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Contracting in the Age of Smart Contracts

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CONTRACTING IN THE AGE OF SMART CONTRACTS

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Abstract: Smart contracts lie at the heart of blockchain technology. There are two principal problems, however, with existing smart contracts: first, the enforceability of smart contracts remains ambiguous. Second, smart contracts are limited in scope and capability barring more complex contracts from being executed via blockchain technology. Drawing from the existing literature on contracts and smart contracting, this Article suggests new approaches to address these two problems. First, it proposes a framework based on reliance-based contracting to analyze smart contracts. Second, the Article analyzes the seismic shifts in contractual disputes, and offers new insights into its features including decentralized decision-making, network-based dispute resolution, and extrajudicial enforcement of decisions. The Article concludes that users' reliance should be the basis for analysis of smart contracts and its associated dispute resolution mechanism.

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INTRODUCTION

Contracts are the bedrock of societies and play a vital role in bringing us together. As the founder of sociology, Durkheim, stated roughly a century ago, contracts serve as a central source of organic solidarity. For him, "in a contract not everything is contractual."[1] Similarly, Hanna Arendt emphasized that promise making and promise keeping arise "directly out of the will to live together with others."[2] Contracting lies at the heart of modern societies and human interaction lies at the heart of contracting.[3]

Digital contracting, on the other hand, promises the opposite: less involvement of human agents and increased automation of obligation performance. What makes a contract "smart" is that it is self-executing and self-enforcing which expunges the need for human intervention.[4] New technologies offer the vision that algorithms, codes, and artificial intelligence determine parties' obligations while parties often remain

1. ÉMILE DURKHEIM, THE DIVISION OF LABOR IN SOCIETY 158 (W.D. Halls trans., The Free Press 1984) (1893).

2. HANNAH ARENDT, THE HUMAN CONDITION 245–46 (2d ed. 1998) (stating that morality, at least politically, does not need support itself other "than the good will to counter the enormous risks of action by readiness to forgive and to be forgiven, to make promises and to keep them").

3. HENRY SUMNER MAINE, ANCIENT LAW: ITS CONNECTION WITH THE EARLY HISTORY OF SOCIETY AND ITS RELATION TO MODERN IDEAS 165 (Frederick Pollock ed., Henry Holt & Co. 1906) (1861) ("[T]he movement of the progressive societies has hitherto been a movement *from Status to Contract*." (emphasis added)).

4. I prefer the term "digital contract" over "smart contract." Smart contracts can only refer to self-executing codes that run on a particular platform or software (e.g., Ethereum smart contracts) similar to apps in smart phones. Digital contracts, however, refer to a broader phenomenon which is automation of obligations and self-execution of contracts through computers and machine thinking. Since the term smart contract has been widely adopted, I keep this term in this Article.

uninvolved and anonymous.[5] The automation has a seismic impact on contracting which traditionally relied on ex ante bargaining and negotiation at arm's length along with ex post dispute resolution and enforcement.[6] This impact requires further (and constant) reexamination and analysis. This Article is a step in this direction.

Smart contracts, broadly defined, refer to transactions that machines form, validate, and enforce. For example, imagine Amazon's Alexa (a virtual assistant) takes your order for pizza on a Sunday before football. Now, Alexa, knowing your past choices for pizza and your preferred time, automatically orders pizza on a Sunday before football. It can go even further by searching all local pizzerias for the best deal and ordering pizza on a Sunday before football. Moreover, if the pizza arrives late (which can be determined via a scanning device at the front door of your house), Alexa only releases half of the value of the pizza based on the pizzeria's declared policies.

Now imagine that all local pizzerias (sellers) and pizza lovers (buyers) are part of a network while each buyer and seller has a virtual assistant that a corporation like Amazon does not control.[7] Additionally, no banks clear monetary transactions between sellers and buyers in this network. Here is how it can work: in this network, virtual assistants incorporate a smart contract (a code) whereby it looks for the best price and best terms, concludes the agreement, and transfers the amount. Once the transaction is concluded, other users (which again are virtual assistants that incorporate smart contracts) review the transaction, verify it, and store it on a shared electronic book (so-called ledger). These transactions are immutable, reviewable by all users, and the stored data can inform future transactions.[8]

Smart contracts have widespread applications in various sectors, particularly in in finance (e.g., Bitcoin, Ripple, Ethereum, Facebook,

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5. *See generally* Lauren Henry Scholz, *Algorithmic Contracts*, 20 STAN. TECH. L. REV. 128 (2017) (discussing the interpretation of electronic contracts whose algorithms may not be understandable ex ante through the principles of agency common law).

6. *See* Daniel Markovits & Alan Schwartz, *The Expectation Remedy and the Promissory Basis of Contract*, 45 SUFFOLK U. L. REV. 799, 808 (2012) ("[A]rm's length dealing remains the right model for private law, especially commercial law . . . .").

7. As this example shows and as was previously stated by Richard Gendal Brown, the smart contracts are not just "a computer program." They are "actor[s] in [their] own right." They can respond to "the receipt of information, [they] can receive and store value – and [they] can *send* out information and send out value." Richard Gendal Brown, *A Simple Model for Smart Contracts*, RICHARD GENDAL BROWN: THOUGHTS ON THE FUTURE OF FIN. (Feb. 10, 2015) (emphasis in original), https://gendal.me/2015/02/10/a-simple-model-for-smart-contracts/ [https://perma.cc/R93G-7J56].

8. *See id.*

Libra) and production and supply chain[9] (e.g., Walmart test pilot of blockchain following the widespread contamination of romaine lettuce).[10] Additionally, there are ongoing efforts to use blockchain in other sectors including insurance (e.g., encoding rules for damages reimbursement), governmental functions (e.g., identity management by automating identity checks), healthcare (e.g., automating processes such as prior authorization for specific treatments), Internet of Things (IoT) (e.g., washing machine automatically ordering a broken part), and sharing economy (e.g., creating member-based autonomous organizations replicating services such as Airbnb and Uber).[11]

Such digitization of contracts is changing the act of contracting along with the socio-legal dynamics surrounding it. For one, this automated process does not allow for the reciprocal recognition found in traditional contracting.[12] Orthodox contract law states that contractual obligations come into existence because they are "immediately chosen"[13] and contracts are enforceable because "respect for [counterparties] as free and rational" requires taking their promises seriously.[14] In smart contracts, however, interactions that occur through negotiations, an exchange of promises, and mutual assent at the time of contracting are largely absent. Smart contracting also directly affects the very notion of promise. Modern

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9. Production refers to the process of creating goods for consumption. Supply chain refers to the process of storing and moving finished goods from the point of production to consumers.

10. Michael Corkery & Nathaniel Popper, *From Farm to Blockchain: Walmart Tracks Its Lettuce*, N.Y. TIMES (Sept. 24, 2018), https://www.nytimes.com/2018/09/24/business/walmart-blockchain-lettuce.html [https://perma.cc/452M-S2S3].

11. Valentina Gatteschi, Fabrizio Lamberti & Claudio Demartini, *Technology of Smart Contracts*, *in* THE CAMBRIDGE HANDBOOK OF SMART CONTRACTS, BLOCKCHAIN TECHNOLOGY AND DIGITAL PLATFORMS 37, 45–53 (Larry A. DiMatteo et al. eds., 2019).

12. [T]he struggle for recognition is conceptually similar to contract formation in an essential respect. Both involve a confrontation between seemingly independent beings, each seeking to make the greatest possible use of the other while making the smallest possible contribution in return. Yet the process in which they both become engaged—bargaining in the context of contract, the dialectical process in that of the struggle for recognition—leads them to accept voluntarily a very different outcome than that originally hoped for.

Michel Rosenfeld, *Hegel and the Dialectics of Contract*, 10 CARDOZO L. REV. 1199, 1229 (1989).

13. Daniel Markovits, *Theories of the Common Law of Contracts*, *in* STANFORD ENCYCLOPEDIA OF PHILOSOPHY (Edward N. Zalta ed., 2015), https://plato.stanford.edu/entries/contracts-theories/ [https://perma.cc/PS8D-AXPZ] ("[A] tort obligation might arise *in connection with* a choice—as the obligation not to be drunk arises in connection with the choice to operate a car; a contract obligation, by contrast, is *itself immediately chosen*—at the core of every offer and every acceptance lies . . . an intention to establish an obligation by communicating this intention." (emphasis in original)).

14. CHARLES FRIED, CONTRACT AS PROMISE: A THEORY OF CONTRACTUAL OBLIGATION 20 (1981); *see also* Charles Fried, Contract as Promise *Thirty Years on*, 45 SUFFOLK U. L. REV. 961, 962 (2012) [hereinafter Fried, *Thirty Years on*] (arguing that contract as promise is based on "morality of autonomy, respect for persons and trust").

contracts—which Weber calls "purposive contract[s]"[15]—entail "projection of exchange into the future."[16] In the same vein, orthodox contract theory has emphasized the forward-looking feature of contracts as the basis for contractual liability.[17] The promise of smart contracts, on the other hand, rests on the notion that exchanges occur synchronously without future obligations remaining. These essential differences necessitate revisiting the legal nature of smart contracts. The notion of consent-based forward-looking contracts does not squarely fit smart contracting.

The current literature has not addressed the nature of smart contracts in light of contractual disputes. Existing legal literature on smart contracting can be classified into three categories: the first category primarily explains the difficult technology underlying smart contracting and providing resemblance to existing legal doctrines.[18] The second category focuses on its limits and the hype around the technology.[19] The third category

15. RICHARD SWEDBERG, MAX WEBER AND THE IDEA OF ECONOMIC SOCIOLOGY 101 (1998) (quoting MAX WEBER, ECONOMY AND SOCIETY: AN OUTLINE OF INTERPRETIVE SOCIOLOGY 673 (1978)). Weber distinguishes between "the status contract" and "the purposive contract." *Id.* The former, which is typical for a primitive society, address a person's total legal situation and result in a change of one status to another (e.g., one's wife). *Id.* The latter "aim[s] solely . . . at some specific (especially economic) performance or result." *Id.*

16. Ian R. Macneil, *The Many Futures of Contracts*, 47 S. CAL. L. REV. 691, 712–13 (1974).

17. Markovits & Schwartz, *supra* note 6, at 799 ("[G]rounding contract in promise highlights two of contract law's most distinctive yet least understood features: that the law establishes liability strictly, rather than based on fault; and that it creates forward-looking rather than the usual backward-looking entitlements, entitlements to be made better off rather than to secure the status quo ante.").

18. *See generally* Jonathan G. Rohr, *Smart Contracts and Traditional Contract Law, or: The Law of the Vending Machine*, 67 CLEV. ST. L. REV. 71 (2019) (arguing that the body of law surrounding vending machines can be applied to smart contracts); Scott A. McKinney, Rachel Landy & Rachel Wilka, *Smart Contracts, Blockchain, and the Next Frontier of Transactional Law*, 13 WASH. J.L. TECH. & ARTS 313 (2018) (discussing the legal nature of smart contracts and suggesting universal smart contracts standards and best practices); Kevin Werbach & Nicolas Cornell, *Contracts* Ex Machina, 67 DUKE L.J. 313 (2017) (arguing that smart contracts will not displace contract law); Stephen McJohn & Ian McJohn, *The Commercial Law of Bitcoin and Blockchain Transactions*, 47 UNIF. COM. CODE L.J. 187 (2017) (arguing that smart contracts may be functionally more like letters of credit); Max Raskin, *The Law and Legality of Smart Contracts*, 1 GEO. L. TECH. REV. 305, 305 (2017) (arguing that smart contract are simply a "new form of preemptive self-help").

19. *See generally* James Grimmelmann, *All Smart Contracts Are Ambiguous*, 2 J.L. & INNOVATION 1 (2019) (showing that all smart contracts are incomplete and ambiguous); Eliza Mik, *Smart Contracts: Terminology, Technical Limitations and Real World Complexity*, 9 L. INNOVATION & TECH. 269, 299 (2017) (showing that smart contracts are not a "semi-mythical technology liberating the contracting parties from the shackles of traditional legal and financial institutions"); Carla L. Reyes, *If Rockefeller Were a Coder*, 87 GEO. WASH. L. REV. 373 (2019) (showing the practical and theoretical challenges arising out of blockchain-based business ventures under existing business organization laws); Jeffrey M. Lipshaw, *The Persistence of "Dumb" Contracts*, 2 STAN. J. BLOCKCHAIN L. & POL'Y 1 (2019) (arguing that traditional contracts will persist to exists since smart

analyzes the regulatory challenges arising from smart contracts.[20] The challenge in all the categories of the existing literature is three-fold: it often focuses too much on the existing technology; it does not provide a comprehensive view of smart contracting; and it mainly analyzes smart contracts from the formation phase and does not take into account the dispute phase.[21] Moreover, the existing literature has largely concentrated on the trust architecture (disintermediation) of the blockchain technology.[22] This Article, on the other hand, focuses more on the distributed feature of the blockchain technology, and in particular smart contracts.[23]

This Article makes two principal contributions. First, it contends that a reliance-based (tort-like) approach better fits and explains the nature of smart contracting. The Article argues the reliance theory best describes smart contract transactions that are concluded largely absent of any human

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contracts cannot replace human decision-making capability); Usha R. Rodrigues, *Law and the Blockchain*, 104 IOWA L. REV. 679, 717 (2019) (arguing that smart contracts do not allow for "legal intervention" points); Shaanan Cohney & David A. Hoffman, *Transactional Scripts in Contract Stacks*, 105 MINN. L. REV. 319 (2020) (arguing that smart contracts—or, as they call it, transactional script—can lower some transactional costs relative to other legally operative instruments).

20. *See generally* Reggie O'Shields, *Smart Contracts: Legal Agreements for the Blockchain*, 21 N.C. BANKING INST. 177 (2017) (discussing the legal and regulatory issues associated with the greater adoption of smart contracts); Shaanan Cohney, David Hoffman, Jeremy Sklaroff & David Wishnick, *Coin-Operated Capitalism*, 119 COLUM. L. REV. 591 (2019) (showing empirically that coin offering codes and initial coin offering disclosures often do not match); Adam J. Kolber, *Not-So-Smart Blockchain Contracts and Artificial Responsibility*, 21 STAN. TECH. L. REV. 198 (2018) (analyzing third-party harms arising from smart contracts and possible regulations); Carla L. Reyes, Nizan Geslevich Packin & Benjamin P. Edwards, *Distributed Governance*, 59 WM. & MARY L. REV. ONLINE 1 (2017) (discussing the new governance structure of organizations based on smart contracts and their regulatory risks); Kevin Werbach, *Trust, but Verify: Why the Blockchain Needs the Law*, 33 BERKELEY TECH. L.J. 487 (2018) (discussing the necessity of regulation of smart contracts).

