

ALGORITHMIC CONTRACTS

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ABSTRACT

Algorithmic contracts are contracts in which an algorithm determines a party's obligations. Some contracts are algorithmic because the parties used algorithms as negotiators before contract formation, choosing which terms to offer or accept. Other contracts are algorithmic because the parties agree that an algorithm to be run at some time after the contract formation will serve as a gap-filler. Such agreements are already common in high speed trading of financial products and will soon spread to other contexts. However, contract law doctrine does not currently have a coherent approach to describing the creation and enforcement of algorithmic contracts. This Article fills this gap in doctrinal law and legal literature, providing a definition and novel taxonomy of algorithmic contracts.

The algorithmic contracts that present the most significant problems for contract law are those that involve "black box" algorithmic agents, whose decision-making is not functionally understandable ex ante – or sometimes not even human-intelligible at all. There is only a tenuous case for their enforceability under currently accepted approaches to contract law. The Uniform Electronic Transactions Act (UETA) was written and widely adopted nearly twenty years ago to make sure that contracts made electronically using basic automation techniques would be recognized as enforceable. However, the language of the UETA may be read to treat all putative contracts made with algorithms as properly formed, simply because they happen to be electronic. Unintended consequences of this approach include opportunities for fraud, market manipulation, and a general lack of algorithmic, and thus corporate, accountability.

This Article's approach looks to the common law of agency for inspiration.

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Some algorithms commonly used in contract formation have been delegated a level of responsibility that justifies the use of agency principles. When algorithms take on a role in contract formation analogous to that of human agents, they should be considered constructive agents for the purpose of contract formation. The company consenting to the contract can be said to have authorized or ratified the contract formed on its behalf by the algorithm. This approach explains easy cases while also showing why algorithmic contracts, even many black box algorithmic contracts, are enforceable. Furthermore, establishing a doctrinally robust connection between the actions of the algorithm and the intent of the contracting party promotes algorithmic accountability.

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I. INTRODUCTION

At 2:45PM on May 6, 2010, the Dow Jones Industrial Average dropped by 9%.¹ No market or political event presented a trigger.² Millions of dollars were lost in a matter of minutes.³ A report by the Securities and Exchange Commission months later stated that the Commission could not declare what caused the crash.⁴ Despite years of study since, the mechanism that triggered the reaction is not fully understood, not least because many of the algorithms involved are proprietary.⁵ And since nobody understands what causes flash crashes like this, they are happening more and more often. The Dow Jones had a flash crash of

1. U.S. SEC. & EXCH. COMM’N, FINDINGS REGARDING THE MARKET EVENTS OF MAY 6, 2010, 1-4 (Sept. 30, 2010), <https://www.sec.gov/news/studies/2010/marketevents-report.pdf> [<https://perma.cc/VF8U-EKCC>].

2. *Id.*

3. *Id.*

4. *See id.* at 6.

5. Tom C.W. Lin, *The New Investor*, 60 UCLA L. REV. 678, 682 (2013).

similar magnitude less than two years later, and similar events have dotted the global landscape.⁶

In the seconds leading up to each of these flash crashes, securities were being bought and sold in milliseconds, with prices being determined by algorithms. What is often missed in discussions of the growing influence of algorithms in trading is that contracts were at work here too, enabling formal alienation of the resources. Algorithms determined when the trades happened and at what prices. It has been said that algorithms shape our world.⁷ But it is contracts that give algorithms the power to change our world by enabling businesses to exchange resources and services, with the law's power backing the transaction.⁸

Without legal reform, flash crashes could become endemic to any number of industries. And the results of such unexpected, undesired aberrations resulting from algorithms might not be so readily reversible in other contexts. In areas such as health care and safety measures, life and death may literally be dependent on the results of algorithms.⁹ Ultimately, regulating the content of algorithms should be the subject, at most, of sector-specific reform. However, creating legal incentives for entities that use algorithms in contracting to understand and take responsibility for the actions these algorithms take is required to preserve human responsibility and conscious choice in an increasingly automated society.¹⁰

Contracts enable individuals to demonstrate their preferences. The freedom of contract allows individuals to express their valuations of property and services and make appropriate exchanges. Traditional contract law assumes that some individual is doing conscious evaluation and that contracts disclose information about how society's collective valuation. Every contract contains information about how parties val-

6. E.g., Pooja Thakur and Jonathan Burgos, *Singapore Strengthens Securities Rules After Stock Rout*, BLOOMBERG (Aug. 3, 2014, 12:00 PM), <http://www.bloomberg.com/news/articles/2014-08-01/singapore-regulators-tighten-rules-after-penny-stock-rout> [<https://perma.cc/N55C-M6BD>].

7. E.g., Kevin Slavin, *How Algorithms Shape Our World*, HUFFINGTON POST (Dec. 9, 2011), http://www.huffingtonpost.com/2011/11/30/kevin-slavin-how-algorith_n_1120684.html [<https://perma.cc/5J6Z-SDKU>].

8. See generally LAWRENCE LESSIG, *CODE: VERSION 2.0* (2nd ed. 2006) (describing law, norms, markets, and architecture as four regulatory mechanism, with computer code the most critical—and least visible and popularly understood—aspect of architectural regulation in modern society).

9. See generally W. Nicholson Price II, *Black-Box Medicine*, 28 HARV. J.L. & TECH. 419 (2015) (describing the use of algorithms in medicine and the legal and ethical problems posed thereby).

10. Yesha Yadav, *The Failure of Liability in Modern Markets*, 102 VA. L. REV. 1031, 1036 (2016) (“Automation raises serious concerns for the effectiveness of the traditional liability framework and the allocation of costs it imposes in securities trading.”).

ued the component terms of the contracts. But, when algorithms are introduced in institutional decision-making, individuals outsource their valuation processes to the algorithm. Their use in high frequency trading has become ubiquitous because machine learning allows algorithms to react to changes in the market quickly, leading to the delegation of responsibility to algorithms so companies can take advantage of their quick judgment.¹¹ However, algorithms have been shown to be limited in their ability to develop and apply long-run knowledge and strategies in their investment strategies.¹² The information bearing and allocative efficiency presumed in traditional markets do not hold in the case of algorithmic markets.¹³

Current contract law presumes algorithms are mere tools, executing the will of their owners directly, with no ability to learn or decide. This is demonstrably not true of many algorithms that are used in contracts today. Some algorithmic contracts divorce critical aspects of decision-making in contractual agreements from conscious determination by any individual.

Two major concerns arise from this divorce. First, the use of algorithms to determine terms in a contract creates the possibility for emergence, that is, results that are not and indeed could not be foreseen by the algorithm's creator. This creates situations where the entity responsible for the algorithm does not know how it works and cannot predict its behavior. This knowledge gap is potentially hazardous for not just the company using the algorithm, but also for those who contract with such companies and society at large. Second, algorithms acting autonomously could choose strategies that amount to fraud or illegally discriminatory practices. The law does not currently provide liability-bearing conduit between the choices made by a sophisticated algorithm and the conscious intent of the individual or corporation using it. A contract law that assumes all algorithms are mere tools cannot effectively contend with these problems.

I argue that both contract law theory and pragmatic policy concerns require an approach to algorithmic contracts that considers algorithms as constructive agents for the purposes of contract formation. This paper will proceed as follows: First, I will define algorithmic contracts, categorizing the different types of algorithmic contracts and discussing

11. Harry Surden, *Machine Learning and Law*, 89 WASH. L. REV. 87, 88 (2014) (discussing artificial intelligence technology and law).

12. Yesha Yadav, *How Algorithmic Trading Undermines Efficiency in Capital Markets*, 68 VAND. L. REV. 1607, 1612-14 (2015).

13. *Id.* at 1616-17 (“As this Article demonstrates, this relationship between informational and fundamental allocative efficiency can no longer be taken for granted in algorithmic markets. As a result, it is debatable whether today’s securities prices offer a thorough, substantive interpretation of corporate value. If not, the law’s wholesale reliance on prices for valuation becomes increasingly misplaced.”).

significant existing examples of algorithmic contracts. Second, I will use black box algorithmic contracts to demonstrate the formal and functional limitations of current contract law, focusing on the inability of algorithmic contracts to contend with the assumptions behind the component parts of traditional contracts, that is, mutual assent and consideration. Finally, the Article proposes an agency approach to evaluating the role of algorithms in contract formation.

Under the approach this Article advocates, contract law would prove a valuable tool in promoting algorithmic accountability. It would encourage the allocation of risk to the least cost avoider without requiring extensive administrative agency action or litigation to work. Furthermore, it could work with and serve as an inspiration for more specific reforms for specialized agencies for specific markets.

II. DEFINING ALGORITHMIC CONTRACTS

The existence of algorithms that must be understood as servants rather than mere tools justifies the creation and analysis of a distinct category called “algorithmic contracts.” This Part creates a taxonomy for algorithmic contracts, and then discusses notable types of algorithmic contracts in action for illustrative use in later parts of this Article. In showing both the role algorithms play in contract formation as well as the emergence that currently characterizes many modern algorithms, and will continue to do so, this Part reveals the notion that algorithms must not be thought of as mere tools. Ultimately, the law of contracts must expressly account for the question of who takes responsibility for emergent acts by artificially intelligent entities.

Machine learning enables sophisticated algorithms to be more similar in function to a human employee with a task to achieve than a tool. In fact, across the financial industry, the field which has been making the most widespread use of algorithmic contracting, algorithms are beginning to replace human workers outright. Eleven major banks cut 100,000 banking jobs in 2015, equivalent to 10% of their combined staff.¹⁴ Much of this downsizing can be attributed to the use of algorithms. For example, in early 2017 influential investment company Blackrock cut 40 “stock picker” roles to specifically to replace the human workers with algorithms.¹⁵ This change was openly highlighted be-

14. Oscar Williams-Grut, *Banking's 'Uber Moment' Is Already Happening—100,000 Bankers Lost Their Jobs in 2015*, BUSINESS INSIDER (Dec. 14, 2015) <http://www.businessinsider.de/banks-uber-moment-100000-bankers-fired-in-2015-2015-12> [https://perma.cc/9HPY-26S9].

15. Lucinda Shen, *Robots Are Replacing Humans at All These Wall Street Firms*, FORTUNE (Mar. 30, 2017, 5:13 PM), <http://fortune.com/2017/03/30/blackrock-robots-layoffs-artificial-intelligence-ai-hedge-fund/> [https://perma.cc/V5LT-

cause algorithms are thought to be more reliable stock pickers than humans.

In so far as it offers an explanation for algorithmic contracts at all, current contract law relies on two outmoded assumptions: (1) algorithms are mere tools, and (2) even if they are not mere tools, a corporation is savvy enough to understand and anticipate all possible outcomes of the algorithms' actions. As early as 1992, a federal district court recognized that an algorithm was more than a "mere tool" because it was given the responsibility of weighing various factors in order to directly determine a motor carrier's safety rating.¹⁶ An algorithm is a servant when a person has entrusted it to achieve a given objective, within certain parameters.¹⁷ It has certain creator-imposed objectives and conditions, but it processes and understands details that the creator or user of the algorithm does not. A "mere tool," then, is an item that is not delegated the responsibility to independently make determinations that change a person or company's legal relationships.¹⁸ As long as contract law relies on the outmoded assumptions that algorithms can only serve as mere tools, contracts made with algorithms will be of dubious enforceability, companies will not have adequate incentive to monitor the actions of their black box algorithms, and several types of fraud and market manipulation will be prevented from prosecution under the law.

A. *A Taxonomy of Algorithmic Contracts*

Algorithmic contracts are contracts in which one or more parties use an algorithm to determine whether to be bound or how to be bound. More specifically, algorithmic contracts are contracts that contain terms that were determined by algorithm rather than a person. An algorithm is a process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer.¹⁹ The critical

QDR7].

16. *Don Ray Drive-A-Way Co. of California, Inc. v. Skinner*, 785 F. Supp. 198 (D.D.C. 1992) (holding that the algorithm was not exempt from a FOIA request because it was not a tool but rather a substantive part of the regulation).

17. *Cf.* *The Golem of Prague*, A TREASURY OF JEWISH FOLKLORE 431 (Nathan Ausubel ed., 1980). (Jewish legend describing how Rabbi Loew, a scholar and mystic, created a golem, a creature made of clay in human form, to protect the Jewish community of Prague against attacks and false accusations. The golem could not speak and did exactly what it was told to do. Rabbi Loew made the golem lifeless every Friday at sundown.)

18. The term "mere tool" is used to differentiate algorithms that can be used only as tools from algorithms that have potential internal uses but also are delegated the responsibility to change their owner's legal relationships with others.

