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Luca Enriques

Dirk A. Zetzsche

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LUCA ENRIQUES† & DIRK A. ZETZSCHE†

This Article introduces the term Corporate Technologies ("CorpTech") to refer to the use of distributed ledgers, smart contracts, Big Data analytics, artificial intelligence and machine learning in the corporate context and analyzes the impact of CorpTech on the future of corporate boards. We focus on the tech manifestation of agency problems within corporations and identify—after considering possible market, governance, and regulatory solutions—elements of a governance framework for the CorpTech age. In particular, we take on a prediction often found in the literature, namely that CorpTech has the potential to solve a number of corporate governance problems for good and even make boards of directors redundant. We argue that this claim is based on what we call the "tech nirvana fallacy," or the tendency of comparing supposedly perfect machines with failure-prone humans. The inherent features of technology and corporate governance reveal that even well-programmed CorpTech leaves the core issue of corporate governance—conflicts of interest among the relevant corporate stakeholders—untouched. In the Corptech age, the key question becomes: "is the human being that selects or controls the firm's tech conflicted?" If so, CorpTech itself will be tainted. In fact, the problems arising from the transition to a CorpTech-dominated governance environment may, in the short-term, make things even worse: insufficient understanding of the promise and perils of CorpTech and over-confidence therein may even aggravate agency problems within firms.

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† Luca Enriques is Professor of Corporate Law at the University of Oxford Faculty of Law and Fellow of the European Corporate Governance Institute (ECGI).

† Dirk Zetzsche is ADA Chair in Financial Law (Inclusive Finance) at the University of Luxembourg Faculty of Law, Economics and Finance, Director of the Centre for Business and Corporate Law, Heinrich-Heine-University, Düsseldorf, Germany, and an Academic Member of ECGI. The Authors are thankful for comments from, and conversations on the topic with, Mark Adams, Nikita Aggarwal, John Armour, Douglas Arner, Daniel Awrey, William Birdthistle, Christopher Bruner, Ross Buckley, Michael Burstein, Isabelle Corbisier, Horst Eidenmüller, Eilís Ferran, Holger Fleischer, Merritt Fox, Joshua Getzler, Ron Gilson, Matthew Jennejohn, Sergio Gramitto Ricci, Jeff Gordon, Andrew Green, David Hiez, Herwig Hoffmann, Edward Iacobucci, David Kershaw, Joshua Mitts, Ulrich Noack, Muna Ndulo, Saule Omarova, Edmund-Philipp Schuster, Gerald Spindler, Eric Talley, Christiane Wendehorst, Arnold Weinrib, Sam Weinstein, Aaron Wright, Charles Yablon, Albert Yoon, as well as participants to presentations and workshops at Bocconi University, Cardozo Law School, Columbia Law School, Consob, Cornell Law School, the Center for International Governance Research, Harvard Law School, the Ibero-American Institute for Law and Finance, the London School of Economics, the University of Luxembourg, Monash University, the National University of Singapore, the University of Chicago-Kent, University College London, the University of Oxford, the Sorbonne, the University of Sydney Law School, the University of Toronto, the Technical University of Munich and Yale Law School. Moritz Spenke and Pamela Cela provided valuable research assistance. Usual disclaimers apply.

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INTRODUCTION

In one of the largest financial scandals to date, Wells Fargo, the United States' largest bank by number of employees, admitted to the opening of some 3.5 million deposit and credit card accounts without consumer knowledge, leading to fabricated quarterly earnings and a boost to the Wells Fargo stock price. The scandal resulted in a dozen U.S. Senate and House Committee hearings, various U.S. and state regulators' inquiries, penalties and fines exceeding $4.5 billion in total costs to date, an unprecedented "asset cap" imposed on Wells Fargo in early 2018 for "widespread consumer abuses," a fundamental revamp of Wells Fargo's compensation, compliance and risk-management system, forfeiture of CEO pay, and the departure of several executives, including three CEOs within three years.[1] The Wells Fargo scandal is the latest reminder of how, almost ninety years after Adolf Berle and Gardiner Means's seminal book *The Modern Corporation and Private Property*,[2] the mechanisms to ensure that agents within corporations perform their tasks and duties in line with the long-term interests of their shareholders (and other stakeholders, as the case may be[3]), rather than pursuing their immediate self-interest, are far from fail-proof.[4]

If laws, best practices, ethical standards, and market pressures have so far been unable to tackle this core corporate governance challenge, perhaps

1. *See* Press Release, Josh Shapiro, Att'y Gen., Off. of the Att'y Gen., Commonwealth of Pa., Attorney General Shapiro Announces $57 Million 50-State Settlement with Wells Fargo for Opening Unauthorized Accounts and Charging Consumers for Unnecessary Auto Insurance, Mortgage Fees (Dec. 28, 2018), https://www.attorneygeneral.gov/taking-action/press-releases/attorney-general-shapiro-announces-575-million-50-state-settlement-with-wells-fargo-bank-for-opening-unauthorized-accounts-and-charging-consumers-for-unnecessary-auto-insurance-mortgage-fees/ (detailing misconduct sanctioned as well as penalties, fines and settlement costs until end of 2018 of $ 3 billion); *see also* Matt Egan, *Wells Fargo Takes $1.6 Billion Hit Linked to Fake-Account Scandal*, CNN (Oct. 15, 2019), https://edition.cnn.com/2019/10/15/investing/wells-fargo-earnings-scandal/index.html (detailing additional inquiries, sanctions and penalties through Oct. 25, 2019).

2. *See* ADOLF A. BERLE, JR. & GARDINER C. MEANS, THE MODERN CORPORATION AND PRIVATE PROPERTY (1933).

3. While the prevailing U.S. corporate governance view has long expected management to focus on wealth creation for shareholders only, things have changed in recent years, as shown, for instance, by the letter from Larry Fink, Chairman and Chief Executive Officer of the world's largest asset manager, Blackrock, to the CEOs of U.S. listed companies. Letter from Larry Fink, Chairman and CEO, BlackRock, to CEOs (2018), https://www.blackrock.com/corporate/investor-relations/2018-larry-fink-ceo-letter ("To prosper over time, every company must not only deliver financial performance, but also show how it makes a positive contribution to society. Companies must benefit all of their stakeholders, including shareholders, employees, customers, and the communities in which they operate."). Multistakeholderism may be understood as the new mainstream. Yet, we will mainly keep our focus here on shareholders for two reasons. First, they are a key constituency with a well-established role in companies' internal governance, given their (hitherto exclusive) power to appoint directors. Second, while not undisputed, the principle under Delaware law is that directors, in the words of Leo Strine, former Chief Justice of the Delaware Supreme Court, have a "legal obligation to make—within the constraints of other positive law—the promotion of stockholder welfare their end." Leo E. Strine, Jr., *The Dangers of Denial: The Need for a Clear-Eyed Understanding of the Power and Accountability Structure Established by the Delaware General Corporation Law*, 50 WAKE FOREST L. REV. 761, 764 (2015).

4. *See* Michael C. Jensen & William H. Meckling, *Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure*, 3 J. FIN. ECON. 305 *passim* (1976) (outlining the concept of managerial agency costs and their implications for corporate governance).

technology can. Would algorithms and machines, with their more powerful, disinterested, and unbiased information-processing capacity, be better at monitoring corporate agents?

Breathtaking advancements in information technology (IT) are characterizing the twenty-first century, from big data analytics,[5] artificial intelligence (AI), and machine learning[6] to distributed ledger technology, including blockchains[7] and smart contracts.[8] Many expect these technologies, which we collectively refer to as "CorpTech," to prompt fundamental changes in the law[9] as well as in corporate governance.[10]

CorpTech comprises all solutions relating to corporate governance, including tools to set executive compensation, identify candidates for top positions within the organization, facilitate investor relations, corporate voting, and the internal workings of the board of directors, manage risk, and enhance compliance functions.[11] However, as used here, the term does not extend to operations software products such as those used for sales, research and development (R&D), and production management.[12]

With regard to corporate governance, scholars have speculated as to the possible use of the new technologies to improve discrete corporate practices, such as shareholder identification,[13] shareholder proposals, proxy fights,[14] electronic voting, virtual shareholder meetings,[15] digitalized compliance and

5. *See, e.g.*, Solon Barocas & Andrew D. Selbst, *Big Data's Disparate Impact*, 104 CALIF. L. REV. 671, 677–93 (2016) (describing big data analytics).

6. *See, e.g.*, Harry Surden, *Machine Learning and Law*, 89 U. WASH. L. REV. 87, 102–10 (2014) (discussing progress on AI research and how it may affect the practice of the law).

7. *See, e.g.*, Dirk A. Zetzsche, Ross P. Buckley & Douglas W. Arner, *The Distributed Liability of Distributed Ledgers: Legal Risks of Blockchain*, U. ILL. L. REV. 1361, 1370–74 (2018) (introducing the concept of distributed ledgers); PRIMAVERA DE FILIPPI & AARON WRIGHT, BLOCKCHAIN AND THE LAW: THE RULE OF CODE 13–57 (2018) (describing blockchains).

8. *See, e.g.*, Jeremy M. Sklaroff, Comment, *Smart Contracts and the Cost of Inflexibility*, 166 U. PA. L. REV. 263, 273–78 (2017) (analyzing features of smart contracts); *see also* Kevin Werbach & Nicolas Cornell, *Contracts Ex Machina*, 67 DUKE L.J. 313, 320–24, 367–81 (2017) (describing smart contracts).

9. *See, e.g.*, Chris Brummer, *Disruptive Technology and Securities Regulation*, 84 FORDHAM L. REV. 977, 1043–52 (2015) (arguing that securities regulation must be adapted to FinTech).

10. *See infra* Part II.

11. CorpTech differs from RegTech. The latter is the use of technology in the context of risk management, compliance, reporting, and regulatory oversight. It thus overlaps with CorpTech only in part—in other words, in its component relating to risk management oversight and compliance. *See, e.g.*, Douglas W. Arner, Jànos Barberis & Ross P. Buckley, *FinTech, RegTech, and the Reconceptualization of Financial Regulation*, 37 NW. J. INT'L L. & BUS. 371, 377–84 (2017).

12. Importantly, though, the boundaries between CorpTech and operations technology will necessarily be hazy, since effective CorpTech requires integration into the rest of a firm's information systems. For instance, in the Wells Fargo case, the fraud originated in the bank's retail sales department. *See supra* note 1 and accompanying text. Effective CorpTech oversight would have required access to fraud indicators available only on the operations level.

13. *See, e.g.*, George S. Geis, *Traceable Shares and Corporate Law*, 113 NW. U. L. REV. 227, 238–53 (2018); *see also* DEL. CODE ANN. tit. 8 §§ 219, 224 (allowing for the use of the blockchain to maintain corporate share registries).

14. *See, e.g.*, Geis, *supra* note 13, at 272–73.

15. *See, e.g.*, Michael D. Goldman & Eileen M. Filliben, *Corporate Governance: Current Trends and Likely Developments for the Twenty-First Century*, 25 DEL. J. CORP. L. 683, 689, 695 (2000); Anne Lafarre &

risk management,[16] as well as to the impact of these new technologies on the corporate purpose.[17] Attention has also been focused on an arguably fringe phenomenon, algorithmic entities, or "self-driving corporations," whereby humans relinquish control over the corporation to an algorithm.[18] Others have delved into discrete legal questions arising from the use of AI to assist, if not replace, boards in their decision-making functions,[19] and into the related question of whether algorithms may themselves (and should be allowed to) serve as board members.[20]

Still others have speculated as to how new technologies will reshape corporate governance more broadly. These scholars, whom we refer to as "tech proponents," share the view that technology will fundamentally change existing corporate governance paradigms and may even eradicate long-standing corporate governance problems.[21] From their perspective, technology is the solution to the ultimate challenge in corporate governance, namely, how to deal with the inherent imperfections of (human) corporate agents, including their dogged self-interestedness and pervasive biases.[22] Multiple corporate scandals

Christoph Van der Elst, *Blockchain Technology for Corporate Governance and Shareholder Activism* 15 (Eur. Corp. Governance Inst., Working Paper No. 390/2018, 2018); Christoph Van der Elst & Anne Lafarre, *Blockchain and Smart Contracting for the Shareholder Community*, 20 EUR. BUS. ORG. L. REV. 111, 128 (2019); Carla L. Reyes, Nizan Geslevich Packin & Benjamin P. Edwards, *Distributed Governance*, 59 WM. & MARY L. REV. ONLINE 1, 18–19 (2017).

16. *See, e.g.*, Kenneth A. Bamberger, *Technologies of Compliance: Risk and Regulation in a Digital Age*, 88 TEX. L. REV. 669, 722–38 (2010) (discussing the governance implications of digitalized compliance and risk management).

17. *See, e.g.*, Christopher Bruner, *Distributed Ledgers, Artificial Intelligence, and the Purpose of the Corporation*, CAMBRIDGE L.J. (forthcoming 2020) (manuscript at 19) (on file with authors) (arguing that the core issues of corporate purpose remain unchanged by technology).

18. *See* Shawn Bayern, *Of Bitcoins, Independently Wealthy Software, and the Zero-Member LLC*, 108 NW. U. L. REV. 1485, 1495–1500 (2014) (discussing algorithmic entities, corporations with no members, no directors and running merely on software); Lynn M. LoPucki, *Algorithmic Entities*, 95 WASH. U. L. REV. 887, 901–06 (2018) (discussing the perils of algorithmic entities); *see also* John Armour & Horst Eidenmüller, *Self-Driving Corporations?*, 10 HARV. BUS. L. REV. 87, 105–14 (2020) (developing a conceptual framework for self-driving corporations and highlighting regulatory challenges).

19. *See* Max Bankewitz, Carl Åberg & Christine Teuchert, *Digitalization and Boards of Directors: A New Era of Corporate Governance?*, 5 BUS. & MGMT. RSCH. 58, 63–64 (2016) (predicting that, under the influence of digitalization, boards will become "virtual networks of people" with diminished needs to monitor management).

20. *See* Sergio Alberto Gramitto Ricci, *Artificial Agents in Corporate Boardrooms*, 105 CORNELL L. REV. 869, 892–902 (2020) (discussing AI algorithms taking the functions of board members under Delaware law and arguing that the Roman law for slaves may offer a model for its legal treatment); Martin Petrin, *Corporate Management in the Age of AI*, 2019 COLUM. BUS. L. REV. 965, 1002–06 (predicting the advent of AI directors). This is of course part of the broader debate on humans' race against the machines. *See generally* ANDREW MCAFEE & ERIK BRYNJOLFSSON, RACE AGAINST THE MACHINE (2011) (detailing the replacement of human labor by computers); Carl Benedikt Frey & Michael A. Osborne, *The Future of Employment: How Susceptible Are Jobs to Computerisation?*, 114 TECH. FORECASTING & SOC. CHANGE 254 (2017) (making predictions about the same).

21. *See infra* Part II.

22. See, for example, Antony Page, *Unconscious Bias and the Limits of Director Independence*, 2009 U. ILL. L. REV. 237, 248–85 (2009) with specific reference to the corporate board setting.

(from Enron and WorldCom in the early 2000s[23] to Wells Fargo[24]) bear testimony to the pernicious consequences that the wrong corporate governance arrangements can have on shareholders and other stakeholders alike. If automated solutions become available that will finally keep corporate agents on a tight leash without unduly constraining their ability to create value, then we might be on the verge of a new era in which corporations, liberated from the negative influence of agent opportunism, can become even more formidable engines for growth and prosperity.

Tempting as it may be to set up perfect machines against failure-prone humans (what we call the "tech nirvana fallacy"),[25] a better understanding of both the available technology and the enduring role of humans in its design and deployment justifies a soberer assessment of technology's impact on corporate governance. In providing this assessment, our Article provides the conceptual groundwork for a sound governance framework in an age where humans and machines interact.

In order to do so, our Article argues that the conflicts of interest and information asymmetries that have always characterized corporate governance seep into the code of CorpTech applications. The allocation of power over the selection of particular CorpTech solutions will determine the degree of control that any constituency (directors, management, shareholders, and other stakeholders) can exert over the firm. We also dismiss as unrealistic the idea that shareholders (let alone other stakeholders) may disintermediate boards and monitor management directly themselves. Boards will continue to perform their core monitoring and mediation functions for the predictable future. Yet, we acknowledge that CorpTech, and hence adaption of corporate governance to CorpTech, is ever more important for the functioning of corporate boards.