21. A handful of articles have endeavored to address this deficiency in the literature. *See generally* Amy J. Schmitz & Colin Rule, *Online Dispute Resolution for Smart Contracts*, 2019 J. DISP. RESOL. 103 (arguing that parties use online dispute resolution to resolve contract disputes); AMY J. SCHMITZ, AM. ARB. ASS'N, MAKING SMART CONTRACTS "SMARTER" WITH ARBITRATION (2020), https://go.adr.org/rs/294-SFS-516/images/Making%20Smart%20Contracts%20Smarter%20with%20Arbitration%20by%20Amy%20Schmitz.pdf [https://perma.cc/9D8H-M5XZ] (arguing that contracting parties should build arbitration into their smart contracts). For a general criticism from a psychological perspective, see Jean R. Sternlight, *Pouring a Little Psychological Cold Water on Online Dispute Resolution*, 2020 J. DISP. RESOL. 1. These articles generally center on the use of existing dispute resolution mechanism for smart contracts. My suggestion is based on the network potentials for dispute resolution. *See infra* Part IV for further discussion.

22. *See* KEVIN WERBACH, THE BLOCKCHAIN AND THE NEW ARCHITECTURE OF TRUST 17–32 (2018).

23. Although the blockchain technology achieves trust in part through the distributed feature, the distributed characteristic of the blockchain technology alone, and in particular smart contracts, has not received the requisite attention in the legal scholarship. Simply put, as this Article shows, the easy and wide access to a distributed network of users has a foundational impact on contracting and contractual disputes.

involvement. Second, it shows that, in smart contracts, the human connection can only exist in ex post dispute resolution. This Article argues that ex post dispute resolution should utilize a large pool of users (proof-of-work model) and not a handful of select users (proof-of-stake model). With this structure, this Article argues, several of the existing problems such as repeat players and consumer arbitration could be minimized.

There are a few caveats to state at the outset of this Article: first, the technology is still nascent and abstract but reachable. Second, to be absolutely precise, the automation of the formation phase is conducted by artificial intelligence (as it predicts future choices based on past choices), and contractual enforcement is based on the blockchain technology which automates enforcement while disintermediating institutions such as banks via verification by other users. Third, not all smart contracts are spot contracts.[24] Some can be relational to a certain extent.[25] The focus of this Article, however, is on fully automated machine-to-machine smart contracts that transact on the spot.

This Article is structured as follows: Part I provides more background on smart contracts and the most relevant features to this discussion. Part II analyzes the limits of the existing theories on the legal nature of smart contracts. Part III provides a novel approach in analyzing smart contracts and argues for a reliance-based theory of smart contracts. Part IV investigates the problem of incompleteness in smart contracts and the lack of entry points for parties and courts to address the inherent incompleteness. Part IV focuses on contractual disputes in the age of smart contracts and proposes a truly decentralized user-based dispute resolution mechanism.

I. WHAT MAKES SMART CONTRACTS SMART?

In the first section below, the Article reviews and analyzes the key features of smart contracts. It explains automation, anonymity, and verification process offered by smart contracts. In the second section, the Article zeros in on the verification and validation process while explaining how it has the capability of creating a network-based enforcement mechanism without relying on a centralized authority.

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24. Here I use the term spot contracts to refer to one-off agreements that occur on a specific date and are not durational. In finance, spot contracts refer to agreements of buying and selling on the spot date as opposed to future (forward) contracts where payments and delivery are stipulated for a later date. *See, e.g.*, James Chen, *Spot Trade*, INVESTOPEDIA (Jan. 23, 2021), https://www.investopedia.com/terms/s/spottrade.asp [https://perma.cc/73GV-9YYW].

25. Stefan Grundmann & Philipp Hacker, *Digital Technology as a Challenge to European Contract Law: From the Existing to the Future Architecture*, 13 EUR. REV. CONT. L. 255, 267–69 (2017).

A. Explaining Smart Contracts

What is smart about smart contracts? The answer lies in the possibility of automatic execution using algorithm and codes.[26] Smart contracts refer to obligations that are programmable and operate on a distributed network. The notion of smart contracts was first proposed by Nick Szabo who is also widely believed to be the Bitcoin founder, Satoshi Nakamoto, a fact he has repeatedly denied.[27] According to Szabo, smart contracts consist of "a set of promises, specified in digital form, including protocols within which the parties perform on these promises."[28] Smart contracts are therefore protocols, or set of rules or procedures for transmitting data. In other words, smart contracts that are embedded in a blockchain can automatically "receive and send assets as well as information."[29] For Szabo, smart contracts "should be *embedded in the world*," meaning "to embed contracts in all sorts of property that is valuable and controlled by digital means."[30]

To simplify, given the existing technology, smart contracts are similar to apps.[31] Just like apps—e.g., Google Maps—smart contracts run on a platform (in this case the blockchain with specific consensus mechanisms) and each has its own rules. In smart contracts, the obligations of the parties are pre-determined by computer programs. More importantly, this new technology enables two vending machines to transact, without direct human involvement, if a condition occurs. For example, if the temperature reaches ninety degrees, vending machine A is programmed to automatically transfer a dollar bill to vending machine B, which in turn delivers a can of cold soda. Another example is fintech companies' algorithmic trading, by which computer programs determine the selling or buying of stocks.[32] For instance, a computer program is set to "sell" an existing stock if its value drops more than 10% while another computer is

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26. Raskin, *supra* note 18, at 306.

27. Nathan Reiff, *Who Is Nick Szabo, and Is He Satoshi Nakamoto?*, INVESTOPEDIA (Apr. 12, 2018), https://www.investopedia.com/news/who-nick-szabo-and-he-satoshi-nakamoto/ [https://perma.cc/99F7-QUHF].

28. NICK SZABO, SMART CONTRACTS: BUILDING BLOCKS FOR DIGITAL MARKETS (rev. ed. 2018).

29. Philipp Hacker, Ioannis Lianos, Georgios Dimitropoulos & Stefan Eich, *Regulating Blockchain, in* REGULATING BLOCKCHAIN: TECHNO-SOCIAL AND LEGAL CHALLENGES 1, 4 (Philipp Hacker et al. eds., 2019).

30. SZABO, *supra* note 28 (emphasis in original).

31. Jeremy M. Sklaroff, Comment, *Smart Contracts and the Cost of Inflexibility*, 166 U. PA. L. REV. 263, 276 (2017).

32. Fintech refers to the use of technology and innovation in banking and financial services. *See* Julia Kagan, *Financial Technology–Fintech*, INVESTOPEDIA (Aug. 28, 2020), https://www.investopedia.com/terms/f/fintech.asp [https://perma.cc/JZS2-7Y49].

programed to "buy" the same stock if its value drops more than 10%. If such automated transactions are built on a blockchain platform where other users verify the transaction, not an external body such as the Security and Exchange Commission, the contract is a smart contract. A key relevant feature of smart contracts in the formation phase of contracting is that computers do not exchange promises.[33] Instead, each computer includes codes that unliterally determine the condition of a transfer (if the stock drops 10%, then buy). Only when other computer codes match the conditions of the first computer, the transaction occurs (if the stock drops 10%, then sell). Smart contracts therefore most resemble cross-offers.[34]

In a general sense, smart contracting refers to the take-over of contract formation and performance by machine thinking.[35] Machine-made contracts by IoT devices such as Alexa or Google Home may be the future of contracting, in which machines take over not only a digital reality (e.g., Bitcoin) but a physical object (e.g., real property).[36] This possibility is not just theoretical as the "perfect pair" of smart contracts (built on a blockchain-based platform) and IoT has led to several startups in food supply, medicine shipping, manufacturing, construction, energy, and transportation, to name a few.[37] Relatedly, as many as fifty major companies, such as Amazon, Walmart, JP Morgan and BP, are adopting the blockchain technology.[38] Walmart and Facebook also announced that

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33. Raskin, *supra* note 18, at 323.

34. Anthony J. Bellia, Jr., *Contracting with Electronic Agents*, 50 EMORY L.J. 1047, 1058 (2001) (The author poses the example of crossing offers: "If I mail you an offer to buy soda for $1.00, and you simultaneously mail me an offer to sell soda for $1.00, no contract results."). In these instances, the contract validity therefore relies on agency principles. *See id.* at 1059.

35. Lipshaw, *supra* note 19, at 5 (describing that smart contracting means to "delegate more and more of the creation, performance, and disposition of legally binding transactions to machine thinking").

36. *See* SURABHI KEJRIWAL & SAURABH MAHAJAN, DELOITTE CTR. FOR FIN. SERVS., SMART BUILDINGS: HOW IOT TECHNOLOGY AIMS TO ADD VALUE FOR REAL ESTATE COMPANIES (2016), https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/real-estate/deloitte-nl-fsi-real-estate-smart-buildings-how-iot-technology-aims-to-add-value-for-real-estate-companies.pdf [https://perma.cc/8AL3-YBFD]; *see also* IOTA, https://www.iota.org [https://perma.cc/8SR2-AAF3] (initiative by IOTA which uses a distributed ledger technology to record and execute transactions between machines and devices in IoT).

37. Rohan Pinto, *Demystifying the Relationship Between IoT and Blockchain*, FORBES TECH. COUNCIL (May 29, 2019, 7:45 AM), https://www.forbes.com/sites/forbestechcouncil/2019/05/29/demystifying-the-relationship-between-iot-and-blockchain/?sh=e78c05f605de [https://perma.cc/L4S7-BVK8]. For example, leasing a car can be done via blockchain technology. Using this technology, searching, negotiating, and concluding the lease contract can be completed on the blockchain platform. If, for example, the lessee fails to make payment, the smart key of the car automatically stops the car until payment is made. Sklaroff, *supra* note 31, at 273–74.

38. Michael del Castillo, *Blockchain Goes to Work at Walmart, Amazon, JPMorgan, Cargill and 46 Other Enterprises*, FORBES (Apr. 16, 2019, 6:00 AM), https://www.forbes.com/sites/

they will launch their own currencies based on blockchain (so-called cryptocurrency).[39]

To summarize, smart contracts offer three features: (1) full automation of contract formation and execution; (2) contract validation by other users; (3) anonymity of contractual parties.[40] One of the principal differences between smart contracts and traditional contracts relates to its autonomous execution and termination. Smart contracts are essentially coded obligations that are enforced autonomously. Such codes are distributed within various nodes (different users/computers) in the underlying platform and network.[41] This design makes several key features of traditional contracting almost impossible: termination, modification, interpretation, and even adjudication.[42] Since codes for smart contracts act as the rule of the game in the platform on which different users/nodes rely, any modification is extremely difficult.[43] In summary, a smart contract encodes certain conditions and outcomes so that if such conditions occur, the contract automatically executes itself.

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michaeldelcastillo/2019/04/16/blockchain-goes-to-work/#192dc52e2a40 [https://perma.cc/9ENZ-8VXY].

39. Ron Shevlin, *Why Does Walmart Want a Cryptocurrency?*, FORBES (Aug. 5, 2019, 11:00 AM), https://www.forbes.com/sites/ronshevlin/2019/08/05/why-does-walmart-want-a-cryptocurrency/#54d8a7e91502 [https://perma.cc/A4TQ-JMF2].

40. Sklaroff, *supra* note 31, at 264. Moreover, smart contracting can cause several groundbreaking shifts in firm contracting and corporate governance. It alters firm contracting since it removes certain transactions costs while adding others. It automates certain organizational and governmental decisions. It provides more power to smaller stakeholders. Alex Murray, Scott Kuban, Matthew Josefy & Jon Anderson, *Contracting in the Smart Era: The Implications of Blockchain and Decentralized Autonomous Organizations for Contracting and Corporate Governance*, ACAD. MGMT. PERSPS. (Apr. 17, 2019), https://journals.aom.org/doi/abs/10.5465/AMP.2018.0066 (last visited Mar. 3, 2021).

41. PRIMAVERA DE FILIPPI & AARON WRIGHT, BLOCKCHAIN AND THE LAW: THE RULE OF CODE 74–75 (2018); *see also* Castillo, *supra* note 38 ("At its core, blockchain is simply a distributed database, with an identical copy stored on many computers.").

42. Stuart D. Levi & Alex B. Lipton, *An Introduction to Smart Contracts and Their Potential and Inherent Limitations*, HARV. L. SCH. F. ON CORP. GOVERNANCE (May 26, 2018), https://corpgov.law.harvard.edu/2018/05/26/an-introduction-to-smart-contracts-and-their-potential-and-inherent-limitations/ [https://perma.cc/8S5W-HB7W].

43. *See id.* ("Indeed, given that blockchains are immutable, modifying a smart contract is far more complicated than modifying standard software code that does not reside on a blockchain. The result is that amending a smart contract may yield higher transaction costs than amending a text-based contract, and increases the margin of error that the parties will not accurately reflect the modifications they want to make."). In such platforms, any change would likely require 51% of the users. For example, in Bitcoin, 51% attack refers to the hypothetical that a group of miners acquire more than 50% of the platform computing power and therefore could change the rules of the game (e.g., confirming transactions, executing payments, and prohibiting double-spending). Jake Frankenfield, *51% Attack*, INVESTOPEDIA (May 6, 2019), https://www.investopedia.com/terms/1/51-attack.asp [https://perma.cc/UEE2-QN36].

This process can be verified by other nodes in the network.[44]

Several states have adopted laws related to smart contracts that include definitions referring to smart contracts as event driven.[45] These laws typically define the smart contract as "an event-driven program, with state, that runs on a distributed, decentralized, shared and replicated ledger and that can take custody over and instruct transfer of assets on that ledger."[46] They also confirm that smart contracts "may exist in commerce" and a contract shall not be denied "legal effect, validity or enforceability solely because that contract contains a smart contract term."[47]

B. Validation and Verification

Smart contracts automate the formation and performance of contractual obligations. Traditional contract law is agential, believing in the notion that human agents can choose to assume certain obligations through contracting (e.g., autonomy principle or will theory in contract law).[48] In smart contracting, much of the contract formation and performance are delegated to an electronic agent.[49] Machines, which can use artificial intelligence and machine learning to predict and exercise new promises, take over the very act of *promising*. In other words, human will is increasingly missing from the ex ante formation of contracts. This casts

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44. ALAN MCQUINN & DANIEL CASTRO, INFO. TECH. & INNOVATION FOUND., A POLICYMAKER'S GUIDE TO BLOCKCHAIN 20–21 (2019), https://itif.org/sites/default/files/2019-policymakers-guide-blockchain.pdf [https://perma.cc/NW4B-5DEK].

45. ARIZ. REV. STAT. ANN. § 44-7061 (2020); TENN. CODE ANN. § 47-10-201 (2020).

46. ARIZ. REV. STAT. ANN. § 44-7061(e)(2). The Tennessee law offers a more detailed definition. It provides a similar definition but adds that the ledger is "used to automate transactions, including, but not limited to, transactions that: (A) [t]ake custody over and instruct transfer of assets on that ledger; (B) [c]reate and distribute electronic assets; (C) [s]ynchronize information; or (D) [m]anage identity and user access to software applications." TENN. CODE ANN. § 47-10-201(2).

