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Should Code Be Law?: Smart Contracts, Blockchain, and Boilerplate

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I. INTRODUCTION

"Smart contracts . . . guarantee a very specific set of outcomes. There's never any confusion and there's never any need for litigation."

~ Jeff Garzik[1]

"If the blockchain promise comes to a reality . . . most goods, labor and capital will be allocated through decentralized global platforms. Disputes will certainly arise."

~ Clément Lesaege and Federico Ast[2]

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* Blockchain-based "smart" contracts may characterize much of the future of exchange as they expand the scope of potentially efficient bargains through restructuring and reducing transaction costs relative to traditional contracts. This Article analyzes the changes in transaction costs and execution efficiencies as contractual "distance"—the number of intermediaries required to make an exchange, weighted by the rational level of actual agreement between parties—increases between bespoke contracts, template contracts, contracts of adhesion, and algorithmic contracts housed on platforms like Ethereum and arbitrated on platforms such as Kleros. This framework shows that smart contracts have the potential to lower the contractual distance required to make an exchange by (1) overcoming trust issues that require intermediaries, (2) lowering the incentive to write certain kinds of boilerplate, and (3) increasing the incentive to understand contractual terms. As a result, wide implementation of smart contracts may return contract law closer to the legal ideal of mutual understanding as the basis for exchange. At the same time, these auto-executing agreements risk making the future of contract law a return to the era of sealed instruments, enforcing themselves regardless of impossibility, fraud, and other legal safeguards. As examples of these costs and benefits, the Article focuses on smart contracts in two industries: the environmental public goods sector and the film industry. These industries illustrate the potential for smart contracts as well as steps that can be taken to ensure that as code becomes law, it will retain the doctrinal wisdom applied to contracts before they became "smart."

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[1] Jeff Garzik is the co-founder of Bloq, a popular blockchain services company. *See Bloq: Tokenization of Things*, BLOQ, https://www.bloq.com/ (last visited Feb. 13, 2019) ("Bloq delivers comprehensive, enterprise class blockchain solutions to business, while continuing to support innovation in the blockchain and open-source ecosystem."). The quote is widely cited in blockchain literature. *E.g.*, Joseph Aamidor, *Blockchain: Coming to a Smart Building Near You*, GREEN TECH MEDIA (Sept. 19, 2017), https://www.greentechmedia.com/articles/read/blockchain-coming-to-a-smart-building-near-you#gs.pJrdM3AM (quoting Garzik); Sue Troy, *What is a Smart Contract and What's It Good For*, TECH TARGET (Apr. 2016), https://searchcio.techtarget.com/feature/What-is-a-smart-contract-and-whats-it-good-for (quoting Garzik).

[2] Clément Lesaege & Federico Ast, *Kleros: Short Paper v1.0.6*, KLEROS (Nov. 2018), https://kleros.io/assets/whitepaper.pdf (motivating Kleros, a "decentralized application built on top of Ethereum that works as a decentralized third party to arbitrate disputes in every kind of contract, from very simple to highly complex ones. It relies on game theoretic incentives to have jurors rule cases correctly. The result is a dispute resolution system that renders ultimate judgments in a fast, inexpensive, reliable and decentralized way.").

Modern contract law is built on a theory of mutual understanding.[3] It should be troubling that the majority of modern contracts, using boilerplate-heavy forms, are largely not mutually understood.[4] This Article argues that "smart" contracts—code-based exchanges of value housed on blockchains—restructure and reduce transaction costs relative to traditional form contracts in ways that can incentivize mutual understanding. They have the potential to increase actual "meeting of the minds," even while facilitating market interactions between physically and socially remote parties. This is possible because smart contracts (1) use shared digital ledgers to eliminate trust issues and contractual intermediaries, (2) reduce costs to record and transfer property rights, especially for fractional amounts, and (3) upfront many of the transactions costs to contract, as parties must overcome ambiguity and deal with eventualities when trusting their agreement to code.[5] Together, these decrease the incentive for drafters to write certain kinds of boilerplate, increase the incentive for acceptors to understand contractual terms, and have the potential to return contracting closer to a "legal regime grounded in actual agreement with common understanding."[6]

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[3] *See* DANIEL MARKOVITS, CONTRACT LAW AND LEGAL METHODS 1240-41 (2012) (good faith work towards a shared project, by non-intimates, in the face of imperfect planning, is at contract's "core," differentiating itself from tort and fiduciary obligation as a distinct legal doctrine).

[4] *See* Robin Bradley Kar & Margaret Jane Radin, *Pseudo-Contract and Shared Meaning*, 132 HARV. L. REV. 1135, 1140 (2019) (arguing that the boilerplate dominating modern contract law should be termed "pseudo-contract"); *see generally* HAROLD J. BERMAN, LAW AND REVOLUTION: THE FORMATION OF THE WESTERN LEGAL TRADITION 34-35 (1983) ("[W]hat was previously conceived to be private law has also been transformed in the twentieth century by the radical centralization and bureaucratization of economic life ... Contract law, for example, which has traditionally been viewed in all Western legal systems as a body of rules for giving effect to voluntary legal agreement according to the intent of the parties, within limits set by broad public policies, has in the twentieth century struggled to adapt itself to a wholly new economic situation in which the detailed terms of the most important kinds of contracts are specifically required by legislation or else set forth in standard forms presented by large-scale business organizations on a take-it-or-leave-it basis.").

[5] For example, smart contracting would typically reduce the cost of observability and verification in execution. Joshua S. Gans, The Fine Print in Smart Contracts (Jan. 13, 2019) (unpublished manuscript), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3309709. *See also* Jeremy M. Sklaroff, *Smart Contracts and the Cost of Inflexibility*, 166 U. PENN. L. REV. 263, 291 (2017) (discussing the inefficiencies in requiring code to reflect human linguistic exchange). In Sklaroff's framework, the lack of inflexibility is a "major challenge" to the technology. *Id.* In our view, the lack of flexibility leads to positive changes in the incentives of party to create boilerplate adhesion contracts. On trust, *see* Trevor I. Kiviat, *Beyond Bitcoin: Issues in Regulating Blockchain Transactions*, 65 DUKE L.J. 569, 574 (2015) ("In short, the blockchain is a 'trustless' technology. 'Trustless' means—for the first time in history—exchanges for value over a computer network can be verified, monitored, and enforced without the presence of a trusted third party or central institution. Because the blockchain is an authentication and verification technology, it can enable more efficient title transfers and ownership verification. Because it is programmable, it can enable conditional 'smart' contracts. Because it is decentralized, it can perform these functions with minimal trust without using centralized institutions. Because it is borderless and frictionless, it can provide a cheaper, faster infrastructure for exchanging units of value.") (footnotes omitted).

[6] Kar & Radin, *supra* note 4, at 1140.

The long history of contract is a story of law interacting with the technology facilitating agreement, such as printing or information technology.[7] Blockchain is no exception.[8] The ability of blockchains to record, execute, and enforce code-based exchanges holds immense promise to increase the contractual surplus available to parties.[9] It is likely not exaggerating to suggest that as

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[7] *See infra* Section 2.

[8] That blockchain is the "future" is touted of such disparate disciplines and endeavors as law, accounting, finance, agriculture, and entertainment. *See, e.g.*, Hugh Son, *JP Morgan Rolls out First US Bank-Backed Cryptocurrency to Transform Payments Business*, CNBC (Feb. 14, 2019), www.cnbc.com/2019/02/13/jp-morgan-is-rolling-out-the-first-us-bank-backed-cryptocurrency-to-transform-payments--.html; Andrew Arnold, *The Agricultural Supply Chain Can Massively Benefit From Blockchain,* FORBES (Sept. 14, 2018), https://www.forbes.com/sites/andrewarnold/2018/09/14/the-agricultural-supply-chain-can-massively-benefit-from-blockchain/#ae83ef190235 ("The use of blockchain could feasibly result in . . . greater trust in global food growers and suppliers would be established, because fraudulent certifications and labeling could be eliminated."); Benny L. Kass, *Does the Future Of Real Estate Include Blockchain Technology?*, WASH. POST (July 13, 2018), https://www.washingtonpost.com/realestate/does-the-future-of-real-estate-include-blockchain-technology/2018/07/12/0a556a50-7bdf-11e8-aeee-4d04c8ac6158_story.html?noredirect=on&utm_term=.9bec082bbd92 ("The Swedish government recently started using Blockchain to register land and properties"); Ana Alexandre, *IBM and Jewelry Industry Leaders to Use Blockchain to Trace Origin of Diamonds,* COIN TELEGRAPH (Apr. 27, 2018), https://cointelegraph.com/news/ibm-and-jewelry-industry-leaders-to-use-blockchain-to-trace-origin-of-diamonds (use of blockchain in "aiming to assure customers that their jewelry purchases are ethically sourced"); Sunny Dhillon, *How Blockchain Can Transform the Future of Entertainment,* FORBES (Feb. 1, 2018), https://www.forbes.com/sites/valleyvoices/2018/02/01/how-blockchain-can-transform-the-future-of-entertainment/#
90505c86b6b5 ("This technology solves the problems surrounding content access, distribution and compensation; managing assets and digital rights; and financing."); Bernard Marr, *This Is Why Blockchains Will Transform Healthcare,* FORBES (Nov. 29, 2017), https://www.forbes.com/sites/bernardmarr/2017/11/29/this-is-why-blockchains-will-transform-healthcare/#6213d2501ebe (discussing how society can use blockchain "to ... create a common database of health information that doctors and providers could access no matter what electronic medical system they used, higher security, and privacy, less admin time for doctors so there's more time to spend on patient care, and even better sharing of research results"); Lisa Walker, *This New Carbon Currency Could Make Us More Climate Friendly,* WORLD ECONOMIC FORUM (Sept. 19, 2017), https://www.weforum.org/agenda/2017/09/carbon-currency-blockchain-poseidon-ecosphere/ (noting blockchain "will be able measure, track and trade emissions transparently.").

[9] *See, e.g.*, Michael Corkey & 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 ("By this time next year, more than 100 farms that supply Walmart with leafy green vegetables will be required to input detailed information about their food into a blockchain database."); Kate Rooney, *84% Of Companies Are Dabbling in Blockchain, New Survey Says,* CNBC (Aug. 27, 2018), https://www.cnbc.com/2018/08/27/84percent-of-companies-are-dabbling--in-blockchain-new-survey-says-.html ("Everyone is talking about blockchain, and no one wants to be left behind."); Kevin Parrish, *Google Bets on Blockchain Technology with Two New Google Cloud Partnerships,* DIGITAL TRENDS (July 23, 2018), https://www.digitaltrends.com/computing/google-cloud-platform-to-support-blockchain-tech/ ("Google now supports distributed ledger technology, aka blockchain, on the Google Cloud Platform."); Muyao Shen, *Facebook Has a New Director of Engineering for Blockchain,* COINDESK (July 6, 2018), https://www.coindesk.com/facebook-appoints-new-blockchain-engineering-director/

technological hurdles are reduced and more physical assets are given digital representations, blockchain-based contracts will replace traditional contracting in many applications.[10]

Consider an example of how recording and transferring property rights on a blockchain might look in practice, compared to traditional exchanges. In the film industry, the basic economic exchange is the viewer's payment given in exchange for the right to view a piece of art. This exchange is facilitated by a vast number of intermediaries. A movie studio might engage in an outside source of funding, hiring a director and producer who then manage production and hire actors. The studio then markets the film and collects funds from theatres as viewers attend. These intermediaries are required to establish the trust needed to secure initial funding in this high-risk business, and trust issues between the intermediaries themselves necessitate long contracts of adhesion covering many eventualities. Smart contracts offer an alternative. Consider the company DECENT,[11] a global blockchain-based distribution platform, launched by Matej Michalko and Matej Boda[12] to overcome the increasing impact of concentrated power in the

("In May that the company launched a team specifically to explore this emerging technology."); Kate Rooney, *Amazon Is Moving into Blockchain with a New Partnership,* CNBC (May 15, 2018), https://www.cnbc.com/2018/05/15/amazon-is-moving-into-blockchain-with-a-new-partnership.html ("The tech giant's cloud computing arm is partnering with a start-up called Kaleido to make it easier for customers to put their services on blockchain."); Hugh McIntyre, *Spotify Has Acquired Blockchain Startup Mediachain,* FORBES (Apr. 27, 2017), https://www.forbes.com/sites/hughmcintyre/2017/04/27/spotify-has-acquired-blockchain-startup-mediachain/#3cbf573969ee ("Many are touting blockchain companies like Mediachain as potential saviors of the industry, as they can typically help not only with correcting payouts, but doing so in a more transparent and efficient manner."). Undoubtedly some of these sources reflect hype or publicity rather than sound forays into the future, but technology is often overestimated in the short run and underestimated in the long run. *See* Stuart D. Levi & Alex B. Lipton, *An Introduction to Smart Contracts and Their Potential and Inherent Limitations*, HARV. L. SCH. F. ON CORP. GOVERNANCE & FIN. REG. (May 26, 2018), https://corpgov.law.harvard.edu/2018/05/26/an-introduction-to-smart-contracts-and-their-potential-and-inherent-limitations/ ("Today, smart contracts are a prototypical example of 'Amara's Law,' the concept articulated by Stanford University computer scientist Roy Amara that we tend to overestimate new technology in the short run and underestimate it in the long run.").

[10] Some have argued that the term "smart contract" is a misnomer, as "'smart contracts' are neither smart nor contracts." James Grimmelmann, *All Smart Contracts Are Ambiguous*, PENN J. L & INNOVATION (forthcoming 2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3315703 (quoting Ed Felten, *Smart Contracts: Neither Smart nor Contracts?*, FREEDOM TO TINKER (Feb. 20, 2017), https://freedom-to-tinker.com/2017/02/20/smart-contracts-neither-smart-notcontracts/). We discuss smart contracts both as "mechanisms that enforce agreements," *id.*, but also as embodying the entire agreement between parties. In our view, both are "smart contracts" meriting discussion.