On this basis, we lay out the pillars of a governance framework designed to steer the cooperation between humans and machines in the CorpTech age: boards should extend their monitoring functions by extending the remit of existing committees to CorpTech oversight or by establishing tech committees with the same task. We also make the case for mandatory disclosure of CorpTech-related corporate governance arrangements.

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23. In the Enron and WorldCom cases, executives had not only misled their boards of directors and audit committees on high-risk accounting practices, but also successfully pressured their audit firm (soon-to-be defunct Arthur Andersen) to ignore the issues. *See, e.g.*, John C. Coffee, Jr., *What Caused Enron? A Capsule Social and Economic History of the 1990s*, 89 CORNELL L. REV. 269, 302 (2004); CURTIS J. MILHAUPT & KATHARINA PISTOR, LAW AND CAPITALISM: WHAT CORPORATE CRISES REVEAL ABOUT LEGAL SYSTEMS AND ECONOMIC DEVELOPMENT AROUND THE WORLD 47–67 (2008) (discussing the Enron scandal).

24. *See supra* note 1 and accompanying text.

25. The nirvana fallacy refers to the misconception, common among legal scholars, of comparing the real world, with its market imperfections, with a failproof, perfectly regulated one. *See, e.g.*, Daniel R. Fischel, *The Corporate Governance Movement*, 35 VAND. L. REV. 1259, 1272 (1982). The economist Harold Demsetz first identified this fallacy, albeit without coining the term "nirvana fallacy" himself. Harold Demsetz, *Information and Efficiency: Another Viewpoint*, 12 J.L. & ECON. 1, 1–2 (1969) (introducing the "nirvana approach," described above, as being susceptible to three common fallacies: the grass is always greener fallacy, the fallacy of the free lunch, and the people could be different fallacy).

We conclude that, while CorpTech may speed up procedures and governance practices may include a greater degree of code deployment and data analytics, CorpTech will not make the corporate boards' core functions obsolete, barring technological breakthroughs that eventually displace human judgment in corporate decision-making processes entirely. So long as humans yield influence over the firm, the question of who decides what code is deployed and what data is processed will be key, and traditional corporate governance mechanisms will retain their core function of curbing agency problems within the firm.

The Article proceeds as follows. Part I provides the technical context of our analysis. Part II presents the tech proponents' view that CorpTech solutions will supplant the monitoring board, while shareholder direct involvement will make the mediating board obsolete. Part III counters these claims, arguing that conflicts of interest are bound to remain at the heart of corporate governance. Who selects the CorpTech for the firm will determine whose interests CorpTech products will cater to. Part IV develops the elements of a CorpTech-dominated governance framework designed to address corporate governance challenges in the CorpTech age. Part V concludes.

I. THE PROMISE OF CORPTECH

This Part briefly describes the technologies that are affecting, or are likely to affect, the functions typically associated with corporate boards: distributed ledgers, blockchains, and smart contracts (Part I.A); and big data analytics, artificial intelligence, and machine learning (Part I.B).

A. DISTRIBUTED LEDGERS, BLOCKCHAINS, AND SMART CONTRACTS

1. The Technologies

A distributed ledger is "a database that is consensually shared and synchronized across networks spread across multiple sites, institutions, or geographies, allowing transactions to have [multiple private or] public 'witnesses.'"[26] The data sharing results in a sequential database distributed across a network of servers all of which together function as a ledger.[27] Distributed ledgers are characterized by an absence or minimal presence of central administration and no centralized data storage. They are, hence, "distributed," in the sense that the authorization for the recording of a given piece of information results from the software-driven interaction of multiple participants. Coupled with cryptographic solutions, such features (decentrali-

26. OLIVER WYMAN, WORLD ECON. F., INNOVATION-DRIVEN CYBER-RISK TO CUSTOMER DATA IN FINANCIAL SERVICES 6 (2017), http://www3.weforum.org/docs/WEF_Cyber_Risk_to_Customer_Data.pdf.

27. DAVID MILLS, KATHY WANG, BRENDAN MALONE, ANJANA RAVI, JEFF MARQUARDT, CLINTON CHEN, ANTON BADEV, TIMOTHY BREZINSKI, LINDA FAHY, KIMBERLEY LIAO, VANESSA KARGENIAN, MAX ELLITHORPE, WENDY NG & MARIA BAIRD, FED. RSRV. BD., DISCUSSION PAPER NO. 2016-095, DISTRIBUTED LEDGER TECHNOLOGY IN PAYMENTS, CLEARING, AND SETTLEMENT 10–11 (2016), https://doi.org/10.17016/FEDS.2016.095.

zation and distribution across a network of computers) curtail the risk of data manipulation, thereby solving the problem of trusting third parties—specifically, data storage service providers.[28]

The modus operandi of distributed ledgers is best understood by contrasting them with traditional electronic ledgers where data is stored under the administration of a single entity. The latter entail a number of risks. First, if the hardware where the register is "located" is destroyed, the information contents and the authority to ascertain that they are correct are lost. Second, an unfaithful administrator (or disloyal employees, as the case may be) may manipulate the information stored in the register. Third, a cyber-attack may result in manipulations and data losses.[29]

Distributed ledgers address these problems by raising the barrier for manipulation. The underlying technology requires consensus of many data storage points ("nodes"). If there are *n* nodes (instead of one concentrated ledger) and *e* describes the effort necessary to break into any single server, all other conditions being equal (safety per server etc.), the effort necessary to manipulate all the linked servers will be *n* x *e* rather than 1 x *e*.

Distributed ledgers are usually paired with a blockchain protocol.[30] Blockchain refers to the storage of all data parts as data bundles (the "blocks") in a strict time-related series which links each block, through a time stamp, to the previous and subsequent blocks. The blockchain renders data corruption even harder, because a successful cyberattack would require simultaneously corrupting not just one, but multiple sets of data (that is, the whole blockchain) as well as the time stamps.

Distributed ledgers have provided fertile ground for the application of another innovation that may solve the problem of trust in human interactions: smart contracts.[31] While neither smart, nor contracts, they are in fact self-executing software protocols that reflect the terms of an agreement between two parties.[32] The conditions of the agreement are written directly into lines of code. Smart contracts permit the execution of transactions between disparate,

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28. *See* MICHÈLE FINCK, BLOCKCHAIN REGULATION AND GOVERNANCE IN EUROPE 12–14 (2019); *see also* Sinclair Davidson, Primavera De Filippi & Jason Potts, *Blockchains and the Economic Institutions of Capitalism*, 14 J. INSTITUTIONAL ECON. 639, 641 (2018) (arguing that blockchain technology is a new governance institution that competes with other economic institutions of capitalism, namely firms, markets, networks, and even governments); DE FILIPPI & WRIGHT, *supra* note 7, at 55, 136–40 (arguing that widespread deployment of the blockchain will lead to tech-based business practices that could prompt a loss in importance of centralized authorities, such as government, and urging a more active regulatory approach).

29. Any server *can* be manipulated with sufficient computing power and time (even if no other weakness in an encryption system is known to the attackers). *See* JEAN-PHILIPPE AUMASSON, SERIOUS CRYPTOGRAPHY: A PRACTICAL INTRODUCTION TO MODERN ENCRYPTION 10–18, 40–48 (2018).

30. *See, e.g.*, DE FILIPPI & WRIGHT, *supra* note 7, at 33–58; *see also* Zetzsche et al., *supra* note 7, at 1372.

31. *See* Sklaroff, *supra* note 8, at 272–75; *see also* Werbach & Cornell, *supra* note 8, at 332–33.

32. *See, e.g.*, Anthony J. Casey & Anthony Niblett, *Self-Driving Contracts*, 43 J. CORP. L. 1, 5 (2017); Joshua Fairfield, *Smart Contracts, Bitcoin Bots, and Consumer Protection*, 71 WASH. & LEE L. REV. ONLINE 35, 36 (2014); Karen E.C. Levy, *Book-Smart, Not Street-Smart: Blockchain-Based Smart Contracts and the Social Workings of Law*, 3 ENGAGING SCI. TECH. & SOC'Y 1, 5–6 (2017); Werbach & Cornell, *supra* note 8, at 313.

anonymous parties without the need for an external enforcement mechanism (such as a court, an arbitrator, or a central clearing facility). They render transactions traceable, transparent, and irreversible. Since processes driven by smart contracts are often saved on distributed ledgers, we refer to these three technologies (distributed ledgers, blockchains, and smart contracts) collectively as "distributed ledger technologies" ("DLTs").

2. DLT-Based CorpTech Solutions

DLTs have the potential of altering the way companies are directed and controlled.[33] Notable experiments centering around shareholder voting support this prediction. For instance, Fidelity Investments, the world's fourth-largest asset manager, has developed SOCOACT, a blockchain-based voting system designed to authenticate voters and ensure fair corporate voting processes.[34] Computershare, a provider of share-registers-as-a-service, tabulation services, and technical vote processing at shareholder meetings, has teamed up with SETL, a provider of blockchain-based central securities depositary services, in an effort to establish the world's first blockchain-based immutable register of securities ownership.[35] Broadridge, whose business includes managing the information flows between the institutional investor holding the shares and the issuer,[36] obtained a patent to utilize the Ethereum blockchain for proxy voting and share repurchases[37] following a trial with J.P. Morgan, Northern Trust, and Banco Santander.[38]

Similarly, Northern Trust, one of the largest and oldest U.S. banks, has developed a blockchain solution for board meetings in cooperation with technology giant IBM.[39] The package includes two smart contracts that record meeting attendance by collecting biometric information from the various devices

33. *See, e.g.*, Assaf Hamdani, Niron Hashai, Eugene Kandel & Yishay Yafeh, *Technological Progress and the Future of the Corporation*, 6 J. BRITISH ACAD. 215, 225 (2018) (arguing that, because DLTs reduce fraud and enhance trust, they have the potential to displace "powerful intermediaries"). *But see* Iris H-Y Chiu & Ernest W.K. Lim, *Technology vs Ideology: How Far Will Artificial Intelligence and Distributed Ledger Technology Transform Corporate Governance and Business?*, 18 BERKELEY BUS. L.J. (forthcoming 2021) (arguing that DLT merely increases efficiency of corporate governance processes).

34. *See* U.S. Patent Pub. App. No. US 2017/0046689 A1 (filed July 14, 2016), http://appft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=15&f=G&l=50&co1=AND&d=PG01&s1=%22Crypto+Voting%22&OS=%22Crypto+Voting%22&RS=%22Crypto+Voting%22.

35. *See* Press Release, SETL, Computershare and SETL Demonstrate Australia's First Working Blockchain Solution, https://www.setl.io/blog/computershare-and-setl-demonstrate-australia-s-first-working-blockchain-solution (Sept. 25, 2019).

36. On custodian chains, see, for example, Marcel Kahan & Edward Rock, *The Hanging Chads of Corporate Voting*, 96 GEO. L.J. 1227, 1236–48 (2008).

37. Press Release, Broadridge, Broadridge Secures Industry-Leading Blockchain Patent for Proxy Processing and Repo Agreements (May 10, 2018), https://www.broadridge.com/press-release/2018/broadridge-secures-industry-leading-blockchain-patent.

38. Pete Rizzo, *Broadridge Completes Blockchain Proxy Voting Trial*, COINDESK (Apr. 13, 2017), https://www.coindesk.com/broadridge-blockchain-proxy-voting-jpmorgan-santander.

39. Christine Kim, *Northern Trust Wins Patent for Storing Meeting Minutes on a Blockchain*, COINDESK (June 6, 2018), https://www.coindesk.com/northern-trust-wins-patent-storing-meeting-minutes-blockchain.

an attendee may carry and all other pertinent information about the meeting.[40] It also converts all such information into meeting minutes, following a standardized format.[41] A third smart contract posts the minutes of the meeting and associated documents in a pre-determined repository.[42] This allows meeting attendance and individual contributions to be instantaneously stored in a predetermined and searchable format.

Developments such as these have stimulated the tech proponents' optimism that DLT applications could also tackle a particularly thorny area of corporate governance: executive compensation. Specifically, smart contracts could be used to make compensation arrangements harder to alter in opportunistic ways further down the road, a phenomenon known as "backdating."[43] More generally, it has been suggested that, instead of relying on (potentially) conflicted compensation consultants and their own (often self-serving) biases,[44] boards could use smart contracts to determine compensation packages.[45] To the best of our knowledge, though, there is no publicly available evidence that any such product has yet been developed.

A. BIG DATA, ARTIFICIAL INTELLIGENCE, AND MACHINE LEARNING

1. The Technologies

Big data analytics refers to the collection and processing of data sets that are either too large or too complex for traditional data processing applications to handle.[46] Big data applications look at the bulk of data points and apply advanced data analytics methods to detect unexpected correlations, test expected correlations for causation, or determine the probability of a predefined pattern.[47]

AI assists in putting the big data gathered to good use by drawing conclusions as to the probability of an event from prior knowledge of conditions related to the event; the greater the volume of data, the more insightful and

40. *Id.*

41. *Id.*

42. *Id.*

43. David Yermack, *Corporate Governance and Blockchains*, 21 REV. FIN. 7, 8–9 (2017). For an account of the option backdating scandal, see, for example, Jesse M. Fried, *Option Backdating and Its Implications*, 65 WASH. & LEE L. REV. 853, 858–64 (2008).

44. On the role of compensation consultants, compare Kevin J. Murphy & Tatiana Sandino, *Executive Pay and "Independent" Compensation Consultants*, 49 J. ACCT. & ECON. 247, 247–62 (2010) (finding evidence for higher recommended levels of CEO pay when executive compensation consultants "cross-sell" services, but also (somewhat counterintuitively) that board pay is higher when consultants work for the board rather than for executives), with Christopher S. Armstrong, Christopher D. Ittner & David F. Larcker, *Corporate Governance, Compensation Consultants, and CEO Pay Levels*, 17 REV. ACCT. STUD. 322, 322–51 (2012) (finding that differences in governance quality explain much of the higher pay in clients of compensation consultants, while there is no support for claims that potentially "conflicted" consultants result in higher CEO pay).

45. Hamdani et al., *supra* note 33, at 229.

46. VIKTOR MAYER-SCHÖNBERGER & KENNETH CUKIER, BIG DATA: A REVOLUTION THAT WILL TRANSFORM HOW WE LIVE, WORK, AND THINK 123–149 (2013).

47. *See id.* at 6.

accurate the inferences drawn from them.[48] The baseline of AI is a computer that mimics human cognitive functions, such as "learning" and "problem solving."[49] Machine learning is a subset of AI that uses statistical, data-based methods to progressively improve the performance of computers on a given task, without humans reprogramming the computer system to achieve enhanced performance.[50] In practice, the learning is achieved through extensive "practice" with multiple feedback rounds through which the machine is told whether it has passed or failed a task.[51]

2. AI-Based CorpTech

Due to their superior performance in data gathering and processing, big data analytics, AI, and machine learning (hereinafter, referred to together as "AI") can be expected to affect all operational as well as internal control matters, from strategy setting to risk management and compliance.[52] While humans tend to use core, salient data for decisions, technology can consider also seemingly unrelated data.

Importantly for risk management, as humans tend to forget, technology can handle data of the past as effectively as data of the present. To the extent that accessibility of data of the past by humans (that is, memory) declines, management of the risk related to those data unduly becomes of secondary importance.

AI-based early detection and subsequent mitigation of non-compliance should prove particularly valuable in reducing liabilities, penalties, and fines, the magnitude of which has starkly increased in the last decade.[53]

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48. *See* STUART J. RUSSEL & PETER NORVIG, ARTIFICIAL INTELLIGENCE: A MODERN APPROACH 495–99 (photo. reprt. 2016) (3d ed. 2009).

49. *Id.* at viii, 1–4 (defining AI as devices that perceive their environment and take actions that maximize their chances of successfully achieving their task and describing the origin of the term AI in the Turing Test where "a computer passes the test if a human interrogator, after posing some written questions, cannot tell whether the written responses come from a person or from a computer," and defining six core capabilities that together compose most of AI, including natural language processing, knowledge representation, automated reasoning, machine learning, computer vision, and robotics). The seminal work on AI is, of course, A.M. Turing, *Computing Machinery and Intelligence*, 59 MIND 433 (1950).

