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# Wrapped and Stacked: 'Smart Contracts' and the Interaction of Natural and Formal Language

https://doi.org/10.1515/ercl-2018-1023

**Abstract:** This article explores 'smart contracts' from first principles: What they are, whether they are properly called 'contracts', and what issues they raise for national contract law. A 'smart' contract purports to record contractual promises in language which is both intelligible to human beings and (ultimately) executable by machines. The formalisation of contracting language that this entails is, I argue, the most important aspect for lawyers—just as important as the automation of contractual performance. Rather than taking a doctrinal approach focused on the presence of traditional indicia of contract formation, I examine the nature of contracts as legal entities created by words and documents. In most cases, smart contracts will be 'wrapped in paper' and nested in a national legal system. Borrowing from the idiom of computer science, I introduce the term 'contract stack' to highlight the complex nature of contracts as legal entities incorporating different 'layers', including speech acts by the parties in both natural and formal languages as well as mandatory legal rules. It is the interactions within this contract stack that will be most important to the development of contract law doctrines appropriate to smart contracts. To illustrate my points, I explore a few issues that smart contracts might raise for English contract law. I touch on the questions of illegality, jurisdiction, and evidence, but my focus in this paper is on exploring issues in contract law proper. This contribution should be helpful not only to lawyers attempting to understand smart contracts, but to those involved in coding smart contracts—and writing the languages used to code them.

**Résumé:** Cet article explore les "smart contracts" (contrats intelligents) à partir de questions fondamentales: que sont-ils, peuvent -ils réellement être qualifiés de contrats et quels problèmes soulèvent-ils sau regard du droit national des con-

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trats? Un contrat intelligent prétend encoder des engagements contractuels dans un langage qui est à la fois intelligible pour les humains et en dernière analyse exécutable par les machines. La formalisation du langage contractuel que cela implique en est, selon moi, l'aspect le plus significatif pour les juristes—aussi important que l'automatisation de l'exécution du contrat. Plutôt que d'adopter une approche doctrinale focalisée sur la présence d'indices traditionnels de la formation des contrats, j'examine la nature du contrat en tant qu'institution juridique créée par des mots et des documents. Dans la plupart des cas, les contrats intelligents seront 'emballés dans du papier' et nichés dans un système juridique national. Empruntant à l'idiome de la science informatique, j'introduis le terme 'contract stack' (empilement contractuel) afin de mettre en lumière la nature complexe of du contrat en tant qu'il incorpore des couches successives, y compris des paroles des parties dans des langues naturelle et formelle, ainsi que des règles impératives. Ce sont les interactions au sein de cet empilement qui seront importantes pour le développement de doctrines de droit des contrats adaptées aux contrats intelligents. Pour illustrer ma thèse, j'explore quelques problèmes que ces contrats peuvent présenter au regard du droit anglais. J'évoque des questions d'illégalité, de compétence juridictionnelle, et de preuve, mais le coeur de cet article consiste à mener l'exploration au regard du droit substantiel des contrats. Cette contribution devrait être utile non seulement aux juristes tentant de comprendre les contrats intelligents, mais aussi à ceux qui les encodent—et à ceux qui créent les langues utilisées à cette fin.

**Zusammenfassung:** Dieser Beitrag beleuchtet die Grundlagen einer Lehre von den 'smart contracts': Was darunter zu verstehen ist, ob es sich überhaupt um Verträge handelt, und welche Fragen sie im nationalen Vertragsrecht aufwerfen. Ein "smart contract" soll Vertragszusagen so kodieren, dass seine Sprache sowohl Menschen verständlich ist als auch eine Durchführung durch Maschinen gestattet (ohne weitere menschliche Intervention). Die Formalisierung der Sprache, die deswegen zur Niederlegung der Vertragsinhalte unverzichtbar ist, bildet – so das Argument des Beitrages – den wichtigsten Aspekt für Juristen, ebenso wichtig wie die automatisierte Vertragsdurchführung. Der Beitrag stützt sich nicht auf dogmatische Überlegungen dazu, ob die herkömmlichen Kriterien für einen Vertragsschluss vorliegen, sondern nimmt vielmehr die Natur von Verträgen, insbesondere digitalen, in den Blick – als Konstrukte aus Worten und Vertextlichung. In den meisten Fällen werden "smart contracts" in einem herkömmlichen vertraglichen Rahmen "gewickelt" ("wrapped in paper") und in ein nationales Rechtssystem eingebettet. Unter Rückgriff auf Terminologien aus der Informatik, schlage ich vor, von "Vertragsschichten" ( "contract stack") zu sprechen, um die Komplexität des Vertragskonstrukts mit einer Reihe vertraglicher Schichten zum Ausdruck zu

bringen – in das Sprechakte der Parteien sowohl in natürlicher als auch in Programmiersprache eingehen sowie auch zwingendes (nationales) Recht. Die Interaktionen in diesem Vertrags-Turm und ihre Analyse bilden den wichtigsten Bestandteil einer Adaption des Vertragsrechts auf ein sinnvolles Regelungsregime für smart contracts. Zur Klarstellung meines Kernanliegens erörtere ich verschiedene Einzelfragen und Einzelfälle – aus Sicht des englischen Vertragsrechts. Dabei werden auch Fragen der Unwirksamkeit wegen Gesetzesverstoß, der Zuständigkeit und des Beweisrechts in den Blick genommen, doch liegt der Hauptfokus auf dem eigentlichen Vertragsrecht. Dieser Beitrag soll nicht nur Juristen helfen, "smart contracts" zu verstehen, sondern auch denjenigen, die "smart contracts" kodieren, sowie diejenigen, die Programmiersprachen für smart contracts erfinden.

# 1 Introduction

Over the course of the past year, lawyers and legal academics have become increasingly aware of the challenges and opportunities of so-called 'smart contracts'. The emerging literature on the topic ranges from stressing business as usual[1] to predicting the end of contract law as we know it.[2] Despite this literature, however, we are some way from a general consensus on (i) what smart contracts actually are, (ii) whether the national legal system should recognise them as 'contracts' in the ordinary legal sense, and, (iii) in either case, what they might entail for the conventional doctrines of contract law.[3] The technologies on which

**1** For example Max Raskin, 'The Law and Legality of Smart Contracts' (2017) 1(2) *Georgetown Law Technology Review* 305 argues that there is 'little difficulty situating smart contracts within existing contract law'; Jenny Cieplak and Simon Leefatt, 'Smart Contracts: A Smart Way to Automate Performance' (2017) 1 *Georgetown Law and Technology Review* 418 stresses the continuity of automated contract *performance* and enforcement with the well-established practice of automated contract *formation* through electronic signature services; Alan Cohn, Travis West, and Chelsea Parker, 'Smart After All: Blockchain, Smart Contracts, Parametric Insurance, and Smart Energy Grids' (2017) 1 *Georgetown Law and Technology Review* 273 argues that smart contracts are enforceable under existing US law, particularly federal statutes governing electronic signatures and transactions.

**2** See e.g. Alexander Savelyev, 'Contract law 2.0: "Smart" contracts as the beginning of the end of classic contract law' (2017) 26(2) *Information and Communications Technology Law* 116.

**3** See Kevin Werbach and Nicolas Cornell, 'Contracts Ex Machina' (2017) 67 *Duke Law Journal* 313, 317. A number of competing definitions of the term are current among computer scientists and lawyers; see C.D. Clack, A.V. Bakshi, and Lee Braine, 'Smart Contract Templates: foundations, design landscape, and research directions' (15 March 2017), arXiv:1608.00771v3, 2.

these instruments rely are still new, and their use is evolving. Though it means tracking a moving target, it is necessary for lawyers and legal academics to define what exactly we are dealing with. In this article, I take these interrelated questions in turn and focus attention on what is, in my view, the most salient feature of smart contracts for lawyers: the formalisation of contractual language into a system of operators expressing actions and modes of obligation in the future.

Section 2 provides the necessary background. Though discussion of smart contracts often begins in the context of 'blockchain' data structures and 'cryptocurrencies',[4] it is instructive to start at a more basic level. First, I explain the notion of a smart contract and explore how digital legal instruments differ from paper ones. The feature most often stressed in the context of smart contracts is the automation of some or all contract performance through the fusion of contractual terms with the computer code that executes performance of those terms. Although this agentive function—performing coded actions autonomously—deserves examination, in this paper I concentrate instead on the *formalisation of contractual language*. This not only shapes the challenges smart contracts pose to contract law, but also the opportunities that smart contracts present for the development of contract law in the coming decades.

