become more volatile. At root, the notion that stock prices will reflect the best estimate of fundamental value depends on the notion that investors are basing trading decisions on material information about the underlying firms' prospects.[240] HFTs, however, generally trade on small-scale price moves, caring little for the individual stock's actual price. With the rise of HFT, "when most trades are based on statistical and often short-lived correlations in stock returns and investors do not hold stocks for the investment purpose (HFT traders typically do not carry any position overnight), the presence of efficient pricing becomes more questionable."[241] The harms stemming from a market with less accurate pricing would be truly systemic, potentially resulting in misallocation of resources throughout the economy.

The actual evidence as to HFT's effect on efficient pricing is still preliminary and mixed. The SEC has noted that HFT's arbitrage activities may help to limit moves away from fundamental value, and "often may contribute to the quality of price discovery in a stock."[242] This notion is supported by several empirical investigations suggesting that HFT has increased the efficiency with which new information is incorporated into securities prices and reduced price discrepancies between related securities.[243] Another study finds that HFT activity causes prices to overreact to news about fundamentals, with prices taking a substantial amount of time to recover from the overreaction.[244]

240. *See* Ray Ball & Philip Brown, *An Empirical Evaluation of Accounting Income Numbers*, 6 J. ACCT. RES. 159, 160, 164–65 (1968); S.P. Kothari, *Capital Markets Research in Accounting*, 31 J. ACCT. & ECON. 105, 108–09 (2001); Charles M.C. Lee, *Market Efficiency and Accounting Research: A Discussion of 'Capital Market Research in Accounting' by S.P. Kothari*, 31 J. ACCT. & ECON. 233, 235–36 (2001).

241. Zhang, *supra* note 222, at 1–2.

242. SEC Concept Release, *supra* note 30, at 3608.

243. *See* IOSCO REPORT, *supra* note 134, at 25 ("Some empirical studies suggest that HFT has a positive impact on efficiency of the price discovery mechanism. An important role identified as being performed by HFT firms is that they contribute to price [convergence] across different trading venues."); Brogaard, *supra* note 91, at 64; Terrence Hendershott & Ryan Riordan, *Algorithmic Trading and Information* 22–23 (Net Inst., Working Paper No. 09-08, 2009), *available at* http://www.netinst.org/Hendershott_Riordan_09-08.pdf.

244. Zhang, *supra* note 222, at 34.

It should, however, be noted that misallocations of capital would be more likely to arise if HFT resulted in prolonged deviations from fundamental value. Spikes and crashes lasting milliseconds—or even minutes and hours—are unlikely to result in substantial misallocation of resources, no matter how large the anomaly.[245] As such, the urgency of regulation on these grounds is attenuated.

More serious, but also more speculative, is the risk that parasitic trading could undermine the conditions necessary for markets to generate and synthesize information, again threatening the allocative function of markets. Traders have an incentive to uncover new information only to the extent that they can profit by trading on that information. If parasitic strategies reduce the profitability of generating new information, they also reduce the incentive to generate it in the first place. In particular, if large traders are unable to hide their trades from parasitic HFTs, it would reduce the ability of those investors to profit from generating or uncovering new information and imperil the mechanisms on which market efficiency depends.[246] Thus, parasitic trading poses the additional systemic risk of impairing the information-generating function of markets. As noted above, however, large fundamental investors are likely well-placed to protect themselves via more sophisticated order-execution algorithms.[247]

The need to develop such algorithms, and other responses to HFT, has led some commentators to decry a "technology arms race."[248] As HFTs develop more sophisticated pattern recognition

245. *See id.* at 3 n.2 ("It is unclear how a price discovery delayed by 50 millisecond [sic] or 2 seconds would affect resource allocation in any meaningful way.").

246. *See* Fischel & Ross, *supra* note 143, at 509–10 ("Traders must be allowed to disguise their trades to avoid disclosing the information they possess to other traders."); Gilson & Kraakman, *supra* note 147, at 577–79; Grossman, *supra* note 147, at 585 ("The price system can be maintained only when it is noisy enough so that traders who collect information can hide that information from other traders."); Sanford J. Grossman & Joseph E. Stiglitz, *On the Impossibility of Informationally Efficient Markets*, 70 AM. ECON. REV. 393, 393 (1980) ("We propose here a model in which there is an equilibrium degree of disequilibrium: prices reflect the information of informed individuals (arbitrageurs) but only partially, so that those who expend resources [to uncover new information] do receive compensation.").

247. *See supra* Part III.A.

248. *See, e.g.*, Yoon, *supra* note 100, at 922 (quoting Liz Mayer & Emily Lambert, *The New Monsters of Wall Street*, FORBES, Sept. 21, 2009, at 40, 44) (internal quotation marks omitted) ("HFT has led to a 'technology arms race' among its players, who invest hundreds of millions of dollars into developing trading software and algorithms."); Sornette & Von der Becke, *supra* note 43, at 20 (suggesting measures to prevent a "technology arms race");

algorithms, other traders seeking to avoid detection and exploitation must revise and improve their own algorithms, potentially resulting in significant deadweight losses.[249] As is often the case, discussion of a technological arms race may simply reflect the (well-founded) fear that innovation will upset the status quo and undermine the legacy firms that benefit from that status quo. As such, claims of a destructive arms race should be met with the same skepticism that would greet similar claims made by, say, an auto manufacturer.

Another kind of broad "efficiency" harm must be taken more seriously: the harm that might result if large numbers of investors withdraw from the markets altogether due to the belief that the market is in some way "rigged" or overly dangerous. Indeed, there is some evidence of large outflows of investment capital following the Flash Crash, amid widespread speculation that HFTs played at least a part in the fiasco.[250] These outflows can potentially generate economy-wide harm. A reduction in invested capital can lead to increased costs of capital for public companies in addition to whatever social harms might flow from small investors being effectively frozen out of the stock markets.[251] These risks emphasize the importance of developing an overall regulatory strategy that is perceived as effective by the general investing public.

F. *Overburdening of Market Infrastructure*

Finally, there have been claims that HFTs are over burdening market infrastructure by the sheer volume of their trading activity. HFTs are, indeed, profligate users of exchange infrastructure. Despite the small number of HFTs, they account for more than half of all trades on U.S. exchanges (although a slightly lower

Leis, *supra* note 124, at 76 (positing the existence of a "technological arms race" in United States and European equity markets); IOSCO REPORT, *supra* note 134, at 28 ("[A]n academic participating in the IOSCO panel sessions stressed the risk that HFT participation in the market may lead to an *arms race*, as market participants compete against one another to possess the fastest and most sophisticated technology, which is very costly.").

249. As is noted subsequently, to the extent innovation in algorithms is generally beneficial, any costs must be set against these benefits. *See infra* Part IV.A.

250. Frank Zhang & Stuart B. Powell, Viewpoint, *The Impact of High-Frequency Trading on Markets: Before Rushing to Judge HFT, Investors Need to Understand the Empirical Evidence*, CFA INST., Mar. 2011, at 10, 11.

251. *See* IOSCO REPORT, *supra* note 134, at 27; Madhavan, *supra* note 217, at 1.

percentage than a few years ago).[252] Because HFT strategies typically involve unusually high order-to-trade ratios—with the vast majority of orders being canceled without being executed—HFTs account for an even higher proportion of total data traffic on exchanges.[253] Even without any deliberate malfeasance on the part of HFTs, this flood of data can strain exchanges, increasing latency and system instability.[254] To cope with the enormous quantities of data, exchanges have been forced to invest hundreds of millions of dollars in technological infrastructure.[255]

Some reports claim that HFTs engage in a tactic known as "quote stuffing," deliberately spamming an exchange with a huge number of rapid orders and cancellations.[256] The purpose of quote-stuffing is two-fold. First, it can cause a slowdown in the consolidated quotation system, increasing the chance of arbitrage opportunities from differences between real-time conditions and orders appearing in the consolidated data.[257] Second, rival HFTs must process and evaluate the quote-stuffer's orders as if they are potentially genuine, while the quote-stuffer's algorithms can safely ignore them, knowing them to be meaningless.[258] Thus, the burst of orders can "distract and slow down rival HFT firms," giving the quote-stuffer a time advantage.[259] Quote-stuffing is a potentially inexpensive way for HFTs to gain the speed advantage that is so crucial in making HFT strategies profitable.

Some commentators—pointing to the delays in the consolidated quotation system noted above—have suggested that quote-

252. *See supra* note 100.

253. *See* Yoon, *supra* note 100, at 922.

254. Prewitt, *supra* note 183, at 133; Jared F. Egginton et al., *Quote Stuffing* 2 (Working Paper, 2013), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1958281.

255. Yoon, *supra* note 100, at 938; *Moving Markets: Shifts in Trading Patterns are Making Technology Ever More Important*, THE ECONOMIST (Feb. 2, 2006), *available at* http://www.economist.com/node/5475381.

256. Egginton et al., *supra* note 254, at 1; Leis, *supra* note 124, at 64.

257. *See* Leis, *supra* note 124, at 64–65; Harold Malmgren & Mark Stys, *The Marginalizing of the Individual Investor: The Inside Story of Flash Crashes, Systemic Risk, and the Demise of Value Investing*, INT'L ECON., Summer 2010, at 22, 24.

258. *See* Leis, *supra* note 124, at 64; Madhavan, *supra* note 217, at 6.

259. *See* Leis, *supra* note 124, at 64; Madhavan, *supra* note 217, at 6 ("Intentional quote stuffing allegedly works by jamming the signal bandwidth of other fast traders who must process quotation changes that *only* the trader posting the rapid quote changes can safely ignore. More generally, the term refers to sudden spikes in quotation activity that appear unrelated to fundamental news events or trading volumes.").

stuffing may have played a significant role in the Flash Crash. Nanex, LLC, a developer of market data feed technology and critic of HFT, has argued that quote-stuffing activity caused the delays, which then led to a vicious circle as algorithmic traders sought to arbitrage a phantom price difference between quotes on the NYSE—which were delayed—and quotes on other exchanges.[260] The CFTC-SEC Initial Report on the Flash Crash acknowledged that "[i]t has been hypothesized that these delays [in the quotation data were] due to a manipulative practice called 'quote-stuffing' in which high volumes of quotes are purposely sent to exchanges in order to create data delays that would afford the firm sending these quotes a trading advantage," but concluded that it was unlikely the data delays played a large role in the extreme market movements.[261]

To the extent these activities are manipulative, the injured parties are largely the same as those already discussed. In addition, however, at least a portion of the harm falls upon the exchanges themselves as the performance of their systems is degraded. The situation is somewhat akin to an email scammer who uses a virus to cause a third party's computer to begin sending thousands of solicitation emails. The targets of the scheme are the recipients of the emails, but the hacked computer also suffers slow-downs and degraded overall performance. Systemic harms are possible as well, if system interference is severe enough to hamper efficient price discovery on the markets.[262]

If excessive HFT activity is clogging up market infrastructure, imposing costs on market operators, then the case for fees designed to shift those costs back to the responsible traders appears strong. Likewise, if savvy HFTs are exploiting liquidity rebate structures to make a profit without generating a corresponding benefit by providing genuine liquidity, the case for an overhaul of those structures is equally strong. Nonetheless, the case for ac-

260. *See Analysis of the Flash Crash*, NANEX (June 18, 2010), http://www.nanex.net/20100506/FlashCrashAnalysis_CompleteText.html. Nanex goes on to claim that "as more HFT systems start doing this, it is only a matter of time before quote-stuffing shuts down the entire market from congestion." Andrew Appel, *Did a Denial-of-Service Attack Cause the Stock-Market "Flash Crash?"*, FREEDOM TO TINKER (June 25, 2010), http://freedom-to-tinker.com/blog/appeal/did-denial-service-attack-cause-stock-market-flash-crash/.