[11] DECENT stands for Decentralized Network; Encrypted and Secure; Content Distribution System; Elimination of 3rd Parties; New Way of Online Publishing; Timestamped Data Records. *See* DECENT, *What is DECENT?*, https://decent.ch/ (last visited Feb. 26, 2019).

[12] *See* Michael Scott, *Decent Launches Global Media Distribution Platform*, BITCOIN MAG. (June 30, 2017), https://bitcoinmagazine.com/articles/decent-launches-global-media-distribution-platform/ (the initial funding for the platform was granted by an ICO that was able to raise an equivalent of $4.2 million at the time).

entertainment sector. Through DECENT, creators are able to distribute (e.g., stream) digital content in a peer-to-peer fashion. Dealing with the blockchain-based system requires additional up-front investment, but then avoids the cost of third-party fees. The founders sought to ease access into the digital entertainment market by lowering the barriers of entry often placed upon incoming content creators. Through the platform, creators can share any type of content, from audiobooks to video files. The content remains void of influence from third parties, and creators have freedom in setting their own IP rights and prices.[13] As a result of its blockchain-based nature, nothing may be removed or censored on the platform, and transactions take place without costly intermediaries.[14]

These potential efficiency gains for smart contracting versus traditional contracting currently face two significant challenges: rendering contracts to code requires a specialized, non-legal skillset, and moving representation of physical assets into digital spaces (referred to as "tokenizing") is currently limited.[15] Rendering an exchange to code-based form requires expertise not typically developed during law school, nor accessible to the average attorney. For example, smart contracts housed on the Ethereum blockchain network are written in a language called Solidity, "an object-oriented, high-level language . . . influenced by C++, Python and JavaScript . . . . Solidity is statically typed, supports inheritance, libraries and complex user-defined types among other features."[16] This is language generally used in computer science, not in contract law. Even if the language is mastered and a contract drafted, digital contracts can only supplement traditional agreements unless the subject matter of the contract has some representation in digital form. When the asset to be exchanged is itself digital, like Bitcoin or Ethereum ether, this is not a problem, but creating a digital representation of a typical rental agreement is challenging.[17] These barriers

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[13] For a discussion of extended issues in blockchain and smart contract copyright issues, *see* Balázs Bodó, Daniel Gervais, & João Pedro Quintais, *Blockchain and Smart Contracts: The Missing Link in Copyright Licensing?*, 26 INT'L J. L. & INFO. TECH. 311 (2018).

[14] This presents issues in solving disputes between creators as it makes involvement from centralized institutions of justice impractical. Federico Ast, Clément Lesage and Nicolas Wagner foresaw this massive issue with the development of decentralized economies and developed a decentralized dispute resolution platform known as Kleros. *See* KLEROS, *The Blockchain Dispute Resolution Layer*, https://kleros.io/ (last visited Feb. 26, 2019). If DECENT chose to implement Kleros into their smart contracts one could flag another's film as containing plagiarized material belonging to her, an anonymous jury would then decide if the claim was accurate and decide how much revenue should be redirected.

[15] *See* Founder Starcoin, Inc. v. Launch Labs, Inc., No. 18-CV-972 JLS (MDD), 2018 U.S. Dist. LEXIS 1137372018, at *113757 (S.D. Cal. July 9, 2018) ("Tokens are the native crypto-assets of a blockchain app.").

[16] SOLIDITY, *Solidity*, https://solidity.readthedocs.io/en/v0.5.3/ (last visited Feb. 16, 2019).

[17] The ability to enter an apartment could be given based on using a smartphone to access the state of a variable on the blockchain, which would be keyed to whether rent has been paid or not. These require additional programming skills beyond Solidity itself. *See Smart Tenancy Contracts*, SMART CONTRACT LEASING: THE BLOCKCHAIN LEDGER, https://smartcontractleasing.io/smart-tenancy-contracts/ (last visited Feb. 26, 2019) (describing the steps to establish blockchain-based lease

involved in implementing smart contracts restrict their use to novelty frameworks or when very specific transactional gains exist, such as transferring large sums of money more quickly than possible with wire transfer.[18]

If, and when, these technological barriers shrink and these types of exchanges become common, they have the potential to transfigure how assets are recorded and transferred.[19] With this potential in mind, it is instructive to carefully consider how smart contracting relates to the long history of exchange, the transactions costs involved in bargains, and how the law has, at various times, dealt with those costs. We organize this history around the idea of the contractual "distance" required to make an exchange, equal to the number of intermediaries needed to facilitate the bargain, weighted by the rational level of actual agreement between parties.[20] A simple point-of-sale contract has low contractual distance, as buyer and seller negotiate and then exchange assets without the need for

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agreements). *See generally* PRIMAVERA DE FILIPPI & AARON WRIGHT, BLOCKCHAIN AND THE LAW: THE RULE OF CODE 77 (2018) ("Smart contracts—at least for the immediate future—will not be able to account for these more open-ended rights and obligations.").

[18] For example, the Bitcoin transaction fee is independent of the actual quantity of coin being transferred. From a computational perspective, changing a ledger entry by one is no different than changing a ledger entry by one million.

[19] With large potential efficiency gains but equally large technological hurdles for parties, blockchain-based smart contracts are similar to a disruptive technology. Disruptive technologies start as non-premium products, ignored by main market competitors focused on higher-margin areas. Over time, the disruptive technology improves, and eventually swallows the larger market. As the technical barriers to implementing smart contracts fall, their potential areas for practical use are exploding. As these changes continue, what is currently a very specialized niche relative to traditional contracting will begin to impact the law, perhaps even to the point it will replace lawyers and traditional dispute resolution mechanisms to a large extent. *See generally* CLAYTON M. CHRISTENSEN, THE INNOVATOR'S DILEMMA: WHEN NEW TECHNOLOGIES CAUSE GREAT FIRMS TO FAIL (1997); Clayton M. Christensen, Michael E. Raynor & Rory McDonald, *What is Disruptive Innovation*, HARV. BUS. REV. 44 (2015), https://hbr.org/2015/12/what-is-disruptive-innovation (revisiting disruptive innovation after twenty years).

[20] *See* Anselm Lenhard, *Origin and Distribution of Debt: Risks and Regulatory Solutions*, 2 EUR. J. RISK REG. 340, 345 (2011) (discussing the "contractual 'distance' between the borrower [of a loan] and the ultimate holder of the risk," and characterizing contractual distance as "zero" when the borrower and lender have a direct contract, and "increasing" when the loan is sold); *cf.* Peter T. Leeson, *Social Distance and Self-Enforcing Exchange*, 37 J. LEG. STUD. 161, 164 (2008) ("Social distance is the extent to which individuals share beliefs, customs, practices, appearances, and other characteristics that define their identity."); *id.* at 162 ("A burgeoning literature highlights the success of self-enforcing exchange relationships between socially homogenous agents. Inside small, homogenous social groups, in which the social distance between actors is minimal, individuals can rely on reputational mechanisms of ex post enforcement to ensure cooperation."). *See generally* Robert A. Levine & Merry White, *Parenthood in Social Transformation*, *in* PARENTING ACROSS THE LIFE SPAN: BIOSOCIAL DIMENSIONS 275 (Jane B. Lancaster, Jeanne Altmann, Alice S. Rossi, & Lonnie R. Sherrod eds., 1987) (discussing "contractual distance" between workers and firms and the process of industrialization); Eyal Zamir, *The Inverted Hierarchy of Contract Interpretation and Supplementation*, 97 COLUM. L. REV. 1710, 1788 (1997) (discussing the "distance" between policymakers and citizens in context of contract law); George A. Akerlof, *Social Distance and Social Decisions*, 65 ECONOMETRICA 1005, 1008-11 (1997) (modeling social distance between individuals and the utility they derive from similar behavior).

intermediaries, with terms generally easy to understand (e.g., exchange of a good, for a price, subject to warranties on the good).[21] The exchange occurs because the transactions costs required to make it are less than the benefits generated by the deal.[22] A typical real estate contract has higher contractual distance, as trust issues require paying for the services of a costly third-party intermediary to hold funds in escrow until closing, and parties find it rational to sign stacks of documents without reading them at closing.[23] A consumer adhesion contract would similarly have higher contractual distance, as the parties may not need intermediaries, but the boilerplate means the non-drafter typically finds the costs of reading exceed its benefits.[24]

The development of contract might be characterized as technology facilitating exchange at increasingly greater contractual distance, with the law struggling to catch up. While kinship networks and trusting relationships likely characterized the beginnings of exchange, at low contractual distance,[25] large

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[21] A consumer might not understand the technicalities of U.C.C. warranties, but most consumers have a sense that, e.g., the store selling the good likely has the right to sell it (title), that the good shouldn't be defective (merchantability), and so on.

[22] This exchange benefits not only the parties themselves, but the sociality of the market generally. *See* Daniel Markovits, *Contract and Collaboration*, 113 YALE L.J. 1417, 1517-18 (2004) ("[P]romises and contracts enable persons to cease to be strangers and to attend to their basic needs for community-as expressed in Arendt's idea of 'the will to live together with others in the mode of acting and speaking' contract also enlists persons' broader ethical interests in the service of overcoming egocentrism. Going forward, I will seek to develop these ideas and to display *the characteristically liberal forms of social solidarity that contract encourages*-forms of solidarity that do without intimacy and so avoid the taint of the clan. I shall try, in effect, to trace the progress of sentiments that defuse egocentrism by analogy to the way in which Hume traced the progress of sentiments that defuse egoism. I shall claim that the practice of contract - through the collaborative ideals that it involves - plays an essential role in this progress. I shall therefore seek to reject the common view that, regardless of their efficiency or other instrumental attractions, contract and other market-based practices present an intrinsically debased form of human interaction, in which persons are motivated by the uglier forms of self-interest, including most notably fear and greed. This view underestimates, to my mind, *the deeply and intrinsically communal character of contractual and market relations, and ignores these relations' contributions to addressing the threats to social solidarity that egoism and egocentrism pose.*") (emphasis added); *id.* at 1517 ("[C]ontract–and through contract the market–has an effect on the reasons persons have, and not just the characters that they display, that supports a particularly ambitious, liberal solution to the problem of social unity.").

[23] *E.g.*, LAWRENCE M. FRIEDMAN, A HISTORY OF AMERICAN LAW 404 (2005) ("The law of contract was essentially negative. Its doctrines gave more or less free play to individual choice. What people freely agreed on, courts would enforce ... Not much of this body of law changed fundamentally between 1850 and 1900—nothing compared to the transformation of tort law, or the law of corporations. Old technicalities [e.g., seals] had been dismantled long before 1850.").

[24] Some would go so far as to refer to a boilerplate adhesion contract as pseudo-contract. Kar & Radin, *supra* note 4, at 1140 ("'[T]erms'—which now include enormous streams of boilerplate text that are delivered but never read by anyone—are no longer terms with shared meaning. . . . The fake 'terms' in a pseudo-contract invite burgeoning forms of deception that are difficult for courts to discern because they are hidden under the mantle of 'contract.'").

[25] *E.g.*, MARCEL MAUSS, THE GIFT: THE FORM AND REASON FOR EXCHANGE IN ARCHAIC SOCIETIES 70 (W.D. Halls, trans., W.W. Norton & Company, Inc. 1990) (1950) ("The system that we propose to

business entities able to set their own adhesion-based contractual terms, often relying on third-party intermediaries, came to dominate most individuals' expectations of contract law.[26] The advent of duplicate copying in the twentieth century facilitated these kinds of contracts, which reached their heyday in the internet era that provided the ability to link to reams of digital boilerplate.[27] In other words, rather than two parties bargaining in individually-negotiated, bespoke transactions, as enterprises became larger and deals more complex, the number of steps and costs involved multiplied, enforced with form contracts. The law came along in fits and spurts. The early common law focused on sealed instruments, enforceable even against arguments going to the heart of the modern assent theory of contract, such as fraud.[28] Perhaps due to legal inadequacies like these, the medieval law merchant created a semi-independent decentralized enforcement system for exchanges and dispute resolution.[29] Eventually, the intervention of

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call the system of 'total services', from clan to clan–the system in which individuals and groups exchange everything with one another–constitutes the most ancient system of economy and law that we can find or of which we can conceive."); *cf.* Markovits, *supra* note 222, at 1419 ("Promises lie at the center of persons' moral experience of one another, and contracts lie at the center of their legal experience of one another. Many of the most important relationships in our moral and legal culture characteristically arise in connection with promises and contracts of some form or other: Persons' families are connected to marriage promises, their work is connected to employment contracts, and even their citizenship is connected (albeit metaphorically) to the social contract. In all these cases, and in myriad others, promises and contracts establish relations among the persons who engage them."); Yannis Bakos, Florencia Marotta-Wurgler, & David R. Trossen, *Does Anyone Read the Fine Print? Consumer Attention to Standard-Form Contracts*, 43 J. LEG. STUD. 1, 1 (2014) ("Standard-form contracts, often called fine print or boilerplate, are the most common type of economic contract. They apply to untold billions of commercial transactions per year."); Russel Korobkin, *Bounded Rationality, Standard Form Contracts, and Unconscionability*, 70 U. CHIC. L. REV. 1203, 1203 (2003) ("[N]early all commercial and consumer sales contracts are form driven.").

[26] W. David Slawson, *Standard Form Contracts and Democratic Control of Lawmaking Power*, 84 HARV. L REV 529, 529 (1971) (noting that as of 1971 "[s]tandard form contracts probably account for more than ninety-nine percent of all the contracts now made. Most persons have difficulty remembering the last time they contracted other than by standard form; except for casual oral agreements, they probably never have. But if they are active, they contract by standard form several times a day. . . . Moreover, standard forms have come to dominate more than just routine transaction. . . . The contracting still imagined by courts and law teachers as typical, in which both parties participate in choosing the language of their entire agreement, is no longer of much more than historical importance.").

[27] *See* Kar & Radin, *supra* note 4, at 1140-41 (describing the history of the technology of form contracts).