In Section 3, I address the question whether a smart contract is a 'contract' at all, or whether the term itself is a misnomer. In a smart contract, automation of contractual performance and/or enforcement is achieved through the structured coding of information in symbols that can be processed by machines *and* are intelligible to humans, ideally such that the latter can predict what the machines will do. Smart contracts claim to merge the legal entity of the contract with its mechanism of performance in a single written instrument. Some proponents of smart contracts assume such a merger and stress the completeness and self-containment of smart contracts—even their isolation from the national legal system. Many empirical applications of 'smart contracts' are, however, only performance mechanisms 'wrapped' in a conventional contractual framework. In such cases, the term is certainly a misnomer and should perhaps be avoided. However, some commentators go so far as to suggest that a smart contract can, conceptually, never be anything more than the performance mechanism of a 'legal contract'. Against this view, I argue that there is no barrier to a single instrument, written in formal language, embodying both the contract as such and its automated mechanism of performance. A more sophisticated view of the

**4** By using the term 'cryptocurrency' I do not want to assume the status of any particular token as 'currency' or 'money', I am merely using the term current in general parlance. See e.g. J.P. Smit, Filip Buekens, and Stan du Plessis, 'Cigarettes, dollars and bitcoins—an essay on the ontology of money' (2016) 12(2) *Journal of Institutional Economics* 327.

ontology of contracts themselves—legal entities created and maintained by speech acts and documents—suggests that we should see contracts as a 'stack' composed of several 'layers'. *Contract stacks* will, increasingly, contain 'smart' components. We should regard contracts as complex legal institutional entities whose legal and technological parts interact. The smart contract layer is incorporated into the stack in a manner not categorically different from conventional contracts with formal appendices, such as mathematical accounting formulae. Nobody would argue that a technical appendix is not part of the contract, and so a technical appendix that comprises executable code should not be seen as categorically non-contractual, either.

The dynamics of the interaction between a contract's various layers is the important aspect of smart contracts' challenge to business as usual, which may in time influence legal theory and practice profoundly. Understanding this potential impact requires us to engage with the nature of language, and in particular with the interaction of formal and natural languages, in a legal institutional context. Assuming that some smart contracts really are 'contracts', Section 4 turns to the challenges and opportunities that smart contracts present for conventional contract law. Many smart contracts purport to create a cyber business entity, a private currency, or private regulatory system, raising a raft of issues beyond contract law.[5] Again, these important questions deserve independent examination. I limit my current discussion to contract law proper. While innovators and investors might wish to build a New Jerusalem outside national law, the more smart contracts are treated as 'real' contracts, the more they will interact with national contract law. The courts will, therefore, need to consider their interpretation and enforcement. I set out the main issues that I think are likely to arise, using English law as an example which mostly concern the translation between formal and natural language. In conclusion, I argue that English contract law is broad and supple enough to absorb smart contracts, though it is likely that they will exacerbate some existing problem areas in the law and create some new ones. Smart contracts will, above all, challenge the courts' approach to ambiguity in contractual language, and in particular the proper treatment of code-based clauses that have a result that is intuitively perverse to any common-sense agent. Lawyers and legal academics must also carefully consider the role of equitable remedies in the context of contracts drafted in whole or part in executable code. At the same time,

**5** Including consumer and investor protection, capital markets law, corporate governance law, and international private law: See e.g. D.G. Post, 'How the Internet is making jurisdiction sexy (again)' (2017) 25(4) *International Journal of Law and Information Technology* 249; J.A.T. Fairfield, 'Smart Contracts, Bitcoin Bots, and Consumer Protection' (2014) 71 *Washington & Lee Law Review Online* 35, 39.

smart contracts present an opportunity for a fundamental rationalisation of contract law doctrine to follow the formalisation of contractual language. In order to ensure that the formalisation of contractual language does not leave too much of conventional contract law behind, it is imperative for lawyers to get involved in the effort to create smart contracting languages.

## 2 What is a 'Smart Contract'?

The term 'smart contract' is generally attributed to a 1996 paper by Nick Szabo, which defines a smart contract as 'a set of promises, specified in digital form, including protocols within which the parties perform on these promises.'[6] Another classical account of digitised contractual instruments, which is generally taken to describe a smart contract as well, is the so-called 'Ricardian contract' presented in the early 2000s by Ian Griggs.[7] Griggs' concern was to create a document form that reconciles the inherent contractual nature of a financial instrument with the requirements of being part of a digital automated payment system, which entails defining parameters to connect legal prose to the sections of computer code that will perform the actions mandated in that prose.[8] C.D. Clack, A.V. Bakshi, and Lee Braine observe that a number of definitions are currently in use, and that a distinction is often made between definitions that focus on the fulfilment of contractual obligations by 'software agents' and those that focus on how legal contracts can be expressed and implemented in software. To avoid begging the central question in the law of smart contracts, I adopt Clark

**6** See Nick Szabo, 'Smart Contracts: Building Blocks for Digital Markets' (1996) 16 *Extropy*, available at http://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart_contracts_2.html; Nick Szabo, 'Formalizing and Securing Relationships on Public Networks' (1997) 2(9) *First Monday*, http://firstmonday.org/ojs/index.php/fm/article/view/548/469; see e.g. Chamber of Digital Commerce, *Smart Contracts: 12 Use Cases for Business and Beyond* (December 2016), file:///D:/Smart%20Contracts/12%20Use%20Cases%20for%20Smart%20Contracts.pdf.

**7** See Ian Griggs, 'Financial Cryptography in 7 Layers' (*Financial Cryptography Fourth International Conference*, Anguilla, 21–24 February 2000) available at http://iang.org/papers/fc7.html; Ian Griggs, 'The Ricardian Contract' (Proceedings of the First IEEE International Workshop on Electronic Contracting, San Diego 6 July 2004), available at http://iang.org/papers/ricardian_contract.html. (pp. 25–31

**8** See Ian Grigg, 'On the Intersection of Ricardian and Smart Contracts' (July 2016), http://iang.org/papers/intersection_ricardian_smart.html; Ian Griggs, 'The Sum of All Chains—Let's Converge!' (*Financial Cryptography*, 29 April 2015), http://financialcryptography.com/mt/archives/001556.html.

*et al*'s higher-order definition, according to which a smart contract is an 'automatable and enforceable agreement'; 'Automatable by computer, although some parts may require human input and control. Enforceable either by legal enforcement of rights and obligations or via tamper-proof execution of computer code.'[9]

As a starting point, then, a 'smart contract' is (i) a recording of a legal agreement between parties that is (ii) written in a language that is both human-intelligible and machine-readable, whose text incorporates (iii) an algorithm which automates some or all performance of the agreement. This means that the performance and enforcement of a smart contract does not rely to the same extent on the parties' own further actions or on the intermediation of a trusted authority such as a court to interpret and enforce the parties' mutual promises. But it also means that the parties will have had to reduce the operational aspects of their agreement into writing in a language that demands a high level of formality such that it can be interpreted and performed by a machine.

## The evolution of 'contractware'

Discussions of smart contracts often begin in the context of cryptocurrencies and blockchain data structures, because current developments associated with these technology layers have cast smart contracts into the limelight. The most basic idea expressed in Szabo's early paper, however, is that contractual terms have long been embedded in technological systems, usually to ensure performance by making breach impossible or prohibitively expensive. A review of the evolution of 'contractware', i.e. technological artefacts designed to embody and perform contracts, helps to frame the issues raised by smart contracts.

Szabo points to vending machines as an illustration. All vending machines contain some technological process—analogue or digital—that responds to actions by agents in the world outside with a predetermined conditional output. These conditionals reflect and embody the contractual terms of the sale. The profound implications of this comparison are due to parallels between algorithms and contracts as sets of if/then conditionals. A legal agreement consists of a set propositions of conditional logic; if A delivers late, then B has/has not a right to refuse delivery, etc.[10] A vending machine automates the process of operation (e.g. performing delivery) by encoding a set of conditional logic that responds to a very

**9** C.D. Clack, A.V. Bakshi, and Lee Braine, 'Smart Contract Templates: foundations, design landscape, and research directions' (15 March 2017), arXiv:1608.00771v3, 2.

**10** Indeed, the law generally, as Max Raskin notes, is a set of conditionals; the general function of the courts is to take a series of inputs, run them through a series of legal conditionals, and then

restricted set of permissible inputs in its gears, rendering much human agency superfluous. *If and only if* the right coin is inserted, *then* the machine will dispense the goods. In so doing, it also renders (albeit at a high level of abstraction) the conditional logic of the contract of sale into its gears. The key to remember is that to 'vend' is to *sell*, not just *dispense*; the machine (i) performs a sale but it also (ii) encodes the terms of that sale in whole or part. If this idea is grasped, the more complex vending processes that have appeared recently make more sense (once their information age technology is understood).

Of course, vending machines have come a long way since their early mechanical history. Modern vending machines contain sophisticated computers, and accept payment from credit cards, mobile wallets, etc., so we must leave this illustration behind. However, we will return in Section 3 to the question whether the set of conditional logic encoded in the vending machine's internal processes is really a 'contract' or merely a mechanism of performance. Already, however, we can anticipate some of the central questions that might arise. For example, if the machine's discriminator is defective and it does not dispense the right product (or the right change), what do I do in the absence of a written contract with the machine's owner? Where would I find the terms of the alleged contract of sale to argue (possibly before some tribunal) that the machine's owner owes me performance or damages in lieu?