261. SEPTEMBER CFTC-SEC STAFF REPORT, *supra* note 1, at 79.

262. *See* Egginton et al., *supra* note 254, at 3 (finding that stocks subject to especially intense quoting activity experience reduced liquidity, higher spreads, and higher volatility).

tion is not the same as the case for regulation. In this case, as explained further below, the trading venues themselves have both the ability and the incentive to make such improvements. Regulators are unlikely to be particularly competent in designing the necessary fee structures themselves, and take the risk of imposing a one-size-fits-all solution that merely serves to cut off innovation and experimentation to find optimal systems.

IV. THE NOVEL RISK OF EXTREME VOLATILITY EVENTS

A. *HFT-Induced Volatility*

The risk of extreme volatility events differs from the risks discussed in Part III in four essential ways. First, the risk is, in important ways, unique to HFT. Second, the risk is potentially serious. Third, the risk of extreme volatility events can be only partially mitigated by private actors. Finally, volatility spikes are highly visible, and thus have attracted a great deal of attention from the media and the investing world. These features combine to make extreme volatility events a prime target for new regulation.

An important challenge for policymakers is that the magnitude of the risk of HFT-related extreme volatility events is uncertain. On the one hand, it is clear that the emergence of HFT has resulted in dramatically reduced spreads and faster execution times, at least under ordinary conditions.[263] On the other hand, extreme volatility events—such as the Flash Crash and the hundreds of mini-flash crashes in individual securities—are taking place at a greater frequency than ever before.[264] The evidence is mixed as to whether HFTs, on net, increase or decrease volatility.[265] Surveying the published research, Sornette and Von der

263. *See* IOSCO REPORT, *supra* note 134, at 26 ("Execution speed has fallen from seconds to as little as microseconds within ten years. Some measures of liquidity have improved with implicit trading costs (like quoted bid-ask spreads) and explicit costs (e.g., trading fees per transaction) declining."); Zweig, *supra* note 134 (reporting by way of example that online brokerage fees from Charles Schwab total, at most, 0.3%, whereas they were at least 2% a decade ago).

264. *See* Graham Bowley, *The New Speed of Money*, N.Y. TIMES, Jan. 2, 2011, at BU1 (noting that "[s]ince May [of 2010] there have been regular mini-flash crashes in individual stocks for which, some say, there are still no satisfactory explanations").

265. *See* Madhavan, *supra* note 217, at 7 (summarizing the state of research on the question, and concluding that "[r]ecent[] evidence . . . is mixed on the impact of high-

Becke conclude that "[w]hile volatility appears to be reduced at the level of individual stocks' bid/ask prices, [HFT] may have amplified tail risk and increased volatility at the macro level."[266]

Some of this increased incidence of extreme volatility may be due to deliberate malfeasance, such as momentum ignition or other forms of illegal market manipulation.[267] Some may be the result of front-running strategies, which potentially amplify the effects of trades by large long-term investors.[268] Some may be a result of HFTs severing the traditional connection between trading volume and liquidity.[269] Legacy order-execution algorithms—like the one the U.S. Commodity Futures Trading Commission ("CFTC") and SEC suspect of causing the Flash Crash—often use volume as a proxy for liquidity, and thus may trigger large price movements where it is a poor proxy.[270] Some may be a result of non-manipulative trading strategies whereby HFTs chase short-term momentum in such a way as to amplify price swings.[271]

But the phenomenon of smoother trading in placid times and choppier trading in turbulent times suggests that the worst volatility spikes may be the result of HFTs having elbowed out tradi-

frequency traders and faster trading"); Zhang, *supra* note 222, at 8 ("Whether HFT increases or reduces stock price volatility is not obvious."). Several papers find that increased HFT activity reduces short-term volatility. *See* Joel Hasbrouck & Gideon Saar, *Low-Latency Trading* 32–33 (Cornell Univ., Johnson Sch. Research Paper Series No. 35-2010, 2013), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1695460; *see also* Brogaard, *supra* note 91, at 1 (finding that "HFTs . . . may dampen intraday volatility"); Sven S. Groth, *Does Algorithmic Trading Increase Volatility? Empirical Evidence from the Fully-Electronic Trading Platform Xetra* § 6.3 (Grothe Universität, Discussion Paper Nov. 16, 2011), *available at* http://www.futuresindustry.org/ptg/downloads/Working Paper_Algo_SvenGroth.pdf (finding evidence that algorithmic trading does not substantially increase volatility); Terrence Hendershott, et al., *Does Algorithmic Trading Improve Liquidity?* 66 J. FIN. 1, 10–11 (2011) (noting that when algorithmic trading increases, it narrows the spread and therefore decreases the volatility between the two prices); IOSCO REPORT, *supra* note 134, at 28 ("The available[] evidence is mixed and while some studies suggest that HFT tend[s] to have a stabilizing effect on market volatility, at least during normal market conditions, others provide negative evidence on the impact of HFT on market volatility."). *But see* Dichev et al., *supra* note 178, at 3 (finding that high trading volume can produce "its own volatility above and beyond that based on fundamentals"); Egginton et al., *supra* note 254, at 5; Zhang, *supra* note 222 at 2 ("[S]tock price volatility is positively correlated with HFT after controlling for the volatility of a firm's fundamentals and other exogenous volatility drivers.").

266. Sornette & Von der Becke, *supra* note 43, at 6.

267. *See supra* text accompanying notes 132, 148.

268. *See supra* note 126 and accompanying text.

269. *See infra* text accompanying note 271.

270. *See supra* Part III.D.

271. *See* Zhang, *supra* note 222 at 8.

tional market makers. As noted above, HFTs generally perform the market making function even more efficiently than their predecessors did, but their speed and lack of any obligation to remain in the market means that they can quickly vanish when market making becomes unappealingly risky, resulting in a dramatic drop in liquidity at just the wrong time. Sornette and Von der Becke, for example, note that "it seems HFT provides liquidity in good times when it is perhaps least needed and takes liquidity away when it is most needed, thereby contributing rather than mitigating instability . . . ."[272] The International Organization of Securities Commissions' ("IOSCO") report on the subject noted that "it is questioned by some market participants whether HFT firms provide liquidity to the market on a consistent basis, i.e. whether they continue to do so during turbulent conditions and whether they withdraw from the market."[273]

The harms that flow from increased volatility are multifaceted. Most basically, high-profile crashes and spikes may lead retail investors to view the markets as little more than a casino, and to withdraw their capital. Furthermore, investors who are risk-averse—which includes virtually everyone[274]—will tend to require a higher risk premium for more volatile stocks (in other words, investors will pay less for the same expected returns).[275] As a result, high volatility can increase firms' cost of capital,[276] and reduce the value of stock-based compensation to employees and officers.[277] It has also been suggested that increased volatility

272. Sornette & Von der Becke, *supra* note 43, at 6; Zhang, *supra* note 222, at 3 ("[T]he positive correlation between HFT and volatility is stronger when market uncertainty is high, a time when markets are especially vulnerable to aggressive HFT strategies and to the withdrawal of HFT market-making activities.").

273. IOSCO REPORT, *supra* note 134, at 26. As Sornette and Von der Becke point out, even market makers with an obligation to remain in the market only fulfilled these obligations in a technical sense during the Flash Crash, posting so-called "stub quotes" far from the market price, in the expectation that they would not be executed against. *See* Sornette & Von der Becke, *supra* note 43, at 5 n.5. These stub quotes were the source of some of the most outlandish trades during the Flash Crash (trades for one cent or $100,000 per share), so one may question whether they were an improvement over no quotes at all. *See* MAY CFTC-SEC STAFF REPORT, *supra* note 2, at 33–34.

274. *See* Prasanna Gai & Nicholas Vause, *Measuring Investors' Risk Appetite*, 2 INT'L J. CENT. BANKING 167, 168 (2006); Zhang, *supra* note 222, at 7.

275. *See* X. Frank Zhang, *Information Uncertainty and Stock Returns*, 61 J. FIN. 105, 135 (2006).

276. *See* Kenneth A. Froot et al., *Shareholder Trading Practices and Corporate Investment Horizons*, 5 J. APPLIED CORP. FIN. 42, 43 (1992).

277. *See id.*; Stanley Baiman & Robert Verrecchia, *Earnings and Price-Based Compen-*

leads to increased securities litigation, with all the attendant deadweight losses of such litigation.[278]

B. *The Regulatory Landscape*

Because HFT is a relatively new practice, it is unsurprising that the governing regulatory regimes are not fully developed. The general regulatory landscape has been sketched above. Before turning to my proposed regulatory response to HFT, however, I offer a brief overview of existing proposals. These proposals are ably summarized in the Joint CFTC-SEC Advisory Committee on Emerging Regulatory Issues' report, "Recommendations Regarding Regulatory Responses to the Market Events of May 6, 2010," and the IOSCO Technical Committee's July 2011 Consultation Report on "Regulatory Issues Raised by the Impact of Technological Changes on Market Integrity and Efficiency." As a result, these regulatory proposals are recapitulated only briefly here.

1. Recommendations of the CFTC-SEC Joint Committee

Following the Flash Crash, the CFTC and SEC convened a Joint Advisory Committee (the "Committee") to consider regulatory responses to the extraordinary events of that day.[279] The result was a series of fourteen recommended actions (some multipart), most of which implicate HFT even if they do not explicitly target it.[280] The report divides the fourteen recommended actions into three broad categories: (1) volatility-related actions; (2) re-

sation Contracts in the Presence of Discretionary Trading and Incomplete Contracting, 20 J. ACCT. & ECON. 93, 94–95 (1995).