47. ARIZ. REV. STAT. ANN. § 44-7061(c).

48. In a classic article from 1941, Lon Fuller defined the autonomy principle as follows:

> the most pervasive and indispensable is the principle of private autonomy. This principle simply means that the law views private individuals as possessing a power to effect, within certain limits, changes in their legal relations. . . . This power of the individual to effect changes in his legal relations with others is comparable to the power of a legislature.

Lon L. Fuller, *Consideration and Form*, 41 COLUM. L. REV. 799, 806–07 (1941). With the expansion of the law and economics approach, scholars also proposed theories of contract law based on efficiency. *See generally* Alan Schwartz & Robert E. Scott, *Contract Theory and the Limits of Contract Law*, 113 YALE L.J. 541 (2003) (discussing traditional theories of contract law and their limits).

49. Electronic agent is defined as "a computer program, or electronic or other automated means used independently to initiate an action or respond to electronic messages or performances without intervention by an individual at the time of the action, response or performance." UNIF. COMPUT. INFO. TRANSACTIONS ACT § 102(a)(28) (UNIF. L. COMM'N 1999).

doubt on the moral theory of contracting since "[p]romises lie at the center of persons' moral experience of one another, and contracts lie at the center of their legal experience of one another."[50]

The validation and verification process of smart contracting changes the network structure based on which contractual parties enter into agreements. In traditional contracting, parties enter into agreements against the backdrop of law and judicial enforcement.[51] Parties rely on trust, law, and a select group of people for validation and verification of their contracts.[52] For instance, in the purchase of a used laptop via Amazon, the buyer has to exercise some level of trust in the platform and in the buyer. The buyer is also under the belief that law has put in place certain measures to protect them from fraudulent activities. The buyer can also rely on reviews about the seller and request a few of their trusted acquaintances to check the specifics of the merchandise or examine it. A similar network structure also exists for the seller.

In traditional contracting, the seller and buyer are mostly reliant on a few centralized networks for their transactions: a group of trusted individuals (e.g., close friends, lawyers, experts, etc.); platform providers (e.g., Amazon); and the legal system (e.g., the judiciary). The contractual parties are also largely familiar with these networks. The form of trust radically changes through smart contracting, in which parties are reliant on computers, codes, and peers (other nodes) to validate their transactions.[53] In this structure, parties (or to be more precise, electronic agents) transact in reliance on a network of unknown individuals (nodes) with whom they are not familiar. Smart contracts function pursuant to a game theory, in which other nodes in the network are incentivized to

50. Daniel Markovits, *Contract and Collaboration*, 113 YALE L.J. 1417, 1419 (2004).

51. Contract enforcement is a matter of public law. *See, e.g.*, Farshad Ghodoosi, *The Concept of Public Policy in Law: Revisiting the Role of the Public Policy Doctrine in the Enforcement of Private Legal Arrangements*, 94 NEB. L. REV. 685, 697 (2016) ("[E]nforcing a contract is a matter of public law."); David A. Hoffman & Cathy Hwang, *The Social Cost of Contract*, COLUM. L. REV. (forthcoming 2021) (manuscript at 1), https://scholarship.law.upenn.edu/faculty_scholarship/2188/ [https://perma.cc/97X4-4GDN] (arguing that contracts are "bargains that always involve the public"); Aditi Bagchi, *Interpreting Contracts in a Regulatory State*, 54 U. S.F. L. REV. 35, 41 (2019) (noting that "[o]ur modern regulatory state can, and sometimes does, directly regulate those terms"); Cathy Hwang & Matthew Jennejohn, Contractual Depth (Nov. 10, 2019) (unpublished manuscript), https://am.aals.org/wp-content/uploads/sites/4/2019/12/AM20BusinessLawHwang Paper.pdf [https://perma.cc/6DSQ-SWHF] (describing how contracts between private parties are written with regulators as an intended audience).

52. For the discussion of trust in contract law see generally Anthony J. Bellia, Jr., *Promises, Trust, and Contract Law*, 47 AM. J. JURIS. 25 (2002).

53. MCQUINN & CASTRO, *supra* note 44, at 5.

validate the contracts.[54] In the process of smart contracting, each time a transaction is concluded, the platform simultaneously broadcast it the entire network. Once different nodes validate and verify the transaction, a new block is added to the blockchain.[55] In other words, once a consensus is reached amongst the users, a block inscribed with the transaction is added to the chain.

Scholars and computer scientists disagree over the technology and the features of blockchain.[56] For example, a key feature of blockchain is its decentralization.[57] As noted, in the current technology, decentralization has not been achieved yet.[58] More importantly, human agency has been instrumental in the blockchain technology as "many actions taken by small, coordinated groups of people" made pivotal changes to Bitcoin and Ethereum.[59]

Technology rapidly changes, so discussing the nuances of it is often times moot. The most salient aspect of blockchain technology is that it allows for record keeping of transactions that are verified by a consensus mechanism in a decentralized system. Imagine a ridesharing company where all rides and payments are recorded on an immutable, decentralized chain of blocks instead of a company recording and managing this data. The types of information and the ways in which this information is recorded are all determined by the validation and verification process of this network (instead of being dictated by a company). To put it more simply, imagine a group of friends who decide to record their daily

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54. *See generally* Giancarlo Bigi, Andrea Bracciali, Giovanni Meacci & Emilio Tuosto, *Validation of Decentralised Smart Contracts Through Game Theory and Formal Methods*, *in* PROGRAMMING LANGUAGES WITH APPLICATIONS TO BIOLOGY AND SECURITY 142, 142 (Chiara Bodei et al. eds., 2015) (combining game theory and formal methods to address the complexity of the analysis and validation of smart contracts).

55. MCQUINN & CASTRO, *supra* note 44, at 5.

56. Adrianne Jeffries, '*Blockchain' Is Meaningless*, THE VERGE (Mar. 7, 2018, 11:36 AM), https://www.theverge.com/2018/3/7/17091766/blockchain-bitcoin-ethereum-cryptocurrency-meaning [https://perma.cc/FH53-5B8J] (noting that "there is widespread disagreement over which qualities are essential in order to call something a blockchain"); *see also* Marco Iansiti & Karim R. Lakhani, *The Truth About Blockchain*, HARV. BUS. REV. (Jan.–Feb. 2017), https://hbr.org/2017/01/the-truth-about-blockchain [https://perma.cc/KSL2-WYJK].

57. Mally Anderson, *Exploring Decentralization: Blockchain Technology and Complex Coordination*, J. DESIGN & SCI. (Feb. 6, 2019), https://jods.mitpress.mit.edu/pub/7vxemtm3/release/1 [https://perma.cc/6N2E-A4S6] ("More importantly, blockchain-supported technologies can potentially facilitate decentralized coordination and alignment of human incentives on a scale that only top-down, command-and-control structures previously could.").

58. Angela Walch, *Deconstructing 'Decentralization': Exploring the Core Claim of Crypto Systems*, *in* CRYPTOASSETS: LEGAL, REGULATORY, AND MONETARY PERSPECTIVE 39, 58 (Chris Brummer ed., 2019) (arguing that decentralization has created a veil for people who are behind the technology in order to limit their liabilities).

59. *Id.* at 67.

expenditure. They can hire an accountant. Alternatively, they can set in place a mechanism by which each transaction is recorded by the members of the group following the pre-approved verification process of other members. The latter resembles the core of what blockchain technology promises to do.[60] To be clear, humans create blockchain platforms and the underlying codes. Humans, however, have limited roles in changing the smart contract codes once they are programmed.

II. LIMITS OF EXISTING LEGAL THEORIES OF SMART CONTRACTS

As discussed, smart contracts consist of "a set of promises, specified in digital form, including protocols within which the parties perform on these promises."[61] In other words, smart contracts—embedded in a blockchain—can automatically receive and send assets and information.[62] For smart contracts to work, parties' obligations should be well thought-out and ingrained in a self-executing code (e.g., if/then). Vending machines are the often-given analogy for smart contracts where parties' obligations are carefully pre-determined.[63] All that is needed to trigger the contract is a dollar bill. Contracts are therefore simple and binary (e.g., if a dollar bill, then soda). Smart contracts further take the automated feature of a vending machine further. In vending machines, only one party's performance is automated (i.e., the vending machine's). In smart contracts, however, both parties' performance of obligations is automated with no future obligations remaining to be executed.[64] Moreover, in smart contracts, parties can even delegate the very conclusion of contracts to electronic agents[65] and their obligations can be "synchronous," unlike the asynchronous relationship between a vending company and a consumer.[66] In these limited contracts, therefore, there are only broken codes, not

60. *See generally* Luke Conway, *Blockchain Explained*, INVESTOPEDIA (Nov. 17, 2020), https://www.investopedia.com/terms/b/blockchain.asp [https://perma.cc/VW2U-53A8]. There are many videos on YouTube on the topic. I have found this very brief explanation by the BBC helpful: BBC News, *Bitcoin Explained: How Do Cryptocurrencies Work?–BBC News*, YOUTUBE (Feb. 12, 2018), https://www.youtube.com/watch?v=SzAuB2FG79A [https://perma.cc/HU3U-AXKR].

61. SZABO, *supra* note 28.

62. Hacker et al., *supra* note 29, at 9.

63. Alexander Savelyev, *Contract Law 2.0: 'Smart' Contracts as the Beginning of the End of Classic Contract Law*, 26 INFO. & COMMC'NS TECH. L. 116, 120 (2017).

64. *Id.* at 129. Some scholars find the lack of future obligation "simply inconsistent" with traditional notions of contracting as "[t]ypical contracts" involve future performance by one or more parties. Kolber, *supra* note 20, at 221–22.

65. Savelyev, *supra* note 63, at 121.

66. SZABO, *supra* note 28.

bargaining nor broken promises.[67] Disputes can arise out of unforeseen coding errors or hacks.[68] As a result, smart contracts include "occasional earthquakes" rather than "continual linguistic drift" that is inherent in traditional contracting.[69]

In the last several decades, contract theory has focused on three paradigms for theorizing about the enforceability of contracts: promisor, promisee, and socio-economics surrounding the transaction.[70] The bargain theory states that the promisor's manifested intention to create legal relations result in contractual obligations and is the basis of enforceability of contracts.[71] This theory has also stressed the element of exchange in which only reciprocal promises are enforceable.[72] The reliance theory, on the other hand, shifts the focus onto the reliance made by the promisee as a result of a promise.[73] Under this view, contracts are

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67. Werbach & Cornell, *supra* note 18, at 322–23 (discussing that in computable contracts if the "computation diverges from the parties' intent, as conventionally understood in contract law, they may disregard the computerized result").

68. One example is the 2016 hack by the Decentralized Autonomous Organization. David Siegel, *Understanding the DAO Attack*, COINDESK (Dec. 17, 2020, 1:50 PM), https://www.coindesk.com/understanding-dao-hack-journalists [https://perma.cc/B998-HHDW]. In this hack, the attacker found a small bug in the DOA contract code and was able to transfer around $60 million to a contract of which they were in sole control. *See id.*

69. Grimmelmann, *supra* note 19, at 20. The latter term—continual linguistic drift—refers to the interpretative feature of traditional contracting whereas the former—occasional earthquakes—emphasizes the failure and incompleteness of codes underlying smart contracts.

70. Markovits, *supra* note 13.

71. *See, e.g.*, FRIED, *supra* note 14; SAMUEL WILLISTON, THE LAW OF CONTRACTS § 21 (1924); Randy E. Barnett, *A Consent Theory of Contract*, 86 COLUM. L. REV. 269, 304–05 (1986); Randy E. Barnett, *Some Problems with Contract as Promise*, 77 CORNELL L. REV. 1022, 1027 (1992); Markovits & Schwartz, *supra* note 6, at 799. Scholars differ whether a moral-based approach to promise forms the basis of contract obligation or objective consent. Charles Fried insists on the moral institution of promising as the basis of contracting whereas Randy Barnett argues for manifestation of an intention, not promising per se, as the most salient aspect of contracting. *Compare* Fried, *Thirty Years on*, *supra* note 14, at 978, *with* Barnett, *supra*, at 305.

72. Charles J. Goetz & Robert E. Scott, *Enforcing Promises: An Examination of the Basis of Contract*, 89 YALE L.J. 1261, 1261–62 (1980). This theory is called the "bargain theory" in which un-reciprocal promises are presumptively unenforceable.

73. *See, e.g.*, GRANT GILMORE, THE DEATH OF CONTRACT (1974) (arguing that the expansion of the reliance theory eroded the classical consideration theory in contract law); L.L. Fuller & William R. Perdue, Jr., *The Reliance Interest in Contract Damages: 2*, 46 YALE L.J. 373, 419 (1937) ("If one means by 'contractual' a liability imposed because a promise was made and broken, then a liability to compensate losses incurred on the faith of a promise is as 'contractual' as any other."). Section 90 of the *Restatement (Second) of Contracts*, which sets out the doctrine of promissory estoppel, is the primary enforcement mechanism for situations where the promisee relies on the promisor's promise. RESTATEMENT (SECOND) OF CONTRACTS § 90 (AM. L. INST. 1981); *see also* Juliet P. Kostritsky, *A New Theory of Assent-Based Liability Emerging Under the Guise of Promissory Estoppel: An Explanation and Defense*, 33 WAYNE L. REV. 895, 964 (1987) (arguing that courts should use promissory estoppel "when persuasive barriers to, or explanations for dispensing with, explicit

enforceable because people *rely* on the promises they receive.[74] The last paradigm centers on the efficiency resulting from an exchange of promises (law-and-economics[75]) or the shared public norms such as coordinating conduct (relational contract theory[76]).

Legal scholars have debated the legal nature of smart contracts. Some believe smart contracts are neither smart nor contracts in part because parties may enter into legal obligations without "knowing it or intending to."[77] This view is reinforced by the fact that smart contracts "are simply business rules encoded in software" and therefore are "not legally binding without contractual agreements."[78] Some believe that smart contracts are contracts "at the conceptual level" but do not necessarily constitute exchange of promises per se.[79] Some point to the limited role of law in smart contracts because there is no entry point for legal intervention in

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reciprocal or formalized contracts exist and a plausible benefit to the promisor can be identified"); Michael B. Metzger & Michael J. Phillips, *The Emergence of Promissory Estoppel as an Independent Theory of Recovery*, 35 RUTGERS L. REV. 472, 482–87, 531–36 (1983) (arguing that promissory estoppel is a tort-like and independent theory of recovery that is different from contractual liability); Jay M. Feinman, *The Last Promissory Estoppel Article*, 61 FORDHAM L. REV. 303, 303–11 (1992) (shedding light on the debate between enforcement of promise or the protection of reliance as the basis for promissory estoppel).