[28] JOHN H. LANGBEIN, RENEE LETTOW LERNER, & BRUCE P. SMITH, HISTORIC OF THE COMMON LAW: THE DEVELOPMENT OF ANGLO-AMERICAN LEGAL INSTITUTIONS 322 (2009) ("Seal or record was conclusive on questions of liability, and accordingly, at common law the defenses of 'fraud, failure of consideration, and accord and satisfaction were not pleadable. . . .'") (quoting WILLIAM T. BARBOUR, THE HISTORY OF CONTRACT IN EARLY ENGLISH EQUITY 23 (1914)). A sealed record even prevent a plea of discharge, unless the discharge was evidenced by, e.g., another seal. *Id.*

[29] *See* BERMAN, *supra* note 4, at 346-47 (1983) ("Market and court fairs . . . were non-professional community tribunals; the judges were elected by the merchants of market or fair from among their numbers . . . . In some countries, royal authority was asserted over merchant guilds and over town markets and fairs, but even then the law merchant continued, in general, to be administered by

equity reduced the importance of sealed instruments, and the law developed a slate of legal doctrines aimed at protecting parties transacting at high distance.[30]

The genius of smart contracts is their ability to bring exchange, and law, full circle, facilitating bargains by lowering contractual distance for complex transactions at each step: removing the need for intermediaries *and* raising the rational level of actual agreement between parties.[31] Consider again the film financing example. The exchange between consumers and producers of film at the heart of modern film-making is an incredibly high-distance transaction, requiring agreements between multiple intermediaries, many of which will be formalized with layers of boilerplate. A blockchain-based platform links creators with consumers in one step, without intermediaries, and polices eventualities through digital terms that rely on auto-execution of conditional statements rather than reams of boilerplate. It can do this because trust issues lie at the heart of both intermediaries and boilerplate: intermediaries are needed, at least in part, because the parties cannot directly engage; boilerplate is needed, at least in part, because the drafter does not fully trust the accepting parties and wishes to include contractual terms covering the many possible ways they may breach.[32] In this way, smart contracts offer an economic solution to the problem of agreement over boilerplate—they incentivize bringing mutual understanding out of the shadow of the contract and into the light, as parties are motivated to understand their agreement and the code memorializing it.[33] Fittingly, one logo used to promote

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merchant judges.... In all types of commercial courts the procedure was marked by speed and informality. Time limits were narrow: in the fair courts justice was to be done while the merchants' feet were still dusty. . . . Often appeals were forbidden. Not only were professional lawyers generally excluded but also technical legal argumentation was frowned upon.").

[30] LANGBEIN ET AL., *supra* note 28, at 323.

[31] *E.g.*, DE FILIPPI & WRIGHT, *supra* note 17, at 81 ("By decreasing the risk of opportunistic behavior, smart contracts open up new avenues for commercial relationships, potentially facilitating an increasing range of economic activities between untrusting parties. . . . When entering into an arrangement involving a smart contract, parties only need to trust that the code accurately memorializes their intent and that the nodes responsible for maintaining the network will properly execute the smart contract code.").

[32] This justification focuses on the underlying need for boilerplate, rather than analyzing the goals a particular seller may have in drafting boilerplate. *See* David Gilo & Ariel Porat, *The Hidden Roles of Boilerplate and Standard- Form Contracts: Strategic Imposition of Transaction Costs, Segmentation of Consumers, and Anticompetitive Effects*, 104 MICH. L. REV. 983, 986-87 (2006) (noting four ways in which drafters may use boilerplate to achieve goals: (1) to segment customers, (2) to stabilize cartels, (3) to deceive customers, and (4) to signal non-negotiability of contract terms). In Grimmelmann, *supra* note 10, at 2, the argument is that "[s]mart contracts do not eliminate ambiguity—they hide it." In our view, they increase incentive to understand and deal with ambiguity at the drafting stage rather than relying on dispute resolution mechanisms after drafting.

[33] Jason Scott Johnston, *The Return of Bargain: An Economic Theory of How Standard-Form Contracts Enable Cooperative Negotiation Between Businesses and Consumers*, 104 MICH. L. REV. 857, 864 (2006) ("[F]irms and individual consumers and employees do not bargain over standard-form terms, they actively bargain in the shadow of those terms.").

smart contracts is a digital-appearing handshake, combining the idea of digital efficiencies with low-distance contractual exchange.[34]

At the same time, the nature of code itself may tend towards obfuscation, and so for smart contracts to enhance agreement, parties must have sufficient incentive to actually understand code. This movement also risks ignoring the doctrinal wisdom developed through centuries of common lawmaking—a body of knowledge slowly evolved in response to real-life dilemmas as judges struggled to enforce bargains.[35] For example, the benefits from reducing contractual distance between parties risks re-adopting the injustice of sealed instruments. An inherent feature of smart contracts is their adherence to code—a digital writing that executes a series of steps the same way, every time. The nature of the blockchain makes this requirement rigid: a smart contract housed on a blockchain must be precisely the same on every node of the chain, or else the blockchain will be brought into disagreement with itself. Because of this, smart contracts lack the possibility of acting on fuzzy logic or matching imprecise states of the world.[36] Contracts that execute automatically regardless of the state of the world (absent information from oracles, which must push the same information to all nodes on the blockchain) risk acting remarkably similar to the seal on a historical instrument, enforcing an agreement as code executes regardless of principles of equity. Unreservedly embracing a contracting system that potentially ignores this history by shouting the praises of self-executing bargains should give us pause, especially as the law policing even traditional form contracts remains controversial.[37]

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[34] *See* Ameer Rosic, *Smart Contracts: The Blockchain Technology that Will Replace Lawyers*, BLOCKGEEKS, https://blockgeeks.com/guides/smart-contracts/ (last visited Feb. 16, 2019), (representing smart contracts as two hands emerging from a digital-appearing background, shaking). At the same time, these digital representations of legal relationships face the same problem as digital representations of human relationships in social media. Social networks can facilitate exchange of ideas and information among peer groups, but are at the same time often impersonal, giving sometimes the veneer of sociality at the cost of face-to-face human interaction. Blockchain-based contracting can facilitate exchange among many parties without intermediaries, lowering contractual distance between parties, but does so without the human interaction that characterized historical low-distance contracts. As with blockchain itself, smart contracting enables the sociality of the market whether the parties would naturally engage in trusting behavior or not. *See* Nancy R. Buchan, Rachel T. A. Croson & Robyn M. Dawes, *Swift Neighbors and Persistent Strangers: A Cross- Cultural Investigation of Trust and Reciprocity in Social Exchange*, 108 AM. J. SOCIOLOGY 168, 170, 200 (2002) (examining cooperation among "neighbors" and "strangers" in various cultural settings and finding that trusting behavior declined significantly when moving from neighbors to strangers).

[35] *See* Kar & Radin, *supra* note 4, at 1140.

[36] Smart contracts can reference the outside world, but must do so through an "oracle," a source of outside information that pushes the *same* outside information to each node on the chain at the same time.

[37] *See infra* the quotations heading the introduction, showing fundamental disagreement as to the scope of what code can or should accomplish; Kar & Radin, *supra* note 4, at 1142 ("As a result of a largely unconscious paradigm slip in contract law, many courts and scholars now assume that all boilerplate text contributes 'terms' to a 'contract' in largely unproblematic ways akin to the simpler uses of language to form contracts in 1883. They assume that pseudo-contractual text should be enforced as 'contract' with minimal requirements of 'assent,' unless there is some standard contract

The remainder of this Article reconciles these costs and benefits of smart adhesion contracts. The next section provides background on blockchain technology generally, and the following section describes the evolution of contract as technology moves toward blockchains. Examples from the environmental public goods and film industry then illustrate smart contracts in the wild. The fourth section uses an economic transactions-cost framework comparing traditional versus smart bespoke contracts, template contracts, and adhesion contracts, illustrating the interplay of intermediaries, externalities, and transactions costs with contractual distance. The final section offers suggestions for how courts and parties might approach smart contracting to maximize the gains from large blockchain-enabled contractual surplus.[38]

II. THE EVOLUTION OF THE EXCHANGE AND CONTRACTUAL DISTANCE

A. "But We Shook on It"—Relationship-Based Contracting

The existence of contract law, that is, the presence of a legal regime which will enforce voluntary private obligations, likely began with relationship-based exchanges.[39] Gift-giving, outcasting the dishonorable and religious conceptions of promise and obligation governed exchange, identifying the exchange with the social identity of the parties involved. As the common law developed, English legal thinking evolved a set of formal rules to govern exchange of value, particularly as pertaining to the creditor-debtor relationship.[40] In the medieval era, what we would term contract law hinged on the formality of sealed instruments.[41] A seal was a piece of wax imprinted with a symbol, equivalent in use to a modern signature, that was affixed to the physical document with the written agreement.[42] Absent allegations such as forgery, the presence of a seal made a bargain enforceable, even against arguments going to the heart of the modern assent theory

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law obstacle to enforcement arising from something like illegality or unconscionability. This is to treat pseudo-contract as contract without adequate reflection. A major noncontractual intrusion into the traditional sphere of contract law and modern market activity has gone largely unrecognized; or, at least, the full depths and problematic nature of the intervention have escaped widespread notice.").

[38] If boilerplate is named after the thick metal shielding passengers from steamboat boilers, then smart contracts can potentially replace the boiler with a digital engine, all parts accessible from the outside, without need of protective shielding.

[39] *See, e.g.*, MAUSS, *supra* note 255, at 70.

[40] *See* LANGBEIN ET AL., *supra* note 28, at 311.

[41] *See* A. W. B. Simpson, *The Penal Bond with Conditional Defeasance*, 82 L. QUART. REV. 392 (1966) ("Far and away the majority of actions on contracts brought in the common law courts in medieval times were actions of debt *sur obligation*; in such actions the plaintiff had to produce a sealed instrument whereby the defendant had acknowledged himself to the debtor of the plaintiff.") (quoted in LANGBEIN ET AL., *supra* note 2828, at 321).

[42] *Id.*

of contract, such as fraud, or to equitable principles like impossibility.[43] Thus, the phrase "seal the deal" was good legal advice.[44]

As Chancery developed in response to inequities arising from the common law, it attacked the fixation of the common law on seals, giving relief to debtors from creditors seeking double payment from those who had paid but not complied with the formalities of the seal.[45] Equitable principles entered contract law, and through the eighteenth century the law centered on the fairness or justice of an exchange.[46] During the nineteenth century, the modern doctrine of contract—centering on a meeting of the minds—developed, leaving the central idea of fairness and adopting the view that so long as consideration was exchanged voluntarily, courts would not question the underlying justice of the exchange.[47] With this doctrinal change focusing on the wills of the parties, the formality of the seal gradually left common use, although it lives on in practices such as today's notary seal.[48] In parallel, much of the commercial life of Europe and England involved a much different legal system. The law merchant governed commercial exchanges without great formality or the use of professional attorneys, applying quick equitable principles to solve problems with exchange.[49]

Despite these doctrinal legal changes over the centuries, the public conception of contracts retains its roots of identity, honor, and community. The deep cultural significance of the handshake deal and its breach illustrates this.[50]

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[43] LANGBEIN ET AL., *supra* note 288, at 322 ("Seal or record was conclusive on questions of liability, and accordingly, at common law the defenses of 'fraud, failure of consideration, and accord and satisfaction were not pleadable ....'") (quoting WILLIAM T. BARBOUR, THE HISTORY OF CONTRACT IN EARLY ENGLISH EQUITY 23 (1914)). A sealed record even prevented a plea of discharge, unless the discharge was evidenced by, e.g., another seal. *Id.*

[44] *Id.*

[45] *Id.* at 323.

[46] MORTON J. HORWITZ, THE TRANSFORMATION OF AMERICAN LAW 164 (1979) ("Modern contract law is fundamentally a creature of the nineteenth century. It arose both in England and America as a reaction to a criticism of the medieval tradition of substantive justice that, surprisingly, had remained a vital part of eighteenth-century legal thought, especially in America. Only in the nineteenth century did judges and jurists finally reject the longstanding belief that the justification of contractual obligation is derived from the inherent justice or fairness of an exchange.").

[47] *See id.* (there is some disagreement about the motivations for the change in contractual doctrine).

[48] The notary's seal today is an embossment rather than a wax seal. *See* Karla J. Elliott, *The Notarial Seal – The Last Vestige of Notaries Past*, 31 J. MARSHALL L. REV. 903, 903-904 (1998) (discussing the role of the notary from medieval seisin ceremonies, at which parties symbolically exchanged dirt or sticks in the presence of a notary to transfer land, to the present, arguing that state policies to remove the seal requirement from notary usage are shortsighted, as notary seals are a "deterrent to thievery and fraud").

[49] *See* BERMAN, *supra* note 4, at 346-347.

[50] The notion of a handshake sealing a bargain is frequent in business, *e.g.*, Juliana Schroeder, Jane Risen, Francesca Gino, & Michael I. Norton, *Handshaking Promotes Cooperative Dealmaking* (Harvard Bus. Sch. Working Paper No. 14-117, May 30, 2014), http://www.hbs.edu/faculty/Publication%20Files/14-117_73032e86-d4d7-4b4b-ad5d-5253e926853a.pdf and is frequently used in movies. *E.g.*, DJANGO UNCHAINED (Columbia Pictures 2012) ("A deal ain't a deal until the two parties have shook hands. Even after all that paper signin', don't mean s*** [if] you don't shake my hand."); PIRATES OF THE CARIBBEAN (Disney 2003)

"But we shook on it" is used as a personal pejorative when a contracting party in an arm-in-arm transaction breaches. By offering their hand, one might say, the individual has committed their identity to the transaction in a way that ought to bind them significantly. The breach is thus viewed as a personal affront, not just an efficient commercial choice.[51] The act of shaking hands may even affect how an exchange is negotiated—in one study, the act of shaking hands at the *beginning* of negotiation led to more cooperative behavior and improved joint outcomes between parties.[52] In essence, the act of shaking hands was nonverbal behavior that elicited real psychological differences in negotiation, such as inducing positive emotions and prosociality.[53]

B. Contracts of Adhesion

As technology changed to allow form contracting with the advent of printing and copying, adhesion contracts rather than handshakes became the contractual norm. Large enterprises found it beneficial to draft lengthy contractual terms, covering many eventualities, which would be offered to consumers of their goods or services on a take-it-or-leave-it basis, without negotiation. The fixed costs of drafting such an agreement would be high, but, once spread over thousands of consumers, could be an efficient way for the enterprise to control many of the terms of a bargain, capturing much of the contractual surplus that would otherwise be split more evenly through negotiation. Consumers facing these contracts rarely find it rational to peruse their terms, as the hour to read the fine print on a small consumer contract largely exceeds the benefits from understanding the terms, especially if every other provider of such goods or services will likely have a similar contract. Trusting that a loud complaint to a customer service representative will likely solve many of the possible problems with the contract, the consumer rationally signs without understanding the terms of the agreement.