50. RUSSEL & NORVIG, *supra* note 48, at 693–859 (describing the training methods).

51. *Id.* at 495–99.

52. *See* Armour & Eidenmüller, *supra* note 18, at 99 (while "strategic questions considered at the C-suite level" are unlikely to justify machine learning analysis, given the insufficiency of available data, "external generic data can be used to assist in scenario planning"); *see also* Saqib Aziz & Michael Dowling, *Machine Learning and AI for Risk Management*, *in* DISRUPTING FINANCE: FINTECH AND STRATEGY IN THE 21ST CENTURY 33, 34 (Theo Lynn, John G. Mooney, Pierangelo Rosati & Mark Cummins eds., 2019) (risk management); Bamberger, *supra* note 16, at 690–93, 701–02 (compliance).

53. For instance, the U.S. Federal Trade Commission has approved a fine of approximately $5 billion against Facebook for mishandling users' personal information. Cecilia Kang, *F.T.C. Approves Facebook Fine of About $5 Billion*, N.Y. TIMES (July 12, 2019), https://www.nytimes.com/2019/07/12/technology/facebook-ftc-fine.html. In 2017, German car manufacturer Volkswagen admitted to having manipulated emissions data for cars manufactured for the U.S. markets, resulting, so far, in penalties and damages of $19 billion. *See* Press Release, DOJ, Volkswagen AG Agrees to Plead Guilty and Pay $4.3 Billion in Criminal and Civil Penalties; Six Volkswagen Executives and Employees Are Indicted in Connection with Conspiracy to Cheat U.S. Emissions

Technology is also said to be unbiased,[54] albeit in the limited sense that technology does not follow its own agenda and is not itself subject to humans' cognitive biases.[55] In particular, by airing unconventional and (fact-based) contrarian views, machines could neutralize two related group dynamics that seriously hamper boards' effectiveness, namely, "groupthink"[56] and the strong social pressure against the expression of dissent in boardrooms.[57]

An oft-cited example of the early adoption of AI to improve board decision-making dynamics involved Hong Kong-based venture capital firm Deep Knowledge Ventures, which assigned a (sort of) board position to an AI software named VITAL.[58] VITAL is designed to conduct due diligence on potential investments with a view to identifying overhyped projects, thereby protecting the firm from investing in trendy, but overpriced, startups.[59]

Better use of internal and external data will also improve intra-firm monitoring, which in turn should result in reduced agency costs[60] and allow for flatter organizational structures.[61]

In particular, AI and big data analytics could improve the design and steering effects of compensation packages. Equilar Inc., a provider of tech solutions for board recruiting, executive compensation, and shareholder engagement, provides an early example. Using publicly available compensation disclosures, performance targets, and performance data, Equilar's applications generate "pay-for-performance" scores that can be used to determine whether an executive is over- or under-paid relative to executives of similarly situated companies.[62]

Tests (Jan. 11, 2017), https://www.justice.gov/opa/pr/volkswagen-ag-agrees-plead-guilty-and-pay-43-billion-criminal-and-civil-penalties-six.

54. *See* Gramitto Ricci, *supra* note 20, at 877 n.28, 901, 903; *see also* Petrin, *supra* note 20, at 1005.

55. *But see, e.g.*, Barocas & Selbst, *supra* note 5, at 692 (describing the risk that decisionmakers mask their intentions by using biased data). *See also infra* notes 124–133 and accompanying text.

56. On groupthink, see generally IRVING JANIS, VICTIMS OF GROUPTHINK (1972).

57. Akshaya Kamalnath, *The Perennial Quest for Board Independence: Artificial Intelligence to the Rescue?*, 83 ALB. L. REV. 43, 52 (2020); JONATHAN R. MACEY, CORPORATE GOVERNANCE: PROMISES KEPT, PROMISES BROKEN 61–62 (2008) (describing the pressure to conform to social norms of collegiality and cooperation within boardrooms).

58. Gramitto Ricci, *supra* note 20, at 871; Michal S. Gal, *Algorithmic Challenges to Autonomous Choice*, 25 MICH. TECH. L. REV. 59, 61 (2018); Armour & Eidenmüller, *supra* note 18, at 88.

59. *Deep Knowledge Venture's [sic] Appoints Intelligent Investment Analysis Software VITAL as Board Member*, GLOBALNEWSWIRE (May 13, 2014), https://www.globenewswire.com/news-release/2014/05/13/635881/10081467/en/Deep-Knowledge-Venture-s-Appoints-Intelligent-Investment-Analysis-Software-VITAL-as-Board-Member.html.

60. *See* Nicholas Bloom, Luis Garicano, Raffaella Sadun & John Van Reenen, *The Distinct Effects of Information Technology and Communication Technology on Firm Organization*, 60 MGMT. SCI. 2859 *passim* (2014) (finding evidence that better information technologies are associated with more autonomy and a wider control span).

61. Philippe Aghion, Benjamin F. Jones & Charles I. Jones, *Artificial Intelligence and Economic Growth*, *in* THE ECONOMICS OF ARTIFICIAL INTELLIGENCE: AN AGENDA 237, 264–66 (Ajay Agrawal, Joshua Gans & Avi Goldfarb eds., 2019).

62. U.S. Patent Pub. App. No. US 2013/0159067 A1 (filed June 20, 2013), https://pdfaiw.uspto.gov/.aiw?PageNum=0&docid=20130159067&IDKey=D5D2F8454786&HomeUrl=http%3A%2F%2Fappft.uspto.gov%2Fnetacgi%2Fnph–Parser%3FSect1%3DPTO1%2526Sect2%3DHITOFF%2526d%3DPG01%2526p%3D1%2526u%3D%25252Fnetahtml%25252FPTO%25252Fsrchnum.html%2526r%3D1%2526f%3DG%2526l

II. CORPTECH'S IMPACT: THE END OF THE BOARD AS WE KNOW IT?

Since Melvin Eisenberg's seminal book, *The Structure of the Corporation*, corporate law scholars posit that a monitoring board is necessary to keep self-interested managers at bay and to ensure that shareholder interests are catered to.[63] Corporate governance practices at U.S. listed companies have increasingly conformed to such a scholarly approach.[64]

Tech proponents argue that shareholders will no longer *need* boards to monitor managers because shareholders will be able to do the monitoring themselves.[65] For the same reason, there will be no need for boards to mediate between the company's management on the one hand and shareholders on the other.[66] Finally, because humans are not prepared for the challenges presented by tech developments, they may even be replaced, partially or fully, by CorpTech automata.[67]

We lay out the tech proponents' view in the following two ways. First, we relay their argument that CorpTech will diminish the need for a monitoring and mediating board (Part II.A). Second, we present the view that the remaining board tasks can be achieved more efficiently by CorpTech algorithms (Part II.B).

A. OBSOLESCENT BOARDS?

1. Real-Time Accounting and "Full Transparency"

According to tech proponents, the days of information asymmetry between firms' insiders and outsiders are numbered: real-time accounting will replace traditional accounting and firms will voluntarily post their ordinary business transactions on a blockchain accessible to the public.[68] In David Yermack's words, thanks to DLTs "[a]nyone could aggregate the firm's transactions into the form of an income statement and balance sheet at any time, and investors would no longer need to rely on quarterly financial statements prepared by the firm and its auditors."[69] Based on the assumption that technology will eventually lead to proprietary information being shared with investors and other market participants, tech proponents argue that full transparency will increase shareholder trust in the integrity of a corporation's data and render costly audits

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%3D50%2526s1%3D%25252220130159067%252522.PGNR.%2526OS%3DDN%2F20130159067%2526RS%3DDN%2F20130159067 (detailing the algorithms and data sources used for calculating the score).

63. *See* MELVIN A. EISENBERG, THE STRUCTURE OF THE CORPORATION: A LEGAL ANALYSIS 156–85 (1976).

64. *See* Jeffrey N. Gordon, *The Rise of Independent Directors in the United States, 1950–2005: Of Shareholder Value and Stock Market Prices*, 59 STAN. L. REV. 1465, 1518–40 (2007) (highlighting how the monitoring board model has prevailed in the U.S. in the decades following Melvin Eisenberg's influential work).

65. *See infra* Part II.A.

66. On the mediating function of boards, see Margaret M. Blair & Lynn A. Stout, *A Team Production Theory of Corporate Law*, 85 VA. L. REV. 247, 269–82 (1999) (arguing that the corporation is a "mediating hierarchy" of partially contradicting interests and that the board's core function is to balance those interests to the benefit of the firm).

67. *See infra* Part II.B.

68. Yermack, *supra* note 43, at 18, 24–25.

69. *Id.* at 24.

by potentially corrupt professional firms useless.[70] In turn, greater transparency, coupled with enhanced post-trade efficiency, will reduce transaction costs and improve liquidity in capital markets.[71]

Ultimately, tech proponents expect lower agency costs arising in connection with the selection of directors and executives,[72] accrued earnings management,[73] related party transactions,[74] and management compensation systems.[75] This should vanquish the need for boards to focus on such issues.[76]

2. More Direct Shareholder Influence

The optimism regarding enhanced transparency is not limited to accounting information but extends to transparency of ownership,[77] prompting the view that DLT-induced transparency could replace mandatory disclosure of beneficial ownership and prevent empty voting.[78]

More generally, according to Yermack, DLTs have the potential of "dramatically affect[ing] the balance of power between directors, managers, and shareholders."[79] Greater transparency on trading and ownership data may erode profit opportunities for active traders, shareholder activists, and raiders, while the (supposed) increased liquidity of a blockchain-based market would reduce the costs of selling and may therefore lead to more emphasis being placed on exit (trading) as opposed to voice (voting).[80] This would reduce the importance

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70. *Id.* at 24–25; Vedat Akgiray, Org. for Econ. Coop. & Dev. [OECD], *Blockchain Technology and Corporate Governance*, at 24–25, Doc. No. DAF/CA/CG/RD(2018)1/REV1 (June 6, 2018); *see also* Reyes et al., *supra* note 15, at 18–21 (albeit more cautiously as to the whether such a setup is desirable).

71. Yermack, *supra* note 43, at 18.

72. Hamdani et al., *supra* note 33, at 229; Kamalnath, *supra* note 57, *passim*; *see* Isil Erel, Léa H. Stern, Chenhao Tan & Michael S. Weisbach, *Selecting Directors Using Machine Learning* 34 (Eur. Corp. Governance Inst., Working Paper No. 605/2019, 2019) (describing an experiment with algorithms to make out-of-sample predictions of director performance, using shareholder approval rates as well as firm returns and profitability as proxies, testing the quality of these predictions, and concluding that "[m]achine learning holds promise for understanding the process by which governance structures are chosen, and has potential to help real-world firms improve their governance").

73. Yermack, *supra* note 43, at 25.

74. *Id.*

75. Hamdani et al., *supra* note 33, at 229; Yermack, *supra* note 43, at 20–21. Yermack also notes that blockchain trading of a company's shares may reduce the effectiveness of equity-based management incentives: assuming that part of management's compensation is *legal* insider trading (that is, trading in compliance with insider trading laws), he predicts real-time transparency to prompt less active managerial trading out of concern of sending adverse signals to the market. Yermack, *supra* note 43, at 20–21. In turn, if management profits less from legal insider trading, firms might have to pay management more to offset their foregone gains. *Id.*

76. Yermack, *supra* note 43, at 20–21, 25; Hamdani et al., *supra* note 33, at 229.

77. Geis, *supra* note 13, at 255–62 (discussing distributed ledgers and blockchain for creating traceable shares in the clearing and settlement system); *id.* at 267–69 (arguing that traceable shares lead to a fully transparent "centralized ledger of owners").

78. Yermack, *supra* note 43, at 24 (arguing that the tech-based increase in transparency will render empty voting more difficult). Empty voting refers to the exercise of shareholder voting rights without the underlying economic interest. *See* Henry T. C. Hu & Bernard Black, *The New Vote Buying: Empty Voting and Hidden (Morphable) Ownership*, 79 S. CAL. L. REV. 811, 828–36 (2006).

79. Yermack, *supra* note 43, at 9.

80. *Id.* at 19–20.

of the board as a mediator among shareholder constituencies with diverging interests.

At the same time, a private distributed ledger recording shareholder voting could increase speed and accuracy, thereby reducing voting costs and increasing shareholder participation.[81]

The blockchain also allows for decentralized, virtual-only shareholder meetings,[82] which may induce shareholders to demand votes on a wider range of topics and with greater frequency than they do today. All in all, the advent of CorpTech would justify the opening of "a debate for a new equilibrium of the division of powers between the shareholders and the board of directors."[83] This could result in shareholders assuming indirect control over management, reducing the need for board monitoring.[84]

B. TOWARD ALGO-BOARDS?

An even bolder prediction is that machines will replace human-populated boards. There are two components to this view: first, board functions are becoming more challenging for humans;[85] and, second, CorpTech solutions will be able to perform board functions better than humans.

With firms depending more and more on technology, and in an environment increasingly characterized by uncertainty and constant disequilibrium,[86] humans may become less fit to serve as board members than machines.[87] Humans may also be less willing to do so: in a fully IT-dominated environment they will be increasingly incapable of reviewing and overseeing self-learning algorithms and yet, as board members, their reputation will be on the line if such algorithms prove to be deficient.

CorpTech could step in and replace human directors as corporate monitors. Assaf Hamdani et al. suggest that "AI algorithms may become better on average at making governance decisions than individuals due to their superior ability to process information, freedom from biases, and lack of side interests."[88] If one role is left to the monitoring board, it is in the choice of algorithms.[89] Liberated

81. *Id.* at 23; Geis, *supra* note 13, at 267–69, 272–73 (arguing that DLT can enhance voting turnout and reduce the costs of shareholder activism).

82. Lafarre & Van der Elst, *supra* note 15, at 25.

83. *Id.*

84. Bankewitz et al., *supra* note 19, at 63.

85. *See, e.g.*, *id.* at 65.

86. *See, e.g.*, Mark Fenwick & Erik P.M. Vermeulen, *Technology and Corporate Governance: Blockchain, Crypto, and Artificial Intelligence*, 48 TEX. J. BUS. L. 1, 2 (2019) (predicting that firms face new "conditions of radical cognitive and normative uncertainty").

87. *See id.* at 8–10 (speculating about AI replacing board functions); *see also* Florian Möslein, *Robots in the Boardroom: Artificial Intelligence and Corporate Law*, *in* RESEARCH HANDBOOK ON THE LAW OF ARTIFICIAL INTELLIGENCE 649, 649–50 (Woodrow Barfield & Ugo Pagallo eds., 2018) (predicting use of AI in the boardroom).

88. Hamdani et al., *supra* note 33, at 229.

89. *Id.* at 230.

from their monitoring tasks, boards could focus on strategic advice instead.[90] Board composition would change accordingly: more business and fewer accounting and monitoring experts would be needed.[91]

But a more radical prediction is that boards will not necessarily continue to exist as we know them, namely as a group of humans. In this view, boards' functions, or board seats, may rather be taken over by algorithms. While qualifying VITAL,[92] its Finnish peer Alicia T,[93] and AI algorithms generally as board members may be nothing more than a publicity stunt, the discussions on whether legal personality (so-called e-personhood) should be assigned to algorithms[94] and whether algorithms should be allowed to sit on boards[95] signal CorpTech's intrusion into the core of corporate governance.

III. THE DEMISE OF THE BOARD AS A TECH NIRVANA FALLACY

Can board functions be automated to the point of making corporate boards superfluous, as the tech proponents envisage?[96]

We argue in this Part that the tech proponents' prediction is unpersuasive: it reflects an excessively optimistic view about the present (and predictable) capabilities of the salient technological developments, while disregarding the impact on CorpTech of human input persistence.

We develop our tech nirvana fallacy critique in three steps. First, we briefly describe what boards do and why they do it (Part III.A). We then take on the prediction that machines will make the monitoring board redundant (Part III.B), before challenging the claim that technology will enable shareholders to oversee managers directly and make mediating boards obsolete (Part III.C). We conclude that, although CorpTech will improve boards' performance, their present core functions will remain unchanged.