19. Defining algorithms is a difficult task, and the subject of scholarly inquiry, but there is broad consensus around a working definition similar to what I have stated above. *E.g.*, Yuri Gurevich, *What is an Algorithm? (Revised)*, CHURCH'S THESIS:

difference between an algorithm and a person determining terms is quite simply the fact that a computer rather than a conscious human being is implementing the rules. When a human makes a choice, ordinary principles of liability and agency clearly link the acts of the human to the company she works for. No such link for the acts of algorithms exists at current contract law. When we have more complicated algorithms, the ability of a human to anticipate the result of the algorithm is limited; indeed the reason why these algorithms are useful is because they can consider a breadth of data and number of conditions that no human could. However, decision-making algorithms can have emergent properties. Algorithms can yield results arising as an outgrowth of complex causes and not analyzable simply as the sum of their inputs. Emergence, or the action of algorithms in manners not predictable by their developers, is a growing part of the algorithmic landscape with significant moral and practical implications.²⁰

To understand why the formation of an algorithmic contract is a hard question, we must understand the possible roles algorithms can play in contract formation. This task is required because different types of algorithmic contracts present different challenges to contract law. While some algorithmic contracts are readily handled by current contract doctrine, others require additional interpretive work for contract law to apply. There are several ways that a party can use an algorithm in contract formation. Algorithms can be employed in contract formation as either mere tools or artificial agents. This distinction is based on the predictability and complexity of the decision-making tasks assigned to the algorithm. Artificial agents themselves can be clear box, when inner components or logic are decipherable by humans, or black box, where the logic of the algorithm is functionally opaque. While courts and policy makers should be mindful of the specific characteristics of algorithmic contracts in their interpretation and enforcement, traditional contract law provides adequate tools to address most algorithmic contracts. The rationale for the approach advocated in Part IV is that it explains

LOGIC, MIND AND NATURE (A. Olszewski et al. eds., 2014), <http://research.microsoft.com/en-us/um/people/gurevich/Opera/209a.pdf> [<https://perma.cc/PZ58-GYCJ>]; Solon Barocas, Sophie Hood, and Malte Ziewitz, *Governing Algorithms: A Provocation Piece* (Mar. 29, 2013) (unpublished manuscript), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2245322 [<https://perma.cc/K3L5-7SH8>]; Rob Kitchin, *Thinking Critically About and Researching Algorithms* (Oct. 28, 2014) (unpublished manuscript), http://papers.ssrn.com/sol3/Papers.cfm?abstract_id=2515786 [<https://perma.cc/4W5R-TW6N>].

20. Ryan Calo, *Robotics and the Lessons of Cyberlaw*, 103 CAL. L. REV. 513, 532 (2015) (“The literature tends to refer to this exciting potential as ‘autonomy’ or ‘true learning,’ but I prefer ‘emergence.’ Emergence refers to unpredictably useful behavior and represents a kind of gold standard among many roboticists for reasons I will describe. Finally, robots, more so than other technology in our lives, have a social valence. They *feel* different to us, more like living agents.”).

the enforceability of all types of algorithmic contracts, from the simplest and most familiar to the most complex and futuristic. Coherence is a bedrock principal of contract law and legal reasoning generally.²¹

Algorithmic contracts can be distinguished first by the role of the algorithm (tool or agent), then by the task assigned to the algorithm (gap-filling or negotiation), and finally, for negotiating algorithms, whether the algorithm is a black box algorithm or a clear box algorithm. There is a gradient of fit between algorithmic contracts and existing contract doctrine. Contracts where the algorithms help the parties as mere tools typically do not present any new issue for contract law. They are no different from a party using a calculator or a basic excel program to determine what to offer or accept. Agent algorithmic contracts acting as gap-fillers have clear analogues in existing contract law, such as agreements to pay market price on a given date. This type of algorithmic contract may enable and encourage excessively broad gaps. Existing doctrines such as incomplete contracts and illusory contracts can cabin this tendency.

When algorithms act as negotiators, more interpretive work is required to show the fit with contract law. Black box algorithmic contracts inherently introduce a gap between the objectively manifested intent of the party using the algorithm and what the artificial agent does. Unlike in typical contracts, where we assume that a “sophisticated party” knows what it is doing enough to bind and be bound, black box algorithms by definition engage in emergent behavior that cannot be anticipated by a principal. The presumption of deference to general acts showing an intent to be bound, even of a sophisticated party using algorithms, must be relaxed in the case of black box algorithmic contracts, and this relaxed presumption could potentially result in a contract being unenforceable.²² Clear box algorithmic contracts are an intermediate case because principals using clear box algorithms can anticipate their behaviors. Clear box algorithmic contracts present no formational impediments if their behavior is foreseeable and limited in scope. Using a clear box algorithm to negotiate a contract may, in such cases, be enough to show intent to be bound to a reasonably firm universe of outcomes.

B. Algorithmic Contracts in Action

When described in general terms as in Part A, it can seem like algorithmic contracts are creatures of the future. But in fact, they are already

21. ERNEST WEINRIB, *THE IDEA OF PRIVATE LAW* 38-42 (rev. ed. 2012).

22. A discussion of why black box algorithmic contracts pose a particularly substantial problem for contract law is found *infra* Part III. *Infra* Part IV suggests a roadmap to enforcement for black box algorithmic contracts.

in use, have been for over a decade, and are growing more widespread.²³ Commentators have discussed the limits of property law to address the complex problems presented by a digital, information age, and subsequent need for contract law in this area.²⁴ This Part describes three examples of algorithmic contracts in action which complicate the application of current contract law: high speed trading, online pricing, and Ethereum's "smart contracts."

In particular, smart contracts illustrate that in some cases, the algorithms used in contract formation do not reflect the considered, consciously anticipated choices of their corporate users. By contrast, dynamic pricing, at least in its most familiar forms, is straightforward gap-filling readily covered by current contract law. However, jurists and lawmakers ignore more complicated cases such as smart contracts and high frequency trading at their peril. Contract law will soon be forced to have as coherent an approach to these hard cases as the simple cases. While litigation over the enforceability of hard algorithmic contract cases is currently rare, this is only due to the presence of repeat players, the norm of industry-specific regulation in high frequency trading, and the extreme marginality of the smart contract-using community. Algorithmic contracting will spread to other areas of commerce, and when it does, breach of contract cases will create uncertainty when contracts are formed with black box algorithms.

1. High Frequency Trading

High frequency trading (HFT) is computerized trading of financial products using proprietary algorithms.²⁵ There are two types of high frequency trading: execution trading and small opportunity trading. Execution trading is when an order (often a large order) is executed via a computerized algorithm. The program is designed to get the best possible price. For example, it may split the order into smaller pieces and execute at different times. The second type of high frequency trading is not executing a set order but looking for small trading opportunities in the market.²⁶ Many scholars have highlighted the contrast between high frequency trading and traditional trading.²⁷

23. Anthony J. Bellia Jr., *Contracting with Electronic Agents*, 50 EMORY L.J. 1047, 1047 (2001) ("The use of computer technology to 'make contracts' for humans is no longer mere prospect but reality.").

24. Christopher J. Cifrino, *Virtual Property, Virtual Rights: Why Contract Law, Not Property Law, Must Be the Governing Paradigm in the Law of Virtual Worlds*, 55 B.C. L. REV. 235, 254-64 (2014).

25. *High Frequency Trading*, NASDAQ FINANCIAL GLOSSARY (May 10, 2017), <http://www.nasdaq.com/investing/glossary/h/high-frequency-trading#ixzz3xkqhACe4> [<https://perma.cc/6BU6-XP6E>].

26. *Id.*

27. *E.g.*, Andrew J. Keller, *Robocops: Regulating High Frequency Trading After the*

Faster is better when trading financial products. Algorithms which make rapid decisions to exploit changes in the market can move in milliseconds; the faster the response rate, the more potential to profit.²⁸ The search for profit has led to the widespread adoption of high speed trading. Despite the relatively small number of entities able to invest in high frequency trading, even the most conservative estimates find that more than half of the volume of trading in American markets is high frequency trading.²⁹

High frequency trading presents many market efficiency and fairness concerns, with several commentators within the industry noting that HFT merely enables practices that otherwise would be illegal to proceed under cover of sophisticated proprietary algorithms.³⁰ “The level of sophistication required makes it difficult for regulators around the world to catch those traders who are not operating legally,” said Peter Castellon, a partner at Proskauer Rose in London.³¹ “That’s what’s evil about high-frequency trading,” Castellon said, “and it’s very hard to catch because of the sophistication of the algorithms.”³²

Algorithmic trading has decreased the information-distributing function of the financial markets.³³ Flash crashes are just the most extreme illustration of this general phenomenon. The very purpose of HFT is to conceal information about the market from some actors in order to profit from their ignorance. While this tends to enrich some actors in the market, it does not promote efficiency, and in fact can lead to dangerous mistakes that no individual party intended. As practitioner Wallace C. Turbeville wrote in a recent Maryland Law Review article “the financial markets have become less efficient in the era of deregula-

Flash Crash of 2010, 73 OHIO ST. L.J. 1457, 1461-64 (2012) (describing the unique features of HFT in contrast to traditional trading).

28. Nick Baumann, *Too Fast to Fail: How High-Speed Trading Fuels Wall Street Disasters*, MOTHER JONES, Jan./Feb. 2013, <http://www.motherjones.com/politics/2013/02/high-frequency-trading-danger-risk-wall-street> [<https://perma.cc/PNX7-BH7D>].

29. Charles R. Korsmo, *High-Frequency Trading: A Regulatory Strategy*, 48 U. RICH. L. REV. 523, 574-75 (2014).

30. Merritt B. Fox et. al., *The New Stock Market: Sense and Nonsense*, 65 DUKE L.J. 191, 226-61 (2015).

31. Maureen Stapleton, *Laws Need to Catch Up to High-Speed Trading*, ABA JOURNAL (Aug. 2015), http://www.abajournal.com/magazine/article/laws_need_to_catch_up_to_high_speed_trading/ [<https://perma.cc/9N2E-SMLZ>].

32. *Id.*

33. Wallace C. Turbeville, *A New Perspective on the Costs and Benefits of Financial Regulation: Inefficiency of Capital Intermediation in a Deregulated System*, 72 MD. L. REV. 1173, 1177-78 (2013) (“Contrary to commonly held beliefs, advances in information technology and quantitative analysis have actually created asymmetries in information among trading market participants.”)

tion even though conventional wisdom dictates that advances in information technology and quantitative analysis should have caused the opposite result.”³⁴

Ironically, the use of algorithms has reinvigorated the importance of physical space in trading.³⁵ One interesting issue that has arisen out of high-frequency trading is the co-location of computer servers that give traders an advantage.³⁶ The widespread use of HFT has made financial markets less effective at their function of distributing information, and has moved the actions of big players closer to pre-industrial age behavior of closeness to a resource, in this case, access to the internet, rather than more sophisticated methods of wealth generation.³⁷

Chris Brummer has observed that “[n]owhere has disruptive technology had a more profound impact than in financial services—and yet nowhere do academics and policymakers lack a coherent theory of the phenomenon more, much less a coherent set of regulatory prescriptions.”³⁸ The overwhelming nature of the change in the way trading happens and the difficulty of regulatory responses stems in part from the technocratic approach that has dominated securities regulation in particular. Technocratic approaches can in fact be less effective than generalist approaches where the pace of technological development is so fast and so proprietary as to preempt true expertise on what is actually happening in the field to develop in government. By contrast, corporate law is still strongly influenced by common law, which has allowed corporate law to adapt to changing situations.

While this Article’s approach to algorithmic contracts does not purport to be a substitute for sector-specific financial regulation, making sense of the background private law of contract that governs algorithmic contracts will (1) provide guidance when rules fail and (2) aid in developing sector-specific approaches by describing a general approach that comports with the actual realities and potentials for contracting with algorithms. Charles Korsmo has observed that any regulatory strategy for high frequency trading should involve ensuring that “reliable information regarding HFT is generated in close to real time,” “an

34. *Id.*

35. Keller, *supra* note 29.

36. Frank Pasquale, *Law’s Acceleration of Finance: Redefining the Problem of High-Frequency Trading*, 36 CARDOZO L. REV. 2085, 2110 (2015).

37. Co-location is the phenomenon of high speed traders aggressively purchasing the right to access locations close to stock exchanges to achieve quicker speeds. Some have linked the phenomenon to environmental harms, and it certainly disputes the popular notion of the internet being agnostic to energy and location. See Geoffrey Rogow, *Colocation: The Root of All High Speed Trading Evil?*, WALL ST. J. (Sep 20, 2012, 1:57 PM ET) <https://blogs.wsj.com/marketbeat/2012/09/20/collocation-the-root-of-all-high-frequency-trading-evil/> [<https://perma.cc/639Q-QYGG>].

38. Chris Brummer, *Disruptive Technology and Securities Regulation*, 84 FORDHAM L. REV. 977, 977 (2015).

evolving body of best practices regulation desired to reduce the systemic risks posted by HFT”, and “strengthen liability for HFT and those who sponsor their access to the markets.”³⁹ A clear backstop of contract rules would help achieve these goals even in absence of specific regulation. Specific regulation is very difficult in an environment of constant innovation and proprietary algorithms.

Furthermore, the need for general private law rules is particularly acute where innovation moves trading outside of traditional trading structures. Dark pools are non-public markets where orders are executed without the scrutiny for regulated exchange trading.⁴⁰ They are anonymous trading platforms for trading stock listed on public markets.⁴² Orders normally placed through an exchange are visible to the public and all other market participants, but an order or an indication of interest entered on a dark pool is revealed only to other dark pool participants.⁴¹ This gives dark pool participants access to information unavailable to the public.⁴² Far from being the province of marginal actors, mainstream banks such as Golden Sachs participate in dark pools.⁴³

Even the basic characteristics of the entity to be regulated in high frequency trading have changed. As Tom C.W. Lin has put it, “changes in finance have transformed prevailing understandings of financial regulation’s main character, the investor. The investor has evolved from a person or group making a decision to a human-cyber hybrid, and regulation should reflect the particular challenges presented by this reality.”⁴⁴

High speed trading, as alluded to above, involves either black box or clear box algorithmic contracts. Algorithms, acting as agents for investors, determine the best way to make money pursuant to general objectives, and will enact their objectives in such a way as to cover their tracks. The algorithms are sophisticated, but ultimately, what happens at each moment of trade is that the algorithm either offers a price based on its program and the current environment, or decides whether or not to accept an offer based on the same. The algorithm’s programming is hidden from whatever person or algorithm on the other side is trying to

39. Charles R. Korsmo, *High-Frequency Trading: A Regulatory Strategy*, 48 U. RICH. L. REV. 523, 530 (2014).

40. Luis A. Aguilar, *Shedding Light on Dark Pools*, SEC (Nov. 18, 2015), <https://www.sec.gov/news/statement/shedding-light-on-dark-pools.html> [<https://perma.cc/8XYM-DJBX>].

