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The New Investor

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ABSTRACT

A sea change is happening in finance. Machines appear to be on the rise and humans on the decline. Human endeavors have become unmanned endeavors. Human thought and human deliberation have been replaced by computerized analysis and mathematical models. Technological advances have made finance faster, larger, more global, more interconnected, and less human. Modern finance is becoming an industry in which the main players are no longer entirely human. Instead, the key players are now cyborgs: part machine, part human. Modern finance is transforming into what this Article calls cyborg finance.

This Article offers one of the first broad, descriptive, and normative examinations of this sea change and its wide-ranging effects on law, society, and finance. The Article begins by placing the rise of artificial intelligence and computerization in finance within a larger social context. Next, it explores the evolution and birth of a new investor paradigm in law precipitated by that rise. This Article then identifies and addresses regulatory dangers, challenges, and consequences tied to the increasing reliance on artificial intelligence and computers. Specifically, it warns of emerging financial threats in cyberspace, examines new systemic risks linked to speed and connectivity, studies law's capacity to govern this evolving financial landscape, and explores the growing resource asymmetries in finance. Finally, drawing on themes from the legal discourse about the choice between rules and standards, this Article closes with a defense of humans in an uncertain financial world in which machines continue to rise, and it asserts that smarter humans working with smart machines possess the key to better returns and better futures.

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INTRODUCTION

The end is near for the human investor.[1] Computers have changed everything.

In May 2010, the Dow Jones Industrial Average lost one thousand points in a matter of minutes, destroying nearly $1 trillion in market value for no apparent reason.[2] After months of investigation, the culprit turned out to be automated computer programs.[3]

One of the most important developments of the past century is the growing and pervasive presence of computers in modern life. The first computer was invented in 1941.[4] In 1946, it acquired electronic memory and software.[5] In 1950, the first commercially produced computer was built.[6] In 1952, computers predicted the presidential election.[7] By 1969, they were common in corporate America.[8] In 1983, the computer was named *Time* magazine's "Machine of the Year" in lieu of a "Person of the Year."[9] By 1991, it connected the world through the internet.[10] In 1997, the computer became world chess champion.[11] By 2003, the computer became a part of a majority of American homes.[12] And in 2011, it became

1. The human investor has long been the main character of modern financial regulation. *See, e.g.*, H.R. REP. NO. 73-1383, pt. 2, at 5 (1934) (focusing on investor protection during the enactment of the Securities Exchange Act of 1934); H.R. REP. NO. 73-85, pt. 1, at 2 (1933) (emphasizing the protection of investors as the purpose of the Securities Act of 1933); Ralph K. Winter, *On "Protecting the Ordinary Investor,"* 63 WASH. L. REV. 881, 882–83 (1988) (noting that safeguarding investors is a primary goal of securities regulation).
2. Graham Bowley, *Dow Falls 1,000, Then Rebounds, Shaking Market*, N.Y. TIMES, May 7, 2010, at A1.
3. Graham Bowley, *Lone Sale of $4.1 Billion in Contracts Led to 'Flash Crash' in May*, N.Y. TIMES, Oct. 2, 2010, at B1.
4. *See* DIANA H. HOOK & JEREMY M. NORMAN, ORIGINS OF CYBERSPACE: A LIBRARY ON THE HISTORY OF COMPUTING, NETWORKING, AND TELECOMMUNICATIONS 78 (2002).
5. *See id.* at 85–86.
6. Norman E. Fry, *Univac*, *in* HISTORICAL DICTIONARY OF THE 1940S, at 390 (James G. Ryan & Leonard Schlup eds., 2006).
7. CARL REYNOLDS & PAUL TYMANN, SCHAUM'S OUTLINE OF PRINCIPLES OF COMPUTER SCIENCE 11 (2008).
8. PAUL E. CERUZZI, A HISTORY OF MODERN COMPUTING 110 (2d ed. 2003).
9. *Time* typically chooses a "Person of the Year," but in 1983 the distinction was granted to a machine for the first time. *See* Otto Friedrich, *The Computer Moves In*, TIME, Jan. 3, 1983, at 14.
10. The World Wide Web debuted on December 25, 1990. *See* STEPHANIE SAMMARTINO MCPHERSON, USA TODAY, TIM BERNERS-LEE: INVENTOR OF THE WORLD WIDE WEB 5 (2010).
11. FENG-HSIUNG HSU, BEHIND DEEP BLUE: BUILDING THE COMPUTER THAT DEFEATED THE WORLD CHESS CHAMPION, at ix (2002).
12. *See* S. CRAIG WATKINS, THE YOUNG AND THE DIGITAL: WHAT THE MIGRATION TO SOCIAL-NETWORK SITES, GAMES, AND ANYTIME, ANYWHERE MEDIA MEANS FOR OUR FUTURE 3 (2009).

Jeopardy! champion.[13] Now, it is an inextricable, existential part of modern life and business.

Computers have changed our world in profound and prosaic ways. This change is especially consequential and pronounced in finance.[14] Computer technology has made finance faster, larger, more global, and more interconnected in form and function.[15] An industry once monopolized by humans has evolved into an industry in which machines play a larger and more influential role. Modern finance is a stage on which the main players are no longer entirely human.[16] Instead, they are cyborgs: part machine, part human. Modern finance is transforming into what this Article calls "cyborg finance," or "cy-fi." This sea change is ongoing, incomplete, and without a final judgment on its normative impact and consequences.

This Article offers one of the first broad, descriptive, and normative examinations of this transformation and its wide-ranging effects on law, society, and finance. The aim of this Article is twofold: First, it strives to capture a descriptive snapshot of the changing landscape in finance that is a result of the rise of artificial intelligence and computerization. Second, building on that picture, this Article aims to identify and address the larger normative consequences for law, society, and finance. Undoubtedly, such an attempt to capture and forecast the story of the constantly evolving modern financial landscape will be incomplete, dated, and tentative.[17] Yet, it must be told and studied, for its transformative effects have grown too large and too important to ignore.

This Article narrates this story and study in five parts. Part I sets the stage. It places the ongoing financial sea change within a larger social context in which

13. John Markoff, *Computer Wins on 'Jeopardy!': Trivial, It's Not*, N.Y. TIMES, Feb. 17, 2011, at A1.

14. *See* Andrew G. Haldane, Exec. Dir., Fin. Stability, Bank of Eng., The Race to Zero, Speech at the International Economic Association Sixteenth World Congress, Beijing, China 3 (July 8, 2011), http://www.bankofengland.co.uk/publications/speeches/2011/speech509.pdf (discussing transformational changes in financial markets over the last century).

15. As indicia of modern finance's global nature, the U.S. Supreme Court recently opined on a securities case involving Australian securities purchased abroad and litigated under federal law. *See* Morrison v. Nat'l Austl. Bank Ltd., 130 S. Ct. 2869 (2010); *see also* Stephen J. Choi & Andrew T. Guzman, *Portable Reciprocity: Rethinking the International Reach of Securities Regulation*, 71 S. CAL. L. REV. 903, 905–07 (1998) (noting that the "internationalization of capital markets continues at a dramatic pace" as a result of technology); Merritt B. Fox, *Securities Disclosure in a Globalizing Market: Who Should Regulate Whom*, 95 MICH. L. REV. 2498, 2501–03 (1997).

16. *See* Shirley J. Ho & Sushanta K. Mallick, The Impact of Information Technology on the Banking Industry: Theory and Empirics 2 (Nov. 7, 2006) (unpublished manuscript) (describing the prominent role of computers in modern banking).

17. Charles Reich concedes a similar sentiment in his commentary of the then-transforming and transformative role of government on property, wealth, and individualism. *See* Charles A. Reich, *The New Property*, 73 YALE L.J. 733, 733 (1964) ("Inevitably, such an effort must be incomplete and tentative. But it is long past time that we began looking at the transformation taking place around us.").

machines are playing greater and more critical roles. Part I describes how the ascent of machines has changed the way we live, love, work, and play. It then describes how that ascension has also transformed modern finance into cyborg finance—a faster, larger, more global, more interconnected, and less human industry.[18]

Part II introduces a protagonist. It examines how changes in finance have transformed prevailing understandings of financial regulation's main character, "the investor," and how law must better account for this metamorphosis. Part II begins with a discussion about the conceptual evolution of the investor from "the reasonable investor" to "the irrational investor" to "the new investor." Part II then presents a dossier of "the new investor," highlights characteristics that make it distinct from previous paradigms, and alludes to the hope possessed by "the new investor."

Part III injects danger into the framework. It warns of perils created and mutated by cyborg finance. Part III recounts the Flash Crash of 2010,[19] which destroyed nearly $1 trillion in market capitalization in minutes, and cautions about future crashes. Part III then highlights new financial vulnerabilities by discussing the threats of hackers, worms, viruses, spies, thieves, and other antagonists. Ultimately, it calls for greater regulatory vigilance about such threats, but it cautions against thoughtless overreactions that would inhibit the "generativity" of cy-fi.[20]

Part IV foreshadows and contends with emerging systemic issues. It explores several key emerging normative consequences. First, Part IV warns of two systemic risks borne out of the enhanced velocity and connectivity of cyborg finance that this Article has respectively termed "too fast to save" and "too linked to fail." It suggests that these two emerging, systemic risks warrant more regulatory attention. Second, Part IV comments on the ongoing race between law and finance, and it discusses the contest's larger effects as finance continues to outpace law. It identifies mismatches in jurisdiction and origination as core problems of law's lagging performance. Third, Part IV studies the impact of growing resource disparities between the regulators and the regulated, and among players within the financial industry.

18. While cyborg finance is ubiquitous throughout all facets of modern finance, it is most prominent in equity markets. Thus, this Article gives special emphasis to cyborg finance in connection with equity markets.

19. *See generally* COMMODITY FUTURES TRADING COMM'N & SEC. & EXCH. COMM'N, FINDINGS REGARDING THE MARKET EVENTS OF MAY 6, 2010, at 1 (2010), *available at* http://www.sec.gov/news/studies/2010/marketevents-report.pdf (summarizing and evaluating the events occurring on May 6, 2010) [hereinafter CFTC & SEC FINDINGS].

20. Jonathan Zittrain suggested that the internet and its related information technology contained an inherent capacity for innovation that he called "generativity." *See* Jonathan L. Zittrain, *The Generative Internet*, 119 HARV. L. REV. 1975, 1980 (2006) ("Generativity denotes a technology's overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences.").

Part V looks further into the future. It offers a defense for humans in finance and society as machines rise. It predicates this defense on the persistence of randomness and the necessity of humans in an era of ascendant machines. Part V offers testimony about the limitations of computers and artificial intelligence in life and finance. It then cross-examines modernity's choice between humans and machines as a recasting of law's choice between rules and standards.[21] Part V rests with an exposition on the essential symbiosis between smarter humans and smart machines as the key to better returns and better futures in an uncertain world.

I. THE RISE OF MACHINES

A chief attribute of the recent past, the ongoing present, and the coming future is the rise of machines and the increasing reliance on computers and artificial intelligence. In 1965, Gordon Moore, the founder of Intel, predicted that the number of components on integrated circuits would increase exponentially about every two years and costs would fall correspondingly, leading to incredible progressions in computing power and electronic processing capacity.[22] Moore's prediction turned out to be so accurate that it is now commonly known as "Moore's Law."[23] Since then, technological advances have made computing power and digital storage faster, cheaper, and smaller.[24] The average smartphone today has more computing capacity than large mainframe computers in previous eras.[25] A single iPhone today possesses more computing power than NASA did during its first lunar mis-

21. For an overview of the legal debate between rules and standards, see Colin S. Diver, *The Optimal Precision of Administrative Rules*, 93 YALE L.J. 65 (1984), Louis Kaplow, *Rules Versus Standards: An Economic Analysis*, 42 DUKE L.J. 557 (1993), Seana Valentine Shiffrin, Essay, *Inducing Moral Deliberation: On the Occasional Virtues of Fog*, 123 HARV. L. REV. 1214 (2010), Kathleen M. Sullivan, *The Supreme Court, 1991 Term—Foreword: The Justices of Rules and Standards*, 106 HARV. L. REV. 22 (1993), and Cass R. Sunstein, *Problems With Rules*, 83 CALIF. L. REV. 953 (1995).

22. Gordon E. Moore, *Cramming More Components Onto Integrated Circuits*, ELECTRONICS, Apr. 19, 1965, at 114, 114–15.

23. *See* NICHOLAS CARR, THE BIG SWITCH: REWIRING THE WORLD, FROM EDISON TO GOOGLE 58 (2009).

24. *See* NICHOLAS CARR, THE SHALLOWS: WHAT THE INTERNET IS DOING TO OUR BRAINS 83 (2011) ("[T]he price of a typical computing task has dropped by 99.9 percent since the 1960s."); ORG. FOR ECON. CO-OPERATION AND DEV. (OECD), 21ST CENTURY TECHNOLOGIES: PROMISES AND PERILS OF A DYNAMIC FUTURE 9 (1998) (stating that "[f]aster, cheaper, [and] smaller" are the key objectives of the technology sector); Chip Walter, *Kryder's Law*, SCI. AM., Aug. 2005, at 32.

25. *See, e.g.*, *How Your Nokia Smartphone Compares With PCs of the Past*, CONVERSATIONS BY NOKIA (Mar. 18, 2011), http://nokiaconnects.com/2011/03/18/how-your-nokia-smartphone-compares-with-pcs-of-the-past (describing how a smartphone contains thousands of times the memory and processing power of the average 1980s computer).

sion.[26] Such technological progress has led to an increasingly ubiquitous presence of machines in our world.[27] This ascent of machines has had a profound impact on society in general and on finance in particular.

A. In Society

The increased reliance on machines, particularly computers, has had significant social effects. A generation ago, computers were bulky, sedentary tools for data computation and word processing; not every business or home had one. Today, computers are everywhere, in every form—from large mainframes to pocket-sized smartphones, from desktops to laptops, from visible to invisible.[28] Globally, more than 350 million personal computers were sold in 2011 alone.[29] And because of high-speed connectivity and the internet, in many parts of the world, anyone with a computer or smartphone has instant access to a plethora of information, services, and entertainment.[30] Compared to bulky, obtuse computers of previous generations, today's computers are smart machines powered by artificial intelligence.[31] Computers and their progeny have changed the way we learn, think, work, play, love, and live.[32] In short, just as humans have changed computers, computers have changed humans.[33]

26. MICHIO KAKU, PHYSICS OF THE FUTURE: HOW SCIENCE WILL SHAPE HUMAN DESTINY AND OUR DAILY LIVES BY THE YEAR 2100, at 21 (2011).
27. *See* CARR, *supra* note 23, at 45–56 (tracing the creation and proliferation of computers); MAURICE ESTABROOKS, ELECTRONIC TECHNOLOGY, CORPORATE STRATEGY, AND WORLD TRANSFORMATION 2 (1995).
28. *See* DEBORAH MORLEY, UNDERSTANDING COMPUTERS IN A CHANGING SOCIETY 44 (4th ed. 2011).
29. *See* Press Release, Gartner, Inc., Gartner Says PC Shipments to Slow to 3.8 Percent Growth in 2011; Units to Increase 10.9 Percent in 2012 (Sept. 8, 2011), http://www.gartner.com/it/page.jsp?id=1786014&source=email_rt_mc.
30. *See* WILLIAM POWERS, HAMLET'S BLACKBERRY: BUILDING A GOOD LIFE IN THE DIGITAL AGE 14 (2010) ("For the last decade, we've worked hard to bring digital connectedness into every available corner of existence and, once it's there, to make it ever faster and more seamless.").
31. Steven Levy, *The AI Revolution*, WIRED, Jan. 2011, at 88 (describing the rise of artificial intelligence in modern life).
32. *See, e.g.*, STACEY L. EDGAR, MORALITY AND MACHINES: PERSPECTIVES ON COMPUTER ETHICS 1 (2003); EUGENE F. PROVENZO, JR. ET AL., COMPUTERS, CURRICULUM, AND CULTURAL CHANGE: AN INTRODUCTION FOR TEACHERS 18 (2005); SHERRY TURKLE, THE SECOND SELF: COMPUTERS AND THE HUMAN SPIRIT 287–88 (MIT Press 20th anniv. ed. 2005) (1984) ("[Computers and] the Internet changed every aspect of life in communications, economics, politics, and the arts. But [they] also changed how we saw ourselves and our relationships."); Stephen Marche, *Is Facebook Making Us Lonely?*, ATLANTIC, May 2012, at 62 ("In a world consumed by ever more novel modes of socializing, we have less and less actual society. We live in an accelerating contradiction: the more connected we become, the lonelier we are.").
33. *See* CARR, *supra* note 24, at 6–8 (discussing how the internet affects our cognitive functions and abilities); SHERRY TURKLE, ALONE TOGETHER: WHY WE EXPECT MORE FROM TECHNOLOGY

Computers have increased business productivity and enhanced personal efficiency.[34] Assembly lines of laborers have been replaced by computer-operated robots, which can often perform tasks with greater precision at lower costs.[35] Online retailers such as Amazon now use robots in their distribution centers to help fill orders at cheaper rates and higher speeds.[36] Artificial intelligence software is replacing journalists in writing news stories.[37] Digital forms that computers process in seconds have replaced reams of hand-filled documents that previously required countless hours of human labor to process.[38] Entire businesses and labor categories have shrunk or disappeared from plain view because of computerization and automation.[39] Think about the last time you used a travel agency to book a flight. Or the last time you used a phone book to look for a phone number.[40] Many of these machine-driven changes have made business activities more productive and personal activities more efficient.[41]

AND LESS FROM EACH OTHER 279–81 (2011) (discussing how technology affects human behavior).

34. *See, e.g.*, Quentin Hardy, *The Matrix of Soap*, FORBES, Aug. 22, 2011, at 32 (reporting on how one company utilizes supercomputer data analysis to manage its global businesses in real time); Daniel Lyons, *Who Needs Humans*, NEWSWEEK, July 25, 2011, at 28 (discussing how robotics has changed labor force composition).

35. *See, e.g.*, JOHN MAYNARD KEYNES, *Economic Possibilities for Our Grandchildren*, *in* ESSAYS IN PERSUASION 358, 364 (Norton Library 1963) (1931) (warning of a "new disease" of "technological unemployment," in which jobs are lost because of rapid technological progress (emphasis omitted)); David H. Autor et al., *The Skill Content of Recent Technological Change: An Empirical Exploration*, 118 Q.J. ECON. 1279 (2003) (explaining how computerization accelerates the substitution of machinery for human labor).

36. *See* Joseph Galante, *Rise of the Orange Machines*, BUS. WK., Nov. 15, 2010, at 47.

37. *See* Steven Levy, *The Rise of the Robot Reporter*, WIRED, May 2012, at 132.

38. IAN AYRES, SUPER CRUNCHERS: WHY THINKING-BY-NUMBERS IS THE NEW WAY TO BE SMART 129 (2007).

39. *See* W. Brian Arthur, *The Second Economy*, MCKINSEY Q., Oct. 2011, at 92 (discussing how technology has replaced human labor with electronic and digital processes in many areas).

40. For readers in the distant future, there was a time when individuals in this country used a large bulky book printed on low-stock paper weighing multiple pounds to locate the telephone number of businesses and individuals manually. For a history of phone books, see AMMON SHEA, THE PHONE BOOK: THE CURIOUS HISTORY OF THE BOOK THAT EVERYONE USES BUT NO ONE READS (2010).

41. This increase in productivity has arguably come at some cost to individuals and society. For individuals, it could be argued that our brains have become less adept at deep thought because of increased reliance on computers. For society, it could be argued that virtual interactions and online connections have taken the place of meaningful physical interactions and real connections. *See* CARR, *supra* note 24, at 120–26 (explaining how the internet affects our cognitive functions); JARON LANIER, YOU ARE NOT A GADGET: A MANIFESTO 1–14 (2010) (noting the social effects of computerization); POWERS, *supra* note 30, at 50–52 (explicating on the detrimental symptoms of digital technology); TURKLE, *supra* note 32, at 279–81 (discussing how computers affects interpersonal and intrapersonal behavior).

In addition to increasing business productivity and personal efficiency, the use of computers has also increased our capacity to be informed and, thus, to act with better information. Modern data analysis with supercomputers has made everyone with a smartphone a walking encyclopedia.[42] Arguments about trivia, questions about directions, and curiosities about the esoteric can readily be satisfied by a few simple taps or voice commands to one's smartphone.[43]

Beyond mere access to more information, modern machines have changed the way we evaluate and respond to information. Data aggregation, analysis, retrieval, and transmission by computers on grand scales, collectively and colloquially referred to as Big Data, are changing the way we process information, what we learn from that information, and how we behave based on that information.[44] Supercomputers are now used to predict when and where storms will strike with meaningful accuracy.[45] Computer analysis of Shakespeare's plays is modifying the way we understand the Bard.[46] Data analysis has created a new field of sports scouting, known as sabermetrics.[47] Computers sorting through mountains of data are advising candidates on how to campaign for political office.[48] Data analysis by companies like Netflix and Amazon has altered how we make purchases and select entertainment.[49] Modern machines have even changed the way people date (and find love) using data.[50]

The future holds more promises from computerized machinery in a host of different fields and functions. Big Data will change consumer habits in ways that

42. *See* AYRES, *supra* note 38, at 154 ("The ability to digitalize and store information means that any laptop with access to the Internet can now access libraries several times the size of the library of Alexandria.").
43. *See* David Pogue, *New iPhone Conceals Sheer Magic*, N.Y. TIMES, Oct. 12, 2011, at B1 (describing the speech recognition features of the iPhone 4S).
44. *See, e.g.*, NATE SILVER, THE SIGNAL AND THE NOISE: WHY SOME PREDICTIONS FAIL—BUT SOME DON'T 9–10 (2012); Andrew McAfee & Erik Brynjolfsson, *Big Data: The Management Revolution*, HARV. BUS. REV., Oct. 2012, at 60, 62–68 (discussing Big Data's impact on corporations); Ashlee Vance, *The Data Knows*, BUS. WK., Sept. 12, 2011, at 71 (reporting on the impact of data analysis on individual and societal behavior).
45. *See* Eliza Strickland, *Supercomputers Predict a Stormy Hurricane Season*, IEEE SPECTRUM, July 2011, at 11.
46. *See* Tom Post, *Bits and the Bard*, FORBES, June 27, 2011, at 46.
47. *See* GABRIEL B. COSTA ET AL., PRACTICING SABERMETRICS: PUTTING THE SCIENCE OF BASEBALL STATISTICS TO WORK 5–8 (2009).
48. *See* Julianna Goldman, *The Obama Campaign's Secret Weapon: Geeks*, BUS. WK., Dec. 19, 2011, at 39.
49. *See* AYRES, *supra* note 38, at 19–20.
50. *See* Nick Paumgarten, *Looking for Someone*, NEW YORKER, July 4, 2011, at 36, 37–38; Jenna Wortham, *With an App, Your Next Date Could Be Just Around the Corner*, N.Y. TIMES, Nov. 3, 2011, at A1.

we cannot fully foresee.[51] Robots will likely play a larger role in warfare and other military affairs.[52] Computers will probably make activities like driving unmanned efforts.[53] Google has already built a car that drives itself using artificial intelligence.[54] In sum, whereas society once viewed computers as crude machines of limited utility, society now views modern computerized machines as intelligent, indispensible tools—with many yet unrealized possibilities—that are becoming more intertwined with our very existence.[55]

B. In Finance

Over the last quarter century, computerization and artificial intelligence have revolutionized finance, and they continue to fundamentally transform finance from an industry dominated by humans to one in which humans and machines share dominion.[56] Modern finance is cyborg finance, an industry in which the key players are part human and part machine.

