Quandary of Smart Contracts and Remedies: The Role of Contract Law and Self-Help Remedies

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Abstract: *Smart contracts provide a quandary for contract law remedies. The self-enforcing nature of smart contracts implies that there is little possibility for breach and thus, little need or opportunity to apply contract law remedies. This article explores if this is really the case. It concludes that contract law remains applicable to smart contracts relating to the enforceability of its terms based on legality, public policy, and contracts policing doctrines. In such cases, post hoc judicial or arbitral claims remain likely and the dispute resolution bodies would seek to apply contract remedies. In order to diminish instances of litigation or arbitration the smart contract should include self-remedying or internal measures (remedies). The article divides internal measures into proactive and reactive measures. These measures should be considered in the drafting of a smart contract in order to diminish resort to contract remedies. In the end, contract law and contract remedies will remain important as default law. In addition, like smart contracts, some of contract law rules are immutable and cannot be made obsolete by blockchain technology.*

Résumé: *Les contrats intelligents constituent un dilemme pour les recours en matière contractuelle. La nature auto-applicable des contrats intelligents implique qu'il y a peu de possibilités de rupture de contrat et par là, peu de nécessités ou d'occasions d'appliquer les recours prévus en droit des contrats. Le présent article recherche si c'est vraiment le cas. Il conclut que le droit des contrats demeure applicable aux contrats intelligents en ce qui concerne l'applicabilité de ses modalités basées sur la légalité, l'intérêt public et les doctrines de 'contracts policing'. Dans de tels cas les recours judiciaires ou arbitraux 'post hoc' restent possibles et les organismes de résolution de conflits chercheront à appliquer les recours prévus en matière contractuelle. Afin de réduire les cas de litiges ou d'arbitrages, le contrat intelligent devrait inclure des mesures autorégulatrices ou des mesures internes (recours). Cet article divise les mesures internes en mesures proactives et mesures réactives. Ces mesures devraient être prises en considération dans l'élaboration d'un contrat intelligent dans le but de réduire l'utilisation de voies de recours en matière contractuelle. Finalement le droit des contrats et les voies de recours en matière contractuelle garderont un rôle important en tant que réglementation par défaut. De plus, comme les contrats intelligents, certaines règles du droit des contrats sont immuables et ne peuvent être rendues obsolètes par la technologie de la blockchain.*

Zusammenfassung: *Smart Contracts erzeugen ein Dilemma für vertragliche Rechtsbehelfe. Die sich selbst durchsetzende Natur der Smart Contracts impliziert, dass nur wenig Raum für Vertragsbruch besteht und daher auch nur wenig Notwendigkeit oder Möglichkeit der*

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Anwendung vertraglicher Rechtsbehelfe besteht. Dieser Beitrag untersucht, ob dem wirklich so ist. Er kommt zu dem Schluss, dass Vertragsrecht auf Smart Contracts anwendbar bleibt in Bezug auf die Durchsetzbarkeit seiner Klauseln vor dem Hintergrund von Rechtmäßigkeit, öffentlicher Ordnung, und vertragsrechtlicher Rechtsgrundsätze. In diesen Fällen bleibt die nachträgliche gerichtliche oder schiedsgerichtliche Geltendmachung von Ansprüchen wahrscheinlich und die entsprechenden Stellen würden eine Anwendung vertraglicher Rechtsbehelfe anstreben. Um gerichtliche oder schiedsrechtliche Streitigkeiten zu vermeiden, sollte der Smart Contract eigene 'self-help'-Rechtsbehelfe oder entsprechende interne Vorrichtungen (remedies) vorsehen. Der Beitrag teilt solche internen Vorrichtungen in proaktive und reaktive ein. Sie sollten bei der Erstellung eines Smart Contracts berücksichtigt werden, um den Rückgriff auf vertragliche Rechtsbehelfe zu vermeiden. Es bleibt jedoch dabei, dass gesetzliches Vertragsrecht und vertragliche Rechtsbehelfe eine wichtige Rolle beibehalten. Darüber hinaus bleiben einige Grundsätze des Vertragsrechts unabdingbar und könne auch durch Blockchain-Technologie nicht ersetzt werden.

1. Introduction

1 This article will examine the impact of smart contracts' ability to self-perform, self-enforce, and self-remedy on the applicability of contract law and contract remedies. Smart contracts,[1] those coupled with blockchain technology, have created visions of self-executing, self-enforcing, and self-remedying contracts that eliminate the need for courts or arbitral tribunals to apply contract law to disputes. The question is whether smart contracts are really contracts under traditional definitions of contracts? The State of Nevada on 5 June 2017 enacted a law that provides a framework for the use of blockchain technology and the enforceability of smart contracts.[2] The new law openly recognizes blockchain as a means to the creation of contracts. It does not expressly state that smart contracts are contracts under contract law, but it implicitly achieves this recognition by approving blockchain as an appropriate means to creating contracts.[3]

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1 A simply definition of smart contracts is stated as follows: 'Smart contracts are self-executing electronic instructions drafted in computer code. This allows a computer to "read" the contract and, in many cases, effectuate the instruction – hence the "smartness" of the contract.' R. O'Shields, 'Smart Contracts: Legal Agreements for the Blockchain', 21. *N.C.B.I.* (*North Carolina Banking Institute*) 2017, p (177) at 179. Smart contracts are different than ordinary electronic contracts in that the actual agreement is embodied in computer code, rather than English or another traditional language. See N. Szabo, 'Smart Contracts: Building Blocks for Digital Markets', 1996, http://szabo.best.vwh.net/smart_contracts_2.html (coined the term 'smart contracts') (accessed 17 June 2018).

2 Senate Bill No. 398 (25 May 2017), https://www.leg.state.nv.us/Session/79th2017/Bills/SB/SB398_R2.pdf (accessed 17 June 2018). See generally, Gayle M. Hyman & M. Digesti, 'New Nevada Legislation Recognizes Blockchain and Smart Contract Technologies', 23. N.L (*Nevada Lawyer*) 2017, p (13).

3 The recognition of 'blockchain as a means' is clear because the new law is actually an amendment to the 'Uniform Electronic Transactions Act' which recognized electronic records, as well as electronic signatures or attribution, as satisfying any writing requirements (statue of frauds).

2   It is best to start the current discussion with defining three important concepts—self-enforcement, self-help remedies, and 'other remedies.' Self-enforcement can be analogized to the remedy of specific performance. Self-help remedies may be analogized, in some cases, as a form of the remedy of injunction, such as the disablement of the time of use of the subject of the contract. Other remedies refer to the menu of remedies provided under contract law and their continued position as default law. The remaining importance of contract law remedies is premised on the view that no matter the degree of self-enforcement and the creation of self-help remedies in smart contracts, the parties will continue to have the ability to seek redress before courts and arbitral tribunals.