(finalizing an "accord" with a handshake); THE EMPEROR'S NEW GROOVE (Disney 2000) (sealing an agreement with a handshake, which when one party breaks, the other party responds with "But we shook on it."); HOUSE, Season 1:19 (Fox 2004) (shaking hands to agree on returning to work in exchange for a date). Whether these depictions provide useful legal guidance for individuals is debatable. Rick Smith, *Here's Why Hollywood Should Kiss the Handshake Deal Goodbye*, 23 LOY. L.A. ENT. L. REV. 503 (2003) (arguing the popular portrayal of handshakes as creating legal obligations is misguided).

[51] In a modern contracting regime, handshakes provide decidedly mixed signals. They might be evidence that offer has met acceptance and a bargain formed, or they might rather be a social nicety to conclude a negotiating session. *See, e.g.*, Rennick v. O.P.T.I.O.N Care, 77 F.3d 309, 314 (9th Cir. 1996) ("Handshakes are significant. When people shake hands, it means something, but several meanings are possible."); PARKS AND REC 6:6 (NBC 2013) (concluding "I *think* we have a deal" and shaking hands after reaching a tentative agreement to sell Rent A Swag) (emphasis added).

[52] Schroeder *et al.*, *supra* note 50.

[53] *Id.* at 24.

C. Smart Contracts Housed on a Blockchain Ledger

A "smart" contract represents a further evolution of contract law in response to technological changes. At heart, a smart contract is one in which part of a contract or the entire contract is encoded and executed automatically via mechanical means or computer code.[54] The classic example of a rather simple smart contract is a vending machine.[55] Coin is inserted, a selection made, and a snack delivered.[56] The action executes without an intermediary or two face-to-face parties, mediated by the technology of the vending machine. More advanced smart contracts have lines of computer code executed by a digital machine, making the code of the contract final and immutable.[57] Traditionally a contract could be perceived as an agreement plus its surrounding law.[58] For example, for sale of goods, the Uniform Commercial Code specifically denotes that an "'Agreement', as distinguished from 'contract', means the bargain of the parties in fact, as found in their language or inferred from other circumstances, including course of performance, course of dealing, or usage of trade . . . ."[59] In contrast, "'Contract', as distinguished from 'agreement', means the total legal obligation that results from the parties' agreement as determined by the Uniform Commercial Code as supplemented by any other applicable laws."[60] To the agreement and its surrounding law, smart contracts add the code itself as an essential aspect of the

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[54] The first digital contract may have resulted from the Berlin Airlift, as the U.S. Army developed a digital manifest system. *See* DE FILIPPI & WRIGHT, *supra* note 17, at 72–88. Grimmelmann, *supra* note 10, at 4 defines a smart contract as "a technical obligation based on a formal-language instrument." Technical obligations are enforced by a system rather than being enforced in case of breach. *Id.* at 3.

[55] *See* Max Raskin, *The Law and Legality of Smart Contracts*, 1 GEORGETOWN L. TECH. REV. 305, 306, 315-316 (2017) (discussing vending machine as smart contract).

[56] Of course, vending machines may sell more than junk food. *E.g.*, Marianne Holman Prescott, *#LightTheWorld Goes Global with New Giving Machines in New York, London, Philippines*, The Church of Jesus Christ of Latter-day Saints (Nov. 30, 2018), https://www.lds.org/church/news/lighttheworld-goes-global-with-new-giving-machines-in-new-york-london-philippines?lang=eng ("Whether it is purchasing a soccer ball, clean water, hygiene supplies, or livestock, individuals and families around the world have the opportunity to #LightTheWorld again through the Church's giving machines available during the Christmas season. . . . The machines will be available through the Christmas season and partner with global charities such as CARE, UNICEF, WaterAid, Water for People, Eye Care 4 Kids, Utah Food Bank, and Utah Refugee Connection.").

[57] *See* Jeffrey M. Lipshaw, *The Persistence of "Dumb" Contracts*, STANFORD J. OF BLOCKCHAIN L. & POL'Y (2019), https://stanford-jblp.pubpub.org/pub/persistence-dumb-contracts.

[58] There is a rich literature on the theoretical aspects of what comprises the parties' intent and what role default law and background rules should play in contractual interpretation. *See, e.g.*, Eyal Zamir, *The Inverted Hierarchy of Contract Interpretation and Supplementation*, 97 COLUM. L. REV. 1710, 1772 (1997) (noting "there is typically a gap between the common understanding and intentions of the parties regarding the behavior expected of each of them, and the obligations laid down in the formal contract."). To this distinction, smart contracts would add a third layer: the expression of the parties through computer code itself.

[59] UCC § 1-201(a)(3).

[60] *Id.* § 1-201(a)(12).

agreement. There are two ways this can be done. First, the parties may use code to express the *entire* agreement, so that the code becomes the integrated contract.[61] Second, the parties may use the code to supplement or execute part of a larger agreement. The first might be referred to as a "code-only" contract, and the second a "hybrid" contract.[62] If the code imperfectly reflects the bargain the parties have reached, yet the parties agree to be bound by the imperfect representation of their agreement in code form, then the bargain, plus the code, plus surrounding law, determine the total legal obligation of the parties.[63]

While possible since the advent of modern technology, the creation of blockchain technology has given smart contracts increased salience, expanding the scope of their potential uses. Blockchain is a shared digital public ledger. Each transaction in the ledger is recorded across the blockchain, giving the record greater stability than centralized repositories of digital assets.[64] Blockchain was initially popularized after its implementation with the cryptocurrency Bitcoin.[65] Bitcoin, and blockchain, represented a solution to the basic problem with creating digital currency: reduplication. If one gives another a physical dollar bill, the giver loses access to the bill. In contrast, if one emails another a piece of digital currency, it is difficult to assure the recipient that the sender hasn't retained a copy. For example, emailing a copy of this article does not destroy its presence on the authors' hard drives. In this way, the non-rival nature of digital files makes the creation of digital coin problematic. Bitcoin attempted to solve this problem through blockchain—the shared ledger records each transfer of coin, solving the reduplication problem, and the existence of the ledger across multiple servers provides heightened assurance to owners that the ledger is secure.[66]

The digital ledger accomplishes this through creating chained series of blocks (hence, "block"-"chain"), that house records of transactions. In one approach, the process of creating a new block in the chain relies on certain computational math defined during the initial implementation of the blockchain.[67]

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[61] Levi & Lipton, *supra* note 9.

[62] By hybrid, we mean a contract in which the code serves an ancillary purpose to a written agreement, not hybrid functionality between various types of smart contracts, such as ERC20 and ERC223 contracts. *See* Omar MK, *Hybrid Smart Contracts*, MEDIUM (Jan. 2, 2018), https://medium.com/hybrid-smart-contracts/hybrid-smart-contracts-ff963db9c702.

[63] *See* Lipshaw, *supra* note 57 ("The smartest contracts, as with cryptocurrencies, *are* the deal. They exist and operate without need for any input from the outside or interpretation of the rules that embody them. But to the extent that the once dumb but increasingly smart contract maps rather than is the deal, it will need to fine tune and fix at the outset the rules that would apply in every relevant future contingency.").

[64] *See* FILIPPI & WRIGHT, *supra* note 17, at 33-71.

[65] *See* Kiviat, *supra* note 5, at 570-573.

[66] As of this writing, in the ten years since the creation of Bitcoin no one has been able to hack the blockchain protocol.

[67] Another, less-implemented approach is to only rely on trusted miners to create blocks. This limits the possible scope of the blockchain to a trusted pool of individuals. *See* POA Network, *Proof of Authority: Consensus Model with Identity at Stake*, MEDIUM (Nov. 11, 2017), https://medium.com/poa-network/proof-of-authority-consensus-model-with-identity-at-stake-

To add a block to the chain, a user (or pooled group of users) must solve or prove a programmer-defined algorithm in order to validate the transaction. This is often referred to as "mining", a fitting term, because it ties trust and credibility to the real-world asset of computing power. When first establishing a new blockchain, the creator can implement various types of computational proofs. The most common are "proof of work" and "proof of stake." Although proof of work and proof of stake techniques are both widely used among blockchain developers, each technique has both great benefits and certain drawbacks.[68]

Proof of work incentivizes creation of blocks by rewarding the blocks' creators with small amounts of the currency housed on the chain.[69] First, the ledger transactions carry a small fee, which the miner collects as incentive for creating the block. Transactions with a greater transaction fee are prioritized, so they are housed on blocks before transactions with a lower fee. A user seeking to enter a transaction on the chain can choose which amount to pay the miner, which gives miners greater incentive to store those transactions on blocks. Second, creating the block may come with a direct currency reward. Miners can run the blockchain's algorithm to try and solve this equation first, and the miner who solves the problem receives a part of the mined coin in addition to the transaction fees.[70]

To understand the logic, consider a group of students taking a math test with a reward for first correct response. The teacher explains that only the student providing the correct answer *and* the steps to provide proof will receive an award. The competition disincentives group manipulation, and the requirement to show proof prevents the students from cheating with answer sheets. There are many advantages to utilizing proof of work, such as reduced vulnerability to attacks as a result of its decentralized nature.[71] The decentralized system incentivizes miners to assist in the creation of new blocks and disincentives actions that try to manipulate the chain. At the same time, opponents argue that the resources spent on mining blocks poses significant societal disadvantage. For example, miners of Bitcoin use around 22 terawatt-hours of electricity every year, which, by comparison, is the same as that of a small nation.[72] There also tends to be a diminishing marginal return on mining block because, as more blocks are added to a blockchain protocol, the reward the miner receives is lower.[73] This poses a problem for the future sustainability of blockchain technologies. There has also

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[68] *See* Ameer Rosic, *Proof of Work vs Proof of Stake: Basic Mining Guide*, BLOCKGEEKS https://blockgeeks.com/guides/proof-of-work-vs-proof-of-stake/ (last visited Feb. 27, 2019).

[69] *Id.*

[70] *Id.*

[71] *Id.*

[72] *The Madness of Crowds*, ECONOMIST 75 (Mar. 30, 2019) (comparing the energy usage to the country of Romania); G.F., *Why Bitcoin Uses So Much Energy*, ECONOMIST (July 9, 2018), https://www.economist.com/the-economist-explains/2018/07/09/why-bitcoin-uses-so-much-energy (comparing the energy usage to the country of Ireland).

[73] Laws of supply and demand dictate that over time the reward for mining blocks should be equal to the transaction fees awarded to the miner.

been rising concern about the centralization of mining power. The rise of 'crypto mining farms' is similar to the Gold Rush of the 1850s, with investors pouring in large amounts of capital to establish new farms around the world.[74] Smaller miners have voiced concern with the increasing costs of GPUs that now present a possible barrier to entry into the crypto market.[75]

With these disadvantages of proof of work in mind, some blockchains are turning to proof of stake. Simply put, the proof of stake algorithm requires miners to *stake* their tokens on the creation of a new block. If selected to validate the block, in addition to transaction fees, the miner receives a reward. Proof of stake has a deterministic winner resulting in the new block—the more stake a miner puts in, the higher the chance of reward. At the same time, there is a high degree of chance and randomization added to the system to ensure that not only the most successful miners on the system continue to get richer. This system gives proof of stake the ability to reduce the risk of consolidation of mining power. Proof of stake is similar to a lottery system, so to continue the student example, in this case the teacher randomly (without bias) chooses to give an A to a student; however, students could "stake" previous grades to increase the chance of receiving another A. However, if it was discovered that the teacher was actually biased in her distribution of the grade, the student that staked their grades would lose every grade they put up and it would be distributed among all the other students.

Finally, blockchains differ in the structure and capabilities. Although much of the public eye has been on the cryptocurrency Bitcoin, more companies have chosen to utilize Ethereum to develop their blockchain-based smart contracts applications.[76] In technical terms, this is because Bitcoin is "Turing incomplete" while Ethereum is "Turing complete," making them fundamentally different.[77] A Turing complete language is a system that could compute any programed code given that it had unlimited memory and time. Ethereum is the most popular Turing complete contracting language, but there are many options. Quorum, Wanchain, Zen, Rootstock, Qtum, and other platforms employ variations on privacy, payments to house transactions, or faster and safer code execution.[78] This Turing complete attribute gives developers on the Ethereum Virtual Machine the ability

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[74] Julia Magas, *Top Five Biggest Crypto Mining Areas*, COINTELEGRAPH (June 23, 2018), https://cointelegraph.com/news/top-five-biggest-crypto-mining-areas-which-farms-are-pushing-forward-the-new-gold-rush.

[75] *See* Lester Coleman, *Declining Profitability for New Miners Threatens Bitcoin Decentralization*, CNN (Sept. 14, 2016), https://www.ccn.com/declining-profitability-for-new-miners-threatens-bitcoin-decentralization.

[76] *See* Neil Ainger, *Bigger than Bitcoin? Enterprise Ethereum Alliance Grows in Size*, CNBC (May 24, 2017), https://www.cnbc.com/2017/05/23/bigger-than-bitcoin-enterprise-ethereum-alliance-grows-in-size.html.

[77] Vasa, *ContractPedia: An Encyclopedia of 40+ Smart Contract Platforms*, HACKERNOON (July 18, 2018), https://hackernoon.com/contractpedia-an-encyclopedia-of-40-smart-contract-platforms-4867f66da1e5 (in more technical terms, Ethereum is Turing "Total" as all contracts must terminate).