A. BOARDS' CORE FUNCTIONS

Before discussing why the tech proponents' view suffers from a tech nirvana fallacy, let us first briefly review why we have boards and what they do. Although most readers will be familiar with these concepts, a brief account of boards' core functions will set the stage for the following analysis of why technology in the foreseeable future will not displace boards.

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90. *Id.*; *see also* Mark Fenwick, Joseph A. McCahery & Erik P.M. Vermeulen, *The End of 'Corporate' Governance: Hello 'Platform' Governance*, 20 EUR. BUS. ORG. L. REV. 171, 191–97 (2019).

91. Hamdani et al., *supra* note 33, at 230.

92. *See supra* note 59 and accompanying text.

93. Alicia T is the nickname of an AI executive of Finnish software company Tieto. Antony Peyton, *Alicia Key to Tieto's AI Leadership Team*, FINTECH FUTURES (Oct. 19, 2016), https://www.fintechfutures.com/2016/10/alicia-key-to-tietos-ai-leadership-team/.

94. *See* European Parliament Resolution of 16 February 2017 with Recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)), EUR. PARL. DOC. P8_TA(2017)0051, at 3 (2017) http://www.europarl.europa.eu/doceo/document/TA-8-2017-0051_EN.pdf. *But see* Gramitto Ricci, *supra* note 20, at 889–91 (arguing against e-personhood).

95. *See* Gramitto Ricci, *supra* note 20, at 899–901.

96. *See* discussion *supra* Part II.B.

The Delaware General Corporation Law, as the most important state legislation on corporate law, states that the "business and affairs of every corporation . . . shall be managed by or under the direction of a board of directors."[97] In practice, boards do not manage corporations, but rather steer them by monitoring the top management in an effort to reduce agency costs.[98] Boards also engage as mediators in order to reduce conflicts with and among shareholders and stakeholders.[99]

1. The Monitoring Board

Collective action problems among dispersed shareholders, coupled with their limited access to information,[100] leave room for managerial opportunism.[101] In particular, shareholders have traditionally been unable to act upon negative signals about managerial performance other than by voting with their feet.[102]

A well-functioning board of directors can reduce agency costs;[103] an independent board may do better than shareholders at monitoring managers on their behalf. Directors can combine the signals of inferior performance coming from stock prices with their access to inside information in order to gain a better sense of whether negative relative stock performance is due to incompetence, bad luck, or neither.[104] They may well come to the conclusion that managers are simply ahead of their times, that is, busy implementing an idiosyncratic vision

97. DEL. COD. ANN. tit. 8., § 141(a) (2020).

98. EISENBERG, *supra* note 63, at 164–65 (stating that directors' task is to hold executives accountable for adequate results under monitoring model); STEPHEN M. BAINBRIDGE, CORPORATE LAW 80 (3d ed. 2015) ("Among [the various board's functions] . . . the board's monitoring role reigns supreme.").

99. Lynne L. Dallas, *The Relational Board: Three Theories of Corporate Boards of Directors*, 22 J. CORP. L. 1, 10–14 (1996) [hereinafter Dallas, *The Relational Board*] (stating that, in addition to monitoring, the board assumes a relational role with the external environment including information access and exchange, support of corporate business and ensuring legitimacy and status in the eyes of shareholders and stakeholders); *see also* Lynne L. Dallas, *Proposals for Reform of Corporate Boards of Directors: The Dual Board and Board Ombudsperson*, 54 WASH. & LEE L. REV. 91, 101 (1997) [hereinafter Dallas, *Proposals for Reform*] (outlining the relational role of boards).

100. *See* ROBERT CHARLES CLARK, CORPORATE LAW 95 (1986) (detailing the effects of rational apathy on shareholder voting); *see also* Lynn A. Stout, *New Thinking on "Shareholder Primacy"*, 2 ACCT., ECON. & L., no. 2, 2012, at 1, 7 (2012) ("[S]hareholders' own rational apathy raises an often-insurmountable obstacle to collective action.").

101. *See, e.g.*, OLIVER E. WILLIAMSON, THE ECONOMIC INSTITUTIONS OF CAPITALISM 47–49 (1985) (stating that opportunism involves self-interested behavior with elements of ploy, deception, misrepresentation or bad faith, resulting in management's appropriation of assets or shirking).

102. *See, e.g.*, Edward B. Rock, *The Logic and (Uncertain) Significance of Institutional Shareholder Activism*, 79 GEO. L.J. 445, 453–57 (1991).

103. In addition to boards, other mechanisms that reduce agency conflicts include reputational incentives, the market for managerial services, the takeover market, and compensation schemes. *See, e.g.*, Bernard S. Black, *Agents Watching Agents: The Promise of Institutional Investor Voice*, 39 UCLA L. REV. 811, 831 (1992) (providing a list of non-legal constraints on managerial behavior).

104. *See* Gordon, *supra* note 64, at 1563 (detailing the shift towards "informative[] stock market prices" and the evaluation of management's decisions with stock market signals); *see also* Enrichetta Ravina & Paola Sapienza, *What Do Independent Directors Know? Evidence from Their Trading*, 23 REV. FIN. STUD. 962, 974, 1000–01 (2009) (finding that independent directors earn positive and substantial abnormal returns when trading in their company shares, which is of course an indication of superior information compared to the market as a whole).

that the market is yet unable to comprehend and/or price correctly.[105] Directors also have the incentives to take the necessary steps, because not only are their reputations on the line if they remain passive,[106] but they are also increasingly compensated with stock options that are of no value unless the company's stock performance is positive.[107]

Directors are therefore in the position of fruitfully engaging with managers if their company is underperforming and determining whether the CEO should stay or go. But, of course, monitoring goes way beyond that; in particular, it includes three additional tasks.

First, oversight of management implies some degree of involvement in strategy setting:[108] a board formally approves a company's strategies, but it does so based on top managers' proposals and the information set made available to it by the latter.[109] Given the information disadvantage of (outside) board members,[110] they are unlikely to be in a position to really *define* a company's strategy. That is why a board's approval of strategies is better understood as part of its monitoring function: a board reviews the top managers' definition and implementation of the company's strategy more as a "sounding board" than as a (real) decision-maker.[111]

In addition, a board's monitoring function, usually via one or more of its committees, focuses on the corporation's governance, risk management, and compliance (hereinafter, "GRC") systems.[112] The board's oversight on GRC systems aims to ensure: first, that the level and characteristics of the risks undertaken by the company are consistent with its risk profile (as resulting also from its strategies); second, that the risk of infidelity on the part of managers and employees is kept low; and, third, that violations of the law are reasonably prevented.

Finally, boards deal with inherent, as well as occasional, conflicts of interest between top managers and the corporation, to ensure the corporation's interest prevails, in particular with regard to executive compensation and self-dealing.[113]

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105. *See* Zohar Goshen & Assaf Hamdani, *Corporate Control and Idiosyncratic Vision*, 125 YALE L.J. 560, 567 (2016).

106. John Armour, Luca Enriques, Henry Hansmann & Reinier Kraakman, *The Basic Governance Structure: The Interests of Shareholders as a Class*, *in* THE ANATOMY OF CORPORATE LAW: A COMPARATIVE AND FUNCTIONAL APPROACH 49, 62 (3d ed. 2017) (describing independent directors as "motivated principally by ethical and reputational concerns").

107. *See, e.g.*, David Yermack, *Remuneration, Retention, and Reputation Incentives for Outside Directors*, 59 J. FIN. 2281, 2286–88 (2004).

108. *See, e.g.*, Renée B. Adams & Daniel Ferreira, *A Theory of Friendly Boards*, 62 J. FIN. 217, 218 (2007).

109. *Id.*

110. *Id.*

111. *Id.*

112. GEOFFREY PARSONS MILLER, THE LAW OF GOVERNANCE, RISK MANAGEMENT, AND COMPLIANCE 73, 543 (2014).

113. MACEY, *supra* note 57, at 51–54, 59–60.

2. The Mediating Board

In the last few decades, with the reconcentration of ownership in the hands of institutional investors[114] and the rise of giant asset management companies,[115] boards' tasks have partly changed. Today, it is the norm for institutional shareholders to engage in a dialogue with both company officers and independent directors.[116] Whether boards should engage in such a relational role has been the subject of discussion among U.S. corporate law scholars,[117] but corporate practice has bypassed the theoretical dispute.

In recent years, institutional investors have pushed hard to establish two-way communication between (non-executive) directors and themselves,[118] thereby breaking management's previously held monopoly in dealing with shareholders. As a matter of fact, the continuous dialogue between a company and its shareholders is increasingly carried out by boards,[119] turning mediation into a second core function of boards.

B. AUTOMATION OF MONITORING AS THE SOLUTION?

We argue in this Subpart that, were CorpTech to replace human-populated boards, decisions would not be better than they are today from the shareholders' perspective. The contrary assertion rests, on the one hand, on an overly optimistic assessment of what technology can do, and, on the other, on an overly simplistic view of a board's current functions. We predict a more limited role

114. Lucian A. Bebchuk, Alma Cohen & Scott Hirst, *The Agency Problems of Institutional Investors*, 31 J. ECON. PERSPS. 89, 91–93 (2017).

115. John C. Coates, *The Future of Corporate Governance Part I: The Problem of Twelve* 2, 8 (Harv. L. Sch., Working Paper No. 19-07, 2018) (predicting that control of most public companies will soon be concentrated in the hands of a very small number of people, that is, those at the top of large management companies).

116. *See* Giovanni Strampelli, *Knocking at the Boardroom Door: A Transatlantic Overview of Director-Institutional Investor Engagement in Law and Practice*, 12 VA. L. & BUS. REV. 187, 199 (2018).

117. *Compare* John C. Coates IV, *Measuring the Domain of Mediating Hierarchy: How Contestable Are U.S. Public Corporations?*, 24 J. CORP. L. 837, 840–46 (1999) (detailing cases when the mediating models fails), *and* Stephen M. Bainbridge, *Director Primacy: The Means and Ends of Corporate Governance*, 97 NW. U. L. REV. 547, 559–60 (2003) (arguing that the mediating model has a small domain), *with* Dallas, *The Relational Board*, *supra* note 99, at 3 (arguing that the board is the right organ to mediate among shareholders and management and holding that relationship management is part of the board's fiduciary duties), *and* John H. Matheson & Brent A. Olson, *Corporate Cooperation, Relationship Management, and the Trialogical Imperative for Corporate Law*, 78 MINN. L. REV. 1443, 1446 (1994) (same). *See also* Blair & Stout, *supra* note 66, at 288 (arguing that corporate law supports the board's mediating role); Margaret M. Blair & Lynn A. Stout, *Director Accountability and the Mediating Role of the Corporate Board*, 79 WASH. U. L.Q. 403, 423–38 (2001) (same).

118. *See* Strampelli, *supra* note 116, at 199 (reporting that U.S. corporations increasingly involve boards, in addition to management, in the dialogue with their shareholders).

119. *See* Stephen M. Bainbridge & M. Todd Henderson, *Boards-R-Us: Reconceptualizing Corporate Boards*, 66 STAN. L. REV. 1051, 1061 (2014) (arguing that shareholder relationship management is an important board task); *see also* Strampelli, *supra* note 116, at 197–200 (reporting that boards, in addition to management, engage in dialogue with shareholders); MCKINSEY & CO., THE BOARD PERSPECTIVE: A COLLECTION OF MCKINSEY INSIGHTS FOCUSING ON BOARDS OF DIRECTORS 49 (2018), https://www.mckinsey.com/~/media/McKinsey/Featured%20Insights/Leadership/The%20board%20perspective/Issue%20Number%202/2018_Board%20Perspective_Number_2.pdf (stating in Exhibit 5 that in 2017 boards spent 9% of their meeting time on shareholder and stakeholder management, up from 0% in 2013).

for CorpTech in the boardroom: similar to how, up until today, operational, financial, legal, accounting, or risk experts advise boards, which then come to their own conclusions based on those experts' input, CorpTech can and will inform board members about options and opportunities without replacing them.

We first discuss the tech-based arguments against the demise of the monitoring board (Part III.B.1) and then turn to the inherent traits of corporate governance that justify the prediction of monitoring as a persistent function of corporate boards (Part III.B.2).

1. IT Limitations

Technology may help address humans' cognitive biases and improve the quality of their decisions.[120] But technology's own limits make the proposed scenario of machines replacing boards unrealistic. These limits[121] are outlined in this Subpart. In their presence, CorpTech will augment boards' effectiveness but will not replace them.

a. Data Dependency

Predictions identify patterns in past data and offer them as projections about future events, basically assuming that history will repeat itself one way or another.[122] Hence, an algorithm is only as good as the data it works with. Where data of the past reflects biases, so too will the machine results:[123] the data could reflect the biases of prior decision-makers[124] or biases that persist in society at large.[125] Developers tend to be unaware of either any particular deficiencies in the data set or the ensuing discrimination.[126] As a study on Facebook's self-pricing algorithm for educational advertisements has shown, an algorithm designed to be gender-neutral still steered advertising for science, technology, engineering, and mathematics courses to more men than women because the algorithm priced advertisement to women higher than advertisement to men; as

120. *See, e.g.*, Cass R. Sunstein, *Algorithms, Correcting Biases*, 86 SOC. RSCH. 499 *passim* (2019) (arguing that algorithms can be designed to be unbiased and perform certain tasks better than biased humans). *But see* Sandra G. Mayson, *Bias In, Bias Out*, 128 YALE L.J. 2218, 2251 (2019) ("It is possible to replace one form of disparity with another, but impossible to eliminate it altogether.").

121. We do not discuss, though, two obvious IT issues: deficient coding as a result of human inaccuracy and exposure to cyber risks. While troublesome, they are not relevant for our purposes as they appear not to have any specific implication in regards to CorpTech.

122. Mayson, *supra* note 120, at 2251.

123. Barocas & Selbst, *supra* note 5, at 673–74; *see also* Mayson, *supra* note 120, at 2251–52.

124. Barocas & Selbst, *supra* note 5, at 673–74; *see also* Rashida Richardson, Jason M. Schultz & Kate Crawford, *Dirty Data, Bad Predictions: How Civil Rights Violations Impact Police Data, Predictive Policing Systems, and Justice*, 94 N.Y.U. L. REV. 192, 204–17 (2019) (detailing examples of manipulated data in the criminal justice system, reflecting racial bias).

125. Barocas & Selbst, *supra* note 5, at 671 ("[D]ata mining can discover surprisingly useful regularities that are really just preexisting patterns of exclusion and inequality.").

126. Conscious choices may, however, be the result of conflicts of interests (*see infra* Part III.B.2.b). And lack of awareness does not exclude racially or gender biased, or otherwise illegal, practices. *See* Richardson et al., *supra* note 124, at 193–97 (detailing examples of such practices in the context of predictive policing).

a consequence, for a given budget more men than women were exposed to the advertisement.[127]

Furthermore, AI's predictive capabilities depend on the training data.[128] The "learning" of a self-learning machine refers to identifying patterns in existing data sets where instances of, say, securities fraud are labeled as such.[129] The machine then looks for patterns among the labeled cases without using explicit instructions.[130] That subset of recurring characteristics can then be used for any other dataset.[131] Where the subset characteristics are found to be present, the machine will assume that securities fraud is also present. What the machine "learns" depends on the examples it has been exposed to, as well as on the quality of the labeling.[132] The closer the training data to the real-world application, the better the predictive ability of the AI.[133] For instance, a data set taken from Enron Corporation has often been used to train many AI-enhanced compliance tools.[134] As we know today, Enron's internal communication methods and (bad) governance were in many respects outliers, even relative to the less governance-aware corporate world of Enron's times.[135] AI trained with outlandish, outdated, and incomplete data from Enron will lack predictive accuracy for most firms.[136]

Firms may seek to enhance predictive accuracy by training the AI with data generated inside their own organization.[137] In this case, data availability may emerge as an issue. Even where firms have the right to use or transfer data,[138] small- and medium-sized firms are likely to lack data pools of sufficient size to train the technology.[139] Large firms that collect sufficient data, however, may

127. Anja Lambrecht & Catherine Tucker, *Algorithmic Bias? An Empirical Study of Apparent Gender-Based Discrimination in the Display of STEM Career Ads*, 65 MGMT. SCI. 2966, 2966–68, 2977–78 (2019) (analyzing an advertisement algorithm intended to be gender-neutral in its delivery and concluding that any algorithm that simply optimizes cost-effectiveness in ad delivery will deliver ads in an apparently discriminatory way).