This transformation resulted from advances in technology and regulatory reforms over the last few decades. Beginning in the 1990s, advances in technology encouraged the Securities and Exchange Commission (SEC) to introduce reforms

51. *See generally* Natasha Singer, *You for Sale*, N.Y. TIMES, June 17, 2012, at BU1 (reporting on the development of consumer data analytics and the potential privacy and customer classification concerns that may result).

52. *See* Elizabeth Bumiller & Thom Shanker, *War Evolves With Drones, Some Tiny As Bugs*, N.Y. TIMES, June 20, 2011, at A1 (reporting on the United States's increased use of unmanned aerial drones in warfare); John Markoff, *War Machines: Recruiting Robots for Combat*, N.Y. TIMES, Nov. 28, 2010, at A1 (discussing the impact of robotics on future warfare).

53. At the same time, certain technological advances have actually made humans more likely to perform some routine tasks. *See, e.g.*, Craig Lambert, *Our Unpaid, Extra Shadow Work*, N.Y. TIMES, Oct. 30, 2011, at SR12 ("Although the automatons were supposedly going to free people by taking on life's menial, repetitive tasks, frequently, technological innovation actually offloads such jobs onto human beings.").

54. *See* John Markoff, *Look Officer, No Hands: Google Car Drives Itself*, N.Y. TIMES, Oct. 10, 2010, at A1.

55. *See, e.g.*, Claire Cain Miller & Nick Bilton, *Google's Lab of Wildest Dreams*, N.Y. TIMES, Nov. 14, 2011, at A1; Ashlee Vance, *Merely Human? So Yesterday*, N.Y. TIMES, June 13, 2011, at BU1 (reporting on futurists who envision a time when "human beings and machines will so effortlessly and elegantly merge that poor health, the ravages of old age and even death itself will all be things of the past"); David Weinberger, *The Machine That Would Predict the Future*, SCI. AM., Dec. 2011, at 52.

56. *See* Frank J. Fabozzi et al., *High-Frequency Trading: Methodologies and Market Impact*, 19 REV. FUTURES MARKETS 7, 9–10 (2011) (describing continuing changes in computerized trading in finance); Michael J. McGowan, *The Rise of Computerized High Frequency Trading: Use and Controversy*, 2010 DUKE L. & TECH. REV., no. 16, at i, iv–vii (chronicling the history of algorithmic trading); Felix Salmon & Jon Stokes, *Bull vs. Bear vs. Bot*, WIRED, Jan. 2011, at 91 ("Algorithms have become so ingrained in our financial system that the markets could not operate without them.").

like decimalization[57] and Regulation Alternative Trading System (Reg ATS)[58] to permit new trading systems and electronic communication networks for finance, which made today's Wall Street possible.[59] Electronic communication networks yielded direct market access, which allowed firms to execute trades on an exchange directly without going through an intermediary such as a salesperson or a market maker.[60] By the mid-1990s, computers took over significant functions at major financial institutions.[61] By then, computerized networks initiated and managed significant trading in many important financial markets such as stocks, bonds, currency, and commodities.[62]

Later in 2005, the SEC passed Regulation National Market System (Reg NMS)[63] to further increase competition and access to financial trading.[64] Reg NMS aimed "to bind together the fragmented electronic marketplace into a single interlinked web of trading—a true national market system."[65] These and other reg-

57. *See* STAFF OF THE SEC, REPORT TO CONGRESS ON DECIMALIZATION 4 (2012), *available at* http://www.sec.gov/news/studies/2012/decimalization-072012.pdf ("Prior to implementing decimal pricing in April 2001, the U.S. equity market used fractions as pricing increments, and had done so for hundreds of years.").

58. *See* Regulation ATS—Alternative Trading Systems, 17 C.F.R. § 242.300(a) (2012); *see also* EDWARD F. GREENE ET AL., U.S. REGULATION OF THE INTERNATIONAL SECURITIES AND DERIVATIVES MARKETS § 14.10, at 10-133 (9th ed. 2009) ("In the [Reg ATS], the SEC expanded its interpretation of an 'exchange' under the Exchange Act to include a broad range of electronic trading systems . . . .").

59. *See* SAL ARNUK & JOSEPH SALUZZI, BROKEN MARKETS: HOW HIGH FREQUENCY TRADING AND PREDATORY PRACTICES ON WALL STREET ARE DESTROYING INVESTOR CONFIDENCE AND YOUR PORTFOLIO 68–78 (2012); BRIAN R. BROWN, CHASING THE SAME SIGNALS: HOW BLACK-BOX TRADING INFLUENCES STOCK MARKETS FROM WALL STREET TO SHANGHAI 2 (2010); DAVID J. LEINWEBER, NERDS ON WALL STREET: MATH, MACHINES, AND WIRED MARKETS 31–64 (2009).

60. ARNUK & SALUZZI, *supra* note 59, 68–78.

61. *See, e.g.*, RAY KURZWEIL, THE AGE OF SPIRITUAL MACHINES: WHEN COMPUTERS EXCEED HUMAN INTELLIGENCE 70 (1999); Markku Malkamäki & Jukka Topi, *Future Challenges for Securities and Derivative Markets*, *in* 3 RESEARCH IN BANKING AND FINANCE 359, 382 (Iftekhar Hasan & William C. Hunter eds., 2003) ("At the end of the 1990s, between 30% and 40% of all U.S. securities transactions were channeled through the Internet and about 15% of all the U.S. equity trades were done on-line.").

62. KURZWEIL, *supra* note 61, at 70; *see also* William M. Bulkeley, *Computers Take On New Role as Experts in Financial Affairs*, WALL ST. J., Feb. 7, 1986, at 23.

63. 17 C.F.R. § 242.601.

64. *See* Regulation NMS, 70 Fed. Reg. 37,496, 37,621–32 (June 29, 2005) (codified as amended at 17 C.F.R. §§ 242.600–242.612); *see also* Laura Nyantung Beny, *U.S. Secondary Stock Markets: A Survey of Current Regulatory and Structural Issues and a Reform Proposal to Enhance Competition*, 2002 COLUM. BUS. L. REV. 399, 426 ("[T]he express purpose of the NMS [is] to promote efficiency and competition across secondary markets.").

65. SCOTT PATTERSON, DARK POOLS: HIGH-SPEED TRADERS, AI BANDITS, AND THE THREAT TO THE GLOBAL FINANCIAL SYSTEM 49 (2012).

ulatory reforms opened access for firms to leverage new technology in finance.[66] Coupled with technological advances in computer science and the growth of digitized information, such reforms gave birth to a new form of finance in which complex mathematical models processed by computers at warp speed played critical roles in the most important decisions concerning capital allocation and risk assessment.[67] According to some experts, today "Wall Street is essentially floating on a sea of mathematics and computer power."[68] This financial current is one that flows beyond Wall Street and America to all parts of the world.

A key feature of cy-fi is the use of incredibly powerful and fast computers to analyze and execute trading opportunities based on complex mathematical models.[69] Many have referred to computer-programmed trading collectively as "black box trading."[70] Today, almost every major financial institution and hedge fund employs black box trading in one form or another.[71]

Two prominent, interrelated forms of black box trading are algorithmic trading and high-frequency trading. Algorithmic trading utilizes preset formulas to buy, sell, and hold positions in various financial instruments.[72] Computers often exclusively execute these complex formulas without any human interference after the initial installation.[73] Computers are programmed to "automatically capture and read market data in real-time, transmit thousands of order messages per second to an exchange, and execute, cancel, or replace orders based on new information on prices or demand."[74] Technology has become so sophisticated that within mere seconds of a securities filing or news report, computers can essentially read them

66. *See, e.g.*, Melanie Rodier, *Wall Street Firms Fine-Tune Reg NMS Compliance, Look Ahead at the Future*, WALL ST. & TECH. (June 12, 2007), http://www.wallstreetandtech.com/articles/199903415.
67. For an overview of contemporary quantitative trading and its leading players, see generally SCOTT PATTERSON, THE QUANTS: HOW A NEW BREED OF MATH WHIZZES CONQUERED WALL STREET AND NEARLY DESTROYED IT (2010).
68. FIN. CRISIS INQUIRY COMM'N, THE FINANCIAL CRISIS INQUIRY REPORT 44 (2011) (quoting Interview by Fin. Crisis Inquiry Comm'n With Scott Patterson (Aug. 12, 2010)).
69. *See* PATTERSON, *supra* note 65, at 36–38 (describing the rise of powerful, high-speed computers in finance).
70. *See* BROWN, *supra* note 59, at 8 ("A 'black box' is a quantitative investment strategy in which the decisions are defined by mathematical formulas.").
71. *See id.* at 2, 11.
72. ROBERT A.G. MONKS & ALEXANDRA REED LAJOUX, CORPORATE VALUATION FOR PORTFOLIO INVESTMENT: ANALYZING ASSETS, EARNINGS, CASH FLOW, STOCK PRICE, GOVERNANCE, AND SPECIAL SITUATIONS 229 (2011).
73. *See* CFTC & SEC FINDINGS, *supra* note 19, at 2–3 (discussing automation in high-frequency trading); PATTERSON, *supra* note 65, at 128–30; David M. Serritella, *High Speed Trading Begets High Speed Regulation: SEC Response to Flash Crash, Rash*, 2010 U. ILL. J.L. TECH. & POL'Y 433, 436 ("Automation is a crucial element in HFT [high frequency trading].").
74. Fabozzi et al., *supra* note 56, at 8.

and send summaries to traders and investors.[75] Computers running algorithmic programs can process a deluge of information in real time, spot trends, and react accordingly within seconds.[76] Investment decisions that previously took dozens of people minutes or even hours to analyze and execute now take only seconds by a single computer.

Algorithmic trading and its progenies have grown so prevalent that the landmark trading floor of the New York Stock Exchange (NYSE) has become a relic of a bygone era as human traders give way to computers on the Big Board's famed floor.[77] In fact, most equity trading today takes place in shadowy, less-regulated private markets instead of lit, better-regulated exchanges like the NYSE or NASDAQ.[78] Moreover, rather than defend the virtues of transparent, better regulated exchanges for trading, the traditional exchanges have initiated steps to create robust, less transparent markets themselves and have aided computerized trading to the detriment of human trading.[79] In 2012, the SEC fined the NYSE $5 million for inappropriately sharing trading data with certain computerized traders before sharing it with all the other traders.[80] Later in December 2012, the IntercontinentalExchange, an electronic derivatives and commodities exchange, announced a takeover of the NYSE.[81] In light of these developments, it is probably safe to predict that a day will come in the near future when human traders no longer roam the NYSE's famed trading floor.

While significant volumes of algorithmic trading still occur on public exchanges, a growing volume of trades are taking place in private exchanges and dark pools, away from the purview of the public.[82] "A dark pool is an anonymous

75. *See* ARNUK & SALUZZI, *supra* note 59, at 121 ("Machine-readable news data feeds enable HFT computers to react within microseconds to news events, beating out traditional institutional and retail investors."); Helen Coster, *Search and Disrupt*, FORBES, Sept. 26, 2011, at 60 (profiling software that reads and summarizes federal securities filings in seconds).

76. *See, e.g.*, Charles Duhigg, *Stock Traders Find Speed Pays, in Milliseconds*, N.Y. TIMES, July 24, 2009, at A1 ("[Algorithmic computer programs] can spot trends before other investors can blink, changing orders and strategies within milliseconds.").

77. *See, e.g.*, Jerry W. Markham & Daniel J. Harty, *For Whom the Bell Tolls: The Demise of Exchange Trading Floors and the Growth of ECNs*, 33 J. CORP. L. 865, 866 (2008) ("Exchange trading floors are fast fading into history as the trading of stocks and derivative instruments moves to electronic communications networks (ECNs) that simply match trades by computers through algorithms.").

78. *See* Nathaniel Popper, *Public Exchanges Duel With Newcomers Over Trade Transparency*, N.Y. TIMES, June 27, 2012, at B1.

79. *Id.*

80. *In re* N.Y. Stock Exch. LLC, No. 3-15023, Exchange Act Release No. 67,857 (Sept. 14, 2012), 2012 SEC LEXIS 2921, *available at* http://www.sec.gov/litigation/admin/2012/34-67857.pdf.

81. Ben Protess & Nathaniel Popper, *Exchange Sale Reflects New Realities of Trading*, N.Y. TIMES, Dec. 21, 2012, at A1.

82. *See* Regulation of Non-public Trading Interest, 74 Fed. Reg. 61,208 (proposed Nov. 23, 2009) (to be codified at 17 C.F.R. pt. 242); Mary L. Schapiro, Chairman, U.S. Sec. & Exch. Comm'n, Statement

crossing network that allows institutions to hide their orders from the marketplace."[83] Private exchanges and dark pools are particularly attractive to many institutional investors, who prefer to move large volumes of securities without disseminating too much information to the public so as not to lose any informational advantages to competitors that may mimic their trades.[84] Unlike public exchanges, which are partially constrained by geography and physical space, private exchanges and dark pools can exist anywhere because they frequently exist in cyberspace, a frontier without similar physical and geographic limitations.[85] In 2010, more than 60 percent of trading in stocks listed on the NYSE occurred on separate computerized exchanges.[86] Partially as a result of private exchanges and dark pools, a "shadow banking" infrastructure now casts a large penumbra over the financial system.[87]

In addition to algorithmic trading, the other prominent form of black box trading is high-frequency trading.[88] High-frequency trading refers to trading that uses computerized platforms to execute a large number of trades at super speeds.[89] The velocity of high-frequency trading is measured not in minutes but in seconds and milliseconds.[90] For many institutional traders utilizing high-frequency trading, the volume and value of the trades can exceed $1 billion and one billion units

on Dark Pool Regulation Before the Commission Open Meeting (Oct. 21, 2009) (transcript available at http://www.sec.gov/news/speech/2009/spch102109mls.htm); ARNUK & SALUZZI, *supra* note 59, at 62 (describing the rise in nonpublic dark pools and alternative trading systems over the last decade); PATTERSON, *supra* note 65, at 61–62; Matthew Philips, *Where Has All the Trading Gone?*, BUS. WK., May 14, 2012, at 49 (reporting on the migration of trading from public exchanges to dark pools).

83. BROWN, *supra* note 59, at 116.

84. *See id.*

85. *See, e.g.*, David R. Johnson & David Post, *Law and Borders—The Rise of Law in Cyberspace*, 48 STAN. L. REV. 1367, 1367 (1996); Lawrence Lessig, *The Law of the Horse: What Cyberlaw Might Teach*, 113 HARV. L. REV. 501, 514–15 (1999).

86. Nelson D. Schwartz & Louise Story, *Surge of Computer Selling After Apparent Trading Glitch Sends Stocks Plunging*, N.Y. TIMES, May 7, 2010, at B7.

87. *See, e.g.*, GARY B. GORTON, SLAPPED BY THE INVISIBLE HAND: THE PANIC OF 2007, at 6–8 (2010) (noting the growing importance of the shadow banking system in modern finance); DAVID SKEEL, THE NEW FINANCIAL DEAL: UNDERSTANDING THE DODD-FRANK ACT AND ITS (UNINTENDED) CONSEQUENCES 62 (2011) (discussing deregulation, financial innovation, and the birth of shadow banking); Andrew W. Lo, *Regulatory Reform in the Wake of the Financial Crisis of 2007–2008*, 1 J. FIN. ECON. POL'Y 4, 14–18 (2009) (summarizing the reach of the shadow banking system).

88. It should be noted that algorithmic trading is not mutually exclusive from high-frequency trading, which is frequently driven by algorithmic models. *See* ARNUK & SALUZZI, *supra* note 59, at 2–3.

89. *See* IRENE ALDRIDGE, HIGH-FREQUENCY TRADING: A PRACTICAL GUIDE TO ALGORITHMIC STRATEGIES AND TRADING SYSTEMS 1 (2010); ARNUK & SALUZZI, *supra* note 59, at 2; *see also* Concept Release on Equity Market Structure, Exchange Act Release No. 34-61,358, 75 Fed. Reg. 3594, 3598 (proposed Jan. 21, 2010) (to be codified at 17 C.F.R. pt. 242).

90. Fabozzi et al., *supra* note 56, at 8.

daily.[91] Under normal circumstances, high-frequency trading can be a positive force in markets, increasing liquidity and decreasing volatility in the short term by enhancing trade volume and execution speeds.[92] During periods of high uncertainty, however, high-frequency trading can exacerbate volatility and hurt liquidity by removing significant trading positions from the markets at warp speeds.[93]

Over the last decade, high-frequency trading has grown more prevalent in finance. Between 2004 and 2010, high-frequency trading increased from about 13 percent of all foreign-exchange flows to 30 percent.[94] In the five-year period from 2005 to 2010, daily trading volume on the NYSE increased by 164 percent.[95] This increase in trading volume is attributable to the rise of high-frequency trading. By 2011, high-frequency trading "account[ed] for about 60 percent of the seven billion shares that change hands daily on United States stock markets,"[96] and for about 35 to 40 percent of European equities trading volume.[97]

Aside from being faster and less human than previous forms of trading, black box trading can be incredibly profitable. "Hedge funds on average gained 10.4 percent annualized, net of fees, from July 1, 1993, through 2010," with top funds generating even better returns employing black box trading platforms.[98] Renaissance Technologies, one of the most successful hedge funds, averaged annual returns of 35 percent (after exceptionally high fees) for nearly two decades following 1990, and "[i]n 2008, . . . [its] flagship Medallion Fund gained approximately 80 percent."[99] The success of black box trading extends beyond the boutique confines of the hedge fund world and into bulge bracket investment banks.[100] Every major investment bank in the world employs some form of black box trading with its own proprietary software.[101] In 2010, with the aid of black box trading, Bank of America and J.P.

91. *See* Eric Dash & Christine Hauser, *As Dizzying Week Ends on Wall St., Dangers Linger*, N.Y. TIMES, Aug. 13, 2011, at A1.
92. *See* FRANK PARTNOY, WAIT: THE ART AND SCIENCE OF DELAY 43 (2012).
93. *See* ARNUK & SALUZZI, *supra* note 59, at 16; PARTNOY, *supra* note 92, at 43.
94. Neil Shah, *High-Speed Traders Dive Into Forex Despite Doubts*, WALL ST. J., Apr. 25, 2011, http://online.wsj.com/article/SB10001424052748704677404576284921020282968.html.
95. Duhigg, *supra* note 76.
96. Graham Bowley, *Fast Traders, in Spotlight, Battle Rules*, N.Y. TIMES, July 18, 2011, at A1.
97. Fabozzi et al., *supra* note 56, at 8.
98. Richard Teitelbaum, *Morgan Stanley Yoga-Troubadour-Crossword-Math Pro Muller Flees*, BLOOMBERG MARKETS MAG., July 7, 2011, http://www.bloomberg.com/news/2011-07-07/morgan-stanley-s-yoga-troubadour-crossword-math-pro-flees-with-20-returns.html.
99. RISHI K. NARANG, INSIDE THE BLACK BOX: THE SIMPLE TRUTH ABOUT QUANTITATIVE TRADING 4 (2009).
100. *See* PATTERSON, *supra* note 67, at 12 (discussing how quantitative trading had "transform[ed] white-shoe bank companies into hot-rod hedge fund vehicles").
101. *See An Introduction to Financial Software Development*, SCOTTLOGIC, http://www.scottlogic.co.uk/careers/financial-software-development (last visited Nov. 24, 2012) ("All of the large financial institutions (e.g. investment banks) have their own software development teams.").

Morgan had two perfect trading quarters, which means that their trading desks were profitable every day for six months of the year.[102] Because of its lucrative potential, trading and trading-related revenues now account for a significant portion of profits and operations for many financial institutions.[103]

Beyond trading, in the age of cy-fi, computers with artificial intelligence are used for asset management and risk assessment.[104] BlackRock, the world's largest asset management firm, uses its proprietary system, Aladdin, to help clients allocate capital, measure risk, and manage risk.[105] Aladdin can analyze stocks, bonds, derivatives, and other complex financial instruments.[106] During the financial crisis of 2008, with the help of Aladdin, BlackRock aided the U.S. Treasury Department with the bailouts related to Bear Stearns, AIG, Citigroup, Fannie Mae, and Freddie Mac.[107]

In sum, increased reliance on computerization and artificial intelligence in finance has fundamentally transformed modern finance into cyborg finance, an industry that is faster, larger, more global, more interconnected, and less human than its previous iterations.[108]

II. THE EVOLUTION OF THE INVESTOR

The transformation of modern finance into cyborg finance has precipitated a conceptual evolution in prevailing legal understandings of financial regulation's main character: the investor. With the aid of computers, a new aspirational investor paradigm has emerged and holds the potential to be more informed, more diversified, more rational, and faster than previous paradigms. And law must become more cognizant of this emerging, new investor paradigm in order to remain effective.