[78] *Id.*

to use programing techniques such as loops and if statements, making it a useful blockchain for implementing smart contracts. On the other hand, the Bitcoin developers have chosen to remove this feature in the Bitcoin blockchain; therefore, Bitcoin's main functionality is limited predominantly to distributing currency. At the same time, with Turing completeness, a program could run forever (such as an infinite loop), and in this way users could attack the system with unnecessary lines of code, essentially causing the blockchain to become stuck. Bitcoin solves this problem by removing the Turing complete aspect while Ethereum has instead opted to implement an operation fee known as "gas." Users would need to pay for lines of code to be executed, essentially paying for computing power; this feature assists in preventing denial of service attacks. This unique aspect of Ethereum is one of the main reasons why so many smart contract developers have chosen this platform over the hundreds of other options.[79]

Contracts housed on Ethereum are written in Solidity, a language written to execute on the blockchain.[80] To make concrete what this looks like, consider two exhibits. Exhibit 1 "Contract 1" is perhaps the simplest possible smart "contract" (in the language of Ethereum, any code housed on the chain is a "contract" whether or not it entails an exchange of value the law would recognize as contractual).[81] It simply sets a variable to a value (the name of the article), then returns it. The entire code follows:

Exhibit 1 "Contract 1"

```
pragma solidity >=0.4.22 <0.6.0;

contract Example1 {
 function getTheName() public view returns (bytes32 TheName)
 {
  TheName = "Should Code Be Law?";
 }
}
```

The code is very simple. The first line tells the compiler which version of Solidity will work (Solidity is quite version-sensitive, which means much older code found online needs to be updated before it will work with the current compiler.) The second begins a contract called Example1, which contains one function, called getTheName. This function simply returns the name of this Article.[82] This contract

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[79] *See id.* (Ethereum is not the only Turing-complete blockchain).

[80] *See* SOLIDITY, *supra* note 16.

[81] For example, see Ethereum's Github page, which notes that "[s]mart contracts are programs that are executed inside a peer-to-peer network where nobody has special authority over the execution and thus they allow to implement tokens of value, ownership, voting and other kinds of logics." *See Solidity, the Contract-Oriented Programming Language*, GITHUB, https://github.com/ethereum/solidity (last visited Jan. 23, 2019).

[82] As Ethereum only handles bytes, it returns a hexadecimal number

is housed on the Ethereum Rinkeby test network—a blockchain used to test applications at reduced cost before deploying to the full blockchain—where the value of the variable (the article name) is registered.[83] Ethereum currently runs three test networks, each named after subway stations in Stockholm. It costs 0.000102 Ether, or about $0.01 to deploy on the blockchain.[84]

To go a step further, Exhibit 2 "Contract 2" illustrates creating a simple token, which could act as the value exchanged in a legally-cognizable contract. Given the institutional affiliation of the authors at the time of writing, "TruCoin" seemed an apt token to create, with symbol "TRCN."[85] The following gives an outline of the code.[86]

Exhibit 2 "Contract 2, Code Outline"

```
...
contract TokenERC20 {
...
 constructor(
   ...
 ) public {
    totalSupply = initialSupply * 10 ** uint256(decimals);
    balanceOf[msg.sender] = totalSupply;
    name = tokenName;
    symbol = tokenSymbol;
 }
...
```

(0x53686f756c6420436f6465204265204c61773f00000000000000000000000000) which can be converted into a string. *See Hex to String (Hex to Text)*, CODE BEAUTIFY, https://codebeautify.org/hex-string-converter (last visited Feb. 27, 2019).

[83] The contract address is 0x9473f42a4917Dbf0935482859924304696l809bF. It can be accessed through Etherscan's Rinkeby registry at rinkeby.etherscan.io (To access the contract, search for the contract address. Click on Code, then "Switch to Opcodes View." The article name follows "PUSH 32"). In practical terms, creating a Rinkeby contract first requires acquiring Rinkeby Ether. Rinkeby grants ether based on a Proof of Authority concept. Ether is available from a faucet at https://faucet.rinkeby.io/. There, a hexadecimal number can be copied and posted to a public social network (Google+, Twitter, or Facebook), to validated that a real person is requesting Ether. The link to the post is then copied and pasted into the faucet, which grants the poster a small quantity of Ether.

[84] Because the contract is deployed on a test network, there is no actual exchange to U.S. dollars, as there would be if housed on the main Ethereum network.

[85] *See* Token TruCoin, RINKEBY ETHERSCAN (last visited Jan. 24, 2019), https://rinkeby.etherscan.io/token/0x42428e95e3833be80116bd419af24e6acdfa7168 (TruCoin is housed on the Rinkeby test network).

[86] Ellipses indicate code omitted for space. The contract was created by modifying code available at Ethereum, *Create Your Own Crypto-Currency with Ethereum*, ETHEREUM (Jan. 23, 2019), https://www.ethereum.org/token (giving code to create a minimum viable token and an ERC-20 token); *see also* Marcus Molchany, *The Easiest Way to Deploy Smart Contracts on Ethereum*, MEDIUM (Jan. 29, 2018), https://medium.com/@marcusmolchany/the-easiest-way-to-deploy-smart-contracts-on-ethereum-65f69ac9a627 (describing the process of smart contract creation through installing Metamask, and so on).

```
function transfer(...) public returns (bool success) {
        ... }
    function transferFrom(...) public returns (bool success) {
        ... }
    function burn(uint256 _value) public returns (bool success) {
        ... }
}
```

This code creates an ERC-20 token, a token created via smart contract and housed on the Ethereum network, which satisfies six basic protocols. The token must (1) create a total supply, (2) track balances in accounts, (3) be able to transfer from the supply and (4) between accounts, (5) approve (check whether a transaction stays within the total number of tokens), and (6) check allowances (prohibiting transfer if the user's account has an insufficient balance).[87] In the code outline above, the space designated "constructor" sets up the basic parameters of the token, such as creating the initial supply, setting up a name, and giving a symbol. The code outlined then creates space to house the transfer functions (3) and (4). The "burn" function at the end allows tokens to be removed from the system.

While TruCoin was created for illustrative purposes, tying the token to real-world assets would enable it to act as a medium of exchange or store of value in the manner of other cryptocurrencies.[88] Consider how the use of TruCoin can facilitate contracting without intermediaries. If the authors of this paper wished to exchange one author's rights to a digital movie for the other's TruCoin, but mistrusted the rights owner to deliver after payment, one solution would be to use a third party. The third party would hold the buyer's TruCoin, inform the seller of the delivery of the coin, and the seller would then deliver the movie. With the movie delivered, the third party would deliver the price to the buyer. The advantage of the smart contract is to eliminate the need for the intermediary. If the authors

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[87] *E.g.*, Maxwell William, *ERC-20 Tokens, Explained*, COINTELEGRAPH (May 12, 2018), https://cointelegraph.com/explained/erc-20-tokens-explained.

[88] For the reader unfamiliar with the mechanics of smart contract creation, the code creating the contract is entered on an Ethereum wallet linked to the correct network. Once the code is entered, it compiles, and the contract can be executed. As set up here, the interface asks for the initial supply, the name of the token, and a symbol. Once entered, the contract is submitted to the network and the creator pays a gas price, with a higher gas price meaning the contract is housed on a node more quickly. Using the required gas, the contract is then distributed across the nodes housing the blockchain and become available to interact with publicly. The account creating the contract in this case retains an administrative page inside the wallet which allows access to the contractual functions, such as transferFrom (giving tokens to wallets) and burn (destroying tokens). For an illustration of this process with screenshots, *see* Lê Yên Thanh, *[ETHER101] Lesson 2: Create a Simple Token (Cryptocurrency) with Ethereum*, MEDIUM (Nov. 26, 2017), https://medium.com/@yenthanh/ether101-lession-2-create-a-simple-token-cryptocurrency-with-ethereum-c6c21fde2ea2; Lê Yên Thanh, *[ETHER101] Lesson 3: Create a Real Token in Production with Ethereum*, MEDIUM (Dec. 10, 2017), https://medium.com/@yenthanh/ether101-lession-3-create-a-real-token-in-production-with-ethereum-66f651091c3b.

create a smart contract, the buyer can fund the sales price to the contract itself, storing the value in TruCoin at the contract address. At that point, the movie is delivered, the buyer confirms the delivery, and the contract releases the funds.[89] The contract acts as a type of digital agent, using coded logic to accomplish what a natural person might do in the traditional contractual setting.

D. Blockchain-Based Dispute Resolution

While smart contracts may simply carry out part of an otherwise ordinary contractual exchange and be subject to usual civil procedure in case of breach, certain smart contracting parties may wish to avoid the traditional legal system. These kinds of deals face a problem: what happens in case of breach? Traditional, natural-language contracts rely on traditional dispute resolution mechanisms in case the contract is not executed; generally arbitration or the civil justice system. The parties engage through these mechanisms, and some sort of remedy such as expectation damages is given the aggrieved. This ability to let courts or arbitrators sort things out gives tremendous efficiency to contractual drafting—many unlikely scenarios in bespoke contracts are not worth the time to draft around, as the cost of drafting contingency plans exceeds the expected value of addressing the unlikely harm.[90] Rather, if they occur, the body of contract law essentially fills in the blanks. In sales contracts, the UCC accomplishes this, and in other contracts, common law rules like impossibility, mistake, and fraud do the same.[91]

Parties expressing their complete wishes via smart contract, who wish to avoid the legal system, face difficulty at this stage. One solution is to host the dispute resolution mechanism on the blockchain. Two of the larger contenders in this space are Kleros and OpenCourt. Kleros attempts to bring justice to smart contracts by leveraging the same economic principles that underlie blockchain itself.[92] Anonymous jurors handed a dispute are given incentives to reach the same

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[89] For a technical representation of this with code, *see* Michael Rice, *Introducing a New Project: A Collection of Legal, Solidity Based Smart Contracts*, MEDIUM (May 8, 2018), https://medium.com/@michaelriceLE/introducing-a-new-project-a-collection-of-legal-solidity-based-smart-contracts-6d6b534e193. For an extended discussion of the mechanics and economics of blockchain-based exchange, *see* Gans, *supra* note 5.

[90] Expected value is the amount of the harm multiplied by its probability. Thus, even a very large harm that is very unlikely may not be worth the time in cost of negotiating and drafting to address in a contract.

[91] For the implications of smart contracts on the UCC, *see* Jeanne L. Schroeder, *Bitcoin and the Uniform Commercial Code*, 24 UNIV. MIAMI L. REV. 1, 8-9 (2015); Stephen M. McJohn, *The Commercial Law of Bitcoin and Blockchain Transactions* (Suffolk University Law School Research Paper No. 16-13, 2016).

[92] For a critique of these systems, *see* Sklaroff, *supra* note 5, at 301 ("However, the decentralized nature of these systems ensures that they will be essentially useless in managing the high costs of smart contracting. By shifting dispute resolution to an online system that relies on an everchanging, unpredictable, unaccountable, and opaque group of decisionmakers, decentralized adjudication cannot generate contract 'public goods' like performance standards, which emerge through the stable application of interpretation rules by courts. . . . In these decentralized resolution systems, parties

conclusion as other jurors, essentially replicating the consensus requirement at the heart of blockchain itself. Kleros adjudication can be invoked in the code, unifying the dispute resolution mechanism with the contract code. In contrast, OpenCourt relies on arbitrators. When invoking the OpenCourt protocol in their code, the coin at issue is forwarded to a virtual escrow account, which holds the funds until an OpenCourt arbitrator, presumably unbiased and learned in principles of virtual exchange, decides the matter.[93]

The development of decentralized, anonymous dispute resolution systems brings the development of contract law back to a significant aspect of its historical roots in the law merchant.[94] The contracting process and dispute resolution all happen through decentralized exchange, without the need to appeal to any one jurisdiction's courts. The substantive law of contract or the desired dispute resolution steps to be applied by a Kleros jury or OpenCourt arbitrator could be specified in the contract itself.

E. Contractual "Distance"

The history of contract law can be characterized as increasingly facilitating exchange between ever-more remote parties. First, sealed documents provided a way to enforce long-distance exchanges with an adjudicator unfamiliar with the contracting parties, then adhesion contracts enabled parties with no personal contact to enter into complex bargains *en masse*. Blockchain-based smart contracts now let remote parties enter into auto-executing exchanges unmediated by traditional court systems. In other words, the long arc of contract law has been to facilitate exchanges at greater "distance" between the parties as technology evolved.[95] We use the term "contractual distance" to indicate the extent to which actual agreement between the ultimate initiator and acceptor of an exchange takes place. It is defined as the number of intermediate parties needed to accomplish an exchange of value, weighted by the rational level of actual agreement between the parties at each step of the exchange. Contractual distance is related to the term "social distance," which indicates the extent to which two people find themselves

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cannot know how to craft their arguments to maximize success or minimize risk."). We are more sanguine about its possibilities, due to the historic roots of contract in precisely this kind of adjudication, and the fact that multiple dispute resolution mechanisms are possible, so that parties may tailor it to their needs.

[93] OpenLaw, *Legally Enforceable Blockchain-Based Arbitration*, CONSENSYS (Oct. 18, 2018), https://media.consensys.net/opencourt-legally-enforceable-blockchain-based-arbitration-3d7147dbb56f.

[94] For discussion of blockchain anonymity, *see* Sklaroff, *supra* note 5, at 295.

[95] *See supra* note 20 (discussing the literature on "social distance" versus "contractual distance" between parties).

demographically and culturally similar to each other but attempts to convey the idea of ultimate agreement at the beginning and end of a contract-based exchange.