128. *See* RUSSEL & NORVIG, *supra* note 48, at 701–02.

129. *See generally id.* at 693–95 (discussing various types of learning algorithms that use input-output pairs).

130. *Id.* at 694–95, 698.

131. Armour & Eidenmüller, *supra* note 18, at 95.

132. *Id.*; RUSSEL & NORVIG, *supra* note 48, at 701–02.

133. *See id.* at 706–08 (describing preconditions of learning from examples).

134. Armour & Eidenmüller, *supra* note 18, at 97 (stating that machine learning developers use coaching data from widely available data sets, such as the Enron email data set that was originally put online by the U.S. Federal Energy Regulation Commission). The data set contains data from about 150 users, mostly senior management of Enron, with a total of about half a million messages. William W. Cohen, *Enron Email Dataset*, CARNEGIE MELLON UNIV., https://www.cs.cmu.edu/~./enron/ (May 8, 2015).

135. *See, e.g.*, Coffee, *supra* note 23, at 270–71, 282–82; CURTIS J. MILHAUPT & KATHARINA PISTOR, LAW AND CAPITALISM: WHAT CORPORATE CRISES REVEAL ABOUT LEGAL SYSTEMS AND ECONOMIC DEVELOPMENT AROUND THE WORLD 47–67 (2008) (discussing the Enron scandal).

136. The e-mails' text had been redacted in response to privacy concerns and attachments to messages had been deleted to reduce data size. Cohen, *supra* note 134.

137. Armour & Eidenmüller, *supra* note 18, at 97–98.

138. The data pool available for Corptech training may be limited by legal barriers, including data protection, intellectual property laws, and confidentiality agreements signed with customers and business partners. *See id.* at 100.

139. *Id.* at 98.

hesitate to share firm-specific data with external developers. These data may be too valuable to share in an environment where "data is the new oil,"[140] as they, or the training results thereof, can be, respectively, copied and (once incorporated into services) sold to competitors. Worse still, external developers may become competitors themselves after assembling a large enough data pool.[141]

Finally, finding some regularities in past data (however recent and "big") is more useful in some areas, such as medical diagnoses and image recognition, than in others, such as social dynamics. Human behavior is less predictable, as markets and people's preferences evolve. Because humans adapt to changes, responses to a given context that were observed regularly in the past will not necessarily be good predictors of the future. To generalize, correlations between complex, dynamic human phenomena that interact with other organizations and an indefinite number of individuals (stakeholders, consumers, etc.), are poor predictors of future outcomes.

The data dependency problems highlighted so far reflect the current state of the relevant technologies. These problems may well be overcome at some point in the future. For instance, an application for bias analysis may recognize and remedy the impact of biased data,[142] and the publicly available data pools can become large enough to allow for accurate training. Even then, however, the core issue with data dependency, namely, its backward orientation, will remain unresolved: in real life, it is normally the case that the right answers to the questions defining the success or failure of a firm, such as whether to enter a new market or to leave the CEO in place, to assume growth or a shrinking global demand mid- to long-term, cannot be found in past data. AI-based predictions can effectively support those decisions, but in the end something very human is required: judgment.[143]

140. The origin of this sentence is uncertain. One of the earliest sources to use it dates back to 2006. Michael Palmer, *Data Is the New Oil*, ANA MARKETING MAESTROS (Nov. 3, 2006, 5:43 AM), http://ana.blogs.com/maestros/2006/11/data_is_the_new.html.

141. *Cf.* Dirk A. Zetzsche, Ross P. Buckley, Douglas W. Arner & Janos N. Barberis, *From FinTech to TechFin: The Regulatory Challenges of Data-Driven Finance*, 14 N.Y.U. J.L. & BUS. 393, 399–415 (2018) (analyzing the entrance of big data firms like Alibaba, Amazon, Apple, Baidou and Google into the financial services sector).

142. *See* Rumman Chowdhury & Narendra Mulani, *Auditing Algorithms for Bias*, HARV. BUS. REV. (Oct. 24, 2018), https://hbr.org/2018/10/auditing-algorithms-for-bias (presenting a tool developed by Accenture and the Alan Turing Institute that measures the discriminatory impact of big data applications and corrects for predictive parity to achieve equal opportunity).

143. *See* Surden, *supra* note 6, at 97–98 (arguing that AI approximates intelligence by detecting proxies, patterns, or heuristics and emphasizing that many complicated problems "may not be amenable to such a heuristic-based technique"); Mohammad Hossein Jarrahi, *Artificial Intelligence and the Future of Work: Human-AI Symbiosis in Organizational Decision Making*, 61 BUS. HORIZONS 577, 580 (2018) ("Unlike board games, in which the probability of the next action can be calculated, real-world decision making is messy and reliance on probabilistic, analytical thinking tends to be insufficient.").

b. Conflicts with Human Ethics

Morally wrong determinations can seriously harm a firm's reputation and its share price.[144] Were CorpTech to make such decisions, the risk of unethical determinations revealing themselves to be spectacular mistakes would skyrocket. That is because training machines in ethical matters is an impossible challenge, as "[ethical] norms are fuzzy."[145] Humans themselves often cannot tell what prompts their value judgments. Even in a CorpTech world, then, aligning corporate behavior with mainstream ethics requires human involvement (and human-populated board oversight).

c. Inferior Handling of Incomplete Law

Where an incident (a violation of the law or an employee's wrongdoing) is reported, the corporate response will depend on a unique combination of factors. In fact, most GRC issues imply discretion, even for cases that are very similar to past ones. Hence, a pre-determined 1/0, yes/no algorithm will be unable to reach good decisions on how to react.[146] This is the inevitable implication of the incompleteness that characterizes the legal environment, where not only are contracts incomplete, but so too is the law itself:[147] neither contracts nor the law can provide for clear-cut rules for every situation. Drafting exhaustive contracts and laws would be incredibly expensive and, in fact, outright impossible, and so too would the creation of a CorpTech solution attempting to do just that.[148] Governance arrangements themselves are incomplete on purpose,[149] and hence unfit for strict tech-based execution.

144. For instance, its relationship with Definers Public Affairs, a Washington-based opposition research firm cost Facebook nine percent of its share price on a single day, or $36 billion, which at the time was slightly less than the total value of the carmaker Ford. Salvador Rodriguez, *Here Are the Scandals and Other Incidents That Have Sent Facebook's Share Price Tanking in 2018*, CNBC, https://www.cnbc.com/2018/11/20/facebooks-scandals-in-2018-effect-on-stock.html (Nov. 20, 2018, 10:22 PM).

145. Eric A. Posner, *Law, Economics, and Inefficient Norms*, 144 U. PA. L. REV. 1697, 1699 (1996).

146. 1/0 is the paradigm of Boolean logic. But human judgment follows neither Boolean logic nor any other conventional mathematical discipline. This is also true when you soften the 0/1 paradigm using probability theory or fuzzy logic (since fuzzy logic can operate with all infinite values within the interval <0, 1>). *See, e.g.*, Václav Bezděk, *Using Fuzzy Logic in Business*, 124 PROCEDIA—SOC. & BEHAV. SCIS. 371, 372–79 (2014). Whether an observer holds an incident to be probable (from her subjective point of view) or she puts an incident into the "more negative rather than positive" box (using fuzzy logic, which requires preferences in a given order), the analysis applying an *ad hoc* mix of factors results in the qualification of conduct as likely (probability) or "more harmful than helpful" (fuzzy logic). If the factors that justify 0 or 1, a given probability assessment, or the preferences for fuzzy qualification are impossible to discern ex ante, they cannot be put into code. *See id.*

147. See H. L. A. HART, THE CONCEPT OF LAW 127–28 (2d ed. 1994) and, more recently, Katharina Pistor & Chenggang Xu, *Incomplete Law*, 35 N.Y.U. J. INT'L L. & POL. 931, 938–44 (2003). With specific reference to compliance issues, see Donald C. Langevoort, Caremark *and Compliance: A Twenty-Year Lookback*, 90 TEMP. L. REV. 727, 734 (2018) ("[C]omplication arises from the subjective nature of law and legal risk. Law is often full of ambiguity, even when factual questions are posed clearly."). *See also* Joshua P. Davis, *Artificial Wisdom? A Potential Limit on AI in Law (and Elsewhere)*, 72 OKLA. L. REV. 51, 61–65 (2019) (arguing that AI is incapable of mimicking value-based decisions since it misses the first-person perspective).

148. *See* Aghion et al., *supra* note 61, at 41–42 (arguing that AI technologies will not overcome contractual incompleteness).

149. *See infra* Part III.B.2.

Even where a board finds that management is responsible for a GRC failure, a formal sanction might not always be warranted: handling GRC situations will often involve an aspect of judgment and/or adjudication under conditions of significant uncertainty regarding the response of the sanctioned person(s) and that of stakeholders (including employees, the public and others). That requires the discretionary, creative, and non-rule based decision-making that is, at least for the predictable future, part of the human skillset that machines are unable to replicate.[150] In an environment that is otherwise under the increasing influence of technology, the board brings in the unpredictable yet indispensable human factor.[151]

2. *Governance's Inherent Traits*

a. *The Incomplete Corporate Contract*

A corporation is often described as a nexus of contracts, that is, a bundle of formal and informal relationships among the various stakeholders.[152] These contracts are incomplete, and intentionally so, since writing a multiplicity of complete contracts between a firm's stakeholders would be either excessively costly or unduly constraining.[153] For these reasons, governance arrangements are incomplete on purpose and, hence, unfit for strict tech-based execution. It is a board's task to continue writing chapters of the corporate contract where necessary. Corporate governance provides the tools to deal with such incompleteness: as circumstances change and new information becomes available, management, boards, and shareholders react by making decisions, each in their own sphere, that allow for adaptation and optimization to a degree that ex ante planning could not match.[154]

CorpTech will not eradicate contractual incompleteness, whether by superior ex ante planning or by better-than-human ex post decisions. Such eradication would require not only access to, and correct processing of, *all* existing data in the world (something that CorpTech may well provide for in the

150. *See* Dylan Hadfield-Menell & Gillian K. Hadfield, *Incomplete Contracting and AI Alignment*, *in* AAAI/ACM CONFERENCE ON AI, ETHICS, AND SOCIETY 417, 419–20 (2019) (arguing that coders are yet incapable of replicating norms and standards that grant discretion to their addressees).

151. This is not to deny that humans, and human-populated boards, make mistakes too. *See infra* notes 156–160.

152. *See, e.g.*, Frank H. Easterbrook & Daniel R. Fischel, *The Corporate Contract*, 89 COLUM. L. REV. 1416, 1426 (1989).

153. *See* FRANK H. EASTERBROOK & DANIEL R. FISCHEL, THE ECONOMIC STRUCTURE OF CORPORATE LAW 91–93 (1991). This point is acknowledged in the literature on new technologies. *See* Sklaroff, *supra* note 8, at 263 (arguing that human-based contracting is flexible due to inherent incompleteness, while machine-based contracting creates new inefficiencies from automation, decentralization, and anonymity); Adam J. Kolber, *Not-So-Smart Blockchain Contracts and Artificial Responsibility*, 21 STAN. TECH. L. REV. 198, 220 (2018) (arguing that the code does not reflect the entirety of the parties' agreement); Hadfield-Menell & Hadfield, *supra* note 150, at 421–22 (emphasizing "parallels between the challenge of incomplete contracting in the human principal-agent setting and the challenge of misspecification in robot reward functions").

154. *See* Easterbrook & Fischel, *supra* note 152, at 1437–39 (arguing that the contract adopted as optimal ex ante may not be optimal ex post, for instance due to changing circumstances such as a takeover bid).

future), but also the ability to predict all future developments. In a non-deterministic world like the one that humans inhabit, and where humans still make meaningful decisions, machines are highly unlikely to become powerful enough to do that. Any set of codes predicting future events would require a significant level of speculation and thus would be certain to be flawed (despite its prohibitive cost).

To be sure, the benchmark of technology, and AI in particular, is not perfection but human parity.[155] Any CorpTech solution completing contracts ex post *better* than human boards would justify algorithmic boards. And it is easy to acknowledge that human boards are themselves far from perfect in making the decisions executing the incomplete corporate contract. Arguably, they are also limited in their ability to learn, as recurring governance scandals demonstrate. Still, one thing human boards are better at than CorpTech, and can be predicted to be for a long time, are *complex* interactions with humans.[156] Take the example of the Wells Fargo scandal.[157] The bank was forced to switch to political mode and face, among other things, multiple U.S. House and Senate Committee hearings[158] in order to minimize the reputational fallout.[159] Such a mode includes intense lobbying action, public relations efforts, and generally presenting in a positive light a firm's corporate culture, values, and ethics. Soft skills and fuzzy matters such as these are unsuitable for automation:[160] any sufficiently intricate, politically charged matter requires humans to interact with humans.

b. Conflicts of Interest

An algorithm is not an "impartial" tool: it assists its creators in settling affairs within a community according to *its creators'* preferences.[161] So long as algorithms are written by humans and, even more importantly, sold to humans, claims that algorithms can be non-conflicted or neutral are ill-founded: CorpTech solutions are bound to reflect the interests and views of those ultimately in control of the code design and/or selection process. If, as has hitherto been the case across corporations, management wields influence over

155. *See* RUSSEL & NORVIG, *supra* note 48, at 2–3.

156. *Simple* communication between machines and humans does take place regularly and frequently.

157. *See supra* note 1 and accompanying text.

158. *See, e.g.*, *Holding Megabanks Accountable: An Examination of Wells Fargo's Pattern of Consumer Abuses: Hearing Before the H. Comm. on Fin. Serv.*, 116th Cong. (2019) (statement of Timothy J. Sloan, President and Chief Executive Officer, Wells Fargo).

159. For an account of how Wells Fargo managed the scandal fallout, see Hilary Fussell Sisco, *Financial Crisis Management and Wells Fargo: Reputation or Profit?, in* THE HANDBOOK OF FINANCIAL COMMUNICATION AND INVESTOR RELATIONS 319, 319 (Alexander V. Laskin ed., 2018).

160. *See* Hadfield-Menell & Hadfield, *supra* note 150, at 421 (acknowledging that "alignment of artificially intelligent agents with human goals and values is a fundamental challenge in AI research").

161. *See* LANGDON WINNER, THE WHALE AND THE REACTOR: A SEARCH FOR LIMITS IN AN AGE OF HIGH TECHNOLOGY 21–22 (1986).

the CorpTech system as a component of its IT system,[162] then CorpTech solutions will reflect management's interests and views. If management's incentives are not perfectly aligned to those of their principals, then boards' (and shareholders') trust in the relevant CorpTech will be misplaced.[163]

The coders (perhaps with the help of their marketing departments if they are independent suppliers) will understand which functions, within corporations, are in charge of selecting them as code suppliers and directing their work. They will naturally make product choices that fit such buyers' interests. If decisions on Corptech products are under managers' control, then the CorpTech will further management's interests.

To illustrate this general point about conflicted coding, take the issue of managerial compensation. It has been debated whether this is an area where abuse and suboptimal bad practices are ripe, be it because CEO compensation packages are excessive or because prevailing compensation practices generate skewed incentives for managers.[164] Contrary to the tech proponents' view,[165] unless the analogic mechanics of executive compensation setting are fixed (so long as they need fixing),[166] digital solutions will be no better than analogue ones. In fact, if the current system relying on compensation consultants selected by independent board committees and assisting the latter in their determinations is flawed, then there is little reason to believe that an algorithm will improve upon current practices: it will instead reflect any flaws arising from them. What it can achieve is the devising of the perfect compensation package *that the existing compensation practices allow for*: this is a different kind of perfect—perfect not in the sense of being optimal for shareholders, but in the sense of

162. Chief Information (or Technology) Officers usually report to the CEO or the CFO. *See, e.g.*, ALEXANDER HÜTTER & RENÉ RIEDL, CHIEF INFORMATION OFFICER ROLE EFFECTIVENESS: LITERATURE REVIEW AND IMPLICATIONS FOR RESEARCH AND PRACTICE 12 (2017).