102. *See generally* Dawn Kopecki, *BofA, JPMorgan Reprise Perfect Trading Records*, BLOOMBERG, Nov. 9, 2010, http://www.bloomberg.com/news/2010-11-09/jpmorgan-reprises-perfect-trading-record-as-goldman-posts-two-losing-days.html.

103. *See* DAVID P. STOWELL, AN INTRODUCTION TO INVESTMENT BANKS, HEDGE FUNDS, AND PRIVATE EQUITY: THE NEW PARADIGM 97–111 (2010) (discussing the prevalence of institutional financial trading).

104. *See* Erik F. Gerding, *Code, Crash, and Open Source: The Outsourcing of Financial Regulation to Risk Models and the Global Financial Crisis*, 84 WASH. L. REV. 127, 130–35 (2009).

105. *Aladdin Enterprise Investment System*, BLACKROCK, http://www2.blackrock.com/US/brs/investment-tools/aladdin (last visited Nov. 24, 2012).

106. *See* Sheelah Kolhatkar & Sree Vidya Bhaktavatsalam, *The Colossus of Wall Street*, BUS. WK., Dec. 13, 2010, at 60, 66.

107. *Id.* at 63.

108. *See* Salmon & Stokes, *supra* note 56, at 93 ("It's the machines' market now; we just trade in it.").

A. The Reasonable Investor

A bedrock concept of financial regulation is "the reasonable investor."[109] Much of state corporate law and federal securities law exist to protect this paragon of investors.[110] For example, analysis under Rule 10b-5[111] of the Securities Exchange Act of 1934, as amended, revolves around the perspective of the reasonable investor. The U.S. Supreme Court in the landmark case, *TSC Industries, Inc. v. Northway, Inc.*,[112] held that for analyzing materiality for securities fraud purposes,

> [a]n omitted fact is material if there is a substantial likelihood that a reasonable shareholder would consider it important in deciding how to vote. . . . Put another way, there must be a substantial likelihood that the disclosure of the omitted fact would have been viewed by *the reasonable investor* as having significantly altered the "total mix" of information made available.[113]

Twelve years later, in *Basic Inc. v. Levinson*,[114] the Supreme Court expressly adopted this holding for securities litigation under the antifraud provisions of Section 10, particularly Rule 10b-5,[115] which is considered one of the most important investor protection measures in financial regulation.[116]

Yet, despite the importance of the reasonable investor in financial regulation, courts have not spoken with one clear voice on its identity.[117] The reasonable inves-

109. *See, e.g.*, David A. Hoffman, *The "Duty" to Be a Rational Shareholder*, 90 MINN. L. REV. 537, 537–39 (2006) (highlighting the importance of the reasonable investor construct to federal securities law); Margaret V. Sachs, *Materiality and Social Change: The Case for Replacing "the Reasonable Investor" With "the Least Sophisticated Investor" in Inefficient Markets*, 81 TUL. L. REV. 473, 475 (2007).

110. *See, e.g.*, H.R. REP. NO. 73-1383, pt. 2, at 5 (1934) (discussing the need to protect individual investors in enacting the Securities Exchange Act of 1934); H.R. REP. NO. 73-85, pt. 1, at 2 (1933) (highlighting protection for reasonable investors as the purpose of the Securities Act of 1933).

111. 17 C.F.R. § 240.10b-5 (2012).

112. 426 U.S. 438 (1976).

113. *Id.* at 449 (emphasis added).

114. 485 U.S. 224 (1988).

115. *Id.* at 231–32.

116. *See* Julie A. Herzog, *Fraud Created the Market: An Unwise and Unwarranted Extension of Section 10(b) and Rule 10b-5*, 63 GEO. WASH. L. REV. 359, 367–70 (1995) (examining the breadth and impact of Rule 10b-5); James J. Park, *Rule 10b-5 and the Rise of the Unjust Enrichment Principle*, 60 DUKE L.J. 345, 351–52 (2011) (highlighting the historical importance of Rule 10b-5 in preventing securities fraud).

117. *See, e.g.*, Stefan J. Padfield, *Is Puffery Material to Investors? Maybe We Should Ask Them*, 10 U. PA. J. BUS. & EMP. L. 339, 365 (2008) (acknowledging the unsettled definition of the "reasonable investor").

tor, thus far, has remained anonymous, elusive, and the subject of much inquiry.[118] Legal scholars and commentators have speculated on the reasonable investor's gender,[119] temperament,[120] and sophistication,[121] among other characteristics.

Despite varying meditations on the reasonable investor, an influential paradigm has prevailed in financial regulation: the rational actor as the reasonable investor.[122] The rational actor is the *homo economicus*, the idealized, utility-maximizing person from neoclassical economic theory.[123] Additionally, regulators have generally and historically viewed the reasonable investor as a long-term investor, not a short-term trader.[124]

Rulemaking with the assumption of the rational actor as the reasonable investor is fairly straightforward since "all human behavior can be viewed as involving participants who maximize their utility from a stable set of preferences and accumulate an optimal amount of information and other inputs in a variety of markets."[125] Financial regulation is, therefore, structured to equip investors with the requisite information and tools so that "investors can protect themselves against corporate abuses and mismanagement" in relatively efficient markets.[126] As a matter of practice, this regulatory modus operandi has resulted in more disclosure by

118. *See, e.g.*, Joan MacLeod Heminway, *Female Investors and Securities Fraud: Is the Reasonable Investor a Woman?*, 15 WM. & MARY J. WOMEN & L. 291, 293–94 (2009).
119. *See id.* at 294–95.
120. *See* Peter H. Huang, *Moody Investing and the Supreme Court: Rethinking the Materiality of Information and the Reasonableness of Investors*, 13 SUP. CT. ECON. REV. 99, 100–04 (2005) (theorizing that reasonable investors invest based on attitudes and noncognitive factors beyond risk and return).
121. *Compare* Barbara Black & Jill I. Gross, *Making It Up as They Go Along: The Role of Law in Securities Arbitration*, 23 CARDOZO L. REV. 991, 1037 (2002) ("[T]oday's 'reasonable investors' are expected to possess a certain level of understanding and sophistication . . . ."), *and* Heminway, *supra* note 118, at 301–02 (advancing arguments supporting the sophisticated investor as the reasonable investor), *with* Sachs, *supra* note 109, at 475–76 (claiming that the most reasonable investors are those who are least sophisticated).
122. *See* Heminway, *supra* note 118, at 297 ("Decisional law and the related literature support the view that the reasonable investor is a rational investor . . . ."); Huang, *supra* note 120, at 111 ("[M]any courts appear to view the reasonable investor as referring to a normative idealized type of behavior, instead of a descriptive realistic depiction of actual behavior.").
123. Carlos Rodriguez-Sickert, *Homo Economicus*, *in* HANDBOOK OF ECONOMICS AND ETHICS 223, 223 (Jan Peil & Irene van Staveren eds., 2009).
124. *See, e.g.*, Regulation NMS, 70 Fed. Reg. 37,496, 37,500 (June 29, 2005) ("Indeed, the core concern for the welfare of long-term investors . . . was first expressed in the foundation documents of the Exchange Act itself.").
125. GARY S. BECKER, THE ECONOMIC APPROACH TO HUMAN BEHAVIOR 14 (1976).
126. Troy A. Paredes, *Blinded by the Light: Information Overload and Its Consequences for Securities Regulation*, 81 WASH. U. L.Q. 417, 418 (2003).

corporations,[127] increased governmental supervision,[128] and enhanced direct governance tools, like "say-on-pay," for investors.[129]

In meaningful ways, the rational actor assumption has served regulators, legislators, and investors well for many decades. Despite serious financial crises, it has predicated a regulatory framework that, while imperfect, is by many accounts the envy of the developed world,[130] producing lengthy periods of significant wealth creation and economic growth.[131] It is, in part, because of such success that the paradigm of the rational actor as the reasonable investor remains so embedded in law and finance.

B. The Irrational Investor

New research has challenged and refined the rational investor paradigm, and it has introduced an alternative paradigm, the irrational investor.[132] The rational investor paradigm, while prevalent and instructive, is not perfect.[133] An original sin of the rational investor paradigm is the assumption that real individuals are always rational like their economic kin.[134] Whereas rational actors comprehend

127. *See, e.g.*, Tom C.W. Lin, *A Behavioral Framework for Securities Risk*, 34 SEATTLE U. L. REV. 325, 336 (2011) ("In practice, this assumption has produced a regulatory framework that emphasizes more information over less information, more disclosure over better disclosure, quantity over quality.").

128. *See, e.g.*, Drake Bennett & Carter Dougherty, *She's With the Government and She's Here to Help*, BUS. WK., July 11, 2011, at 58, 60–64 (chronicling efforts to establish the Consumer Financial Protection Bureau as a sentinel for protecting investors and consumers).

129. Shareholder Approval of Executive Compensation and Golden Parachute Compensation, Exchange Act Release No. 33-9178, 76 Fed. Reg. 6010, 6013 (Feb. 2, 2011) (to be codified at 17 C.F.R. pts. 229, 240, 249) (granting shareholders a nonbinding vote on certain executive compensation matters).

130. *See* CHARLES ROXBURGH ET AL., MCKINSEY GLOBAL INST., GLOBAL CAPITAL MARKETS: ENTERING A NEW ERA 9 (2009) (charting the growth of U.S. capital markets); Bengt Holmstrom & Steven N. Kaplan, *The State of U.S. Corporate Governance: What's Right and What's Wrong?*, J. APPLIED CORP. FIN., Spring 2003, at 8, 8–11 ("Despite the alleged flaws in its governance system, the U.S. economy has performed very well, both on an absolute basis and particularly relative to other countries. U.S. productivity gains in the past decade have been exceptional, and the U.S. stock market has consistently outperformed other world indices over the last two decades . . . .").

131. *See* OFFICE OF MGMT. & BUDGET, BUDGET OF THE UNITED STATES GOVERNMENT, FISCAL YEAR 2006, at 20–21 (2005) (detailing the rise of the U.S. gross domestic product since 1940).

132. *See* David Brooks, *The Unexamined Society*, N.Y. TIMES, July 8, 2011, at A23 ("[T]oday we are in the middle of a golden age of behavioral research. Thousands of researchers are studying the way actual behavior differs from the way we assume people behave."); *see also* BEHAVIORAL LAW & ECONOMICS (Cass R. Sunstein ed., 2000).

133. A pillar of the influential field of behavioral economics is built on challenging the rational actor assumption of neoclassical economics. *See, e.g.*, Christine Jolls et al., *A Behavioral Approach to Law and Economics*, 50 STAN. L. REV. 1471 (1998); Richard A. Posner, *Rational Choice, Behavioral Economics, and the Law*, 50 STAN. L. REV. 1551 (1998).

134. *See* David L. Faigman, *To Have and Have Not: Assessing the Value of Social Science to the Law as Science and Policy*, 38 EMORY L.J. 1005, 1047 n.151 (1989) ("[E]conomists who assume that people

and synthesize information perfectly, real individuals do not.[135] Whereas rational actors make decisions dispassionately without being influenced by irrelevant factors, real individuals often make decisions based on emotions, biases, and irrelevant stimuli.[136] Whereas rational actors live in a simple world filled with other perfectly monochromatic, rational actors, real individuals exist in a complex world filled with other flawed, colorful characters. Plainly stated, real individuals and real investors are not rational actors.

Despite their incongruence with rational actors, real investors are not entirely irrational and unpredictable. Instead, the rationality of real investors is imperfect, bounded, and in many ways, predictable.[137] Biases,[138] heuristics,[139] framing effects,[140] and other cognitive stimuli that result in suboptimal decisions affect the

are "rational" decisionmakers have articulated highly sophisticated models that purport to make predictions of great exactitude. In the real world, of course, people are not rational decisionmakers, and the economists' models suffer accordingly."); Lin, *supra* note 127, at 336–49 (highlighting differences between rational actors and real individuals).

135. *See* Jeffrey J. Rachlinksi, *Misunderstanding Ability, Misallocating Responsibility*, *in* THINKING AND SEEING: VISUAL METACOGNITION IN ADULTS AND CHILDREN 251, 252 (Daniel T. Levin ed., 2004) (comparing the reasonable person to "a kind of superhero" because of her superior cognitive abilities relative to lay people); Erwann Michel-Kerjan & Paul Slovic, *An Idea Whose Time Has Come*, *in* THE IRRATIONAL ECONOMIST: MAKING DECISIONS IN A DANGEROUS WORLD 1, 3–7 (Erwann Michel-Kerjan & Paul Slovic eds., 2010).

136. *See, e.g.*, DANIEL KAHNEMAN, THINKING, FAST AND SLOW 377–85 (2011); Paul J.H. Schoemaker, *A Two-Edged Sword: Implications of Decision Psychology for Decision Analysis*, *in* THE IRRATIONAL ECONOMIST, *supra* note 135, at 53, 57–59.

137. *See* DAN ARIELY, PREDICTABLY IRRATIONAL: THE HIDDEN FORCES THAT SHAPE OUR DECISIONS 239 (2008) ("Our irrational behaviors are neither random nor senseless—they are systematic and predictable."); Stephen J. Choi & A.C. Pritchard, *Behavioral Economics and the SEC*, 56 STAN. L. REV. 1, 2 (2003) ("These [cognitive] biases are not merely isolated quirks, rather, they are consistent, deep-rooted, and systematic behavioral patterns."); Jolls et al., *supra* note 133, at 1475 ("Behavioral economics does not suggest that behavior is random or impossible to predict; rather it suggests, with economics, that behavior is systematic and can be modeled.").

138. *See* Margit E. Oswald & Stefan Grosjean, *Confirmation Bias*, *in* COGNITIVE ILLUSIONS: A HANDBOOK ON FALLACIES AND BIASES IN THINKING, JUDGEMENT AND MEMORY 79 (Rüdiger F. Pohl ed., 2004) (explaining the confirmation bias); Lin, *supra* note 127, at 340–44 (surveying various cognitive biases); William Samuelson & Richard Zeckhauser, *Status Quo Bias in Decision Making*, 1 J. RISK & UNCERTAINTY 7, 7–10 (1988) (discussing the status quo bias); Amos Tversky & Daniel Kahneman, *Loss Aversion in Riskless Choice: A Reference-Dependent Model*, 106 Q.J. ECON. 1039, 1040–42 (1991) (studying the loss aversion bias).

139. *See, e.g.*, ROY F. BAUMEISTER & BRAD J. BUSHMAN, SOCIAL PSYCHOLOGY AND HUMAN NATURE 161 (2008) ("Mental shortcuts, [or] heuristics, provide quick estimates (though sometimes inaccurate ones) for decisions about uncertain events." (emphasis omitted)); Abhijit V. Banerjee, *A Simple Model of Herd Behavior*, 107 Q.J. ECON. 797, 798–800 (1992) (discussing the heuristics of herd behavior); Amos Tversky & Daniel Kahneman, *Judgment Under Uncertainty: Heuristics and Biases*, 185 SCIENCE 1124, 1128–29 (1974) (discussing the anchoring heuristic).

140. *See* Amos Tversky & Daniel Kahneman, *The Framing of Decisions and the Psychology of Choice*, 211 SCIENCE 453, 454–57 (1981) (describing the concept of "framing").

rationality of real investors. Real investors, for instance, generally possess unhealthy surpluses of confidence,[141] optimism,[142] and loss aversion.[143]

Given the cognitive limitations of real investors as compared with the limitless cognition of mythical, rational investors, a serious chasm exists between the regulatory world and the real world. Financial regulations crafted primarily for one illusive population of rational investors actually govern a significantly distinct population of real investors.

This mismatch between the reasonable investor and the real investor has exhibited itself in prosaic and profound ways. During the dot-com boom of the late 1990s, investors failed to read and heed the warning of securities filings and invested in companies based solely on names that suggested technology or internet affiliations.[144] For example, in 1999, Computer Literacy Inc. changed its name to fatbrain.com, and its stock subsequently shot up 33 percent in one day.[145] More recently, in the years preceding the financial crisis of 2008, overly optimistic investors purchased homes that they could not afford based on assumptions that were not reasonable, like perpetually rising housing prices.[146] Similarly, banks made loans that they should not have made, and individuals signed mortgages that they did not understand; and they collectively caused the housing market to collapse.[147]

In the aftermath of the financial crisis, many—including some prominent free-market apologists—have questioned the utility of the rational actor–investor

141. *See* Robert J. Shiller, *Measuring Bubble Expectations and Investor Confidence*, 1 J. PSYCHOL. & FIN. MARKETS 49, 50–52 (2000) (studying the impact of investor overconfidence on stock markets).

142. *See* David A. Armor & Shelley E. Taylor, *When Predictions Fail: The Dilemma of Unrealistic Optimism*, *in* HEURISTICS AND BIASES: THE PSYCHOLOGY OF INTUITIVE JUDGMENT 334, 334 (Thomas Gilovich et al. eds., 2002) (addressing the cognitive bias of overoptimism); Shiller, *supra* note 141, at 50–52.

143. *See* Choi & Pritchard, *supra* note 137, at 13; Hoffman, *supra* note 109, at 553.

144. *See* JASON ZWEIG, YOUR MONEY AND YOUR BRAIN: HOW THE NEW SCIENCE OF NEUROECONOMICS CAN HELP MAKE YOU RICH 8 (2007) ("During 1998 and 1999, one group of stocks outperformed the rest of the technology industry by a scorching 63 percentage points—merely by changing their official corporate names to include *.com*, *.net*, *or Internet*.").

145. *Id.*

146. *See, e.g.*, Oren Bar-Gill, *The Law, Economics and Psychology of Subprime Mortgage Contracts*, 94 CORNELL L. REV. 1073, 1081–82 (2009) (speculating on the irrationality of lenders, borrowers, and homeowners in the years prior to the financial crisis).

147. *See* STAFF OF S. PERMANENT SUBCOMM. ON INVESTIGATIONS, 112TH CONG., WALL STREET AND THE FINANCIAL CRISIS: ANATOMY OF A FINANCIAL COLLAPSE 48–51 (2011) [hereinafter LEVIN-COBURN REPORT] (reporting on bad lending process that led to the financial crisis); Gerald H. Lander et al., *Subprime Mortgage Tremors: An International Issue*, 15 INT'L ADVANCES ECON. RES. 1, 4 (2009) ("Numerous borrowers say they didn't understand the loan structure and the escalating payments; in many cases, they couldn't afford them."); Tom C.W. Lin, *Too Big to Fail, Too Blind to See*, 80 MISS. L.J. 355, 367–71 (2010) (critiquing the rational actor model in connection with the financial crisis of 2008).

paradigm.[148] Acknowledgment of the incongruence between economics's rational actor and reality's real individuals has increased, and it is evidenced, in part, by the growing prominence of behavioral law and economics.[149] Nonetheless, while efforts have been made to craft financial regulations for the irrational investor,[150] most of the regulatory framework continues to exist for the mythical, rational investor.[151]

C. The New Investor

The resilience of the rational investor paradigm in the face of new evidence is both a triumph of ignorance over knowledge as well as a triumph of hope over reality. While new studies continue to highlight the fallacies of equating real investors to their rational kin, new science and technology also continue to narrow the gulf between the irrational investor and the rational investor.[152] The narrowing of this gulf is giving birth to "the new investor," an aspirational paradigm with positive attributes distinct from previous conceptions of investors.

First, the new investor is better informed than the irrational investor, or at least has better access to better information. Advances in information technology have given modern investors more investment information through more mediums. Investors today can receive high-quality, user-friendly investment information through television, radio, satellite radio, websites, social media tools, smartphone applications, and other fora, customized to each investor's interests regardless of their wealth or connections.[153] Information technology advances have moved the new investor beyond the insular, segmented information exchanges

148. *See, e.g.*, *The Financial Crisis and the Role of Federal Regulators: Hearing Before the H. Comm. on Oversight and Gov't Reform*, 110th Cong. 46 (2008) (statement of Alan Greenspan, Former Chairman of the Fed. Reserve Board) (acknowledging that he "found a flaw in the [neoclassical] model that . . . defines how the world works"); Richard A. Posner, *How I Became a Keynesian*, NEW REPUBLIC, Sept. 23, 2009, at 34.

149. *See, e.g.*, Richard A. Posner, *The Rise and Fall of Administrative Law*, 72 CHI.-KENT L. REV. 953, 958 (1997); Guhan Subramanian, *Fixing Freezeouts*, 115 YALE L.J. 2, 37 n.149 (2005); Brooks, *supra* note 132 (noting the proliferation of behavioral research).

150. *See, e.g.*, Ron Lieber, *Consumer Watchdog Is All Ears for Ideas*, N.Y. TIMES, July 16, 2011, at B1.

151. *See, e.g.*, Basic Inc. v. Levinson, 485 U.S. 224, 231–32 (1987).

152. *See, e.g.*, RAY KURZWEIL, THE SINGULARITY IS NEAR: WHEN HUMANS TRANSCEND BIOLOGY 1–5 (2005) (discussing the ability of humans to expand their limitations through science and technology).

153. *See* Patricia Sánchez Abril, *The Evolution of Business Celebrity in American Law and Society*, 48 AM. BUS. L.J. 177, 178 (2011) ("Over the past half-century, digital communications, globalization, mass-market media and advertising, and a heightened public interest in business matters have conspired to shine a brighter spotlight on business leaders as stars."); Tom C.W. Lin, *Undressing the CEO: Disclosing Private, Material Matters of Public Company Executives*, 11 U. PA. J. BUS. L. 383, 389–92 (2009) (discussing the increase in media for business information).

of its predecessors, toward a more egalitarian form of information exchange. Today, any individual with online access can find and review every public company's filings with the SEC.