A garage-sale exchange has very low contractual distance. It requires no intermediaries, so buyer and seller are connected directly, and the terms are generally completely understood by the parties. A small amount of cash is exchanged for a good sold as is, perhaps after some negotiation. Marriage, so far as it can be understood as a contract, similarly has low distance. Unless the marriage is arranged, the parties bargain with each other to begin their joint lives and generally understand the implications of entering into a new social relationship with each other.[96] Contracts embedded in a meaningful social context outside family ties might also have low contractual distance, as agreements are made relying on well-understood social pressures to police eventualities rather than form contracting.[97]

In contrast, contracts of adhesion are characterized by large contractual distance. In a typical consumer adhesion contract, the consumer confronts a faceless behemoth with take-it-or-leave-it terms. The contract has no social context and what negotiating takes place occurs over an ex post customer-service hotline, not a draft of a contract.[98] The consumer typically understands the core nature of the bargain (e.g., exchanging money for cell phone service), but little of the boilerplate text given them, such as arbitration provisions or limitations on liability. The exchange might not have intermediaries, but the lack of actual agreement makes it a high-distance exchange. A multilevel exchange of value, requiring many boilerplated-intermediate contracts, such as the film example in the Introduction, represents extremely high contractual distance.[99]

In general, contract law developed doctrines responding to low-distance situations. The nature of offer and acceptance presupposes that parties come to actual agreement, not a sham agreement a consumer clicks on pretending to have

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[96] *See* Markovits, *supra* note 222, at 1419.

[97] For example, the Jewish diamond industry in New York embeds exchanges in a religious community that self-polices. *See* Barak D. Richman, *Community Enforcement of Informal Contracts: Jewish Diamond Merchants in New* York 11 (Harvard Law Sch. John M. Olin Ctr. for Law, Econ. & Bus. Discussion Paper No. 384, 2002) ("[T]his paper contends that the diamond industry found its way to Jewish communities because of efficiency considerations, and since the traditional social structure remains intact in New York's ultra-Orthodox communities, an understanding of what generates their current competitive advantage can also serve to explain Jewish merchants' historical predominance in the diamond industry.").

[98] Although adhesion contracts are typically thought of as take-it-or-leave-it, one can conceive of adhesion contracts as being negotiated in a larger societal sense by competitive pressures or through the ability to vary contractual terms through customer service negotiations. *See* Johnston, *supra* note 33, at 858 ("[R]ather than precluding bargaining and negotiation, standard-form contracts in fact facilitate bargaining and are a crucial instrument in the establishment and maintenance of cooperative relationships between firms and their customers. . . . In practice, acting through its agents, a firm will often provide benefits to consumers who complain beyond those that its standard form obligates it to provide. . . .").

[99] *See* Kar & Radin, *supra* note 4, at 1182 (if the boilerplate is accepted by sophisticated parties, a likely different set of incentives applies).

read pages and pages of text. Technology then enabled higher distance exchanges. An extensive law review literature examines the shortcoming of these high-distance contracts, going so far as to call such contracts "pseudo-contracts" because they are entered into without actual agreement.[100] By resolving trust issues through blockchain technology rather than costly intermediaries, smart contracts shorten the chain of parties needed to effectuate exchanges of value. Because code will execute automatically as parties fulfill the conditional exchanges built into the code, there is less incentive for boilerplate to be drafted to cover the many ways the contract could go wrong, more incentive to resolve ambiguity in drafting, and greater incentive for the consumer to understand the exchanges embodied in contractual code.[101]

III. SMART CONTRACT APPLICATIONS

A. Environmental Public Goods

With many comparing the advent of blockchain to the dawning of the Internet, a broad number of industries are racing to implement them in some form. Companies have begun to implement blockchain technology in industries from agriculture and food supply logistics,[102] to copyright protection,[103] digital voting,[104] personal identification,[105] real estate and property transfers,[106] and transportation logistics.[107] Most recently, JPMorgan became the first United States bank to

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[100] *Id.* at 1142.

[101] *See* Buchan, *supra* note 34. The nature of the blockchain itself was designed to overcome trust issues in the maintenance of a public ledger, so it should not be surprising that it may help solve contractual trust issues. Low contractual distance occurs regardless of whether high *social* distance would otherwise hinder cooperative dealmaking.

[102] Andrew Rossow, *Why Walmart's Move to the Blockchain Could Do More than Prevent E. Coli Outbreaks*, FORBES (Sept. 25, 2018), https://www.forbes.com/sites/andrewrossow/2018/09/25/why-walmarts-move-to-the-blockchain-could-do-more-than-cure-e-coli-outbreaks/#61c02ad01100.

[103] Tom Kulik, *How Blockchain Just May Transform Online Copyright Protection*, ABOVE THE LAW (Feb. 12, 2018), https://abovethelaw.com/2018/02/how-blockchain-just-may-transform-online-copyright-protection/.

[104] Phil Daian, Ian Miers, Oded Naor, & Ari Juels, *Bribery-Resistant Voting Schemes for Smart Contracts*, RESEARCH (Sept. 13, 2018), https://ethresear.ch/t/bribery-resistant-voting-schemes-for-smart-contracts/3354.

[105] Zachary Diebold, *Self-Sovereign Identity Using Smart Contracts on the Ethereum Blockchain*, UNIV. DUBLIN (May 2017), https://scss.tcd.ie/publications/theses/diss/2017/TCD-SCSS-DISSERTATION-2017-016.pdf.

[106] *The Purchase and Sale of Real Property on Ethereum*, CONSENSYS (Apr. 24, 2018), https://media.consensys.net/the-purchase-and-sale-of-real-property-on-ethereum-55bdc289a7b5.

[107] Hamid Nach & Rachid Ghilal, *Blockchain and Smart Contracts in the Logistic and Transportation Industry*, RESEARCHGATE (Nov. 2018), https://www.researchgate.net/publication/319764963_Blockchain_and_Smart_Contracts_in_the_Logistic_and_Transportation_Industry_The_Demurrage_and_Maritime_Trade_Use_Case.

implement its own blockchain-based coin.[108] This Section considers the presence of blockchain and smart contracts in two major industries: the environmental goods sector and the TV/film industry. These industries are particularly interesting from a contracting perspective because they center around public goods—goods that are difficult to exclude others from using, and which can be used by many simultaneously.[109] The non-exclusive, non-rival nature of these goods makes them ideal targets for entities to distribute property rights via fractionalized assets embedded in adhesive smart contracts.

In the environmental sector, there are two major causes of market inefficiencies: insufficiently developed property rights and high transaction costs.[110] The emergence of blockchain-focused companies reduces contractual distance between the producer and consumer, while enabling exchange of fractionalized property rights. For example, Social Plastic is a charity organization attempting to stop the flow of plastic into the ocean by utilizing a blockchain-based application to incentivize recycling in developing countries. The organization has set up collection centers around the world where people can trade used plastic in exchange for currency and services. "By enabling the exchange of plastic for money, items or Blockchain secured digital tokens, we reveal the value in plastic. This empowers recycling ecosystems around the world and stops the flow of plastic into our oceans. All while helping people living in poverty build better futures."[111] Another company called SolarCoin uses cryptocurrency to reward producers of solar power with SolarCoin which can be traded for Bitcoin or cash.[112] The goal of the company is to help encourage the installation of solar panels by reducing the payback return time.[113] Similarly, the company Electron has risen to help individuals trade their surplus electricity to other consumers nearby through the use of decentralized smart meters and smart contracts on a blockchain network. The longer electricity travels from its initial creation, through electrical lines and finally to its destination, the greater energy lost in the process. By enabling peer-to-peer transactions, households that require extra electricity could engage in transactions with households nearby with excess electricity, leading to less energy loss compared to when all households rely solely on a central power source.

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[108] Son, *supra* note 8.

[109] *See, e.g.*, Ernst Fehr & Simon Gächter, *Cooperation and Punishment in Public Goods Experiments*, 90 AM. ECON. REV. 980, 993 (discussing experimental evidence on public goods and social pressure to not free-ride).

[110] *See* Pedro Schwartz, *Ronald Coase, the Unexpected Economist*, LIBR. ECON. & LIBERTY (Oct. 7, 2013), https://www.econlib.org/library/Columns/y2013/SchwartzCoase.html (discussing the history of the Coase Theorem and transaction cost analysis).

[111] *What We Do*, PLASTICBANK, https://www.plasticbank.com/what-we-do/#.XCOn089Kju0 (last visited Jan. 28, 2019).

[112] *SolarCoin*, SOLARCOIN, https://solarcoin.org/ (last visited Feb. 27, 2019).

[113] Current research by Paul Johnson, Columbia School of Business, and Nick Gogerty, SolarCoin, has found that the underlying interactive structures of SolarCoin are quite promising. Nich Gogerty & Paul Johnson, *Network Capital: Value of Currency Protocols Bitcoin & SolarCoin Cases in Context* (2018), https://ssrn.com/abstract=3281845or http://dx.doi.org/10.2139/ssrn.3281845.

A platform called Aqua Rights utilizes the Ethereum blockchain and smart contracts to better define and trade water rights.[114] Ironically, water rights are illiquid assets, and initial purchases of water require a large amount of upfront capital. It is also quite difficult to establish agreements of tied ownership, but with the creation of the AQUA token on the Ethereum blockchain, representing ownership of water rights, this barrier to entry would be removed as buyers would be able to pool initial capital or buy smaller fractional sections to water rights. This tokenization also mitigates the illiquidity of water rights by introducing smart contracts for greater exchangeability.

B. Blockchain and Blockbusters

Blockchain technology has the potential to transform the underlying structure of how entertainment is funded and distributed. The platform Movie Coin has been offered to help raise funds for production of new content through an initial coin offering.[115] The token would help raise initial funds and capital to produce video content. Movies, TV series, or VR content would have their own tokens which anyone could buy (e.g., a Game of Thrones Season 9 Coin, or a Zatanna Coin). This token system would help finance content that failed to receive adequate funding from a venture capitalist or a massive studio, yet still had public support. Using the coin, the consumer would then be able to buy or rent films without the need to pay an intermediary. Today, many contract deals are made solely through film studios to a filmmaker or production company, but a platform like MovieCoin enables the consumer to transact directly with the filmmaker, reducing the contractual distance between seller and buyer. This decrease in contractual distance would lead to greater efficiency, as content would become more reflective of consumer preferences, leading to a potentially complete radicalization of how consumers view their entertainment.

Breaker is a platform aimed at content production and hiring crew.[116] The platform utilizes the Ethereum protocol and Solidity to build smart contracts that help connect filmmakers with crew members and other production related services located near the area of a project. The peer-to-peer model of the application leads to removal of intermediaries like studio executives, thus cutting costs significantly. Since the contracts are stored on a blockchain, there is better traceability on what members contributed to each part of the film, and the low contractual distance

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[114] *Digitizing Water Rights: Creating a New Tradeable Asset Class with Liquidity*, AQUA RIGHTS, https://aquarights.com/ (last visited Jan. 28, 2019).

[115] *Hollywood 2.0: The Fintech Platform for the Entertainment Industry*, MOVIECOIN, https://movie.io/en/ (last visited Feb. 27, 2019) (an initial coin offering is an exchange of real-world currency for crypto-tokens of one sort or the other); *see* Alibaba Grp. Holding Ltd. v. Alibabacoin Found., No. 18-CV-2897 (JPO), 2018 U.S. Dist. LEXIS 72282, at *72284 (S.D.N.Y. Apr. 30, 2018) (discussing initial coin offerings).

[116] *Welcome to Breaker*, BREAKER, https://www.breaker.io/ (last visited Feb. 27, 2019).

between filmmaker and the crew member allow payouts to those crew members to be executed more quickly and transparently.

A Swedish company called Cinezen Blockchained Entertainment has teamed up with Slate Entertainment Group to start work on a transparent blockchain-based Video on Demand Streaming Service platform.[117] The platform would use Ethereum-based smart contracts to give content creators control to all data on the titles they own; thus removing the complex process of royalty payouts. Currently, filmmakers have no way of verifying third party royalty payouts, which are at the mercy of the integrity of the company's executives. Because of this, some companies fail to even acknowledge royalty payouts to content creators, especially smaller creators. On the Cinezen platform each piece of content (film, TV episode, web show, etc.) would be considered a smart asset, and every rental or sale transaction would be stored on the blockchain, giving both the consumer and supplier equal access to this information. The ability to make these transactions without the need for a third party reflects a dramatic change for the industry.[118] In sum, and in our terminology, the first adopters of smart contracts represent dramatic decreases in contractual distance between parties, removing intermediaries and connecting producers and consumers more directly through smart contract-enabled digital markets.

IV. A TRANSACTIONS-COST APPROACH TO SMART CONTRACTS

From a law and economics standpoint, the body of legal principles known as contract law exists because of transactions costs.[119] In a frictionless world in which people with perfect information bargain costlessly to efficient outcomes, we would have no need of the corpus of legal doctrines developed to handle the friction inherent in exchanges.[120] Examples of friction are the cost to research

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[117] Liz Shackleton, *Sales Agents Including LevelK and Celsius Sign Up to New Blockchain VOD Platform*, SCREENDAILY (Feb. 20, 2018), https://www.screendaily.com/news/sales-agents-including-levelk-and-celsius-sign-up-to-new-blockchain-vod-platform/5126846.article.

[118] "This is the first time in human history that we've been able to make a transaction without the need of a third party and that is an exciting part of the DNA of the technology itself." Ashley Turing, of LiveTree ADEPT CEO, another Movie and TV Series funding and distribution application. COINTELEGRAPH, *Livetree ADEPT ICO To Announce A $10 Million Dollar Partnership In Blockchain Summit London*, https://cointelegraph.com/press-releases/livetree-adept-ico-to-announce-a-10-million-dollar-partnership-in-blockchain-summit-london (Mar. 10, 2018).

[119] *See, e.g.*, JANET TAI LANDA, TRUST, ETHNICITY, AND IDENTITY 4 (1994) ("[M]ainstream (neoclassical) theories of exchange implicitly assume a world with zero transaction costs. In such a world, there is no role for exchange institutions such as money, middleman, contract law, . . . and gift-exchange. The study of these exchange institutions has been relegated to subfields within economics such as monetary theory or to sister disciplines of marketing theory, law, sociology, and anthropology. But precisely because these institutions facilitate exchange via their role in coordinating the activities of independent traders, and hence promoting order, they should be amenable to economic analysis.").