278. *See* Jennifer Francis et al., *Shareholder Litigation and Corporate Disclosures*, 32 J. OF ACCT. RES. 137, 144–46 (1994).

279. JOINT CFTC-SEC ADVISORY COMM. ON EMERGING REGULATORY ISSUES, RECOMMENDATIONS REGARDING REGULATORY RESPONSES TO THE MARKET EVENTS OF MAY 6, 2010, at 2 (2010) [hereinafter JOINT ADVISORY REPORT].

280. *Id*. at 3–14. As the Joint Committee noted in the introduction to its recommendations, "[t]he broad, visible, and often controversial, topic of High Frequency Trading . . . has been pervasive in our discussions and in comments received from others. Rather than detail specific recommendations about HFT in this report, steps to address issues associated with this practice are evident throughout our report." *Id*. at 2.

strictions on co-location and direct access; and (3) liquidity enhancement issues.[281]

Under the heading of "volatility," the report makes a number of recommendations, most of which have either been implemented or are scheduled to be implemented by the end of 2013.[282] First, the Committee endorsed the broader use of circuit breakers for individual stocks to temporarily halt trading when prices change by more than a certain amount (usually 10%) in a certain period (usually five minutes), and suggested consideration of similar circuit breakers for options and other derivatives.[283] Circuit breakers are intended to short-circuit liquidity freezes, giving time for liquidity to be attracted to the market, and giving algorithmic traders enough time to curb runaway algorithms.[284] Circuit breakers of one form or another were probably the single most called for response in the wake of the Flash Crash,[285] and the SEC and Financial Industry Regulatory Authority ("FINRA") acted quickly, beginning to implement them in S&P stocks in 2010, and expanding their use thereafter.[286] The Committee also recommended rules creating greater certainty as to when individual trades will be cancelled as erroneous in the case of aberrant price movements, and the elimination of stub quotes.[287]

281. *Id* at 2–14.

282. *Id* at 2–6; *see, e.g.*, *Regulatory Newsletters; Current Regulatory Initiatives: Limit Up-Limit Down Proposals*, NASDAQ OMX, http://www.nasdaqtrader.com/trader.aspx?id=currentregulatory (last visited Dec. 6, 2013).

283. JOINT ADVISORY REPORT, *supra* note 279, at 3 & n.1, 5.

284. *See id*. at 3 n.1. ("Where there is extreme volatility in a stock, this solution provides for a pause in trading that will allow market participants to better evaluate the trading that has occurred, correct any erroneous 'fat finger' orders and to allow a more transparent, organized opportunity to offset the order imbalances that may have caused the volatility.").

285. *See* Gould, *supra* note 32, at 275 (noting that "[t]he SEC quickly implemented circuit breakers reminiscent of the 'Black Monday' market crash of 1987"); *SEC Approves New Stock-by-Stock Circuit Breaker Rules,* U.S. SEC. AND EXCH. COMM'N (June 10, 2010), *available at* http://www.sec.gov/news/press/2010/2010-98.htm (releasing rules "establishing a set of circuit breakers that uniformly pauses trading in a given security across all venues . . . ensur[ing] that all markets pause simultaneously and provide time for buyers and sellers to trade at rational prices").

286. JOINT ADVISORY REPORT, *supra* note 279, at 3 n.1. These single-stock circuit breakers are scheduled to be replaced by "limit-up/limit-down" rules in 2013. *See* Office of Investor Education & Advocacy, *SEC Investor Bulletin: New Measures to Address Market Volatility* (last updated Apr. 9, 2013) [hereinafter *SEC Investor Bulletin*], http://www.sec.gov/investor/alerts/circuitbreakersbulletin.htm).

287. JOINT ADVISORY REPORT, *supra* note 279, at 3–4. In November 2010, the SEC approved rules effectively barring stub quotes. *See* Order Granting Accelerated Exchange Act

Circuit breakers are somewhat blunt tools, in that a single erroneous trade can cause a complete halt in the trading of a security, at least for a few minutes. As such, the Committee recommended implementation of a so-called "limit up/limit down" process that, instead of halting trading of a security altogether, restricts trading to a price band within a certain percentage of the average price over the past few minutes.[288] Like a circuit breaker, a limit up/limit down rule arrests liquidity-driven spikes and crashes, but it does so without halting trading altogether—if liquidity returns within the price band, trading can resume as normal.[289] The SEC has approved a limit up/limit down mechanism, and it is in the process of being implemented, first for S&P 500 stocks and later for all securities.[290]

The last recommendation under the heading of "volatility" was that the SEC consider several alterations to the existing market-wide circuit breakers, under which trading is halted across the entire market if the market drops by a certain amount.[291] Most importantly, they suggested considering the amount of the decline necessary to trigger a halt, reducing the minimum duration of the halt, and using the S&P 500 index as the reference instead of the narrower DJIA.[292] The SEC has approved most of these changes, and they have begun to go into effect.[293]

The second group of recommendations deals with co-location and direct access to exchange infrastructure, and seeks to control the risks associated with manipulative or poorly designed algo-

Release No. 34,63255 Approval to Proposed Rule Changes to Enhance the Quotation Standards for Market Makers, 75 Fed. Reg. 69,484, 69,484 (Nov. 5, 2010).

288. *See* JOINT ADVISORY REPORT, *supra* note 279, at 4–5 (internal quotation marks omitted).

289. *See id.*, at 4.

290. *SEC Investor Bulletin*, *supra* note 286.

291. JOINT ADVISORY REPORT, *supra* note 279, at 5–7.

292. *See id.* at 6.

293. *See SEC Investor Bulletin*, *supra* note 286. Among other things, the scheduled changes include: 1) switching from the Dow Jones Industrial Average to the S&P 500; 2) reducing the "trigger points" from 10%, 20%, and 30% declines to 7%, 13%, and 20% declines; and 3) reducing the lengths of the halt for various declines, with a minimum halt of only 15 minutes. *See* Order Granting Accelerated Approval to Proposed Rule Changes Relating to Trading Halts Due to Extraordinary Market Volatility, Exchange Act Release No. 34,67090, 77 Fed. Reg. 33,531, 33,532 (June 6, 2012); *see also* Ian Poirier, Note, *High-Frequency Trading and the Flash Crash: Structural Weaknesses in the Securities Markets and Proposed Regulatory Responses*, 8 HASTINGS BUS. L.J. 445, 460 (2012) (defining stub quoters as "bids or offers that are far removed from the best price available for a given security").

rithms.[294] In particular, the Committee suggested that the SEC work with FINRA and the various exchanges to design and implement risk management controls, ensure that parties with access to the market are in compliance with regulatory requirements, and put in place testing and screening measures to prevent erroneous or manipulative trades.[295] In November 2010, the SEC unanimously approved a rule banning so-called "naked access" to exchanges, requiring any trader with direct access to the exchange—or anyone "sponsoring" a trader by providing them access[296]—to implement pre-trade risk controls to minimize the risk of erroneous or overly risky trading.[297]

The Committee further endorsed the CFTC's moves to make similar efforts to prevent "disruptive trading activities," including potentially screening algorithms used by traders for how they might affect liquidity and volatility, prior to their use in the market.[298] The Committee "applaud[ed]" the CFTC's request for comment on "whether it is appropriate to restrict large order execution design that results in disruptive trading," including whether to prohibit "large order algorithms that employ unlimited use of market orders or that permit executions at prices which are a dramatic percentage below the present market price without a pause for human review" (like the one the CFTC-SEC Report argued triggered the Flash Crash).[299]

294. JOINT ADVISORY REPORT, *supra* note 279, at 7.

295. *See id*.

296. Broker-dealers who are members of an exchange typically have two ways of providing trading services to their customers, including HFTs. First, they could provide so-called direct market access ("DMA") by allowing the customer to place orders through the broker-dealer's trading systems. When, however, customers—like HFTs—have a speed-dependent trading strategy, such a relay system can cause problematic delays. As a result, some broker-dealers provided so-called "sponsored access," allowing the customer to access the exchange directly. When there are no pre-trade filters or controls in place, such access is sometimes known as "naked" access. The danger is that the "sponsored" customer may not comply with appropriate risk limits or other regulations, resulting in a greater potential that an erroneous or ill-conceived series of trades could result in the sponsoring broker-dealer defaulting on its trading obligations. Yoon, *supra* note 100, at 928–29.

297. Risk Management Controls for Brokers or Dealers with Market Access, 75 Fed. Reg. 69,792, 69,792, 69,825–26 (Nov. 15, 2010) (codified at 17 C.F.R. pt. 240); *SEC Adopts New Rule Preventing Unfiltered Market Access*, U.S. SEC. AND EXCH. COMM'N (Nov. 3, 2010), http://www.sec.gov/news/press/2010/2010-210.htm.

298. JOINT ADVISORY REPORT, *supra* note 279, at 7–8.

299. *Id*. at 8–9.

The third group of recommendations concerns measures designed to improve the quality of liquidity.[300] The first recommendation is that the SEC work with exchanges to develop a system of liquidity rebates and charges that provides stronger incentives to provide liquidity during turbulent times.[301] Particular emphasis is placed on "peak load" pricing that would offer higher rebates for liquidity providers (and/or higher access fees for liquidity takers) when liquidity is low.[302] In addition, the Committee—while admitting that it "does not believe it is competent" to determine how best to do so—recommends that the SEC seek ways to urge (or force) traders who engage in market making to maintain quotations that are "reasonably related to the market" (in other words, not so-called "stub quotes" at $0.01 or $100,000) in bad times as well as good.[303] Similarly, the Committee suggests that the SEC consider ways to prevent broker-dealers who typically internalize a large proportion of trades from withdrawing liquidity during volatile markets.[304] Suggested methods include a requirement that internalized trades be "executed at a price materially superior" to the best available bid or offer in the market, or a requirement that "some material portion" of orders be executed under volatile conditions.[305]

The Committee also takes note of the "disproportionate impact that HFT has on Exchange message traffic and market surveillance costs," particularly from the huge numbers of orders placed and subsequently cancelled.[306] In response, the Committee recommends that regulators look for ways to pass these costs back to the HFTs responsible for creating them, "perhaps requiring a uniform fee across all Exchange markets that is assessed based on the average of order cancellations to actual transactions effected by a market participant."[307] The rule is intended to make certain "that if a broker-dealer is going to loan his keys [to HFTs], he not only must remain in the car, but he must also see to it that the

300. *Id*. at 8.
301. *Id*. at 9–10.
302. *Id*. at 9 (internal quotation marks omitted).
303. *Id*. at 10–11 (internal quotation marks omitted).
304. *Id*. at 12.
305. *See id*. at 12.
306. *Id*. at 11.
307. *Id*.

person driving observes the rules before the car is ever put into drive."[308]

Finally, the Committee makes a series of recommendations regarding the gathering and dissemination of trading information by exchanges. One suggestion is to provide incentives for traders to post resting limit orders by instituting a "trade at" rule that requires exchanges to route orders to the best displayed price, rather than being able to simply match the best price without ever publicly displaying an order.[309] Such a rule would essentially end the use of flash orders as currently practiced, as they involve offering an exchange's customers the opportunity to fill an order by matching the best price without ever placing a publicly visible order.[310] Another suggestion is to include some or all limit order book information in the consolidated quotation data, rather than just the best bids and offers.[311] Still another is to make available real-time statistics on liquidity and buy or sell order imbalances, to better allow market participants to profit by supplying liquidity when it is needed.[312] Finally, pointing to the enormous time and resources regulators were forced to expend to perform a forensic reconstruction of even a few minutes of trading activity during the Flash Crash, the Committee recommends that the SEC and CFTC "proceed with a sense of urgency" to create a "consolidated audit trail for the US equity markets," so that orders and executions can be more easily reconstructed and examined by regulators.[313] Development of such a system is underway.[314]

308. Scott Patterson, *SEC Aims to Ban 'Naked Access'—Critics See Liquidity Hit, but Agency Cites Market Stability in Pushing Move*, WALL ST. J., Jan. 14, 2010, at C1 (internal quotation marks omitted).