3   The allure of smart contracts may be a reflection of the perceived shortcomings of written contracts and contract law: (1) contract drafting either leads to incomplete contracts, 'artificial complexity,' or both; (2) the unevenness of contract interpretation; and (3) uncertainty of contract remedies.[4] These criticisms of traditional contracts are not without merit but they also lead to potentially reciprocal criticisms of smart contracts. First, do smart contracts suffer from artificial simplicity, does the translation of words to code and re-translation in case of disputes lead to additional interpretive problems, and do smart contracts solve the issue of the uncertainty of remedies? Second, are smart contracts complete contracts or are they complete only because of their simplicity?

4   Just as the false argument that word contracts can be made to be clear and complete, the completeness of smart contracts is an illusion.[5] One commentator noted that: 'Terms of contracts, which are more complex than the immediate transfer of value and property are likely to not be efficiently encoded.'[6] There remains 'a risk of *divergence* expressed in natural language between the meaning of the original contractual provision and its expression in code.'[7] If word contracts are hopelessly incomplete, how can word contracts translated into code be any less incomplete? In the end, contract remedies will always play a role since completeness is illusionary given the unpredictability of future events and code is no different than the use of words since both are creations of human beings, meaning that perfect completeness will never by achievable. The issue analysed in this article

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4   J. Sklaroff, 'Smart Contracts and the Cost of Inflexibility', 166. *UPLR* (*University of Pennsylvania Law Review*) 2017, p (263) at 265.

5   G. Cordero-Moss, 'Interpretation of Contracts in International Commercial Arbitration: Diversity on More than One Level', 22. ERPL (*European Review of Private Law*) 2014, p (13) (sufficiently detailed and clear contracts can be interpreted internally 'without them being influenced by any governing law. This impression has proven to be illusionary').

6   S. Farrell, H. Machin & R. Hinchliffe, 'Lost and found in smart contract translation—considerations in transitioning to automation in legal architecture' (King & Wood Mallesons, Australia), p 3, http://www.uncitral.org/pdf/english/congress/Papers_for_Programme/14-FARRELL_and_MACHIN_and_HINCHLIFFE-Smart_Contracts.pdf (accessed 22 April 2018).

7   Farrell, Machin & Hinchliffe.

is whether a complete set of remedies can be incorporated into smart contracts to preclude the need for contract law remedies in a default role. The article concludes that this is unlikely because of the immutability of some contract law rules, change of circumstances, and the continued right to bring post-enforcement claims. However, internal remedial provisions may fill in a void where enforcement of traditional remedies are not practical or too costly.

5   The optimistic prognostications of the potential of smart contracts to be self-executing, freeing business transactions from the transaction costs of court and arbitral proceedings, and the formal application of contract law, raises numerous questions.[8] Are smart contracts really smart or are they simple[9] in what they can do? Smart contracts have already proven themselves as efficient in financial trans-actions, but can they be made efficient in complex contract scenarios? Are smart contracts really contracts or simply Internet-like in serving as a means of commu-nication and not as a self-executing substantive private law? No matter whether smart contracts are viewed as fully self-referential contracts or merely as a techni-que of communicating or effectuating performance (within the domain of contract law) are additional regulatory mechanisms needed to police problems created by this new 'contract-type?'[10] Finally, does the use of self-help remedies unduly narrow the remedial menu and act as a device for abuse, especially in cases of change of circumstances?

6   It is in the area of self-enforcement and remedies where the vision of smart contracts confronts the reality of contract law and business lawyering. Smart contracts need to be drafted by lawyers, focused on client interests and not technological prowess. In order for lawyers to best serve their clients, they would have to learn to write computable code, while judges would have to learn codes to interpret the contract or rely on an expert interpretation. Assuming that there is only a single interpretation of a computer code, does the issue over the correct or reasonable legal interpretation of contracts miraculously resolve itself? Put, simply is this a step too far in the advancement of the self-executing, self-enforcing smart contracts? Code will need to be converted into words, which reengages the same quandaries that have persisted in contract interpretation over the centuries.

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8   J. FAIRFIELD, 'Smart Contracts, Bitcoin Bots, and Consumer Protection', 71. WLLRO (*Washington & Lee Law Review Online*) 2014, p (35) at 39, http://scholarlycommons.law.wlu.edu/wlulr-online/vol71/iss2/3 (accessed 17 June 2018).

9   An example of the coding of standard terms involves the coding of the International Chamber of Commerce's Incoterms (Incochain). R. DE CARIA, 'A Digital Revolution in International Trade? The International Framework for Blockchain Technologies', p 7, http://www.uncitral.org/pdf/english/congress/Papers_for_Programme/5-DE_CARIA-A_Digital_Revolution_in_International_Trade.pdf (accessed 25 June 2018).

10   K. LLEWELLYN, *The Common Law Tradition* (Boston: Little, Brown & Co. 1960).

7   If smart contracts are completely self-enforcing, then there is no need for a remedial scheme. If smart contracts are not completely enforcing, can smart contracts provide a self-contained remedial system? Even if that is possible, the argument here is that self-enforcement or self-remedialization would still need to conform to the immutable rules of contract law. An unenforceable clause under contract law cannot be made enforceable simply by embedding it into a code. A contract term that is considered illegal or against public policy cannot be made legal in a smart contract. Finally, if a smart contract is too simple, then it may fail as to indefiniteness of terms.[11] In the end, the judicial remedies of adjustment (reformation) or voidance (rescission) will play the same roles in coded contracts as they do in language contracts. Ultimately, courts will remain relevant in the enforcement and interpretation of smart contracts.

8   Part 2 will examine the relationship between smart contracts and contract law, as well as the future complications posed by artificial intelligence on the self-enforcing nature of smart contracts and whether contract law will play any role in such contracts. Part 3 looks at the issue of enforcement and remedies in smart contracts including the idea of the enforcement of self-help remedies incorporated into smart contracts and the potential for abuse of self-help remedies. Part 4 provides concluding remarks on the continuing role of contract law remedies in the era of smart contracts.

2. Smart Contracts and Contract Law

9   The use of smart contracts can never entirely avoid contract law. Contract law will remain important, especially in areas, such as legal rights, obligations, and remedies. The need to translate digital code to words in order to be interpreted by judges and lawyers can create problems of translation (incorrect coding and decoding), just as words transplanted from one language to another may create issues of meaning. Also, coding and self-enforcement presents a level of rigidity at odds with modern relational contract law.[12] The modern contract is an amalgamation of fixed terms and flexible standards. Contracts and contract law provide flexible terms and doctrines, such as

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11   The indefiniteness of a contract may lead to its unenforceability (as a non-contract):

> Certainty as to what constitutes the contractual terms (and whether they are comprehensive enough) is often a critical factor necessary to establish the formation of a legally binding contract in many jurisdictions. Smart contracts ... may not satisfy such requirements.