## Digital contractware

Where early computers were mechanical devices that performed a limited range of functions, such as a mechanical shop till with a direct mechanical process that encoded the desired function, modern computers are universal machines that can be programmed with any number of functions. 'Digital contractware' renders the terms of a contract not into mechanical clockwork, but into symbols which a computer can read (ultimately in binary on/off code) and respond to. The symbols that comprise a modern coding language (like C++, Python, Haskell, or Solidity) correspond to true *machine code*, which identifies physical locations in a microprocessor that perform functions desired by the programmer, with predictable outcomes. It is perhaps instructive to remind ourselves that modern coding languages are already the product of impressive developments to make symbols that ultimately identify physical addresses in a hardware system intelligible to

have an agent (such as a bailiff) enforce their output: Max Raskin, 'The Law and Legality of Smart Contracts' (2017) 1(2) *Georgetown Law Technology Review* 305, 312.

human programmers. Making those symbols *also* encapsulate the substance of a complex social practice—the law—is the challenge behind digital smart contracts.[11]

In a modern vending machine, an internal processor is attached to digital sensors that identify coins and a computer-operated lever mechanism to deliver the goods. Their input and output is not encoded in gears but rather is governed by language-based rules. These rules are written in a *formal language*. This language is, hypothetically, readable by both humans and machines with predictable outcomes—i.e. humans can programme in this language with a set of expected actions in mind, and the machine's output will conform to those expectations. That is, one could read the code and determine what was meant to happen. For something to constitute 'contractware', the rules (en)coded in its technological processes must reflect both the legal terms of the agreement between the parties and the constraints of the technology—in this case, the linguistic constraints of the formal language, i.e. a formal logic of operators and conditionals that correspond to machine code. Essentially, therefore, digital contractware requires the formalization of the legal process of contract formation, performance, and enforcement into a machine-readable syntax, such that performance of the contract terms comes to approximate 'execution' of the 'code' in which the contract is written. For example, in Szabo's proposal for a formalized contract drafting language, the legal obligation to dispense candy is expressed in terms that resemble something like JavaScript.[12] As I argue below, the language in which we make agreements cannot but influence those agreements themselves, and this is why smart contracts have the potential to influence contract law profoundly.

The penultimate development to date is the digitalization of both means of payment and of goods themselves. As the subject matter of contracts and the means of performance are moved into cyberspace, the scope for using smart contracts and the potential advantages for doing so increase. Consider the most straightforward case, electronic payment for an e-commerce transaction: informa-

**11** Thanks to James Scheibner for his advice on this point. An overview of the evolution of digital agreements is given in Keven Werbach and Nicolas Cornell, 'Contracts Ex Machina' (2017) 67 *Duke Law Journal* 313, 319 and following; see also Harry Surden, 'Computable Contracts' (2012) 46 *UC Davis Law Review* 629. See also Raymond Turner and A.H. Eden, 'Towards a Programming Language Ontology' in Gordana Dodig-Crnkovic and Susan Stuart (eds.), *Computation, Information, Cognition—The Nexus and the Liminal* (Cambridge Scholars Press 2008).

**12** See Nick Szabo, 'A Formal Language for Analyzing Contracts' (2002) http://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/contractlanguage.html.

tion passes between my computer, an online seller's server, and our respective banks' servers.[13] If this process satisfies the conditionals embedded in the online store's code, an instruction is sent to an agent which delivers the goods, as it were.[14] This final stage may be automated two ways. First, the physical delivery of a physical good may be automated, as where a drone delivers my DVD.[15] Secondly, the product itself may subsist in digital form. For example, the content of a DVD is just information that instructs my machine to perform certain functions. In this case, I may get my movie by being given access to digital information without any physical good (storage medium). In effect, the need for physical delivery is made redundant by the virtualization of performance. Significantly, my counter-performance is digitalised and automated as well. Once I have entered my credit card details into Amazon.com, for example, my click sets off a cascade of instructions such that the balance of my account on my bank's digital ledger is depleted by $n$ units and the balance of the seller's account with its bank is increased by $n$ units. Indeed, the accounting records which form the fabric of the financial system are now almost exclusively digital.

## Distributed ledger technology

The final development of which we must take notice is the use of blockchain data structures to record and verify flows of information between nodes in a computer network. A blockchain is not stored on any one computer or server, but is replicated on each of the nodes running the relevant protocol—a virtual super-computer—and the integrity of the chain of transactions is protected by the protocol's cryptography and consensus features.[16]

**13** See J.H. Sommer, 'Where is a Bank Account?' (1998) 57(1) *Maryland Law Review* 1 for an overview of bank-based electronic payments at the dawn of the e-commerce era.

**14** This transformation often involves turning traditional goods into a type of service, or a hybrid, i.e. granting licenses to access digital content rather than selling traditional goods such as storage media with that content in analogue or digital form. This is significant in its own right but peripheral to my substantive point.

**15** See Ferran Giones and Alexander Brem, 'From toys to tools: The co-evolution of technological and entrepreneurial developments in the drone industry' (2017) *Business Horizons* (forthcoming).

**16** See Nick Szabo, 'The dawn of trustworthy computing' ('Unenumerated' blog, 11 December 2014), http://unenumerated.blogspot.de/2014/12/the-dawn-of-trustworthy-computing.html. In so-called permissionless blockchain data structures, such as the Bitcoin blockchain, transactions are protected by cryptographic puzzles, which other nodes in the network need to solve in order for a transaction to be recorded as a link in the chain. Each block incorporates an encrypted reference to the previous block, and so on, so that no block can be changed without changing the

Blockchains have become familiar largely due to the success of the 'cryptocurrencies', especially Bitcoin[17] and Ethereum.[18] There has, in particular, been a flurry of innovation using Ethereum-based applications since its launch in 2015. In such applications, conditionals are pre-programmed to occur at the outset in a smart contract written in Ethereum's own 'Solidity' language. These businesses often issue digital 'coins', which are intended to circulate as a private currency, but which often mirror an issue of securities to raise capital.[19] An Ethereum blockchain, however, can be used to record transaction data irrespective of the subject matter, and many applications extend beyond payments.[20] In a recent

entire chain. Nodes check each other's work, ensuring the integrity of the record by means such as an anonymous and probabilistic 'Byzantine consensus'. The so-called Byzantine Generals Problem is an abstraction in computer science terms for how a distributed system deals with dysfunctional components: see Leslie Lamport, Robert Shostak, and Marshall Pease, 'The Byzantine Generals Problem' (1982) 4(3) *ACM Transactions on Programming Languages and Systems* 382. Blockchain-based systems achieve communication between the network of potentially dysfunctional components using public and private key communication. This process is driven by an incentive mechanism, a reward for each node that dedicates processing power to solving the puzzle (and thus verifying the authenticity) of a transaction. This means that an agent can trust the outcome of a blockchain without trusting any other agent in particular. Only in the case that a malicious agent controlled 51 % of the network's nodes or more would this consensus mechanism break down.

**17** Bitcoin, the first cryptocurrency based on a distributed ledger, was launched in 2009. See www.bitcoin.org and in particular Satoshi Nakamoto, 'Bitcoin: A Peer-to-Peer Electronic Cash System', https://bitcoin.org/bitcoin.pdf.

**18** Ethereum is currently the second largest cryptocurrency after Bitcoin. Its main innovation is that it creates a so-called 'Turing complete' virtual machine. While the Bitcoin protocol is only capable of calculating the transaction of Bitcoins, the Ethereum software was designed to be able to compute anything (that is computable). This was to create a platform for a much richer suite of smart contracts. See https://www.ethereum.org/ and Vitalik Buterin, 'A Next-Generation Smart Contract and Decentralised Application Platform', https://github.com/ethereum/wiki/wiki/White-Paper. Turing-completeness has been controversial; more recently Vitalik Buterin, one of the creators of Ethereum, has expressed a preference for 'rich statefulness' instead of 'Turing completeness'. See for example Buterin's tweet of 18 April 2017, https://twitter.com/VitalikButerin/status/854271590804140033?ref_src=twsrc%5Etfw&ref_url=https%3A%2F%2Fhackernoon.com%2Fmedia%2Ffab472fb800755fae284b5b118e4396d%3FpostId%3De650db7fc1fb.

**19** The volume of capital raised by early-stage companies via an 'Initial Coin Offering' or ICO surpassed the amount raised through traditional Venture Capital investment in July 2017, according to a widely-cited report by investment bank Goldman Sachs. See https://www.cnbc.com/2017/08/09/initial-coin-offerings-surpass-early-stage-venture-capital-funding.html.

**20** See Chamber of Digital Commerce, *Smart Contracts: 12 use Cases for Business and Beyond* (Washington D.C., December 2016); Mark Walport, *Distributed Ledger Technology: beyond block chain* (UK Government Office for Science, London 2016); see also the Outlier Ventures tracker of blockchain startups at https://outlierventures.io/startups/browse/.

empirical analysis, Massimo Bartoletti and Livio Pompianu propose a taxonomy of smart contracts according to their intended application in 'financial', 'notary', 'game', 'wallet', and 'library'[21] domains. In the 'financial', 'notary', and 'wallet' domains, applications range from certification of ownership, crowdfunding venture capital, and collective investment schemes, to the certification of documents, copyrighting digital art files, and identity services, to ancillary services that enable digital payments. We can therefore expect smart contracts to crop up in a plethora of commercial and financial contexts.

The connection between smart contracts and cryptocurrency is not accidental, because smart contracts lend themselves particularly well to manipulating assets such as digital tokens that take the form of *immaterial objects*.[22] While they could be used to regulate access to physical assets (for example using remotely controlled solenoid locks or ignition switches),[23] the core use case of smart contracts would seem to be where the subject matter of the contract is an immaterial object which can be manipulated directly by the smart contract algorithm. It is important to remember that many traditional securities are immaterial objects, too, consisting in a digital computer entry kept by some financial intermediary.[24] Indeed, even 'real' property appears in the eyes of the legal system as land registry entries which exist in an informational domain (i.e. the servers of a land registry), [25] which are also lend themselves to the application of blockchain data structures and smart contracts.[26] This makes a large part of our financial economy *prima facie* open for the application of smart contract technology.