[120] Indeed, there would be no need for a legal order at all, other than one making property rights clear! *See* Ronald Coase, *The Federal Communications Commission*, 2 J. L. & ECON. 1 (1959); Thomas W.

information pertaining to the contract, negotiation (perhaps with unequal bargaining power), drafting of contractual text, drafting of smart contract code, recording the transfer of assets, recovering damages for breach, and so forth. In a theoretical Coasean framework without these costs, law would establish initial property rights and then leave parties alone to reach efficient conclusions. Legal solutions to fraud, mistake, impossibility, ambiguity, parol evidence, and so on, would never have developed because they would not be needed. For example, perfect information about all states of the world, combined with the ability to costlessly draft, would mean every agreement would be completely integrated and perfectly rendered to capture the will of the parties, doing away with the need for evidentiary rules to resolve contractual incompleteness.

Thankfully for these authors and the legal profession, the real world is not frictionless. Transactional attorneys owe their jobs to the efficiencies parties find in paying third parties to negotiate and draft agreements. Litigators are employed because parties cannot always bargain to perfect settlements absent counsel.[121] These real-world costs are thus an instructive viewpoint from which to analyze developments in contract law. When the potential gains from trade minus the transaction costs involved in the exchange are positive, the exchange occurs.[122] When intermediaries are involved, each intermediary must similarly find that the gains from aiding the exchange exceed the costs in rendering aid.

The disruptive potential for smart contracts stems from the potential to vastly reduce these transaction costs, thus enabling exchanges too costly to otherwise occur.[123] Particularly for creating and distributing fractionalized assets of public goods, where the transaction costs required to involve traditional intermediaries would otherwise be prohibitive, this opens up new possibilities for exchange. Transaction costs in contracting are relevant in at least four stages of the contracting process—during (1) negotiation, (2) drafting, including the cost of coding for smart contracts, (3) performance, especially the costs to record and transfer records of ownership, and (4) in case of breach.[124]

Hazlett, David Porter, & Vernon Smith, *Radio Spectrum and the Disruptive Clarity of Ronald Coase*, Paper for *Markets, Firms, and Property Rights: A Celebration of the Research of Ronald Coase*, Conference at the University of Chicago School of Law (Dec. 4-5, 2009), http://www.chapman.edu/ESI/wp/Porter-Smith-Hazlett-RadioSpectrum.pdf (discussing success of Coase theorem).

[121] *See* STEVE SHAVELL, FOUNDATIONS OF ECONOMIC ANALYSIS OF LAW 391-411 (2004) (discussing the economic theory behind settlement negotiations).

[122] *See* Sklaroff, *supra* note 5, at 296-97 (lowered transaction costs also mean that more exchanges will be engaged within a firm, rather that with outside contractual parties).

[123] On smart contracts as a disruptive technology, *see* Elizabeth Sara Ross, *Nobody Puts Blockchain in a Corner: The Disruptive Role of Blockchain Technology in the Financial Services Industry and Current Regulatory Issues*, 25 CATHOLIC UNIV. J. L. & TECH. 353, 365 (2017) (discussing the disruptive role of blockchain on the finance industry).

[124] *See generally* SHAVELL, *supra* note 121, at 296 (discussing economic theory behind why contracts are made).

Exhibit 3: Relative Transaction Costs by Contract Type

	Negotiation	Drafting	Performance	Breach
Bespoke Traditional	High	High	High *(parties perform, trust issues require third-party intermediaries)*	High *(courts)* / Low *(arbitration)*
Bespoke Smart	High	Very high	Low *(code executes)*	High / Low / Impossible*
Template Traditional	Medium *(parties negotiate over "fill in the blank" elements)*	Low	High *(parties perform, trust issues require third-party intermediaries)*	High *(courts)* / Low *(arbitration)*
Template Smart	Medium *(parties negotiate over "fill in the blank" elements)*	Low	Low *(code executes)*	High / Low / Impossible*
Adhesive Traditional	Low *(any negotiations occur ex-post)*	Low *(on average)*	High *(parties perform, trust issues require third-party intermediaries)*	Low *(typically arbitration or customer-service modification of terms)*
Adhesive Smart	Low *(ex-post negotiations impossible)*	Low *(on average, higher relative to traditional)*	Low *(code executes)*	Low / Impossible*
	* High *(if resolved in courts)* / Low *(if resolved in arbitration)* / Impossible *(if resolution is impossible due to pseudo-anonymization)*			

Exhibit 3 summarizes the relative transaction costs of six basic types of contract: bespoke contracts, negotiated and drafted for specific situations, template contracts, such as fill-in-the-blank leases, and contracts of adhesion drafted by one party and offered to many others on a take-it-or-leave-it basis. Each type of contract might be executed traditionally, or by using code. For space, the Table does not distinguish between hybrid smart contracts, in which code supplements or implements a written agreement, and code-only contracts, in which the code *is* the agreement of the parties.[125]

Negotiating a bespoke traditional or smart contract is often costly. In a sales contract, the parties must come to agreement on product specifications, delivery terms, consequential damages, and so on. In a settlement agreement, coming to a price, the scope of release, and method of payment can be arduous. This is mitigated by the parties' knowledge that legal doctrines will fill in the gaps

[125] *See supra* note 62 and accompanying text.

in their contracts if problems arise with performance. This is particularly salient in commercial contracts governed by the UCC, which contains elaborate rules governing situations in which parties behave as if a contract exists when their terms conflict.[126] In turn, drafting the agreement is costly. It may be difficult to draft terms that capture the agreement of the parties, and attorneys' fees to draft original language can run high.[127] In a smart contract, the costs of drafting the contract now include the costs to write code to implement the agreement, which raises the up-front costs of contracting.[128] This is especially true given current smart contract technology, which is difficult to interact with or understand for people without computer science training. While blockchains capable of housing smart contracts may try to make themselves user friendly, they remain bewilderingly arcane for non-programmers, far beyond the agony consumers may feel when reading through boilerplate legalese in a written form contract.

Despite the increased cost to write code, a crucial difference between traditional and smart is the costs to perform. Transferring assets through traditional contractual means often requires third-party involvement.[129] For example, when executing the contract for purchase of a home, third-party escrow accounts are used to hold funds, verifying title uses third-party services, and transferring and recording deeds requires yet another. In a smart contract, by contrast, the nature of blockchain eliminates the need for third-party intermediaries, lowering the contractual distance for exchange. The code, which may have been costly to set up, executes automatically without human intervention. The transaction costs involved in execution may be very small, perhaps only the blockchain transaction fees needed to perform transactions as the contract executes. In the ideal smart contract, the reward of the, perhaps, high up-front cost of rendering an agreement in code is the simplicity and certainty with which it executes. Breach may be costly in either the smart or traditional case. In the real-estate example, a breaching party often does not simply move out while handing the keys over to a perfectly maintained residence. The transaction costs may be substantial, totaling months of lost rent and legal costs involved in proceeding with an eviction.

A smart contract that ends up in court may similarly bear high transaction costs, with the costs involved in breach depending on the type of contract. If the contract only references information stored internally, that is, if the contract is independent of external events or information, then the contract approaches the

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[126] *See* UCC § 2-207.

[127] *See* SHAVELL, *supra* note 121, at 299-300 ("[I]t might take fifteen minutes to discuss and include a term about what to do if the photographer is involved in a car accident on the way to the wedding, but if such an event is unlikely, it will not be worth the parties' while to include a provision for such an outcome in the contract.").

[128] *See* Sklaroff, *supra* note 5 (discussing the inherent inefficiency of forming "complete" smart contractual agreements). In our framework, the low transaction costs from auto-execution will balance out the higher up-front costs of drafting, or parties will choose not to smart contract.

[129] *See* Jackson Ng, *Escrow Service as Smart Contract: The Business Logic*, MEDIUM (May 19, 2018), https://medium.com/coinmonks/escrow-service-as-a-smart-contract-the-business-logic-5b678ebe1955.

Garzik no-litigation ideal.[130] In this way, the extra costs involved in coding the contract pay off—by investing early on in making the contract purely self-referential, the parties gain the advantage of certainty in execution. If the contract does reference external events, such as through the use of an oracle or other means, the cost of breach parallel those in traditional contracts.[131] One author noted "we are, at the very least, many years away from code being able to determine more subjective legal criteria, such as whether a party satisfied a commercially reasonable efforts standard or whether an indemnification clause should be triggered and the indemnity paid."[132] If the parties have entered the smart contract anonymously, known to each other only through smart contract addresses, then dispute resolution may be impossible. This special case deserves attention and will be discussed in the following Section.[133]

A template contract, which a party perhaps downloads from the internet and fills in the blanks, has similar transaction costs to a bespoke contract, except that the negotiation phase is less costly (the parties negotiate over the blanks, not over every word), and the drafting cost is lower. Fill-in-the-blanks smart contracts are also possible, with digital code ready to accept the parties' inputs. For instance, Contract Vault centers its entire business model on the idea of creating smart contract templates using markup, a common word-processing programming system.[134]

In contrast, in modern adhesion contracts, transaction costs are different. For the non-drafting party, negotiation costs are zero, save for possibly comparing various non-negotiable offers and choosing among them. For the drafting party, the fixed cost of drafting the initial contract can be very high. The drafting party wishes to ensure that every eventuality is covered, as the contract will be distributed to many contracting parties with many potential ways to breach. The average cost of drafting, spread out over thousands or millions of customers, is small. Once the contract is drafted, the cost of executing the individual contracts may be large, such as maintaining cell phone towers, providing customer service agents to deal with customers, and so on.[135] For these contracts, transaction costs

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[130] *See supra* quotations heading the Introduction.

[131] *See supra* note 36 and accompanying text.

[132] Stuart D. Levi & Alex B. Lipton, *An Introduction to Smart Contracts and Their Potential and Inherent Limitations*, SKADDEN (May 7, 2018), https://www.skadden.com/insights/publications/2018/05/an-introduction-to-smart-contracts; *see also* Ibrahim Mohamed Nour Shehata, *Arbitration of Smart Contracts Part 1*, WOLTERS KLUWER (Aug. 23, 2018), http://arbitrationblog.kluwerarbitration.com/2018/08/23/arbitration-smart-contracts-part-1/.

[133] *See infra* Section 5; DE FILIPPI & WRIGHT, *supra* note 17, at 85 ("To file a lawsuit, an injured party will need to know the identity of the opposing party. . . .").

[134] Gordon Mickel & Perica Grasarevic, *Next Generation Agreements for Everyone on the Ethereum Blockchain*, CONTRACT VAULT (last visited Feb. 27, 2019), https://www.contractvault.io/files/Whitepaper.pdf.

[135] *See* Kar & Radin, *supra* note 4, at 1208-1209 (describing the use of adhesion contracts to house "ride-along" text describing, e.g., customer service).

in case of breach are small, by design.[136] These contracts typically contain arbitration provisions which are designed to keep litigation costs down by keeping disputes in chosen arbitration locations and preventing class actions, the means by which most consumers might ordinarily find redress for small claims.

Adhesive smart contracts generally have low transaction costs. The cost to render the take-it-or-leave-it agreement to code may be high, especially with deals that are not simple exchanges of values. Code requires unambiguity and preciseness beyond a linguistic exchange. At the same time, as with drafting traditional adhesion contracts, the costs to develop code are small when spread out over thousands of consumers of the contract. After the smart contract is written, the contract executes with the efficiency of code, and the contract may have dispute resolution mechanisms built into the code itself, avoiding the costs of engaging the court system.

V. ADHESIVE SMART CONTRACTS AND THE INCENTIVES TO CREATE BOILERPLATE

This Section offers several suggestions to retain the efficiencies and low-distance nature of smart contracts while avoiding a contractual regime in which automatically executing code acts as a return to the sealed instruments of the past, or in which smart contracts amplify the disadvantages of adhesion contracts and extend them onto the blockchain.

A. Revenge of the Common Law

The common law of contracts evolved an elaborate set of doctrines to deal with formation and execution problems in contract—such as the doctrines of mistake, impracticality, and frustration of purpose. Mistake, for example, might let one party out of contractual obligations if the other party knows and takes advantage of the mistake.[137] The doctrine of impracticality and impossibility allow one out of contractual obligations in the event of circumstances unforeseen by either party at the time of contracting, such as when an act of God fundamentally alters the reasons for contracting, as in a contract to renovate a building destroyed in a hurricane before work could begin.[138] The concept of frustration of purpose grew out of this, letting parties out of bargains not just when circumstances rendered fulfilling the contract impossible but also when the basic purpose behind

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[136] *See id.* at 1203-1206 (describing the practice of arbitration clauses in adhesion contracts).

[137] *E.g.*, Anderson Bros. Corp. v. O'Meara, 306 F.2d 672, 675 (5th Cir. 1962) (discussing potential mistake of the capabilities of a dredger).

[138] *E.g.*, Waldinger Corp. v. CRS Group Eng'rs, Inc., 775 F.2d 781, 788 (7th Cir. 1985) (discussing the commercial impracticality of meeting design specifications of a filter press).

the formation of the contract had been rendered void, such as the building to be renovated being condemned to be destroyed by city legal action.[139]

Considering these doctrines in the context of smart contracts is instructive. If the smart contract is hybrid to an agreement by known parties, then the parties could appeal to the court system and resolve via traditional doctrinal application. Similarly, if the contract has blockchain-based alternative dispute resolution built into it, the anonymous jurors might consider the same ideas. The most interesting cases occur if the smart contract code is intended to be the complete agreement of the parties and the code fails to contain a dispute resolution mechanism. If the parties have not anonymized the contract, they might take the code to court, hope the court can understand Solidity, and attempt to implement common-law solutions post-execution. If the parties are anonymous in a code-only contract, and fail to include dispute resolution mechanisms, then they have no redress: their counterparty is anonymous, and so cannot be sued.[140] If the code does not allow alternative dispute resolution, then the code simply executes with no possible legal recourse.

In this final type of contract, the parties have essentially agreed to waive legal remedy, trusting their agreement entirely to the algorithm. This possibility should give pause.[141] Common law contractual problems developed over hundreds of years to resolve real-life problems in forming and resolving bargains.[142] While technology has changed in marvelous ways that expand the scope of what can be contracted for, the basic problems that arise in exchange remain the same: purposes will be frustrated, parties will have made mistakes, contractual objectives will be rendered impossible by unforeseeable events, and so forth. Parties who have agreed to remove their bargain from any possibility of adjudication, through courts, blockchain-based juries, or otherwise, risk ignoring the evolved wisdom of contract law.