Norton Rose Fulbright White Paper, 'Can Smart Contracts be Legally Binding Contracts: Key Findings', p 4, http://www.nortonrosefulbright.com/files/norton-rose-fulbright–r3-smart-contracts-white-paper-key-findings-nov-2016-144554.pdf (accessed 17 June 2018).

12   'The immutability [of smart contracts] means that [the] contracts cannot keep up with changing circumstances.' ERIC TJONG TJIN TAI, 'Formalizing Contract Law for Smart Contracts', Tilburg Private Law Working Papers No. 06/2017, http://www.ssrn.com/link/Tilburg-Private-Law.html (accessed 17 June 2018).

renegotiation and reopener clauses (change of circumstances); duty to use reasonable or best efforts (duty of good faith); and adjustment clauses (duty of cooperation).

10   The flexibility and adaptability of contract law is what makes it such a powerful instrument for a wide range of business transactions. The malleability of contract law is essential in areas relating to long-term, relational, and joint venture or alliance-type contracts. In the end smart contracts will likely play an important role, such as the Internet, in future business transactions, but is unlikely to advance its self-enforcing and self-remedying features into areas of complex and relational contracts.[13]

2.1   *Smart Contracts + AI = Regulation*

11   The above conclusion is made based on the current environment. Some prognosticators see the continued advancement of Artificial Intelligence (AI) as the breakthrough that will elevate smart contracts as the dominant form of future contracting, severely diminishing the roles of contract law and the legal system. Currently, AI can be used to conduct specific tasks, but the idea of generalized AI and its future role is an unknown. Smart contracts technology may be an example of the first practical use of AI. Proponents of AI see it as the means to reduce waste, increase efficiency, and increase net utility to society.

However, AI is likely to suffer from the problem of misalignment, which has been compared to the agency problem often discussed in economics.[14] If AI is given the power to adjust contracts due to extrinsic issues like a change of circumstances there will be the risk that AI's value judgment may not align with the values of the human parties.[15] In highly advanced AI, the study of superintelligence focuses on the ability of AI to strategize in order to achieve goals including its ability 'to rewrite their reward functions, alter their hardware, or manipulate humans.'[16] Cynics of AI reject it as a replacement for human action and, more seriously, as an instrument able to make decisions divergent to a person's intentions or expectations. This danger of misalignment of values presented by the 'independence' of AI, whether related to smart contract or in other areas, will require new regulations through private law and governmentally imposed rules. Microsoft, a key player in AI research, has already

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13   T. FOLAKE ALABI, 'Taking Contracting Digital: Examination of the Smart Contracts Experiment', p 20, https://ssrn.com/abstract=3015843 (accessed 17 June 2018).

14   D. HADFIELD-MENELL & G. HADFIELD, 'Incomplete Contract and AI Alignment', Legal Studies Research Papers Series No. 18-103 (18 April 2018), p 3, https/ssrn.com/abstract=3165793 (accessed 17 June 2018).

15   In the area of robotics, makers of self-driving cars worry about how their machines will perform in 'edge cases'—complicated and unusual situations that cannot be foreseen during training. 'The Kamprad Test' in THE ECONOMIST 14 (27 April 2018), p 24. This same problem presents itself when AI is combined with smart contracts.

16   D. HADFIELD-MENELL & G. HADFIELD, 'Incomplete Contract and AI Alignment', (18 April 2018) p 9.

signalled the need for new regulations.[17] The role of AI in smart contracting will be more fully explored in the next section's discussion of self-driven contracts.

2.2 Self-Sufficient and Self-Driven Contracts

12   Smart contracts are envisioned as potentially eliminating the need for extrinsic enforcement of legal agreements, thereby making business transactions cheaper, quicker, and more efficient.[18] *Economic Forum* has speculated that smart contracts utilizing blockchain technology could codify financial agreements in a shared platform and guarantee execution.[19] But, can one extrapolate the executing of financial agreements without the use of banks to mean that smart contracts in other scenarios can be used without the need for courts?

The self-sufficient contract is an illusion in cases of contract interpretation, as well as the applicability of immutable rules. The idea of a self-sufficient contract (fully comprehensive, perfect clarity) is a cognitive impossibility. The claim that smart contracts can be fully self-executing belies the continuing role of contract law's interpretive and remedial functions in all types of contracts—whether smart or 'dumb.' The fact that smart contracts may be self-executing does not mean that they overcome the problems of interpretation or prevent the right to seek a remedy in court. Self-enforcement does not mean that human agents cannot move to block or prevent enforcement. While self-help remedies can be included in smart contracts, they do not block the use of the range of remedies that parties may seek under the general law of contracts.

13   If smart contracts are to claim the mantel of a fully self-contained, privatized legal system, then it will need to be fully self-enforcing and self-remedying. Can all issues of performance be converted to computer code? Can complicated or complex contracts be self-enforcing or are smart contracts best suited to certain targeted transactions such as the execution of financial obligations? Is enforcement of a smart contract immune from the interpretive problems associated with ordinary contracts? All of these questions relate to the issue of contract remedies and their applicability to smart contracts. At the present, the conclusion is that contract law and judicially created remedies will continue to play a prominent role.

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17   Microsoft has produced a 149-page book entitled 'The Future Computed'. It states that: 'Companies making and selling AI software will need to be held responsible for potential harm caused by 'unreasonable practices.' D. Bass, 'Microsoft Says AI Advances Will Require New Laws, Regulations', Bloomberg Technology (18 January 2018).

18   O'Shields, *N.C.B.I.* 2017, pp 177–178, citing 'Not-So-Clever Contracts', The Economist (30 July 2016), http://www.economist.com/news/business/21702758-time-being-least-human-judgment-still-better-bet-cold-hearted (accessed 17 June 2018).

19   World Economic Forum, 'The Future of Financial Infrastructure: An Ambitious Look at How Blockchain Can Reshape Financial Services', 2016, p 29, http://www3.weforum.org/docs/WEF_The_future_of_financial_infrastructure.pdf (accessed 17 June 2018).