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**21** Massimo Bartoletti and Livio Pompianu, 'An empirical analysis of smart contracts: platforms, applications, and design patterns' in Michael Brenner *et al* (eds.), *Financial Cryptography and Data Security Proceedings 2017* (Springer 2017).

**22** See J.G. Allen, 'What's Issued in an ICO? Digital Tokens as Things', (14 March 2018), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3140499; see also Pierluigi Cuccuru, 'Beyond bitcoin: an early overview on smart contracts' (2017) 25(3) *International Journal of Law and Information Technology* 179.

**23** For example, slock.it (the team that brought us The DAO—see Section 4) aims to automate access to Airbnb properties, among other things, using smart contracts.

**24** See Barry Smith, 'How to Do Things with Documents' (2012) 50 *Revisti di estetica* 179, 183.

**25** Christian von Bar posits land parcels—the legally constituted entities that delineate an area on the surface of the land or a stratum of air as an object of property rights—as 'normative things with a physical substrate': Christian von Bar, *Gemeineuropäisches Sachenrecht* (C.H. Beck 2015), 249.

**26** The Government of the Republic of Georgia signed an initiative with the Bitfury Group Limited to register land titles on the Bitcoin blockchain in April 2016: see Laura Shin, 'Republic Of Georgia To Pilot Land Titling On Blockchain With Economist Hernando De Soto, BitFury' (*Forbes*, 21 April 2016), https://www.forbes.com/sites/laurashin/2016/04/21/republic-of-georgia-to-pilot-land-titling-on-blockchain-with-economist-hernando-de-soto-bitfury/#57d3903e44da. See e.g. L.D. Griggs, Rod Thomas, Rouhshi Low and James Scheibner, 'Blockchains, trust and land admin-

### A working definition

To sum up, then, it seems accurate to say that a smart contract is a piece of text in a formal language that purports to be both (i) a written instrument embodying and recording contracting parties' mutual promises with (ii) code that performs and/or enforces those promises on a digital computer.[27] For the time being, only human beings make contracts,[28] but we outsource tasks in negotiation, execution, and performance to algorithms because they are quicker, more efficient, or more reliable. Digital contractware combines the written contract and the algorithm which performs these tasks in one highly structured language-based digital instrument housed in the memory of a computer network. Although the automation of performance is often stressed, equally important is the *formalisation of contractual language* that smart contracts entail, as 'contracts' are written by programmers in languages that include more formal systems of logical operators. But are these instruments really 'contracts', or is it misleading to think of them as such?

## 3 Is a Smart Contract Really a 'Contract'?

Lee Bacon and George Bazinas observe that the term 'smart contract' is used to refer both to 'software code that embodies a contract', and to 'contracts expressed in executable code'.[29] It is, however, not straightforward that any given instrument really can embody both the contract—a legal entity created when certain conditions are satisfied—and the code that performs it. According to Cheng Lim, T.J. Saw, and Calum Sargeant, for example, the term is a misnomer: 'smart contracts' are merely computer programmes that parties use to *perform* their

istration: The return of historical provenance' (2017) 6 *Property Law Review* 179 for a discussion of the application of DLT to land title registration.

**27** See Pierluigi Cuccuru, 'Beyond bitcoin: an early overview on smart contracts' (2017) 25 *International Journal of Law and Information Technology* 179, 185.

**28** Actually, this is a little more complicated: *personae fictae* such as corporations make contracts, too, albeit through human agents—the acts of the human being are legally the acts of the corporation, but the law only attributes the acts of human beings to corporations such that corporations cannot act without human organs. These lines are blurring as human beings increasingly act through algorithms, but the acts of a software agent are attributed the human being in question and thence to the corporation. We are not at the stage yet where a corporation may act directly through software agents, although innovations such as distributed autonomous organisations ('DAOs') are pushing the envelope.

**29** Lee Bacon, '"Smart contracts"—the next big battleground?' (June 2017) *Finance & Credit Law* 1.

contracts, and are not properly called 'contracts' at all. A so-called 'smart contract', they argue, operates irrespective of the absence or presence of legal indicia of contract formation (such as consideration in English law), and indeed independently of the legal context itself. Although code may cover some, or even all, of the functions of a contract (such as recording obligations, regulating the relationship between the parties, and providing a blueprint for execution) it is not self-standing and cannot be seen as if in a legal vacuum. In particular, legal doctrines such as mistake and misrepresentation form part of the legal contract and this, in some cases, must impinge on the operation of the 'smart contract' execution mechanism. Lim *et al* therefore draw a bright distinction between the 'smart contract' and what they call the 'legal contract', and express doubt that a code-based instrument can ever merge with the legal contract.[30] They use the metaphor of a smart contract 'wrapped' in a legal contract to express the relation between these two components.

Such views have force, in my view, for two reasons. The first reason is that, empirically, many of the software processes currently hailed as 'smart contracts' are indeed more accurately described as performance mechanisms. Many financial institutions, for example, are using smart contracts more to determine their own financial position (with the advantages of granular detail and real-time reporting) than to replace conventional paper contracts with the counterparty. In other words, many of the use-cases of smart contracts bandied about in whitepapers, blogs, and forums are aspirational at this stage. The second reason is that no legal relationship can exist in a legal vacuum. In order to be enforced as a contract by a national court, it is right to point out that that court would have to be satisfied that the 'smart contract', and the relationship it purported to structure, possessed all the indicia of a contract according to the relevant national law. This type of argument should be seen against overblown claims that smart contracts can operate without any overarching legal framework, and that they represent a technological alternative to the legal system as a whole.[31]

But problems lurk beneath both of these reasons, which take some effort to unpack. Taking the second point first, it is important to remember that significant economic activity takes place outside national legal systems. Although the global order of national jurisdictions and private international law fairly cover the globe

**30** See Cheng Lim, T.J. Saw, and Calum Sargeant, 'Smart Contracts: Bridging the Gap Between Expectation and Reality' (Oxford Business Law Blog, 11 July 2016) https://www.law.ox.ac.uk/business-law-blog/blog/2016/07/smart-contracts-bridging-gap-between-expectation-and-reality.

**31** See e.g. Alexander Savelyev, 'Contract law 2.0: "Smart" contracts as the beginning of the end of classic contract law' (2017) 26(2) *Information and Communications Technology Law* 116.

in a seamless web of norms, there are interstitial spaces.[32] We do not need imagine stateless castaways swapping fish for coconuts on the high seas to accept the basic proposition that while economic activity nestles within the substrate of a legal system, where one exists, it can also thrive outside the law.[33] Trying to understand smart contracts, and how they might change the contract law of the future, is therefore not an exercise best undertaken from a perspective that puts national law indicia in the foreground. Given the fundamental challenges that Internet-based commerce poses for the system of territorial-based jurisdiction as a whole,[34] it seems disingenuous to deny at the outset that a trans-national body of norms might arise to regulate trans-national e-commerce and e-finance. We can see parallel developments, for example, in the law of intellectual property with the Creative Commons licensing protocols, which then reverse-engineer 'ports' to national legal orders.[35] Globally dispersed open-source communities are a fascinating *situs* for development of normative order outside the nation state. As so many smart contract proponents are ideologically committed to an Internet beyond national jurisdiction, the denial of contractual status to formal language-based digital instruments seems oddly out of touch with the techno-libertarian[36] challenge that smart contracts are intended to mount to contract law as a sphere regulated by national law. Thus, while I agree that there is a gap between expectation and reality, and that certain hopes for smart contracts are misplaced, we should not dismiss the challenge quite so easily.

As to the first point, which is the more important one, it is clear that at least *some* smart contracts purport to combine the document which creates the contract with the digital means by which the parties perform their obligations under it.

**32** The medieval *lex mercatoria*, for example, stands in counter-point, as do (to a lesser degree) international regimes such as the Convention on the International Sale of Goods.

**33** We do not need such examples because, empirically, a great many individuals live nominally under the law of a nation-state but operate, as economic agents, almost entirely within informal economies with informal normative orders; they never actually interact with the national contract law they live under. Hernando de Soto, for example, describes the formal legal economy of developed countries as the inside of a 'bell jar', while four fifths of human society exists outside it: see Hernando de Soto, *The Mystery of Capital* (Black Swan 2000).

**34** See Dan Sventsson, 'The holy trinity of legal fictions undermining the application of law to the global Internet' (2015) 23(3) *International Journal of Law and Information Technology* 219.

**35** See e.g. https://wiki.creativecommons.org/wiki/Version_3#Further_Internationalization. More recently, Creative Commons has shifted away from porting to simply creating uniform CC licenses irrespective of jurisdiction.

**36** See e.g. Adam D. Thierer and Clyde Wayne Crews Jr, 'The Libertarian Vision for Telecom and High-Technology' (Cato Institute, 3 April 2001), https://www.cato.org/publications/techknowledge/libertarian-vision-telecom-hightechnology.