Second, the new investor is faster than its predecessors and continues to accelerate with technological progress.[154] Over the last century, financial technology evolved from couriers, to ponies, to tickers, to telegrams, to telephones, to computers, and most recently to supercomputers.[155] As a result, the new investor is capable of investing and trading faster than any of its predecessors and can do so from nearly any place on the globe.[156] This enhanced velocity has shortened the timeline of finance from days to hours, to minutes, to seconds, to nanoseconds.[157] The accelerated velocity means not only faster trade executions but also faster investment turnovers. "At the end of World War II, the average holding period for a stock was four years. By 2000, it was eight months. By 2008, it was two months. And by 2011 it was *twenty-two seconds* . . . ."[158]

Third, compared to previous paradigms, the new investor is more capable of better investment diversification. If investment diversification is a hallmark of sound investing,[159] the new investor is better equipped than its predecessors are in this regard. The new investor can invest in bonds, stocks, and commodities like its predecessors. Unlike its predecessors, however, the new investor can also readily invest in more exotic investments like foreign currencies, exchange-traded funds, options, and swaps.[160] Access to such diverse assets, in theory, allows the new investor to spread its risks across various types of investments.

154. *See* KEN AULETTA, GOOGLED: THE END OF THE WORLD AS WE KNOW IT 15 (2009) ("It took telephones seventy-one years to penetrate 50 percent of American homes, electricity fifty-two years, and TV three decades. The Internet reached more than 50 percent of Americans in a mere decade[, and] . . . Facebook built up a community of two hundred million users in just five years.").

155. *See* LABOR STATISTICS BUREAU, CAREER GUIDE TO INDUSTRIES 2008–2009, at 188 (2008) ("The securities industry is continuously changing because of improvements in technology . . . .").

156. *See* Haldane, *supra* note 14, at 5 (discussing how modern financiers continue to break new frontiers in execution speed for their investments and trades).

157. *See* Graham Bowley, *The New Speed of Money*, N.Y. TIMES, Jan. 2, 2011, at BU1 (reporting on the astounding velocity of modern finance).

158. PATTERSON, *supra* note 65, at 46.

159. *See* IAN AYRES & BARRY NALEBUFF, LIFECYCLE INVESTING: A NEW, SAFE, AND AUDACIOUS WAY TO IMPROVE THE PERFORMANCE OF YOUR RETIREMENT PORTFOLIO 1–3 (2010) (analyzing the importance of asset and time diversification in investing); GARY BELSKY & THOMAS GILOVICH, WHY SMART PEOPLE MAKE BIG MONEY MISTAKES—AND HOW TO CORRECT THEM: LESSONS FROM THE NEW SCIENCE OF BEHAVIORAL ECONOMICS 250–51 (2010) (highlighting the benefits of diversification in investments). *But see* GERALD M. LOEB, THE BATTLE FOR INVESTMENT SURVIVAL 103–04 (John Wiley & Sons 2007) (1935) (espousing the virtues of concentrated investments over diversified investments).

160. *See, e.g.*, Houman B. Shadab, *Fending for Themselves: Creating a U.S. Hedge Fund Market for Retail Investors*, 11 N.Y.U. J. LEGIS. & PUB. POL'Y 251, 277 (2008) ("Finally, with the development of

Fourth, relative to the irrational investor, the new investor is less emotional and more rational. The new investor is more self-aware of its personal and psychological pitfalls, and more capable of tempering its emotional and irrational impulses.[161] Recent studies in behavioral finance and psychology have made the new investor more mindful of its cognitive vulnerabilities.[162] Such awareness, in turn, has led to the creation of new investment tools to help the new investor allocate its assets more rationally.[163] For example, the new investor frequently trades using computer models and mathematical algorithms, which are more impervious to the irrational cognitive whims of market players.[164] Dispassionate computerized analysis mitigates the arbitrariness of fear and greed that often motivate investors.[165] Computers running "statistical regressions don't have egos or feelings,"[166] and they are not prone to overconfidence.[167] While these tools dominate the upper echelons of finance,[168] they also exist outside high finance. Free and inexpensive tools allow pedestrian investors to better evaluate the risk and diversity of their investments. For instance, online brokers such as Charles Schwab and E-Trade have user-friendly tools that help investors assess the risks and balance of their

sophisticated at-home trading tools and publicly registered exchange traded funds (ETFs), retail investors can implement hedge fund trading strategies on their own, at low cost.").

161. *See generally* RICHARD H. THALER & CASS R. SUNSTEIN, NUDGE: IMPROVING DECISIONS ABOUT HEALTH, WEALTH, AND HAPPINESS (2009) (discussing many circumstances in which individuals and institutions can create choice architectures that better protect them from their cognitive limitations); Cass R. Sunstein & Richard H. Thaler, *Libertarian Paternalism Is Not an Oxymoron*, 70 U. CHI. L. REV. 1159 (2003) (finding that individuals are slow to join 401(k) plans that offer more choices because they are prone to procrastination).

162. *See* Posner, *supra* note 149, at 958 (alluding to the proliferation of behavioral economics scholarship); Subramanian, *supra* note 149, at 37 n.149; *see also* KAHNEMAN, *supra* note 136, at 377–97.

163. *See* BELSKY & GILOVICH, *supra* note 159, at 207–11 (advising on various methods to improve financial decisions based on the science of behavioral economics); Donald C. Langevoort, *Selling Hope, Selling Risk: Some Lessons for Law From Behavioral Economics About Stockbrokers and Sophisticated Customers*, 84 CALIF. L. REV. 627, 635 (1996); Lin, *supra* note 127, at 356–63 (discussing various ways to improve federal securities disclosures based on insights from behavioral economics); Troy A. Paredes, *On the Decision to Regulate Hedge Funds: The SEC's Regulatory Philosophy, Style, and Mission*, 2006 U. ILL. L. REV. 975, 1026 (espousing default rules to enhance financial regulation); David H. Freedman, *The Perfected Self*, ATLANTIC, June 2012, at 42.

164. MONKS & LAJOUX, *supra* note 72, at 229 ("The goal of algorithmic trading is to take the human factor out of trading as much as possible to avoid the irrational aspects of fear (economic panics) and greed (irrational exuberance).").

165. NARANG, *supra* note 99, at xii.

166. AYRES, *supra* note 38, at 115.

167. *See, e.g.*, Tom C.W. Lin, *The Corporate Governance of Iconic Executives*, 87 NOTRE DAME L. REV. 351, 373–76 (2011) (describing the perils of overconfidence in business decisions).

168. *See* Joe Nocera, *Risk Management*, N.Y. TIMES MAG., Jan. 4, 2009, at 24 (discussing the wide use of the Value at Risk model by investment banks to manage risk).

portfolios.[169] In the future, advances in transcranial magnetic stimulation technology may permit the brain to be reprogrammed to make better financial decisions.[170] While new awareness and corresponding developments help make the new investor more rational, they do not make it completely impervious to all of its cognitive quirks and limitations. Investors will continue to make mistakes,[171] but they now have better tools to correct and prevent them.[172]

Fifth, compared to the other models, the new investor is more humble about its capabilities and knowledge. While the new investor possesses more knowledge and investing capabilities relative to its predecessors, the new investor is also more mindful of its limitations, the limitations of models, and the limitations of technology.[173] The new investor is more aware of the role of randomness, serendipity, and uncertainty in life and finance.[174] The new investor has a vast library of data and information but also has a vast antilibrary[175]: a collection of known unknowns and unknown unknowns; a repository of unlearned knowledge.[176] The antilibrary tempers the new investor's confidence in its capabilities and knowledge as it relates to financial markets.

In sum, the aspirational new investor is a modest cyborg.[177] When famed finance professor Benjamin Graham published his landmark book, *The Intelligent*

169. *See* ANN C. LOGUE, DAY TRADING FOR DUMMIES 195 (2d ed. 2011) (describing the numerous investment tools and services available to clients of Charles Schwab); E-trade, *E-trade Baby Girlfriend Super Bowl Commercial 2010*, YOUTUBE (Feb. 7, 2010), http://www.youtube.com/watch?v=tbLTl7egwlU.

170. *See* Sharon Begley With Jean Chatzky, *Stop! You Can't Afford It*, NEWSWEEK, Nov. 7 & 14, 2011, at 50.

171. *See, e.g.*, BELSKY & GILOVICH, *supra* note 159, at 151–53 (acknowledging that awareness of one's cognitive limitations does not necessarily mean that one will perfectly correct them).

172. Cass R. Sunstein, Essay, *Empirically Informed Regulation*, 78 U. CHI. L. REV. 1349, 1410–11 (2011) (discussing the use of empirical findings about human behavior in crafting better regulations).

173. *See, e.g.*, EMANUEL DERMAN & PAUL WILMOTT, THE FINANCIAL MODELERS' MANIFESTO 1 (2009), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1324878 ("Our experience in the financial arena has taught us to be very humble in applying mathematics to markets, and to be extremely wary of ambitious theories, which are in the end trying to model human behavior. We like simplicity, but we like to remember that it is our models that are simple, not the world.").

174. *See, e.g.*, LEONARD MLODINOW, THE DRUNKARD'S WALK: HOW RANDOMNESS RULES OUR LIVES 216–18 (2008) (expounding on the role of randomness in life and markets).

175. NASSIM NICHOLAS TALEB, THE BLACK SWAN: THE IMPACT OF THE HIGHLY IMPROBABLE 1 (2d ed. 2010) (introducing the term "antilibrary" as a collection of knowledge that one does not yet possess).

176. The terms "known unknowns" and "unknown unknowns" were popularized by former Secretary of Defense Donald Rumsfeld. *See* Donald H. Rumsfeld, Sec'y of Def., Remarks at Department of Defense News Briefing (Feb. 12, 2002), *available at* http://www.defense.gov/Transcripts/Transcript.aspx?TranscriptID=2636.

177. *See* Donna J. Haraway, *A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century*, *in* READINGS IN THE PHILOSOPHY OF TECHNOLOGY 161, 161 (David M. Kaplan ed., 2004) ("A cyborg is a cybernetic organism, a hybrid of machine and organism, a creature

Investor, in 1973, it is unlikely that he envisioned his title character would be a cyborg, but modernity has made it so.[178] The new investor is in many ways Graham's intelligent investor modernized, and it is neither wholly human nor wholly machine. Instead, it is the hybrid offspring of both human and machine. In fact, Sherry Turkle, a leading sociologist, and others have declared that, "We are all cyborgs now."[179] And because we are all cyborgs, we all hold the promise and potential of becoming a better investor—of becoming the new investor.

* * *

New science and technology have precipitated a conceptual evolution of the investor from the reasonable investor to the irrational investor to the new investor. While the reasonable investor model remains statically and theoretically dominant, regulators need to become more mindful of the dynamism and realism of the new investor model if they hope to remain relevant.

III. CLEAR, PRESENT, AND FUTURE DANGERS

The new investor offers the promise of smarter, faster, and better results, but this paradigm also poses new challenges and dangers from within and without. The enhanced speed and interconnectedness of cyborg finance makes it more endogenously vulnerable to volatile crashes, and the heavy reliance on machines makes the system more exogenously vulnerable to cyber perils.

A. The Flash Crash and Future Crashes

On May 6, 2010, the perils of cyborg finance became clear. On that day, the world witnessed a crash and recovery of spectacular volatility and velocity in the U.S.

of social reality as well as a creature of fiction."); Peter Norberg, *Trading Trust: Post-aristocratic Finance in the City of Stockholm* 11 (SSE/EFI Working Paper in Bus. Admin. No. 2009:8, 2009), *available at* http://swoba.hhs.se/hastba/papers/hastba2009_008.pdf ("Fused with algorithms, hybrid cyborg investors occupied with trading online take the place of simple human beings.").

178. *See* BENJAMIN GRAHAM, THE INTELLIGENT INVESTOR: A BOOK OF PRACTICAL COUNSEL (4th rev. ed. 1973) (providing a guide to becoming an intelligent investor—one that is thoughtful, rational, and value driven).

179. *See* TURKLE, *supra* note 32, at 152; *see also* David J. Hess, *On Low-Tech Cyborgs*, *in* THE CYBORG HANDBOOK 371, 373 (Chris Hables Gray ed., 1995) ("[A]lmost everyone in urban societies could be seen as a low-tech cyborg, because they spend large parts of the day connected to machines such as cars, telephones, computers, and, of course, televisions."); Amber Case, *We Are All Cyborgs Now*, TED.COM (Jan. 2011), http://www.ted.com/talks/amber_case_we_are_all_cyborgs_now.html.

stock market.[180] In less than thirty minutes, approximately $1 trillion in market value vanished.[181] The events of that day are now known simply as the Flash Crash.[182]

The Flash Crash occurred on a day when the markets opened with concerns about an ongoing European debt crisis.[183] At approximately 2:32 p.m., with an automated computer program, a Kansas mutual fund company initiated a trade to sell $4.1 billion of E-Mini S&P futures contracts.[184] The sale was executed via a high-speed computerized algorithm that was programmed to execute the trade "without regard to price or time."[185] The program completed the sale in merely twenty minutes.[186] A sale of this value would normally take several hours or days to complete in years past.[187]

The execution of this trade led to corresponding trades in the futures and equity markets. Seconds after the completion of the $4.1 billion sale, other black box programs began selling large blocks of S&P futures, accounting for over 33 percent of the total trading volume.[188] Between 2:41 p.m. and 2:44 p.m., S&P futures dropped by approximately 3 percent. By 2:42 p.m., the Dow Jones Industrial Average (Dow) had declined 3.9 percent to 10,445.85. At 2:45:28 p.m., the Chicago Mercantile Exchange's curbs were triggered, pausing the sale of S&P futures for a few seconds to slow the freefall in price.[189] When trading resumed at 2:45:33 p.m., the S&P futures gradually began to stabilize and recover.[190] The Dow, however, continued to decline, dropping to 9872.57, or a 9.16 percent drop from the previous day's close, before recovering nearly all of the decline by 3:00 p.m.[191] During the Dow's precipitous drop, the share prices of blue-chip stocks like Proctor & Gamble and 3M experienced losses exceeding 18 percent, wiping out billions of dollars in shareholder wealth in a few minutes.[192] "Peak to trough, Accenture shares fell by over 99%, from $40 to $0.01. At precisely the same time, shares in Sotheby's rose three thousand–fold, from $34 to $99,999.99."[193] At the end of the

180. CFTC & SEC FINDINGS, *supra* note 19, at 9.
181. Haldane, *supra* note 14, at 2.
182. Bowley, *supra* note 3.
183. CFTC & SEC FINDINGS, *supra* note 19, at 1.
184. *Id.* at 2; Bowley, *supra* note 3.
185. Bowley, *supra* note 3.
186. CFTC & SEC FINDINGS, *supra* note 19, at 2.
187. *See id.*
188. *Id.* at 3.
189. *See id.* at 4.
190. *Id.*
191. *Id.*
192. *Id.* at 84–85.
193. Haldane, *supra* note 14, at 2.

trading day, "major futures and equities indices 'recovered' to close at losses of about 3% from the prior day."[194]

Following the Flash Crash, the SEC and the Commodity Futures Trading Commission (CFTC) commenced inquiries on the events of that day and took steps to mitigate the damage from similar episodes in the future. Unsurprisingly, the inquiry showed that the volatility and declines of the Dow during the Flash Crash mirrored volatility and declines of the S&P 500 futures.[195] The inquiry, however, did not blame the Flash Crash entirely on black box traders but rather acknowledged that such traders played a critical role in eroding liquidity and exacerbating volatility.[196]

In response to the Flash Crash, the SEC shortly thereafter implemented a new circuit breaker program to pause trading for five minutes once a security has experienced a 10 percent price change over the preceding five minutes.[197] The purpose of circuit breakers is to serve as speed bumps during periods of extreme volatility that may induce more volatility and destabilization in the marketplace. The SEC approved this circuit breaker on June 10, 2010, for the S&P 500.[198] On September 10, 2010, the SEC expanded the circuit breaker to include the Russell 1000 Index and certain exchange traded funds.[199] The SEC also proposed a "consolidated audit trail" rule to make it easier for regulators to monitor and track the happenings of the complex securities execution system.[200] The SEC and the CFTC also planned further studies and actions on black box trading.[201]

While no other crash matching the magnitude of the Flash Crash has occurred since May 6, 2010, there have been several minicrashes and disruptions.[202] On September 27, 2010, Progress Energy's stock plunged almost 90 percent, fall-

194. CFTC & SEC FINDINGS, *supra* note 19, at 1.
195. *Id* at 3.
196. *See id.* at 6.
197. *Id.* at 7.
198. *Id.*
199. *Id.*
200. *See* Consolidated Audit Trail, 75 Fed. Reg. 32,556 (proposed June 8, 2010) (to be codified at 17 C.F.R. pt. 242).
201. *See* CFTC & SEC FINDINGS, *supra* note 19, at 6–8. In September 2011, the SEC proposed additional rules to protect against crashes related to high-frequency trading. Notice of Filing of Proposed Rule Change to Update Rule 6121 (Trading Halts Due to Extraordinary Market Volatility) and Amend Rule 6440 (Trading and Quotation Halt in OTC Equity Securities), 76 Fed. Reg. 61,429 (proposed Sept. 28, 2011).
202. *See* Graham Bowley, *The Flash Crash, in Miniature*, N.Y. TIMES, Nov. 9, 2010, at B1 ("The crashes continue even as Washington regulators investigate the structure of modern markets and as a report traced the main trigger of May's big crash to a poorly timed trade by a mutual fund in Kansas."); Edward E. Kaufman, Jr. & Carl M. Levin, *Preventing the Next Flash Crash*, N.Y. TIMES, May 6, 2011, at A27 (discussing minicrashes since the Flash Crash).

ing from $44.57 per share to $4.57 per share in a matter of minutes.[203] The circuit breakers instituted by the SEC were set off, but the plunge occurred so quickly that the stock price continued to fall on the NASDAQ.[204] After numerous trades were voided, it was determined that the faulty trades were a mistake; an errant execution of a computer algorithm was to blame for the loss and recovery of millions of dollars in market capitalization.[205] Several months later, on May 13, 2011, the stock of Enstar, a natural gas company, fell from $100 to $0 and then bounced back to $100; Focus Morningstar Health Card Index opened at $25.32 then fell to $0.06, before recovering, due in large part to black box trading.[206] Then in March 2012, the initial public offering of BATS Global Markets, an electronic stock exchange pioneer, had to be withdrawn after major technical difficulties caused serious volatility and confusion in its first hours of trading.[207] Later in 2012, the markets again experienced instability caused by computerized trading with Facebook's initial public offering in May and a rogue computer program related to Knight Trading in August.[208]

While no other major crash has occurred since the Flash Crash, experts and regulators fear that it is only a matter of time before the "Big One."[209] And in the interim, smaller market disruptions have grown and will likely continue to grow more prevalent as cy-fi advances and proliferates.[210]

B. Cybercrimes and Cyberthreats

In the age of cyborg finance, financial institutions have to guard against new and emerging threats relating to cyberspace and intellectual property.[211] Computer

203. Bowley, *supra* note 202.
204. *Id.*
205. *Id.*
206. Matt Krantz, *Mini Flash Crashes Worry Traders*, USA TODAY, May 16, 2011, http://www.usatoday.com/money/markets/2011-05-16-mini-flash-crashes-market-worry_n.htm.
207. *See* Michael J. de la Merced, *BATS Chief on Friday's Troubles*: *'My Stomach Sank*,' N.Y. TIMES DEALBOOK (Mar. 26, 2012, 12:11 AM), http://dealbook.nytimes.com/2012/03/26/bats-chief-on-fridays-meltdown-my-stomach-sank; *see also* Nathaniel Popper, *BATS Flaw Not So Rare, Data Shows*, N.Y. TIMES, Mar. 29, 2012, at B1 (citing the erratic actions of BATS's trading platform).
208. *See* Nathaniel Popper, *Runaway Trades Spread Turmoil Across Wall St.*, N.Y. TIMES, Aug. 2, 2012, at A1.
209. *See* Bowley, *supra* note 202 (citing experts' speculations about another big crash); Kaufman & Levin, *supra* note 202 ("[A]lgorithmic trading has caused mini-Flash Crashes since, and surveys suggest that most investors and analysts believe it's only a matter of time before the Big One.").
210. *See* Popper, *supra* note 207.
211. *See* David Barboza & Kevin Drew, *Security Firm Sees Global Cyberspying*, N.Y. TIMES, Aug. 4, 2011, at A11 ("Cybersecurity is now a major international concern, with hackers gaining access to sensitive corporate and military secrets, including intellectual property."); Michael Joseph Gross, *Exclusive: Operation Shady RAT—Unprecedented Cyber-espionage Campaign and Intellectual-Property Bonanza*,

codes and platforms are some of the most valuable and the most vulnerable assets of many firms, particularly financial firms.[212] With cy-fi, safeguarding trade secrets, intellectual property, and the integrity of proprietary systems is the key to sustainable success for many financial institutions and financial systems.[213] Serious crimes and threats against financial institutions now often involve computers as the weapon of choice, intellectual property as their targeted bounty, and cyberspace as their default setting.[214] In 2008, the Conficker worm, a malicious software program with unknown origins, "infected 1.5 million computers in 195 countries."[215] In 2009, a former Goldman Sachs computer programmer was arrested and initially sentenced to more than eight years in prison for stealing computer codes used in Goldman Sachs's algorithmic trading platforms.[216] In 2011, hackers affiliated with WikiLeaks threatened to release sensitive information relating to Bank of America, sending its shares down significantly.[217] In 2012, the U.S. Department of Labor enhanced the security of its economic data in response to hacking threats aimed at benefitting high-speed traders.[218] That same year, the world also witnessed two large coordinated attacks, one against global financial institutions of every class and type, called "Operation High Roller," and another one specifically targeting American banks; some of these attacks have been attributed to Iran.[219] By some

VANITY FAIR, Aug. 2, 2011, http://www.vanityfair.com/culture/features/2011/09/operation-shady-rat-201109 (discussing the increase in cyberattacks on many prominent governmental agencies and corporations like "Sony, Fox, the British National Health Service, and the Web sites of PBS, the U.S. Senate, and the C.I.A., among others").

212. *See* Alex Berenson, *Arrest Over Software Illuminates a Secret of Wall St.*, N.Y. TIMES, Aug. 24, 2009, at A1 (discussing the importance of computer programs to financial institutions).

213. *See* BROWN, *supra* note 59, at 49 (discussing the urgent need for black box firms to safeguard successful strategies for as long as possible); *see* Deborah Radcliff, *Three Industries, Three Security Needs*, COMPUTERWORLD, Nov. 29, 1999, at 38 ("Now that banks are moving to Internet-based transactions, they must also ensure the security of their Web servers and the information they store, along with providing secure transport of customer information over the Internet.").