Anthony Kasey and Anthony Niblett provide one possible glance into the future. They surmise that the likelihood of needing remedies and the chances of interpretive misunderstanding are greatly diminished, if nor erased, when smart contracts include the ability to adjust terms through the incorporation of analytics.[20] In what they refer to as 'self-driving contracts,' which are based on coded objectives of the smart contract and where specific terms are filled in post hoc (during performance) through a variation of big data, analytics, and artificial intelligence.[21] Kasey and Niblett define self-driving contracts as 'an agreement where (1) the parties set only broad ex ante objectives; but (2) the contract uses machine-driven analytics and artificial intelligence to translate the general ex ante objective into a specific term or directive at the time of performance; where (3) those terms are based on information gathered after the parties execute the initial agreement.'[22]

According to Kasey and Niblett, the next generation of smart contracts will only require the contracting parties to agree on a desired outcome and the allocation of any future surplus. The contract will then 'monitor both the external world and the parties' behaviour. As facts in the world change, the machine updates its directives and breach is defined as failure to comply with those directives.'[23] The parties are then required to follow the directives or be held in breach of contract. In this way, self-driving contracts are not self-enforcing as are simpler forms of smart contracts. The difference between the self-driven contract and traditional contracts is that the former contract contains fewer possibilities for ambiguities through a post-hoc means of self-correcting or filling in gaps. Currently, the filling of gaps or clarifying ambiguity in contracts entails high transaction costs requiring renegotiation by the parties or the resolution of disputes over meaning through judicial or arbitral proceedings.

Self-driven contracts, however, do not exist and it may be some time before AI can be used to translate general contract objectives to specific terms. However, it is likely to be the case that future AI or algorithm learning-driven[24] smart contracts will be disruptive to the exercise of contract law as currently constituted. Core contract concepts such as consent, definiteness or agreement-in-fact (consent), remedies, as well as policing doctrines like mutual mistake, the US doctrine of unconscionability, and the German concept of 'surprising terms' may all have to be re-thought.

In this future state, there will remain the possibility of coding errors. Kasey and Niblett surmise that just as traditional contract doctrine recognizes the principle of the scrivener's error, 'the law of self-driving contracts will need a doctrine

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20   A. KASEY & A. NIBLETT, 'Self-Driving Contracts', 43. *JCL* (*The Journal of Corporation Law*) 2017, p 1.

21   Self-driven contracts may be a future end point in the evolution of electronic contracts. See generally, H. SURDEN, 'Computable Contracts', 46. *UCDLR* (*University of Davis Law Review*) 2012, p 629 (describing the development of data-oriented and computable digital contracts).

22   KASEY & NIBLETT, *JCL* 2017, p 3.

23   KASEY & NIBLETT, *JCL* 2017, p 6.

24   See L. SCHOLZ, 'Algorithmic Contracts', 20. *STLR* (*Stanford Technology Law Review)* 2017, p 128.

for coding error to fix obvious mistakes in coding that cause the contract to glitch.'[25] The other concern is the use of such contracts in consumer transactions. Businesses use of coded contracts with self-correcting algorithms places the consumer at more of a disadvantage as opposed to standard and fixed terms of the word-based contract. In the end, this may require governmental regulation given the 'shrouded nature of the obligation' in self-driven contracts.[26] Finally, the problem of misalignment of values, discussed in Section 2.1, persists in the self-driving contract.

2.3 Inflexibility of Smart Contracts

14   Smart contracts are ultimately limited by their inflexibility. One of the great features of contract law is its inherent flexibility and malleability. It allows parties to improvise new types of contract terms that are customized to different types of contracts. In long-term, relational, and complex contracting, the contract is a combination of fixed terms, open-textured rules, and standards.[27] Smart contracts currently are only capable of replicating hard or bright line fixed terms or highly formalized rules. It is no surprise that smart contracts have first made their mark in financial transactions. Banking and finance laws are based on highly formalized rules with very little room for adjustment or standards like reasonableness.[28] It is these types of formal rules and terms that are more easily translatable to code.

15   The shifting away from human-language contracts creates new inefficiencies. It is extremely costly to form smart contracts in a volatile environment or whenever there's a level of uncertainty surrounding the agreement. On the other hand, semantic contracts are flexible. They enable parties to use performance standards, generally-

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25   Kasey & Niblett, *JCL* 2017, p 25.
26   Kasey & Niblett, *JCL* 2017, p 33. See also, K. Werbach & N. Cornell, 'Contracts *Ex Machina*', 67. *DLJ (Duke Law Journal)* 2017, p (313) at 377.

> Indeed, the paradoxical result of smart contracts may be to expand the scope of government intervention into technological advancements, which has traditionally been a paradigmatic environment of private ordering. Once again, the shift from ex post adjudication to ex ante enforcement creates an inversion. Contracts free individuals to trust each others' commitments because they can rely on the power of the state to enforce them in cases of breach. Smart contracts remove the state from adjudication, but in so doing, they create pressure to reintroduce the state at the front end of the process. The only way to prevent smart contracts from facilitating illegal or disfavoured conduct is to regulate them.

27   Open-textured rules or terms are those that encourage the interpreter to look to the real world to find the correct interpretive meaning. The robust use of the reasonableness standard in Art. 2 of American Uniform Commercial Code (UCC) is an example of an open-textured rule. Open-textured rules allow for the use of contextual input in the defining and application of the rule. See W. Twining, *Llewellyn Papers* (U. Chicago Law School 1968), 86.
28   See UCC Art. 3 (Negotiable Instruments) and Art. 9 (Secured Transactions).

defined contract terms, to create an enforceable agreement without requiring complete knowledge of what might happen in the future. Standards also allow parties to responsively incorporate commercial customs into their agreement, circumventing the need for explicit but redundant negotiation. And once their agreement is formed and executed, the parties are nonetheless free to dynamically shape their relationship through informal modifications or by selectively enforcing breaches. These two forms of flexibility—linguistic ambiguity and enforcement discretion—create important efficiencies in the contracting process. By eliminating this flexibility, smart contracting imposes costs that are more severe and intractable than the ones it seeks to solve.[29]

The inflexibility of smart contracts versus word contracts provides a major obstacle to smart contracts expansion into the realm of more complex contracting where self-enforcement and self-remedying features may prove unattractive and inefficient.[30] Some contractual terms simply cannot be expressed through formal logic, because they imply human judgment. [For example,] a machine has no precise way to assess whether a party used 'best efforts'.[31] Word contracts help overcome the unpredictability of future events (change of circumstances) through provisions, which require a performance adjustment and the appropriate remedial response that smart contracts are unable to perform. Also, contracts are contextual endeavours. Business custom and commercial practice are resources that provide meaning to contracts. Such contextual meaning is lost in the smart contract because the difficulty and high transaction costs of coding such meaning.[32] Thus the smart contract movement needs to be placed in the context of the complexity of contracts and the widened variety of contract types not amenable to coding due to the inflexibility of smart contracts.