309. JOINT ADVISORY REPORT, *supra* note 279, at 13.

310. *Id*. at 12–13. In theory, flash orders would still be possible, so long as the customer filling the order was willing to provide a slight improvement over the best price available in the market. *Id*.

311. *Id*. at 13.

312. *Id*. at 13–14.

313. *Id*. at 14.

314. In 2010, the SEC proposed that market operators be required to establish and maintain a consolidated audit trail allowing regulators to trace orders and executions across securities markets. *See* Consolidated Audit Trail, Exchange Act Release No. 34-62,174, 75 Red. Reg. 32,556 (June 8, 2010). A Final Rule was approved in July of 2012, with implementation to take place in stages over the next two years. *See* Consolidated Audit Trail, Exchange Act Release No. 34-67,457, 77 Fed. Reg. 45,722, 45,809 (Aug. 1, 2012).

2. IOSCO Recommendations

Most of the recommendations in IOSCO's 2011 report overlap with those introduced in the previous section. Nonetheless, a few additional proposals—regulatory possibilities, really—bear special mention. In its report, IOSCO breaks the "suggestions" into three categories, based on the market level at which the proposed regulation would operate: (1) at the trading firm level; (2) at the market operator level; and (3) at the structural level.[315]

At the trading firm level, IOSCO's report makes the following suggestions for measures that should be given fuller consideration by regulators: (1) "stress testing" and approval requirements for new HFT and other algorithms; (2) taxes or fees for unusually high order placement or cancellation volumes; (3) SEC/CFTC registration requirements for exchange members; and (4) a ban on direct market access for traders unless their trading is subjected to "appropriate pre-trade controls."[316]

At the market operator level, in addition to echoing the CFTC/SEC Joint Committee recommendations with regard to circuit breakers and erroneous trade cancellation procedures, IOSCO suggests the following possible actions: (1) requiring stress testing for market infrastructure operators; (2) requiring market operators to provide "appropriate testing environments" for HFTs and other algorithmic traders to test their algorithms; and (3) introducing larger minimum price changes and/or a minimum time orders must remain on the books before being cancelled.[317]

At the structural level, IOSCO calls for consideration of a ban on flash orders, and of whether layering the book should be considered a form of market manipulation.[318]

315. IOSCO REPORT, *supra* note 134, at 38–40.

316. *See id.* at 38.

317. *Id.* at 39. IOSCO also echoes several other recommendations made by the Joint Committee, in particular: (1) imposing market making responsibilities on HFTs engaged in market making; (2) banning stub quotes; and (3) assessing fees or taxes on high order entry and cancellation rates. *Id.*

318. *Id.* at 39–40. IOSCO also follows the Joint Committee in calling for creation of a consolidated audit trail, "able to track orders, quotes and trades in the market," including a system of entity identifiers able to quickly and reliably identify the party responsible for order and trade activity. *Id.* at 40.

3. The Possibility of Outright Bans

One particularly straightforward regulatory possibility that has not been emphasized by any of the responsible authorities in the United States—but that has been bruited about by market observers and participants—is simply banning HFT.[319] It may seem that trying to ban HFT would pose insuperable problems of definition, as banning all forms of algorithmic trading is not likely to be desirable. But in practice, it would likely be a relatively simple matter of imposing a small tax or fee on financial transactions—large enough to render HFT strategies unprofitable, but small enough to not substantially increase the cost of trading for traditional market participants. The EU is in the process of implementing just such a tax.[320] Less drastically, but in a similar vein, some industry participants have called for bans on co-location and direct data feed access on fairness grounds.[321] Finally, the SEC has repeatedly called for comment on whether steps should be taken to ban "order anticipation" strategies, though it has yet to make a firm proposal on the matter.[322]

319. Katherine Heires, *High Frequency Trading: A New Study Finds a Divide on the Impact*, SEC. TECH. MONITOR, http://www.securitiestechnologymonitor.com/news/-24116-1.html (last visited Dec. 6, 2013).

320. The European Commission has proposed a financial transaction tax along these lines, proposed to take effect in 2014. *See* Press Release, European Comm'n, Financial Transaction Tax under Enhanced Cooperation: Commission Sets Out the Details (Feb. 14, 2013), *available at* http://europa.eu/rapid/press-release_IP-13-115_en.htm; *see also* Zhang, *supra* note 222, at 35 n.23 ("From a policy perspective, reining in the scope of HFT would be fairly easy if HFT were found to be harmful to the capital market. A small tax on financial transactions would dramatically reduce the volume of high-frequency trading."). Zhang reports a "top hedge fund" telling him that its strategy involved earning five basis points (0.05%) per trade, with an average transaction cost of three basis points (0.03%). Zhang, *supra* note 222, at 35 n.23. If accurate, a tax of just 0.03% would be enough to render this hedge fund's HFT unprofitable, while still constituting only a small fraction of the cost of trading for traditional investors.

321. Letter from Edward E. Kaufman, United States Senator, to Mary L. Schapiro, U.S. Sec. & Exch. Comm'n (Nov. 20, 2009), *available at* http://green.lib.udel.edu/webarchives/kaufman.senate.gov/imo/media/doc/Schapiro Mary 11 20 094.pdf.

322. *See, e.g.*, SEC Concept Release, *supra* note 30, at 3609; Press Release, Futures Indus. Ass'n, SEC Roundtable Reveals Sharp Differences of Opinion on High-Frequency Trading (June 2, 2010), *available at* http://www.futuresindustry.org/ptg/sec-roundtable-reveals-sharp-differences-of-opinion-on-highfrequency-trading.asp.

V. CHOOSING A REGULATORY STRATEGY FOR HIGH-FREQUENCY TRADING

How, then, should policymakers respond to the risks associated with HFT? Helpfully, in Section 11A of the Exchange Act, Congress set forth a set of five "objectives" to guide the SEC in constituting a national market system.[323] In particular, Congress instructed the SEC to pursue the following objectives:

> (i) economically efficient execution of securities transactions; (ii) fair competition among brokers and dealers, among exchange markets, and between exchange markets and markets other than exchange markets; (iii) the availability to brokers, dealers, and investors of information with respect to quotations for and transactions in securities; (iv) the practicability of brokers executing investors' orders in the best market; and (v) an opportunity, consistent with [efficiency and best execution], for investors' orders to be executed without the participation of a dealer.[324]

To these objectives, we can add some more general guidelines. In a recent paper, Professors Merrill and Schizer offer—in the context of hydraulic fracturing in oil and gas drilling—a helpful template for choosing a regulatory strategy.[325] Following their basic roadmap, I will begin with a brief reminder of the dangers of over-regulation. I will then survey four alternative regulatory strategies identified by Merrill and Schizer: (1) prohibitions; (2) command and control regulations; (3) liability rules; and (4) what they refer to as "Coasean bargains," which I will consider more broadly as private ordering.[326] Next, I will introduce four factors they identify as bearing on the proper choice of regulatory strategy: (1) the feasibility of one-size-fits-all solutions; (2) the seriousness of the potential harm; (3) the administrative costs associated with ex post liability determinations; and (4) the novelty of the technology involved.[327] Finally, I will apply these factors to HFT, and set forth a summary of my proposed regulatory strategy.

323. *See* 15 U.S.C. § 78k-1(a)(1)(C) (2012).

324. *Id*.

325. *See generally* Merrill & Schizer, *supra* note 36, at 211–16.

326. *Id*. Merrill and Schizer also discuss disclosure as a potential regulatory strategy—for example, requiring oil drillers to disclose the risks associated with fracking to surrounding landowners. *Id*. at 208. Such a strategy has no obvious analog—at least not a *useful* analog—and is thus not considered here.

327. *See id*. at 216–17, 218 n.345, 219–22.

A. *Over-Regulation*

While HFT does not inspire the kind of dread and hysteria that often accompany environmental or terrorist risks, there is nonetheless some reason to be concerned about the risk of regulatory overkill. In particular, HFTs are new and relatively small fish in a large, shark-infested pond. Politically influential and well-financed legacy market actors—including investment banks, hedge funds, mutual funds, market makers, and other institutional investors—could potentially seek to stifle competition from HFTs by calling for debilitating regulation. Thus it is important to approach calls for additional regulation of HFT by other financial industry players with an appropriate level of skepticism.

B. *Possible Regulatory Strategies*

1. Prohibitions

As noted above, one obvious strategy for dealing with the risks of HFT is simply to ban it, as the EU is in the process of doing.[328] As Merrill and Schizer point out, "[p]rohibition is obviously the most protective regulatory strategy."[329] Prohibition can be an appropriate strategy when the risks of the activity in question outweigh the benefits, together with the enforcement costs associated with prohibition. Prohibition, where it is completely effective, reduces both the costs and the benefits of the banned activity to zero.