74. *See generally* Jay M. Feinman, *Promissory Estoppel and Judicial Method*, 97 HARV. L. REV. 678 (1984) (arguing that promissory estoppel represents a failed attempt to address the contradictions of legal classicism); Barnett, *supra* note 71 (summarizing the problems with the promise theory of contract); P.S. ATIYAH, THE RISE AND FALL OF FREEDOM OF CONTRACT (1979) (showing the history and limits of promise-based liability as opposed to reliance-based liabilities); Omri Ben-Shahar, *Contracts Without Consent: Exploring a New Basis for Contractual Liability*, 152 U. PA. L. REV. 1829 (2004) (exploring the "no-retraction" theory of contract where each party is obligated to the terms manifested by them and can refrain only with some liability); Richard Craswell, *Offer, Acceptance, and Efficient Reliance*, 48 STAN. L. REV. 481 (1996) (exploring efficient reliance as an economic rationale in contract formation cases); Avery Katz, *When Should an Offer Stick? The Economics of Promissory Estoppel in Preliminary Negotiations*, 105 YALE L.J. 1249 (1996) (examining promissory estoppel as it applies in the context of preliminary negotiations through a lens of rational choice economic theory); Lucian Arye Bebchuk & Omri Ben-Shahar, *Precontractual Reliance*, 30 J. LEGAL STUD. 423 (2001) (analyzing the decision to invest in precontractual reliance under alternative legal regimes).

75. RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 4–7, 17–19 (1986).

76. For example, according to Patrick Atiyah, it is the society, not law, that determines and defines obligations and entitlements. P.S. ATIYAH, PROMISES, MORALS, AND LAW 129 (1981); Ian R. Macneil, *Contracts: Adjustment of Long-Term Economic Relations Under Classical, Neoclassical, and Relational Contract Law*, 72 NW. U. L. REV. 854, 862 n.24 (1978) (arguing that all aspects of contractual relations are subject to the norms characterizing contracts generally and identifying (1) harmonizing conflict and (2) preservation of the relation as two norms particularly applicable to contractual relations).

77. Grimmelmann, *supra* note 19, at 4; *see also* Rohr, *supra* note 18, at 72 ("'Smart contract' is an unfortunate name for something that is not necessarily smart, or necessarily a contract.").

78. MCQUINN & CASTRO, *supra* note 44, at 24.

79. Werbach & Cornell, *supra* note 18, at 341.

these contracts.[80] Others have categorized smart contracts based on the role of the algorithm. Depending on whether the algorithm is a gap-filler or a negotiator (tool or agent), the legal nature of such contracts differs.[81]

Some have criticized that smart contracts eliminate the social function of the act of contracting because the "technology of smart contracts neglects the fact that people use contracts as social resources to manage their relations."[82] Moreover, contracts are purported to be the main avenue for private lawmaking where individuals can solve their problems and regulate their behavior at the micro level.[83] Such private lawmaking becomes automated and atomized with smart contracts. Smart contracts are also not reliant on third-party intermediaries or human agency for their execution.[84]

The critique of smart contracts therefore comes from both legal and social angles. The skepticism towards smart contracts in law derives in large part from the nature of smart contracts that aim to resolve all issues ex ante and leaves little to no room for corrective measures ex post.[85] Smart contracts are entirely reliant on "ex ante formalizations, which can never match the flexibility of ex post human decision-making."[86] In other words, it is the lack of human connection and decision-making that has in part sparked the skepticism about the legal and social nature of smart contracts. These studies have largely focused on the *immutability* and *automation* of smart contracts while overlooking the *distributed* aspects of smart contracts.[87] The distributed function enables new methods of contract-making and resolution of disputes. This Part surveys the various approaches to the nature of smart contracts while providing fresh insights.

A. No Contract

Assent is a foundational requirement for contracts. Contract law

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80. Rodrigues, *supra* note 19, at 717 ("[W]hen gaps arise in the blockchain's smart contracts, there are no legal intervention points upon which the law can work.").

81. Scholz, *supra* note 5, at 136 ("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. . . . When algorithms act as negotiators, more interpretive work is required to show the fit with contract law.").

82. Karen E. C. Levy, *Book-Smart, Not Street-Smart: Blockchain-Based Smart Contracts and the Social Workings of Law*, 3 ENGAGING SCI. TECH. & SOC'Y 1, 1 (2017).

83. Avery W. Katz, *Contract Theory—Who Needs It?*, 81 U. CHI. L. REV. 2043, 2046 (2014) ("The key feature of contract law . . . is that it affords private parties the power of lawmaking.").

84. Alex Murray et al., *supra* note 40, at 36–42.

85. Arvind Narayanan, *Lecture 11–The Future of Bitcoin?*, YOUTUBE (Apr. 27, 2015), https://youtu.be/YG7l0XPtzD4 [https://perma.cc/R2L7-XRCB].

86. WERBACH, *supra* note 22, at 163.

87. Sklaroff, *supra* note 31, at 276.

requires mutual assent between parties or a "meeting of the minds."[88] With the advancement of technology, it was this requirement that led some to believe that smart contracts are not contracts since they lack human assent.[89] Moreover, along with the rapid progress of artificial intelligence (AI), AI can take over more aspects of contracting including bargaining, negotiation, and formation of contracts.[90] This means lesser involvement of human agents and lesser relevance of consent.

Codes and algorithms can be expressions of assent,[91] but it is the mutuality that can be a problem in smart contracts.[92] This approach suggests that smart contracts are not enforceable because they do not satisfy the requirement of "manifestation of assent."[93] In other words, lack of (apparent) assent forms the basis for doubting the contractual nature of smart contracts.[94] The *Restatement (Second) of Contracts* provides that for a contract to be formed, each party should manifest assent with reference to manifestation of the other.[95] This requirement casts doubt on the notion of assent in smart contracts where neither side of the bargain manifests assent *in reference* to the other side's offer.[96] Simply put, as mentioned above, smart contracts resemble unilateral offers that cross each other and are not in reference or in response to another offer.[97]

Due to the challenges arising from the lack of explicit assent, the law

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88. This requirement has been repeated in court decisions and can be inferred from the *Restatement (Second) of Contracts*. *See* RESTATEMENT (SECOND) OF CONTRACTS § 17 cmt. c (AM. L. INST. 1981). For the opposite and minority view, see Val Ricks, *Assent Is Not an Element of Contract Formation*, 61 KAN. L. REV. 591 (2013). *See also* SMART CONTS. ALL., CHAMBER OF DIGIT. COM., SMART CONTRACTS: IS THE LAW READY? 17 (2018) [hereinafter SMART CONTRACTS] ("The use of smart contracts may raise questions about whether the contracting parties have had a 'meeting of the minds,' when at least one side of the contracting process is consummated without human participation or intervention.").

89. SMART CONTRACTS, *supra* note 88, at 17–18.

90. *Id.* at 9.

91. Harry Surden, *Computable Contract*, 46 U.C. DAVIS L. REV. 629, 656 ("[B]asic contracting principles actively accommodate data-oriented representation.").

92. SMART CONTRACTS, *supra* note 88, at 41–42.

93. In the same vein, some scholars point that code cannot literally be a contract because "no physical representation of an agreement can ever entirely represent the agreement." Kolber, *supra* note 20, at 219. Moreover, a mutually-binding agreement, in their view, "cannot be reduced to a press of a button." *Id.* at 220.

94. Werbach & Cornell, *supra* note 18, at 340 ("Do smart contracts involve promises or obligations? In a significant sense, 'no.'").

95. RESTATEMENT (SECOND) OF CONTRACTS § 2(1) (AM. L. INST. 1981); *id.* § 23 ("It is essential to a bargain that each party manifest assent with reference to the manifestation of the other.").

96. Bellia, Jr., *supra* note 34, at 1052–53.

97. *See id.* at 1058. In these instances, the contract validity therefore relies on agency principles. *See id.* at 1059.

moved towards agency theory and attribution.[98] Most notably, the United States Uniform Computer Information Transaction Act (UCITA) provided that individuals are bound by the "operations of the electronic agent" even if such individuals are not "aware of or [have not] reviewed the agent's operations or the results of the operations."[99] Under this theory, human agents provide a general assent to electronic agents even if human agents are not aware of the details of each transaction.[100] This approach is also reflected in the Electronic Signature in Global and National Commerce Act (E-Sign Act), which provided that contracts formed as a result of electronic agents may not be denied legal effect so long as "the action of [the] electronic agent is legally attributable to the person to be bound."[101]

B. Unilateral Contracts

A key feature of smart contracts is that parties do not exchange promises.[102] The promises are in the form of offers that cross each other.[103] In these types of contracts, one party puts a contract in the form of codes (smart) on a platform such as Ethereum.[104] The smart contract therefore contains a set of unilaterally stipulated codes (conditions) that allow for the transfer of a digital asset or e-currency if those conditions are met.[105] Pursuant to this approach, smart contracts are "interrelated unilateral contracts,"[106] by which each party presents its side of the bargain unilaterally.

Under this approach, performance of the conditions presented by the

98. *See id.* at 1059–65; *see also* SMART CONTRACTS, *supra* note 88, at 17.

99. UNIF. COMPUT. INFO. TRANSACTIONS ACT § 107(d) (UNIF. L. COMM'N 1999).

100. Bellia, Jr., *supra* note 34, at 1059–65.

101. Electronic Signature in Global and National Commerce Act § 101(h), 15 U.S.C. § 7001(h). Agency theory however has its own critics. For example, electronic agents do not have human judgments and intentionality and cannot hold fiduciary duties towards their principal. Werbach & Cornell, *supra* note 18, at 341; *see also* Bellia, Jr., *supra* note 34, at 1065; SAMIR CHOPRA & LAURENCE F. WHITE, A LEGAL THEORY FOR AUTONOMOUS ARTIFICIAL AGENTS 55–61 (2011).

102. Raskin, *supra* note 18, at 323.

103. Bellia, Jr., *supra* note 34, at 1058. In these instances, the contract validity therefore relies on agency principles. *See id.* at 1059.

104. Loi Luu, Duc-Hiep Chu, Hrishi Olickel, Prateek Saxena & Aquinas Hobor, *Making Smart Contracts Smarter*, CCS '16: PROC. OF THE 2016 ACM SIGSAC CONF. ON COMPUT. & COMMC'NS SEC., Oct. 2016, at 254 ("Recently, Ethereum's smart contract system has seen steady adoption, supporting tens of thousands of contracts, holding millions [of] dollars worth of virtual coins."); Rodrigues, *supra* note 19, at 698 ("The Ethereum blockchain permits the central recording not just of an exchange, but of contractual conditions and limits on the circumstances under which an exchange can occur.").

105. Werbach & Cornell, *supra* note 18, at 343.

106. *Id.*

smart contract is key for the analysis of the contractual nature of the transaction. In a unilateral contract, the offeree can only accept the offer by performance rather than exchanging promises.[107] The classic illustration of a unilateral contract is where the offeror states "I will give you $100 if you walk across the Brooklyn bridge."[108] In these types of contracts, contractual liability exists upon performance without the need for exchange or return of promise. This feature has been the reason for judges adopting the unilateral contracts framework in instances where a promise given goes unreciprocated. For example, one study shows that judges have used the concept of unilateral contracts and found "promissory liability" of the employer in the context of employee benefits "without the necessity of finding a return promise by the employee."[109]

The same analysis applies to the blockchain technology where initiators of smart contracts offer certain digital assets or crypto-currency if offerees perform by, for example, solving complex mathematical problems.[110] Smart contracts therefore create a digital escrow where funds can only be released if certain conditions (performance) are satisfied by the offeree.[111]

C. Agreement to Agree

Another theory of smart contracts rests on the notion that such contracts are agreements to agree. Smart contracts therefore simply invite further agreements and lack essential contractual terms. Although in most current

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107. The *Restatement (Second) of Contracts* does not refer to unilateral contracts but discusses the topic in section 45, i.e., option contracts that are created by part performance or tender. *See* RESTATEMENT (SECOND) OF CONTRACTS § 45 (AM. L. INST. 1981). As one scholar stated, the drafters of the second restatement tried to purge the term "unilateral contract" but kept its legal device. Daniela Caruso, *Then and Now: Mark Pettit's* Modern Unilateral Contracts *in the 1980s and in the Age of Blockchains*, 98 B.U. L. REV. 1789, 1790 (2018). The drafters' skeptical view towards unilateral contracts originated from Professor Karl Llewellyn, who criticized the common law categorization of unilateral versus bilateral contracts. *See generally* K.N. Llewellyn, *On Our Case-Law of Contract Offer and Acceptance, I*, 48 YALE L.J. 1 (1938). A few decades later, however, Professor Mark Pettit showed that courts have consistently invoked the concept of unilateral contracts in their decisions including in the context of employee benefits. *See generally* Mark Pettit, Jr., *Modern Unilateral Contracts*, 63 B.U. L. REV. 551 (1983).

108. I. Maurice Wormser, *The True Conception of Unilateral Contracts*, 26 YALE L.J. 136, 136 (1916); *see also* Brackenbury v. Hodgkin, 102 A. 106, 107 (Me. 1917) (ruling that performance of the act accounts for acceptance and creates a binding contract).

109. Pettit, Jr., *supra* note 107, at 565; *see also* Caruso, *supra* note 107, at 1791.

110. Caruso, *supra* note 107, at 1793.

111. Werbach & Cornell, *supra* note 18, at 341–44. ("[T]he smart contract somewhat breaks down the traditional line between executory and executed contracts. Like the conveyance, there is no promise left to be performed. Unlike the conveyance, though, the smart contract does not transfer property at the time. It is neither executory, insofar as there is no action left to be performed, nor is it executed, insofar as the result is yet to be accomplished. This causes conceptual difficulty. Smart contracts are both committing to something in the future, but not exactly making a promise.").

forms of smart contracts important terms are specified due to simplicity (for example, if mining is completed first, the miner receives Bitcoin), this theory may be applied to more complex smart contracts. Under this approach, again, reliance is key and mutual assent is not necessary.[112] The agreement to agree, or precontractual agreement, lies in the grey area of "full-blown contracts" and "no obligation."[113] More importantly, this framework can work well for smart contracting where each side puts forward its own set of conditions and, as discussed, parties dispatch cross offers.[114] Under this view, the inherent incompleteness of smart contracting stems from the fact that each party attaches different meanings to the obligations.[115] The discord over the meanings and scope of the obligations, however, does not negate liability.[116] In other words, liability should always arise from unilateral promises, but not necessarily from consensus and agreement.[117]

The negotiations between parties fall into three categories. First, parties simply have engaged in preliminary negotiations.[118] "Second, the parties have agreed on all material terms and intend to memorialize this agreement in a formal document."[119] Third, parties have negotiated and "agreed on certain terms but left some terms open."[120] In the first category, the party who did not benefit from the negotiations cannot recover any damages.[121] In the second category, the contract is binding "when the evidence supports a finding that the parties did not intend the

112. Ben-Shahar, *supra* note 74, at 1833 n.6 (arguing that promise (which does not require consent) rather than harm or benefit should be the basis of liability).