3. Smart Contracts as Self-Enforcing and the Continuing Need for Contract Law Remedies

16   Smart contracts may be outside the law, but they are not above the law. Terms that are unenforceable at law cannot be legally self-enforced under a smart contract.[33] The use of smart contracts to escape the legal system will not render

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29   SKLAROFF, *UPLR* 2017, p 264 ('[Semantic contracts enable parties to use performance standards, generally-defined contract terms, to create an enforceable agreement without requiring complete knowledge of what might happen in the future.').

30   Although one commentator notes that a degree of flexibility may be obtained by the use of a subsequent smart contract to amend or adjust an existing smart contract: 'One possibility for achieving the effect of a reversal or change in terms is to create that result through the creation of a new smart contract which, when added to the existing contracts.' FARRELL, MACHIN & HINCHLIFFE, p 6. However, the speed of smart contract execution and the need of the parties to negotiate to any such changes may prevent a timely adjustment.

31   WERBACH & CORNELL, *DLJ* 2017, p 365.

32   SKLAROFF, *UPLR* 2017, p 264.

33   FARRELL, MACHIN & HINCHLIFFE, p 2.

traditional contractual defenses useless. Smart contracts self-enforcement ability does not prevent that self-enforcement from being subject to post hoc judicial review. In such cases, the remedies of restitution and disgorgement of profits may become more common since performance is not subject to breach.

17   The continuing importance of contract law remedies is supported by the role of such remedies in ex post adjudication. The ex ante view of contract law with its focus on the time of contract formation (consent of the parties), which is the domain of smart contracts, ignores contract law's ex post regulatory and remedial function.[34] In this regard smart contracts cannot transplant contract law.[35]

         An example of the irreplaceability of contractual remedies can be shown through a simple example. A transfer of an asset is executed by a smart contract, but is later invalidated in court due to fraud, duress, incapacity, illegality, and so forth. In the blockchain the asset remains the property of the transferee, but in the real world the law recognizes the title being held by the transferor. The only way to square this bifurcated ownership is for the court to issue an order of specific performance requiring the transferee to re-convey ownership in the blockchain.[36]

18   Finally, the problem of code writing and the possibility of contamination through a virus may lead to a breach of a smart contract: 'the code embedding the contract terms can contain bugs or produce results that are not in accordance with the expectations of the parties.'[37] Therefore, the self-enforcement can be viewed as a breach in cases where 'its performance would not be as expected or intended by the parties.'[38] Because of such possibilities, smart contracts may lead to the recognition of *extracontractual* legal remedies. The one that comes to mind is the tort of negligence. The divergence between a smart contract as intended and expectations of outcome could result in the emergence of torts 'for negligent coding or negligent update.'[39] One could also imagine cases of intentional miscoding as the basis for an action of misrepresentation or fraud.

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34   WERBACH & CORNELL, *DLJ* 2017, p 361.

35   'Smart contracting functions to ensure action. Contract law functions to recognize and remedy grievances. Smart contracts could not – even in theory – replace contract law.'WERBACH & CORNELL, *DLJ* 2017, p 363.

36   A. SAVELYEV, 'Contract law 2.0: "Smart" contracts as the beginning of the end of classic contract law', 26. Information & Communications Technology Law 2017(2), pp 116–134, DOI: 10.1080/ 13600834.2017.1301036.

37   S. HOURANI, 'Cross-Border Smart Contracts: Boosting International Digital Trade Trough Trust and Remedies', http://www.uncitral.org/pdf/english/congress/Papers_for_Programme/11-HOURANI-Cross-Border_Smart_Contracts.pdf (accessed 17 June 2018).

38   HOURANI, 'Cross-Border Smart Contracts: Boosting International Digital Trade Trough Trust and Remedies'.

39   M. RASKIN, 'The Law and Legality of Smart Contracts', *GLTR* (*Georgetown Law Technology Review*) 2017, p (305) at 328.

3.1 Self-Help Remedies: Self-terminating Software or Shareware

19 Public choice economist Gordon Tullock noted that: 'We tend to forget that there is such a thing as technological progress in contracts. People discover new ways of making agreements, and over a period of time we obtain considerable benefit from this sort of technological progress.'[40] We also tend to forget that there is such a thing as technological progress in contract remedies. Smart contracts allow lawyers and scholars to realize that contractual remedies are merely tools to be used when helpful. Like a hammer or a screwdriver, each tool might apply in a different situation. Moreover, like tools, remedies are subject to innovation. Remedial innovation can stem from the law or through contract created solutions.

20 It is helpful to consider the opportunities that the parties of smart contracts exploit, and the arrangements they invent, to enhance the security of their agreements where no legal remedies for breach exist, or where those that do, are plainly inadequate. In particular, scholars in the relational theory of contracts have contributed in exploring 'extra-legal or informal devices' for the regulation of contractual relations.[41] In formal relational contracts, standard like provisions such as re-negotiation or re-opener clauses encourage parties to adjust their contracts according to change of circumstances in order to preserve their relationships instead of pursuing arbitration or litigation.[42] Outside of the contract, relational (extra-legal) norms such as cooperation, loyalty, and solidarity (trust) emphasize the importance of relationship over the formal rights and obligations stated in the contract.[43] Finally, studies have shown that entire industries have created their own practices, governance structures, and dispute resolution processes that make resort to the legal system a rare event.[44] Often negative reputational consequences deter parties from pursuing litigation in order to preserve

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40 G. TULLOCK, *Private Wants, Public Means: An economic analysis of the desirable scope of government* (NY: Basic Books 1970).

41 See S. MACAULAY, 'Non-Contractual Relations in Business: A Preliminary Study', 28. *ASR (American Sociological Review)* 1963, p 55; I.R. MACNEIL, 'The Many Futures of Contracts', 47. *SCLR (Southern California Law Review)* 1974, p 691.

42 When the parties could not agree on changes to the contract, arbitration may represent an option. See, recently, recently Associated British Ports v Tata Steel UK Ltd [2017] EWHC 694 (Ch), 3 April 2017. A long-term licence agreement provided that if the parties could not agree on changes to the contract to reflect a major change in circumstances the matter would be referred to an arbitrator who would decide the new terms. This was enforceable despite there being no guidance in the contract as to the matters that were within the scope of the arbitrator's jurisdiction, nor as to the basis on which he or she should amend the licence.

43 I.R. MACNEIL, *The New Social Contract: An Inquiry into Modern Contractual Relations* (New Haven: Yale University Press 1981) (the author argues that modern contracts have more to do with implicit social relations than the formal contract).