41. *Id.*

42. Jerry W. Markham, *High-Speed Trading on Stock and Commodity Markets—From Courier Pigeons to Computers*, 52 SAN DIEGO L. REV. 555, 563 (2015).

43. Justin Baer and Scott Patterson, *Goldman, Barclays, Credit Suisse Draw High-Speed Trading Scrutiny*, WALL ST. J. (May 9, 2014, 6:01 PM), <https://www.wsj.com/articles/goldman-sachs-faces-scrutiny-related-to-high-speed-trading-hiring-1399634396> [<https://perma.cc/AE7R-BAVA>].

44. Tom C.W. Lin, *The New Investor*, 60 UCLA L. REV. 678, 682 (2013).

achieve. All that the other party sees is the offer of a price, or a rejection of an offer.

Despite the prevalence of HFT and the huge amount of damage the practice has done to investors collectively, case law about contract law and HFT is practically nonexistent.⁴⁵ On January 31, a huge SEC settlement involving many top industry players saw the organizations admitting guilt in deceiving participants in a dark pool by lying to them about whether the HFT would serve to mislead them when trading in the dark pool.⁴⁶ The teachable lesson for crafting policy solutions for algorithmic contracts is that contract rules have impacts on the behaviors of companies.⁴⁷ The lack of a private law foundation for algorithmic contracts is preventing the agencies that regulate HFT from successfully pursuing action against many potential wrongdoers.⁴⁸ The ambiguity in contract law allows bad actors to have it both ways: (presumably) binding contracts⁴⁹ for sale of financial products without the level of intent in each individual trade to be brought into court for fraudulent trading strategies. This status quo is untenable.

2. *Dynamic Pricing*

Dynamic pricing uses information about the market, product, and the buying party to set prices at the highest price a given buying party is willing to pay.⁵⁰

Dynamic pricing provides a fairly clear example of gap-filling algorithmic contracts. Retailers use algorithms that take into account information about the market and, increasingly, personalized information about the particular potential buyer to determine what price to offer. In most retailing situations, be it business to business or to consumer, the price is a “take it or leave it offer.” An algorithm does not appear to the buying party, only the term which is determined by an algorithm. Most

45. Leading corporate law scholar Tom C. W. Lin did not cite a single case in his 2013 article describing high frequency trading and its legal discontents. Tom C.W. Lin, *New Investor*, 60 *UCLA L. REV.* 678, 682 (2013)

46. Sarah N. Lynch, *Barclays, Credit Suisse Strike Record Deals with SEC, NY over Dark Pools*, REUTERS (Jan. 31, 2016, 9:01 PM), <http://www.reuters.com/article/us-sec-new-york-darkpools/barclays-credit-suisse-strike-record-deals-with-sec-ny-over-dark-pools-idUSKCN0V90UE> [<https://perma.cc/2HUZ-VLDV01M>].

47. See Avery W. Katz, *Contract Theory—Who Needs It?*, 81 *U. CHI. L. REV.* 2043, 2067-68 (2014) (discussing the underrated importance of considering contract theory for transactional lawyers).

48. See *infra* Part IV.

49. See *infra* Part III (arguing that the doctrine is ambiguous at best about the enforceability of black box algorithmic contracts.)

50. Robert M. Weiss & Ajay K. Mehrotra, *Online Dynamic Pricing: Efficiency, Equity and the Future of E-Commerce*, 6 *VA. J.L. & TECH.* 11, 1. (2001) (defining dynamic pricing and discussing its rise in the digital economy through reference to Amazon.com).

issues with these contracts may largely be addressed with reference to the case law on incomplete contracts. Some room for indeterminate rules has foundation in the Uniform Commercial Code, but there is the potential for complicated configurations to pose more difficult questions of incompleteness. Incomplete contracts have been the subject of much recent scholarship, and the law has difficulty determining when a contract is too incomplete to be enforceable.⁵¹ Scholars and courts differ as to how incomplete contracts should be handled. The classic view, and the one that still prevails in the courts, is that such contracts are unenforceable.⁵² Several scholars have discussed the significance of acknowledging the reality of incomplete agreements at law.⁵³ Specifically, some have found that courts should interpret incomplete contracts in a way that would have the most efficient consequences in terms of information sharing.⁵⁴

51. See generally Wendy Netter Epstein, *Facilitating Incomplete Contracts*, 65 CASE W. RES. L. REV. 297 (2014) (discussing the merits of incomplete contracts and arguing that contract law should make them easier to complete); Avery W. Katz, *Contractual Incompleteness: A Transactional Perspective*, 56 CASE W. RES. L. REV. 169 (2005) (discussing particular problems and potential solutions related to incomplete contracts between private parties); Robert E. Scott, *A Theory of Self-Enforcing Indefinite Agreements*, 103 COLUM. L. REV. 1641 (2003) (arguing that since about half of all people behave as if reciprocity were an important motivation deliberately incomplete contracts that rely on self-enforcement through reciprocal fairness are fairly common, and may even be more efficient than the alternative of more complete, legally enforceable agreements).

52. See Ian Ayres & Robert Gertner, *Filling Gaps in Incomplete Contracts: An Economic Theory of Default Rules*, 99 YALE L.J. 87, 106 (1989) (arguing for default rules that neither party would want in order to encourage parties to reveal information, and stating that “the common-law standard [is] that indefinite contracts are unenforceable”).

53. See Subha Narasimhan, *Of Expectations, Incomplete Contracting, and the Bargain Principle*, 74 CAL. L. REV. 1123, 1130 (1986) (“I will suggest a theory of bargain based on the premise that parties assume a truncated risk distribution when they negotiate. . . . Under this theory, if the value of the contract at the time of dispute is outside the agreed-upon range, the parties are entitled to their expectations based on that range, leaving an excess to distribute. . . . Viewed in this light, the current doctrines of impossibility, mistake, and modification merge into the enforcement question of whether the value of the contract at the time of enforcement is within the range of values assented to.”).

54. See generally JOHN FINNS, NATURAL LAW AND NATURAL RIGHTS 307 (1980) (“Suffice it to observe here that although promissory obligations do not come into being without some voluntary and intentional act such as might be said to manifest an ‘act of will’ on the part of the promisor, the occurrence of that act is only one of the several facts relevant to the emergence of the necessity which we call obligation, and has no special role in explaining the obligation of the performance promised. The need for a voluntary assumption of duty requires some independent justification. Indeed, recent scholarship suggests that imposing no liability for precontractual reliance (i.e., reliance before there is a voluntary assumption of a duty) may lead to inefficient outcomes.”); Ian Ayres & Robert Gertner, *Filling Gaps in Incomplete Contracts: An Economic Theory of Default Rules*, 99 YALE L.J. 87, 97 (1989) (“From an efficiency perspective, penalty default rules can be justified as a way to encourage

A classic example of dynamic pricing is the purchase of airline tickets. If I plan to visit my parents in Atlanta this June, the cost of the ticket that I will be offered will vary based on variable factors, such as how close to the date of departure I decide to buy the ticket, whether or not there are major events happening in the city at the time I choose to go, and more fixed factors, such as how many flights there are between New York and Atlanta and the distance between the two cities. The airline, or the third party vendor selling the ticket, will use an algorithm to take these factors into account when offering me the ticket price. This example takes place online, but dynamic pricing is spreading to the brick and mortar context, too.⁵⁵

Since as early as 2000, a feature of dynamic pricing has been the use of personal information to customize the price term to what a business's algorithm suggests a consumer might accept.⁵⁶ Contract is a liminal feature of interactions between consumers and businesses. Regardless of how intellectual or intellectual quasi-property rights like privacy⁵⁷ set defaults, contract can still control the rights and responsibilities that most consumers face.⁵⁸ While there are some limits to what can be agreed to, by and large in most jurisdictions as a matter of law and practice these contracts are immune to challenge.⁵⁹ A consumer protection concern might arise where we begin to think that algorithms may allow businesses to set price terms to squeeze the maximum profit out of each consumer.⁶⁰ Some have the intuition that violence is being done to basic

the production of information. The very process of "contracting around" can reveal information to parties inside or outside the contract.").

55. Greg Bensinger, *Amazon Plans Hundreds of Brick-and-Mortar Bookstores, Mall CEO Says*, WALL ST. J. (Feb. 2, 2016, 6:40 PM), <https://www.wsj.com/articles/amazon-plans-hundreds-of-brick-and-mortar-bookstores-mall-ceo-says-1454449475> [<https://perma.cc/7VM8-4XJU>] (noting that the prices for goods in the brick-and-mortar Seattle store will be the same as the online prices, which are known for dynamic pricing techniques).

56. Akiva A. Miller, *What Do We Worry About When We Worry About Price Discrimination? The Law and Ethics of Using Personal Information for Pricing*, 19 J. TECH. L. & POL'Y 41, 48-49, 84, 88 (2014).

57. See generally Lauren Henry Scholz, *Privacy as Quasi Property*, 101 IOWA L. REV. (2016) ("Privacy is quasi-property. Quasi-property is a relational entitlement to exclude. Unlike real property, there is no freestanding right to exclude from a quasi-property interest absent reference to a relationship between individuals. Rather, the right to exclude arises from the behaviors of the plaintiff and defendant. A defendant is identified based on a trigger arising from a relationship, action, or harm to a plaintiff.").

58. Jonathan M. Barnett, *Is Intellectual Property Trivial?*, 157 U. PA. L. REV. 1691, 1705-06 (2009).

59. See *id.* ("While the enforceability of these contracts is sometimes contested, the law seems fairly settled in most jurisdictions that these contracts are relatively immune to challenge so long as certain notice and other procedural requirements to satisfy judicial concerns over aggressive 'fine print' tactics are met.").

60. See David A. Hoffman, *From Promise to Form: How Contracting Online*

principles of fairness, where one party has an algorithm that allows them to know the lowest price that an individual will accept, and the average consumer is operating with much less information about what price the company would accept.⁶¹

The fairness of and potential for price discrimination in dynamic, digital pricing from data mining and processing has been examined in the literature from several perspectives. Some take it to be as an issue of competition and antitrust law.⁶² Some scholars address it as a fundamentally an ethical issue.⁶³ It does not enter into our analysis of whether algorithmic contracts constitute contract formation. Exposing an unknowing consumer to a sophisticated algorithm tailoring its terms to the worst terms that consumer would accept would tend to remove all consumer surplus from transactions. This may justify intervention based on a policymaker's interpretation of efficiency and justice. However, some, notably Professor Matthew A. Edwards, have argued that price discrimination actually could be desirable for consumers.⁶⁴ As he

Changes Consumers, 91 N.Y.U. L. REV. 1595, 1595 (2016) (“I hypothesize that different experiences with online contracting have led some consumers to see contracts—both online and offline—in distinctive ways. Experimenting on a large, nationally representative, sample, this paper provides evidence of age-based and experience-based differences in views of consumer contract formation and breach. I show that younger subjects who have entered into more online contracts are likelier than older ones to think that contracts can be formed online, that digital contracts are legitimate while oral contracts are not, and that contract law is unforgiving of breach. I argue that such individual differences in views of contract formation and enforceability might lead firms to discriminate among consumers. There is some evidence that businesses are already using variance in views of contract to induce consumers to purchase goods they would not otherwise have.”)

61. Cf. Aniko Hannak et al., *Measuring Price Discrimination and Steering on E-commerce Web Sites*, 2014 CONF. ON INTERNET MEASUREMENT, PROC., 305, [<https://perma.cc/ZZ5Q-ABY2>] (empirical study confirming the role of price discrimination online, finding that there are “numerous instances of price steering and discrimination on a variety of top e-commerce sites”).

62. E.g., Rory Van Loo, *Helping Buyers Beware: The Need for Supervision of Big Retail*, 163 U. PA. L. REV. 1311, 1330 (2015) (analyzing how sophisticated institutions capitalize on consumer limitations and considering what might be done about it); Nathan Newman, *Search, Antitrust, and the Economics of the Control of User Data*, 31 YALE J. ON REG. 401, 405 (2014) (arguing that antitrust investigation should focus on how control of personal data by corporations can entrench monopoly power in an economy shaped increasingly by the power of “big data”).

63. See Amy J. Schmitz, *Secret Consumer Scores and Segmentations: Separating “Haves” from “Have-Nots,”* 2014 MICH. ST. L. REV. 1411, 1414-15, 1455 (2014) (“Consumers should not be essentially punished based on who their friends are. This seems to offend basic morality and asks for consumers to base their social networks on creditworthiness instead of kindness, love, and familial ties.”); Miller, *supra* note 56, at 68-98 (discussing ethics of price discrimination under the following headings: freedom, consumer harm, antitrust, deceptiveness, unfairness, and social harm).