113. *Id.* at 1829.

114. Bellia, Jr., *supra* note 34, at 1057–58 (describing the problem of "crossing offers" in which parties may express assent with reference to the anticipated but unknown assent of the other).

115. Ben-Shahar, *supra* note 74, at 1830–31 ("In contrast to the mutual assent approach, the no-retraction principle developed here suggests that when two parties attach different, but equally plausible, meanings to their agreed-upon contractual obligation, the absence of consensus would *not* negate any liability. Instead, under the no-retraction principle, each party should have *a right to enforce a contractual obligation according to the meaning intended by the other*." (emphasis in original)).

116. *Id.* at 1831.

117. *Id.* at 1834 ("[I]t is nonetheless the will of a party—a 'promise'—that ignites liability. The obligation is voluntary and promise-based, yet decoupled: A contract can be two, potentially different, bargains, with each party 'responsible' for one." (emphasis omitted)).

118. Alan Schwartz & Robert E. Scott, *Precontractual Liability and Preliminary Agreements*, 120 HARV. L. REV. 661, 664 (2007).

119. *Id.*

120. *Id.*

121. E. Allan Farnsworth, *Precontractual Liability and Preliminary Agreements: Fair Dealing and Failed Negotiations*, 87 COLUM. L. REV. 217, 221 (1987).

formalization of their agreement to be essential."[122] Under the third category, a prevailing rule is that parties should bargain in good faith over open terms, or else the refusing party will be responsible for the reliance expenditure.[123]

The third category most resembles smart contracts. Smart contracts can only envision a limited world with a limited set of automated conditions. Inevitably, all contingencies cannot be determined ex ante. In such digital environments, however, parties cannot negotiate in good faith for open terms. This is consistent with the criticism of some law and economics scholars who stated that good faith negotiations are "deficient," and the law should only "protect the promisee's reliance interest if [t]his promisor deviated from an agreed investment" without the requirement for good faith negotiations.[124]

Although courts have adopted a narrow approach to precontractual liability,[125] this approach can also be helpful in understanding the nature of smart contracts. As mentioned, smart contracts are similar to a "pail of water on top of a door" that would inevitably and automatically drop once the door opens.[126] This contract determines the main (automated) quid pro quo between parties. However, it leaves many contingencies out. What if the door does not open due to an external event or faulty codes?[127] What if the code does not specify the contingency where multiple recipients complete the tasks simultaneously? Smart contracts can fit the definition of a pre-contract because codes have not determined many contingencies of an agreement. In case of a fall-out, the party who relies on the code should be awarded the reliance damages (and not expectation interest).[128]

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122. Schwartz & Scott, *supra* note 118, at 664.

123. *Id.* at 664–65.

124. *Id.* at 667.

125. *Id.* at 672–73. ("In sum, the sample shows that courts consistently have denied recovery for precontractual reliance unless the parties, by agreeing on something significant, indicated their intention to be bound.").

126. Werbach & Cornell, *supra* note 18, at 340.

127. One of the problems with blockchain is 51% attacks. It is a special type of collusion that occurs in a blockchain network if 51% of the users decide to take certain actions. Frankenfield, *supra* note 43.

128. Schwartz & Scott, *supra* note 118, at 704 ("This analysis should help courts for three significant reasons. First, it shows what must be settled for there to be an actionable preliminary agreement: the parties must agree on the type of project, such as a shopping center or a financing; on an imprecise but workable division of authority for investment behavior; and on the rough order in which their actions are to be taken. These three conditions are each necessary and together sufficient. Second, the analysis clarifies that a deviation from the agreed investment sequence is a breach. Third, it recognizes that the law has two related goals: to deter strategic behavior and to encourage investment. These goals are advanced by awarding the faithful party her verifiable reliance costs if the other has wrongfully delayed investment. There is no need to protect the promisee's expectation, which would be difficult to do in any event for projects that never get past the preliminary stage." (footnote omitted)).

The agreement-to-agree framework can also be helpful. However, as mentioned, precontractual liability is contested. Moreover, smart contracts, which currently only contain basic transaction formulas, do not have many essential elements left open to be determined (e.g. price of a commodity). Third, the theory of precontractual reliance rests on the idea of avoiding underinvestment in reliance.[129] Whether this reliance incentive may work in the digital world where computers conduct transactions is unclear. As such, the agreement-to-agree framework, even though very helpful, may not capture the entirety of smart contracts.

As explained above, the existing contractual theories of smart contracts do not capture the nature of smart contracts nor do they fully explain their enforceability. Part III below argues for the reliance-based theory for smart contracts as the best theory to protect users.

III. RELIANCE AS THE BASIS FOR SMART CONTRACTS

Automation of contracts requires a new framework for analyzing contract law. The existing theories, as explained above, do not fully explain smart contracts. The prevailing bargain theory, which focuses on assent and mutuality, does not fully capture the intricacies of smart contracts and does not fully furnish a theory that can protect users. In this Part, the Article argues for reliance-based theory of smart contracts that aims to protect users' reliance. In section A, it provides an overview of promissory estoppel as the chief theory of reliance in contract law. In section B, it argues for the reliance-based theory of smart contracts that protects users' reliance.

A. Reliance Theory Best Explains Smart Contracts

Promissory estoppel is the reliance theory of promise enforcement. It is reflected in section 90 of the *Restatement (Second) of Contracts*. The consideration requirement under contract law dictates that only bargained-for promises form contracts.[130] A promise is bargained for "if it is sought by the promisor in exchange for his promise and is given by the promisee in exchange for that promise."[131] Promises that are gratuitous and open-ended are not enforceable.[132]

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129. Craswell, *supra* note 74, at 490–94; Katz, *supra* note 74, at 1267–77; Bebchuk & Ben-Shahar, *supra* note 74, at 423–29.

130. RESTATEMENT (SECOND) OF CONTRACTS § 71 (AM. L. INST. 1981).

131. *Id.*

132. Promissory estoppel originally was limited to non-bargain promises in donative settings. *See* Ricketts v. Scothorn, 77 N.W. 365 (Neb. 1898). Later courts expanded its scope to business

Pursuant to the promissory estoppel doctrine, however, promises that induce action or forbearance from the promisee can result in liability if, among others, the promisee reasonably relies on the promise to their detriment.[133] Under promissory estoppel, an equitable remedy, contracts are binding if "injustice can be avoided only by enforcement of the promise."[134] Promisee's detrimental reliance renders the promise binding and enforceable. This doctrine has introduced a reliance-based tort-like liability into contract law.[135]

Scholars have debated the scope of promissory estoppel for many decades.[136] Professor Jay Feinman summarized the debate by stressing on the distinction between enforcement promise or protection reliance as the two possible bases for promissory estoppel, while arguing for a third approach based on relational theory of contract law.[137] What is clear is that promissory estoppel of section 90 of the *Restatement (Second) of*

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relationships. *See* Hoffman v. Red Owl Stores, Inc., 133 N.W.2d 267 (Wis. 1965); *see also* Randy E. Barnett & Mary E. Becker, *Beyond Reliance: Promissory Estoppel, Contract Formalities, and Misrepresentations*, 15 HOFSTRA L. REV. 443, 450 (1987).

133. RESTATEMENT (SECOND) OF CONTRACTS § 90 (AM. L. INST. 1981) ("A promise which the promisor should reasonably expect to induce action or forbearance on the part of the promisee or a third person and which does induce such action or forbearance is binding if injustice can be avoided only by enforcement of the promise. The remedy granted for breach may be limited as justice requires.").

134. *Id.*

135. GILMORE, *supra* note 73, at 87–91 (arguing that contract and tort were artificially separate and that contract would ultimately evolve into a reliance-based tort); Randy E. Barnett, *The Death of Reliance*, 46 J. LEGAL EDUC. 518 (1996) (discussing the shift from consent-based to reliance-based approach in contract law); Charles L. Knapp, *Reliance in the Revised* Restatement*: The Proliferation of Promissory Estoppel*, 81 COLUM. L. REV. 52, 53 (1981) ("[T]he principle of section 90 . . . has become perhaps the most radical and expansive development of this century in the law of promissory liability."); Sidney W. DeLong, *The New Requirement of Enforcement Reliance in Commercial Promissory Estoppel: Section 90 as Catch-22*, 1997 WIS. L. REV. 943, 949–50 (showing that section 90 promissory estoppel has been "virtually extinguished" from much of the commercial contracting). Law and economics scholars have debated whether the reliance-based approach of the promissory estoppels is consistent from efficiency and economics. *See* Eric A. Posner, *Economic Analysis of Contract Law After Three Decades: Success or Failure?*, 112 YALE L.J. 829 (2003). Some scholars also rejected the tort-like characterization of promissory estoppel by arguing that promissory estoppel doctrine is "merely [a] substitute doctrinal method[] for showing the assent required for an enforceable consensual exchange." *See* Kostritsky, *supra* note 73, at 901–02; *see also* Juliet P. Kostritsky, *The Rise and Fall of Promissory Estoppel or Is Promissory Estoppel Really as Unsuccessful as Scholars Say It Is: A New Look at the Data*, 37 WAKE FOREST L. REV. 531 (2002).

136. *See, e.g.*, Kostritsky, *supra* note 73, at 964 (arguing that courts should use promissory estoppel "when persuasive barriers to, or explanations for dispensing with, explicit reciprocal or formalized contracts exist and a plausible benefit to the promisor can be identified"); Metzger & Phillips, *supra* note 73, at 863–64 (arguing that promissory estoppel is a tort-like and independent theory of recovery that is different from contractual liability); Feinman, *supra* note 73, at 303–11 (shedding light on the debate between enforcement of promise or the protection of reliance as the basis for promissory estoppel).

137. Feinman, *supra* note 73, at 303–11.

Contracts made its way for courts to impose liability when the relationship is not contractual. As Professor Randy Barnett & Professor Mary Becker stated after analyzing the case law, "courts have . . . used promissory estoppel as a remedy for promissory or factual misrepresentation . . . on the basis of conventional tort or (possibly) contract doctrines."[138] Promissory estoppel protects reliance trust of promisees even if the bargain is deficient or lacking. This approach fits our increasingly automated contractual relationship as described below.

B. Reliance Theory Can Help to Protect Users' Reliance

As stated above, promissory estoppel furnishes a competing basis for enforcement of non-bargained-for promises. This Article argues that smart contracts are enforceable because the offeree has detrimentally relied on the set of conditions presented.[139] There is doubt that conditions coded as smart contracts constitute a "promise" as discussed in contract law generally (and promissory estoppel).[140] Smart contracts resemble a "pail of water on top of a door" that would inevitably and automatically drop once the door opens.[141] Smart contracts set in motion unalterable conditions that can only be completed.[142]

Despite such skepticism, the framework of promissory estoppel best fits smart contracting. On the one hand, the promisor should "reasonably expect"[143] that the set of coded conditions are likely to induce actions (and even forbearance) within the platform. On the other hand, the promisee detrimentally relies on the codes (conditions) provided to attain the promised reward or return.

Furthermore, the promissory estoppel approach has several advantages in framing smart contracts. First, the doctrine does not rely on mutuality of assent or exchange of promises. In fully-automated contracting with minimal human agent involvement, this doctrine can best explain the contractual nature of the transaction. Second, instead of the forward-looking feature of the bargain theory, it is backward-looking—aiming to remedy harms caused by reliance or misrepresentation.[144] Third, the

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138. Barnett & Becker, *supra* note 132, at 496.

139. Ricketts v. Scothorn, 77 N.W. 365 (Neb. 1898).

140. Werbach & Cornell, *supra* note 18, at 340.

141. *Id.*

142. *See id.*

143. The first element of promissory estoppel according to section 90 of the *Restatement (Second) of Contracts* is that the promisor "should reasonably expect" that the promise "induce action or forbearance on the part of the promisee." RESTATEMENT (SECOND) OF CONTRACTS § 90(1) (AM. L. INST. 1981).

144. Markovits & Schwartz, *supra* note 6, at 802.

reliance-based approach is the "thinnest form of trust," where trust is only limited to the statements of another, in this case codes.[145] Fourth, the reliance by the computer may be considered reasonable since it triggers the transfer only if it sees a match with another computer.[146] Fifth, the doctrine of promissory estoppel arguably provides limited avenues for damages.[147] The party who relies on the promise can claim reliance losses (as opposed to often more expansive expectation damages).[148] In the digital world, contractual breaches occur largely due to incomplete or poor coding, not forward-looking promises that trigger expectations. Hence, awarding reliance losses—often awarded in tort cases[149]—can be a more appropriate remedy.[150] Moreover, due to automated and binary features of smart contracts, partial performances are rare. Equally, smart contracting present few opportunity costs that justify expectation damages.[151]

This view of smart contracts also avoids the problems legal scholars have faced with the issue of consent and assent in other new forms of contracting. In the last several years, consent has been the subject of

145. *Id.* at 801.

146. *See, e.g.*, Craswell, *supra* note 74, at 491–95 (arguing that the offeree should be reasonable in its reliance on a promise to avoid inefficient reliance); *see also* Richard Craswell, *Performance, Reliance, and One-Sided Information*, 18 J. LEGAL STUD. 365, 365–66 (1989) ("The only remedy capable of optimizing both parties' incentives (at least, the only remedy identified in the existing literature) is one that limits the promisee to recovering no more than the value that his expectation interest would have had if he had chosen the socially optimal level of reliance." (emphasis omitted)).

147. Mary E. Becker, *Promissory Estoppel Damages*, 16 HOFSTRA L. REV. 131, 131–32 (1987).

148. *See id.* at 132–33.

149. *See id.* at 155–63. The mismatch between what the code is and what the code ought to be is most similar to misrepresentation in tort. Courts seem to have used promissory estoppel to afford tort remedy for misrepresentation. Put differently, courts awarded reliance damages in promissory estoppel cases, which most closely resemble non-intentional misrepresentation. *See id.*

150. Moreover, promissory estoppel in this context also does not have the problem of part-performance as in unilateral contracts. Under unilateral contract doctrine, part-performance can lead to irrevocability of offers. Arguably, the doctrine of part-performance cannot be reconciled with blockchain technology. For example, in the context of Bitcoin, many computers perform complex computational mechanisms in order to be the first to solve the problem and receive the reward (Bitcoin). RESTATEMENT (SECOND) OF CONTRACTS § 45 (AM. L. INST. 1981) ("Where an offer invites an offeree to accept by rendering a performance and does not invite a promissory acceptance, an option contract is created when the offeree tenders or begins the invited performance or tenders a beginning of it."); *see, e.g.*, Steiner v. Thexton, 226 P.3d 359 (Cal. 2010) (ruling that in the context of unilateral contracts when part of the consideration requested is rendered, the offeror is bound to a contract).