Prohibition has several well-known downsides as a regulatory strategy. First, where the benefits of the prohibited activity are significant, and the risks are either small or can be managed in a less drastic fashion, prohibition constitutes over-regulation.[330] By ending the activity altogether, prohibition also cuts off the possibility of innovations that would reduce risk while preserving benefits.[331] Finally, enforcement costs may be high where detection is

328. *See supra* Part IV.B.3.
329. Merrill & Schizer, *supra* note 36, at 206.
330. *Id.*
331. *See id.*

difficult and where the prohibited activity closely resembles legitimate activities.[332]

2. Command and Control Regulation

A less drastic alternative to prohibiting an activity is to regulate it. Command and control regulations refer to requirements imposed by a regulator that are mandatory for the regulated entity.[333] Such regulations often come in the form of standards, such as a maximum level of arsenic in drinking water,[334] or a maximum number of insect parts in 100 grams of peanut butter.[335] Perhaps the most common form of command and control regulation, however, is some form of "best practices" regulation, requiring regulated entities to follow basic prescriptions that are found to constitute the state of the art in the industry.[336] The basic judgment involved in such regulation is that if some firms are able to operate profitably with certain safeguards in place, it should not be overly burdensome to require those safeguards of the entire industry.[337]

The advantage of command and control regulation is that it can potentially achieve substantial reductions in risk without depriving society of all of the benefits of the regulated activity.[338] At the same time, command and control is likely more reassuring to the public than less direct forms of regulation.[339] With such regulation, the public can see what protections are in place in a way that is not generally the case with incentive-based regulation like excise taxes or ex post fines and liability.[340] Furthermore, best practices regulation tends to be fairly stable and predictable, and

332. *See id*. at 205.

333. *See id*. at 206; *cf*. MARK THORNTON, THE ECONOMICS OF PROHIBITION 76 (1891).

334. *See* National Primary Drinking Water Regulations, 66 Fed. Reg. 6976, 6981 (Jan. 22, 2001) (codified at 40 C.F.R. pt. 9, 1541, 142 (2012)).

335. FOOD & DRUG ADMIN., DEFECT LEVELS HANDBOOK 18 (2013), *available at* http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/SanitationTransportation/ucm056174.htm.

336. Merrill & Schizer, *supra* note 36, at 206 (internal quotation marks omitted). Merrill and Schizer give as examples "rules requiring ships to carry lifeboats [and] cars to have seat belts." *Id.*

337. *Id*.

338. *See id*.

339. *See id*. at 206–07.

340. *See id*. at 207.

is for that reason often popular with regulated industries, which often favor predictability over perfect efficiency.[341]

One disadvantage of command and control regulation is that it is obviously less protective than outright prohibition.[342] Another is that it can result in either over- or under-regulation of the activity, depending as it does on the state of the art in the industry, rather than any explicit cost-benefit analysis.[343] Still another is that best practices regulation can serve to freeze innovation.[344] As long as regulated entities comply with existing best practices, they will escape liability, and thus have little incentive to invest resources in reducing risk further.[345]

3. Liability Rules

Regulation can also be ex post, rather than ex ante, imposing penalties on entities that impose harms on others. Perhaps the best-known system of retrospective liability is tort law. In a typical tort action, a party that has been harmed by the actions (usually the *wrongful* actions) of another party may sue, establish certain elements including injury and causation, and recover monetary compensation for the harm done. In general, however, "liability rules operate after the fact to levy a financial charge on externality-generating activity."[346]

Liability rules offer some significant advantages over ex ante regulation. First, in contrast to the potentially ossified nature of command and control regulation, liability provides an incentive to the regulated firms to look for all cost-justified ways to reduce negative externalities.[347] This advantage is potentially substantial where the state of the art is still developing, and it is uncertain what constitutes best practices. Furthermore, liability rules often offer compensation directly to the injured parties.[348] Command

341. *Id.*

342. *See id.*

343. *Id.*

344. *Id.*

345. *See* Charles R. Korsmo, *Lost in Translation: Law, Economics, and Subjective Standards of Care in Negligence Law*, 118 PENN. ST. L. REV. (forthcoming 2014).

346. Merrill & Schizer, *supra* note 36, at 209.

347. *Id.* at 209–10 (noting that "[l]iability . . . is especially effective in encouraging risk-reducing innovation").

348. *Id.* at 209.

and control, standing alone, may work to prevent harms, but does nothing to ameliorate harms that have actually occurred.

Along with these advantages come potentially serious disadvantages. Liability can generate substantial uncertainty for the regulated industry, which cannot be certain either of the standards it will be held to nor the magnitude of the damages until after the fact.[349] In addition, the public may find the ability to be compensated after the fact less reassuring than knowing that appropriate regulatory safeguards are in place ahead of time.[350] If, as is the case in most tort actions, private litigants must come forward, individuals suffering small harms may have insufficient incentive to bring suit, thus resulting in under-deterrence. This phenomenon is most acute where harms are diffuse—small for any individual, but affecting many people and thus large in the aggregate.[351] Finally, difficulty in establishing causation may make ex post liability assignments impractical.

4. Private Ordering

A final strategy is to allow externalities to be regulated by private ordering, contractual or otherwise.[352] Formal contractual solutions will not be possible where transaction costs are high or property rights are unclear.[353] Where HFT injures parties who lack relevant legal rights, Coasean bargaining will not be possible.[354] Nonetheless, such bargaining may be feasible for some risks associated with HFT. More broadly, often parties will be able to protect themselves against externalities at lower cost than an effective regulatory system would impose. Sometimes, to take an everyday example, an eyesore is better addressed by a fence

349. *See id.*

350. *See, e.g.*, STEPHEN D. SUGARMAN, DOING AWAY WITH PERSONAL INJURY LAW: NEW COMPENSATION MECHANISMS FOR VICTIMS, CONSUMERS, AND BUSINESS 6–7 (1989).

351. This difficulty is somewhat ameliorated by the availability of class actions, though aggregate litigation tends to be beset by a host of agency problems. *See, e.g.*, Samuel Isaacheroff, *The Governance Problem in Aggregate Litigation*, 81 FORDHAM L. REV. 3165, 3167 (2013) (discussing alternate efforts to structure class actions in light of agency problems).

352. The notion that, in the absence of transaction costs, private parties would be able to solve externality problems by contract is generally associated with the work of Ronald Coase. *See, e.g.*, Ronald H. Coase, *The Problem of Social Cost*, 3 J. L. & ECON. 1 (1960).

353. *Id.* at 16–17.

354. *See id.* at 9–10 (noting that when a party has no relevant legal right, that party has no bargaining power).

than by instituting an architectural review board with plenary powers.

C. *Factors Influencing the Choice of Regulatory Strategy*

Each of the above regulatory techniques entails competing considerations. These considerations should inform our choice of regulatory strategy—or combination of regulatory strategies. The literature on selection of a regulatory strategy is not as developed as one might expect.[355] Some ideas may be gleaned, however, from writings on the respective merit of ex ante regulations that seek to prevent harms before they occur, and ex post regulations that seek to sanction conduct that has already led to some harm and thereby also provide incentives to avoid harmful externalities in the first place.[356] Most of this literature focuses on the respective costs of determining optimal behavior, either before some harmful accident has occurred, or after the fact.[357] Merrill and Schizer helpfully distill the literature into four considerations that may help choose among regulatory strategies.[358]

The first factor is heterogeneity—how much variation is there among harm-producing scenarios?[359] Where accident scenarios recur repeatedly, or fall into predictable templates, ex ante regulation may be cost effective. Where each accident is sui generis, determining optimal behavior before the fact may be difficult, which tends to favor ex post judgment.[360] With HFT, the risks are likely to be relatively heterogeneous. Every algorithm is unique. While

355. *See generally* REGULATION VERSUS LITIGATION: PERSPECTIVES FROM ECONOMICS & LAW (Daniel P. Kessler ed. 2011) (exploring trade-offs between two approaches to market failure: developing administrative rules to ensure private party compliance and allowing the courts to enforce standards set by private parties); Steven Shavell, *Liability for Harm versus Regulation of Safety*, 13 J. LEGAL STUD. 357 (1984) (comparing liability in tort with the regulation of safety in controlling activities that create risk of harm to others).

356. *See* Merrill & Schizer, *supra* note 36, at 211–16; Samuel Issacharoff, *Regulating After the Fact*, 56 DEPAUL L. REV. 375, 377–78 (2007); Robert Innes, *Enforcement Costs, Optimal Sanctions, and the Choice Between Ex-Post Liability and Ex-Ante Regulation*, 24 INT'L REV. L. & ECON. 29, 35 (2004); Donald Wittman, *Prior Regulation versus Post Liability: The Choice Between Input and Output Monitoring*, 6 J. LEGAL STUD. 193, 195–201 (1977).

357. As a simple example, consider the costs of determining a reasonable speed limit for each stretch of road versus the costs of asking a jury to determine whether the defendant was going too fast after an accident has occurred.

358. Merrill & Schizer, *supra* note 36, at 213–16.

359. *Id.* at 213.

360. *See id.* at 212–14.

the dangers involved can be categorized to some extent, the best preventive measures will depend sensitively on changing market conditions.[361] While best practices may be developed to minimize certain risks, it is likely some form of ex post regulation will also be needed, at least in the near term.

The second factor is the expected frequency and severity of the anticipated harm.[362] Frequent harms like car accidents and catastrophic harms like nuclear meltdowns may justify an up-front expenditure in determining optimal behavior ex ante.[363] For rare or less severe harms, it may be more expedient to wait for an accident to occur, and then assign responsibility.[364] With HFT, of course, life and limb are not at risk. In addition, most of the harms surveyed above are relatively small for any given victim. For these harms, ex ante regulation may not be worth the cost. An extreme volatility event, however, is a possible exception. Dramatic events like the Flash Crash can impose very large costs on society, and ex ante regulation may be justified to prevent their occurrence.

A third factor is the "settlement costs" associated with making ex post judgments.[365] Where responsibility for a harm is diffuse, or victims are numerous and difficult to identify, ex post liability may not be feasible as a mode of regulation.[366] Merrill and Schizer give the example of air pollution caused by automobiles.[367] Millions of drivers contribute to the harm, and millions of individuals are harmed, making assignment of liability virtually impossible.[368] As a result, ex ante rules designed to reduce exhaust pollution may be the only realistic regulatory possibility.[369] With HFT, the possible harms vary in their likely settlement costs. Front-running, for example, will usually have an identifiable victim and an identifiable perpetrator, and pose few problems for regulation by ex post liability. At the other end of the spectrum, major volatility spikes are likely to involve contributions from a multitude of

361. *See id*. at 213.
362. *Id*. at 213–14.
363. *Id*. at 214.
364. *Id*.
365. *Id*. (internal quotation marks omitted).
366. *Id*. at 214–15.
367. *Id*. at 215.
368. *Id*.
369. *Id*.

market actors, and affect millions of investors, making a system of ex post liability problematic. Phenomena like market manipulation, flash orders, and quote-stuffing fall somewhere in between, in that those harmed may be widely dispersed. It is important to note, however, that ex post liability can consist of fines levied by regulators and exchange operators, instead of or in addition to traditional tort-like liability.[370]

Finally, the novelty of the technology involved and the attendant risks may be an important factor.[371] With novel technology and circumstances, the harms involved and the best methods for avoiding them are unlikely to be fully understood with any great confidence.[372] Without significant experience, it may not be possible to develop efficient and effective ex ante regulations.[373] Here, the novelty of HFT and the uncertainty surrounding its risks argues strongly for some form of ex post liability, and for caution in undertaking comprehensive ex ante regulation.