64. See generally Matthew A. Edwards, *Price and Prejudice: The Case Against Consumer Equality in the Information Age*, 10 LEWIS & CLARK L. REV. 559 (2006).

observes, “vigorous anti-equality stance is neither inimical to consumer rights nor incompatible with progressive critiques of laissez faire approaches to contract law.”⁶⁵ This is a rich area of analysis that ultimately is an application of justice concerns about what contract law should do and how it should distribute power in society.⁶⁶ Except for the considerations of policy justifications for algorithmic contracts in Part III B, this Article will bracket this issue as not relevant to the issue of contract formation. Consumer-facing term algorithmic contracts are an application of the general weakness of the “unequal bargaining power” defense to a fair contract where a consumer has willingly entered into the contract.⁶⁷

While I’ve only discussed examples from dynamic contracting in consumer contracts, dynamic pricing works in business-to-business contract function in similar ways. The aim here is simply to illustrate how such contracts are formed with examples readily accessible to all readers. In fact, consumer contracts present unique issues, and this article is fundamentally about business ethics, that is, the incentives businesses have for algorithmic accountability. Consumer contracts present unique issues that business-to-business contracts do not, however. I have introduced this issue here but plan to more carefully examine algorithmic contracts in the consumer contracts in future work.

3. *Ethereum and “Smart Contracts”*

The first two examples presented have reached mainstream society, but it is the example of lesser known “smart contracts” that truly illustrates the level of automation that is possible in creating contracts, thus

65. *Id.*

66. See generally Duncan Kennedy, *Distributive and Paternalist Motives in Contract and Tort Law, with Special Reference to Compulsory Terms and Unequal Bargaining Power*, 41 MD. L. REV. 563 (1982) (arguing that the dilemmas of paternalism are “inescapable” for the decisionmaker who wields power over others’ lives and that paternalism in contract law is permissible on the grounds that consensual transactions do not necessarily increase utility).

67. Some law and economics-oriented scholarship has been skeptical of unequal bargaining power as an argument against contract in the absence of true duress. E.g., Richard A. Epstein, *In Defense of the Contract at Will*, 51 U. CHI. L. REV. 947, 953 (1984) (defending contract at will between employers and employees, that is, contracts to work that essentially provide for dismissal at will for almost any reason, a classic case of unequal bargaining power in the American economy). Another kind of argument against interfering with consumer contracts in the social media mediated climate has it that current technology has actually made it easier for consumers as a class to bargain with companies in the creation of form contracts than ever before, which throws into question the argument that legal intervention is necessary. Wayne R. Barnes, *Social Media and the Rise in Consumer Bargaining Power*, 14 U. PA. J. BUS. L. 661 (2012) (arguing that social media has given consumers as a group more bargaining power against companies).

laying bare the inadequacy of current contract law in addressing algorithmic contracts. As Joshua Fairfield has discussed in recent work in the consumer context, decentralized applications like smart contracts could lead to widespread consumer usage of sophisticated algorithms to select for price and conditions.⁶⁸ But there is a failure in the market to provide consumers with algorithms to help them make rational choices in a complex market, caused by the lack of incentive for current big plays to create and distribute such an application.⁶⁹ This could be corrected by new, innovative actors seeking to provide a useful service to consumers, much like search applications rose in the early days of the internet to help consumers achieve their goals in light of a surfeit of information online.

Bitcoin has been the subject of debate and regulation as a cryptocurrency, but much of the discussion has centered around Bitcoin in its current form rather than block chain technology more broadly, which enables Bitcoin. Blockchain technology, which can roughly be described as a decentralized database, enables “trustless” transactions: value exchanges over computer networks that can be verified, monitored, and enforced without central institutions.⁷⁰ The blockchain can be described as a public ledger that records every transaction that has ever been made and will ever be made on the bitcoin network, and a copy of this is distributed to every single user connected to the network. All users agree to abide to a certain set of procedures: the Bitcoin protocol.⁷¹ The blockchain is an authentication and verification technology, enabling automated title transfers and ownership verification based on conditions.⁷² No trust is needed, and these functions can be performed without trusted intermediaries subject to government regulation such as

68. Joshua Fairfield, *Smart Contracts, Bitcoin Bots, and Consumer Protection*, 71 WASH. & LEE L. REV. ONLINE 35, 40-45 (2014).

69. See Rory Van Loo, *Helping Buyers Beware: The Need for Supervision of Big Retail*, 163 U. PA. L. REV. 1311, 1330 (2015) (“The second way in which technologies have failed to live up to their potential is in their ability to enable consumers to gather and analyze all market prices available. To see the theoretical potential for this to happen, consider a shopping application in which consumers input location, means of transportation, and a shopping list. The application would aggregate prices from all relevant brick-and-mortar and online retailers and run sophisticated algorithms to create optimized shopping itineraries from which the consumer could choose. Importantly, the application would be immune from irrational decisions such as being more likely to purchase a product ending in ‘9’ and being influenced by exposure to an advertisement for an overpriced \$799 television. It would be able to determine rationally which retailer had the best price on like items.”).

70. Trevor I. Kiviat, *Beyond Bitcoin: Issues in Regulating Blockchain Transactions*, 65 DUKE L.J. 569, 574 (2015).

71. Primavera De Filippi, *Ethereum: Freenet or Skynet?*, BERKMAN CENTER FOR INTERNET AND SOCIETY (Apr. 15, 2014), <https://cyber.law.harvard.edu/events/luncheon/2014/04/difilippi> [<https://perma.cc/P9MJ-XU95>].

72. Satoshi Nakamoto, *Bitcoin: A Peer-to-Peer Electronic Cash System* (unpublished), <https://bitcoin.org/bitcoin.pdf> [<https://perma.cc/33WC-BGUR>].

banks.⁷³ The borderless, arguably frictionless nature of the blockchain enables it to provide a cheap, fast infrastructure for exchanging units of value.⁷⁴

Ethereum builds upon the technology of Bitcoin to form a next generation smart contract and decentralized application platform.⁷⁵ On top of a decentralized database, digital tokens, and encryption, it builds a Turing-complete scripting language that allows anyone to deploy their his or her application on top of the blockchain.⁷⁶ This enables the development of applications that operate autonomously on the blockchain.⁷⁷ Smart contracts are self-executing and, in theory, can be self-enforcing. One example of a smart contract type currently in use for a corporate bond with a specified par value, tenor, and coupon payment stream is a smart contract that automatically executes payments on the specified schedule to the assigned owner over the life of the bond.⁷⁸ As this example shows, smart contracts can be entirely written in code.

A smart contract removes the need for trust between parties.⁷⁹

73. *Id.*

74. While Bitcoin proponents highlight the “frictionless” nature of the currency, a growing chorus critics have argued that there is substantial friction associated with the virtual currency. *E.g.*, Alexander Kroeger & Asani Sarkar, *Is Bitcoin Really Frictionless?*, FEDERAL RESERVE BANK OF NEW YORK (Mar. 23, 2016, 7:00 AM), <http://libertystreeteconomics.newyorkfed.org/2016/03/is-bitcoin-really-frictionless.html#.VvPHVWPjCxp> [<https://perma.cc/TM4M-ZJRJ>].

75. Vitalik Buterin, et al., *A Next Generation Smart Contract and Decentralized Application Platform*, GITHUB (last updated May 29, 2017) (“The intent of Ethereum is to create an alternative protocol for building decentralized applications, providing a different set of tradeoffs that we believe will be very useful for a large class of decentralized applications, with particular emphasis on situations where rapid development time, security for small and rarely used applications, and the ability of different applications to very efficiently interact, are important. Ethereum does this by building what is essentially the ultimate abstract foundational layer: a blockchain with a built-in Turing-complete programming language, allowing anyone to write smart contracts and decentralized applications where they can create their own arbitrary rules for ownership, transaction formats and state transition functions.”) <https://github.com/ethereum/wiki/wiki/White-Paper> [<https://perma.cc/3M7G-2BXV>]; The term “platform” implies a level of neutrality by the creators that may or may not reflect reality. This Article will largely bracket the influence that third parties might have on the type of algorithmic contracts that are created, while flagging its potential significance. *See generally* Tarleton Gillespie, *The Politics of ‘Platforms’*, NEW MEDIA & SOC’Y (2010), <http://rws511.pbworks.com/w/file/attach/99638039/Gillespie%20Platforms%20CDL%20rhetoric.pdf> [<https://perma.cc/SP8B-WHNV>] (discussing the use and significance of the term “platform”).

76. Buterin et.al, *supra* note 95

77. *Id.*

78. Governor Lael Brainard, Speech at the Institute of International Finance Annual Meeting Panel on Blockchain, Washington, D.C. (Oct. 7, 2016), 2016 WL 5921752, at *2.

79. TIM SWANSON, GREAT CHAIN OF NUMBERS: A GUIDE TO SMART CONTRACTS, SMART PROPERTY AND TRUSTLESS ASSET MANAGEMENT 14-31 (2014).

Smart contracts are self-enforceable: the contract and the code are matching to one thing.⁸⁰ The contract is defined by the code and is also automatically being enforced by the code that defined it.⁸¹ This creates the possibility of one decentralized application interacting and agreeing with another application.⁸²

What distinguishes smart contracts from other areas of algorithmic contract is the ability of Ethereum to create what are known as decentralized autonomous organizations (DAOs). DAOs implement a constitution that stipulates the governance of the organization. DAOs also implement a system of equity allowing people to invest by purchasing some of their shares to help the organization achieve its objective. Instead of trusting an organization to operate by rules, one can encode a series of rules for behaviors for an organization that it will then be bound to follow. For an investor, this may in some ways be more desirable than investing in actual founders. As the Ethereum website puts it, the platform enables “applications that run exactly as programmed without any chance of downtime, censorship, fraud or third-party interference.”⁸³

The most (in)famous example of a DAO is the entity known as “The DAO.”⁸⁴ The DAO was launched with \$150 million in crowdfunding in June 2016 to invest in cryptocurrency startups. Once it went live, in an incident known as the “DAO hack,” The DAO was immediately drained of US\$50 million in cryptocurrency by a hacker that exploited weaknesses in the code.⁸⁵ There was a debate within the community as to whether the “hacker” had precipitated properly executed smart contracts that should be honored or whether it was a wrongful use of the Ethereum infrastructure that should not be allowed. This ideological debate split up the Ethereum community, and as of this writing, two different currencies with two different blockchains exist: Ethereum itself, which unwound the DAO hack and removed it from the blockchain, and Ethereum classic, which did not. Perhaps of the ideological commitments of the investors into The DAO, legal action has not been brought to bear against anyone involved.

In the next Part, I show that the contracts made by a DAO would

80. *Id.*

81. *Id.*

82. *Id.*

83. ETHEREUM, <https://www.ethereum.org/> [<https://perma.cc/9GPT-2CLB>]

84. For clarity’s sake, when I am referring to this specific DAO, I will refer to it as “The DAO” with a capitalized letter “T.”

85. Nathaniel Popper, *A Hacking of More Than \$50 Million Dashes Hopes in the World of Virtual Currency*, N.Y. TIMES (June 17, 2016), https://www.nytimes.com/2016/06/18/business/dealbook/hacker-may-have-removed-more-than-50-million-from-experimental-cybercurrency-project.html?_r=0 [<https://perma.cc/BH2D-VXGC>].

probably not be enforceable, because the intent of the investors in a DAO is too far removed from the contracting actions of the DAO. In Part IV, I construct a legal argument for the enforceability of contracts formed by black box algorithms.

III. BLACK BOX ALGORITHMIC CONTRACTS: AN ILLUSTRATION OF THE LIMITS OF CURRENT CONTRACT LAW FOR ADDRESSING ALGORITHMIC CONTRACTS

As discussed in Part II, DAOs present the clearest example of black box algorithmic contracts. They show that a contract law that does not specifically account for sophisticated, self-teaching, self-reliant algorithms is fundamentally unstable in light of the next wave of contracts. In order to achieve the advantages of this type of corporate structure while checking the risks, we need a contract law that acknowledges that algorithms are more than mere tools and does not wrongly presume that sophisticated businesses can always predict the behavior of a sophisticated algorithm. This Part discusses the inadequacy of current contract law to clearly find black box algorithmic contracts enforceable as a class.

A. *Black Box Algorithmic Contracts Are Probably Not Enforceable at Current Contract Law*

As Part II B illustrates, black box algorithmic contracts are already in use. As a social matter, they serve the function of binding parties. After all, most contract disputes are handled in-between parties out of court. In the financial services industry, where black box algorithmic contracts are currently the most common, administrative agencies are the primary enforcers. But, enforceability questions about these contracts remain. It is still not clear whether a party could go into court and demand enforcement of a black box algorithmic contract. As of this writing, no party has attempted to bring a case against the creator of a decentralized autonomous organization.⁸⁶

The commonly held presumption that electronic contracts are enforceable comes largely from corporate custom. There are some judicial holdings, not specifically about black box algorithmic contracts, which find all electronic contracts enforceable under the Uniform Electronic Transactions Act. However, when algorithmic contracting moves to a different business context outside of finance, litigation may erupt. As

86. May 12, 2017 Westlaw searches for cases containing the terms “decentralized autonomous organizations” and “decentralized autonomous corporation” returned zero results in federal jurisdictions and in all state jurisdictions.

Lea Shaver observed in the context of patent law, “litigation is the continuation of business strategy by other means.”⁸⁷ As this Part will show, litigation against algorithmic contracts on the grounds that they are unenforceable is a loaded gun. It has gone unused thus far, but corporations will use it when it will serve their business interests to find a given set of black box algorithmic contracts unenforceable.