163. In other words, the governance risk of CorpTech stems not only from "bad coding" in a technical sense, but also from the fact that code developed under management influence is bound to be skewed towards management's interests. John Armour, Luca Enriques, Ariel Ezrachi & John Vella, *Putting Technology to Good Use for Society: The Role of Corporate, Competition and Tax Law*, 6 J. BRIT. ACAD. 285, 298 (2018) ("[T]he incentives of the persons designing a firm's internal performance monitoring systems are likely to become even more significant.").

164. *Compare* Lucian Arye Bebchuk, Jesse M. Fried & David I. Walker, *Managerial Power and Rent Extraction in the Design of Executive Compensation*, 69 U. CHI. L. REV. 751 *passim* (2002) (arguing that structural flaws in corporate governance have enabled managers to influence their own pay and extract rents to the detriment of shareholders), *with* Kevin J. Murphy, *Explaining Executive Compensation: Managerial Power Versus the Perceived Cost of Stock Options*, 69 U. CHI. L. REV. 847 *passim* (2002) (criticizing Bebchuk, Fried, and Walker's theses), *and* Steven N. Kaplan, *Are U.S. CEOs Overpaid?*, 22 ACAD. MGMT. PERSPS. 5, 8–14 (2008) (criticizing the view that U.S. CEOs are overpaid and not paid for performance).

165. As we have seen, some have suggested that AI and Big Data may allow a company to consider all relevant information and possibly learn from other companies' best practices to devise the optimal compensation package, while smart contracts could make the compensation arrangement harder to alter in opportunistic ways further down the road. *See supra* notes 44–46 and accompanying text.

166. The jury, of course, is still out on whether executive compensation is more a solution to, or a manifestation of, managerial agency problems. For a recent discussion of the various facets of the problem, see, for example, Guido Ferrarini & Maria Cristina Ungureanu, *Executive Remuneration*, *in* THE OXFORD HANDBOOK OF CORPORATE LAW AND GOVERNANCE 334 *passim* (Jeffrey N. Gordon & Wolf-Georg Ringe eds., 2018).

perfectly processing all information in the way that best caters to the interests of those who control the process.

c. Information Flows

The biggest hindrance to a more balanced distribution of power between management, boards, and shareholders in publicly held corporations is management's exclusive access to the inner workings of the corporate business and its ensuing filtering role regarding the information set that is needed to monitor its performance.[167] Can IT solutions overcome such a hitherto inevitable corporate governance trait? So long as management retains control of the coding, data sources, and algorithms used for reporting to a board,[168] the answer is no.

Take again here the example of executive compensation. Optimal compensation packages are firm- and employee-specific.[169] Coding optimal compensation models requires in-depth, firm-specific, forward-looking information usually monopolized by management. If management is involved, it can be expected to use its superior knowledge to make sure that the code reflects its interests.

When an AI CorpTech product processes data, understanding the extent to which management manipulates a board by providing more or less data than necessary and whether the algorithm presents them in an unbiased way is increasingly difficult. The risk of algo-supported board members becoming executives' puppets without the slightest suspicion of being manipulated may be even higher than for analogue boards. In fact, well-functioning analogue boards are trained to second-guess the completeness and reliability of the supporting information selected by the CEO. They may rely on their experience and on their instincts. In an algorithmic world, these instincts may prove less useful and it may be harder to question the completeness and reliability of information that a supposedly objective machine, rather than a self-interested human, has selected and processed.

C. THE BOARD DISINTERMEDIATION HYPOTHESIS

Involvement in shareholder dialogue grants independent directors an important mediating role between shareholders and the company's management. The mediating role is premised on shareholder identification and shareholder intelligence: companies have to get to know their shareholders (something that CorpTech will facilitate).[170] In addition, if companies are to secure shareholder

167. *See, e.g.*, EISENBERG, *supra* note 63, at 144 ("[T]he amount, quality, and structure of the information that reaches the board is almost wholly within the control of the corporation's executives."); *see also* Bengt Holmlström, Pay without Performance *and the Managerial Power Hypothesis: A Comment*, 30 J. CORP. L. 703, 711 (2005) (highlighting how boards need to have the CEO's trust for the latter to be willing to share essential information about the company with the former).

168. *See* discussion *supra* Part III.B.1.a.

169. *See, e.g.*, David I. Walker, *Evolving Executive Equity Compensation and the Limits of Optimal Contracting*, 64 VAND. L. REV. 609, 621–23 (2011).

170. *See supra* Part I.A.2 for examples of DLT-based CorpTech solutions.

backing, they also have to know their individual shareholders' preferences. Shareholder dialogue, finally, is more than simple information transmission (something at which CorpTech is particularly good): it can include the difficult task of persuading shareholders that something (seemingly) at odds with their preferences should nevertheless be given support. In practice, this often involves various rounds of negotiations and requires—as we argue in this Subpart—a significant degree of human judgment.

Tech proponents argue that CorpTech will change the (relatively new) mediating role of a board in two ways. First, it may enable shareholders to monitor management themselves, making the board's monitoring on their behalf obsolete. In a CorpTech-dominated environment where the costs of shareholder engagement, and voting in particular, are greatly reduced, direct shareholder-to-management relations may substitute for the present board-centered governance framework.[171] Second, CorpTech could make the mediating functions of non-executive members similarly passé, as the new information tools may allow shareholders to directly engage with management just as effectively.

In this Subpart, we show that this board disintermediation hypothesis is flawed: again, it disregards inherent governance features, which technology cannot cure, and IT limitations.

1. Governance's Inherent Features

The board disintermediation hypothesis rests on two assumptions: first, that CorpTech allows for real-time accounting and "full transparency;" and, second, that CorpTech further reduces the cost of processing available information and deciding how to vote. The combination of the two should enable shareholders to do the monitoring board's job themselves. We do not question the technical possibility of processing and analyzing a virtually unlimited volume of information. And, incidentally, we leave apart the fact that DLTs reduce the risk of data manipulation but, of course, do not ensure that data stored via DLTs is correct.[172] We argue instead that the full transparency hypothesis is unrealistic and that, even if it was realistic, shareholder monitoring would still be patchy at best. We finally contend that shareholder dialogue exclusively involving executives, rather than directors, would lead to inferior outcomes.

a. Information Asymmetries to Persist

Corporations are engines of innovation. Shareholders delegate the power to conduct a company's business to a management team which has full control over the company's operations and resources under the board's oversight. Delegation is also needed to preserve confidentiality of a company's plans and strategies, which in turn is necessary for it to make profits. This is a simple fact

171. *See supra* Part II.A.2.

172. *See, e.g.*, Zetzsche et al., *supra* note 7, at 1374.

that is ignored in the assumption that technology-enabled full transparency can be realized.[173]

Issuer disclosures, whether mandatory or voluntary, have become more frequent and rich,[174] and will become even more so in an AI-enhanced environment where the use of machines should make information overload less of a concern for policymakers.[175] Yet, U.S. corporations can be particularly reticent when it comes to discussing their plans, strategies, R&D projects, and anything that may be of crucial interest to competitors. One example of that is Apple's protracted silence over its Apple Watch sales. While analysts agree that such sales figures would be extremely valuable information for investors,[176] U.S. securities regulation does not require Apple to disclose them and Apple's management has consistently refused to voluntarily provide the market with the relevant figures.[177]

Not only are corporate disclosures bound to remain patchy, but it is also highly unlikely that technology will prevent traders from concealing their trades, given the value of secrecy for their success.[178] Tech proponents themselves acknowledge this and present the scenario of full trading and ownership transparency as just one option that may become available on the market for individual issuers to choose.[179] However, even issuers most worried about hostile takeovers and activist campaigns will find an all-transparent trading environment unattractive, and prefer tools less harmful to their cost of capital in order to insulate themselves from hostile bidders and activists.

b. Passive and Closet Index Funds: Collective Action Problems to Persist

Even in a world with lesser (or no) information asymmetry, the board disintermediation hypothesis disregards the real problem with informed voting: rational reticence. If a passive mutual fund invests in information in order to cast the right (shareholder-value maximizing) pivotal vote, it will improve a company's stock performance, which means that free-riding competitors will

173. *See, e.g.*, Kevin S. Haeberle & M. Todd Henderson, *Making a Market for Corporate Disclosure*, 35 YALE J. ON REGUL. 383, 391–92 (2018) (highlighting how sharing information about a firm's successes and failures may have a negative impact on its profitability).

174. *See* Gordon, *supra* note 64, at 1545–61.

175. *See, e.g.*, Troy A. Paredes, *Blinded by the Light: Information Overload and Its Consequences for Securities Regulation*, 81 WASH. U. L.Q. 417 *passim* (2003) (outlining the argument that too much information can be counterproductive).

176. *See, e.g.*, Don Reisinger, *Here's How Popular Apple Watch Was Last Quarter*, FORTUNE (Feb. 8, 2017, 9:09 AM), http://fortune.com/2017/02/08/apple-watch-2016-sales/ (reporting analysts' estimate of Apple Watch's sales during the fourth quarter of 2016).

177. *Id.* ("While Apple has said that its smartwatch is popular, the company has never revealed actual sales figures. Apple CEO Tim Cook has argued that sharing sales figures could help competitors."); *see also* Haeberle & Henderson, *supra* note 173, at 392–94 (using the example of Apple's iPad sales to illustrate how disclosure thereof would lead to reduced cashflows).

178. Note that this argument is independent of technological progress; it will hold true even if data processing and storage capacity keep growing exponentially.

179. Yermack, *supra* note 43, at 18.

gain more than the passive mutual fund does.[180] Unless the costs of getting informed and voting become negligible, technology will not alter the incentive of passive institutional investors (and closet index funds)[181] to remain reticent. We expect reticence to be particularly persistent given the increasing market share of passively managed mutual funds in the asset management market.[182]

Delegating the whole process of deciding how to vote to a machine would drive down the (marginal) costs of becoming informed and voting to close to zero. An algorithm would gather all available information, evaluate it according to a set of criteria based on its own data-crunching algorithms and spit out a voting recommendation. That is what, with a human touch, proxy advisors do.[183] It is immediately clear, though, that developing proprietary software for these purposes would be too large an investment for an institution that mainly competes on management fees. Existing providers of proxy services are thus most likely to be the ones that will come up with such a product. Alternatively, perhaps asset management service providers, such as BlackRock, could develop this product as part of their management and administration analytics tools.[184] BlackRock itself, though, is an unlikely supplier of such a product. If it were to provide the tools for determining other institutions' voting decisions, existing concerns about the disproportionate power of behemoth institutional investors and the anticompetitive effects of common ownership would substantially increase.[185] The prospect of a negative political reaction would likely discourage BlackRock (or other large players in the asset management industry) from entering into the proxy advice market.

Even if we assume, for the sake of argument, that one large investment house develops voting decisions algorithms, it is open to question whether an algorithm would, on average, do better at issuing voting recommendations than

180. *See* Ronald J. Gilson & Jeffrey N. Gordon, *The Agency Costs of Agency Capitalism: Activist Investors and the Revaluation of Governance Rights*, 113 COLUM. L. REV. 863, 867 (2013).

181. In addition to overtly passive index funds, a number of "closet index funds" exist that are marketed as actively managed funds but de facto replicate the composition of entire markets or segments thereof. K.J. Martijn Cremerst & Quinn Curtis, *Do Mutual Fund Investors Get What They Pay For? Securities Law and Closet Index Funds*, 11 VA. L. & BUS. REV. 31, 46–67 (2016) (finding that twelve percent of mutual fund assets can be categorized as closet index funds).

182. *See, e.g.*, Lucian Bebchuk & Scott Hirst, *Index Funds and the Future of Corporate Governance: Theory, Evidence, and Policy*, 119 COLUM. L. REV. 2029, 2033 (2019).

183. *See, e.g.*, Paul H. Edelman, Randall S. Thomas & Robert B. Thompson, *Shareholder Voting in an Age of Intermediary Capitalism*, 87 S. CAL. L. REV. 1359, 1398–99 (2014).

184. For a description of BlackRock's management and administration analytics tools suite, known as Aladdin, see Daniel Haberly, Duncan MacDonald-Korth, Michael Urban & Dariusz Wójcik, *Asset Management as a Digital Platform Industry: A Global Financial Network Perspective*, 106 GEOFORUM 167, 172, 176–80 (2019) (quoting Larry Fink's dubbing of Aladdin as "the Android of finance"); Dirk A. Zetzsche, William A. Birdthistle, Douglas W. Arner & Ross P. Buckley, *Digital Finance Platforms: Toward a New Regulatory Paradigm*, 23 U. PA. J. BUS. L. (forthcoming 2020).

185. *See, e.g.*, Einer Elhauge, *Horizontal Shareholding*, 129 HARV. L. REV. 1267, 1268–72 (2016) (outlining the antitrust perils of ownership of firms within the same industry by the same large institutions).

the staff of Institutional Shareholder Services or Glass Lewis, the two dominant proxy advisors today.[186]

In turn, if those designing and selling the software are the two proxy advisory firms themselves, as can reasonably be predicted, their product may avoid some human error. But it is far from clear that the relevant software would succeed in overcoming the (apparent) deficiencies of today's proxy advisory services, which many characterize as box-ticking, one-size-fits-all exercises mirroring the majority views among institutional investor clients,[187] which are themselves often laden with conflicts of interests.[188] In theory, algorithms may be equally good at that, if not better, but it is hard to understand how they could do things in a different, more tailored and more granular way without obtaining specific input from the institutional investor client using them, which institutions other than the world's largest would find burdensome and hence competitively harmful.[189]

c. Active Investing and Shareholder Activism: Less or More?

Rational reticence is not a problem for institutional investors that are overweighted on a given stock, that is, when they "own a greater share of the specific company than [they] own of the market generally,"[190] as is usually the case for (truly) actively managed funds and activist funds.[191]

Active traders and activist investors are in fact among the main participants in the dialogue between corporate boards and shareholders: active investors may respond to unexpected negative information by selling the corporate stock unless the company's ongoing dialogue with them has laid the foundations for good relations and trust long before difficulties emerge. Activist investors' demands, in turn, keep boards on their toes, prompting directors to assess the merits of such demands, attempt to persuade the activists that their demands are unjustified, and/or secure support from other shareholders against the activists.

Tech proponents predict lower returns for both investor types because of the full transparency they envisage, which would reduce the likelihood of

186. *See, e.g.*, Stephen Choi, Jill Fisch & Marcel Kahan, *The Power of Proxy Advisors: Myth or Reality?*, 59 EMORY L.J. 869 *passim* (2010) (finding that ISS is the most influential proxy advisor, with Glass Lewis coming closely behind it).

187. *See id.* at 883–84.

188. Tao Li, *Outsourcing Corporate Governance: Conflicts of Interest Within the Proxy Advisory Industry*, 64 MGMT. SCI. 2951, 2969 (2016).

189. Proxy advisors provide tailored services only to their largest clients. Luca Enriques & Alessandro Romano, *Institutional Investor Voting Behavior: A Network Theory Perspective*, 2019 U. ILL. L. REV. 223, 237–38 (2019). Machines could, of course, do the same, but the fact remains that they would either be developed by proxy advisors themselves or by the few giant institutions whose size would justify their (nontrivial) development costs.

190. Bernard S. Black & John C. Coffee, Jr., *Hail Britannia?: Institutional Investor Behavior Under Limited Regulation*, 92 MICH. L. REV. 1997, 2048 (1994).

191. *See supra* note 181 (regarding actively managed funds); *see, e.g.*, Leo E. Strine, Jr., *Who Bleeds When the Wolves Bite?: A Flesh-and-Blood Perspective on Hedge Fund Activism and Our Strange Corporate Governance System*, 126 YALE L.J. 1870, 1885–1910 (2017) (describing activist hedge funds and their governance-related strategies).

profiting from informational advantages. If both strategies became less profitable, fewer investors of this kind would have to be expected. That, in turn, should reduce the need for board mediation.[192]

For the sake of argument, let us leave aside the fact that the full transparency scenario is unrealistic.[193] Even in a hypothetical full transparency scenario, it would follow from the Grossman-Stiglitz paradox that there would be room for active (informed) trading.[194] Consider that even in a CorpTech world, information gathering and processing requires *some* investment. If share prices perfectly and constantly reflected all available information, those who spent resources to obtain information would receive no compensation and hence would have no incentive to invest in information gathering and processing to begin with. Without active trading, however, prices would no longer reflect all available information, which in turn would make it profitable for active traders to come back to the market and push prices "back" to the levels justified by the available information.