Parties can take affirmative steps to avoid these general negatives of smart contracts. First, the parties should be aware of the auto-execution of code, and so smart contracts should be entered specifically looking forward to the potential for disputes. Jurisdictions should generally recognize smart contracts as satisfying the statute of frauds, but the technology is new and the law unproven.[143] If so, the

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[139] *E.g.*, Chase Precast Corp. v. John J. Paonessa Co., 566 N.E.2d 603, 604 (Mass. 1991) (examining frustration of purpose in constructing concrete median barriers).

[140] Completely anonymous, no-adjudication contracts could thus be considered "complete" contracts, in that every contractual possibility is either considered and coded, or excluded from the contract and unenforceable by reason of anonymity.

[141] From an economic standpoint, it is troubling that parties may find it rational to enter into agreements without the possibility of recourse. Imperfect information about legal remedies, or underestimating the probability of difficulties with the contract may contribute.

[142] *See* FRIEDMAN, *supra* note 233.

[143] *See* DE FILIPPI & WRIGHT, *supra* note 17, at 79-80 (discussing the enforceability of smart contracts and concluding that memorializing an agreement in code should "make little difference, at least in the United States"); Benjamin Van Adrichem, *Enforceability of Smart Contracts Under the Statute of Frauds*, COLUM. SCI. & TECH. L. REV. (Jan. 31, 2018), http://stlr.org/2018/01/31/enforceability-of-

parties should execute a document that satisfies legal formalities and keep the smart contract hybrid. Dispute resolution mechanisms should be specifically contemplated, whether by invoking blockchain protocols, or by specifying traditional contractual remedies like liquidated damages, using an arbitration clause, or forum selection clauses.

Second, in a hybrid smart contract, the parties should contemplate whether code or the written document should control in case they conflict. Careful attention to how code implements the intention of the parties helps, but transferring understanding of real-world agreement into computing code is an imprecise art. Most smart contracts today are some form of template contract, due to the high cost of developing code to match the parties' intentions. Template contracts offer the advantage of lower drafting costs, but may very imperfectly reflect the wills of the parties.

Third, the nature of code development offers a particularly attractive path forward for adhesion contracts. In law, it would be uncommon for natural persons to find the cost of drafting lengthy boilerplate contracts worth the benefit. Large adhesive contracts are generally drafted by large entities for acceptance by consumers.[144] In technology, however, open-source software development, sustained in large part by the efforts of interested individuals, maintains large code-bases used in countless settings. The collaborative nature of coding and the benefits from maintaining open-source software incentivize large communities of developers to contribute to projects.[145] Smart contracts, as code, can maintain the same advantages. Open-source banks of smart contracts or "chunks" of smart contracts, tailored to a variety of settings, could be drafted and maintained by a community of programmers. Rather than being drafted by a single entity with aim to extract as much contractual surplus as possible, the open-source smart contract community can function as an additional path to avoid the negatives of smart contracts. The disadvantage of such open-source standardization is the incentive it gives parties to adopt an agreement not memorializing their exact contractual needs.[146]

Finally, courts should attempt to develop a deep understanding of not only the technology behind blockchain-based disputes, but also of the incentives for parties to adopt it. So far as contracts serve public policy purposes larger than merely enforcing agreements, courts with a sound perspective on the larger issues

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smart-contracts-under-the-statute-of-frauds/; Florian Möslein, *Legal Boundaries of Blockchain Technologies: Smart Contracts as Self-Help?* (Nov. 10, 2018), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3267852 (discussing the legal enforceability of smart contracts).

[144] *See* BERMAN, *supra* note 4.

[145] For example, Linux, which runs the majority of software applications around the world, is maintained as an open-source project. *What is Linux?*, OPENSOURCE.COM, https://opensource.com/resources/linux (last visited Feb. 27, 2019).

[146] *See* DE FILIPPI & WRIGHT, *supra* note 17, at 86.

involved in smart contract disputes will provide more surefooted guidance for the law. [147]

B. Smart Adhesion Contracts

Smart contracts of adhesion may offer special challenges and opportunities. A true meeting of the minds never occurs in many consumer adhesive contracts, as the consumer finds it rational to ignore most of the text to which they purport to agree. The drafting party's power to control terms which are blindly accepted then leads to problems with unfairness, unconscionability, and so on.[148] While consumer groups and market backlash to terms may temper this somewhat, the drafting party in an adhesion contract has tremendous power. At least in great part, these common problems in adhesion contracts stem from a common fount: the drafting party in an adhesive contract does not fully trust its contracting parties, and so must draft large amounts of boilerplate to cover the many ways in which things might go wrong among its many customers. As the costs of drafting will be spread out among many customers, it is worth the time in drafting to cover these many scenarios. The boilerplate gets thick.

Smart contracts of adhesion offer an *economic*, rather than legal solution to this problem.[149] Ironically, this solution stems from the major difficulty with smart contracts discussed in the prior section: auto-execution and its effect on trust issues.[150] In addition to the low execution costs involved in auto-executing code, the transactions costs in smart contracts are low because they offer novel ways of ensuring trust from parties with incentives toward bad behavior. As trust issues decrease, so does the need for contractual terms irrelevant to most consumers of the contract. The auto-execution of conditional statements in code replaces the "if-then" linguistic statements in traditional contracting, except now much is left to auto-execution to exclude eventualities rather than boilerplate provisions

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[147] For example, the doctrine of unconscionability of form contract text arises from the broad conception of such form contracting being unfair from a policy perspective.

[148] *See* Kar & Radin, *supra* note 4, at 1169.

[149] *See* Korobkin, *supra* note 25, at 1206 (arguing for legal solutions to form contracting issues and noting "[a]ctual assent to each contract term in a transaction of complexity simply is not possible; if terms are not imposed on one party by the other, some terms will almost certainly be imposed on both parties by the government."). One solution, as we propose, is for economic incentives to simply write fewer terms.

[150] Absent such economic solutions, the problems with adhesive contracts are amplified in the smart contract setting. The drafting party has the ability to draft the contract *and* control the code which executes it. As code can be opaque to even trained legal minds, this puts ordinary consumers at a disadvantage, particularly if the smart contract code is given preference over the written document in case of conflict. Finally, as smart contract code executes automatically, it is difficult for equitable ex post adjustments of contractual code to be implemented the way a phone call to a cell phone provider customer service hotline might resolve an issue with contractual terms in the traditional setting.

contemplating them.[151] For example, a traditional contract for transfer of real estate may contain boilerplate provisions stating that time is of the essence, that facsimile signatures are binding, the currency which may be accepted for payment, effective dates for if execution by buyer and seller differ in time, and so on. These clauses cover many ways the contracting parties may do each other wrong. They may delay, attempt to pay in a strange currency, argue about an event that occurs between the time the parties sign, and so on. These are unnecessary in a smart contract transferring assets. The time is embodied in the contract itself, which might become unavailable to interact with if excessive time has passed. The issue of facsimile signatures disappears, as the contract is executed via secure blockchain wallets. The contract will accept only the specific coin for payment, by design, and the contract will specify what occurs as the parties sequentially interact with the contract. Due to the nature of the technology implementing the contract, the incentive to write boilerplate is reduced.

This does not mean that smart contracts will be short. Smart contracting restructures transaction costs relative to traditional contracting by increasing them up-front through the costs to code and the increased precision required by code, while lowering the costs in execution. In place of many legal eventualities, the price of smart contracting is the need to render agreements more completely and unambiguously than with traditional written agreements. The nature of code incentivizes the drafting party to be precise, and it may take length to establish precision. This type of length is different than length due to boilerplate contemplating unlikely states of the world, which the algorithm will not let occur. It is length that may *invite* agreement, rather than disincentivize it.[152] At the same time, length does not mean that smart contracts will be complete. Even very precise smart contracts will not rationally contemplate every state of the world, and so including specific mechanisms for dispute resolution is still wise.

From the consumer side, the incentive to understand a smart contract is enhanced relative to a printed adhesion contract. Because the code will largely auto-execute with reduced post-signing appeal to customer service, the accepting party has increased incentive to understand the terms to which they are agreeing, even if they are embodied in code.[153] In other words, the blockchain-based,

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[151] *See* Kar & Radin, *supra* note 4, at 1156 ("The common understandings that parties produce with if-then statements are critical to contractual meaning."); Grimmelmann, *supra* note 10, at 3 (distinguishing "natural" and "formal" languages and arguing the "paradigm of a legal contract is a relation of legal obligation based on a natural-language instrument").

[152] This is not to say that code can ever eliminate ambiguity. *See* Grimmelmann, *supra* note 10. Rather, it incentives reduction of ambiguity due to the need to render agreements to code form, with code's ability to auto-execute. When the parties have contemplated dispute resolution with the agreement, any ambiguity left after drafting and coding can be resolved.

[153] *See* DE FILIPPI & WRIGHT, *supra* note 17, at 74-75 ("Because smart contracts are autonomous in nature, promises memorialized in a smart contract are—by default—harder to terminate than those memorialized in a natural-language legal agreement. Because no single party controls a blockchain, there may not be a way to halt the execution of a smart contract after it has been triggered by the relevant parties."); Gilo & Porat, *supra* note 32, at 987 (in a traditional adhesion contract, one

unalterable nature of the coded contract lowers the ability of the offeror to waive breach or consider special circumstances, making a larger up-front investment in understanding contractual terms rational for the offeree.[154] As more offerees find it rational to inspect smart contract terms, particularly those with technical savvy, this in turn lowers the incentive for drafters to include terms giving themselves inefficient shares of contractual surplus vis-à-vis those with and without technical expertise to understand code.[155] In sum, the drafter of the adhesion contract has less motivation to write boilerplate, and the acceptor of the adhesion contract has greater incentive to understand the drafted terms. The significant problem of non-agreement in form contracts is thus lowered when moving to the smart contract setting.

VI. CONCLUSION

Articles on blockchain sometimes cite Amara's law: "We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run."[156] This is almost certainly true of smart contracts. Smart contracts are a vogue topic with rather limited current use due to the substantial technical challenges facing their implementation. At the same time, the ability to create fractionalized digital representations of physical assets, which transfer without the

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potential use of boilerplate is to send a signal to consumers of non-negotiability); *but see* Johnston, *supra* note 33, at 858 (arguing that form contracts can facilitate bargaining). In this view, smart contracts of adhesion represent an extreme in non-negotiability.

[154] In a printed contract of adhesion, the implicit calculation made by a consumer is generally that the opportunity cost of their time to read and understand the contract exceeds the expected sum of the costs involved with problems with the contract, each problem weighted by the probability that customer service will modify the contract ex-post or otherwise excuse breach. If the consumer reasonably contemplates softness on behalf of the drafter's agents, she rationally finds less incentive to read. In an auto-executing adhesive smart contract, the probability that customer service will not modify terms is one, as the contract will simply and inflexibly execute. The weighted sum of the expected costs of breach is higher, and so the consumer rationally chooses to invest more time to understand contractual terms. *See* Korobkin, *supra* note 25, at 1206 ("Because buyers are boundedly rational rather than fully rational decisionmakers, when making purchasing decisions they take into account only a limited number of product attributes and ignore others. While sellers have an economic incentive to provide the efficient level of quality for the attributes buyers consider ('salient' attributes), they have an incentive to make attributes buyers do not consider ('non-salient' attributes) favorable to themselves, as doing so will not affect buyers' purchasing decisions. Assuming that price is always a salient product attribute for buyers, market competition actually will force sellers to provide low-quality non-salient attributes in order to save costs that will be passed along to buyers in the form of lower prices. Ironically, the consequence of market forces in a world of boundedly rational buyer decision making is that contracts will often include terms that are socially inefficient, leave buyers as a class worse off (judged from the perspective of buyers' subjective preferences) than they would be if their contracts included only efficient terms, and leave sellers as a class worse off as well.").

[155] *See* Bakos, *supra* note 25, at 24 (noting that a "informed minority" paying attention to contractual terms may discipline the drafters of boilerplate contracts and tend towards efficiency). As parties do so, the incentives to write boilerplate for purposes of obfuscation decreases. *See* Gilo & Porat, *supra* note 32, at 987.

[156] *See* Levi & Lipton, *supra* note 9 (discussing Amara's law).

need for intermediaries, housed on shared digital ledgers which are replicated around the world, has the potential to change the practice of contract law in fundamental ways. Attorneys will find themselves increasingly needing to understand how written agreements interact with the code meant to implement them, requiring skills not traditionally taught in law school. Courts will find themselves sidelined as blockchain-based dispute resolution mechanisms increasingly supplement the traditional legal system.

Considering how this potential future of contract law intersects with its present, in which the contracting process for many consumers is dominated by adhesion contracts, is instructive. The nature of the blockchain decreases trust issues in the contracting process, disincentivizing drafting boilerplate to capture trust-based eventualities and incentivizing clarity due to the precision required by code. At the same time, it raises the incentives for acceptors of adhesion contracts to understand contractual terms, as they understand that post-signing modification is unlikely due to the auto-executing nature of code. Together, this means smart contracts of adhesion have the potential to increase actual agreement between parties who do not trust each other, helping solve the key critique of form contracts as not reflecting mutual understanding of contractual terms. The contractual distance for many adhesive exchanges will thus lower, enabling the sociality of the market in previously unrealized ways, such as is beginning to occur in the environmental and film industries.

The efficiencies of blockchain-based adhesion contracting mean that code will continue to take increasing legal significance as a way for parties to express and execute their agreements. At the same time, code should not become law until it incorporates the lessons from contract that developed in response to centuries of real-life situations. Truly "smart" adhesive smart contracts will include dispute resolution mechanisms that incorporate the safeguards built into traditional contracting methods, lest parties find themselves repeating the same mistakes of the premodern contracting era, which often prized formality over intention and failed to incorporate principles of equity into dispute resolution. Calling for self-executing code to sustain these values is easier than implementing algorithms to actually do so, but diligent practice by attorneys and computer scientists can yield the benefits of smart contracts while mitigating their risks.