To support the enforceability of black box algorithmic contracts, current contract law would need to adopt at least one of two legal fictions: (1) black box algorithmic contracts are mere tools, and (2) sophisticated corporations can anticipate the conduct of black box algorithms. The agency approach that this Article advocates in Part IV would also allow many black box algorithmic contracts to be enforced. But this Article’s approach would have dual advantages over the status quo. It would reflect the reality of how black box algorithms work rather than willfully ignoring their characteristics. And it would provide a natural avenue of limiting potential for both irresponsible, unknowing use and willful abuse of algorithms in contract formation.

In commercial law, the traditional requirements of mutual assent and consideration are sometimes relaxed due to assumptions about the sophistication of the parties.⁸⁸ But omniscience cannot be imputed to even the most sophisticated business. Many empirical studies have shown that companies are not as savvy about their own contracting policies in areas such as arbitration as previously assumed.⁸⁹ It has been ably argued that the sophisticated-unsophisticated dichotomy is doing an unjustifiable amount of work in contract law more generally, creating effectively two different contract laws for companies and individuals.⁹⁰ The argument for party sophistication is stretched to its breaking point in the case of black box algorithmic contracts. Black box algorithms can, by definition, move far beyond the intents and capacities of their authorizing entities. The private law generally has not accounted for the new realities of artificial intelligence, but it is nimble enough to do so without fundamental reform.⁹¹

87. Lea Shaver, *Illuminating Innovation: From Patent Racing to Patent War*, 69 WASH. & LEE L. REV. 1891, 1926-47 (2012) (a historical discussion of the movement from relative peace to patent wars in the case of light bulb and smartphone patents).

88. Meredith R. Miller, *Contract Law, Party Sophistication and the New Formalism*, 75 MO. L. REV. 493, 497 (2010).

89. E.g., Andrea Doneff, *Arbitration Clauses in Contracts of Adhesion Trap “Sophisticated Parties” Too*, 2010 J. DISP. RESOL. 235, 236 (2010); Kabir Masson, *Paradox of Presumptions: Seller Warranties and Reliance Waivers in Commercial Contracts*, 109 COLUM. L. REV. 503 (2009).

90. See generally Meredith R. Miller, *Party Sophistication and Value Pluralism in Contract*, 29 Touro L. REV. 659, 665 (2013); Meredith R. Miller, *Contract Law, Party Sophistication and the New Formalism*, 75 MO. L. REV. 493, 497 (2010).

91. F. Patrick Hubbard, *“Sophisticated Robots”: Balancing Liability, Regulation, and Innovation*, 66 FLA. L. REV. 1803, 1871 (2014).

There is a very strong argument for the unenforceability of algorithmic contracts. Traditionally, contracts reflect a meeting of the minds between two or more parties to alter the legal rights between them. As contractual doctrine evolved, it moved beyond attempting to evaluate whether or not the parties actually exchanged something fairly of value to whether or not there was a bargaining between the parties. The idea of the freedom of contract holds a special position in the American tradition.⁹² Whether sophisticated or not, every competent party that is not under duress or one of the other very limited exceptions to enforcement has the power to choose what she sees fit to be bound by. The conscious, objectively manifested choice to agree to terms is a critical element of a contract. In other areas of law, the awareness by a conscious person is thought to have different status than an observation or processing by a machine.⁹³

The predominant approach to contract law considers a contract as fundamentally an expression of will, the conscious, objectively manifested intention of two parties or more to be bound to terms.⁹⁴ Note that the term of art “objective assent” requires a level of intersubjective

92. *E.g.*, Epstein, *supra* note 67, at 953-54 (“Freedom of contract is an aspect of individual liberty, every bit as much as freedom of speech, or freedom in the selection of marriage partners or in the adoption of religious beliefs or affiliations. Just as it is regarded as *prima facie* unjust to abridge these liberties, so too is it presumptively unjust to abridge the economic liberties of individuals.”).

93. Priscilla J. Smith, Nabiha Syed, David Thaw & Albert Wong, *When Machines Are Watching: How Warrantless Use of GPS Surveillance Technology Violates the Fourth Amendment Right Against Unreasonable Searches*, 121 YALE L.J. ONLINE 177, 189-94 (2011) (describing constitutional concerns with GPS technology due to the fact that it operates independently of humans). The Supreme Court rejected warrantless GPS tracking in *U.S. v. Jones*, with Justice Sotomayor’s influential concurring opinion in particular adopting an approach sensitive to whether a machine or human is watching. *United States v. Jones*, 132 S. Ct. 945 (2012) (Sotomayor, J., concurring) (reasoning that determining whether government behavior constitutes a search requires considering “whether people reasonably expect that their movements will be recorded and aggregated” in such a manner).

94. *E.g.*, CHARLES FRIED, *CONTRACT AS PROMISE: A THEORY OF CONTRACTUAL OBLIGATION* (1981); Randy E. Barnett, *A Consent Theory of Contract*, 86 COLUM. L. REV. 269 (1986). The alternative theory of contract finds that contractual obligation springs at law from the right to a remedy of one who has acted in justifiable reliance on another. *E.g.*, P.S. ATIYAH, *THE RISE AND FALL OF FREEDOM OF CONTRACT* (1979); Daniel A. Farber & John H. Matheson, *Beyond Promissory Estoppel: Contract Law and the “Invisible Handshake”*, 52 U. CHI. L. REV. 903, 927 (1985). There are also theories that combine these approaches in a social theory of contracts, arguing that contract springs from trust arising between individuals; an act of will is relevant but not determinative. *E.g.*, JOHN FINNIS, *NATURAL LAW AND NATURAL RIGHTS* 307, 323-24 (1980) (“Suffice it to observe here that although promissory obligations do not come into being without some voluntary and intentional act such as might be said to manifest an ‘act of will’ on the part of the promisor, the occurrence of that act is only one of the several facts relevant to the emergence of the necessity which we call obligation, and has no special role in explaining the obligation of the performance promised.”).

awareness that blurs the line between the ordinary understanding of objective and subjective assent.⁹⁵ Under Randy Barnett's will-oriented and permissive view of form contracts, consenting to form contracts is not about making a promise that a party would need to have actually understood. Instead it is "about manifesting consent to be legally bound."⁹⁶ Conscious intent is on the non-corporate side of the form contract even when the individual chooses not to read lengthy terms and conditions; the person who agrees to the form contract has just determined that rational ignorance is appropriate.⁹⁷ Barnett finds that there are limits on what can be consented to in a form contract; terms which "exceed some bound of reasonableness" should not be considered part of the contract.⁹⁸ Recently, several scholars have proposed a more limited scope for the enforceability of form contracts,⁹⁹ but Barnett reflects the conventional view on this matter.

Black box algorithmic contracts present a different type of problem than form contracts. Where those who accept form contracts can be said to be "rationally ignorant," in black box algorithmic contracts there is no fixed set of things of to which a party can be said to be ignorant. What the algorithm is going to do is unknown to both parties. Agreements to agree, or to pursue an objective only when profitable, have never been considered contracts.¹⁰⁰ While the algorithm itself is making more granular choices, the idea that automated choice has legal standing different from conscious choice by some person undergirds many areas of law, such as the law governing government surveillance and autonomous

95. BRIAN H. BIX, *CONTRACT LAW: RULES, THEORY, AND CONTEXT* 24-25 (2012); see also Katz, *supra* note 47, at 2049-53 ("For purposes of contracts, law, or indeed any aspect of human communication, it is the interpersonal definition that is relevant. In order for words to have communicative effect, the listener and hearer must speak the same language; functionally, they must share the same conventions regarding what sounds are used to refer to what concepts. Such conventions constitute what the literary and legal critic Stanley Fish has labeled an "interpretive community.") Once one recognizes this point about the way that language works, the distinction between subjective and objective interpretation loses much of its bite, because whether two people share the same linguistic convention is a social fact that can be determined by interpersonally objective criteria.").

96. Randy E. Barnett, *Consenting to Form Contracts*, 71 *FORDHAM L. REV.* 627, 629-30 (2002).

97. *Id.* at 640.

98. *Id.* at 639.

99. Kenneth K. Ching, *What We Consent to When We Consent to Form Contracts: Market Price*, 84 *UMKC L. REV.* 1 (2015) ("My argument is not just that form contracts should be enforced at market price. It is that consent to form contracts should be construed as consent to pay market price."); Andrew A. Schwartz, *Consumer Contract Exchanges and the Problem of Adhesion*, 28 *YALE J. ON REG.* 313, 363-66 (2011) (arguing that consumer exchange contracts should be excluded from the doctrine of adhesion).

100. *E.g.*, *Wood v. Lucy, Lady Duff-Gordon*, 222 *N.Y.* 88 (1917).

weaponry.¹⁰¹

Like agents, algorithms must not be understood as mere extensions of the will of an individual or company. Robotics law expert Ryan Calo defines emergence as “unpredictably useful behavior” that “represents a kind of gold standard among many roboticists[].”¹⁰² Emergent behavior accomplishes goals in ways the algorithm’s creators could not have predicted by learning from previous behavior and modifying its own program. An example of an algorithm demonstrating emergent behavior would be a stock-picking algorithm in use by a financial institution. While the financial institution’s quantitative analyst might program the algorithm to achieve particular goals, the financial institution is unable to predict *ex ante* what stocks the algorithm will pick. If the instructions given to an algorithmic-agent by its principal are vague, they cannot be considered the level of objectively manifested intent necessary to ground a contractual promise. Furthermore, emergence is a widespread business goal in algorithm development and use, so the law must have a coherent and descriptive account of the liability profile in the case of algorithmic emergence.¹⁰³ The concern is, unless the law incorporates an accurate view of the role algorithms play relative to their human principals, agreements that do not reflect the actual theoretical grounding of contract law will be swept into contract law. What’s more, the gap between the role of contract law and improperly formed black box algorithmic contracts has important negative policy effects, which will be discussed in Part III B.

Black box algorithmic contracts present problems for both mutual assent and consideration. The Article will go over each of these issues in turn.

Mutual assent is an agreement by both parties to a contract, usually in the form of offer and acceptance.¹⁰⁴ In modern contract law, mutual assent is determined by an objective standard — that is, by the apparent

101. Several authors have discussed the rise of autonomous weapons, and sources are remarkably consistent in their awareness that a choice made by an artificially intelligent agent is different from one made directly by a human principal. A. Michael Froomkin & P. Zak Colangelo, *Self-Defense Against Robots and Drones*, 48 CONN. L. REV. 1, 6 (2015); Rebecca Crootof, *The Killer Robots Are Here: Legal and Policy Implications*, 36 CARDOZO L. REV. 1837, 1844-45 (2015). The question of how machine learning in the context of NSA surveillance is different from reading by a human government is also a live debate.

102. Ryan Calo, *Robotics and the Lessons of Cyberlaw*, 103 CAL. L. REV. 513, 532 (2015).

103. *Id.*

104. RESTATEMENT (SECOND) OF CONTRACTS § 1 (Am. Law Inst. 1981) (defining contract as “a promise or a set of promises for the breach of which the law gives a remedy, or the performance of which the law in some way recognizes as a duty”)

intention of the parties as manifested by their actions.¹⁰⁵ But the objective intent at issue in the formation of a contract is not the general intention to make some kind of contract, or to come to some kind of terms with another party to reach an objective.¹⁰⁶ It is objective manifestation of intent to be bound by a contract with particular terms.¹⁰⁷

In the traditional account of bilateral contracts, one party makes an offer and the other party evaluates it and then chooses to accept or deny.¹⁰⁸ However, in the case of a black box algorithmic contract, where one party uses an algorithm to choose, for example, price and who to ask to contract with, the offeror (that is, the company or individual using the algorithm) is not directly offering. Rather, an automated agent is offering on behalf of the offeror, in a combination that the offeror may or may not have consciously considered.¹⁰⁹ The question is: is the manifested intent of a party to use an algorithm to select prices and contractual terms for them the same thing as actually, objectively, and manifestly assenting to the actual contracts the algorithm selects? Not necessarily. The algorithm as agent theory mediates between the intent of the creator of the algorithm and the acts of the algorithm. If the algorithm is acting within the parameters of what the offeror specifically planned for it to do, the algorithm acting on behalf of the offeror is acting as a conduit for the objective intent of the offeror to be bound. To put it another way, the extent to which the offeror can be said to be agreeing to a black box algorithmic contract is merely an illusory promise. When illusory promises are all that support a purported bilateral contract, there is no mutuality of obligation and thus no contract. A new technology should not enable contracting parties to end-run around the bedrock principle of contract law; parties should agree to be bound by promises, but only those that are non-illusory and non-gratuitous.¹¹⁰

The instinct of many operating with more limited knowledge of algorithms in society is to assume a party using an algorithm has an idea

105. K.N. Llewellyn, *Our Case-Law of Contract: Offer and Acceptance, II*, 48 YALE L.J. 779, 783 (1939); K.N. Llewellyn, *On Our Case-Law of Contract: Offer and Acceptance, I*, 48 YALE L.J. 1 (1938).

106. See Robert A. Prentice, "Law" & Gratuitous Promises, 2007 U. ILL. L. REV. 881, 909 (2007); Melvin Aron Eisenberg, *Donative Promises*, 47 U. CHI. L. REV. 1 (1979).

107. See Joseph M. Perillo, *The Origins of the Objective Theory of Contract Formation and Interpretation*, 69 FORDHAM L. REV. 427, 428-29 (2000).