We can go one step further and argue that it is far from certain that *less* active investing would follow the widespread adoption of CorpTech. We can understand active investing as the outcome of an inequation with three values: information costs (I), trading costs (T), and returns from trading (R). If $R > I + T$, active investing will follow. Technology, by making big data analytics tools widely available, may indeed reduce profit opportunities from informed trading (resulting in a lower R). But at the same time, both information costs (I) and trading costs (T) would go down: DLT (as a storage tool) and AI (as an analytical tool) will reduce information costs, while one of DLT's core applications will be clearing and settlement, implying lower trading costs. If, due to technology, I and T become lower than today, then *more* informed trading could result, even where R is lower than today. All in all, similar to the present world we expect an "equilibrium degree of disequilibrium,"[195] with a varying degree of active trading—at times more, at times less—to continue.

This insight can be transferred to activist strategies. Activist strategies are the outcome of a similar inequation as above: if $R > I + T + E$, activism will

192. *See supra* notes 79–84 and accompanying text.

193. *See supra* Part III.C.2.a. It is easily conceded that AI is bound to lower profits from active trading, because it allows active investors to make better use of existing available information; it does so by unearthing patterns and highlighting correlations that help devise trading strategies and ideas and thereby enhance market efficiency. Share price efficiency itself yields greater managerial discipline, but, to a considerable extent, that is mediated by internal governance mechanisms such as boards and there is no intuitive reason to expect that a higher degree of market efficiency should make the current internal governance mechanisms redundant. *See* Gordon, *supra* note 64, at 1541.

194. *See* Sanford J. Grossman & Joseph E. Stiglitz, *On the Impossibility of Informationally Efficient Markets*, 70 AM. ECON. REV. 393 *passim* (1980). Grossman and Stiglitz argued that a competitive equilibrium, "defined as a situation in which prices are such that all arbitrage profits are eliminated," is impossible "for then those who arbitrage make no (private) return from their (privately) costly activity. Hence the assumptions that all markets, including that for information, are always in equilibrium and always perfectly arbitraged are inconsistent when arbitrage is costly." *Id.* at 393.

195. *Id.*

follow.[196] Here, R stands for returns from activism while I and T are, again, information and trading costs and E stands for engagement costs. If R, thanks to technology, were the only variable to fall, then the outcome would be less activism. However, DLTs, big data analytics, and AI should reduce I and T.[197] Hence, even a lower R may still generate profits.

The important point here is that, as long as there is *any* gain to be made from informed trading or activist strategies, with new technologies driving down costs we may see *more*, rather than less, active trading, or activism, respectively. If this is the case, technology would make the need for a mediating institution like a board of directors even greater than it is today.

d. Shareholder Dialogue with Conflicted Managers Less Fruitful

If dialogue with and among shareholders reverted to being mediated by managers, outcomes would be different, and arguably worse: to start with, some ideas presented by shareholders would not find fertile ground when presented to management. For instance, shareholders asking for the removal of the CEO, proposing a control sale, or pressing against a CEO's pet project that, in their view, destroys corporate value, will receive, at best, a lukewarm response when they contact the CEO. On the contrary, they might more easily sow the seeds of doubt when meeting independent directors. Their mediation, in turn, may reduce either the cost of implementing the change or the risk of escalation in case the company resists the appeal for change.

In addition, in the absence of board involvement, information flows among shareholders, as currently mediated to some degree by the companies' boards, may become less fluid. If shareholders fear that management is taking advantage of the views they share with it, they may be less inclined to air them, preventing the company from relaying such views to other shareholders. With less fluid communications among shareholders, the risk of polarization of views among shareholders would increase and uncompromising and suboptimal positions would correspondingly be more likely to prevail.

2. IT Limitations

One could also imagine a world in which algorithms replace boards in their mediating functions. For such a scenario to be realistic, it would have to be the case that the relevant CorpTech is able to imitate the full variety of human behavior, in an effort to accommodate various parties with antagonistic views

196. *Cf.* Brian R. Cheffins & John Armour, *The Past, Present, and Future of Shareholder Activism by Hedge Funds*, 37 J. CORP. L. 51, 61–62 (2011) (providing a simple model for predicting when activists will engage with a given company).

197. While some phases of engagement could be automated (for example, the initial contact with issuers on matters identified by applying big data analysis), the core of engagement activities cannot, given the social nature of the interactions involved; no meaningful reduction in E can therefore be expected. *See infra* note 199 and accompanying text.

and to facilitate the emergence of value-creating solutions. That is highly unlikely to be the case.[198]

Technology experimenting with adjudication functions does exist[199] but is limited to either non-complex adjudication tasks (including claims collection for traffic violations, paying/denying insurance and public benefits) or supervisory orders in time-sensitive situations (such as gas leaks, nuclear fall-out, and intervention in algo-based trading systems).[200] Neither of these settings present similarities with the environment where board-style mediation tasks are performed.

To be sure, technology will make progress and will possibly become able to manage complex social interactions: Google's virtual assistant scheduling barber appointments is one prototypical example, with many more certain to follow.[201] In a distant future, technology may entertain "social" interactions with humans. Nevertheless, the coding of mediating board functions will be particularly challenging: while technology may be particularly good at juggling a variety of conflicting interests (for example, in data terms, variables), in corporate matters it is rarely certain which constituencies pursue which interests. At the beginning of controversial processes, all constituencies demand the maximum, use side demands to cloak their true motives, or remain silent, according to the circumstances, in an effort to generate strategic advantages in negotiations.

Given AI CorpTech's dependency on data,[202] where there is no (or in our case, no reliable) data to process, technology cannot help. Human board members spend significant time (through conversations and other forms of human interaction) on identifying crucial and less crucial interests, in an effort to pinpoint the crunch line for a brokered compromise among antagonistic shareholder groups and/or between management and the shareholder base.[203] The challenge lies in the dynamic nature of such interactions. Governance mediation takes place within a highly volatile system involving multiple actors, diverse interests, and a firm's very future, which is, of course, uncertain. In

198. *See* Frey & Osborne, *supra* note 20, at 262 (predicting that machines will be unable to replicate social intelligence tasks in "the next decade or two;" what will happen after that is, of course, anyone's guess).

199. Note that algorithmic adjudication differs from algorithmic Big Data-driven legal predictions; the latter have been developed to reach an impressive degree of accuracy. *See* Daniel Martin Katz, *Quantitative Legal Prediction—Or—How I Learned to Stop Worrying and Start Preparing for the Data-Driven Future of the Legal Services Industry*, 62 EMORY L.J. 909, 928–47 (2013) (citing prediction results from e-discovery, securities litigation, and U.S. Supreme Court cases).

200. *See* Cary Coglianese & David Lehr, *Regulating by Robot: Administrative Decision Making in the Machine-Learning Era*, 105 GEO. L.J. 1147, 1167–75 (2017) (describing and giving examples for automated administrative decision-making in the U.S. context); Gregory Scopino, *Do Automated Trading Systems Dream of Manipulating the Price of Futures Contracts? Policing Markets for Improper Trading Practices by Algorithmic Robots*, 67 FLA. L. REV. 221 *passim* (2015) (discussing digital supervision of trading systems).

201. *See* Paresh Dave & Arjun Panchadar, *Google Eases Tech Stress with App Controls, Table-Booking Assistant*, REUTERS (May 8, 2018, 11:14 AM), https://www.reuters.com/article/us-alphabet-developers-idUSKBN1I92ME.

202. *See* discussion *supra* Part III.B.1.a.

203. On the complex dynamics of negotiations with activists, see, for example, Lucian A. Bebchuk, Alon Brav, Wei Jiang & Thomas Keusch, *Dancing with Activists*, 137 J. FIN. ECON. 8, 21–34 (2020).

short, this system is a complex one in the scientific meaning, that is, a system with "a significant number of interconnected parts that as a whole tend to interact in a nonlinear manner."[204] From a technological perspective: "[a]s the dynamics of the system being modeled become more volatile, so too do the predictions of that system's behavior."[205] In plain language, AI-driven predictions, in such a setting, are random.

D. INTERMEDIATE RESULTS: UTOPIA RECONSIDERED

Based on what we know today about technology and corporate governance, the scenario of corporate board obsolescence is unrealistic. As we have shown in this Subpart, corporate governance challenges will persist even in a tech-dominated environment, so long as human beings wield influence over the firm's assets. As ever, corporate governance will ultimately be about who controls corporate assets and how much the interests of those in control deviate from those of the shareholders. As a corollary, contrary to the tech proponents' view, technological changes are unlikely to trivialize the board's core monitoring and mediating functions.

Yet, in a CorpTech age, the focal point of corporate governance conflicts will indeed change and is arguably changing already:[206] one key question is becoming who controls the CorpTech within the firm. Decisions such as whether the firm develops its own algorithms internally and under which chain of command, which algorithms are licensed for which purpose, which data pool is analyzed, and so on, now affect the quality of a firm's governance as never before. If management is in control of those decisions, we expect it to choose coders and technology designs catering to its own interests, which may not be perfectly aligned with the interests of shareholders. On top comes the risk that, in the transition to a CorpTech-dominated environment, insufficient understanding of the limits of CorpTech and over-confidence in its promise may even aggravate agency problems within firms.

Depending on how CorpTech governance itself is designed, the implementation of CorpTech solutions may cut both ways: it can be instrumental in either enhancing or reducing agency costs. Correspondingly, CorpTech is bound to either reinforce the board's monitoring role, by improving the factual basis for human judgement-based decisions and the detection of compliance failures, or weaken it, by feeding directors with management-friendly analytical tools. The former will happen if human-populated boards exist that control the CorpTech choice and application, while the latter is likely if boards are replaced by, or disregard the risks associated with, CorpTech. To conclude, CorpTech by itself will not ensure better governance, but requires a governance framework ensuring that its benefits come to the fore, while associated risks are under control.

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204. Katz, *supra* note 199, at 959.
205. *Id.* at 953.
206. *See supra* Part III.B.2.b.

This conclusion holds with one important caveat: if predictions, as per the old saw, are difficult, especially about the future, predictions about technological innovation and its impact are even harder to make. At some point in the distant future, CorpTech may become so sophisticated as to be able to keep management under control better than humans. If and when that will be the case, however, no one can tell today.

IV. A GOVERNANCE FRAMEWORK FOR THE CORPTECH AGE

What are the elements of the governance framework that will ensure CorpTech's beneficial impact? In the following Subparts we lay out some normative considerations and provide some ideas on how to shape board governance in the CorpTech age.

A. PRODUCT MARKET COMPETITION?

A focus on CorpTech governance is only justified if market mechanisms do not already ensure that CorpTech serves shareholders' interests. In fact, one could counter that the natural solution to the new tech-centered dimension of intracorporate conflicts of interest is the market itself, that is, competition among suppliers of CorpTech products.[207] This Subpart casts doubt on the idea that product market competition can be sufficient to let us stop worrying and unreservedly embrace CorpTech.

First of all, there are reasons to be skeptical about the likelihood of the market for CorpTech solutions delivering products that are genuinely in line with the interests of shareholders. For one, product market competition works only where a sufficient number of suppliers of CorpTech systems offer services, struggling for clients' attention through innovation and product differentiation. With the sector still being in its infancy, it is pure speculation whether one, a handful, or many CorpTech providers will survive in the medium to long term. Yet, if past trends are of any guidance, time and again long-term software market dynamics yield a small number of dominant IT platforms.[208] Given the network effects and economies of scale inherent in data-driven applications, which increase switching costs and entry barriers,[209] a different equilibrium is unlikely in the CorpTech market.

To be sure, even in a market dominated by a few firms, one or more among them may start competing by building a pro-shareholder brand. Corporations'

207. *See* Bamberger, *supra* note 16, at 713 (arguing in favor of diversification of risk management systems to counter implicit biases).

208. *See generally* TIM WU, THE MASTER SWITCH: THE RISE AND FALL OF INFORMATION EMPIRES (2010) (arguing that information markets tend to turn into monopolies until they are replaced by superior technology). *See also* Lina M. Khan, *Amazon's Antitrust Paradox*, 126 YALE L.J. 710, 716, 784–86 (2017) (detailing how traditional antitrust law interpretation furthers the build-up of monopolies in platform markets); Aghion et al., *supra* note 61, at 32–33 (arguing that data access may act as an entry barrier for creating competing networks, hence the incumbent's platform prevails).

209. Khan, *supra* note 208, at 772–73, 785–86.

use of CorpTech products with a pro-shareholder reputation could bring some gains in the form of higher stock prices.

Consider, though, that a brand-building strategy is much more likely to pay off for standardized software tools than for tailored, firm-specific ones. In fact, the more firm-specific the CorpTech, the less credible the pro-shareholder signal sent by choosing a given CorpTech application. That is because management input for the development of the tailored code will be key. Correspondingly, the greater the coder's specific investments in the relationship with an individual company, the weaker the signal of independence. For this reason, a brand-building strategy is unlikely to work wherever the CorpTech's added value comes from customization, as is arguably the case with most CorpTech applications. In fact, no two firms are alike; software developed for one firm will not work as well for others.

In addition, similar to what has traditionally happened with audit firms and other gatekeepers, unless the governance of a firm's (and its management's) relationship with the supplier is effectively taken care of, there is a risk of collusion with managers, that is, a risk of deviation ex post from shareholders' interests.[210] Developing a reputation for producing good (shareholder-friendly) CorpTech would arguably be even harder than developing a reputation for providing good audit services, if only because there are, to date, no generally accepted coding standards that outsiders could use to understand what the coders have done. In addition, outside monitoring and review of algorithms is highly problematic.[211]

The contractual governance point can be generalized to cast doubt on the ailing effects of product market discipline: competitors will have to sell products that the relevant decision-makers within corporations will find attractive. Unless such decision-makers' incentives are fully aligned with the interests of shareholders, there is scope for suboptimal products to prevail on the market. But if full alignment is ensured, there will be no need for CorpTech.

B. BEST PRACTICES: EXPANDING THE BOARD COMMITTEES' REMIT TO CORPTECH OVERSIGHT

Information technology has traditionally been outside the board of directors' remit: the selection and management of technological solutions has

210. *See* JOHN C. COFFEE, JR., GATEKEEPERS: THE PROFESSIONS AND CORPORATE GOVERNANCE 15–47 (2006) (describing the failure of gatekeepers and their collusion with management in the early 2000s corporate scandals).

211. *See* Joshua A. Kroll, Joanna Huey, Solon Barocas, Edward W. Felten, Joel R. Reidenberg, David G. Robinson & Harlan Yu, *Accountable Algorithms*, 165 U. PA. L. REV. 633 *passim* (2017) (arguing that research on AI review is in its infancy and that disclosure of results does not allow review of the underlying algorithm); *see also* Pauline T. Kim, *Auditing Algorithms for Discrimination*, 166 U. PA. L. REV. ONLINE 189, 196–97, 202 (2017) (arguing that code review does not result in desirable outcomes since the biases lie in broader social processes that cannot be countered by reviewing the code alone, but calling for code disclosure to let the public review the code outcome).

rather been, and still is, part of the executives' domain.[212] Banks represent an important exception here: with the ever-growing use of algorithms in risk management, banks increasingly ask their risk committees to review technology-related risks.[213]

But even in non-financial corporations, where technology has typically been part of the oversight functions of the compliance or audit committee,[214] things are changing fast. With technology taking center stage both as a managerial and a governance tool, and with boards currently being composed mainly of individuals often lacking the competence to understand such aspects,[215] more systematic oversight of technology on the part of a (independent) risk or audit committee is becoming more common.[216]

Importantly, the practice of having tech committees, sometimes separate from risk management committees, sometimes as joint risk and technology committees, is spreading out,[217] with cyber-attacks and IT-related operational risk representing their core focus on the technology side.[218] To the best of our

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212. *See* HÜTTER & RIEDL, *supra* note 162, at 11–12 (stating that Chief Information Officers (CIOs) either belong to the top management team or a department reporting to top management); *see also* Sid L. Huff, P. Michael Maher & Malcom C. Munro, *Information Technology and the Board of Directors: Is There an IT Attention Deficit?*, 5 MIS Q. EXEC. 55 *passim* (2006) (stating that boards are focused on IT risks only and that only half of the financial firms and none of the non-financial firms surveyed discuss regularly IT issues other than IT risks) (arguing that the CIO's IT vision for the company, the IT strategic plan, major IT application decisions, IT leadership, IT functional structure, IT function effectiveness, and whether or not IT applications provide competitive advantage deserve discussion in the boardroom).