214. *Cf.* Michael Joseph Gross, *Enter the Cyber-dragon*, VANITY FAIR, Sept. 2011, http://www.vanityfair.com/culture/features/2011/09/chinese-hacking-201109 ("Hackers from many countries have been exfiltrating—that is, stealing—intellectual property from American corporations and the U.S. government on a massive scale, and Chinese hackers are among the main culprits.").

215. MARK BOWDEN, WORM: THE FIRST DIGITAL WORLD WAR 116 (2011).

216. *See* Ahmed Azam, *Ex-programmer Is Sentenced to 8 Years for Stealing Code From Goldman*, N.Y. TIMES, Mar. 19, 2011, at B2.

217. *See* Nelson D. Schwartz, *Facing Threat From WikiLeaks, a Bank Plays Defense*, N.Y. TIMES, Jan. 3, 2011, at B1.

218. *See* John H. Cushman, Jr., *Guarding the Numbers*, N.Y. TIMES, July 17, 2012, at B1.

219. *See* DAVE MARCUS & RYAN SHERSTOBITOFF, MCAFEE & GUARDIAN ANALYTICS, DISSECTING OPERATION HIGH ROLLER 3 (2012), *available at* http://www.mcafee.com/us/resources/reports/rp-operation-high-roller.pdf; Nicole Perlroth, *Attacks on 6 Banks Frustrate Customers*, N.Y. TIMES, Oct. 1, 2012, at B1; Nicole Perlroth & Quentin Hardy, *Bank Hacks Were Work of Iranians, Officials Say*, N.Y. TIMES, Jan. 9, 2013, at B1.

accounts, cybercrime costs the United States an estimated $400 billion annually.[220] Because of the borderless and anonymous nature of cyberspace, cyberattacks are difficult to trace ex post and difficult to prevent ex ante.[221]

All industries are susceptible to cybercrimes and cyberthreats, but the modern financial industry is particularly vulnerable because of its heavy reliance on computerized systems to store information, analyze data, and allocate capital.[222] The modern financial industry is essentially a high-tech industry in which computer codes and computer networks are at the heart of its very existence. This vulnerability is magnified by the fact that once established, many of these systems are self-executing and devoid of human control. Attackers could trigger a crash by injecting the system with bad data and fake trades.[223] The impact of such a cyberattack on the financial system would be economically crippling and confidence shattering.[224]

In the age of cy-fi, firms and governments have to safeguard their interests from an expanding cast of elusive antagonists including their employees, competitors, rogue hackers, and even other nation-states.[225] A recent study indicated that cyberattacks—that may have been state sponsored—were specifically targeting American corporations.[226] Given the importance of the American financial industry, cyberattacks on our financial institutions make much strategic sense for those who seek to harm American interests.

220. Sean S. Costigan, *Terrorists and the Internet: Crashing or Cashing In?*, *in* TERRORNOMICS 113, 117 (Sean S. Costigan & David Gold eds., 2007).

221. *See, e.g.*, BOWDEN, *supra* note 215, at 48–52 (describing challenges in creating a cybersecurity defense system); Gross, *supra* note 214 ("Because virtual attacks can be routed through computer servers anywhere in the world, it is almost impossible to attribute any hack with total certainty.").

222. *See* Michael Riley & Ashlee Vance, *The Code War*, BUS. WK., July 25, 2011, at 51, 52.

223. *See id.* at 56 ("Computer-security specialists warn that the automated, high-frequency trading systems now prevalent on Wall Street would be prime targets in a cyber war. Attackers could cause a panic by injecting the systems with streams of bad data and fake trades."); FIN. STABILITY OVERSIGHT COUNCIL, 2012 ANNUAL REPORT 136–37 (2012) (acknowledging the emerging threat of cyberattacks on automated trading programs).

224. *See* JOE KLEIN, THE NATURAL: THE MISUNDERSTOOD PRESIDENCY OF BILL CLINTON 190 (2002) ("[Following September 11, 2001,] the Treasuries Secretaries Robert Rubin and Lawrence Summers opposed cyber-warfare on grounds that it may threaten the stability of the international financial system.").

225. *See* BOWDEN, *supra* note 215, at 48 ("Today the most serious computer predators are funded by rich criminal syndicates and even nation-states, and their goals are far more ambitious."); INTELLIGENCE & NAT'L SEC. ALLIANCE (INSA), CYBER INTELLIGENCE: SETTING THE LANDSCAPE FOR AN EMERGING DISCIPLINE 7–9 (2011); PATTERSON, *supra* note 67, at 116 (discussing a hedge fund's fears of potential misappropriation of trade secrets by former employees); *cf.* SEC v. Dorozhko, 574 F.3d 42, 44–51 (2d Cir. 2009) (involving hackers who traded on illicitly acquired material, nonpublic information).

226. *See* DMITRI ALPEROVITCH, MCAFEE, REVEALED: OPERATION SHADY RAT 7–9 (2011) (providing a complete list of the targeted countries), *available at* http://www.mcafee.com/us/resources/white-papers/wp-operation-shady-rat.pdf; Barboza & Drew, *supra* note 211.

While it may appear far-fetched to believe that the prominent theater of future warfare is cyberspace,[227] reality is not too far off.[228] In 2007, during a dispute with Russia, Estonia experienced a massive cyberattack on its cyberinfrastructure, which some attributed to Russia, making it difficult for Estonians to engage in any online activities.[229] A few years later in 2011, it was widely believed that coordinated cyberattacks by Israel and the United States caused a serious blow to Iran's nuclear weapons program.[230] The initial weapon of choice in a 2011 attack was Stuxnet, a computer virus superworm, deemed by some as "the most sophisticated cyberweapon ever deployed."[231] A year later, it was reported that another computer super virus called the Flame—which some again attributed to the United States and Israel—was "afflicting computers in Iran and the Middle East."[232] That same year, the U.S. Secretary of Defense, Leon Panetta, warned that the United States was facing a potential "cyber–Pearl Harbor."[233] Furthermore, experts suspect that China has long engaged in cyberwarfare and cyberespionage against American interests and businesses for many years.[234]

In response to the emerging threat of cyberwarfare, the federal government has taken notice. In 2011, recognizing the burgeoning importance of cybersecurity to commerce, the SEC for the first time issued disclosure guidance relating to cybersecurity as a business risk that could materially affect firms.[235] That same year, the White House and the Department of Defense published a number of

227. *See, e.g.*, Thomas Rid, *Think Again: Cyberwar*, FOREIGN POL'Y, Mar.–Apr. 2012, at 80, 80 ("Cyberwar is still more hype than hazard.").

228. *See* RICHARD A. CLARKE & ROBERT A. KNAKE, CYBER WAR: THE NEXT THREAT TO NATIONAL SECURITY AND WHAT TO DO ABOUT IT, at x–xii, 69–71 (2010); Andrea Stone, *Cyberspace Is the Next Battlefield: U.S., Foreign Forces Prepare for Conflict Unlike Any Before*, USA TODAY, June 19, 2001, at 1A (reporting on military measures in connection with an anticipated rise in "informational warfare"); Misha Glenny, *A Weapon We Can't Control*, N.Y. TIMES, June 25, 2012, at A19 (commenting on the unforeseeable and unintended dangers of cyberweapons).

229. *See* Mark Landler & John Markoff, *After Computer Siege in Estonia, War Fears Turn to Cyberspace*, N.Y. TIMES, May 29, 2007, at A1.

230. *See* William J. Broad et al., *Israeli Tests Called Crucial in Iran Nuclear Setback*, N.Y. TIMES, Jan. 16, 2011, at A1.

231. *Id.*

232. Andrew E. Kramer & Nicole Perlroth, *Expert Issues a Cyberwar Warning*, N.Y. TIMES, June 3, 2012, at B1.

233. Elisabeth Bumiller & Thom Shanker, *Panetta Warns of Dire Threat of Cyberattack*, N.Y. TIMES, Oct. 12, 2012, at A1.

234. *See* Barboza & Drew, *supra* note 211 ("Many security experts say the Chinese government has built up a sophisticated cyberwarfare unit and that the government might be partnering with professional hackers."); Michael Riley & Ashlee Vance, *Inside the Chinese Boom in Corporate Espionage*, BUS. WK., Mar. 19, 2012, at 78–84.

235. *CF Disclosure Guidance: Topic No. 2: Cybersecurity*, SEC.GOV (Oct. 13, 2011), http://sec.gov/divisions/corpfin/guidance/cfguidance-topic2.htm.

white papers,[236] including the latter's first strategic statement for cyberspace.[237] Additionally, the Pentagon has aggressively accelerated its cyberwarfare programs in recent years.[238] As of 2012, the Air Force alone spends approximately $4 billion annually on its cyberprograms.[239]

While the perils posed by cybercrimes and cyberthreats are many, serious, and real,[240] they should not be overblown, nor should they lead to rash overreactions.[241] Attempts at cybersecurity should not inhibit the "generativity" of information technology and finance.[242] Cybersecurity prevention and protection efforts are undoubtedly difficult,[243] but they must also be sensible, thoughtful, and not obstruct the promise and progress of cyborg finance.[244] This will, undoubtedly, be a difficult endeavor, given the amorphous and evolving nature of cyberspace, its technologies, and its threats. However, it is an endeavor that must be pursued vigorously because, ultimately, technological advances in finance may hold more promise than threat in the future.

IV. EMERGING IMPLICATIONS AND CONSEQUENCES

The transformation of modern finance into cyborg finance contains numerous implications and consequences. Some have emerged, others are emerging, and many remain unknown. That said, three meaningful, budding, and underappreciated outgrowths of this ongoing financial transformation relate to (1) systemic risks involving increased financial speed and connectivity, (2) law's capacity

236. *See, e.g.*, THE WHITE HOUSE, INTERNATIONAL STRATEGY FOR CYBERSPACE: PROSPERITY, SECURITY, AND OPENNESS IN A NETWORKED WORLD (2011); DEP'T OF DEF., CYBERSPACE POLICY REPORT: A REPORT TO CONGRESS PURSUANT TO THE NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2011, SECTION 934 (2011).

237. DEP'T OF DEF., STRATEGY FOR OPERATING IN CYBERSPACE (2011).

238. Julian E. Barnes, *Pentagon Digs in on Cyberwar Front*, WALL ST. J., July 6, 2012, at A4.

239. *Id.*

240. *See, e.g.*, NAT'L RESEARCH COUNCIL & NAT'L ACAD. OF ENG'G, TOWARD A SAFER AND MORE SECURE CYBERSPACE 49–50 (Seymour E. Goodman & Herbert S. Lin eds., 2007) (warning against the possibility of a "digital Pearl Harbor").

241. *See, e.g.*, Paul Ohm, *The Myth of the Superuser: Fear, Risk, and Harm Online*, 41 U.C. DAVIS L. REV. 1327, 1348–62 (2008) (discussing the dangers of overreacting to online threats).

242. *See* Zittrain, *supra* note 20, at 1980–81; *see also* Richard A. Booth, *The Uncertain Case for Regulating Program Trading*, 1994 COLUM. BUS. L. REV. 1, 54–55 (arguing against regulations that would stifle the benefits of program trading during its nascent period).

243. *See* Derek E. Bambauer, *Conundrum*, 96 MINN. L. REV. 584, 598–603 (2011) (describing the various challenges of cybersecurity efforts).

244. *See* LAWRENCE LESSIG, THE FUTURE OF IDEAS: THE FATE OF THE COMMONS IN A CONNECTED WORLD 8–16 (2001) (arguing that misguided regulations can limit the potential of new technology); Zittrain, *supra* note 20, at 1997–2000.

to adapt itself to this transformation, and (3) critical resource asymmetries within the financial industry spurred by this transformation.

A. Of Speed and Links

Modern finance has produced great opportunities for wealth creation and societal progress by providing capital and financing for the new developments of businesses and governments, but it has also produced profound challenges for economic stability and social welfare in the form of new systemic risks.[245] Regulators have paid much attention to the systemic risk of "too big to fail" in recent years, and rightfully so.[246] "Too big to fail" describes a deleterious systemic risk of modern finance in which financial institutions grow too large and too important to the economy for them to falter, such that the government has to rescue these private businesses with public funds.[247] As modern finance transforms into cyborg finance, two new deleterious systemic risks have arisen: one related to velocity, which this Article terms "too fast to save," and the other related to connectivity, which this Article terms "too linked to fail."

1. Too Fast to Save

Cyborg finance operates at velocities previously unattainable and poses perils previously unimaginable.[248] Billions of dollars move across borders and oceans through cables and spectra at the speed of milliseconds.[249] Mere seconds are too

245. *See, e.g.*, Amir E. Khandani et al., *Systemic Risk and the Refinancing Ratchet Effect* 38 (MIT Sloan Sch. of Mgmt. Research Paper No. 4750-09, 2009) ("[S]ystemic risk . . . arises when large financial losses affect important economic entities that are unprepared for and unable to withstand such losses, causing a cascade of failures and widespread loss of confidence.").

246. *See, e.g.*, LEVIN-COBURN REPORT, *supra* note 147, at 15–17.

247. *See, e.g.*, *id.* (reporting on the rise and dangers of too-big-to-fail U.S. financial institutions); ANDREW ROSS SORKIN, TOO BIG TO FAIL: THE INSIDE STORY OF HOW WALL STREET AND WASHINGTON FOUGHT TO SAVE THE FINANCIAL SYSTEM FROM CRISIS—AND THEMSELVES 538–39 (2009) (opining on the difficulties in solving the problem presented by "too big to fail" institutions); Brendan Greeley, *The $120 Billion Not-Bailout Bailout*, BUS. WK., July 9, 2012, at 11, 11 ("Five banks—JPMorgan, Bank of America, Citigroup, Wells Fargo, and Goldman Sachs—held more than $8.5 trillion in assets at the end of 2011, equal to 56 percent of the U.S. economy, according to the Federal Reserve.").

248. *See, e.g.*, Concept Release on Equity Market Structure, Exchange Act Release No. 34–61,358, 75 Fed. Reg. 3594, 3605 (proposed Jan. 21, 2010) (to be codified at 17 C.F.R. pt. 242) (noting the emphasis on accelerating velocities in modern equity markets); Duhigg, *supra* note 76.

249. *See* Fabozzi et al., *supra* note 56, at 8.

slow, and cy-fi does not intend to slow down.[250] In 2012, work began on a "$300 million transatlantic fiber-optic line called Project Express" aimed at reducing trade execution times by a mere five milliseconds.[251] The new frontiers of financial speed are nanoseconds (billionths of a second) and picoseconds (trillionths of a second).[252] Such velocities can create problems of "too fast to save" relating to the underlying components of cyborg finance: computers and humans.

In terms of computers, the accelerated speed of transactions in and of itself can increase the error rate and the utilization of bad data by automated computer programs before remedial measures can be taken.[253] Popular author Tom Clancy described a nightmare scenario in his novel *Debt of Honor*, in which falsified data are intentionally injected into the securities markets causing global financial chaos as automated programs instantaneously reacted to the bad information before it could be detected.[254] While that nightmare scenario, to the best of our knowledge, has not yet materialized, smaller malfeasances may have already occurred.[255] During the financial crisis of 2008, many blamed short sellers for injecting misinformation into the market to create profitable positions for themselves by driving down the price of financial stocks with false rumors during a time of distress.[256] The problems surrounding automated programs reacting to bad data likely will persist and grow as reliance on black box programs increases in finance.

Beyond computers, humans can also trigger serious problems that are "too fast to save." Today, a single rogue trader or a well-intentioned but misinformed trader can now cause catastrophic damage to a financial institution or the entire sys-

250. *See, e.g.*, Bowley, *supra* note 157 ("Almost each week, it seems, one exchange or another claims a new record: Nasdaq, for example, says its time for an average order 'round trip' is 98 microseconds—a mind-numbing speed equal to 98 millionths of a second.").

251. Matthew Philips, *Trading at the Speed of Light*, BUS. WK., Apr. 2, 2012, at 46.

252. *See* David Schneider, *Trading at the Speed of Light*, IEEE SPECTRUM, Oct. 2011, at 11–12; A.D. Wissner-Gross & C.E. Freer, *Relativistic Statistical Arbitrage*, 82 PHYSICAL REV. E 56, 104-1 (2010) (studying arbitrage opportunities as trading approaches the speed of light); Haldane, *supra* note 14, at 5.

253. *See* THOMAS NEAL FALKENBERRY, HIGH FREQUENCY DATA FILTERING: A REVIEW OF THE ISSUES ASSOCIATED WITH MAINTAINING AND CLEANING A HIGH FREQUENCY FINANCIAL DATABASE (2002), *available at* http://www.tickdata.com/pdf/Tick_Data_Filtering_White_Paper.pdf; Fabozzi et al., *supra* note 56, at 11.

254. *See* TOM CLANCY, DEBT OF HONOR 294–312 (1994). While this scenario may appear far-fetched, in the same novel Mr. Clancy also envisioned enemies of America intentionally crashing jets into strategically important buildings, which became a reality on September 11, 2001. *See id.* at 760–64.

255. *See* Bowley, *supra* note 3.

256. *See, e.g.*, HOWARD DAVIES, THE FINANCIAL CRISIS: WHO IS TO BLAME? 171 (2010) ("[T]hose firms which suffered very sharp falls in their stock prices and, in some cases, went out of business identified short-selling as a powerful contributor to their problems."); SORKIN, *supra* note 247, at 14–15, 81–82, 201; SEBASTIAN P. WERNER, SHORT SELLING ACTIVITIES AND CONVERTIBLE BOND ARBITRAGE: EMPIRICAL EVIDENCE FROM THE NEW YORK STOCK EXCHANGE 13 (2010) ("Short sellers had been largely blamed for the tumble in stock prices of financial institutions . . . .").

tem with just a few clicks before anyone can intervene. In 2008, a trader at the French investment bank Societe Generale nearly destroyed the storied firm with $69 billion in unauthorized positions.[257] The unwinding of those trades resulted in a $7 billion loss.[258] In 2011, another trader at the Swiss investment bank UBS caused losses of $2.3 billion.[259] While such trades and bad acts could have occurred in the analog ages of finance, they would likely have taken much longer to execute and required more clearance by more individuals prior to execution. Today, many checks and balances have been sacrificed for velocity and efficiency because of cy-fi's insistence on speed. This insistence has made it more difficult to catch and prevent such bad acts and bad actors.

While some argue that certain modern financial products are "unsafe at any rate,"[260] the speed at which many transactions are being executed suggests that some products are simply unsafe at high speeds.[261] The emphasis on speed in cyborg finance has led to more automated trading platforms, more reactive executions, less reflective deliberation, and less opportunity for safeguarding:

> For the first time in financial history, machines can execute trades far faster than humans can intervene. That gap is set to widen. In some respects the 2010 Flash Crash and the 1987 stock market crash have common genes—algorithmic amplification of stress. But they differ in one critical respect. Regulatory intervention could feasibly have forestalled the 1987 crash. By the time of the Flash Crash, regulators might have blinked—literally, blinked—and missed their chance.[262]

Following the Flash Crash, the national exchanges proposed rules for more stringent circuit breakers in the event of accelerated market decreases.[263] These enhanced circuit breakers were intended to serve as speed bumps for a market in descent. While they may prove to be helpful, they nonetheless do not fully address the problems posed by "too fast to save," as trading in less regulated dark pools and electronic markets without circuit breakers will continue to grow,[264] and hyperspeed trades with detrimental consequences may not timely trigger the proposed breakers.

257. Nicola Clark, *Rogue Trader at Société Générale Gets 3 Years*, N.Y. TIMES, Oct. 6, 2010, at B1.
258. *Id.*
259. *See* Julia Werdigier, *Revealing Details of Rogue Trades, UBS Raises Loss Estimate to $2.3 Billion*, N.Y. TIMES, Sept. 19, 2011, at B3.
260. Elizabeth Warren, *Unsafe at Any Rate*, DEMOCRACY J., Summer 2007, at 8.
261. Frank Partnoy, *Don't Blink: Snap Decisions and Securities Regulation*, 77 BROOK. L. REV. 151, 155 (2011) (espousing the virtues of slower speeds in financial markets).
262. Haldane, *supra* note 14, at 15.
263. *See, e.g.*, Notice of Filing of Proposed Rule Change to Update Rule 6121 and Amend Rule 6440, Exchange Act Release No. 34-65,430, 76 Fed. Reg. 61,429 (Oct. 4, 2011).
264. It should likely not be shocking to industry insiders and learned observers if in the near future dark pools and electronic markets become the dominant space of trading for all investors.

The future speed of finance, undoubtedly, will become faster, and too fast to save will be one of the greatest regulatory challenges for regulators and policymakers in the coming years.

2. Too Linked to Fail

Modern finance exists as an expansive, interconnected network that crosses institutions, industries, states, and products—creating a systemic problem that this Article terms "too linked to fail." In the age of cy-fi, commercial banks, investment banks, hedge funds, mutual funds, pension funds, private equity firms, nation-states, wealthy traders, and a host of other players and institutions are all bounded together as part of this growing financial web of mutuality. And within the mesh of that financial web are financial products that have also grown more linked to one another.

The connectedness of cyborg finance has enhanced the mobility of capital and dispersed certain risks.[265] Despite its many positive externalities, however, cyborg finance's connectedness has also created new challenges and magnified old ones.[266] Whereas in eras past the failure of one financial institution, one sovereign treasury, or one financial product was largely and better contained by geography, cyborg finance has obliterated all borders and boundaries. The financial problems of one nation-state can now affect all nation-states like never before.[267] The demise of one financial institution can now affect many financial institutions.[268] The mistake of one trader can now cause catastrophic consequences for entire market segments. The volatility of one financial product can now ripple across many

265. *See, e.g.*, Jamie Morgan, *How Reality Ate Itself: Orthodoxy, Economy and Trust*, *in* REAL WORLD ECONOMICS: A POST-AUTISTIC ECONOMICS READER 105, 107 (Edward Fullbrook ed., 2006) (discussing policy commentary on opportunities for financial risk dispersion as a result of new technology).