Partially this is a question of definition, and in particular of whether one wishes to focus on the code-based automation of a 'smart contract' or on its ability to express the terms of a legal agreement. As I have argued above, the first is relevant but the second is the equally interesting for legal theory, as it entails the formalisation of contractual language and the merger of contractual terms with machine-parsable code. When one adopts a broader definition, as I have done in this paper, it becomes necessary to examine the legal status of smart contracts and at least to ask whether they are legally cognisable as contracts in the conventional sense.

For example, we might ask whether a piece of code might not satisfy the writing requirements under a statute of frauds, and we might define a 'smart contract, properly so called' as a piece of code that does. In my view, attempts to capture the terms of a legal contract in code should be taken seriously; it is at least conceivable that they will achieve some degree of success in the future, if they are not doing so already.[37] The problem seems to rest on a conceptual dualism between the contract and its written embodiment.[38] To address this problem successfully, it is necessary to explore how we encode information for human and machine interpretation, what legal entities such as 'contracts' actually are, and how such entities arise through documentation. I will take these matters in turn.

## Natural and formal languages

Szabo speaks of 'wet' and 'dry' code,[39] but it is perhaps better just to speak of 'natural' and 'formal' languages. Natural languages such as English have evolved from human prehistory to the present day within more or less organic linguistic

**37** See Henning Diedrich, *Ethereum: Blockchains, Digital Assets, Smart Contracts, Decentralised Autonomous Organisations* (CreateSpace 2016), 94, cited in J.M. Sklaroff, 'Smart Contracts and the Cost of Inflexibility' (2017) *University of Pennsylvania Law Review* , 16.

**38** Similar issues arise in the context of accounts—is an 'account' the ledger of debits and credits between two parties, or the 'actual', 'true', or 'objective' state of credit and debt? How do we determine that the account exists, let alone where it stands, apart from its embodiment in some medium of recording—whether a person's memory, tally-sticks, paper, or digital records? See e.g. *WH Smith Travel Holdings Limitd v Twentieth Century Fox Home Entertainment Limited* [2015] EWCA Civ 1188; See J.H. Sommer, 'Where is a Bank Account?' (1998) 57(1) *Maryland Law Review* 1.

**39** This tracks the idiom of referring to the human brain as 'wetware' mirroring the 'hardware/software' dichotomy, but the colourful metaphor does not seem to add much. See Nick Szabo, 'Wet code and dry' ('Unenumerated' blog, 24 August 2008), http://unenumerated.blogspot.de/2006/11/wet-code-and-dry.html.

communities. Formal computer languages such as C++ are much more recent and have been intentionally constructed not only to allow communication between members of a human community, but to programme deterministic agents (i.e. machines which ultimately follow a binary logic encoded in transistor states). Both natural and formal languages consist of structured, symbolic content, but they differ in several important respects.

Linguists study three main aspects of language. First, all languages have *syntax*—a logic inherent in devices such as pre-, in-, and suffixes, articles, and word order that express logical relations such as subject-object relations, action, transitivity, time, etc. Natural and formal languages have similar syntactic properties, when viewed at a certain level of abstraction, although the syntax of natural languages is more path-dependent and generally less rigorous than that of formal languages.[40]

Secondly, linguists study *semantics*, or the meaning that different words and combinations of words have.[41] The semantic content of natural and formal languages is very different—so much so that, even assuming the formality of legal language assumed by traditional legal studies,[42] the semantic content of a natural language is difficult to formalise and make machine-readable. There are more shades of meaning and ambiguity in natural language than would ever be possible in a formal language. This is partly because machines are not good at drawing inferences from the context in which words of natural human language are uttered as a tool for resolving ambiguity.

In other words, computers are not as good as human agents at the third element of language, *pragmatics*. Pragmatics, the newest branch of linguistics, studies what words mean in the context in which they are uttered, i.e. not by reference only to the utterance as an isolated unit of meaning but as part of a

**40** The habit of gendered nouns, for example, originally expressed something meaningful about the world to a hunter-gatherer or agricultural society, but has become essentially meaningless today in most gendered languages which assign it to inanimate objects like rocks and abstract objects like centimetres that are wholly alien to the idea of gender.

**41** We could study the syntax of a sentence like 'the dog chased the cat' without knowing what a 'dog' or a 'cat' is, or what it is 'to chase'. Assuming a knowledge of English syntax were possible without any knowledge of its semantics, we would know (i) that the dog was doing the chasing, (ii) that the cat was the one being chased, and (iii) we are reading of an event that happened in the past and is complete. (I do not assume such a neat division between syntax and semantics.) Equally we would know that a sentence like 'the dog chased the cat tomorrow' contains a logical error. A sentence like 'the dog weighed the Thursday', on the other hand, is syntactically correct but is nonsense.

**42** See Peter Goodrich, 'Law and Language: An Historical and Critical Introduction' (1984) 11(2) *Journal of Law and Society* 173.

discursive exchange against a background.[43] As in normal speech, the commercial and social context of a legal utterance informs our judgment of what the parties actually meant. However, the pragmatics of legal language is peculiarly institutionalised; the institutions of the legal system (such as courts) always claim the residual authority to interpret contractual utterances in light of the law's historical lexicon. Context is especially important to interpreting and constructing the meaning of utterances in legal language, even while legal language strives for a greater degree of formality than every day speech. Ambiguity always subsists, however, and the scope of permissible context, its role in interpretation, and the relationship between interpretation and construction is controversial.[44]

The interplay of syntax, semantics, and pragmatics has been significant in the development of English contract law over the previous decades. Take, for example, Lord Hoffmann's classical approach in *Investor Compensation Scheme Ltd v West Bromwich Building Society*,[45] particularly principles (i) and (v) of his five-point list:

> (i) Interpretation is the ascertainment of the meaning which the document would convey to a reasonable person having all the background knowledge which would reasonably have been available to the parties in the situation in which they were at the time of the contract. [...]
>
> (v) The 'rule' that words should be given their 'natural and ordinary meaning' reflects the common sense proposition that we do not easily accept that people have made linguistic mistakes, particularly in formal documents. On the other hand, if one would nevertheless conclude from the background that something must have gone wrong with the language, the law does not require judges to attribute to the parties an intention which they plainly could not have had. Lord Diplock made this point more vigorously when he said in *The Antaios Compania Neviera SA v Salen Rederierna AB* [that] '... if detailed semantic and syntactical analysis of words in a commercial contract is going to lead to a conclusion that flouts business commonsense, it must be made to yield to business commonsense.' [46]

**43** Two syntactically and semantically identical utterances can have completely different meanings depending on the context—I might say 'I'm going to kill you!' in the context of a game with my son, or in the course of a bar-fight, with very different implications. See S.C. Levinson, *Pragmatics* (Cambridge University Press 1983) for a classical overview.

**44** English lawyers and judges do not generally distinguish between interpretation and construction as discrete activities, but our counterparts across the Atlantic do: see Gregory Klass, 'Interpretation and Construction in Contract Law', (Georgetown Law Faculty Publications and Other Works 1947, 2018) https://scholarship.law.georgetown.edu/cgi/viewcontent.cgi?article=2971&context=facpub.

**45** [1998] 1 WLR 896.

**46** *Ibid*. 912, citing *The Antaios Compania Neviera SA v Salen Rederierna AB* [1985] 1 AC 191, 201.

What lies at the core of the smart contract project then, is an effort to formalise the language in which contractual promises are expressed to the extent that the written instruments we call 'legal contracts' merge into (ultimately) machine-readable code. It is, first and foremost, a project to change the way that parties express their promises; while the benefit of automation arises in virtue of this formalisation of legal speech, it should not be the focus of attention for lawyers interested in smart contracts as a development. Our focus should be rather on the way that computer scientists are setting about 'hacking' the quasi-formal language in which contractual obligations are now expressed and recorded. This represents the primary challenge to contract law as a product of lawyers' lore, and the point to which we can make the most positive contribution to the development of the smart contract phenomenon.

## The contract and the speech act(s) creating it

A 'contract' is a kind of promise that meets the requirements of some legal system (not necessarily one's own)[47] and generates, within that legal system's logical universe, special 'legal' consequences in a way that non-qualifying promises do not. A contractual promise (like all other acts-in-the-law) is an *intentional speech act*. That is, when I offer to sell you my car, I am not making any truth claims, but doing an action; I am not *saying* something so much as *doing* something by uttering words.[48] The question is whether that speech act is cognisable by the relevant legal system.[49] Assuming the pre-conditions of our chosen legal system are met, my utterance has legal effects[50]—it changes our respective legal positions.[51] In this, a contractual undertaking is more like a ritual incantation (e.g. the consecration of 'holy ground' or the naming of a ship) than it is like everyday

**47** For example, both in everyday speech and for the purposes of international private law, we often talk about a contract formed under the law of another jurisdiction as a legally cognisable contract.

**48** I do make the implicit assertion that I own the car, etc., but the 'contracting' part is a declaration that I promise to sell it to you, not any of these assertions.

**49** For example, they may not be legally cognizable as a contractual promise because I use the wrong form, or because I am not recognized as an agent with contractual capacity.