151. Opportunity costs refer to the loss of an opportunity for contracting parties to make alternative contracts. *See* Robert Cooter & Melvin Aron Eisenberg, *Damages for Breach of Contract*, 73 CALIF. L. REV. 1432 (1985). Opportunity damages award the non-breaching party the benefit that party would have enjoyed by signing an alternative contract. *Id.* Opportunity costs form part of expectation damages. *Id.*

debates in legal scholarship.[152] Even though contract law is premised on the notion of consent, the importance of finding consent is diminishing due increasingly to cyber contracts and boiler plates. Scholars have discussed that true consent in this new age is amorphous and can be obtained by manipulation.[153] This approach can be traced in the Uniform Electronic Transaction Act[154] that stipulates that a contract "may be formed" even if "no individual was aware of or reviewed the electronic agents' actions."[155]

This trend is notable in consumer contracts where the new draft restatement called for a "grand bargain" in which consent is exchanged for a more robust unconscionability doctrine.[156] Recent behavioral law scholarship further shows that individuals have a formalistic view of contracts and often blame themselves for contractual harms even though they have not properly consented to the contractual terms and disclosures.[157] Studies show that individuals find contracting a matter of formalizing an agreement rather than an assent.[158] The historical data from the Harvard Case Law Access Project also shows a sharp decline in recent years on the reference to the notion of consent in case law.[159]

Against this background enters smart contracts and blockchain technology. The problem is more acute in blockchain technology where

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152. *See, e.g.*, Chunlin Leonhard, *The Unbearable Lightness of Consent in Contract Law*, 63 CASE W. RSRV. L. REV. 57 (2012) (arguing that consent can be obtained through manipulation).

153. *See id.* at 60 ("To begin with, consent is an amorphous, difficult-to-define concept that is made increasingly more difficult by the marketplace manipulations of human decision making biases.").

154. UNIF. ELEC. TRANSACTIONS ACT § 14 (NAT'L CONF. OF COMM'RS ON UNIF. STATE L. 1999).

155. *Id.*

156. Gregory Klass, *Empiricism and Privacy Policies in the Restatement of Consumer Contract Law*, 36 YALE J. ON REGUL. 45, 57 (2019). By restructuring the relationship between consumers and companies, some argue that smart contracts can offer a solution to "mass-market consumer contracting" and increase the ability of consumer to negotiate their own contract terms. Joshua Fairfield, *Smart Contract, Bitcoin Bots, and Consumer Protection*, 71 WASH. & LEE L. REV. ONLINE 35, 42–43 (2014).

157. *See, e.g.*, Tess Wilkinson-Ryan, *A Psychological Account of Consent to Fine Print*, 99 IOWA L. REV. 1745, 1758 (2014) ("[T]he cognitive psychology literature explain[s] why most people do not deliberate carefully over the fine print, and the moral psychology literature suggest[s] that most people view their contractual agreements as serious moral obligations.").

158. Tess Wilkinson-Ryan & David A. Hoffman, *The Common Sense of Contract Formation*, 67 STAN. L. REV. 1269, 1300 (2015) ("The picture that emerges from the studies suggests that intuitions in this area are actually quite nuanced. Most people have a sense that the law of contracts is one of formality. On the other hand, their own behavior appears quite sensitive to social and moral dimensions of promise and disappointment, such that they are reluctant to even revoke an offer, much less break a deal.").

159. *Historical Trends*, HARV. L. SCH.: CASELAW ACCESS PROJECT, https://case.law/trends/ [https://perma.cc/EY5L-S6K2] (To view this data: go to the URL; delete any words in the search bar; type the word "consent"; and view the chart, which shows the historical use of the word consent in court cases from 1800 until 2018).

automation, anonymity, and synchronous transactions further isolate the notion of consent. The legal analysis of smart contracts, therefore, cannot be based on the notion of consent and mutual assent. As suggested above, it is the reliance on the technology of blockchain and codes that should lead the way for the legal analysis of smart contracts. As the recent hacks of blockchain show, it is the broken codes (or incomplete codes) that will be at the epicenter of contractual breach.[160] The problem of mismatched codes—between what codes say they would do and what they actually do—is present in the context of initial coin offerings.[161] Some of the intentional instances of mismatch is fraudulent.[162] Most instances, however, are codes that are insufficient or can be manipulated.[163]

With the exception of contract-as-reliance, all major contract theories require mutuality and bargain. The bargain theory requires intention or mutuality. The reliance theory, which is based on section 90 of the *Restatement (Second) of Contracts* on promissory estoppel, does not require a full quid-pro-quo bargain.[164] It is aimed to protect reasonable reliance in the absence of a bargained-for exchange.[165] Under this approach, the focus of contract enforceability shifts from manifestation or assent and consideration to promisee's reliance and would create a distinct type of liability.[166]

In smart contracts, however, the manifestation of human intention occurs solely at the outset of entering the platform while human involvement, let alone mutuality of assent, is absent from each transaction. The socio-economics approach to contracting also requires an exchange of promises or societal norms. Neither of these elements can be found in an automated digital world.[167] Smart contracts resemble the

160. Reza M. Parizi, Ali Dehghantanha, Kim-Kwang Raymond Choo & Amritraj Singh, *Empirical Vulnerability Analysis of Automated Smart Contracts Security Testing on Blockchains*, CASCON '18: PROC. OF THE 28TH ANN. INT'L CONF. ON COMPUT. SCI. & SOFTWARE ENG'G, Oct. 2018, at 103.

161. Cohney et al., *supra* note 20, at 598–99 (showing empirically that CO code and ICO disclosures often do not match).

162. *Id.* at 595–97.

163. Parizi et al., *supra* note 160.

164. For the discussion of promissory estoppel, see *supra* section III.A.

165. Feinman, *supra* note 73, at 303–11 (shedding light on the debate between enforcement of promise or the protection of reliance as the basis for promissory estoppel); Farnsworth, *supra* note 121, at 677; Barnett & Becker, *supra* note 132, at 445–46; Michael I. Swygert & Donald W. Smucker, *Promissory Estoppel in Florida: Growing Recognition of Promissory Obligation*, 16 STETSON L. REV. 1 (1986); James Gordley, *Enforcing Promises*, 82 CALIF. L. REV. 547, 548 (1995).

166. Hoffman v. Red Owl Stores, Inc., 133 N.W.2d 267, 275 (Wis. 1965) ("We deem it would be a mistake to regard an action grounded on promissory estoppel as the equivalent of a breach of contract action.").

167. In law and economics, for example, contracts are enforceable since parties are better off ex

"truly discrete" exchange transaction hypothetical that Professor Macneil put forward in 1977.[168] Such a transaction would be separated from all present, past, and future relations, and occur between "total strangers, brought together by chance (not by any common social structure)" while each party "would have to be completely sure of never again seeing or having anything else to do with the other."[169]

As explained above, therefore, a reliance-based approach can be a better fit for framing smart contracting. This view is also relevant for resolution of smart contract disputes. The consent theory leads parties to decipher and find programmer's elusive intent. My approach, however, is to place the emphasis on the *collective* reliance of all users. As a result, the best contractual dispute mechanism would be collective wisdom of the users, as I explain below in Part IV. But first it is important to understand the foundational problems with smart contracts from a contract law perspective before understanding the best dispute resolution mechanism. The following Part addresses two main problems with smart contracts.

IV. TWO PROBLEMS OF SMART CONTRACTS

Despite the name, smart contracts are not smart in every aspect. Some main issues include the perpetual incompleteness—a problem shared with the traditional form of contracts—and the lack of entry point for legal resolution. This Part identifies readily available solutions to enhance smart contracts, such as finding the collective users' reliance, creating a common fund to provide compensation, and adopting a hybrid contract approach.

A. Smart Contracts Are Incomplete

Almost all contracts are incomplete.[170] Contracts are incomplete at least for two reasons: parties fail to specify all future contingencies or the

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ante as a result of an exchange of promises. ERIC A. POSNER, CONTRACT LAW AND THEORY 27–28 (2d ed. 2016) ("The conventional, utilitarian or welfarist explanation for why courts should normally enforce contracts is that if the parties are rational and fully informed, the contract will make both parties better off (ex ante) without making third parties worse off. . . . [F]or example, a contract in which Seller sells an apple to Buyer in return for $1. Buyer prefers the apple to $1 and Seller prefers $1 to the apple; no third party is affected by this transaction.").

168. Macneil, *supra* note 76, at 856 (emphasis omitted).

169. *Id.* This hypothetical cannot always apply to the blockchain technology because in retail, parties know other parties well. They simply automate the enforcement of their transaction by using smart contracts.

170. *See generally* Ian Ayres & Robert Gertner, *Filling Gaps in Incomplete Contracts: An Economic Theory of Default Rules*, 99 YALE L.J. 87 (1989) (explaining that contracts are incomplete when parties fail to specify parties' duties or are insensitive in the face of future constituencies).

contract is "insensitive to relevant future contingencies."[171] Smart contracts, similar to all other contracts, are destined to be *incomplete*.[172] This was proven in the 2016 hack of a firm that used smart contracts to create a decentralized organization. The DAO—or decentralized autonomous organization—was a crowdfunding platform on blockchain that used Ethereum.[173] Using the code of the smart contract for the platform, the hacker managed to transfer ether cryptocurrency to a "child DAO" that had a similar structure as the main DAO.[174] The term hacking may not be accurate; the hacker in fact applied the terms of the smart contract in a way that allowed the hacker to transfer funds elsewhere.[175] The hacker later wrote a letter arguing that the transfer of funds was legal since smart contracts are their own arbiters and no outside authority can change the rules of the transactions.[176] The attacker may have been right. Smart contracts are supposed to be immutable and account for all contingencies. In the same vein, some have argued that smart contracts are new forms of self-help "because no recourse to a court is needed for the machine to execute the agreement."[177] Following the attack, several users suggested splitting the DAO but could not get the votes. It was the attacker who appeared to voluntarily stop after hearing of the split proposal.[178]

The incompleteness in smart contracts, however, can be different.

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171. *Id.* at 92 n.29 ("There are two distinct ways for a contract to be incomplete. First, a contract may fail to specify the parties' duties for specific future contingencies. For example, a contract for the construction of a third floor to a house may not state the parties' respective rights and responsibilities should the entire house burn down before construction is started. Since construction of a third floor is impossible (without the lower two floors), the contract does not cover the contingency of the house burning down. The second form of contractual incompleteness is more subtle. A contract may also be incomplete in that it is insensitive to relevant future contingencies. . . . For example, consider a contract that simply obligates one party to construct a garage adjacent to a house. On the face this contract imposes a duty to build a garage whether or not the adjacent house burns down before construction of the garage is complete. The contract is incomplete in this second sense, however, because the duty to build a garage is not sufficiently dependent on future contingencies. If the adjacent house burns down, the parties probably would want to adjust the terms of contract. Such contracts we call insufficiently state-contingent.").

172. Grimmelmann, *supra* note 19, at 3 (arguing that smart contracts do not eliminate ambiguity).

173. *See generally* Nathan Reiff, *Decentralized Autonomous Organization (DAO)*, INVESTOPEDIA (June 25, 2019), https://www.investopedia.com/tech/what-dao/ [https://perma.cc/W2KJ-Y8XH].

174. Siegel, *supra* note 68.

175. Raskin, *supra* note 18, at 336–37. The DAO terms and conditions stated that DAO's code superseded all explanations, guarantees, and statements. Therefore, the DAO code was controlling (code is the entire contract). However, despite this explicit language, the code cannot be the entire contract in the DAO and possibly all smart contracts. Kolber, *supra* note 20, at 217–24.

176. Siegel, *supra* note 68.

177. Raskin, *supra* note 18, at 333.

178. Siegel, *supra* note 68.

Generally, there are three layers of contractual agreements in a transaction involving smart contracts. One is the code of the smart contract (if/then). The second is the code of the platform which determines the validation mechanism. The last layer concerns the terms and conditions that users subscribe to prior to using the platform. Scholars have shown that inconsistency often exists between these three layers.[179] Moreover, the syntax used in coding (e.g., if/then) could be subject to controversy and "requires something outside the program itself" for it to have meaning.[180] The incompleteness of smart contracts therefore largely arises out of broken codes and inconsistency of the aforementioned three layers.

A recent case from the Singapore International Commercial Court, decided based on common law, further illuminates this issue.[181] In this case, the defendant installed a software to ensure cryptocurrency trades occur at their market price.[182] Due to an oversight in coding, however, seven trades of cryptocurrency occurred at 250 times the market exchange rate.[183] The defendant, upon discovery of this issue, reversed the seven trades.[184] The plaintiff who benefited from this software glitch sued for breach of contract.[185] The terms and conditions of the software states that "once an order is filled" the transfer is "irreversible."[186]

The court continued by stating that the intent of "the operator or controller of the machine" should be considered.[187] In other words, "the mind of the programmer" at the time of drafting the code is most relevant in cases of software glitches.[188] As a result, the court decided that the trades should not have been reversed and the reversal goes against the intent of the coder.[189] This case is not directly about smart contracts but it

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179. *See* Cohney et al., *supra* note 20 (showing empirically that CO code and ICO disclosures often do not match); Kolber, *supra* note 20, at 220. To further explain, one can analogize it with apps in smart phones. One layer is computer codes underlying the app. Another layer refers to the codes of the platform on which the app runs (e.g., Android). Another layer that can govern parties' relationship is the terms & conditions users agree to prior to using the app.

180. Grimmelmann, *supra* note 19, at 11. The author further argues that "no computer program can determine its own semantics." *Id.*

181. Anisha Franklin & Kimarie Cheang, *How Are Contract and Trust Law Principles Applied in Cryptocurrency Disputes?*, HFW LITIG. BRIEFING (Holman Fenwick Willan LLP, London, U.K.), July 2019, http://www.hfw.com/How-are-contract-and-trust-law-principles-applied-in-cryptocurrency-disputes-July-19 [https://perma.cc/SSV3-VGNC].

182. *See id.*

183. *Id.*

184. *Id.*

185. *Id.*

186. *Id.* (emphasis omitted).

187. *Id.* (emphasis omitted).

188. *Id.* (emphasis omitted).