213. *See* Lawrence J. Trautman & Kara Altenbaumer-Price, *The Board's Responsibility for Information Technology Governance*, 28 J. MARSHALL J. COMPUT. & INFO. L. 313, 319 (2011). Morgan Stanley has introduced a technology committee in 2015 that advises the board and management team on Big Data tools and systems that control stock trading. Kim S. Nash, *Morgan Stanley Board Pushes Emerging Area of Tech Conference*, WALL ST. J. (Mar. 26, 2015, 4:21 PM), https://blogs.wsj.com/cio/2015/03/26/morgan-stanley-board-pushes-emerging-area-of-tech-governance/. Tech advisory boards are becoming common outside the banking sector as well. *See, e.g.*, Josh King, *The Growth of Digital Advisory Boards*, LINKEDIN (Jun. 2, 2016), https://www.linkedin.com/pulse/growth-digital-advisory-boards-josh-king/ ("All types of firms, from start-ups and growth companies to Fortune 500 businesses and even PE/advisory firms, are developing these advisory boards.").

214. Richard Nolan & F. Warren McFarlan, *Information Technology and the Board of Directors*, 83 HARV. BUS. REV. 96, 101 (2005).

215. Elizabeth Valentine & Glenn Stewart, *Director Competencies for Effective Enterprise Technology Governance*, *in* THE 24TH AUSTRALASIAN CONFERENCE ON INFORMATION SYSTEMS 5 (2013), https://eprints.qut.edu.au/63374/ (highlighting the need for boards to provide enterprise technology governance oversight of technology-related strategy, investment and risk, and to be competent in doing so) ("[T]he gaps are large between the stated importance of business technology, actual board involvement . . . [and] knowledge and experience to effectively oversee technology strategy . . . ."); *see also* MCKINSEY & CO., *supra* note 119, at 48 (detailing that approximately 45% of directors claim to have neutral or no competence on digitization, 49% on disruptive business models, and approximately 60% on cybersecurity in Exhibit 4).

216. *See* Trautman & Altenbaumer-Price, *supra* note 213, at 319.

217. *See* Bankewitz et al., *supra* note 19, at 65. As of 2011, special board committees dealing with tech and cybersecurity were in place in less than 25% of organizations. *Id.* Bankewitz et al. expect that the "changing board agenda based on the shifts in organizational threats and opportunities may as well affect the committee structure of an organization," resulting in a greater role for, and wider diffusion of, tech committees. *Id.*

218. *Id.* ("Main tasks of such a [tech] committee may be for instance to ratify that information systems architecture will support the strategies of the company to validate the effective use of data security tools to evaluate data breach response plans and to oversight the managements' abilities to execute them."); *see also* Julia L. Higgs, Robert E. Pinsker, Thomas J. Smith & George R. Young, *The Relationship Between Board-Level*

knowledge, however, tech committees are not in the business of monitoring the conflicts of interest inherent to CorpTech governance.[219]

An extension of tech committees' remit (or the remit of other board committees with the necessary tech knowledge in the ranks) to include CorpTech governance/oversight would seem to be a natural evolution in a tech-augmented governance framework.[220] Their extended focus should be on monitoring contract negotiations with coders, designing the governance of the contractual relationship with the coders, reviewing the design settings of crucial algorithms as well as, possibly, having a say on (internal) coders' compensation.

As with any governance tool, a board committee in charge of CorpTech oversight would be no silver bullet. Again, we can distinguish between technological limitations and governance's inherent traits. One considerable challenge in terms of technological limitations is that, at least at the current stage of IT development, ex post review of the functions, limits, and biases of an algorithm is of limited effectiveness.[221] Moreover, while independent directors themselves can work better than shareholders as monitors of management, including in overseeing management's exercise of discretion when it comes to CorpTech, they are bound to suffer themselves from information asymmetries and imperfect incentives alignment.[222]

As a corollary, putting an independent (tech) committee in charge of selecting CorpTech may sacrifice business efficiency in the name of conflict monitoring. In fact, in modern corporations, business operations depend on the efficiency of systems, while such efficiency depends, in turn, on accuracy as to process details. Meanwhile, given the elusive boundaries between CorpTech and operations IT,[223] putting an independent (tech) committee in between management and tech deployment could slow down information transfer from management to coders. Oversight by an independent (tech) committee—rather than replacing management with independent directors in the task of managing a firm's IT—seems to be a balanced solution.

Technology Committees and Reported Security Breaches, 30 J. INFO. SYS. 79, 79–83 (2016) (arguing that tech committees are understood as part of the firm's IT governance to signal the firm's ability to detect and respond to security breaches).

219. *Cf.* Martin Lipton, *Spotlight on Boards*, HARV. L. SCH. F. ON CORP. GOVERNANCE (Feb. 29, 2020), https://corpgov.law.harvard.edu/2020/02/29/spotlight-on-boards-6/. While this widely circulated client alert memorandum refers to oversight risks arising, inter alia, from technological developments as one of the items boards are expected to focus on in 2020, oversight of CorpTech solutions is not mentioned as one such item. *Id*.

220. *Cf.* Armour & Eidenmüller, *supra* note 18, at 102 (similarly suggesting the setup of a committee of independent directors in charge of "data governance").

221. *See supra* note 211 and accompanying text.

222. *See* Stephen M. Bainbridge, *The Board of Directors*, *in* THE OXFORD HANDBOOK OF CORPORATE LAW AND GOVERNANCE, *supra* note 166, at 275, 316–20, 327–31 (describing independent directors' time constraints, limited access to the relevant firm's inside information, and skewed incentives, even after they started being given stock-based compensation, and summarizing the available empirical evidence).

223. *See supra* note 11 and accompanying text.

C. THE CASE AGAINST CORPTECH REGULATION

Does the prospectively pervasive role of CorpTech in listed companies' governance warrant any changes in the statutory law (state or federal) of corporations?

We are hesitant to suggest so (with one exception laid out in the next Subpart, namely enhanced CorpTech governance disclosure). The main reason for being cautious and recommending a wait-and-see approach is that corporate governance practices are bound to change in the direction of sharpening the focus on CorpTech issues.[224] It would be premature, and contrary to a long-standing tradition in corporate governance reforms, to implement corporate governance-focused changes in state corporate statutes, federal securities regulation, or stock exchange listing rules before best practices have emerged on the market. Furthermore, corporate governance practices are firm-specific. Firms differ, for instance, in the extent to which they rely on their employees' creativity, suppliers' tailored inputs, intellectual property, and technology integration, among other factors. The downside of any prescriptive rule would be the risk of freezing much-needed experimentation in this area.

This is particularly true for a CorpTech licensing regime:[225] any licensing regime potentially limits innovation since innovators would focus on the development of permissible products only. Besides general concerns aired against public tech oversight,[226] a licensing regime also raises the perennial issue of who would administer these rules.

If authorization powers lie in public hands, we would expect supervisory expertise and resources to be limited, resulting in slow-motion supervision, while potential liability and the risk of reputational loss may skew incentives towards a timid, anti-innovative supervisory approach.[227] Novel regulatory approaches, such as regulatory sandboxes,[228] would deliver minor relief for CorpTech supervision. These tools assist where the core issue is both the innovators' and supervisors' shortage of expertise, time, and resources by providing a temporary safe space for examining the impact of an invention under almost real-time conditions and determining the adequate supervisory response. A sandbox approach for CorpTech, however, would provide little comfort for shareholders: it is far from clear that algorithms would show their true face in a

224. *See supra* Part IV.B.

225. As a form of private licensing, policymakers could impose liability insurance as a precondition for doing business where technology makes most business decisions such as in self-driving corporations or algorithmic entities. Armour & Eidenmüller, *supra* note 18, at 112–13 (proposing a mandatory liability insurance for "self-driving corporations").

226. *See* Julie E. Cohen, *The Regulatory State in the Information Age*, 17 THEORETICAL INQ. L. 369, 370–71 (2016) (stating that it has become difficult to define "what constitutes 'normal' economic activity and what qualifies as actual or potential harm" for society, firms and its shareholders and stakeholders).

227. *Cf.* Chris Brummer & Yesha Yadav, *Fintech and the Innovation Trilemma*, 107 GEO. L.J. 235, 248–49 (2019) (arguing that innovation poses a challenge for regulators since regulators are expected to warrant financial innovation, simple rules *and* market integrity at the same time, with limited resources).

228. Steven Van Uytsel, *Artifical Intelligence and Collusion: A Literature Overview*, *in* ROBOTICS, AI AND THE FUTURE OF LAW 155, 175–77 (Marcelo Corrales, Mark Fenwick & Nikolaus Forgó eds., 2018) (discussing the testing of colluding algorithms in a sandbox).

sandbox.[229] And, of course, the "learning" in machine learning does not stop with the final moment in the sandbox: any assessment achieved during the sandbox period would soon be outdated.

If authorization powers lie, by way of indirect supervision, in private hands, the usual question of who watches the watchers takes the foreground. This question has been long and widely discussed, and rarely answered convincingly, in the similar context of auditors and rating agencies.[230] Second, CorpTech licensing is compounded by an additional layer of IT complexity, turning IT audit into an emerging research field.[231] The difficulties with code review are particularly pronounced for advanced machine-learning algorithms that receive feedback from non-human sources, for instance the price data feeds from stock and other markets. Technical means to review the function and limitations of self-learning algorithms do not yet exist.[232]

D. ENHANCING CORPTECH-RELATED DISCLOSURES

Instead of product regulation, policymakers could require the disclosure of the CorpTech *code*. The case for disclosure would rest on the assumption that knowledgeable shareholders, market analysts, and traders would analyze the disclosures and trade on the basis of their analysis until the share price fully reflects the implications of those disclosures relative to the company's profitability.[233] Anticipating market scrutiny, management would have an incentive to choose good software. Applying this logic, external IT experts, whether individually or as a group, could undertake such code reviews on an experimental basis. The more experiments of this kind that are undertaken, the greater the likelihood of imperfect CorpTech solutions being exposed as such. In fact, in IT circles, crowdsourced testing has been acknowledged as a powerful analytical tool for detecting code deficiencies.[234]

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229. *See* ARIEL EZRACHI & MAURICE E. STUCKE, VIRTUAL COMPETITION: THE PROMISE AND PERILS OF THE ALGORITHM-DRIVEN ECONOMY 230–31 (2016) (arguing with respect to competition law that sandbox test results finding collusion and non-collusion of algorithms are notoriously unreliable).

230. *See, e.g.*, COFFEE, supra note 210, at 15–47 (2006) (describing the failure of gatekeepers and their collusion with management in the early 2000s corporate scandals).

231. *See* Christian Sandvig, Kevin Hamilton, Karrie Karahalios & Cedric Langbort, Auditing Algorithms: Research Methods for Detecting Discrimination on Internet Platforms 6–10 (May 22, 2014), http://social.cs.uiuc.edu/papers/pdfs/ICA2014-Sandvig.pdf (providing an overview of audit methods and outlining their deficiencies).

232. *See supra* note 211 and accompanying text. Code reviews are limited to experiments where certain data feeds are provided to the algorithm, and the algorithm's output is assessed. But these experiments are by no means complete, nor can these experiments mimic real life conditions for enterprise software, especially if the exercise is undertaken without access to all the firm's and market data that feeds into the software. In order to control risks stemming from the self-learning dimension of algorithms, IT coders tend to limit the data access and processing functions of self-learning algorithms, thereby weakening one of the competitive advantages of CorpTech vis-à-vis humans, which is that those algorithms consider *all* available data and correlations.

233. *See generally* Zohar Goshen & Gideon Parchomovsky, *The Essential Role of Securities Regulation*, 55 DUKE L.J. 711 (2006).

234. Niklas Leicht, Ivo Blohm & Jan Marco Leimeister, *Leveraging the Power of the Crowd for Software Testing*, 34 IEEE SOFTWARE 62, 62–63 (2017) (arguing that crowdsourced testing replaces manual testing since manual testing is becoming less economically viable and useful).

However, code disclosure will likely stifle innovation since it facilitates, if not encourages, the copying of the code; less investment in code development would follow. Furthermore, code disclosure is of no use where little, if any, firm-specific data is available to crowd testers.[235] Firms will not voluntarily disclose the data they process in algorithms, as disclosure may harm their competitiveness, contravene confidentiality duties, and/or infringe third party privacy rights.

Given the increasing centrality of tech issues for corporate governance, one contiguous area where a change in the law could help is the disclosure of listed companies' tech governance arrangements. As is the case with similar disclosures, for instance on internal controls and executive compensation,[236] the dissemination of information about individual companies' practices with regard to CorpTech oversight may help issuers become aware of better practices and further their adoption. The need to articulate CorpTech governance arrangements in disclosure documents, not to mention the risk of securities litigation regarding their contents, would also provide directors with the incentives to adopt appropriate CorpTech governance arrangements.[237] Where disclosure shows that management and boards are lagging behind, shareholders—possibly themselves assisted by CorpTech that monitors tech-related disclosures—may press for improvements.

Existing periodic disclosures on corporate governance arrangements could thus be supplemented with additional explanations on, for instance, whether the issuer has a tech committee (or whether one of the other existing committees have CorpTech oversight functions), whether any of the board members are tech experts, how compensation for the coders is determined, how the board oversees code design, development, and upgrading, whether the board regularly engages in the review of existing IT structure, and so on. This could be part of annual disclosures mandated either by the Securities and Exchange Commission[238] or the stock exchange listing rules.[239]

CONCLUSION

There is no doubt that CorpTech will have a significant impact on *how* corporate boards perform their functions: new technologies are in fact bound to

235. Any more limited disclosure allows management to argue that the deficiencies that the shareholders' and/or IT expert groups' analyses may reveal are due to "wrong" data used for the test or an incomplete embedding of the test software into the firm's operating system.

236. *See* 17 C.F.R. § 229.407 (2019) (requiring disclosures, respectively, on audit committee composition, tasks and activities and on compensation committee, composition, tasks and functioning).

237. *See* Robert B. Thompson & Hillary A. Sale, *Securities Fraud as Corporate Governance: Reflections upon Federalism*, 56 VAND. L. REV. 859, 904 (2003) (highlighting the role of mandatory disclosures in ensuring that directors fulfill their duty of care). We are grateful to Christopher Bruner for drawing our attention to this point.

238. *See* 17 C.F.R. § 229.407 (2019) (requiring disclosure on a number of corporate governance arrangements).

239. *See, e.g.*, NYSE LISTED COMPANY MANUAL § 303A.09 (2009) (requiring companies to have and disclose corporate governance guidelines and listing the items to be included therein).

enhance boards' effectiveness by improving the information collection and processing tools available to them. But, as this Article has argued, CorpTech will not replace boards.[240] Neither will CorpTech significantly change what boards do, namely monitoring managers and mediating between them and the company's shareholders and other stakeholders. That is because technology will not itself solve the agency problems characterizing corporations. The core insight of this Article is in fact that such agency problems cannot be coded away: those in control of the CorpTech will (continue to) control the corporation and therefore preserve their ability to engage in self-serving behavior.

As building blocks of a governance framework for the CorpTech Age, we propose to tackle CorpTech manifestations of governance issues through rather traditional means, namely CorpTech board committees and disclosure of tech governance arrangements. These old-style, "analogue" tools, imperfect as they may be, can reduce the risk that CorpTech actually *exacerbates* agency problems within corporations by making it even easier for managers to pursue their own agenda. Only if and when humans relinquish corporate control to machines, may the problems at the core of corporate governance be solved, but by then humans will have more pressing issues to worry about than corporate governance.

240. *Cf.* Curtis P. Langlotz, *Will Artificial Intelligence Replace Radiologists?*, 1 RADIOLOGY: A.I. 1, 1–2 (2019) ("'Will AI replace radiologists?' is the wrong question. The right answer is: Radiologists who use AI will replace radiologists who don't.").