**50** See J.L. Austin, *How To Do Things With Words* (Oxford University Press 1962), 19.

**51** On legal position generally, and how it can be modelled formally in a manner useful to understanding code as law, see Lars Lindahl, *Position and Change* (Riedel 1977).

speech: when we perform these acts, the world itself changes.[52] In particular, performative speech acts in conventional systems like law create new things. J.L. Austin called his speech act theory 'legal phenomenology', because it explains how things come into existence out of thin air—contracts, marriages, rights, debts, corporations, promises, etc.[53] These things are invisible and their existence fundamentally mind-dependent, but they are as 'real' as the legal system itself can purport to be.[54]

Consistent with their basis in speech acts, contracts can be formed by oral utterances as well as by written ones. Indeed, the proto-typical contract is probably an oral one evidenced by a handshake or other gesture, ideally in front of witnesses drawn from the normative community whose collective practices and beliefs sustain the existence of contractual promising as an institution. Thus, as a basic premise, we can stipulate that speech acts create legal objects like contracts[55] whether the words are uttered in spoken or written form.[56] As David

**52** See Adolf Reinach (J.F. Crosby trans.), *The Apriori Foundations of Civil Law* (1983) 3 *Alatheia* 1, 9; Barry Smith, 'How to Do Things with Documents' (2012) 50 *Revisti di estetica* 179, 181; Alois Brinz, *Lehrbuch der Pandekten Band I* (2nd Edition, Deichert 1873), 211 on 'invisible legal effects'. Reinach was a lawyer and part of the Munich phenomenological school—see Alessandro Salice, 'The Phenomenology of the Munich and Göttingen Circles' in Edward N. Zalta (ed.), *The Stanford Encyclopedia of Philosophy* (Winter 2016 Edition), https://plato.stanford.edu/archives/win2016/entries/phenomenology-mg/; see generally Kevin Mulligan (ed.), *Speech Act and* Sachverhalt*: Reinach and the Foundations of Realist Phenomenology* (Springer 1987).

**53** See Paul Amselek, 'Philosophy of Law and the Theory of Speech Acts' (1998) 1(3) *Ratio Juris* 187.

**54** The role of speech acts reveals deep parallels between law and computer science as disciplines built on some kind of modal logic: see e.g. R.H. Thomason, 'Conditionals and Action Logics' (AAAI Spring Symposium 'Commonsense 2007', 26-28 March 2007, Stanford University), www.ucl.ac.uk/commonsense07.

**55** Whether they create 'institutional facts' or 'social objects' is a matter of debate between social ontologists—John Searle, for example, takes a 'reductionist' view that does not admit of the existence of social objects as such and explains institutional facts (effectively as emergent) in terms of collective intentional states within a community; Maurizio Ferraris, on the other hand, considers social objects as more ontologically real or material. This is not a question that we have to answer here; it is sufficient to accept the intuitively obvious fact that invisible, immaterial entities do exist in the legal domain and are treated by the legal system as 'real', and that we need to explain their existence carefully if we wish to avoid accepting the existence of faeries, too. Social ontologists attempt, in various ways, to square the circle and all of them have insights which can be usefully applied in law. I attempt to do so ecumenically without, however, adopting inconsistent premises.

**56** Like 'speech' in American constitutional jurisprudence, we can even recognise gesture—consider purchasing three apples for one dollar by communicating with hands and feet in a foreign market-place.

Koepsell and Barry Smith explain, however, the spoken word is transient, and the increasing complexity of society has proceeded with (and through) the inscription of performative utterances in more enduring, written form.[57] As a result, documents have come to play an increasingly important role as category of performative act. As Maurizio Ferraris argues, documents are not just an 'accessorial' element of social reality, but are rather its 'condition of possibility' insofar they ensure the fixation of individual and collective memory.[58] Documents inscribed on media such as clay, stone, leather, and paper support the existence of both more complex social objects (consider the complexity of a joint stock company's financial records compared to those of a medieval partnership) and more enduring ones (consider the immortality of a modern corporation, as a separate legal person, compared to a partnership which is an aggregation of partners as natural persons).[59] Tampering and destruction are avoided by the best currently available institutional and technological means.

What, then, is the relationship between a contract and the documents recording the speech acts that created it? Before turning to the more complex case of smart contracts, let us consider the normal case. As a preliminary, not all documents that evidence the existence of a social object are necessarily involved in its creation. Imagine that we use our smartphones to make a video recording of an oral contract whereby I contract sell you my apple for $1.00. The video *records* the legally operative event (in English law, offer and acceptance plus consideration) but it is not identical with the event; the recorded speech acts of declaration themselves change our legal position and cause the contract to come into existence, not the recording of the acts. So, an oral contract, according to Koepsell and Smith, is *ontologically non-dependent* on documentation. In other cases, documents play both a 'recording' and an 'object-generating' role. Under the law governing my marriage, for example, the act of signing the marriage certificate was the operative event that created a marriage. So that document plays such a dual role.[60] However, I would not cease to be married should the only copy of our certificate be destroyed in a house fire. The law would provide ways and means for us to prove the existence of our marriage and some authority would issue a replacement certificate, not declare us married *do novo*. Such a social object is,

**57** David Koepsell and Barry Smith, 'Beyond Paper' (2014) 97(2) *The Monist* 222, 222.

**58** See Maurizio Ferraris, 'Perspectives of Documentality' (2012) 2 *Phenomenology and Mind* 41, 41; Maurizio Ferraris (Richard Davies trans.), *Documentality: Why it is Necessary to Leave Traces* (Fordham University Press 2012).

**59** See A.W. Crosby, *The Measure of Reality: Quantification and Western Society 1250–1600* (Cambridge 1997), 204 and following.

**60** David Koepsell and Barry Smith, 'Beyond Paper' (2014) 97(2) *The Monist* 222, 224.

then, *proto-typically dependent*. A bearer bond, on the other hand, is *specifically dependent* on the existence of the document. If such a negotiable instrument is lost or destroyed, the object itself lapses into non-existence.[61]

It seems fair to say that ordinary written contracts are proto-typically dependent on documentation. The written contract (for example under the parole evidence rule of English law and 'entire contract' clauses) purports to embody all the relevant speech acts and determine the contract's content authoritatively. But of course, as Lim *et al* rightly point out, content is added as a result of speech acts by other entities—e.g. Acts of the legislature, rulings of regulatory bodies, judgments of the courts. These incorporate terms into the contract, sometimes retrospectively, to complement the terms defined in the parties' contractual speech acts.[62] Court judgments have a special status because they determine, at a much later date, what the parties' utterances are taken (by the law) to have meant at the time they were uttered.

## Smart contracts as 'legal contracts'

What does this tell us about the distinction between the 'legal contract' and the 'smart contract' a.k.a. 'code-based performance mechanism'? In my view, it partially confirms the notion that smart contracts are not 'contracts' but also reveals a serious problem. It confirms that view insofar as it underscores a dualism between the 'legal contract' (an invisible legal object created by speech acts) and the instrument that records the relevant speech acts. As noted above, a contract *per se* exists separately from the writing that creates it; additional content is provided to the contract by the legal system and the definitive content of the contract 'floats' in suspense until it is interpreted (by a court, in the last instance). To identify the contract with the writing that creates it directly—to view the contract in a legal vacuum—might even exclude some of its most important terms. The problem is that, if we deny that smart contracts can be 'legal contracts', we would have to deny that ordinary paper contracts are 'legal contracts', too. A written contract is also distinct from the legal contract it creates and purports to embody.[63] Consider the English doctrine of rectification, for example,

**61** David Koepsell and Barry Smith, 'Beyond Paper' (2014) 97(2) *The Monist* 222, 226.

**62** See also C.D. Clack, A.V. Bakshi, and Lee Braine, 'Smart Contract Templates: foundations, design landscape, and research directions' (15 March 2017), arXiv:1608.00771v3, 5.

**63** See the discussion in Stewart Macaulay, 'The Real and the Paper Deal: Empirical Pictures of Relationships, Complexity, and the Urge for Transparent Simple Rules' (2003) 66(1) *Modern Law*

by which the written terms of a contract are changed to reflect the 'true' legal position formed by the parties' speech acts.

I therefore take the view that there is no conceptual reason why a formal language instrument, recorded on a blockchain or elsewhere, cannot be a 'legal contract' in the same sense that a natural language instrument on paper is a 'legal contract'. Even though a contract arises from the agreement of two contracting parties, a contract is not just a meeting of the minds, it is one that has been *expressed* through performative speech acts and *recorded* in some lasting format.[64] As Kevin Werbach and Nicolas Cornell rightly note, smart contracts erode the distinction between executory and executed contracts insofar as they set an unstoppable chain of actions and responses in motion, and this challenges the conventional remedial role of contract law.[65] But this does not mean that they are categorically not contracts. It is simply an empirical question of how far the smart contracting project has come along in terms of developing a formal contracting language, i.e. how accurately that formal language captures the syntactic and semantic content of ordinary legal English and how it deals with the problems of pragmatics.[66] Distinguishing between the *phenomenon* of a written memorandum and the *epiphenomenon* of a contract *qua* social object is important, but it is the start rather than the end of a fascinating enquiry into the ontology of acts-in-the-law and the legal objects they create in the context of new technologies.[67]

New technologies are not only regulated by the law—they are they leaven by which legal institutions themselves change and evolve. Take the advent of writing, the invention of paper, the creation of double-entry bookkeeping, or electronic data interchange ('EDI').[68] By filling forms, registering, conveying, validating,

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*Review* 44; Zhong Xing Tan, 'Beyond the Real and the Paper Deal: The Quest for Contractual Coherence in Contractual Interpretation' (2016) 79(4) *Modern Law Review* 623.