266. *See* Serritella, *supra* note 73, at 437 (noting the potential perils resulting from "the interconnectivity of financial markets and their participants, as well as increased interconnections between securities and their derivatives").

267. *See, e.g.*, Robert W. Kolb, *Introduction*, *in* FINANCIAL CONTAGION: THE VIRAL THREAT TO THE WEALTH OF NATIONS, at xiii (Robert W. Kolb ed., 2011) ("Similarly, financial distress in one nation can affect another . . . .").

268. ROBERT W. KOLB, LESSONS FROM THE FINANCIAL CRISIS: CAUSES, CONSEQUENCES, AND OUR ECONOMIC FUTURE 128 (2010) ("The failure of just one large financial institution might lead to the failure of one or more other institutions that would then spread to yet more financial institutions in a contagion that was feared might end in the collapse of the entire financial system.").

financial products.[269] This may be the case not only for too-big-to-fail firms, which have received most of the regulatory attention,[270] but also for smaller firms, financial intermediaries, and financial products that are simply "too linked to fail" because their failure may unravel other institutions that are bound to it as part of the modern financial network. In 1998, Long-Term Capital Management, a hedge fund located in Greenwich, Connecticut, with less than two hundred employees caused serious panic on Wall Street when several of its positions turned sour as a result of the financial crises in Asia and Russia.[271] To prevent significant losses for several investment banks and to stem wider panic on Wall Street, the Federal Reserve orchestrated a $3.6 billion industry-led bailout for Long-Term Capital Management.[272]

More than a decade later, investors continue to witness the mutating problems of "too linked to fail" with greater magnitude as financial problems and financial products of individual institutions and sovereign states, oceans away, affect the U.S. financial system, and vice versa. The demise of Bear Stearns and the bankruptcy of Lehman Brothers in 2008[273] sent destructive waves through the global financial system.[274] The potential failure in 2008 of credit default swaps conceived by an American International Group (AIG) subsidiary in London and bought by all the major investment banks was at the crux of the financial crisis.[275] In 2011 and 2012, problems relating to the sovereign debt of Greece, Italy, and Spain created significant economic stresses for America, China, Europe, and much of the developed world.[276] In 1944, President Franklin D. Roosevelt made the following statement that rings truer today than it did then: "Economic diseases are highly

269. *See* Kathryn Judge, *Fragmentation Nodes: A Study in Financial Innovation, Complexity, and Systemic Risk*, 64 STAN. L. REV. 657, 659 (2012) (arguing that new financial products born of the shadow banking system create new sources of systemic risk).

270. *See, e.g.*, Authority to Designate Financial Market Utilities as Systemically Important, 76 Fed. Reg. 44,763, 44,765 (July 27, 2011) (codified at 12 C.F.R. pt. 1320 (2012)) (correlating systemic importance largely based on monetary value).

271. *See* ROGER LOWENSTEIN, WHEN GENIUS FAILED: THE RISE AND FALL OF LONG-TERM CAPITAL MANAGEMENT, at xviii–xx (2000).

272. *See* FRANK PARTNOY, INFECTIOUS GREED: HOW DECEIT AND RISK CORRUPTED THE FINANCIAL MARKETS 261 (2003).

273. *See* Andrew Ross Sorkin, *Lehman Files for Bankruptcy; Merrill Is Sold*, N.Y. TIMES, Sept. 15, 2008, at A1.

274. *See* Bryan Burrough, *Bringing Down Bear Stearns*, VANITY FAIR, Aug. 2008, http://www.vanityfair.com/politics/features/2008/08/bear_stearns200808.

275. SORKIN, *supra* note 247, at 394–400.

276. *See* Clive Cook, *Who Lost the Euro*, BUS. WK., May 28, 2012, at 9, 10–12; Peter Coy, *Greece: Why the Beast Is Back*, BUS. WK., May 30, 2011, at 10, 10–11; Carol Matlack & Jeff Black, *Exit the Euro Zone? Think Before You Leap*, BUS. WK., Sept. 19, 2011, at 15.

communicable. It follows, therefore, that the economic health of every country is a proper matter of concern to all its neighbors, near and distant."[277]

Like a vast alignment of dominoes of all shapes and sizes, the demise of one institution or one instrument can send ripples through all and cause many to falter and many to fall.[278] These effects are compounded by a factor of many multiples when players engage in similar strategies and algorithms.[279] This mass mimicry can lead to a "crowded trade" phenomenon in which a few trades lead to a cascade of trades as spillover effects and feedback loops effectuated by automated programs that permeate the financial system.[280] Because of the growing number of linked participants and linked products within the modern financial network, these ripples could become more frequent, thereby leading to increased volatility in the marketplace.[281]

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The combination of enhanced velocity and connectivity in cyborg finance poses profound dangers for investors and society as more financial actors and actions become too fast to save and too linked to fail. Many experts have predicted that as computerized trading expands deeper into foreign markets the next financial crash could be quicker and more pervasive than any previously witnessed.[282] Harnessing the power of cy-fi's speed and linkage while managing its risks will be a critical challenge for financial regulators in the coming years.[283]

277. HANS KELSEN, COLLECTIVE SECURITY UNDER INTERNATIONAL LAW 257 (Lawbook Exchange Ltd. 2001) (1954) (quoting Franklin D. Roosevelt, Address to the Monetary and Fin. Conference, Washington, D.C. (June 29, 1944)).

278. Bernard S. Donefer, *Algos Gone Wild: Risk in the World of Automated Trading Strategies*, J. TRADING, Spring 2010, at 31.

279. *See* Concept Release on Equity Market Structure, Exchange Act Release No. 34-61,358, 75 Fed. Reg. 3594, 3611 (proposed Jan. 21, 2010) (to be codified at 17 C.F.R. pt. 242) ("[M]any proprietary firms potentially could engage in similar or connected trading strategies that, if such strategies generated significant losses at the same time, could cause many proprietary firms to become financially distressed and lead to large fluctuations in market prices.").

280. *See* BROWN, *supra* note 59, at 7.

281. *See* PATTERSON, *supra* note 65, at 9 (discussing the financial dangers of "a vicious self-reinforcing feedback loop"); Louise Story & Graham Bowley, *Market Swings Are Becoming New Standard*, N.Y. TIMES, Sept. 12, 2011, at A1.

282. *See, e.g.*, Kaufman & Levin, *supra* note 202; Jim McTague, *Next Danger: "Splash Crash,"* BARRON'S (May 21, 2011), http://online.barrons.com/article/SB50001424052970203869804576327391603772726.html (reporting on the possibility of a global "widespread and catastrophic" crash across asset classes and markets caused by high-speed trading computers).

283. Jason Zweig, *Could Computers Protect the Market From Computers*, WALL ST. J., May 26, 2012, at B1.

B. Of Laws and Rules

Law constantly plays tortoise to finance's hare. Technological and market innovations in finance often bound ahead of laws and regulations.[284] Developments in finance over the last three decades exemplify this Aesopian dynamic as financial innovation outpaced the rules and laws designed to govern financial markets.[285] In some instances, innovations were designed to skirt existing regulations and regulators.[286] In other instances, the reactive, yet tedious slog of rulemaking was simply no match for the swiftness of financial and technological innovation.[287] And in some instances, regulations inadvertently sowed the seeds of financial risk and peril.[288] The computerization of finance over the last few decades has enhanced the specter of law's inadequacy over financial innovation, which can be traced to matters of jurisdiction and origination, among others.[289]

On matters of jurisdiction, law is bounded by sovereign and regulatory borders,[290] but cyborg finance knows no borders.[291] Technology has made the in-

284. *See* INSA, *supra* note 225, at 6 ("National and international laws, regulations, and enforcement are still struggling to catch up to cyber activities worldwide."); Lyria Bennett Moses, *Recurring Dilemmas: The Law's Race to Keep Up With Technological Change*, 2007 U. ILL. J.L. TECH. & POL'Y 239, 239–41.

285. *See* Stephen J. Choi & Andrew T. Guzman, *National Laws, International Money: Regulation in a Global Capital Market*, 65 FORDHAM L. REV. 1855, 1856–57 (1997) (discussing how globalization has increased the burden of capital market regulators to maintain adequate disclosure, antifraud, and antimanipulation rules); Charles K. Whitehead, *Reframing Financial Regulation*, 90 B.U. L. REV. 1, 2–5 (2010) (noting the lack of regulatory innovation in response to financial innovation); Tara Bhupathi, Note, *Technology's Latest Market Manipulator? High Frequency Trading: The Strategies, Tools, Risks, and Responses*, 11 N.C. J.L. & TECH. 377, 377–78 (2010) ("Rapid technological advances have . . . caus[ed] the legal world to either choose to judicially adapt old laws and policies to the new digital situations or to legislatively create new doctrines to deal with unforeseen challenges.").

286. *See, e.g.*, GILLIAN TETT, FOOL'S GOLD: HOW THE BOLD DREAM OF A SMALL TRIBE AT J.P. MORGAN WAS CORRUPTED BY WALL STREET GREED AND UNLEASHED A CATASTROPHE 39–47 (2009) (discussing how the derivatives markets grew by working around existing regulations); Charles W. Calomiris, *Financial Innovation, Regulation, and Reform*, 29 CATO J. 65, 65 (2009) (explaining how financial innovation is often born out of "sidestepping regulatory restrictions").

287. *See, e.g.*, Claudio Gonzalez-Vega, *Nonbank Institutions in Financial Sector Reform*, *in* SEQUENCING?: FINANCIAL STRATEGIES FOR DEVELOPING COUNTRIES 127, 133 (Alison Harwood & Bruce L.R. Smith eds., 1997) (discussing how swift financial innovation is frequently met with slow regulation).

288. *See, e.g.*, Calomiris, *supra* note 286, at 67–68 ("Risk-taking was driven by government policies; government's *actions* were the root problem, not government *inaction*.").

289. *See, e.g.*, Moses, *supra* note 284, at 239–40 (chronicling incidents in which new technology generated new legal questions).

290. *See* Morrison, 130 S. Ct. at 2885 ("Like the United States, foreign countries regulate their domestic securities exchanges and securities transactions occurring within their territorial jurisdiction.").

291. *See* JACK GOLDSMITH & TIM WU, WHO CONTROLS THE INTERNET?: ILLUSIONS OF A BORDERLESS WORLD, at vii–viii (2006); Johnson & Post, *supra* note 85, at 1367 (discussing the need for new legal conceptions of jurisdiction with the emergence of the internet); Lawrence Lessig, *The Path of Cyberlaw*, 104 YALE L.J. 1743, 1743–45 (1995). *Contra* Allan R. Stein, *The*

vestment market a global market with little regard for the jurisdiction of countries and regulators.[292] In the age of cy-fi, boundaries matter little to financiers but matter greatly to regulators.[293] This territorial dissonance between regulators and the regulated has a large impact on financial governance. Because of this territorial dissonance, financial players are in some cases governed by a multiplicity of uncoordinated regulators spanning seas and states with rules that sometimes overlap and conflict.[294] In other cases, financial players simply operate in a regulatory penumbra with little or no governance.[295]

This jurisdictionally based patchwork of regulations and regulators allows financial players to engage in dangerous games of regulatory arbitrage within and across countries.[296] Various regulators with complex sets of rules, for example, govern investment banking operations in the United States and the United Kingdom.[297] Credit-default-swap operations, on the other hand, existed with little to no meaningful government regulation and oversight for many years.[298] In the lead up to

Unexceptional Problem of Jurisdiction in Cyberspace, 32 INT'L LAW. 1167, 1191 (1998) (arguing that jurisdictional issues relating to cyberspace are "not uniquely problematic").

292. *See* BROWN, *supra* note 59, at 149 ("Advancements in electronic trading technology have rapidly accelerated the globalization of equity markets.").

293. *See* EEOC v. Arabian Am. Oil Co., 499 U.S. 244, 248 (1991) ("It is a longstanding principle of American law 'that legislation of Congress, unless a contrary intent appears, is meant to apply only within the territorial jurisdiction of the United States.'" (quoting Foley Bros., Inc. v. Filardo, 336 U.S. 281, 285 (1949))).

294. *See Morrison*, 130 S. Ct. at 2885 ("And the [financial] regulation of other countries often differs from ours as to what constitutes fraud, what disclosures must be made, what damages are recoverable, what discovery is available in litigation, what individual actions may be joined in a single suit, what attorney's fees are recoverable, and many other matters.").

295. *See, e.g.*, ALEXANDER DAVIDSON, HOW THE GLOBAL FINANCIAL MARKETS REALLY WORK: THE DEFINITIVE GUIDE TO UNDERSTANDING INTERNATIONAL INVESTMENT AND MONEY FLOWS 17–19 (2009) (discussing shadow banking and the less regulated areas of finance); Robert A. Eisenbeis, *Agency Problems and Goal Conflicts in Achieving Financial Stability: The Case of the EMU*, *in* THE STRUCTURE OF FINANCIAL REGULATION 232, 235 (David G. Mayes & Geoffrey E. Wood eds., 2007) (discussing conflicting state and federal financial regulation); James J. Park, *The Competing Paradigms of Securities Regulation*, 57 DUKE L.J. 625, 665 (2007) (discussing how regulatory competition creates regulatory-gamesmanship opportunities for industry players).

296. *See* Victor Fleischer, *Regulatory Arbitrage*, 89 TEX. L. REV. 227, 229 (2010) ("Regulatory arbitrage exploits the gap between the economic substance of a transaction and its legal or regulatory treatment, taking advantage of the legal system's intrinsically limited ability to attach formal labels that track the economics of transactions with sufficient precision."); Frank Partnoy, *Financial Derivatives and the Costs of Regulatory Arbitrage*, 22 J. CORP. L. 211, 227 (1997) ("Regulatory arbitrage consists of those financial transactions designed specifically to reduce costs or capture profit opportunities created by differential regulations or laws.").

297. *See* Jack Ewing, *Global Rules for Banks Draw Near*, N.Y. TIMES, Sept. 11, 2010, at B1 (discussing the complexities in creating banking rules and standards across different sovereignties).

298. *See* James E. Kelly, *Transparency and Bank Supervision*, 73 ALB. L. REV. 421, 424 (2010) (highlighting regulatory gaps relating to "hedge funds; derivatives markets; off balance sheet entities; the credit ratings agencies; firms' disclosure of risk, valuation, . . . compensation policies; [and] securitized and structured products"); Interview by Michael Kirk With Brooksley Born, CFTC Chair 1996–1999

the financial crisis in 2008, credit default swaps, a crucial financial product used by all major investment banks, were largely unregulated because the industry created and situated itself within a regulatory gap.[299]

As financial players continue to innovate with little regard for sovereign and regulatory borders, lawmakers and regulators must continue to examine whether the current jurisdictionally based apparatus is adequate or whether a new paradigm is necessary.[300] This recommendation for more thoughtful examination is not an endorsement of a supercoordinated global regulator that obliterates borders and sovereignties because friction-free coordinated governance also contains serious risks.[301] Rather, this recommendation is a call for thinking anew about harmonizing financial regulation that moves beyond traditional spaces bounded by anachronistic barriers of jurisdiction.

On matters of origination, law operates in a structure built on precedent and rootedness,[302] but cyborg finance operates in a structure built on novelty and change.[303] Because of this dichotomy, new financial problems and grievances in cyfi often lack elegant legal and regulatory solutions and remedies. Financial regulations often do not organically innovate; instead, they are the children of busts, scares, and scandals (and they become orphans in boom times).[304] The Great

(Aug. 28, 2009) (PBS television broadcast Oct. 20, 2009), *available at* http://www.pbs.org/wgbh/pages/frontline/warning/interviews/born.html (discussing the lack of attention paid to credit default swaps and other derivatives prior to the financial crisis).

299. Kelly, *supra* note 298; Frank Partnoy & David A. Skeel, Jr., *The Promise and Perils of Credit Derivatives*, 75 U. CIN. L. REV. 1019, 1046–47 (2007); Whitehead, *supra* note 285, at 34.

300. *See, e.g.*, Choi & Guzman, *supra* note 15, at 904–08; Fox, *supra* note 15, at 2501–03; Orin S. Kerr, *Applying the Fourth Amendment to the Internet: A General Approach*, 62 STAN. L. REV. 1005, 1007–10 (2010); John Seo, *Everything Will Be Too Big to Fail*, FOREIGN POL'Y, Sept./Oct. 2011, at 74, 75 (discussing the need for global regulations to prevent financial catastrophes in the future); Bart Chilton, Comm'r, Commodities Futures Trading Comm'n, Speech to Goldman Sachs Global Commodity Conference: Stopping Stammering: Overcoming Obstacles in Financial Regulatory Reform (Mar. 28, 2011), *available at* http://www.cftc.gov/pressroom/speechestestimony/opachilton-43.html (calling for more international harmonization in regulating derivatives).

301. *See* Charles K. Whitehead, *Destructive Coordination*, 96 CORNELL L. REV. 323, 326 (2011) ("By promoting coordination, regulations and standards can erode key presumptions underlying financial risk management, reducing its effectiveness and magnifying the systemic impact of a downturn in the financial markets.").

302. *See* Frederick G. Kempin, Jr., *Precedent and Stare Decisis: The Critical Years, 1800 to 1850*, 3 AM. J. LEGAL HIST. 28, 28 (1959) ("The modern doctrine of stare decisis as applied in the United States is a general policy of all courts to adhere to the ratio decidendi of prior cases decided by the highest court in a given jurisdiction . . . .").

303. Lawrence Lessig presciently noted in the infancy of cyberspace that this new space contained changing features that reject old modes of governance. *See* Lawrence Lessig, *Foreword*, 52 STAN. L. REV. 987, 990–95 (2000).

304. *See* Stuart Banner, *What Causes New Securities Regulation? 300 Years of Evidence*, 75 WASH. U. L.Q. 849, 850 (1997) ("[M]ost of the major instances of new securities regulation in the past three hundred years of English and American history have come right after crashes."); Joseph A. Grundfest,

Depression gave birth to the Securities Act of 1933, the Securities Exchange Act of 1934, and the formation of the SEC.[305] The Enron and WorldCom scandals led to the adoption of the Sarbanes-Oxley Act.[306] The financial crisis of 2008 spurred the Dodd-Frank Wall Street Reform and Consumer Protection Act.[307] Following the Flash Crash in 2010, regulators rushed to create new rules to address problems relating to black box trading.[308] In 2011, following years without meaningful regulation,[309] the SEC finally adopted rules to regulate hedge funds, albeit in a limited manner, after their perceived role in the recent financial crisis.[310]

As finance continues to innovate, old policies, old laws, and old regulatory frameworks will grow more inadequate to govern and protect new investors in the age of cy-fi.[311] New questions and challenges will arise: Should regulators place speed limits and fees on high-frequency trading?[312] How should current disclosure requirements adapt to new markets of dark pools driven by Big Data and deep secrecy?[313] How will laws concerning insider trading and securities fraud account for computerized trading platforms dictated by artificial intelligence?[314] Does ar-

Punctuated Equilibria in the Evolution of United States Securities Regulation, 8 STAN. J.L. BUS. & FIN. 1, 1 (2003) ("[E]very dramatic change in the structure of our securities laws has been provoked by a perceived failure in the capital markets that stimulated a regulatory response."). For critiques of recent crisis-driven financial regulation, see Stephen M. Bainbridge, *Dodd-Frank: Quack Federal Corporate Governance Round II*, 95 MINN. L. REV. 1779 (2011); Roberta Romano, *The Sarbanes-Oxley Act and the Making of Quack Corporate Governance*, 114 YALE L.J. 1521 (2005).

305. *See* JACK E. KIGER ET AL., ACCOUNTING PRINCIPLES 409 (1st rev. ed. 1984).

306. *See* Larry E. Ribstein, *Bubble Laws*, 40 HOUS. L. REV. 77, 83, 86 (2004).

307. SKEEL, *supra* note 87, at 43–57.

308. *See* Speech by Troy A. Paredes, Comm'r, SEC: Remarks at the Symposium on Hedge Fund Regulation and Current Developments (June 8, 2011), http://www.sec.gov/news/speech/2011/spch060811tap.htm (remarking on new regulatory proposals following the Flash Crash).

309. *See* Whitehead, *supra* note 285, at 5 ("Although hedge funds grew by 260% between 1999 and 2004 to become a one trillion dollar business, they were largely exempt from regulation under the federal securities and investment advisory laws.").

310. *See* Edward Wyatt, *Rule Allows U.S. a Close Look at Big Hedge Funds*, N.Y. TIMES, Oct. 27, 2011, at B1; Press Release, SEC, SEC Approves Confidential Private Fund Risk Reporting (Oct. 26, 2011), http://sec.gov/news/press/2011/2011-226.htm.

311. Regulating cy-fi may require a pathbreaking governing model. During the infancy of the internet, Lawrence Lessig suggested that cyberspace required cyberlaw, a distinct legal field in which technology itself would serve as a governing apparatus in addition to laws and rules. *See* LAWRENCE LESSIG, CODE AND OTHER LAWS OF CYBERSPACE 19–20 (1999).

312. *See* Nathanial Popper, *As U.S. Discusses Limits on High-Speed Trading Other Nations Act*, N.Y. TIMES, Sept. 27, 2012, at B1; Haldane, *supra* note 14, at 3, 18–19.

313. *See, e.g.*, Henry T.C. Hu, *Too Complex to Depict? Innovation, "Pure Information," and the SEC Disclosure Paradigm*, 90 TEX. L. REV. 1601, 1611–12 (2012) (calling for a new "pure information" model of regulated disclosures); Tom C.W. Lin, *Executive Trade Secrets*, 87 NOTRE DAME L. REV. 911, 919–22 (2012) (describing the current disclosure obligations of public firms).