To these factors, we can add the set of five "objectives" set forth by Congress in Section 11A of the Exchange Act to guide the SEC in constituting a national market system.[374] The following principles build off of those objectives and are intended to provide a starting point; a relatively uncontroversial set of propositions from which initial impressions can be drawn.

First, to the extent possible, the positive effects of HFT on efficient execution should not be destroyed. As detailed previously, at least under ordinary circumstances, HFT has led to dramatically improved speed of execution and far narrower spreads than prevailed even ten years ago.[375] Long-term investors benefit from a lower cost of trading as a result.[376] Thus, all else being equal, an option that preserves these benefits is preferable to one that destroys them.

370. *Id*. at 209.

371. *Id.* at 215.

372. *Id*.

373. *Id*. ("Without experience, we generally will be better off with some form of *ex post* regulation . . . . "The general lesson is that we need significant exposure to a novel technology before developing efficient *ex ante* regulations.")

374. *See supra* note 324 and accompanying text.

375. *See supra* text accompanying notes 134.

376. *See supra* notes 142 and accompanying text.

Second, competition—between traders and between trading venues—should typically be encouraged, rather than curtailed. Unfair or inefficient practices can endure only when customers are either ignorant or powerless to go elsewhere. Where true competition exists between trading venues, venues that enable or allow unfair, abusive, or destructive trading practices will be punished by the marketplace, as investors (and listers) take their business elsewhere.[377] Those that find innovative ways to reduce the risks associated with HFT will be rewarded and increase their market share. Thus, while harmonization of rules across trading venues may sometimes be necessary or desirable, it should not be allowed to smother the innovative power of competition, and should not be pursued for its own sake when it undercuts the ability of exchanges to compete on quality.

Third, in keeping with Congress's desire for quotation and transaction information to be widely available to market participants, transparency should be encouraged. As IOSCO has stated, "[m]arket transparency . . . is generally regarded as central to both the fairness and efficiency of a market, and in particular to its liquidity and quality of price formation."[378] Transparency as to procedures and structures is essential to competition among trading venues. Transparency as to quotations and orders—and as to real-time liquidity in general—is just as essential if competition among traders is to be effective in reducing volatility and improving price discovery. The more easily market participants can determine when and where liquidity is most needed, the more effectively they can compete to provide it.

Finally, where possible, arrangements that provide market actors incentives to avoid or rectify problems should be preferred to attempts to impose solutions from without. In recommending the SEC work with exchanges to encourage market makers to remain in the market during periods of extreme volatility, the Joint CFTC-SEC Committee candidly and admirably confessed that it "does not believe it is competent" to determine how best to do

377. Already, responding to market demand, trading venues are beginning to materialize that aim to exclude HFTs. *See* Philip Stafford, *New Platform Aims to Limit 'Flash' Orders*, FIN. TIMES (May 30, 2012), *available at* http://www.ft.com/intl/cms/s/0/3f8cf658-aa43-11e1-8b9d-00144feabdc0.html#axzz2g6kvmyjg (describing the planned creation of a new HFT-free trading venue, "respond[ing] to a market desire to do this").

378. IOSCO REPORT, *supra* note 134, at 3.

so.[379] This is undoubtedly true far more often than it is admitted. As a result, especially when dealing with sophisticated market participants, we might tend to be chary about measures that protect actors from the consequences of failing to protect themselves.

D. *A Regulatory Strategy for High-Frequency Trading*

With these principles in mind, we can now sketch an initial regulatory strategy. In brief, I would utilize at least some degree of best practices regulation, backstopped by liability to encourage risk-reducing innovation. In order to make ex post liability feasible, a consolidated audit trail should be developed, such that regulators and litigants can accurately and efficiently investigate incidents and assign responsibility. Finally, the risk of catastrophic volatility events like the Flash Crash should be controlled by an improved system of circuit breakers.

Utilizing at least some best practices regulation offers several advantages here. First, it can be used to control familiar risks and types of malfeasance, and regulate the most blatant forms of unfairness.[380] Second, it can provide some regulatory certainty for market participants, allowing them the predictability they need in order to invest in the necessary technology and human capital.[381] Perhaps most importantly, the existence of at least some body of public ex ante regulating would help to assure the public that regulators are aware of and seeking to control the risks of HFT.[382] This serves two purposes. First, it minimizes the risk of investors pulling their resources out of the markets and putting them to less productive use, in the belief that markets are unsafe or unfair. Second, it reduces the risk that opponents of HFT—many of whom have vested interests that are threatened by HFTs—will be able to use such fears to build support for a ban on HFT, which would destroy all of the benefits of the practice.

379. JOINT ADVISORY REPORT, *supra* note 279, at 10–11.

380. *See* Merrill & Schizer, *supra* note 36, at 150.

381. *See* Randall Billingsley, *Arbitrage, Hedging, and the Law of One Price*, FIN. TIMES (Nov. 4, 2005), *available at* http://www.ftpress.com/articles/article.aspx?p=417513 (explaining that "[t]he act of arbitraging mispriced assets should return prices to their appropriate values").

382. *Cf.* Ashutosh Bhagwat, *Modes of Regulatory Enforcement and the Problem of Administrative Discretion*, 50 HASTINGS L.J. 1275, 1312 (1999) (describing how ex ante regulating assures firms of regulator's intentions so that firms can clarify their positions).

Importantly, however, best practices regulation need not come entirely—or even primarily—from government regulators. The structure of the modern markets gives exchange operators and other so-called self-regulatory organizations the ability and incentive to enact many protective reforms themselves.[383] Such private ordering itself represents an appropriate regulatory strategy.

Best practices regulation has some drawbacks that prevent it from being fully effective in this context. First, such regulations can only be effective where regulators are able to enforce them.[384] Given the difficulties of effectively monitoring the markets, and the highly technical nature of the issues involved, enforcement is especially unlikely to be optimal. Second, HFT is a fast-changing field with a high degree of heterogeneity and novelty.[385] Best practices will undoubtedly develop over time, allowing ex post regulation to gradually be replaced by best practices regulation,[386] but the body of ex ante regulations must necessarily remain incomplete for the foreseeable future. Third, as noted above, best practices regulation may offer insufficient incentives for risk-minimizing innovations.[387]

383. Anthony Malakian, *The Industry Needs to Come Together on Policing Itself When it Comes to HFT*, WATERS TECH. (Oct. 18, 2012), http://www.waterstechnology.com/buy-side-technology/opinion/2218386/the-industry-needs-to-come-together-on-policing-itself-when-it-comes-to-hft; World Federation of Exchanges, *Understanding High Frequency Trading*, FOCUS (May 2013), http://www.world-exchanges.org/focus/2013-05/m-2-1.php; Zachary J. Ziliak, *Regulation Ahead: Advice and Options for Automated and High-Frequency Traders*, BLOOMBERG L., http://about.bloomberglaw.com/practitioner-contributions/regulation-ahead-advice-and-options-for-automated-and-high-frequency-traders/ (last visited Dec. 6, 2013); *The Laws That Govern the Securities Industry*, U.S. SEC. & EXCH. COMM'N, http://www.sec.gov/about/laws.shtml (last visited Dec. 6, 2013)

384. *Cf.* Vince Heaney, *High Frequency Traders' Claims Refuted by Studies*, FIN. TIMES (Sept. 30, 2012), http://www.ft.com/cms/s/0/2b1723c4-0704-11e2-92b5-00144feabdc0.html#ixzz2jEbSctKj (discussing a Federal Reserve Bank of Chicago study's finding that "many high frequency trading firms fail to implement all the industry's best practice recommendations or rely on other companies in the trade process to catch an out-of-control algorithm or erroneous trade"); Jeff Carter, *Is High Frequency Trading Good? Or Bad?,* TOWNHALL FIN. (June 28, 2012), http://finance.townhall.com/columnists/jeffcarter/2012/06/28/is_high_frequency_trading_good_or_bad/page/full (lamenting the failure of "ethical HFT traders" to "self polic[e] their own people").

385. *High Frequency Trading in FX: Open for Business*, AITE GROUP (Apr. 26, 2010), http://www.aitegroup.com/report/high-frequency-trading-fx-open-business.

386. Pierre Schlag, *Rules and Standards*, 33 UCLA L. REV. 379, 379–89 (1985) (pointing out the differences between a rule, such as Holmes' "stop and look" requirement at a railroad crossing, and a standard, such as Cardozo's "reasonable caution" requirement, and noting the development in new areas of law from rules to standards.).

387. Merrill & Schizer, *supra* note 36, at 263.

Liability rules help to address each of these drawbacks. Most important in this regard is to ensure that HFTs and those who sponsor their access to their markets are capable of making good on the obligations they incur from their trading activities. Few things are more destructive to the functioning of public securities markets than the introduction of significant counter-party risk.[388] HFTs and their facilitators must be required to demonstrate that they have the financial wherewithal to make good on any obligations that their algorithms—even unintentionally—cause them to incur.

Most importantly with respect to truly novel and catastrophic volatility risk, these regulatory measures should be backstopped by improved circuit breakers designed to temporarily halt trading in individual securities during periods of unusual volatility. Improved circuit breakers are already in the process of being implemented for most securities, and should help to limit the most troubling risk posed by HFT.[389]

VI. DESIGNING A REGULATORY REGIME FOR HIGH-FREQUENCY TRADING

In this part, I offer more detail about the proposed regulatory regime, together with consideration of the optimal institutional actors for implementing it.

A. *Consolidated Audit Trail*

The first step towards effective regulation of HFT is to implement a consolidated audit trail. At present, while trades that are actually executed are reported to the consolidated market data system, there is no single database providing comprehensive records of all order activity, including orders that are cancelled without being executed.[390] Each exchange instead uses its own

388. *See, e.g.*, Iman Anabtawi & Steven L. Schwarcz, *Regulating Systemic Risk: Towards an Analytical Framework*, 86 NOTRE DAME L. REV. 1349, 1394 (2011).

389. *See supra* note 286.