108. RESTATEMENT (FIRST) OF CONTRACTS § 12 (Am. Law Inst. 1932).

109. For the purposes of this discussion we will take the perspective that the contracting party is the offeror. The same analysis holds for when an algorithm serves as the agent of the accepting party to a contract; that is, determining whom to contract with, which terms to accept, and whether to counteroffer.

110. See Prentice, *supra* note 106, at 909; Melvin Aron Eisenberg, *Donative Promises*, 47 U. CHI. L. REV. 1,32 (1979) (describing substantive and procedural grounds for enforcing donative promises and finding that in general, donative promises should not be enforced outside of proven reliance).

of what it will do on its behalf. However, this is based on the idea of algorithms as mere tools, like a calculator. The potential of Ethereum and the inscrutable sources of the flash crashes, as discussed in Part II B, are real world examples of how far the behaviors chosen by algorithms can stray from the intentions of any conscious person. In agency law, principal is not always bound by the actions of their agents; the agents might act in a way that goes directly contrary to the stated goals and interests of the principles. The principal is usually liable for the mistakes the agent makes because the principal assumed such a risk by opting to use an agent in the first place. But assumption of risk is a concept from tort, and should be analyzed as such. If the offeror using a black box algorithmic contract is bound by a contract that goes beyond the scope reasonably anticipated by the offeror, or the offeror gave the algorithm so broad an objective, such as “do X if it is within my business interest” that it demonstrates no intent to be bound by a particular type of contract, there is a strong argument that there is no objective manifestation of intent to contract in any particular black box algorithmic contract. “

The investors in The DAO are a great example of this. Prior to the DAO hack, the New York Times described the attitude of the investors in the DAO as “the digital equivalent of buying into a bakery with no baker, no menu and no assurance that the ovens will even be delivered. But among the crowd that has invested, faith in the computer code that governs the project appears strong enough to override all those concerns”¹¹¹ The person who used the algorithm is still liable for the actions of the algorithm in tort. However, the broad sense that “a party used an algorithm to make a contract, but they basically knew what was going to happen” does not rise to the level of mutual assent in contract.

Some properly formed contracts find parties agreeing to an algorithm or a future market price. However, using a black box algorithm to agree to the agreement is different. In the first case, a term being agreed to is, at least at the time of the formation of the contract, undetermined. In the case of black box algorithmic contracts, the choice to be bound itself is indeterminate, even if what is agreed upon is fixed. When what the algorithm will agree to cannot be determined at the time the company puts the algorithm into use, the company has not objectively manifested the intent to be bound at a sufficient level of specificity to form an enforceable contract.

The second area of contractual formation that black box algorithmic contracts call into question is consideration. Consideration is something (such as an act, a forbearance, or a return promise) bargained for

111. Nathaniel Popper, *A Venture Fund With Plenty of Virtual Capital, but No Capitalist*, N.Y. TIMES (May 21, 2016), https://www.nytimes.com/2016/05/22/business/dealbook/crypto-ether-bitcoin-currency.html?_r=0 [<https://perma.cc/4W25-FKXX>].

and received by a promisor from a promisee; that which motivates a person to do something, especially an agreement to engage in a legal act.¹¹² Consideration, or a substitute such as promissory estoppel, is necessary for an agreement to be enforceable. So, even if a black box algorithmic contract can be said to be grounded on mutual assent, if there is no consideration, the contract is non-enforceable.¹¹³

Modern contracts scholars have adopted the bargain theory of contract in place of the benefit-detriment model:¹¹⁴ as long as there was a bargaining process between the two parties, what arises from it is a contract.¹¹⁵ When considering black box algorithmic contracts under this theory, it is doctrinally relevant that the offeror is not bargaining, it is the algorithm bargaining. This attenuates the issue because both parties can talk about what should be in the algorithm, what it should do, when to accept results, etc. The agreement to an algorithm presumes that the algorithm will reach results that are amenable. In a black box algorithmic contract, there is an agreement to agree rather than a true bargain between humans.

Consideration is a particularly thorny problem for black box contracts that feature algorithms on both sides of the negotiation. When algorithms are doing the bargaining rather than the offeror and accepting party, it's less clear that we can say that it is a bargained for agreement. Perhaps there is a rational benefit and detriment, but the law has already moved away from that approach to consideration.

Ultimately, there are serious concerns about whether the bargain theory of contract can be applied to black box algorithmic contracts. Just running through a suite of examples above creates the provocation that it might not. Given that black box algorithmic contracts create the potential that the very low bar of bargaining not be met in a large range of business-to-business agreements, this supports the idea that the theoretical infrastructure for contract law needs tweaking to apply consistently to black box algorithmic contracts.

There are several defenses to contractual formation that might arise in the case of a black box algorithmic contract. These include the excuses for non-performance (mistake, misrepresentation, frustration of

112. RESTATEMENT (SECOND) OF CONTRACTS §§ 71, 81 (Am. Law Inst. 1981).

113. *Id.*

114. RESTATEMENT (SECOND) OF CONTRACTS § 3 (Am. Law Inst. 1981) (“An agreement is a manifestation of mutual assent on the part of two or more persons. A bargain is an agreement to exchange promises or to exchange a promise for a performance or to exchange performances.”)

115. Roy Kreitner, *The Gift Beyond the Grave: Revisiting the Question of Consideration*, 101 COLUM. L. REV. 1876, 1878-79 (2001); Val D. Ricks, *The Sophisticated Doctrine of Consideration*, 9 GEO. MASON L. REV. 99, 104 (2000); Melvin Aron Eisenberg, *The World of Contract and the World of Gift*, 85 CAL. L. REV. 821, 825 (1997); Melvin Aron Eisenberg, *The Principles of Consideration*, 67 CORNELL L. REV. 640, 641 (1982); Lon L. Fuller, *Consideration and Form*, 41 COLUM. L. REV. 799 (1941).

purpose, impossibility, impracticability, illegality, unclean hands, unconscionability, accord, and satisfaction) and the defenses against formation (lack of capacity, duress, undue influence, and *non est factum*).¹¹⁶ The purpose of this Article is to evaluate whether algorithmic contracts are contracts, and if they are, how they should be interpreted. To this end, the Article will not consider defenses to contract.¹¹⁷

B. Policy Reasons to Place Limits on the Enforceability of Algorithmic Contracts

Contract scholarship has been critiqued for being too theoretical and divorced from the realities of contracts in action.¹¹⁸ The challenge to contract law presented by black box algorithmic contracts bridges this gap between theory and practice. The previous Part has shown that black box algorithmic contracts are probably not enforceable under current contract doctrine. This Part will show how when black box algorithmic contracts fail as a matter of formality, they demonstrate real policy concerns about the prospect of negating all black box algorithmic contracts without additional interpretive work. By accounting for this connection, common law reasoning can support the technocratic, administrative approach favored in the modern era.¹¹⁹

As Melvin Eisenberg put it, “[I]nterpretation cannot possibly be

116. RESTATEMENT (SECOND) OF CONTRACTS CH. 6-8, 11 (Am. Law Inst. 1981).

117. Pragmatically, concentrating on defenses has proven less successful than attacking from formation in the context of consumer contracts for a number of reasons explored deftly by other scholars. Anne Fleming, *The Rise and Fall of Unconscionability as the “Law of the Poor”*, 102 GEO. L.J. 1383, 1395 (2014) (chronicling the decline in success of the use of unconscionability from a legal historical perspective); Edith R. Warkentine, *Beyond Unconscionability: The Case for Using “Knowing Assent” as the Basis for Analyzing Unbargained-for Terms in Standard Form Contracts*, 31 SEATTLE U. L. REV. 469, 523 (2008); John P. Dawson, *Economic Duress—An Essay in Perspective*, 45 MICH. L. REV. 253, 288 (1947) (commenting on the “conflict and confusion” in economic duress doctrine). *But see* Grace M. Giesel, *A Realistic Proposal for the Contract Duress Doctrine*, 107 W. VA. L. REV. 443, 451 (2005); Melvin A. Eisenberg, *Mistake in Contract Law*, 91 CALIF. L. REV. 1573, 1575-76 (2003) (both theoretical arguments for expansionary roles for defenses).

118. Katz, *supra* note 47, at 2076 (“For Bix, as for Baird and Eisenberg, contract theory matters. Most teachers of the subject, if not most practicing lawyers, would agree—as do I. But these authors miss an opportunity to show that contract theory is relevant for practitioners as well, and, importantly, for law students who aspire to be practitioners.”); Allan Farnsworth, *A Fable and a Quiz on Contracts*, 37 J. LEGAL EDUC. 206, 208 (1987) (“The urge to have a ‘theory’ of contract law has tended to increase the distance between contracts scholarship and practice. In particular, it has led to an excessive emphasis by scholars on why promises are enforced.”).

119. David Rosenberg, *The Path Not Taken*, 110 HARV. L. REV. 1044, 1046 (1997) (discussing how the traditional role common of law courts has changed and modern attitudes towards the limitations of courts and the rise of faith in a technocratic, specialist state).

more accurate with less information and less accurate with more information.”¹²⁰ Formation theory gives us reason to doubt that algorithmic contracts are properly formed at law. The evaluation of practical considerations in this Part adds to the argument for an approach to enforcing algorithmic contracts that considers the context of their formation. The approach that I advocate for in Part IV fills the gap in formation by allowing rules imported from agency law to fill the “objective intent” gap. Failing to do so harms social and economic efficiency by allowing some actors to hoard and conceal information. Furthermore, the status quo creates an incentive for parties to both hoard the information and not mine the social implications of the information.

1. Valuation Principle

Black box algorithmic contracts are uniquely able to undermine the use of contracts as a principle for evaluating the demonstrated preferences of people beyond market price valuation.¹²¹ Contracts show how people value items. A contracting to sell a house to B for 1000 units shows that A values the 1000 units more than the house. A and B bring their own impressions, biography, and context to the transaction. 1000 may represent the market value, but that is likely not the sole reason B chose to buy that house. Perhaps B strongly prefers brick houses and this house was one of very few brick houses in the area, or perhaps she liked the particular community because of the access to hiking. A may strongly value the house, perhaps at even more than 1000 units, but may have to leave the area for other reasons.

This classic, intuitive illustration shows that contracts mean more than just an indication of what market prices are.¹²² Contracts are a venue through which individuals can express preferences that are not grounded in “rationalist” market pricing. In this way, they can promote information sharing in society.¹²³ Contract doctrine reflects this in its

120. MELVIN A. EISENBERG, FOUNDATIONAL PRINCIPLES OF CONTRACT LAW (forthcoming 2019).

121. See Kevin E. Davis, *Contracts As Technology*, 88 N.Y.U. L. REV. 83, 89-90 (2013) (“The value of a contract to its parties will reflect the net effect of the behavior it induces, taking into account enforcement costs and the levels of reading costs, investigation costs, and residual uncertainty the parties have chosen to incur. A rational actor should decide whether to adopt one contractual document or another based on a rational assessment of these costs and benefits. In practice, this calculation will require a fair amount of guesswork.”).

122. See Henry E. Smith, *Law and Economics: Realism or Democracy?*, 32 HARV. J.L. & PUB. POL’Y 127, 127-28 (2009) (“Law and economics and democracy are not enemies, but I contend that legal realism—or its lingering aftershocks—causes law and economics to be more technocratic and less democratic than necessary. While legal realism as a movement itself may be dead, it rules us from the grave.”).

123. See Richard Craswell, *Taking Information Seriously: Misrepresentation and Nondisclosure in Contract Law and Elsewhere*, 92 VA. L. REV. 565, 566-67 (2006)

transition from the benefit-detriment theory of contract, in which courts used to try to objectively analyze whether the deal was “fair,” to an acknowledgment of the fact that contract law is all about accepting the actual preferences of individuals. There is a presumption among non-specialists that algorithms are typically right, but that is far from true, at least in the ordinary sense of “rightness.”¹²⁴ Algorithms are, by definition, bound by the terms, context, and limitations of their human programmers. To put it another way, if the question the algorithm is told to solve is “wrong,” the algorithm will not necessarily be able to correct the question, and thus will produce a “wrong” answer. The law needs to make provisions in line with how algorithms really work. If a given firm’s programmers and their supervisors do not value a particular type of information, it will not be evaluated, even if the corporation is the sole holder of the information. If the corporation’s lawyers determine that understanding certain aspects of the data available to the corporation would expose the corporation to liability, the corporation may actively seek to make sure that data is not processed in a way that promotes understanding of the aforementioned information.

When we take the accountability to the conscious preferences of individuals out of the equation, as with black box algorithmic contracts, we lose the use of contracts as an indicator of what humans or companies consciously prefer. The contract becomes just another predictor of actual preferences (like price). Contracts are a unique area of law where an individual’s objective acts to reveal a preference are given precedence. The concept of e-governance is based on the idea that understanding the experiences and opinions of the public will allow for better policy decision-making;¹²⁵ contract law has the same function in the private sector. To uphold what an algorithm agreed to, especially when it conflicts with or is unrelated to an actual objective intent of the principal, is not just ethically questionable, but also robs society of a valuable, unique source of information about social and business norms.

(“[T]he common law of contracts . . . attempts in various ways to regulate the information that parties exchange.”); Melvin A. Eisenberg, *Disclosure in Contract Law*, 91 CALIF. L. REV. 1645, 1648-49 (2003) (on the Disclosure Principle, which states that “the law should require disclosure of material facts except in those classes of cases in which a requirement of disclosure would entail significant efficiency costs”); Anthony T. Kronman, *Mistake, Disclosure, Information, and the Law of Contracts*, 7 J. LEG. STUDIES 1, 13-14 (1978) (on the information distributive functions of contracts).