314. *See, e.g.*, Lawrence B. Solum, *Legal Personhood for Artificial Intelligences*, 70 N.C. L. REV. 1231, 1231–34 (1992) (forecasting legal challenges presented by the emergence of artificial intelligence).

tificial intelligence constitute legal personhood?[315] How will the mens rea element of financial crimes apply when machines act with no mental state?[316] Should financial fiduciary duties evolve to match the evolution of financial operations?[317] What role should financial regulators play in protecting the financial system from cyberthreats?[318] Should securities regulation, which has traditionally focused on protecting long-term investors, expand to protect short-term investors as well?[319] These and other questions will continue to force law to rethink and reimagine its content and purpose in the face of financial innovation.[320]

In Aesop's fable, the tortoise eventually catches up to the hare. In the race between law and finance, the race continues with finance far ahead. In the fable, when the hare was ahead, there were no real consequences. With finance ahead of law, societies have suffered through financial crises costing investors and nation-states trillions of dollars and through psychological crises of confidence with immeasurable economic costs.[321] Law needs to better situate itself at the intersection

315. *See, e.g.*, Ralph D. Clifford, *Intellectual Property in the Era of the Creative Computer Program: Will the True Creator Please Stand Up?*, 71 TUL. L. REV. 1675, 1686 n.73 (1997) (predicting the legal challenges posed by "autonomous and self-aware artificial intelligence"); Solum, *supra* note 314, at 1262 (arguing that artificial intelligence cannot constitute legal personhood).

316. *See, e.g.*, Gabriel Hallevy, *"I, Robot—I, Criminal"—When Science Fiction Becomes Reality: Legal Liability of AI Robots Committing Criminal Offenses*, 22 SYRACUSE SCI. & TECH. L. REP. 1, 9 (2010) (questioning the criminal liability of artificial-intelligence robots); Solum, *supra* note 314, at 1267 (suggesting that machines with artificial intelligence cannot possess intentionality); *cf.* Gary Fields & John R. Emshwiller, *As Federal Crime List Grows, Threshold of Guilt Declines*, WALL ST. J., Sept. 27, 2011, http://online.wsj.com/article/SB10001424053111904060604576570801651620000.html (opining on the decline of mens rea in federal crimes).

317. *See* Andrea M. Matwyshyn, *Imagining the Intangible*, 34 DEL. J. CORP. L. 965, 967 (2009) (proposing new corporate fiduciary duties for an information-driven marketplace).

318. *See, e.g.*, INSA, *supra* note 225, at 3–4 (proposing a public–private partnership to address cyberthreats); *Cyber Crime*, FBI.GOV, http://www.fbi.gov/about-us/investigate/cyber (last visited Nov. 26, 2012).

319. *See* Regulation NMS, 70 Fed. Reg. 37,496, 37,500 (June 29, 2005) ("[W]hen the interests of long-term investors and short-term traders conflict . . . , the Commission believes that its clear responsibility is to uphold the interests of long-term investors. Indeed, the core concern for the welfare of long-term investors . . . was first expressed in the foundation documents of the Exchange Act itself.").

320. Some policymakers, scholars, and commentators have already begun to contemplate such questions, and the author also plans to address in greater detail these inquiries in future scholarship as these questions evolve and ripen with the maturation of cyborg finance. *See* FIN. STABILITY OVERSIGHT COUNCIL, *supra* note 224, at 136–37 (acknowledging the regulatory challenges posed by the expansive and growing electronic trading infrastructure); Choi & Guzman, *supra* note 15, at 904–08; John C. Coffee, Jr. & Hillary A. Sale, *Redesigning the SEC: Does the Treasury Have a Better Idea?*, 95 VA. L. REV. 707, 707–17 (2009); Fox, *supra* note 15, at 2501–03; Whitehead, *supra* note 285, at 6 (advocating for more flexible financial regulations that break away from outdated "fixed categories, intermediaries, business models, or functions").

321. *See, e.g.*, ARNUK & SALUZZI, *supra* note 59, at 1–6 (describing the loss of investor confidence associated with the rise of computerized trading); MICHAEL LEWIS, BOOMERANG: TRAVELS IN THE NEW THIRD WORLD 1–3, 41–45, 83–87, 133–38 (2011) (discussing the catastrophic impact of the 2008 financial crisis on various nations across the world, particularly Germany, Greece, Iceland, Ireland, and the United States).

of technology and finance in order to remain relevant and effective. As a new investor emerges, old rules must be reexamined and reimagined for a new financial landscape.[322] Just as technology and finance adapt and evolve, law "in its eternal youth" ultimately must do the same.[323]

C. Of Resources and Asymmetries

Cyborg finance's reliance on capital-intensive, advanced information technology is creating huge resource asymmetries between government regulators and the regulated industry, and within the industry itself. Both of these asymmetries could have profound effects on finance, law, and beyond.

1. Between Regulators and the Industry

The information technology that is at the heart of cy-fi often requires huge expenditures, and regulating cy-fi also requires huge expenditures as the industry expands, diversifies, and grows more complicated. While competition for profit drives financial firms to invest and innovate in information technology, investments in government regulators lack similar driving forces and are often plagued by political constraints.[324] Financial engineers and analysts can make millions of dollars in the cyborg finance era.[325] Regulators, alternatively, earn a fraction of that income.[326] Financial firms invest billions of dollars in their operations while finan-

322. *See* Aryeh S. Friedman, *Law and the Innovative Process: Preliminary Reflections*, 1986 COLUM. BUS. L. REV. 1, 2 (theorizing on the impact of technological breakthroughs on legal norms); Moses, *supra* note 284, at 265 ("Rules are devised in a particular technological context, with explicit and implicit assumptions as to what is possible. . . . Technological change may render existing rules obsolete or less useful for different reasons . . . .").

323. *See* O.W. Holmes, *The Path of the Law*, 10 HARV. L. REV. 457, 474–75 (1897) (highlighting the necessity of law to adapt itself to novel technology); Samuel D. Warren & Louis D. Brandeis, *The Right to Privacy*, 4 HARV. L. REV. 193, 193 (1890) ("Political, social, and economic changes entail the recognition of new rights, and the common law, in its eternal youth, grows to meet the demands of society.").

324. Jesse Eisinger, *Greater Power Over Wall Street, Left Unexamined*, N.Y. TIMES DEALBOOK (May 4, 2011, 3:12 PM), http://dealbook.nytimes.com/2011/05/04/more-power-over-wall-street-but-little-chance-to-discuss-it ("And monetary policy can be in conflict with banking regulation.").

325. *See, e.g.*, U.S. GOV'T ACCOUNTABILITY OFFICE, GAO–11–654, SECURITIES AND EXCHANGE COMMISSION: EXISTING POST-EMPLOYMENT CONTROLS COULD BE FURTHER STRENGTHENED (2011) (studying the revolving door between the SEC and the private sector); JAMES Q. WILSON ET AL., AMERICAN GOVERNMENT: INSTITUTIONS & POLICIES 279 (2010) ("Every year, hundreds of people leave important jobs in the federal government to take more lucrative positions in private industry.").

326. While this has traditionally been the case, the compensation gap between those in the industry and those regulating the industry has grown exponentially in the last few decades. Admittedly, there exist better compensated financial regulators and monitors, namely private industry and intra-

cial regulators face limited budgets that continue to stagnate or shrink relative to their growing mandates and the dynamic, complex marketplace.[327] As a result, a large gulf exists between the resources of the industry and its regulators.

This resource asymmetry between the regulators and the regulated has made it extremely difficult for regulators to police key players in cy-fi actively and meaningfully in the face of intense industry lobbying and innovation.[328] Resource asymmetry between the regulators and the regulated has created significant compensation disparities that make it difficult for government regulators to attract and retain talented individuals.[329] Additionally, cy-fi's high speed and high connectivity has also increased its complexity, which has rendered it more challenging for regulators to timely monitor and investigate misdeeds with scarce resources.[330] Thus, instead of vigilant prevention, regulators are constrained to limited prosecution.[331] The end result is a financial marketplace in which significant sectors are largely regulated on paper but not in practice, and are prone to cause serious shocks

institution regulators like stock exchange officials, in-house attorneys, risk officers, and compliance directors. Nevertheless, the commentary herein focuses on external, government regulators, who serve as arguably the most prominent and consequential regulators of the financial industry. *See supra* note 325.

327. *See* James B. Stewart, *As a Watchdog Starves, Wall Street Is Tossed a Bone*, N.Y. TIMES, July 15, 2011, at A1 (discussing successful political efforts to reduce the budgets of financial regulators like the SEC); *Oversight of the U.S. Securities and Exchange Commission's Operations, Activities, Challenges, and FY 2012 Budget Request: Hearing Before the Subcomm. on Capital Mkts. and Gov't-Sponsored Enters. of the H. Comm. on Fin. Servs.*, 112th Cong. 49 (2011) (prepared statement of the SEC), *available at* http://www.sec.gov/news/testimony/2011/ts031011directors.htm ("Over the past decade, the SEC has faced significant challenges in maintaining a staffing level and budget sufficient to carry out its core mission. The SEC experienced three years of frozen or reduced budgets . . . that forced a reduction of 10 percent of the agency's staff. Similarly, the agency's investments in new or enhanced IT systems declined about 50 percent . . . .").

328. Admittedly, technological advances have improved the regulator's effectiveness in some respects, but, on balance, it has diluted the regulator's effectiveness as resource disparities allow industry players to outmaneuver regulators. *See* HENRY KAUFMAN, ON MONEY AND MARKETS: A WALL STREET MEMOIR 229 (2000) ("[R]egulatory responses to new financial methods and instruments tend to be desultory. . . . Regulators fail[] to grasp the technical complexities of these new tools, instruments, and techniques, or to comprehend their broader significance for the financial system."); Michael Corkery, *SEC Chairman Admits: We're Outgunned by Market Supercomputer*, WALL ST. J. DEAL J. BLOG (May 11, 2010, 2:38 PM), http://blogs.wsj.com/deals/2010/05/11/sec-chairman-admits-were-outgunned-by-market-supercomputers.

329. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 325; Edward Wyatt, *Study Questions Risk of S.E.C. Revolving Door*, N.Y. TIMES, Aug. 6, 2012, at B2.

330. *See* Fabozzi et al., *supra* note 56, at 30 (describing the regulatory challenges of high-speed finance); Nathaniel Popper & Ben Protess, *To Regulate High-Speed Traders, S.E.C. Turns to One of Them*, N.Y. TIMES, Oct. 8, 2012, at B1.

331. Despite limited and asymmetric resources, the SEC had a series of high profile victories in 2011 and 2012 against large investment banks, hedge funds, and other better-resourced participants in the financial industry. *See* Devin Leonard, *Outmanned, Outgunned, and on a Roll*, BUS. WK., Apr. 23, 2012, at 60.

to the system.[332] Prior to the fallout of the financial crisis, credit default swaps and derivatives were largely unregulated by the federal securities and commodities regulators despite their paramount importance and relevance to the financial markets.[333] Many have pointed to the credit default swap and derivatives markets in the first decade of the millennium as prime examples of this dynamic in which intense lobbying and innovation by the resource-rich, politically connected industry players allow them to outmaneuver resource-scarce, politically constrained regulators.[334]

The resources between the regulators and the regulated need not be equal, but at the same time, the disparity in resources cannot be so large that it renders regulators impotent and unable to achieve their mandates. As previously noted, law often plays tortoise to finance's hare. However, that comparison may need to be amended: Law often plays tortoise to finance's supersonic, mechanical hare. Cyborg finance may have become too fast for old, government centered regulatory schemes, especially given the resource disparities.[335] As finance continues to innovate, regulators must ask and answer some difficult questions of themselves: Do we need a new funding model for regulators in the age of cy-fi?[336] Do we need a fundamental change in financial regulation that breaks away from old modes of top-down, government oriented regulation?[337] How these questions are answered will have profound effects on finance, law, and society.[338]

332. Serritella, *supra* note 73, at 437.

333. *See* 7 U.S.C. § 16(e)(2) (2006); Partnoy & Skeel, *supra* note 299, at 1046–47; Whitehead, *supra* note 285, at 34.

334. *See* Fabozzi et al., *supra* note 56, at 30 (describing the regulatory challenges of high-speed finance); *Frontline: The Warning* (PBS television broadcast Oct. 20, 2009), *available at* http://www.pbs.org/wgbh/pages/frontline/warning/view.

335. *See, e.g.*, Serritella, *supra* note 73, at 439–43 (critiquing the SEC's initial regulatory response to the Flash Crash as "rash"); *see also* Rodier, *supra* note 66.

336. *See, e.g.*, Arthur Levitt, Jr., *Don't Gut the S.E.C.*, N.Y. TIMES, Aug. 8, 2011, at A19 (discussing the funding and political constraints on the SEC); Richard Rubin, *House Panel Endorses Budget Cuts at IRS, Consumer Bureau*, BLOOMBERG (June 16, 2011, 12:12 PM), http://www.bloomberg.com/news/2011-06-16/house-panel-endorses-budget-cuts-at-irs-consumer-bureau-1-.html ("[Because of budget cuts], the SEC wo[n]'t be able to carry out the new responsibilities it received in the Dodd-Frank law.").

337. *See* Saule T. Omarova, *Wall Street as Community of Fate: Toward Financial Industry Self-Regulation*, 159 U. PA. L. REV. 411, 427 (2011) (advocating for more financial self-regulation as a form of new governance); *see also* Orly Lobel, *The Renew Deal: The Fall of Regulation and the Rise of Governance in Contemporary Legal Thought*, 89 MINN. L. REV. 342, 343–44 (2004) (describing a new governance model based on decentralization, localization, and collaboration).

338. This Article raises these inquiries herein to draw attention to some of the difficult fundamental issues that should be considered by policymakers in ongoing and future efforts to craft meaningful regulations for cyborg finance. The author plans to address in greater depth these inquiries in future scholarship.

2. Within the Industry

Cyborg finance has created resource asymmetries, not just between the regulators and the regulated but also among industry players. Whereas the asymmetry between the regulators and the regulated has created a competitive gap in the current regulatory framework, the asymmetry within the industry has bred more competition within the industry on one level but has also created barriers to competition on another level.[339]

On one level, cy-fi has made more investing more efficient and more inexpensive for more investors.[340] Whereas in eras past, stockbrokers, money managers, and investment advisors were necessary for many investors, today they are not. Technology has made it possible for new players like online brokerages and online banks to compete using fewer resources than traditional players. This has meant additional market access and savings for retail investors. For instance, when the NASDAQ instituted the Small Order Execution System (SOES), made possible by new technology, it opened up access to NASDAQ execution for smaller investors who historically did not have direct access to the major stock exchanges.[341] As a result of SOES, "[a]nyone with a few thousand dollars could rent a desk and trading terminal that provided a trading platform equivalent to most of the trading floors on Wall Street."[342]

Nonetheless, on another level, the resource asymmetries within the industry have also created new barriers to competition that have fundamentally changed the financial industry.[343] The increasing dependence on advanced information technology has led to competition for scarce talent and resources that are often captured by the most successful and most moneyed[344]:

339. *See* Duhigg, *supra* note 76 (describing the "technological arms race" on Wall Street) (quoting Joseph M. Mecane, NYSE Euronext).

340. *See* Salmon & Stokes, *supra* note 56 ("For individual investors, trading with algorithms has been a boon: Today, they can buy and sell stocks much faster, cheaper, and easier than ever before."); LARRY TABB, TABB GRP., LLC, WRITTEN TESTIMONY TO THE U.S. SENATE COMMITTEE ON BANKING, HOUSING, AND URBAN AFFAIRS 2 (Sept. 20, 2012) (discussing how electronic trading creates greater efficiency and lower costs for investors).

341. BROWN, *supra* note 59, at 29.

342. *Id.*

343. *See* Elimination of Flash Order Exception From Rule 602 of Regulation NMS, Exchange Act Release No. 34-60,684, 74 Fed. Reg. 48,630, 48,633 (proposed Sept. 18, 2009) (to be codified at 17 C.F.R. 242.602), *available at* http://www.sec.gov/rules/proposed/2009/34-60684.pdf (discussing the dangers of "two-tiered market[s]" in finance due to resource asymmetries); Jane K. Winn, *Catalytic Impact of Information Technology on the New International Financial Architecture*, 34 INT'L LAW. 137 (2000).

344. *See* PATTERSON, *supra* note 65, at 230 ("The new hierarchy would be all about who owned the most powerful computers, the fastest links between markets, the most sophisticated algorithms—and the inside knowledge of how the market's plumbing was put together.").

> The most successful black-box firms all have one thing in common: state-of-the-art execution platforms. Their technology allows them to participate in market rallies, to hedge risk in real time, and to capitalize on short-term price discrepancies. Without their technologies prowess, they couldn't stay one step ahead of their peers in the marketplace.[345]

Not every firm can afford the best programs, the brightest analysts, and the fastest computers. In 2010, it was estimated that high-frequency transactions in the U.S. equity markets were initiated by just 2 percent of the 20,000 trading firms in the United States—that is to say, by some 400 firms.[346] Many of these firms are hedge funds or trading desks of large investment entities with abundant resources like Goldman Sachs and BlackRock.[347]

Additionally, because speed is an essential ingredient for success in cy-fi, better-resourced institutions often possess a significant competitive advantage. Firms with more resources, for example, are able to rent expensive real estate at or near trading centers so as to reduce the amount of latency in their trade executions by fractions of seconds, a process known as colocation.[348] Latency refers to the time between an order submission and the receipt of an acknowledgement of the order.[349] "It is estimated that for each 100 miles the server is located away from the matching engine, 1 millisecond of delay is added to the transmittal and execution time."[350] By reducing latency, firms with more resources can consistently execute trades faster than their competitors, even if all market players receive actionable information at the same time. As a result of such disparities, the industry is fragmenting, and industry participants with fewer resources simply will not be able to compete and may choose to withdraw from the marketplace.[351]

The fact that some financial players have more resources than others is neither new nor revolutionary. That said, some of the resource disparities in cy-fi may be differences not only in degree but in kind—differences that have arguably unparalleled impact on the very function and integrity of the financial system. Whether

345. BROWN, *supra* note 59, at 43.

346. CAROL L. CLARK, FIN. MKTS. GRP., CHI. FED LETTER NO. 272, CONTROLLING RISK IN A LIGHTNING-SPEED TRADING ENVIRONMENT (2010), *available at* http://qa.chicagofed.org/digital_assets/publications/chicago_fed_letter/2010/cflmarch2010_272.pdf.

347. Fabozzi et al., *supra* note 56, at 8–9.

348. *See* Concept Release on Equity Market Structure, Exchange Act Release No. 34-61,358, 75 Fed. Reg. 3594, 3610 (proposed Jan. 21, 2010) (to be codified at 17 C.F.R. pt. 242); BROWN, *supra* note 59, at 63.

349. *See* BROWN, *supra* note 59, at 64.

350. Fabozzi et al., *supra* note 56, at 10.

351. *See id.* at 29; Matthew Baron et al., The Trading Profits of High Frequency Traders (Nov. 2012) (unpublished manuscript), *available at* http://conference.nber.org/confer//2012/MMf12/Baron_Brogaard_Kirilenko.pdf (finding that high-frequency traders profit at the expense of ordinary investors).

these disparities of resources within the financial industry are unfair is subject to legitimate debate, but they must be acknowledged and addressed if society values a sustainable, successful, and competitive financial industry.[352]

V. A DEFENSE OF OUR FUTURE

Cyborg finance and technological advances in artificial intelligence do not necessitate the fall of humans in society and finance. The algorithmically supercharged machines that attempt to distill order from chaos and wisdom from data need humans more than ever. In a world in which machines seek to tame the savages of randomness with elegant models, humans are nonetheless needed to create those models and harvest their true value. Rather than restrain human advancement, technological progress holds the promise of accelerated human progress—in finance and beyond.

A. On Certainty and Randomness

The speed, precision, accuracy, and convenience of computerized, data-driven analysis has led many in finance and elsewhere to adore such analysis with its elegant models as the antidote to the hostilities of randomness and uncertainty, of human action and human folly.[353] There exists a certain enchantment with the magic of technology and artificial intelligence in finance. As the noted science fiction writer Arthur C. Clarke wrote, "Any sufficiently advanced technology is indistinguishable from magic."[354] Magical or not, such adoration is misplaced; elegant models do not generate truth, nor do they eliminate randomness from an uncertain world.[355]

Financial engineers frequently operate by Leonardo da Vinci's adage that "simplicity is the ultimate sophistication"[356] as they try to impose the methodologies of physics on finance. Rough edges in data are smoothed away by assumptions and generalizations for the sake of elegance and convenience. Sometimes, when improperly acknowledged, these assumptions and generalizations can render a

352. *See* Fabozzi et al., *supra* note 56, at 28–29 (debating the market benefits of algorithmic trading).
353. *See* EMANUEL DERMAN, MODELS BEHAVING BADLY: WHY CONFUSING ILLUSION WITH REALITY CAN LEAD TO DISASTER, ON WALL STREET AND IN LIFE 143–87 (2011).
354. ARTHUR C. CLARKE, PROFILES OF THE FUTURE 21 n.1 (rev. ed. 1973).
355. *See* Paul Krugman, *How Did Economists Get It So Wrong?*, N.Y. TIMES MAG., Sept. 6, 2009, at 36 ("[E]conomists, as a group, mistook beauty, clad in impressive-looking mathematics, for truth.").
356. TAL BEN-SHAHAR, HAPPIER: LEARN THE SECRETS TO DAILY JOY AND LASTING FULFILLMENT, at xi (2007) (quoting Leonardo da Vinci).

model dangerously false.[357] In an effort to transpose the rules of the physical world onto the financial world, some financial engineers mistook elegance for truth and uncertainty for risk. Risk can be measured in terms of probabilities, but uncertainty is immeasurable.[358] Finance is not physics despite decades of attempts to transplant the analytical tenets of the physical world to the financial world.[359] Forecasting the movements of atoms is easy relative to predicting the actions of humans.[360] After losing a large sum of his investments during the South Sea Bubble in 1720, Isaac Newtown noted, "I can calculate the motion of heavenly bodies but not the madness of people."[361]

Despite the proliferation of data, there exists no dataset so large and no algorithm so refined that it generates consistent, flawless forecasts in an uncertain world.[362] Likewise, no model can perfectly predict and solve all our problems, financial or otherwise.[363] Humans can be random, and the world can be unpredictable; therefore, life cannot be perfectly modeled.[364] Data of past events help forecast future outcomes but not perfectly predict them. When properly calibrated, computer models can be incredibly powerful and instructive tools for decisionmakers in finance and beyond. Even when properly calibrated, however, they are not failsafe because randomness remains.[365] For instance, while models can have high predictive value, they cannot properly account for rare, high-impact events—so-called black swans—which exhibit the following characteristics:

> First, it is an *outlier*, as it lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. Second, it carries an extreme impact (unlike the bird). Third, in spite of

357. *See* PAUL SAMUELSON, FOUNDATIONS OF ECONOMIC ANALYSIS 4 (1947) (criticizing faulty economic models based on oversimplified assumptions that "[t]ake a little bad psychology, add a dash of bad philosophy and ethics, and liberal quantities of bad logic").