390. Press Release, SEC, SEC Approves New Rule Requiring Consolidated Audit Trail to Monitor and Analyze Trading Activity (July 11, 2012) [hereinafter July Press Release], *available at* http://www.sec.gov/News/PressRelease/Detail/PressRelease/1365171483188#.UkXTmMi3A0M.

system, with widely varying content, form, and quality.[391] With respect to HFTs, which often place and rapidly cancel enormous numbers of unexecuted orders, the lack of comprehensive data on unexecuted orders cripples attempts to monitor or even understand their activities. In the wake of the Flash Crash, it took regulators weeks and months to even partially reconstruct the trading activity over even a few hours.[392]

The SEC has already promulgated a rule requiring the national securities exchanges and FINRA to establish a market-wide consolidated audit trail, which is scheduled to be implemented in stages by 2015.[393] Creation of a consolidated audit trail, while certainly a technical challenge, should be relatively uncontroversial. It will help to address several of the difficulties mentioned above. First, by providing easily accessible records of orders and trades, available in near real time, it will greatly simplify the task of regulators, and improve their ability to enforce ex ante regulations.[394] Second, it will enable private parties injured by HFT manipulation or other activities the possibility of reconstructing trading activity to establish causation and responsibility.[395] More broadly, it will provide a wealth of information about HFTs' activities, allowing the development of better best practices regulation, and enabling market participants to understand HFT and protect themselves against parasitic or predatory strategies.

B. *Best Practices Regulation*

It is, of course, not possible to lay out a full program of best practices regulation here. Certainly it should include a clarification of what kinds of HFT activities qualify as market manipulation—namely, by expanding the definition given by Easterbrook and Fischel to include strategies where the placement and cancellation of large numbers of orders that are intended to move prices, even where there is no actual manipulative trading.[396] A program of best practices regulation should likely also include

391. *Id.*

392. *See supra* note 40 and accompanying text.

393. *See* 17 C.F.R. § 242.613 (2012); July Press Release, *supra* note 390.

394. July Press Release, *supra* note 390.

395. *See supra* text accompanying notes 124–33.

396. FRANK H., EASTERBROOK & DANIEL R. FISCHEL, THE ECONOMIC STRUCTURE OF CORPORATE LAW 253–54, 279–81 (1991).

requirements that trading algorithms—whether used by HFTs or by other algorithmic traders—be stress-tested against a full range of market conditions prior to being introduced into the real market.

Increasing transparency by requiring more information be provided in the consolidated data feed would also likely be beneficial. The ability to view the entire limit order book in real time, together with liquidity and order imbalance statistics, would allow traders to assess liquidity and compete to provide it when needed. Perhaps the only real argument against requiring such information to be provided to the consolidated feed is that it is unnecessary. Responding to market demand, most markets already make such information available in near real time for a fee,[397] and it is unclear whether many traders exist who could and would make use of such information, but lack access to it. The main impact of a regulatory requirement may thus be that the cost of providing the information is spread across the whole market, rather than being borne by the traders who profit most directly from it. Nonetheless, this may be desirable if the information leads to systemic improvements in liquidity and reductions in trading costs.

More useful than a catalog of such regulations, however, is a word of caution about how *not* to proceed, with an emphasis on various proposals for ex ante regulation that are problematic. Some commentators have called for a registration requirement for HFTs.[398] As an initial matter, there is no bright line between HFT and other forms of algorithmic trading. As a result, any registration requirement is likely to involve arbitrary line drawing and subsequent distortions as market actors adjust their activities to remain on one side of the line.[399] Furthermore, by adding compliance costs to trading, a registration requirement would hinder entry by new firms and degrade competition.[400] Registra-

397. *See NYSEOpenBook*, NYSE TECH., http://www.nyxdata.com/openbook) (last visited Dec. 6, 2013).

398. Nina Mehta, *High-Frequency Traders Should Be Registered to Aid Oversight, Chilton Says*, BLOOMBERG (Mar. 9, 2012), http://www.bloomberg.com/news/2012-03-09/boost-high-frequency-trading-firm-oversight-cftc-s-chilton-says.html.

399. Ziliak, *supra* note 383.

400. Edgar Ortega Barrales, *Lessons from the Flash Crash for the Regulation of High-Frequency Traders*, 17 FORDHAM J. CORP. & FIN. L. 1195, 1251–52 (2012).

tion is also likely to be of dubious value in policing HFT.[401] As an advisory group convened by the CFTC concluded—in a report recommending against registration of HFTs—"[f]ocus should be on specific behaviors that undermine market integrity irrespective of the means or pace of order entry."[402] A reliable audit trail is likely to be of far more value in detecting such behaviors, and without the distortions that would accompany a registration requirement.

Bans on whole types of HFT activity would face similar definitional problems, as they would inevitably overlap with legitimate trading strategies. Some, for example, have called for a wholesale ban of "layer[ing],"[403] but legitimate market making activities can involve placing and rapidly adjusting limit orders not easily distinguishable from objectionable layering.[404] Thus, such a ban would need to be crafted with great care to avoid disrupting legitimate activities in a way that harms liquidity. It should also be recalled that those most likely to be fooled by layering are other sophisticated traders and HFTs.[405] Not only are such traders likely able to protect themselves by designing better algorithms, but they are only fooled in the first place because they are engaging in a form of liquidity hunting that is itself of dubious value to the markets.[406] As a result, the net gains from bans are not necessarily compelling, as compared to a more limited strategy of targeting individual bad actors.[407]

Other crude steps to curb HFT activity, such as minimum order durations, are also potentially destructive with unclear bene-

401. Silla Brush, *High-Frequency Trading Registration Studied by U.S. Regulator*, BLOOMBERG (June 20, 2012), http://www.bloomberg.com/news/print/2012-06-20/high-frequency-trading-registration-studied-by-u-s-regulator.html.

402. *Id.*

403. *See* Prewitt, *supra* note 183, at 156.

404. *Compare* Jones, *supra* note 197, at 6 (describing limit orders as an instrument trading vendors use to allow market makers to quickly post and update their interest in particular trades), *with* Herbert Lash, *Update 2- Regulators Fine Trillium for Illicity "Layering" Trades*, REUTERS, Sept. 13, 2010, http://www.reuters.com/article/2010/09/13/financial-trillium-settlement-idusn1318717320100913 (describing layering as using non-bona fide limit orders to create the appearance of substantial buying or selling interest).

405. *See supra* text accompanying note 168.

406. *See supra* Part IV.

407. In addition to the Trillium case mentioend at notes 151–56, in September of 2012, the SEC levied $4 million in fines against Hold Brothers On-Line Investment Services for allowing its clients to engage in allegedly manipulative layering. *See* Whitney Kisling, *SEC Says New York Firm Allowed High-Speed Stock Manipulation*, BLOOMBERG (Sept. 25, 2012), http://www.bloomberg.com/news/2012-09-25/sec-says-new-york-broker-allowed-high-speed-stock-manipulation.html.

fits. The ability to readjust orders at a very high speed in reaction to changing market conditions is one of the primary drivers of the narrowing of spreads in the past decade. Reducing the speed at which market makers are allowed to react would necessarily require them to increase spreads to compensate for the increased risk of being wrong footed by changing conditions.[408] European regulators have recently voted to implement a 500 millisecond "minimum resting time" for orders.[409] Formal implementation is not due to occur until 2015,[410] but U.S. regulators would do well to wait to observe the effects in Europe before going down the same road.

Nor should regulators be overeager to protect exchange operators from HFTs. As noted above, the trading venues themselves have both the ability and the incentive to protect themselves against HFTs abusing market infrastructure or exploiting liquidity rebates without providing corresponding benefits. A one-size-fits-all solution imposed by regulators may simply serve to cut off competition among venues to develop optimal systems.

Similarly, as noted above, regulators should resist the temptation to protect sophisticated entities from the consequences of their own negligence. There is an inherent tension in trying to prevent harm from negligence in this context, in that the greatest harm tends to fall on the negligent party itself. With this in mind, a number of recent regulatory actions appear suspect. The SEC moved to ban "stub quotes" soon after the Flash Crash.[411] While this is unobjectionable in itself, stub quotes would not have existed in the first place except for poorly designed market making requirements, preventing market makers from leaving the market, but allowing meaningless participation via stub quotes.[412] The

408. Owain Self, head of algorithmic trading at the investment bank UBS, explained that "if you're trading an ETF . . . where the underlying price of the constituents could change thousands of times a second, and you are only allowed to update your quotes twice a second, you are going to have to have a wider spread to allow for that volatility on the underlying price. So spreads are bound to widen." *Minimum Resting Time*, *supra* note 136.

409. *Id.*

410. *Id.*

411. Proposed Rule Change Relating to Quotation Requirements on the Alternative Display Facility, Exchange Act Release No. 34–62,953, 75 Fed. Reg. 59,300, 59,300 (September 20, 2010) (internal quotation marks omitted). The SEC rule requires market makers to place bids and offers within a "band" around the best bid or offer—a band of 8% on either side for most securities. *Id.*; FINRA Manual § 6272(a)(5)(B)(i) (2011)).

412. *See* Testimony Concerning the Severe Market Disruption on May 6, 2010 Before the H. Subcomm. On Capital Mkts., 111th Cong. 8–9 (2010) (statement of Mary L.

SEC also quickly moved to require trading venues to clarify when trades would be cancelled as "clearly erroneous"—a subject of some confusion in the immediate aftermath of the Flash Crash.[413] Ironically, these two new rules may work together to injure retail traders. A market order by a retail investor[414] that executes against a stub quote would almost certainly be considered clearly erroneous, and would be cancelled. The 2010 rule disallows true stub quotes of a penny or $100,000, but allows quotes up to eight percent away from the best price under most circumstances—far enough away to injure an unsuspecting retail trader placing a market order, but not always far enough away to be cancelled as clearly erroneous.[415]

Cancellation of "clearly erroneous" trades is problematic for at least two additional reasons. First, and most related to negligence harms, perhaps the most likely party to an "erroneous" trade is the trader whose negligence precipitated the unwarranted price move in the first place.[416] To allow them out of the trade would be to allow the negligent party to escape some of the consequences of their negligence, reducing deterrence.

Furthermore, often the quickest way for the price of a security to recover from a sudden spike or plunge caused by trading irregularities is for arbitrageurs to enter the market and drive the price back toward fundamental value.[417] To reduce the risk involved, arbitrageurs typically attempt to hedge their trades.[418] If, for example, IBM plunges fifty percent for no apparent reason, an arbitrageur might simultaneously buy large amounts of IBM and

Schapiro, Chairman, U.S. Securities and Exchange Commission), *available at* http://www.sec.gov/news/testimony/2010/ts051110mls.pdf.