44 L. BERNSTEIN, 'Private Commercial Law in the Cotton Industry: Creating Cooperation through Rules, Norms, and Institutions', 99. *UMLR (University of Michigan Law Review)* 2001, p 1724 (explores the private legal system created by the cotton industry in order to opt-out of the formal legal system).

their status in the community in which they do business.[45] Under the traditional view, legal rules in general, and formal rules of remedies in particular, play a marginal role in factual settings that fall under the purview of a 'relational contract'.[46]

21   A type of extra-legal remedies are self-help remedies, which consist of 'legally permissible conduct that individuals undertake absent the compulsion of law and without the assistance of government officials in efforts to prevent or remedy a civil wrong.'[47] However, these self-administered remedies—such as termination, reduction of price, set-off and the right to withhold performance of an opposing obligation—remain susceptible to formal litigation. Self-help remedies are a natural fit for smart contracts in their quest for self-sufficiency.

As previously noted, it is important to underline that smart contracts' abilities to provide self-remedying options do not exclude the traditional remedies offered through litigation. However, in the words of an author, the remedial perspective with respect to smart contracts is mainly a matter of 'private ordering' of the blockchain environment.[48] Put differently, traditional remedies, such as damages, specific performance and termination are harder to apply to blockchain-based contracts.[49] This is because of the problem of identifying pseudonymous parties, finding an appropriate remedy, and deciding jurisdiction. These problems vary in magnitude and volume depending upon the types of blockchain networks and environments that underpin the smart contract.

22   In the light of the above, this section constructs a remedial framework for smart contracting grounded on the current 'state of knowledge', while recognizing that blockchain environments are likely to foster the design of new measures *within* the blockchain ecosystems over the coming years. The term 'measure' is used here

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45   E.g. the losing party in cotton industry arbitration will almost never contest the award through litigation due to fear if reputational harm and 'de facto ouster from the industry.' BERNSTEIN, *UMLR* 2001, p 1740, fn 73.

46   'In a relational contract ... it is suggested that legal remedies play a secondary role ... and non-legal factors ... play a critical role in the resolution of disputes.' E. McKENDRICK, 'The Regulation of Long-Term Contracts in English Law', in J. BEATSON & D. FRIEDMAN (eds), *Good Faith and Fault in Contract Law* (Oxford: Oxford University Press 1995) pp (305) at 309–310. See also, I. MACNEIL, 'Contracts: Adjustment of long-term economic relations under classical, neoclassical, and relational contract law', 79. *NWULR (Northwestern University Law Review)* 1978, p 854 (Ian Macneil is considered the father of relational contract theory).

47   M.P. GERGEN, 'A Theory of Self-Help Remedies in Contract', 89. *Boston U. L. Rev.* 2009, p 1397. D.I. BRANDON ET AL., 'Self-Help: Extrajudicial Rights, Privileges and Remedies in Contemporary American Society', 37. *VLR (Vanderbilt Law Review)* 1984, p (845) at 850 (self-help remedies include liquidated damage, self-help repossession, and arbitration).

48   O. WILLIAMSON, 'Credible Commitments: Using Hostages to Support Exchange', 73. *AER (American Economic Review)* 1983, p 519.

49   E.g. laws cannot be easily applied to blockchain users in different countries, since each geographic jurisdiction has its own separate legal system, and there is little chance of forcing a person from the Internet (especially if they are anonymous) to appear in court in a different country. S. ROWAN, *Remedies for Breach of Contract* (Oxford: OUP 2012), p 265.

instead of 'remedy' to distinguish traditional approaches to breach of contract and contractual remedies with those relating to self-help remedies developed with blockchain technology.[50] It recognizes that smart contracts are likely to develop within the scope of blockchain ecosystems, with traditional contract remedies acting in default. This is because self-executing technologies necessarily focus on *ex ante* compliance rather than on *ex post* enforcement measures.[51]

23   Internal smart contract remedies can be divided into two types—proactive and reactive measures. The next two sections will explore proactive and reactive measures. Proactive measures include, but are not limited to, data security and integrity, making non-performance or breach technologically impossible, and opt-out provisions tailored to minimize the loss to one of the parties. Reactive measures include, for example, trust, reputation, and social repudiation. Other technology-centred remedies include the use of private ('expert oracles') or public authorities ('public super-user') with the ability to modify the content of blockchain ecosystem in case of fraud or mistake.[52]

3.2 *Proactive Measures*

24   Smart contracts are immutable, meaning that the code by default cannot be changed. One of the most compelling reasons for the use of smart contracts is their ability to *lessen the likelihood of breaches.* This is based upon the assumption that the electronic format and Boolean logic remove the need for nuance and interpretation by eradicating the ambiguity found in traditional contracts. Also, by automating the contractual exchange opportunistic breach is precluded. Moreover, non-legal remedies can be programmed into the smart contract in the event of a coding error or breach.

Proactive remedies include procedures that render breach technically impossible or, alternatively, providing ex ante for a party to exit the contract with a specified loss. In other words, these measures protect the security of a blockchain transaction.[53] By using smart contracts, the parties aim at changing the paradigm of contract practice from *ex post* authoritative judgment to *ex ante*-automated assessments. Parties that

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50 N. SZABO, 'Formalizing and Securing Relationships on Public Networks' (1 September 1997), http://firstmonday.org/ojs/index.php/fm/article/view/548/469-publisher=First (accessed 20 June 2018) (author uses the word 'measures').

51 A. NARAYANAN, 'The Future of Bitcoin?', YouTube (27 April 2015), https://youtu.be/YG7l0XPtzD4 (accessed 20 June 2018). Smart contracts seek to insulate performance from outside intervention: 'To maintain knowledge and control, performance must be encapsulated: protected from outside influences,' such as third-party claims. N. SZABO, 'Formalizing and Securing Relationships on Public Networks', 2. First Monday (1997), https://firstmonday.org/ojs/index.php/fm/article/view/548 (accessed 17 June 2018).

52 A. SAVELYEV, *ICTL*, p 22.

53 N. SZABO, 'Smart Contracts: Building Blocks for Digital Markets', 1996, http://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart_contracts_2.html (accessed 17 June 2018).

use smart contracts believe that the *ex ante* automated results will only infrequently diverge from an authoritative decision maker such as a judge. In this way, the parties deliberately preclude *ex-post* corrections for the sake of *ex ante* efficiency. In other words, parties to smart contracts re-design the contractual framework to increase legal certainty by agreeing up-front to abide the contracts' automated conclusions.[54]

3.3 Reactive Measures

25   The benefits of self-enforcement include lower transaction costs and certainty of performance. However, the immutability of smart contracts presents a special challenge for programmers. In writing a smart contract, correctness matters a great deal since the consequences of bad code writing can be dire. 'Bugs' are inherent in computer code so the effectiveness of smart contracts is dependent on the careful writing of code, since errors cannot be fixed after the fact.