189. *Id.*

shows how the court had to navigate between the terms of the software and its underlying code to determine an incompleteness in the agreement. Another interesting aspect of the case lies in the argument put forward by the defendant. The defendant argued for unilateral mistake.[190] The mistake was the software glitch which the plaintiff was aware of and benefitted from.[191] The court, however, stated that at the time of the contract (transfer) there was no "human involvement" and consequently the doctrine of unliteral mistake did not apply here.[192]

B. Smart Contracts Do Not Allow Entry Points

Smart contracts are incomplete because the underlying codes do not account for all errors. They are also ambiguous because the platform codes are subject to change and modification. The problem, however, is that smart contracts do not allow for any intervention to remedy the incompleteness or breach.[193] In traditional contracting, parties can re-negotiate the terms of the agreement or a third party (e.g., a judge) determines the points of contention upon disagreement or change of circumstances. In smart contracting, there is no entry point for legal intervention because: (1) parties are anonymous, (2) codes forming smart contracts are immutable, and (3) no one can issue a "fiat" to change the code and the underlying platform.[194]

How can automated codes which no one controls undergo change or revision? Imagine *A* sets up a smart contract whereby *B* gets paid $1 if it rains on Thursday or else *A* will get paid $1. This process is automated with no human involvement. Now imagine that it hails on Thursday. Who is supposed to receive the $1?[195] On a blockchain, the next block is added by the consensus mechanism. If consensus is reached that hail is similar to rain, *B* will receive $1. If not, *A* will receive $1. If there is disagreement, there is a possibility of split. No one can regulate this issue ex post if the code is not sufficient. This shows that blockchain technology does not allow for legal entry points.[196]

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190. *See id.*

191. *Id.*

192. *Id.*

193. *See* Rodrigues, *supra* note 19, at 714–27.

194. Anna Gelpern, *Abandoned at the Nexus of Contracts*, CORP. L. JOTWELL (Jan. 29, 2019), https://corp.jotwell.com/abandoned-at-the-nexus-of-contracts/ [https://perma.cc/B4R3-CYJB] (reviewing Rodrigues, *supra* note 19).

195. This is not just a hypothetical. MetLife insurance developed a smart contract whereby as soon as a patient uploads a positive diabetes test result, an insurance payment is made into the patient's account. *See* Castillo, *supra* note 38.

196. Rodrigues, *supra* note 19, at 714–27.

The solutions to this problem are not clear yet. One possible solution is to create a pool of funds by users. Under this proposal, each user gives some tokens (e.g., cryptocurrency) to a pool of funds in each of the transactions. The fund can then be used to compensate any contractual damages. For example, in the DAO attack, the fund could be used to compensate those who lost cryptocurrency as a result of the attack. The users can decide on a solution and transfer the necessary amount from the fund to those users who have been affected by the breach.

Another solution lies in hybrid contracts. Businesses increasingly intend to use blockchain technology.[197] They primarily use "hybrid contracts," which are smart contracts that use off-blockchain information and include it in the chain of blocks.[198] Take Walmart for example. In response to an E. coli infection linked to romaine lettuce, Walmart launched a pilot blockchain platform to record the supply chain of lettuce.[199] The information that is recorded on blockchain comes from farmers, warehouse keepers, truck drivers, and others. The hybrid architecture combines both on- and off-blockchain components, similar to the Walmart example. Therefore, "[s]ome of the clauses [of the contracts] are monitored/enforced off-blockchain, whereas others are enforced on-blockchain."[200] In short, hybrid blockchain and contracts allow for external information (external to the chains in the block) to be fed into the blockchain.

Businesses do not simply let go of their control of the contracts. After all, contracts and their residual rights create governance.[201] Under hybrid contracts, parties automate their obligations in whole or in part against a backdrop of a traditional contract. In these circumstances, parties may stipulate that the code embedded in smart contracts is *part* of their agreement.[202] Under this approach, smart contracts form part of the

197. Castillo, *supra* note 38, at 4.

198. Carlos Molina-Jimenez, Ioannis Sfyrakis, Ellis Solaiman, Irene Ng, Meng Weng Wong, Alexis Chun & Jon Crowcroft, *Implementation of Smart Contracts Using Hybrid Architectures with On- and Off-Blockchain Components*, IEEE '18: 8TH INT'L SYMP. ON CLOUD & SERV. COMPUTING, Nov. 2018, at 1, 3–8. New efforts are underway to improve the hybrid transactions involving on-blockchain and off-blockchain technology. *See id.*

199. *See* Michael Corkery & Nathaniel Popper, *From Farm to Blockchain: Walmart Tracks Its Lettuce*, N.Y. TIMES (Sept. 24, 2018), https://www.nytimes.com/2018/09/24/business/walmart-blockchain-lettuce.html [https://perma.cc/LZW7-46CB].

200. Ellis Solaiman, Todd Wike & Ioannis Sfyrakis, *Implementation and Evaluation of Smart Contracts Using a Hybrid On- and Off-Blockchain Architecture*, 33 CONCURRENCY & COMPUTATION: PRAC. & EXPERIENCE (SPECIAL ISSUE PAPER) e5811, e5813 (2020).

201. Oliver Hart, *Incomplete Contracts and Control*, 107 AM. ECON. REV. 1731 (2017).

202. FILIPPI & WRIGHT, *supra* note 41, at 80 ("[P]arties can draft master agreements written in traditional legal prose and can include provisions stipulating that the parties agree that smart contract code qualifies as valid writing.").

agreement between parties. In the case of a disagreement concerning the smart contract, the traditional contract may prevail.[203] This is because the traditional contract seems to be closer to the parties' intent. Ricardian contract is a type of hybrid contract by which a parent document determines parties' obligations before its performance through codes (smart contracts).[204] In other words, a Ricardian contract is a *traditional* contract whereby parties agree to automate some of its provisions through smart contracts and blockchain technology.

Hybrid contracts are another way of combatting the problem of entry points. Parties can always bring their disputes pursuant to the traditional contract portion of their agreement. However, the hybrid structure still relies on off-blockchain legal recourses to make smart contracts function. This limits smart contracts and makes the adjudicative process reliant on traditional contractual methods. For this reason, there is a need for an effective and truly decentralized dispute resolution. Part IV analyzes the current ongoing yet inchoate efforts for decentralized dispute resolution and offers a new way of doing so.

V. TOWARDS TRULY DECENTRALIZED USER-BASED DISPUTE RESOLUTION

New efforts are underway to create a built-in dispute resolution mechanism in smart contracts. Dispute resolution clauses are already common in traditional contracting. The majority of consumer and employment contracts include a dispute resolution clause stipulating that an arbitrator or a panel of arbitrators decides the dispute between parties.[205] Similar to contracts, adjudication or dispute resolution also leads to solidarity as it brings "disputants into reciprocal recognition and into the shared perspective."[206] Such dispute resolution mechanisms,

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203. Existing laws seem to be silent on this point. For example, Uniform Electronic Transaction Act provides that automated transactions are binding (§ 14) and render all electronic records admissible in trial (§ 13). UNIF. ELEC. TRANSACTIONS ACT (NAT'L CONF. OF COMM'RS ON UNIF. STATE L. 1999). However, it does not directly address the issue of hybrid contracts where contracts are in part automated and in part non-electronic as described above.

204. Ian Grigg, *The Ricardian Contract*, IEEE: PROC. OF THE FIRST INT'L WORKSHOP ON ELEC. CONTRACTING, 2004, at 25.

205. *See* Alexander J.S. Colvin, *The Growing Use of Mandatory Arbitration*, ECON. POL'Y INST. (Apr. 6, 2018), https://www.epi.org/publication/the-growing-use-of-mandatory-arbitration-access-to-the-courts-is-now-barred-for-more-than-60-million-american-workers/ [https://perma.cc/2YUE-ZGE9].

206. Daniel Markovits, *Arbitration's Arbitrage: Social Solidarity at the Nexus of Adjudication and Contract*, 59 DEPAUL L. REV. 431, 469 (2010). In Markovits's view, adjudication and contract both result in solidarity with differences in "paths to recognition" between subjects:

which are built into the contract algorithm ex ante, aim to handle more complex disputes via a distributed system.[207]

Blockchain technology is benefitting from this common practice. There are several startups that specialize in blockchain dispute resolution, and each has its own unique solution to this problem. For example, OpenBazaar uses the multisig feature[208] of Bitcoin and therefore requires at least three signatures (buyer, seller, and a moderator) for completion of each transaction.[209] Mattereum tries to connect real property rights to smart contracts to create legally enforceable contracts.[210] In doing so, Mattereum promises dispute resolution that is effective.[211] Kleros operates on a decentralized network that randomly assigns disputes to a group of self-selected jurors.[212] Aragon selects several anonymous arbitrators from its pool to determine the outcome of a dispute.[213] Sagewise devised an

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> Adjudicative solidarity employs an intensive, transformative process in order to draw disputants into reciprocal recognition and into the shared perspective that such recognition establishes, even when the disputants do not intend to engage one another in this way, and indeed to induce them to recognize each other against their initial intentions. Contractual solidarity, by contrast, must itself be directly intended by those who participate in the contract, even if they are motivated not by solidarity but rather by self-interest.

Id.

207. *See* Federico Ast & Clément Lesaege, *Kleros, A Decentralized Court System for the Internet (Abridged)*, MEDIUM (Sept. 18, 2017), https://medium.com/kleros/kleros-a-decentralized-court-system-for-the-internet-abridged-1e415c04604a [https://perma.cc/8SWR-557V].

208. Multisig (multisignature) refers to requiring multiple keys to authorize a Bitcoin transaction. *See What Is a Multisig Wallet?*, BINANCE ACAD. (Oct. 21, 2020), https://academy.binance.com/en/articles/what-is-a-multisig-wallet [https://perma.cc/SE46-ETUE].

209. *How Moderators and Dispute Resolution Work in OpenBazaar*, OPENBAZAAR (Feb. 23, 2016), https://openbazaar.org/blog/how-moderators-and-dispute-resolution-work-in-openbazaar/ [https://perma.cc/E6CY-SSV3] ("Instead of just having one person control the bitcoins in a certain account (called addresses), you can have multiple people control the same bitcoins. However, they can only send those coins to another address if a certain number of people controlling the bitcoins agree. For example, you can have a 2-of-2 multisig address. This means that there are two people who control the address, and both of them must agree to a transaction before the bitcoins can be sent anywhere else. A 2-of-3 address means three people control the address, and two of them must agree before the funds can be spent. OpenBazaar uses 2-of-3 multisig addresses for transactions. When a buyer wants to purchase a listing, instead of sending the funds directly to the seller, he will send the funds to the multisig account. The three people who control this account are the buyer, the seller, and a trusted third party selected beforehand. We call these trusted third parties 'moderators.'").

210. *See For Truth in Trade*, MATTEREUM, https://mattereum.com [https://perma.cc/3YMW-XJYA]; *see also* Darcy W. E. Allen, Aaron M. Lane & Marta Poblet, *The Governance of Blockchain Dispute Resolution*, 25 HARV. NEGOT. L. REV. 75, 85–90 (2019); Vinay Gupta, *The First Mattereum Briefing*, MEDIUM (Dec. 15, 2017), https://medium.com/humanizing-the-singularity/the-first-mattereum-briefing-11a67c75d840 [https://perma.cc/D22U-4NT3].

211. *Id.*

212. *See About Kleros*, KLEROS, https://kleros.io/about [https://perma.cc/2FBJ-GEKE]; Allen et al., *supra* note 210, at 91.

213. Tatu Kärki, *Aragon Network Jurisdiction Part 1: Decentralized Court*, ARAGON (July 18, 2017), https://aragon.org/blog/aragon-network-jurisdiction-part-1-decentralized-court-c8ab2a675e82 [https://perma.cc/ZL6X-H59K].

embedded layer into smart contracts, which enables a toolkit to resolve coding errors and security vulnerabilities along with features to amend contracts or resolve disputes.[214] An academic article also suggests creating an "open-source platform ecosystem" for smart contract dispute resolution that preserves its anonymity and calls it "distributed jurisdiction."[215]

The blockchain technology is nascent and so is dispute resolution premised on this technology. It is also evolving rapidly. Such nascent systems largely rely on a so-called "proof-of-stake model," in which a select stakeholder resolves the disputes.[216] After a dispute arises, a few users are selected to serve as jurors to decide the dispute. If such a mechanism is built into contracts, it is possible that more complex contracts that require judgment can be "smart." For example, a smart contract code can state that if it rains on Sunday, $1 will be transferred from party *A* to *B*. If, however, it hails on Sunday, the question arises whether such transfer should be made. This incompleteness in the contract requires judgment and decision-making. The built-in dispute resolution mechanism enables judgments to be made in such events that are unaccounted for in the code. Unlike traditional dispute resolution mechanisms, the new efforts involve other users within the platform to exercise their judgments, not third parties outside of the platform. Due to the importance of judgment and decision-making, the future of smart contracts, arguably, depends on an effective blockchain-based dispute resolution.[217]

Based on the existing technology, this Article argues that blockchain-based dispute resolution can offer three important features capable of

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214. *See* Jonathan Shieber, *Sagewise Pitches a Service to Verify Claims and Arbitrate Disputes over Blockchain Transactions*, TECHCRUNCH (Aug. 3, 2018, 12:51 PM), https://techcrunch.com/2018/08/03/sagewise-pitches-a-service-to-verify-claims-and-arbitrate-disputes-over-blockchain-transactions/ [https://perma.cc/LP4N-6FKG]; *see also* Allen et al., *supra* note 210, at 85.

215. Wulf A. Kaal & Craig Calcaterra, *Crypto Transaction Dispute Resolution*, 73 BUS. LAW. 109, 148 (2018). According to this piece, several limitations exist in the current dispute resolution efforts. First, the existing solutions do not assure "full anonymity." *Id.* Second, random selection of arbitrators would fail since users would like to appoint the arbitrators with the "highest possible expertise." *Id.* Third, the democratic selection of arbitrators along with a lack of subject-matter expertise would result in users' lack of confidence. *Id.* Fourth, the current solutions do not necessarily allow for use of attorneys. *Id.* Fifth, the current solutions do not always allow users to use a different dispute resolution mechanism. *Id.*

216. *See infra* section IV.A.

217. The future effectiveness of the blockchain is also dependent on the reliability of Oracle-type blockchain platform for uncontroversial cases. *See* Benjamin Pirus, *Oracle Blockchain Platform Helps Big Businesses Incorporate Blockchain*, FORBES (July 22, 2019, 1:05 PM), https://www.forbes.com/sites/benjaminpirus/2019/07/22/oracle-blockchain-platform-helps-big-businesses-incorporate-blockchain/#2c7a9d55797b [https://perma.cc/5ATS-GTKM].

transforming contractual disputes, distinct from traditional dispute resolution: (1) a mechanism for consensus that may be based on a larger pool of arbitrators (or jurors), (2) dispute resolution that can be distributed and functions on a random basis (avoiding the repeat problems), and (3) enforcement that is independent from judicial systems. The inclusion of a dispute resolution mechanism can change the smart contract scene through the interjection of human interaction at the tail end of the process (i.e., resolution of the dispute). Moreover, this Article argues that instead of a handful of users that are selected to resolve disputes, blockchain technology has the ability to access a large pool of users who can be selected randomly to resolve disputes. In sum, the dispute resolution mechanism brings back the human connection ex post and helps with existing problems such as mandatory arbitration or repeat players through enabling a large anonymous group of users randomly selected to resolve controversies.