413. Proposed Rule Change to Amend FINRA Rule 11892 (Clearly Erroneous Transactions in Exchange-Listed Securities), Exchange Act Release No. 34–62,341, 75 Fed. Reg. 36,756, 36,756 (June 21, 2010).

414. A "market order" is an order seeking immediate execution at the best available price, no matter what that price is. *See supra* note 107.

415. The SEC rule generally requires a trade to be at 10% away or more from the average price over the preceding five-minute period to be broken as "clearly erroneous." *US to Adopt Harmonised Erroneous Trade Breaks*, THE TRADE NEWS (June 18, 2010), *available at* http://www.thetradenews.com/news/Trading___Execution/Regulation/US_to_adopt_harmonised_erroneous_trade_breaks.aspx.

416. *See* Press Release, U.S. Sec. & Exch. Comm'n, SEC Approves New Exchange Rules for Breaking Clearly Erroneous Trades (Oct. 5, 2009), http://www.sec.gov/news/press/2009/2009-215.htm.

417. Randall Billingsley, *Arbitrage, Hedging, and the Law of One Price*, FIN. TIMES (Nov. 4, 2005), http://www.ftpress.com/articles/article.aspx?p=417513&seqnum=3.

418. *See id.*

short an index fund. If, however, the trades in IBM are subsequently canceled as "clearly erroneous," while the hedging trades are not, the arbitrageur could be left with a large loss. The net result is to increase the risk to arbitrageurs of correcting severe mispricings. While clear rules for handling of erroneous trades are likely better than unclear rules, these considerations demonstrate the importance of proceeding with care in their design.

Also problematic are proposals for registration, review, and approval of new algorithms. While some regulation of new algorithms is likely justified, an advisory group convened by the CFTC to study the issue recently concluded that such measures "would be an ineffective use of budgetary resources with unclear benefits."[419] The potential problems with registration and audit are at least three-fold. First, given the ubiquity of algorithmic order execution, regulators would face serious definitional problems if they are to avoid micromanaging all trading. Second, regulators are highly unlikely to have—or to be able to obtain—the necessary expertise to do a better job of evaluating the soundness of new algorithms than the actual creators of those algorithms, who already have enormous incentives to ensure their safety and quality.

Third, in response to changing market conditions and a changing competitive landscape, HFTs (and other traders) adjust their algorithms and introduce new ones on a continuous basis. The life cycle of a typical HFT algorithm can be as short as a few weeks.[420] Not only would this speed of turnover swamp the resources of regulators, but anything other than the most cursory review process would radically slow the speed at which new algorithms could be developed, introduced, and improved. This could result in an undesirable choking off of innovation in what is still very much a maturing industry. It could also result in older algorithms remaining in the market longer, where they will be more vulnerable both to changing market conditions that render them suboptimal, and also to reverse engineering and exploitation by other traders.

419. Brush, *supra* note 401.

420. *See* Frank Partnoy, *Don't Blink: Snap Decisions and Securities Regulation*, 77 BROOK. L. REV. 151, 172 (2011).

Thus, despite the surface appeal of greater regulatory supervision of HFTs, in practice, regulators must tread carefully, lest the costs and disruptions involved swamp any tangible improvements. Nor is window-dressing regulatory approval simply harmless. Indeed, there is some risk that regulatory approval—even where such approval is of dubious value—will come to substitute for more effective diligence by HFTs themselves. Just as mortgage brokers and investment banks were able to hide behind ratings agencies and Fannie Mae during the mortgage securitization debacle, HFTs whose algorithms go rogue could plausibly deflect accountability by pointing to SEC or CFTC approval of those algorithms as evidence they took appropriate care.

C. *Ex Post Liability*

Ex post liability can mean at least two things in this context. Most obviously, it means tort-like liability to parties who are harmed by HFT misconduct. In this sense, plaintiffs will be able to take advantage of the doctrine of negligence per se to recover from HFTs who engage in market manipulation or otherwise fail to comply with applicable protective regulation. Private litigation can serve to supplement regulatory enforcement actions as deterrence to wrongdoing. Perhaps more importantly, litigants can attempt to demonstrate that behavior that is not covered by ex ante regulation was nonetheless wrongful under the particular circumstances. As such, liability can not only remedy incomplete enforcement, but also incomplete regulatory coverage.

More important than tort liability, however, is straightforward contract liability. As the example of Knight Capital Group shows, a single rogue algorithm is capable of generating hundreds of millions of dollars in losses before human intervention is able to rein it in.[421] In the event, Knight had sufficient trading capital to cover its losses, though doing so effectively destroyed the firm.[422] It is quite possible, however, for HFTs' algorithms to generate losses beyond those HFTs' ability to pay, thus introducing counterparty risk to the public securities markets.

Protecting against this risk should be a regulatory priority. Neither regulatory fines nor liability regimes can be effective in

421. Ruhle et al., *supra* note 232.

422. *Id.*

achieving their deterrence and compensation goals if defendants are insolvent.[423] Private solutions to insolvency risk, such as insurance and bonding, are potentially available.[424] Indeed, exchanges and brokerages generally require posting of collateral, and all manner of engineered insurance mechanisms are available.[425] Such private solutions may not be fully effective where HFTs have naked access to an exchange via a sponsoring exchange member.[426] In the immediate wake of the Flash Crash, the SEC moved to ban naked access.[427] While this is a measure that likely could have been taken by trading venues themselves, if subjected to competitive pressure, it at least serves to make clear the responsibility (and liability) of the sponsoring broker for trades made using their systems. It is unclear, though, whether such clarity actually necessitates orders being physically routed through the exchange member's systems, as the SEC proposal requires. This requirement may create unnecessary latency issues for sponsored traders, while not reducing risk any more than a simple requirement of liability for the sponsoring member.

If these measures fail to eliminate HFT-generated counterparty risk, a mixed liability/government insurance regime may be feasible. The FDIC is an example of such a system.[428] Under such a regime, algorithmic traders could be required to contribute to a central fund that would cover liabilities if the responsible trader becomes insolvent. The fund could be backed up by taxpayers. The result is a responsibility waterfall: first the responsible firm to the limit of its resources, then the fund, then the government. Firms could be assessed fees according to their level of risk in order to mitigate moral hazard.

D. *Improved Circuit Breakers*

Improved circuit breakers have probably received the most regulatory attention in the wake of the Flash Crash. This single,

423. *See* Merrill & Schizer, *supra* note 36, at 249.

424. *Id.*

425. *See, e.g.*, *id.* at 249–50.

426. Yoon, *supra* note 100, at 928–29; *see supra* 296–97 and accompanying text.

427. *See supra* note 297 and accompanying text.

428. 12 U.S.C. § 1821 (2012). Examples abound in other industries as well. *See, e.g.*, The Oil Pollution Act, 33 U.S.C. § 2712 (2010) (regarding oil spills); The Price Anderson Act, 42 U.S.C. § 2210 (2006) (regarding nuclear accidents).

relatively simple measure is likely sufficient to mitigate the most unique and dangerous risk associated with HFT. Single-stock circuit breakers were among the first regulatory proposals rolled out, and implementation of improved market-wide circuit breakers and a full limit up-limit down system for individual securities is imminent.[429] While some have questioned the complexity of the new rules,[430] circuit breakers are the most straightforward way to prevent a repeat of the major dislocations of the Flash Crash or the smaller dislocations seen in the numerous mini-Flash Crashes before and since. Particularly once the limit up-limit down procedures are fully in place, such systems should prevent the worst incidences of extreme volatility while preserving the positive benefits of HFT. While individual trading venues could implement circuit breakers themselves—and would have incentives to do so if investors believed them to be beneficial—the reality of a national market system likely makes harmonization necessary. If one trading venue were to institute a trading halt while others did not, spillover trading in the affected securities—and related derivatives—could flow to and overwhelm other trading venues.[431]

CONCLUSION

The market events of May 6, 2010 were a wake-up call that the new world of HFT brought with it new dangers, in addition to its benefits. Thus far, however, a scholarly debate on how best to approach HFT—or even to think about the issues involved—has been strangely lacking in the legal literature. This article seeks to begin the conversation. As such, I have provided at least a sketch

429. Exchange Act Release No. 62,252, *see supra* note 42, at 8–9, 11. The new procedures were scheduled to be introduced in February, 2013, but have now been delayed until at least April. *See FINRA Pushes Back Circuit Breaker Implementation*, CME GROUP (Feb. 7, 2013), http://www.cmegroup.com/education/market-commentary/industry-news/2013/02/pre-open-industry-news_295.html?source=rss; Anish Puarr, "Market Opts for Cautious US Circuit Breaker Rollout," THE TRADE NEWS (Jan. 8, 2013), http://www.thetradenews.com/USA/newsarticle.aspx?id=6442451270.

430. *See, e.g.*, Tom Steinert-Threlkeld, *Switching Chairs at SEC Delays Market Structure Changes*, SEC. TECH. MONITOR (Jan. 24, 2013), *available at* http://www.securitiestechnologymonitor.com/news/switching-chairs-at-sec-delays-market-structure-changes-31551-1.html? (quoting one trader as saying "I kind of fear [the new rules] will make markets more complex" and another as saying "If anybody really understood [how to carry out the rules], I would be really surprised").

431. *See* IOSCO REPORT, *supra* note 134, at 58–59.

of the main forms of HFT activity, and attempted to erect a useful framework for considering regulation of those activities.

This framework is a mix of structural reform and regulation. A core element of the strategy is best practices regulation, which will serve to reassure a worried public, and can gradually expand as we develop more experience and knowledge of HFT. Meanwhile, continuing private incentive to develop improved best practices can be maintained by backstopping regulation with a robust regime of liability. Such a backstop will also allow regulators the luxury of not being forced to mandate best practices before we know enough to do so effectively. A key challenge in such a liability regime is ensuring that defendants do not escape liability via insolvency, a problem addressed above.

Aiding both of these regulatory strategies will be a consolidated audit system ensuring that reliable and comprehensive information regarding HFT is generated in close to real time. A consolidated audit trail would allow regulators and private actors to rapidly reconstruct all trading activity and identify the parties responsible for each order. Such a system will enable the quick investigation of unusual market events and, if appropriate, the reliable assignment of liability to the responsible parties. It will also provide a valuable source of data for identifying emerging risks and designing new regulatory strategies to address those risks.

Finally, the most novel and dangerous risk posed by HFT—the risk of catastrophic volatility spikes like the Flash Crash—can be prevented by improved market-wide circuit breakers designed to temporarily halt trading in individual securities during periods of unusual volatility.

A full program of regulation is well beyond the scope of this article. The general framework presented here is targeted to the particular risks of HFT, but avoids measures that threaten to undermine the liquidity and efficiency benefits of HFT while providing only questionable protection against the targeted harms.