Two authors suggest that blockchain autonomy might be tempered with fuller consideration of the human side of business dealings including the loss of a blockchain private key,[55] receipt of a defective product, the ability to show ownership, to invoke state consumer protection rights, or the need to verify title to land before entering a transaction on the blockchain.[56] Smart contracts cannot access outside information unless it is written into the blockchain.[57] One commentator provides this example:

> [By] setting up a blockchain based land register on a server or coding smart contract to be recorded as a transaction on a blockchain application may prove to be the easy part. Verifying that a person claiming that he has title to a piece of land or verifying that the holder of a public key is who he claims to be, will often be an impossible task (...).[58]

In other words, by nature, 'smart contracts' are limited in their functionality since they cannot deal with ambiguity, programmers cannot plan for every contingency, nor do they have the capability of translating a complete set of the real-world data to respond

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54   A. ROBINSON & T. HINGLEY, *Smart Contracts: The Next Frontier?*, Oxford Law Faculty Business Law Blog (23 May 2016), https://www.law.ox.ac.uk/business-law-blog/blog/2016/05/smart-contracts-next-frontier (accessed 20 June 2018).

55   A private key is a secret code that authenticates your ownership of resources on the blockchain.

56   J. GRIMMELMANN & A. NARAYANAN, *The Blockchain Gang*, Slate (16 February 2016), http://www.slate.com/articles/technology/future_tense/2016/02/bitcoin_s_blockchain_technology_won_t_change_everything.html (accessed 20 June 2018).

57   For instance, a smart contract by itself has no access to weather data. To condition a contract on the temperature, e.g. there must be a third party that takes the data from a weather API and writes it to the blockchain in a way that is accessible to other users. This trusted data source is called an oracle.

58   M. VON HALLER GRONBAEK, *Blockchain 2.0, Smart Contracts and Challenges*, Working Paper (2016), http://www.twobirds.com/en/news/articles/2016/uk/blockchain-2-0-smart-contracts-and-challenges (accessed 16 June 2018).

to future events.[59] In this sense, one may conclude, contrary to the claims of promoters of blockchain technologies the rule of the word cannot be fully replaced by the rule of the code.[60] This implies that a proactive (*ex ante*) approach many not be sufficient in all cases. Thus, contrary to the myth of self-enforcement, the design of reactive measures is inevitable. Reactive measures for smart contracts include, for example, trust, reputation, and social repudiation, as discussed below.

3.3.1 Trust

26 Trust is the bedrock of contracting, especially in long-term contracts. Contracting parties might make promises, but given the opportunity, might break them and pursue their own self-interests. However, business deals depend on being able to trust that a promise will be kept. Does blockchain technology act as a substitute for trust due to its immutability? An affirmative answer makes smart contracting a tempting means of doing business. It should be reiterated that, in blockchain environments, each member maintains his own copy of the information, and members must validate any updates collectively. The information could represent transactions, contracts, assets, identities, or practically anything else that can be described in digital form. Entries are permanent, transparent, and searchable, which makes it possible for community members to view transactional histories. Each update is a new 'block' added to the end of the 'chain.' A protocol manages new edits or entries, validate, record, and distribute the new blocks. Thus, cryptology replaces third-party intermediaries as the keeper of trust as blockchain participants by running complex algorithms certify the integrity of the whole blockchain and its embedded information. But, the blockchain cannot be a complete surrogate for trust because human actors still play crucial roles as programmers, develops, and as owners or managers of electronic platforms.[61]

3.3.2 Reputation

27 Reputation is invaluable in small communities with repeated transactions (like private blockchain environments). Parties not conforming to communal norms or breach contracts suffer negative reputation consequences resulting in exclusion from future interactions. Thus, it is in parties' self-interest to build a reputation of reliability, honesty, and fair dealing.

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59 E. Mɪᴋ, 'Smart contracts: Terminology, technical limitations and real world complexity', 9. *LIT (Law, Innovation and Technology)* 2017, p 269.

60 A. Wʀɪɢʜᴛ & P. Dᴇ Fɪʟɪᴘᴘɪ, *Blockchain and the Law: The Rule of Code* (Cambridge: 2018); A. Wʀɪɢʜᴛ & P. Dᴇ Fɪʟɪᴘᴘɪ, 'Decentralized Blockchain Technology and the Rise of Lex Cryptographia' (10 March 2015), https://ssrn.com/abstract=2580664 (last assessed 15 May 2018) and http://dx.doi.org/10.2139/ssrn.2580664 (accessed 17 June 2018).

61 Nakamoto, 'Bitcoin: A Peer-to-Peer Electronic Cash System', p 9, https://bitcoin.org/bitcoin.pdf (accessed 20 June 2018) (summarizes the Bitcoin project 'as system for electronic transactions without relying on trust'). R. Jᴀᴄᴋsᴏɴ, 'After Facebook's Privacy Debacle, How Blockchain Will Secure Our Digital Lives', (3 April 2018), https://cryptoslate.com/facebook-privacy-debacle (accessed 20 June 2018).

However, integrity and reputation are of little importance in blockchain transactions. Misbehaving parties can simply erase their history by creating a new pseudonym.[62] In contrast, most people that conduct business over the Internet are more interested in interconnectedness that results from the exchange than in the legal consequences of their transactions. This can be seen in the way that people rate their experiences on eBay, Uber, and TripAdvisor. Users of these services rate their experiences with the vendors based on the quality and timeliness of the service or delivery of the product. These ratings create a reputation for the service provider and build relationships of trust in the network or community. Thus even though the participants never meet, their interactions are based on each other's status in the community, rather than the strict legal rights expressed in terms and conditions.[63]

In fact, participants use a variety of tools to promote their 'reputations' in a decentralized blockchain. 'Uprightly' is an example. It is a decentralized reputation protocol empowers users to build their reputation with reviews and encourages cooperation in all marketplaces.[64] Those who use this system make it easier for users to submit reviews relating to the platform and efficiently search for reviews of the platform. This way, users can become a market participant and safeguard their interests in the process. Further, Uprightly encourages and incentive structure so that users can apply this system, and benefit from it as well. It requires no third-party intervention. It is censorship-resistant and decentralized as well.

3.3.3 Social repudiation: 'hard-forking'[65]

28   The DAO incident[66] involved the stealing of fifty million dollars of Ether cryptocurrency and ultimately led the Ethereum community to rescind (hard-fork)

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62   N. Nisan, T. Roughgarden, É. Tardos, V.V. Vazirani & C.H. Papadimitriou, *Algorithmic Game Theory* (Cambridge: CUP 2008), p 682. Being able to cheaply create a new pseudonym in order to dodge a bad reputation is called whitewashing. One response is to distrust newcomers since their identities may mask a bad reputation or to require that pseudonyms be linked to a real person or business.