**64** See Maurizio Ferraris and Guiliano Terrengo, 'Documentality: A Theory of Social Reality' (2014) 57(3) *Revisti di estetica* 11.

**65** Keven Werbach and Nicolas Cornell, 'Contracts *Ex Machina*' (2017) 67 *Duke Law Review* 313, 335.

**66** In this respect, while languages such as Solidity are attracting much attention, future developments are likely to occur in the context of more advanced programming languages. See e.g. C.D. Clack, V.A. Bakshi, and Lee Braine, 'Smart Contract Templates: foundations, design landscape, and research directions' (15 March 2017), arXiv:168.00771v3 for a discussion of the

**67** See D.R. Koepsell, *The Ontology of Cyberspace* (Open Court 2000), Chapter 2; Philip Brey, 'The Social Ontology of Virtual Objects' (2003) 62(1) *American Journal of Economics and Sociology* 269; Neil MacCormick and Ota Weinberger, *An Institutional Theory of Law* (Reidel 1986), 51.

**68** See Harry Surden, 'Computable Contracts' (2012) 46 *UC Davis Law Review* 630, 639.

attaching, etc., we change the world.[69] From ancient Mesopotamia to the present, innovations in what we would now call information and communications technology have enabled social and economic developments which the law has then structured and regulated using the same technologies. Smart contracts are quite likely an important part of the next chapter in this story.

## Smart contracts: 'wrapped' or 'stacked'?

How, then, do we characterise smart contracts? Bearing the above qualifications in mind, it is neither inconceivable nor conceptually incoherent for a writing to express a legal contract in formal language and thereby render it intelligible to humans and machines. What emerges is simply a more complex form of 'contract stack'.[70] In computer science, a 'technology stack' refers to the the underlying elements of an application, i.e. the languages and software products that the application is built on. This, I think, provides a way of describing the various components of a contract as a complex entity. An oral contract stack contains (i) spoken words (recorded in the memories of the parties and their witnesses or on some other medium such as video) and (ii) the legal rules which a) imply terms and b) give words their legal meaning.[71] A 'paper' contract, comprises (i) the spoken words through which the contractual terms were negotiated and against which the text was drafted, (ii) the written text, and (iii) legal rules implying terms and governing construction. The written text (ii) is often highly complex, with cross-references incorporating various documents. Further, the legal rules (iii) are generally fairly strict in the way that the circumscribe (i) the words outside the text, especially pre-contractual negotiations, which are allowed only exceptionally.

In a smart contract, (ii) is complemented (or supplanted) by code which is also, incidentally, wholly or partially executable by a machine. Depending on the design of the smart contract, the code component of the written layer of the

**69** See also A.W. Crosby, *The Measure of Reality: Quantification and Western Society 1250–1600* (Cambridge 1997), 204–205.

**70** I was inspired by a conversation with Björn Scheuermann to adopt this term from computer science to explain the complex structure and sources of contracts, which I think is generally underappreciated by lawyers who see the contract as a monolithic entity that is later subjected to remedial doctrines.

**71** An important category of these rules govern which words count as part of the contract, which aspects of the context are relevant to its interpretation, and how these are to be determined in evidence.

contract stack may be comprehensive or cover only a small part of the contract as a whole. The type of formal language in which this code is written will also be relevant to the complexity of the contract stack, e.g. whether it is a compiled or interpreted language; a compiled language, which translates ('compiles') machine-readable code from the human-readable source code, will add another sub-layer within this layer of the stack. Again, this reinforces the impression that the ultimate goal of the smart contract movement is (or should be) to develop a formal language which is intelligible to humans *and* executable by machines to use for whole or part of the written layer of a contract stack.

In this light, the stronger libertarian claims that smart contracts herald the end of contract law as we know it reveal themselves to rest on an over-simplification of the contract stack. The 'smart' component of contracts will likely remain but one part of a more complex stack, which will include more conventional 'legal' components including conventional 'paper' agreements and mandatory rules of national law expressed in natural language; these conventional components of the stack will continue to govern aspects of the parties' relationship around the software processes that comprise the 'smart' layer. To the extent that the smart layer replaces the paper layer, it will have to serve the same function, i.e. of expressing a conventional contractual relationship, and will have to treated as paper contracts are treated now (even if this means halting automated performance). Irrespective of whether or not 'wrapped in paper', smart contract layers will remain nested in a stack that includes, at base, a national contract law (not necessarily the law of the forum, and possibly some trans-national normative framework in the future). The dynamics of this wrapping and stacking is the focus of the balance of this paper, which explores the interaction between formal and natural language contract layers using English law by way of illustration.

## 4 Smart Contracts and Conventional Contract Law

In this section, I briefly explore some issues concerning the legality of smart contracts and the problems of jurisdiction and procedure they may raise for national courts. I cannot, however, explore these issues fully, as they warrant an independent examination. I focus instead on eight issues in contract law proper: (i) the syntax of legal operators; (ii) translation from natural to formal language and *vice versa*; (iii) the unintentional loss of semantic richness; (iv) the intentional loss of semantic richness; (v) the relational aspect of contracts in the real world; (vi) changing canons of contractual interpretation; (vii) textualism and contextualism, and; (viii) the place for equity in the changing landscape.

## Smart contracts in the courts: illegality, jurisdiction, and procedure

Szabo stresses the continuity of smart contracting with conventional doctrine and practice, and assumes the continuity of the legal background to smart contracts (i.e. property law, criminal law, etc.) as well as those doctrines of contract law that remain relevant in his new paradigm. It would take too long to start from scratch, he argues; the aim is to extract principles and practices from the 'laws, procedures, and theories' that we have inherited in order to develop useful 'digital institutions' more quickly.[72] The idea is not a radical displacement of paper-era contracts, but an augmentation of long-established practices with new digital tools and the integration of paper-era practices into the new digital economy.[73] However, the future which many smart contract enthusiasts envisage is one in which technology disrupts established processes and practices more radically, from the way contracts and negotiated and recorded to the way performance is audited to the way that business organisations themselves are formed and run.

The first and most obvious point in this context is the potential for conflict between the terms of a smart contract and the mandatory terms of the applicable law (or laws). Max Raskin distinguishes between 'strong' and 'weak' smart contracts. The former entail prohibitive costs of revocation and modification, where the latter may be revoked or modified after the contract has been executed. The 'stronger' or 'harder' a smart contract is, the further it will cast its own projection of the parties' legal position from that of objective (i.e. state-projected) legal reality.[74] The most obvious example is the situation where the terms of a smart contract are illegal, either from the outset or in virtue of a supervening change in the law. This is not a conceptually challenging issue. In fact, this is no different to the case of an ordinary contract: we may agree to terms that are unenforceable or even illegal under the laws of a relevant national legal system.

The problem is, however, sharpened by the self-executing nature of the smart contract and by the potential for parties to transact in contravention of national law and its institutions. Some of the innovation behind smart contracts is driven by the zeal to remove economic transactions from the purview of national law *in toto*. For innovators of this bent, the perceived failings of the

**72** Nick Szabo, 'Formalizing and Securing Relationships on Public Networks' (1997) 2(9) *First Monday*, http://firstmonday.org/ojs/index.php/fm/article/view/548/469, 1.

**73** Nick Szabo, 'Formalizing and Securing Relationships on Public Networks' (1997) 2(9) *First Monday*, http://firstmonday.org/ojs/index.php/fm/article/view/548/469, 4.

**74** See generally D.W.P. Ruiter, *Legal Institutions* (Kluwer 2001).

legal system[75] outweigh its perceived benefits. The flight response is reflected in a reformist agenda within national legal orders, as well, for example the desire to reorganise the corpus of legal knowledge, make it machine-readable, and to oust legal professionals from their position as gatekeepers through market forces.[76] Jeremy Sklaroff points to a larger project associated with the so-called 'Californian ideology' to substitute human-controlled public institutions with automated digital processes within which individuals can order their private affairs.[77] It is perhaps no accident that many innovators are from former Soviet jurisdictions where confidence in public institutions is traditionally low, or that a particular American brand of libertarianism has inspired this movement.[78]

Many smart contracts may never come before a national court for practical, rather than legal reasons, as their parties seek anonymity and the ability to dispense with trusted intermediaries. Such an ideological commitment to non-contestability in traditional forums may undermine the rule of law, which thrives in a space typified by deliberative, normative disagreement by reference to shared higher-order norms.[79] The strength of the impetus behind this project is, in my view, at least partly a function of the quality of the response of the profession, the academy, and the bench to current developments. The law often responds *ex post* to innovations in the way that commerce is transacted. By remaining pro-active and receptive to the legal and commercial affordances of new technologies, legislatures and courts can perhaps even pre-empt some of the push and pull factors that might lead subjects to (attempt to) opt out of the order of national legal systems. The core challenge in this is to formalise contractual language without losing too much of the breadth, depth, and nuance of contract law itself—and to ensure that a legal language drafted for machine intelligibilty continues to serve the needs of its human constituency.

**75** Or rather, the global system of national legal systems, international law public and private, and para-statal alternative dispute resolution systems.

**76** Some of these processes are discussed in Richard Susskind, *The End of Lawyers? Rethinking the Nature of Legal Services* (Oxford University Press 2010).