124. See Tarleton Gillespie, *Can an Algorithm Be Wrong?*, LIMN (2012) <http://limn.it/can-an-algorithm-be-wrong/> [<https://perma.cc/CBB6-NK4C>] (on the Twitter Trends algorithm and #occupywallstreet).

125. See generally BETH NOVECK, *SMART CITIZENS, SMARTER STATE: THE TECHNOLOGIES OF EXPERTISE AND THE FUTURE OF GOVERNING* (2015).

2. Uncertainty

The use of algorithms creates a great deal of uncertainty. Sophisticated algorithms can quickly find connections that humans would be unlikely or unable to ascertain, but can also create problems that humans are unlikely to foresee.¹²⁶ This is a rational, calculated risk on the part of any person or business who decides to use an algorithm in making decisions. It is certainly not the aim of this Article to argue that businesses should stop using these algorithms or be regulated when they use algorithms for internal decision-making.¹²⁷ Businesses and individual can manage their own risks, and when their risk-taking impacts others, tort law can allow people to recover in some cases. However, the uncertainty surrounding algorithmic contracts calls for reconsideration of the borders of contract law.

The reality of how many firms use algorithms internally is best described by the much-maligned algebra method “guess and check.” Instead of having any idea of how a database may be used, firms just poke around looking for patterns. And once patterns are found, they operate based on them.¹²⁸ It is unlikely that this way of using data and algo-

126. SIVA VAIDHYANATHAN, *THE GOOGLIZATION OF EVERYTHING (AND WHY WE SHOULD WORRY)* 129-45 (2012) (discussing the limitations to how algorithms can help us to know things and the benefits of uncertainty); Ian Bogost, *The Cathedral of Computation*, ATLANTIC (Jan. 15, 2015), <http://www.theatlantic.com/technology/archive/2015/01/the-cathedral-of-computation/384300> [<https://perma.cc/BCK3-HFTF>] (discussing the rightness of algorithms as an article of faith in modern society and their fallibility in reality); Jenna Burrell, *How the Machine “Thinks”: Understanding Opacity in Machine Learning Algorithms*, 1 (Sep. 15, 2015) (unpublished manuscript), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2660674 [<https://perma.cc/5733-76WF>] (identifying three types of opacity associated with algorithms: 1) opacity as intentional corporate or state secrecy (2) opacity as technical illiteracy, and (3) an opacity that arises from the characteristics of machine learning algorithms and the scale required to apply them usefully).

127. This is a rich and growing area of research, with spirited empirical and theoretical arguments about whether and how internal usage of algorithms should be regulated. See generally, e.g., FRANK PASQUALE, *THE BLACK BOX SOCIETY: THE SECRET ALGORITHMS THAT CONTROL MONEY AND INFORMATION* (2015); Zeynep Tufekci, *Algorithmic Harms Beyond Facebook and Google: Emergent Challenges of Computational Agency*, 13 COLO. TECH. L.J. 203 (2015). It is important to note here that even the most extreme arguments for data as constitutionally protected speech, see Jane Bambauer, *Is Data Speech?*, 66 STAN. L. REV. 57, 64 (2014) (presenting the conclusion that “data should receive speech protection any time it is regulated as information”), do not limit the analysis in this Article. It is settled law that contracts are not speech, but “legal acts.” See, e.g., *Coghlan v. S. Carolina R.R. Co.*, 142 U.S. 101, 111 (1891) (referring to contracts as legal acts).

128. Charles Vaccaro, *Look Before You Leap into Predictive Coding: An Argument for a Cautious Approach to Utilizing Predictive Coding*, 41 RUTGERS COMPUTER & TECH. L.J. 298, 318-19 (2015) (discussing “garbage in garbage out” and the principle that

rithms will change without external pressure, given that so many successful results have come from it and that access to many databases is severely limited and proprietary.¹²⁹ This is true of the black box algorithms used in high speed trading.¹³⁰

Algorithms are increasingly being used to develop culture,¹³¹ for example, algorithms curate newsfeeds on most social platforms and bot posters on Twitter and Reddit automate entertainment for users. Culture is an area where it is less obvious than in finance when a “crash” has occurred, and how to fix one if one were to happen. No money is lost when there is a culture crash, but there may be other losses to society such as chilling effects for individuals vis-à-vis expressing controversial opinions and reinforcement of outmoded and socially undesirable stereotypes.

The uncertainty problem becomes untenable when many actors are using algorithms to conduct transactions. In *Property as the Law of Things*, Henry Smith makes the argument that the reason why property law works so well is that it leaves to the owner’s discretion many aspects of use and enjoyment and only steps in on the borders, where individuals seek to sell their property, or one of the sticks that compose it (like, access to a piece of land).¹³² The law can come in and regulate at the borders.

When an algorithm has unpredictable results because a business is not sure what causes the algorithm to have positive results, the business can manage the risk presented by the algorithm internally. The problem with using algorithms to reallocate legal rights between parties is that since the algorithms are not operating within anyone’s domain, no one entity is keeping track of and minimizing potential risks for the unanticipated negative results of the pervasive use of algorithms. When nobody is responsible for managing the risk, the risk continues unabated.

And that can lead to crises where nobody understands what went wrong. An example of this is the Flash Crashes, but it is possible everywhere black box algorithmic contracts are found. Someone needs to

most lawyers and non-quantitative business people do not understand the predictive limitations of algorithms).

129. Astrid Mager, *Algorithmic Ideology: How Capitalist Society Shapes Search Engines*, 15 INFO., COMM. & SOC’Y. 769, 779-82 (2012).

130. See Yadav, *supra* note 13, at 1649. (“Trading firms develop their own, in-house proprietary models. Regarded as the ‘secret sauce’ for success, firms face competitive pressures to ensure that their particular algorithm emerges a winner by virtue of its superior, speedier, and smarter programming.”)

131. See Tarleton Gillespie, *#trendingistrending: When Algorithms Become Culture*, in ALGORITHMIC CULTURES: ESSAYS OF MEANING, PERFORMANCE AND NEW TECHNOLOGIES 52-75 (Robert Seyfert & Jonathan Roberge eds., 2016).

132. Henry E. Smith, *Property as the Law of Things*, 125 Harv. L. Rev. 1691 (2012).

have responsibility. The place to insert regulatory liability and incentives is at the borders where transactions between parties are being made.

3. *Repository of Responsibility*

More and more significant tasks are being delegated to algorithms, and these are tasks not just of increasing complexity, but tasks that require judgment (both financial and moral). It needs to be made clear who has responsibility for judgments made by artificial agents.

Delegating moral responsibility has meaning in society. This is true not just of criminal law, but also of tort law.¹³³ Even when we move beyond the responsibility that can legitimately be claimed in a contract, the way that we understand algorithms at law must be compatible in lodging the responsibility of specific individuals or companies in a way that makes intuitive sense. The use of algorithms in agreements presents unique incentives and mechanisms for avoidance of accountability by the actors that use them.¹³⁴

4. *Social Welfare*

Black box algorithmic agreements can enable price discrimination and allow companies with market power to avoid taking responsibility for external harms.¹³⁵ They also can enable contracting contexts that

133. John C.P. Goldberg & Benjamin C. Zipursky, *Torts As Wrongs*, 88 TEX. L. REV. 917, 918-19 (2010) (“As the law of private and privately redressable wrongs, tort law is rightly treated as a cornerstone of legal education along with criminal law (the law of public and publicly redressable wrongs) and contract law (the law of consensually defined duties). Looked at through the lens of litigation, Torts is about the wrongs that a private litigant must establish to entitle her to a court’s assistance in obtaining a remedy and the remedies that will be made available to her. Looked at through the lens of daily life, Torts is about which duties of noninjury owed to others are counted as legal duties and what sorts of remedial obligations one will incur for failing to conduct oneself in accordance with those duties.”).

134. See, e.g., Bryant Walker Smith, *Proximity-Driven Liability*, 102 GEO. L.J. 1777, 1779 (2014) (“[T]hese tools also raise concerns about privacy and autonomy as against companies, governments, and malicious actors Legal regimes can support this design by clarifying rights and responsibilities with respect to information, access, and control. Tort law, contract law, and the hybrid that is products liability will confront some of the failures of this design. As this Article has argued, the result could be expanded duties for sellers.”); Michael Mattioli, *Disclosing Big Data*, 99 MINN. L. REV. 535, 577-83 (2014) (evaluating the sufficiency of intellectual property as an avenue for encouraging “big data” producers to disclose how they “collect, organize, and transform valuable sources of data”).

135. Dennis D. Hirsch, *The Glass House Effect: Big Data, the New Oil, and the Power of Analogy*, 66 ME. L. REV. 373, 375-76 (2014) (comparing the management of big data to the management of big oil due to the common features of high negative externalities and high market power in both fields).

would enable companies to take a lot of surplus.¹³⁶ Furthermore, as Andrea M. Matwyshyn's recent article illustrates, there is a strong, reinforcing connection between contract law norms and the law's ability to protect consumer privacy against the interest of sophisticated business actors.¹³⁷

While conceiving of contract law as a mechanism for distributive justice has fallen out of fashion,¹³⁸ there is a tradition of strong works that support being critical of a type of contract that systemically allows powerful parties to consume surplus and impose negative externalities on society.¹³⁹ However, recently, there has been a reemergence of interest in using other parts of common law to correct for the unjust potential of some powerful parties in society using sophisticated algorithms and big data to extract rents from less sophisticated parties.¹⁴⁰

The use of black box algorithmic contracts could enrich powerful parties and disempower the weak under the guise of "objective" algorithms.¹⁴¹ To the extent that society wants to create fair rules of play that do not effectively take from A to give to B, this justifies government action.

136. See Michael L. Rustad & Thomas H. Koenig, *Wolves of the World Wide Web: Reforming Social Networks' Contracting Practices*, 49 WAKE FOREST L. REV. 1431, 1436 (2014) ("Based on our statistical findings in Parts I, II, and III, which demonstrate that TOUs are systematically unfair and imbalanced, we propose procedural and substantive reforms in Part IV that will fortify the rights of consumers entering into these adhesive TOUs."); Larry A. DiMatteo & Blake D. Morant, *Contract in Context and Contract As Context*, 45 WAKE FOREST L. REV. 549, 552 (2010); Omer Tene & Jules Polonetsky, *Judged by the Tin Man: Individual Rights in the Age of Big Data*, 11 J. TELECOMM. & HIGH TECH. L. 351, 352-53 (2013).

137. Andrea M. Matwyshyn, *Privacy, the Hacker Way*, 87 S. CAL. L. REV. 1, 1 (2013) ("[This Article] challenges three commonly held misconceptions in privacy literature regarding the relationship between contract and data protection—the proertization fatalism, the economic value fatalism, and the displacement fatalism—and argues in favor of embracing contract law as a way to enhance consumer privacy.").

138. See Eyal Zamir, *Contract Law and Theory: Three Views of the Cathedral*, 81 U. CHI. L. REV. 2077, 2118 (2014) (commenting on the lack of analysis of distributive justice and feminist perspectives in three influential new contracts treatises).

139. See e.g., Richard Craswell, *Passing On the Costs of Legal Rules: Efficiency and Distribution in Buyer-Seller Relationships*, 43 STAN. L. REV. 361 (1991); Duncan Kennedy, *Distributive and Paternalist Motives in Contract and Tort Law, with Special Reference to Compulsory Terms and Unequal Bargaining Power*, 41 MD. L. REV. 563 (1982); Anthony T. Kronman, *Contract Law and Distributive Justice*, 89 YALE L.J. 472 (1980).

140. E.g., Irina D. Manta & David S. Olson, *Hello Barbie: First They Will Monitor You, Then They Will Discriminate Against You. Perfectly*, 67 ALA. L. REV. 135, 179-187 (2015) (arguing that "rather than discouraging the use of restrictive software licenses, the law should adapt to better facilitate such licenses," and noting that perfect price discrimination will likely help the poor).

141. See generally Pasquale, *supra* note 127 (chronicling the ways in which proprietary algorithms control our world and reinforce wealth and power discrepancies in society).

Algorithms also do not evolve in response to changing circumstances in the same way humans do. It may be that the use of algorithms could lead to a functional freezing of today's social hierarchies and perceptions in a more neutral-seeming package. Making the aims of algorithms explicit, as Part IV's proposal incentivizes, would allow relevant actors and regulators the opportunity to be more thoughtful in these choices.

IV. AN AGENCY APPROACH TO ALGORITHMIC CONTRACTS

This Part will describe an agency approach to the formation of algorithmic contracts, describe potential ways forward using this approach for government agencies, courts, and stakeholders, and discuss the implications of this Article for legal theory.

A. *Artificial Agents and Contract Law*

Companies using algorithms to make contracts have a more general intent than is ordinarily required to form a contract.¹⁴² The company does not have the specific, objectively manifested intent to agree to the contracts the algorithm chooses when the algorithm is sufficiently complex to have emergent behavior and has been delegated the responsibility to select and enter into contractual relation on behalf of the company.¹⁴³ While this case has not been litigated, analogous cases in other areas of law support this result. For example in intellectual property law, algorithms have not been found able to vest ownership in a company using it under the work-for-hire doctrine, because an algorithm is not a person legally competent to turn over the rights to its work to its employer.¹⁴⁴ Because an algorithm is not a person, it lacks the legal interest to make a contract on its own behalf. However, algorithms can act on

142. See e.g., Tom Allen & Robin Widdison, *Can Computers Make Contracts*, 9 Harv. J. L. Tech 25, 47-50 (1996) (“[A]n autonomous computer is capable of altering its stored program and developing new instructions in response to information it acquires in the course of trading. Since the program changes over time, without any human intervention, it would be very difficult to characterize it as the embodiment or expression of human intention. Hence, the doctrine as it now stands would deny validity to agreements generated by an autonomous computer.”).