63   W.L. Felstiner, R.L. Abel, & A. Sarat, 'The Emergence and Transformation of Disputes: Naming, Blaming, Claiming...' 15. *LSR (Law & Society Review)* 1980, p 631.

64   'Uprightly' is discussed at https://bitcoinexchangeguide.com/uprightly-ico-upt-token/ (accessed 17 June 2018).

65   Hard-forking refers to:
A hard fork or hardfork, as it relates to blockchain technology, is a radical change to the protocol that makes previously invalid blocks/transactions valid (or vice-versa). This requires all nodes or users to upgrade to the latest version of the protocol software. Put differently, a hard fork is a permanent divergence from the previous version of the blockchain, and nodes running previous versions will no longer be accepted by the newest version.
Investopedia at https://www.investopedia.com/terms/h/hard-fork.asp#ixzz5E3U9U2Pg (assessed 20 June 2018).

66   The DAO is a digital Decentralized Autonomous Organization, and a form of investor-directed venture capital fund. The DAO had an objective to provide a new decentralized business

the blockchain (violating the underlying principle of distributed ledger technology). Interestingly, the taking of Ether did not constitute a breach since the hacker followed DAO rules but in a strategic and malicious manner. The ETH community's hard-fork was a way to protect the agreement (crowd-sourced venture capital), but it did so via social repudiation (breach) of the 'contract' itself. While 'hard-forking' is not a readily available contract remedy (although it may be subject to specific performance order), it provides an extra-legal measure to correct errors or manipulation of the blockchain.

3.3.4 Blockchain Community and Contractual Measures

29   This preliminary analysis of the state of the art concerning proactive and reactive measures points out the 'centrality' of the blockchain community in preventing or when necessary reacting to vitiating elements, such as breach, eavesdropping, and interference in smart contracts. The blockchain is described as a community since the participants believe in a similar cause: the use of technology to ensure transparency, trust, and anonymity (decentralization). Importantly, blockchain environments can be customized to reflect the needs of different types of participants. For example, blockchain environments can be private with restricted membership (known as 'permissioned blockchains') or they can be accessible to any person in the world ('unpermissioned blockchains'). There are also 'consortium blockchains' where the process of validating transactions is controlled by a fixed set of nodes.

30   Blockchain ecosystems can be conceived as 'tribes' that allow its members to trust one another, much like the Maghribi traders of the eleventh-century.[67] Maghribis coalitions established informal mechanisms (measures) to prevent breach of contracts. These measures included trust, reputation, and exclusion from the social group. Contemporary traders rely on trust in coding, oracles and their ecosystems to avoid what is perceived as an overregulated world, and are, thus, likely to seek out remedies or, more specifically, measures within their blockchain communities.

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model for organizing both commercial and non-profit enterprises. It was instantiated on the Ethereum blockchain. The DAO raises funds and 'members' write smart contracts to manage the investing of the funds. A hacker managed to create a parallel DAO and stole 3.6 million units of Ether (cryptocurrency).

67   A. GRIEF, 'Reputation and Coalitions in Medieval Trade: Evidence on the Maghribi Traders' 49. *JEH (Journal of Economic History)* 1989, p 857 (discusses 'informal contract-enforcement mechanism based on multilateral relationships within a closely-knit 'coalition'). See also, A. GRIEF, 'Contract Enforceability and Economic Institutions in Early Trade: The Maghribi Traders' Coalition', 83. *AER (American Economic Review)* 1993, p 525; A. GRIEF, *Institutions and the Path to the Modern Economy: Lessons from Medieval Trade* (Cambridge: CUP 2006).

4. Concluding Remarks

31   Given the great variety of contract types, smart contracts are currently limited to simplistic, mostly financial, types of transactions.[68] This is not to say smart contracts and blockchain technology are not major advancements and that they are not likely to play bigger roles in future contracting. But, currently the use of smart contracts in more complex transactions is limited to a piecemeal approach. They can be used to execute certain obligations within the framework of a more complex word contract.[69] Some obligations can be efficiently coded, others cannot; smart contracts can be used to execute fixed, formal components of a contract, but the flexibility needed in long-term or relational contracts would need to remain in word form.

32   The point here is that reliance on formal remedies is less frequent in smart contracts. In particular, it will be important to monitor the emergence of measures (proactive and reactive) aimed at preventing or (when necessary) responding to vitiating elements (manipulation, errors in coding), breach, eavesdropping, and interference in smart contracts, as well as *extracontractual* or business responses, before resort is made to contract law and the legal system. The article develops a preliminary categorization and analysis of proactive and reactive measures that are available to the users of the blockchain and their communities.

33   Such measures may diminish the use of the formal legal system, but they cannot transplant the legal system or prevent the use of the legal system to obtain contractual remedies. Smart contracts cannot avoid law, as coded terms remain subject to review of the courts. This is especially in cases where codes terms do not comply with the mandatory provisions of the law, for example, in the case of EU consumer law. Smart contracts also remain subject to contract laws policing doctrines, such as mistake, duress or coercion, 'surprising terms' (if the smart contract incorporates stand terms),[70] misrepresentation or fraud, as well as implied in law terms, such as the duty of good faith and the duty of reasonable efforts in agency contracts.

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68   See e.g. John Armour asserts that: 'the foreseeable future will confine smart contracts to simplistic types of transactions. In more complex transactions, the word contract will remain dominant, however, portions of such contracts may be allocated to smart contract technology'. J. Armour, 'Mechanisation of Law', https://www.law.ox.ac.uk/research-and-subject-groups/research-collection-law-and-technology/blog/2017/03/mechanisation-law (accessed 3 March 2017).

69   Anil Awasthi discusses such as scenario: 'Smart legal contracts would contain a combination of smart contract code and more traditional legal language.' A. Awasthi, 'Revolutionary' Smart Contracts Automate Trust', 1. *AB (American Banker)* Bank Technology Section (9 September 2016), https://www.americanbanker.com/opinion/revolutionary-smart-contracts-automate-trust (accessed 17 June 2018).

70   See e.g. s. 305c of the German Civil Code ('Provisions [that are] are so unusual that the contractual partner of the user could not be expected to have reckoned with them, do not form part of the contract.').

34 Self-enforcement is not a panacea against judicial intervention. In the end, self-enforcement will not prevent a party from seeking redress through litigation or arbitration. The need for redress may be predicated upon the occurrence of unexpected events that appear after the conclusion of the smart contract, which change the contractual balance. Once there is litigation or arbitration then contract law's remedial scheme is re-engaged.