358. Frank Knight, a leader of the highly influential Chicago school of economics, made this distinction a central thesis of his landmark book, *Risk, Uncertainty, and Profit*. *See* FRANK H. KNIGHT, RISK, UNCERTAINTY, AND PROFIT (1921).

359. *See* Andrew W. Lo & Mark T. Mueller, *Warning: Physics Envy May Be Hazardous to Your Wealth!*, 8 J. INV. MGMT., no. 2, 2010, at 13, 15; JAMES OWEN WEATHERALL, THE PHYSICS OF WALL STREET: A BRIEF HISTORY OF PREDICTING THE UNPREDICTABLE 105–29 (2013) (chronicling the rise of physics in finance).

360. Lo & Mueller, *supra* note 359, at 17.

361. PATTERSON, *supra* note 67, at 12 (internal quotation marks omitted).

362. *See* Mark Whitehouse, *Economists' Grail: A Post-crash Model*, WALL ST. J., Nov. 30, 2010, at A1 (reporting on the fallacies of financial models in light of the financial crisis of 2008).

363. *Cf.* WEATHERALL, *supra* note 359, at 36–39.

364. *See* Lo & Mueller, *supra* note 359, at 21.

365. *Id.* at 14.

> its outlier status, human nature makes us concoct explanations for its occurrence *after* the fact, making it explainable and predictable.[366]

The inability to account perfectly for randomness and black swan events coupled with irrational faith in computer analysis can lead to catastrophic outcomes.[367] The financial crisis of 2008 occurred partially because many financial models failed to properly account for a potential (and eventual) steep and steady decline in the U.S. housing market.[368] During the crisis, investment banks and hedge funds suffered catastrophic losses by investing based on their computer models.[369] Most of the prevailing models at that time did not forecast the precipitous and sustained fall of the American housing market.[370] Thus, humans should not wholly surrender their rationality and free will to imperfect but elegant mathematical models, which can be misused and abused.[371] Following the crisis, Warren Buffett famously warned, "Beware of geeks bearing formulas."[372]

Where does this realization leave investors in the age of cy-fi? The answer: in a better place, if we acknowledge randomness, uncertainty, and our inability to perfectly tame them.[373] More mindful of the strengths and limitations of our tools and of ourselves, we can develop enhanced frameworks for making better and more sophisticated financial decisions.[374]

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366. TALEB, *supra* note 175, at xxii.
367. *See* Scott Patterson & Tom Lauricella, *Did a Big Bet Help Trigger 'Black Swan' Stock Swoon?*, WALL ST. J., May 10, 2010, at C2 (describing the Flash Crash as a black swan event caused by computerized trading).
368. *See, e.g.*, ANTHONY SAUNDERS & LINDA ALLEN, CREDIT RISK MANAGEMENT IN AND OUT OF THE FINANCIAL CRISES: NEW APPROACHES TO VALUE AT RISK AND OTHER PARADIGMS 31 (2010); Amir E. Khandani & Andrew W. Lo, *What Happened to the Quants in August 2007?*, 5 J. INV. MGMT., no. 4, 2007, at 5, 5–9; Krugman, *supra* note 355 ("There was nothing in the prevailing models suggesting the possibility of the kind of collapse that happened last year.").
369. *See, e.g.*, Khandani & Lo, *supra* note 368; Nocera, *supra* note 168 (chronicling the overreliance on the Value at Risk model prior to the 2008 financial crisis).
370. *See* Krugman, *supra* note 355; Nocera, *supra* note 168 (discussing how a prevailing risk management model, Value at Risk, failed during the financial crisis).
371. *See, e.g.*, Paul Wilmott, *The Use, Misuse and Abuse of Mathematics in Finance*, 358 PHIL. TRANSACTIONS ROYAL SOC'Y LONDON A 63, 63 (2000).
372. Letter From Warren Buffett, Chairman, Berkshire Hathaway, Inc., to Shareholders 15 (Feb. 27, 2009), *available at* http://www.berkshirehathaway.com/letters/2008ltr.pdf.
373. *See, e.g.*, Krugman, *supra* note 355 ("[E]conomists need to abandon the neat but wrong solution . . . that everyone is rational and markets work perfectly. The vision that emerges as the profession rethinks its foundations may not be all that clear; it certainly won't be neat; but we can hope that it will have the virtue of being at least partly right.").
374. *See* TOBIAS ADRIAN & MARKUS K. BRUNNERMEIER, FED. RESERVE BANK OF N.Y., STAFF REPORT NO. 348, COVAR 1–6 (2011), *available at* http://www.ny.frb.org/research/staff_ reports/sr348.pdf (proposing a new tool for measuring systemic risk in financial markets); Andrew Lo, *The Adaptive Markets Hypothesis: Market Efficiency From an Evolutionary Perspective*, 30 J. PORTFOLIO MGMT. 15, 15–17 (2004) (proposing an alternative model of markets that accounts for uncertainty better than the neoclassical model's based on rational actors and efficient markets); *see also* ABHIJIT

B. On Machines and Humans

As computers play larger and more pivotal roles in law, finance, and society, it naturally raises the question: What is the role of humans in a world dominated by computers?[375]

Computers are cognitively and physically superior to humans in many ways. Computers do not suffer from irrational or emotional whims. Computers possess nearly perfect memory and recall. Computers process large amounts of data faster and more accurately than humans. Computers do not tire from work or require rest the way humans do. As a result, businesses are relying more and more on computers.[376]

The advantages of computers over the human brain—of artificial intelligence over human intelligence—extend beyond the mechanical and rote to the subjective and judgmental.[377] Computers aid movie studios in selecting scripts at a fraction of the cost and at many times the speed and box office success of humans.[378] Computers are used to read and grade student essays.[379] Computers have bested legal experts in predicting Supreme Court decisions.[380] Computers are superior to humans in conducting certain types of legal document review.[381] Today, we even use computers to spot lies.[382] Oliver Wendell Holmes may have been partly right when he wrote decades ago that "[f]or the rational study of the law the black-letter man may be the man of the present, but the man of the future is the man of statistics and the

V. BANERJEE & ESTHER DUFLO, POOR ECONOMICS: A RADICAL RETHINKING OF THE WAY TO FIGHT GLOBAL POVERTY 1–16 (2011) (discussing successful applications of behavioral economics to solve the challenges in development work with the poor).

375. *See, e.g.*, John O. McGinnis, *Accelerating AI*, 104 NW. U. L. REV. COLLOQUY 366, 366 (2010) (noting the anxiety induced by improvements in artificial intelligence); Lyons, *supra* note 34, at 28 (discussing the permanent displacement of human workers by robots and computers).

376. Andrea M. Matwyshyn, *Corporate Cyborgs and Technology Risks*, 11 MINN. J.L. SCI. & TECH. 573, 573 (2010).

377. *See, e.g.*, RICHARD NISBETT & LEE ROSS, HUMAN INFERENCE: STRATEGIES AND SHORTCOMINGS OF SOCIAL JUDGMENT 141 (1980) ("Human judges make less accurate predictions than formulas do, whether they have more information than is fed into the formula or precisely the same amount of information.").

378. *See* Malcolm Gladwell, *The Formula*, NEW YORKER, Oct. 16, 2006, at 138 (reporting on Epagogix, a company that uses software to predict the potential success of movies based on narrative elements in screenplays).

379. *See* CARR, *supra* note 24, at 223 ("[In 2009,] Edexcel, the largest educational testing firm in England, had announced it was introducing 'artificial intelligence-based, automated marking of exam essays.'").

380. *See* Theodore W. Ruger et al., *The Supreme Court Forecasting Project: Legal and Political Science Approaches to Predicting Supreme Court Decisionmaking*, 104 COLUM. L. REV. 1150, 1150 (2004).

381. *See* Joe Dysart, *A New View of Review: Predictive Coding Vows to Cut E-discovery Drudgery*, A.B.A. J., Oct. 1, 2011, at 26 (discussing how computers using predictive coding software are at least as efficient as humans at reviewing legal documents).

382. *See* Anne Eisenberg, *Software That Listens for Lies*, N.Y. TIMES, Dec. 4, 2011, at BU5.

master of economics."[383] Holmes was only partly right because the man of statistics today is not a man but a machine (or perhaps a cyborg).

In the face of strong and growing evidence of the cognitive superiority of computers over humans, it is perhaps easy to relegate humanity to a secondary role in the operations of finance and society.[384] However easy, that instinct would be misplaced and wrong.[385]

In a world driven by data and machines, humans are needed more than ever. Humans are needed to make the preliminary decisions on experimentation and analysis.[386] Humans are needed to attest to the veracity and utility of the data. Humans are needed to imagine and create the algorithms, strategies, and programs for the machines.[387] Humans are needed to analyze and apply the experimental findings of the machines.[388] Humans are needed to establish the rules and regulations that govern all these interactions. In short, humans are needed to interact with the other humans and the world that they inhabit. Machines still cannot do all that we can do.[389] The numbers do not contain all the answers. "Torture numbers, and they'll confess to anything."[390] Even quantitative traders who rely heavily on machines do not dispute the necessity of humans in a world full of machines:

> The first thing that should be made clear is that people, not machines, are responsible for most of the interesting aspects of quantitative trading. . . . Despite this talk of automation and systematization, *people* conduct the research and decide what the strategies will be, *people* select the universe of securities for the system to trade, and *people* choose what

383. Holmes, *supra* note 323, at 469.
384. *See* LANIER, *supra* note 41, at 24–30 (lamenting the self-subordination of humans to technology).
385. This instinct is not unique to modernity, as people of previous eras have expressed similar trepidations about new technology and the demise of humanity. *See* RICHARD HOLMES, THE AGE OF WONDER: HOW THE ROMANTIC GENERATION DISCOVERED THE BEAUTY AND TERROR OF SCIENCE 94 (2008).
386. AYRES, *supra* note 38, at 124.
387. *See* NARANG, *supra* note 99, at xi; Steve Lohr, *Google Schools Its Algorithm*, N.Y. TIMES, Mar. 6, 2011, at WK 4 ("Computers are only as smart as their algorithms—man-made software recipes for calculation[.]").
388. Shvetank Shah et al., *Good Data Won't Guarantee Good Decisions*, HARV. BUS. REV., Apr. 2012, at 23.
389. *See* BRIAN CHRISTIAN, THE MOST HUMAN HUMAN: WHAT TALKING WITH COMPUTERS TEACHES US ABOUT WHAT IT MEANS TO BE ALIVE 5–10 (2011) (discussing the limitations of computers to have meaningful communications with humans); CHRISTOPHER STEINER, AUTOMATE THIS: HOW ALGORITHMS CAME TO RULE OUR WORLD 5–6 (2012) (opining on the need for humans to manage processes run by algorithms); John Markoff, *How Many Computers to Identify a Cat? 16,000*, N.Y. TIMES, June 26, 2012, at B1 (reporting on efforts to create artificial intelligence that can simulate human visual recognition).
390. NARANG, *supra* note 99, at 149 (quoting Gregg Easterbrook).

> data to procure and how to clean those data for use in a systematic context, among a great many other things.[391]

Human ingenuity is needed to create an infrastructure of checks and balances to manage technology meaningfully.[392] Artificial intelligence, despite its advances, still lacks the awareness, judgment, and sophistication of human intelligence.[393] Human ingenuity in persuasion, culture, spirit, and emotion—in the matters that are difficult to capture with data but nonetheless important—are all key ingredients that must be accounted for in any successful enterprise, financial or otherwise.[394]

The discourse in finance surrounding the choice between machines and humans echoes the discourse in law surrounding the choice between legal rules and legal standards.[395] Like machines, legal rules often are appreciated for their clarity, precision, and accuracy,[396] but they are criticized for their rigidity and occasional obtuseness.[397] Like humans, legal standards are "often valued for their flexibility and their susceptibility to nuanced, context-sensitive interpretation,"[398] but they are criticized for their uncertainty and amorphousness.[399]

The emergence of cyborg finance has reduced many financial decisions to an elegant set of rules and mathematical models in which human intervention is

391. *Id.* at xi.

392. *See, e.g.*, Nat Durlach et al., *Source Separation, Localization, and Comprehension in Humans, Machines, and Human–Machine Systems*, *in* SPEECH SEPARATION BY HUMANS AND MACHINES 221, 225 (Pierre Divenyi ed., 2005) (explaining how humans are needed to monitor and correct errors in machine-driven processes); Matwyshyn, *supra* note 376, at 579 ("[Corporations] sometimes neglect to build the internal management infrastructure necessary to use new technologies responsibly . . . ignoring or unwittingly assuming significant technology risks that can meaningfully damage corporate assets and goodwill.").

393. *See* STEPHEN BAKER, FINAL JEOPARDY: MAN VS. MACHINE AND THE QUEST TO KNOW EVERYTHING 148–69 (2011) (discussing the limitations of artificial intelligence).

394. *See* AYRES, *supra* note 38, at 117 (discussing the role of human expertise in a data-driven world); NEIL POSTMAN, TECHNOPOLY: THE SURRENDER OF CULTURE TO TECHNOLOGY 71–72 (1993) (criticizing the surrender of humanity to technology); Steven Schwartz et al., *Clinical Expert Systems Versus Linear Models: Do We Really Have to Choose*, 34 BEHAV. SCI. 305, 305–10 (1989); *see also* DANIEL GOLEMAN, EMOTIONAL INTELLIGENCE 60–72 (1995) (explicating on the importance of emotional intelligence in human interactions); Ronald H. Humphrey, *The Right Way to Lead With Emotional Labor*, *in* AFFECT AND EMOTION: NEW DIRECTIONS IN MANAGEMENT THEORY AND RESEARCH 1, 12 (Ronald H. Humphrey ed., 2008) (noting the value of employing emotions in leadership roles).

395. *See* sources cited *supra* note 21.

396. Shiffrin, *supra* note 21, at 1214 ("Legal *rules* are usually celebrated for their clarity and certainty.").

397. *See* Sullivan, *supra* note 21, at 26; Sunstein, *supra* note 21, at 991–92.

398. Shiffrin, *supra* note 21, at 1214.

399. *See, e.g.*, Russell B. Korobkin, *Behavioral Analysis and Legal Form: Rules vs. Standards Revisited*, 79 OR. L. REV. 23, 37–38 (2000); Antonin Scalia, *The Rule of Law as a Law of Rules*, 56 U. CHI. L. REV. 1175, 1178–79 (1989).

unnecessary and often unwelcomed. But those models are not the end of history[400] for humans because markets populated by humans do not behave perfectly in accordance with elegant rules and mathematical models.[401] Beyond machines and rules, humans and standards are needed for progress. Standards, because of their uncertain nature, induce and require human deliberation and judgment.[402] And such deliberation "promotes moral health and development,"[403] which increases the likelihood of sound financial decisions as reflective thought balances reflexive action.[404] Advances in technology must be matched with advances in "technologies of the self" for there to be meaningful progress.[405] The clarity, precision, and accuracy of legal rules and machines must be balanced with the nuance, flexibility, and empathy of legal standards and humans. Thus, that is why law needs both standards and rules[406] and why finance needs both machines and humans.

The choice of humans versus machines is a false one because every human is a cyborg now. We are all part human and part machine. The competition of the future is not a competition of humans against machines[407] but a competition among humans with machines.[408] The future of cyborg finance is not about what

400. Francis Fukuyama coined the term "the end of history" to describe the "end point of mankind's ideological evolution" following the triumph of Western democracy at the end of the Cold War. *See* FRANCIS FUKUYAMA, THE END OF HISTORY AND THE LAST MAN, at xi (2006). Given the incredible capacity of machines in finance, it may be easy to think that we, humans, are nearing our own "end of history" moment in finance, but such thoughts of our demise are greatly exaggerated.

401. *See* JEROME FRANK, LAW AND THE MODERN MIND 129 (2009) ("The acts of human beings are not identical mathematical entities; the individual cannot be eliminated as, in algebraic equations, equal quantities on the two sides can be cancelled.").

402. *See* Shiffrin, *supra* note 21, at 1222.

403. *Id.* at 1224.

404. *Cf.* Yuval Feldman & Alon Harel, *Social Norms, Self-Interest and Ambiguity of Legal Norms: An Experimental Analysis of the Rule vs. Standard Dilemma*, 4 REV. L. & ECON. 81, 81 (2008) (suggesting that legal standards and rules each balance one another to create more optimal decisions). *But cf.* Loran F. Nordgren & Ap Dijksterhuis, *The Devil Is in the Deliberation*, 36 J. CONSUMER RES. 39, 39–46 (2009) (finding that deliberation can lead to inconsistent and suboptimal choices).

405. *See* Michael Foucault, *Technologies of the Self*, *in* TECHNOLOGIES OF THE SELF: A SEMINAR WITH MICHAEL FOUCAULT 16–20 (Luther H. Martin et al. eds., 1988) (referring to methods of self-improvement as "technologies of the self").

406. *See* FRANK, *supra* note 401, at 129 ("The law is not a machine and the judges not machine-tenders. There never was and there never will be a body of fixed and predetermined rules alike for all.").

407. Popular culture's often suggests that the critical battles of the future are ones between machines and humans. *See, e.g.*, DANIEL H. WILSON, ROBOPOCALYPSE: A NOVEL (2011); TRANSFORMERS: DARK OF THE MOON (Paramount Pictures 2011); TERMINATOR 2: JUDGMENT DAY (Carolco Pictures 1991). Despite these popular suggestions, the true contests of the future will likely be human battles with the aid of machines.

408. *See* Nikhil Hutheesing, *Better Trading Through Science*, BLOOMBERG (Aug. 31, 2011, 11:50 AM), http://www.bloomberg.com/news/2011-08-31/better-trading-through-science.html ("Perhaps one day investors and traders will have a biometric contraption connected to their computers. It could scan the prefrontal cortex of the brain, determine testosterone levels and measure sweaty palms in microseconds before warning you not to make a trade.").

machines can do *to* humans but about what humans can do *with* machines. "Every technology is an expression of human will. Through our tools, we seek to expand our power and control over our circumstances—over nature, over time and distance, over one another."[409] This is true in law, in society, and in finance. Ultimately, the sensible use of smart machines by smarter humans will hold the key to better returns and better futures for investors, and it should be a key objective of financial regulators in the coming years.[410]

CONCLUSION

A sea change is happening in finance. Human endeavors have become unmanned endeavors. Computer analysis and mathematical models have replaced human thought and human deliberation. This Article has been an examination of this ongoing sea change—an examination of the pervasive ascension of machines and its wide-ranging effects on law, society, and finance. It has revealed and addressed regulatory and systemic dangers, challenges, and consequences tied to the increasing reliance on computerization and artificial intelligence in finance. And with that revelation, this Article has forecasted this ongoing transformation's impact on the future of laws and humans as traditional finance transforms into cyborg finance.

This Article began with an ominous claim about the fall of human investors as machines rise, but it ends on a more hopeful note. In the final analysis, the critical contests of the future—in law, society, and finance—are not ones between humans and machines but ones among humans *with* machines. Machines will aid new investors in their financial decisions, but despite all the advanced technology, financial tragedies and triumphs will remain the responsibility of humans.[411] Smart computers, smart programs, and smart algorithms still do not stand a chance against stupid human policies. In the wake of the financial crisis of 2008, a blue-ribbon commission was formed to study the crisis. One of its key conclusions was that "[t]he crisis was the result of human action and inaction, not of Mother Nature or computer models gone haywire."[412] The greatest ally and the greatest enemy of

409. CARR, *supra* note 24, at 44.

410. *See, e.g.*, Jenny Strasburg, *Computer Trading Takes Human Turn*, WALL ST. J., May 22, 2012, at C1 (reporting on new efforts to better combine human financial analysis with computerized trading models).

411. *See* NARANG, *supra* note 99, at xi (stating that quantitative finance "is thoroughly dependent on human decision making"); *see also* CARR, *supra* note 24, at 3 ("We are too prone to make technological instruments the scapegoats for the sins of those who wield them. The products of modern science are not in themselves good or bad; it is the way they are used that determines their value." (quoting David Sarnoff, Speech at the Univ. of Notre Dame (1955)) (internal quotation marks omitted)).

412. FIN. CRISIS INQUIRY COMM'N, *supra* note 68, at xvii.

our financial system and our society is not a machine or a network of machines; it is us. The telos of technology is not to render us useless but to aid us in our progress and evolution.[413] This is the very nature and "perfection of man."[414] Just as the spear, the wheel, and the printing press aided our predecessors in the past,[415] the computer, its memory, its speed, and its programs will aid us in the future. And so we must build new constructs—legal, financial, and others—to harness the potential of this transformative technology while taming its hostilities. In the end, this is the challenge, the promise, and the hope of the new investor.

413. *See, e.g.*, TURKLE, *supra* note 33, at 16–17 (describing how technology has become like a "phantom limb" for humans); Lisa Guernsey, *At Airport Gate, a Cyborg Unplugged*, N.Y. TIMES, Mar. 14, 2002, at G4 (reporting on wearable computer systems that enhance memory, vision, and awareness); Rob Walker, *You Tunes*, N.Y. TIMES MAG., Nov. 27, 2011, at 32 (discussing a software application intended to improve the user's musicality).

414. SAM KEEN, IN THE ABSENCE OF GOD: DWELLING IN THE PRESENCE OF THE SACRED 41 (2010) ("This is the very perfection of man, to find out his own imperfections." (quoting St. Augustine)).

415. *See* JARED DIAMOND, GUNS, GERMS, AND STEEL: THE FATES OF HUMAN SOCIETIES 257 (1999) (outlining how technology has fueled human evolution and progress); ROGER LEWIN, HUMAN EVOLUTION 10 (2005) (explaining how tool use aided human evolution, brain expansion, and social development among early humans).