143. *Id.*

144. Annemarie Bridy, *Coding Creativity: Copyright and the Artificially Intelligent Owner*, 2012 Stan. Tech. L.R. 5, 68 (2012) (“As the work made for hire provisions of the U.S. Copyright Act are currently drafted, however, they cannot be stretched to cover procedurally generated works. Such works do not fall under the definition of ‘work made for hire’ in section 101(1), because the relationship between the programmer and the authoring code is not an employment relationship in the agency sense, which the Supreme Court has interpreted the provision to contemplate. Nor do they fall under the definition in section 101(2), because they are not among the nine categories of commissioned works specified there.”).

behalf of persons to alter their interests. Political scientist Sam Lehman-Wilzig has observed that there are several possible analogous types of accountability for algorithms acting on behalf of humans, including product liability, dangerous animals, slavery, diminished capacity, children, agency, and personhood.¹⁴⁵

I propose that the best way to think about the accountability model for algorithmic contracts is to cast the algorithms as constructive agents for the company. The algorithms are acting as human agents would, so agency law is an appropriate source of law, but must be tempered by the “constructive” qualification because algorithms are not persons and so cannot be regarded as human agents. Agency law allows the law to impute knowledge and intent to principals who are not directly involved in tasks, including forming contracts¹⁴⁶ Principals can authorize their agents formally, by implication, or by ratification, i.e., accepting the benefits of the acts of the agent after the agent has acted.¹⁴⁷

The law should treat the intent and knowledge level of companies or individuals who use algorithms for contracting in the same way as the law would treat the intent and knowledge level of a principal in agency law. I will set aside, for the moment, whether or not algorithms can be persons or agents in the traditional sense. Nothing in this analysis suggests that algorithms could or should be considered persons. Algorithms can be agents without legal personality, or quasi-agents for the purpose of understanding the legal obligations of their principles.¹⁴⁸ What is at stake here is the accountability situation faced by the principles using the algorithms.

This approach has firm grounding in current contract law, but it pushes the law slightly further by formally making enforceability turn on these agency principles. The Uniform Electronic Transactions Act, adopted by 47 states, includes an understanding of algorithms as agents.¹⁴⁹ UETA facilitates the creation of algorithmic contracts by allowing for such contracts to be formed through electronic records and

145. Sam N. Lehman-Wilzig, *Frankenstein Unbound: Towards a Legal Definition of Artificial Intelligence*, 13 *FUTURES* 442, 447-553 (1981).

146. RESTATEMENT (THIRD) OF AGENCY § 1.01 (Am. Law Inst. 2006).

147. RESTATEMENT (THIRD) OF AGENCY §§ 2.01, 2.03, 4.01 (Am. Law Inst. 2006).

148. Samir Chopra & Laurence White, *Artificial Agents and the Contracting Problem: A Solution Via an Agency Analysis*, 2009 *U. ILL. J.L. TECH. & POL'Y*, 363, 368-380 (“The first four potential solutions to the contracting problem in open systems involve minor changes to the law, or suggestions that existing law, perhaps with minor modifications or relaxations, can accommodate the problem. The fifth is more radical and involves treating artificial agents as legal agents without legal personality, while the sixth, the most radical, giving legal personality to artificial agents. The fifth and sixth potential solutions are collectively referred to as the ‘agency law approach.’”).

149. UNIFORM ELECTRONIC TRANSACTIONS ACT, UNIF. LAW COMM'N (1999), <http://uniformlaws.org/Act.aspx?title=Electronic%20Transactions%20Act>

signatures, thereby giving electronic records and signatures the same legal equivalence as traditional paper records and manual signatures.¹⁵⁰ The stated goal of the UETA is to “establish the legal equivalence of electronic records and signatures with paper writings and manually-signed signatures.”¹⁵¹ It sought to avoid having the selection of medium govern the outcome of any disputes or disagreements.¹⁵² It would be contrary to the purpose of the law to find that algorithmic contracts are enforceable simply because they were formed electronically. The enforceability of algorithmic contracts must turn on general private law rules.

There is consensus around the notion of some algorithms being able to act as agents.¹⁵³ There is not, however, consensus around what is meant by agent and how to answer the question of enforceability. The commission for the Uniform Commercial Code amended the UCC in 2003 to include a definition of electronic agents, but the amendment was withdrawn in 2009 due to opposition from states and industry.¹⁵⁴

As Anthony J. Bellia observed soon after the adoption of the UETA in 2001, “legislative initiatives have addressed the use of ‘electronic agents’ in contract formation, but have not resolved the difficult enforceability questions The initiatives, like the common law, provide no clear answer to the question of enforceability when these conditions are not fulfilled.”¹⁵⁵ Unfortunately, since 2001, courts and legislatures have come no closer to a workable solution for an approach to enforcing algorithmic contracts.

There are two ways to create an agency relationship: by agreement

[<https://perma.cc/B64Y-NFLM>].

150. See Patricia Brumfield Fry, *Introduction to the Uniform Electronic Transactions Act: Principles, Policies and Provisions*, 37 IDAHO L. REV. 237, 248 (2001) (“[The UETA] is designed to be evolutionary, leaving existing law undisturbed while establishing certainty and stability by affirming the equivalency of electronic records and signatures with paper media.”).

151. *Why States Should Adopt UETA*, UNIF. LAW COMM’N (2017), <http://uniformlaws.org/Narrative.aspx?title=Why%20States%20Should%20Adopt%20UETA> [https://perma.cc/MHW2-T62C]

152. *Id.*; See also *Electronic Transactions Act Summary*, UNIF. LAW COMM’N (2017), <http://www.uniformlaws.org/ActSummary.aspx?title=Electronic+Transactions+Act> [https://perma.cc/XUV8-ZS7D] (“The objective of UETA is to make sure that transactions in the electronic marketplace are as enforceable as transactions memorialized on paper and with manual signatures, but without changing any of the substantive rules of law that apply.”).

153. See, e.g., Chopra & White, *supra* note 148, at 376; Juliet M. Moringiello & William L. Reynolds, *From Lord Coke to Internet Privacy: The Past, Present, and Future of the Law of Electronic Contracting*, 72 MD. L. REV. 452, 483-87 (2013); Anthony J. Bellia Jr., *Contracting with Electronic Agents*, 50 EMORY L.J. 1047, 1048 (2001).

154. U.C.C. § 2-103(g) (Am. Law Inst. & Unif. Law Comm’n 2003) (withdrawn 2011).

155. Bellia, *supra* note 153, at 1048.

or by ratification.¹⁵⁶ An agency relationship by agreement must have a manifestation of consent to the agency relationship, either express or implied.¹⁵⁷ For an agency relationship to arise by ratification, the principal must accept the benefit or affirm the conduct of the person purporting to act on the principal's behalf.¹⁵⁸ Importantly, there must be some objective evidence that the principal knew of the act and elected to be bound by it.¹⁵⁹

Ratification is likely to be a predominant method for authorizing algorithms as agents. This is because it may not be possible or desirable for many companies using algorithms as agents to predict and claim to authorize every decision the algorithm may make with the requisite specificity required. The agency model adds the important interpretive piece to the equation of making the company using the algorithm provide some objective evidence that it knew of the act of the algorithm and intended to be bound by it.

There are at least three possible ways a company can show intent to be bound. First, the principal can create a stalking algorithm that delivers real time updates on the relevant actions of the contracting algorithm and theories as to why the algorithm might be acting in this way. Second, the principal can acquire insurance for the algorithm's potential for uncertainty. Finally, and most simply, the principal can, I argue, introduce a human approval node for each transaction.

This approach to evaluating algorithmic contracts does a better job at achieving the goals of reducing externalities and preserving fair play in commerce than the ambiguous status quo of ignoring algorithmic contracts as a special category of agreement. The approach does this while doing justice to the actions and risks assumed by the parties to the agreement. Put another way, this multi-pronged approach to algorithmic contracts allows the law to uphold algorithmic agreements when they are fairly made, but rightfully gives relief when they are not. State legislatures, courts, and organizations that advise on private law, such as the American Legal Institute, should update their approach to the law to reflect this view of algorithmic contracts. This modern problem requires renewed interest in and clarification of agency, an area of private law that has been considered arcane.¹⁶⁰ This is a rule that seeks internalization of costs of the use of algorithms. As Robert Cooter and Ariel Porat recently wrote: "When internalization is the legal goal of private

156. RESTATEMENT (THIRD) OF AGENCY §§ 1.01, 4.01 (Am. Law Inst. 2006).

157. RESTATEMENT (THIRD) OF AGENCY § 1.03 (Am. Law Inst. 2006).

158. RESTATEMENT (THIRD) OF AGENCY §§ 4.01, 4.02 (Am. Law Inst. 2006).

159. *Id.*

160. See George S. Geis, *Gift Promises and the Edge of Contract Law*, 2014 U. ILL. L. REV. 663, 666 (2014) (defining and discussing the "edges" of contract law and their increasing import to shore up the argument that "third-party beneficiary law should receive independent legal significance").

law, the appropriate remedy is compensation for harms and disgorgement of benefits. Besides internalization, another goal of private law is to stop injurers from harming others (deter), and more rarely, to spur people to benefit others (encourage). Courts have recognized least cost avoider status as a factor in determining when to recognize inherent agency.¹⁶¹ The law minimally deters a harmful act when the injurer neither gains nor loses from acting.”¹⁶² In order to have enforceable contracts, which any entity wants, the agency model for algorithmic contracts requires that the entity form the requisite level of intent to be culpable for its actions in tort and other causes of action.

To make this section concrete, consider the legal entitlements of those involved in the “DAO hack” as an example. Under the argument I have advanced above, contract law could recognize the DAO as an agent able to bind its principals (the investors) in contract via code. Therefore, the investors who lost money in the DAO hack should not be able to recover their money from the hacker, and the hacker should be able to sue for breach of contract if the money were not delivered. This raises the risk associated with the DAO as a business structure. However, the DAO structure has other structural advantages. This rather harsh legal position encourages algorithmic accountability for creators of and investors in DAOs.

Any argument that the DAO hack should not be considered an enforceable contract should not come from the notion that the algorithm does not reflect the intent of investors. This would be a blow to any incentive for the creator of a DAO to carefully structure the organization to minimize risk. However, there may be other limits on the enforceability of algorithmic contracts. There might be some policy reasons to limit the scope of an algorithm’s ability to bind a party in contract. Furthermore, there might be limits to which code can be considered contracts. These will be areas of future study and debate in algorithmic contracts.

B. Impact of Agency Analysis for Other Causes of Action

The agency approach to algorithmic contracts would allow agencies

161. See e.g., *Zanac, Inc. v. Frazier Neon Signs, Inc.*, 215 S.E.2d 265 (1975) (holding that even without express, apparent, or inferred authority, an assistant manager could bind principal under inherent agency powers. Zanac should bear the cost of the assistant manager acting outside the scope of his authority because Zanac was better placed than anyone else to control its wayward assistant managers. Thus, it was a fair result to bind Zanac here.).

162. Robert Cooter & Ariel Porat, *Unity in Torts and Restitution: The Model of Internalization and Deterrence*, (Feb. 18, 2017) (unpublished manuscript on file with author).

to successfully pursue actions against companies for fraud, market manipulation, and other wrongful acts under current standards. This promotes algorithmic accountability, allowing companies to have the requisite intent to be held accountable. Currently, because of the uncertain status of the law, companies are able to have it both ways with their algorithmic contracts with respect to intent. They use algorithmic contracts, which would imply the specific intent to agree to a given transaction. But when it comes to liability for the bad outcomes of the trade made by the algorithm, agencies struggle to show the intent as specific enough. The regulation of the market for futures contracts by the U.S. Commodities Futures Trading serves as an illustrative example.

Gregory Scopino recently published an article describing a regulatory quandary faced by the agency where he used to work. There are several plainly illegal trading practices under the Commodity Exchange Act (CEA) and the CFTC's regulation that are nonetheless routinely carried out by trading algorithms.¹⁶³ The CFTC cannot pursue a successful case against companies that use algorithms to make the trades because the laws require either specific intent or outright recklessness.¹⁶⁴ The algorithms are considered to be too attenuated from the intent of the companies who use them to rise to that level of intent.¹⁶⁵

On an agency interpretation of algorithmic contracts, the CFTC or another actor could make the argument that companies that had algorithms that engaged in this type of fraud actually did have the requisite intent to be brought into court for breach of the CEA and CFTC regulations.

In this way, the intent that we can draw from algorithmic contracts can promote algorithmic accountability in society.

V. CONCLUSION

Machine learning algorithms are increasingly involved in the formation of business-to-business contracts, so it is important to think about how law comes into play when analyzing how algorithms are in contract formation. This Article has provided a justification for how they are formed and deemed enforceable that promotes algorithmic accountability. Algorithms should be considered constructive agents for the purpose of contract formation in order to enable finding liability for wrongful acts such as fraud or market manipulation arising from the contracts and to promote algorithmic accountability.

163. 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, 258-73 (2015).

164. *Id.* at 253-58.

165. *Id.* at 258-73.