A. Dispute Resolution Should Be Truly Decentralized

Traditional dispute resolution often does not involve consensus. Typically, parties appoint an arbitrator or a panel of arbitrators (often three) to resolve their disputes outside of the judicial system.[218] One of the main breakthroughs of blockchain technology, however, pertains to its consensus mechanism as explained above. Several consensus mechanisms exist in blockchain technology. Two of the most widely used are proof-of-work and proof-of-stake. Under the proof-of-work consensus mechanism, every node in the network can validate transactions. Nodes often compete to verify the transactions to receive a reward. This is the consensus mechanism for Bitcoin.[219] The other most common consensus mechanism is proof-of-stake, in which the system chooses a node based on the tokens held by the node (its stake). For example, if a node holds ten tokens and the other node 100, the latter is more likely to be chosen to validate the next transaction and hence add the next block.[220]

The consensus mechanisms of the blockchain technology may vary.[221]

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218. *What We Do*, AM. ARB. ASS'N, https://adr.org/Arbitration [https://perma.cc/2MYV-K4XN].

219. MCQUINN & CASTRO, *supra* note 44, at 7–8; *see also* Andrew Tar, *Proof-of-Work, Explained*, COINTELEGRAPH (Jan. 17, 2018), https://cointelegraph.com/explained/proof-of-work-explained [https://perma.cc/CE8Y-ZFSW].

220. *See* MCQUINN & CASTRO, *supra* note 44, at 7–8; Ameer Rosic, *Proof of Work vs Proof of Stake: Basic Mining Guide*, BLOCKGEEKS, https://blockgeeks.com/guides/proof-of-work-vs-proof-of-stake/ [https://perma.cc/U7XV-4PH3].

221. For a more nuanced analysis of the different consensus mechanisms, see ARATI BALIGA, PERSISTENT, UNDERSTANDING BLOCKCHAIN CONSENSUS MODELS (2017),

The relevant point here is that the blockchain technology enables a structure in which different nodes engage in the validation process. In other words, the network allows for more nodes to participate in the decision-making process. Underlying the idea to build a dispute resolution on blockchain is its capacity to reach a wider network of individuals. This capacity is essential for the consensus mechanisms described above as various nodes must participate in the network for the validation process. The current efforts related to blockchain-based dispute resolution focus again on expertise (and a proof-of-stake model) whereby the system selects a handful of individuals for dispute resolution.[222]

Regardless of current efforts, blockchain has the capability of transforming the dispute resolution mechanism. For example, in the blockchain technology, any node can be an arbitrator of a dispute. Decisions can also be made through voting.[223] Imagine a dispute between a buyer and a seller in which each side proposes its own narrative. Each participant in the network can review the dispute and vote for either the buyer or the seller. The users are incentivized to conduct such review because either they would receive a token (e.g., cryptocurrency) or because they are stakeholders of the platform. This development alone, which is technologically feasible with blockchain,[224] can transform dispute resolution (and law generally) if it receives wide acceptance. This trend can also go against the tendency towards centralization in the judiciary which has happened in the United States and elsewhere.[225]

B. Network-Based Dispute Resolution Can Solve Some Arbitration Problems for Small Claims

The distributed and decentralized feature of the blockchain technology can help combat one of the principal problems of the current dispute resolution mechanism. Arbitration—as the leading method for dispute resolution—is believed to be elitist and involves only a handful of

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https://www.persistent.com/wp-content/uploads/2017/04/WP-Understanding-Blockchain-Consensus-Models.pdf [https://perma.cc/WHU4-JGLJ].

222. *See* KLEROS, *supra* note 212; *see also* Allen et al., *supra* note 210, at 86.

223. A Startup has already put forward a system which is based on this model. Under the JUR model, any user can stake their token to verify the raised dispute and cast a vote. *See Blockchain Technology Is Now Entering the Dispute Resolution Arena*, NASDAQ (Aug. 7, 2018, 11:37 AM), https://www.nasdaq.com/article/blockchain-technology-is-now-entering-the-dispute-resolution-arena-cm1003487 [https://perma.cc/4FQA-4BGE].

224. *See id.*

225. *See, e.g.*, MICHAEL DICHIO, THE US SUPREME COURT AND THE CENTRALIZATION OF FEDERAL AUTHORITY 6 (2018) ("The judiciary's tendency to centralize federal authority over time represents a crucial dimension in the construction of political authority.").

individuals over a wide range of cases.[226] For example, in international arbitration, recent data suggests that only a handful of individuals in the network of professionals decide the majority of the disputes.[227]

The problems of repeat appointments and the repeat player effect commonly occur in arbitration. Under the current system (both in domestic and international arbitration), a small group of individuals are often selected to adjudicate disputes.[228] In the same vein, studies show that those who utilize arbitration often (repeat players) have a significant advantage over others.[229] Proponents of the system often claim that this phenomena is due to the need for expertise.[230] This is not necessarily supported by existing data, which to the contrary shows that participants do not list expertise as their main reason to use arbitration and complain about the repeat players problem.[231] The problem may be structural. Individuals often are channeled by their counsels and the arbitral institutions to appoint the same arbitrators. Moreover, the repeat players have a significant advantage due to their information and influence on the selection of arbitrators among others.[232]

The promise of blockchain-based dispute resolution rests on the notion that it is distributed, randomized, and anonymized. The distributed feature guarantees more participants in the decision-making process while randomization prevents concentration of decision-making in select nodes. This does not negate the possibility that over time users will "inevitably

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226. *See* Susan D. Franck, *The Legitimacy Crisis in Investment Treaty Arbitration: Privatizing Public International Law Through Inconsistent Decisions*, 73 FORDHAM L. REV. 1521 (2005); Anthea Roberts, *Clash of Paradigms: Actors and Analogies Shaping the Investment Treaty System*, 107 AM. J. INT'L L. 45 (2013); David Hacking, *Ethics, Elitism, Eligibility: A Response: What Happens if the Icelandic Arbitrator Falls Through the Ice?*, 15 J. INT'L ARB. 73, 74–75 (1998); Diane A. Desierto, *Rawlsian Fairness and International Arbitration*, 36 U. PA. J. INT'L L. 939 (2015).

227. In investment arbitration one study reveals that the top twenty-five arbitrators, which only account for 4% of all arbitrators, are appointed in over a third of all arbitration cases. Malcolm Langford, Daniel Behn & Runar Hilleren Lie, *The Revolving Door in International Investment Arbitration*, 20 J. INT'L ECON. L. 301, 310 (2017).

228. Daphna Kapeliuk, *The Repeat Appointment Factor: Exploring Decision Patterns of Elite Investment Arbitrators*, 96 CORNELL L. REV. 47, 68–78 (2010).

229. Andrea Cann Chandrasekher & David Horton, *Arbitration Nation: Data from Four Providers*, 107 CALIF. L. REV. 1, 2 (2019).

230. *See, e.g.*, Jan Paulsson, *Ethics, Elitism, Eligibility*, 14 J. INT'L ARB. 13, 19 (1997) ("Given the high stakes and great sensitives frequently involved in arbitration, there seems to be a good case for supporting the emergence and recognition of an elite corps of international arbitrators.").

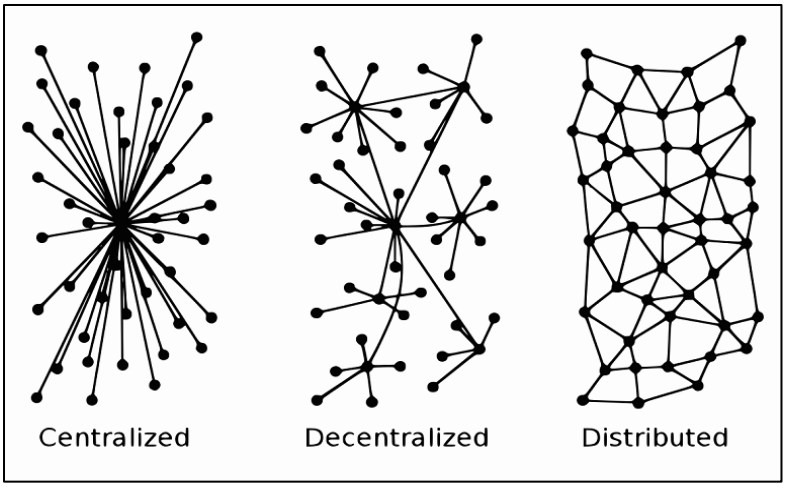
231. WHITE & CASE, 2018 INTERNATIONAL ARBITRATION SURVEY: THE EVOLUTION OF INTERNATIONAL ARBITRATION (2019), https://www.whitecase.com/sites/whitecase/files/files/download/publications/qmul-international-arbitration-survey-2018-19.pdf [https://perma.cc/7L3D-NAK5].

232. Alexander J.S. Colvin, *An Empirical Study of Employment Arbitration: Case Outcomes and Processes*, 8 J. EMPIRICAL LEGAL STUD. 1, 1 (2011).

demand the highest possible expertise of their judges and arbitrators."[233] Network-based dispute resolution simply promises that a wider network of individuals be available to disputants. Anonymization can also improve any biases that exist in current dispute resolution mechanisms.

A simple graph can demonstrate the difference between the judiciary, extrajudicial dispute resolution mechanism, and a possible blockchain-based dispute resolution. The centralized network best resembles the judiciary system while the decentralized network shows the existing dispute resolution system, in which some nodes attract most of the connections. The third graph shows the possibility of a blockchain-based dispute resolution in which everyone could have easy and equal access to all the nodes. As explained above, this system can mitigate the problem of repeat appointments and repeat players.

Figure 1:
Three Types of Network Connectivity



C. Smart Dispute Resolution Awards Are Enforceable

Blockchain-based dispute resolution may also obviate the need for judicial enforcement. For the dispute resolution to be effective, smart contracts should be designed to allow for direct enforcement mechanisms. For this reason, some existing startups have come up with solutions such

233. Kaal & Calcaterra, *supra* note 215, at 161.

as freezing the smart contract,[234] live contract,[235] or Ricardian contracts.[236] Although these efforts are still developing, they demonstrate a trend where contracts would include a built-in enforcement mechanism. The inclusion of an ex ante built-in enforcement mechanism shows another possible major breakthrough of the blockchain technology in dispute resolution.

One of the breakthroughs in globalization was the wide ratification of the New York Convention where 159 countries accepted to recognize and enforce international arbitral awards issued elsewhere.[237] The New York Convention allowed for limited reviewability by national courts prior to their recognition and enforcement of awards.[238] Blockchain technology, on the other hand, is promising a self-enforcement mechanism which is built into smart contracts.

This self-help feature of smart contracts[239] can have unprecedented challenges. One of the main developments could be the elimination of the reviewability function of national courts for dispute resolutions outside of the judiciary. This development has already begun where courts rarely review arbitral awards.[240] Courts can limit dispute resolution outside of

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234. *See, e.g.*, *Sagewise, Leading Smart Contract Dispute Resolution Company, Raises $1.25 Million Seed Funding, Led by Wavemaker Genesis*, BUS. WIRE (Aug. 7, 2018, 9:00 AM), https://www.businesswire.com/news/home/20180807005319/en/Sagewise-Leading-Smart-Contract-Dispute-Resolution-Company [https://perma.cc/2WM2-UBZB] ("The company's SDK provides the tools and infrastructure needed for the effective handling of disputes at any stage in the development and execution of smart contracts, freezing contracts in place while they are being resolved.").

235. The LTO platform creates an ad hoc private blockchain for each Live Contract. Such a blockchain is not intended as an immutable ledger but ensures all parties have an up-to-date countersigned history of events and shared states. . . . Live Contracts do not directly hold value but describe how two or more parties should interact. The intent is much closer to that of a traditional (paper) contract.

LTO NETWORK, BLOCKCHAIN FOR DECENTRALIZED WORKFLOWS 3, https://lto.network/documents/LTO%20Network%20-%20Technical%20Paper.pdf [https://perma.cc/M9VT-U724].

236. *See* MATTEREUM, *supra* note 210; *see also* Allen et al., *supra* note 210, at 85; Gupta, *supra* note 210.

237. Convention on the Recognition and Enforcement of Foreign Arbitral Awards art. V, June 10, 1958, 21 U.S.T. 2517, 330 U.N.T.S. 3; *Status: Convention on the Recognition and Enforcement of Foreign Arbitral Awards (New York, 1958) (the "New York Convention")*, UNCITRAL, https://uncitral.un.org/en/texts/arbitration/conventions/foreign_arbitral_awards/status2 [https://perma.cc/9HNL-HW3P].

238. Convention on the Recognition and Enforcement of Foreign Arbitral Awards, *supra* note 237, at art. V.

239. Raskin, *supra* note 18, at 333.

240. *See generally* FARSHAD GHODOOSI, INTERNATIONAL DISPUTE RESOLUTION AND THE PUBLIC POLICY EXCEPTION (2018) (showing the impact of the notion of transnational public policy on enforceability of arbitral award); Farshad Ghodoosi, *Fall of Last Safeguard in Global Dejudicialization: Protecting Public Interest in Business Disputes*, 98 OR. L. REV. 99 (2020) (showing with empirical data the decreasing importance of public policy review in the context of international commercial arbitration).

the judiciary. With blockchain technology, it is much harder for the judiciary to know of the existence of disputes since even enforcement of awards do not need judicial help.

CONCLUSION

Contracts are increasingly becoming digitized. In parallel, businesses are rapidly adopting digital contracts. Such digital (smart) contracts operate as self-executing, self-enforcing, automated contracts in which parties involved are often anonymous. This trend is a departure from the traditional notion of contracts, whereby consent and forward-looking promises play a pivotal role in ex ante formation and ex post enforcement of contracts.

The legal nature of smart contracts remains shrouded in ambiguity. For example, terms and conditions of the platform, the underlying platform codes, and smart contract codes may be conflicting when it comes to parties' obligations and the binding nature of smart contracts.[241] Moreover, the possibility of hacks or code failures always exist.[242] Given the new developments, this Article suggests that smart contracts should be analyzed through the lens of reliance-based contracting (similar to promissory estoppel or tort-based misrepresentation). Moreover, the reliance-based approach solves some of the problems posed by the consent-based approach in digital contracting. Further, this Article analyzes the new efforts aimed at the resolution of disputes on the blockchain platform. It identifies key features of blockchain-based dispute resolution that have the capability of modifying contractual disputes and the very act of contracting. The Article argues that blockchain-based dispute resolution results in seismic changes such as decentralized decision-making, network-based dispute resolution, and extrajudicial enforcement of decisions. More importantly, human connection and recognition can only be found in the dispute phase of contracting. This marks a shift from traditional contractual solidarity to digital solidarity.[243]

241. Kolber, *supra* note 20, at 217–26.

242. *See id.* at 203–04.

243. Markovits, *supra* note 206, at 469.