**77** J.M. Sklaroff, 'Smart Contracts and the Cost of Inflexibility' (2017) *University of Pennsylvania Law Review* (forthcoming), 1; on the so-called Californian ideology, see Richard Barbrook and Andy Cameron, 'The Californian Ideology' (1996) 6 *Science as Culture* 44.

**78** See e.g. https://themerkle.com/eastern-blockchain-financial-liberation-through-crowdsales/.

**79** See Mareille Hildebrandt, 'Law *as* Information in the Era of Data-Driven Agency' (2016) 79(1) *Modern Law Review* 1, 27.

## Towards a smart(er) contract law

Leaving illegality, jurisdiction, procedure, and the rule of law to one side, what issues will smart contracts raise for contract law? In my view, most problems will relate to the 'smart' contract layer interacting with its conventional layers, namely conventional (paper) contractual text, the background ('factual matrix') of the parties' dealings, and the applicable rules of national contract law such as statutory implied terms. These problems will relate to the fact that natural languages have looser syntax and richer semantics than formal languages, and that machines are bad at pragmatics.

The following eight issues represent challenges and opportunities. They are areas in which contract law will have to adapt, and in which computer scientists and lawyers should work together closely. If addressed properly, they are all areas in which contract law could itself be improved through increased formalisation of contractual language.

### (i) Logical operators in contract drafting

The first and most obvious point relates to contractual syntax. At the moment, not only is contractual language ambiguous, but the contractual logic behind it is fuzzy. That is, not only do we struggle with the inherent ambiguity of natural language to express ideas, but we lack consensus on a rigorous logic of contractual operations. Two centuries after Bentham presented his 'logic of imperation' as a branch of logic 'untouched by Aristotle',[80] and a century after W.N. Hohfeld's attempt to formalise the way we speak about legal relations with a structured, constrained vocabulary,[81] it is not uncommon to hear efforts to systematise deontic logic dismissed as 'academic'. Practitioners and judges routinely use words like 'right' and 'privilege' in an unstructured, undisciplined manner. This kind of posture is, in my view, increasingly untenable. My point is not that we

**80** Jeremy Bentham (J.H. Burns and H.L.A. Hart eds.), *An Introduction to the Principles of Morals and Legislation* (Athlone 1970), 299. Bentham's logic used the operators 'obligation', 'prohibition', and 'permission'. The first attempt to organise relationships of legal obligation into a logical scheme was in fact made by Gottfried Wilhelm Leibniz in the late 17th century, but Leibniz' account remained unpublished until much later: See Lars Lindahl, *Position and Change* (Reidel 1977), 11; G.W. Leibniz, 'Elementa Juris Naturalis' in *Sämtliche Schriften und Briefe 1. Band* (Preussische Akademie der Wissenschaften 1930), 465.

**81** See W.N. Hohfeld, 'Fundamental Legal Conceptions as Applied in Judicial Reasoning' (1917) 26 *Yale Law Journal* 710; see Pierre Schlag, 'How to Do Things With Hohfeld' (2015) 78(1) *Law and Contemporary Problems* 185.

should all accept the Hohfeldian scheme (or any other particular scheme) but that we need, now more than ever, to reach a broad level consensus that *some* more formal logical scheme is necessary. We urgently need a logic of jural relations and operators, and we need an agreed, constrained syntax to talk about them.[82] This will not only involve a logic of obligation and prohibition, but also of actions and their consequences within the contract's legal and technological framework.

This is the area in which lawyers probably have to challenge their own preconceptions most radically, not only to understand smart contracts in the first place but to respond to them adequately and to harness their potential to influence contract law praxis positively as well as to disrupt it. Formal languages may lack some of the semantic richness and nuance of natural languages, but their syntax is more logically rigorous. Embracing some of this rigour and developing a more standardised vocabulary to describe the states of a contract and the actions of its parties is a worthwhile and exciting project and ought to be welcomed by lawyers.

### (ii) Translation (there and back again)

Disputes concerning smart contracts will require the translation of an instrument's formal language into natural language. A basic characteristic of artificial languages is that they can be fully circumscribed and studied in their entirety, so they have to be understood by human users in a meta-language—ultimately a natural human language such as English.[83] Post-breach negotiation, for example, or disagreements about the intended function of the code, would take place in legal English with references to the formal language used to draft the smart contract.

In fact, a smart contract is already the product of translation from a natural language into a formal one. The language of a smart contract will start its life as an idea (in natural language, or something like it) in the mind of a developer, or a discussion between developers, in response to a design brief (more likely in natural language) given by a client, possibly mediated by a conventional lawyer.[84] It will then be rendered into a machine-parsable language, and back again

**82** See for example Eric Tjong Tjin Tai, 'Formalising Contract Law for Smart Contracts' (Tilburg Private Law Working Paper Series 06/2017), http://www.ssrn.com/link/Tilburg-Private_Law.html.

**83** C.A. Gunter, *Semantics of Programming Languages: Structures and Techniques* (MIT Press 1992), 4.

**84** Human thoughts might be informed by the structure of a formal language but no-one really *thinks* in C++. Much as a lawyer's thoughts are informed the structure of contractual language; she will 'think' in categories of contract doctrine, in contrast to the layman client who will brief her in

in the case that the machine has done something undesirable and the parties have to argue about it. (As discussed above, depending on the structure of the formal language, this will also include translation from source code to machine code. I will assume that the language is sufficiently reliable that this element of the translation is unrproblematic.)

Essentially, the challenge is to ensure that the terms written as down in the formal language by a programmer are isomorphic with the natural language understandings on which it is based. This is difficult because of the way that natural and formal languages work. It is not possible at the present time, in my view, and may never be fully possible. Even should we design systems which generate a natural and a formal language version simultaneously, it is impossible to say that their semantic content will be identical in all possible future states of the contract. What is probably needed is a much more wide-spread and long-term project of creating smart contracting language which parties can then adopt as a comprehensive 'private dictionary' for drafting purposes with predictable interpretations under national law.[85] This is an involved, long-term project, that will require the involvement of conventional parties, including lawyers.

### (iii) The unintentional loss of semantic richness

In consequence, there is a real risk that those now working on smart contract drafting languages (such as Solidity) will try, but fail, to capture the richness of existing contract law. The syntax will usually be the easiest part to translate, as operators can be explained in terms of their causal effects within the relevant universe.[86] As suggested above, this might even be a salutary influence on the law, or at least galvanise lawyers into bringing their own house in order. The semantics of legal concepts will prove more difficult. The semantics of most formal languages less complete than we would like, and the semantics of natural languages inherently ambiguous. Some central concepts of English contract law are among the most ambiguous of all. Consider how contractual terms such as 'good faith', 'best endeavours', or 'reasonable delay' would be defined in a formal language. True, 'big data' may promise opportunities for mining opinion from

terms of relationships and commercial objectives. Of course, to some extent we all operate with our own private dictionary, and so it is difficult to say categorically that all my thoughts start their existence in 'English', as opposed to *my* English. But the general point, I think, is good.

**85** I thank Philipp Thurner for our discussion on this subject, which helped to clarify this point.

**86** See e.g. Massimo Bartoletti and Roberto Zunino, 'A Calculus of Contracting Processes' (University of Trento Technical Report #DISI-09–056, October 2009).

large constituencies within the relevant community, or indeed to distil judicial precedent in new ways. But the core of a concept such as 'reasonableness' is flexibility and sensitivity to context, which is inherently difficult for machines. This presents a greater risk of dimorphism and incorrect translation: The greater ability of human agents to construct meaning from context presents the danger that human parties will understand their agreed terms to mean one thing, and their machines will understand it to mean something entirely different.

### (iv) The intentional loss of semantic richness

The critical input of information scientists into the eldritch world of law is something to be welcomed as a healthy cross-pollination of disciplines concerned with 'doing things with words'. But if, instead of carefully developing a new and better language for expressing contractual obligations, we subject contract law to a weekend hackathon, we will surely discard some things of value. For example, many would hail the abolition of 'good faith' as a step in the right direction. But it would also raise serious problems from the perspective of consumer and investor protection, among other things.

More importantly, as Sklaroff argues, the ambiguity and flexibility of natural languages actually create efficiencies. Once initialised, a smart contract creates a 'permanent and unalterable link between the terms of the contract and the information system it manipulates', which lasts until the transaction is complete.[87] The straitjacket of immutable, unstoppable code requires parties to know (or attempt to know) everything relevant about every possible future state of the contract. This is costly in the due diligence phase and the drafting phase, as every contingency has to be imagined and negotiated. When affairs nevertheless take an unexpected turn, it raises the costs of responding to breach by making informal negotiation impossible. Totally inflexible contractual performance might sound attractive, but brings its own difficulties and inefficiencies when the universe conspires to 'alter the equilibrium of the contract'.[88]

A more promising line of development might be to think carefully about how the smart contract and the rest of its stack interact, and to incorporate a human element into the stack where this could create efficiencies. For example, one response to the difficulty of making 'good faith' comprehensible to a machine

**87** Jeremy Sklaroff, 'Smart Contracts and the Cost of Inflexibility' (2017) 166 *University of Pennsylvania Law Review* (forthcoming), 18–19.

**88** Stefan Vogenauer and Jan Kleinheisterkamp (eds.), *Commentary on the UNIDROIT Principles of International Commercial Contracts* (Oxford University Press 2009), commentary to Article 6.2.2.

might be to include a mechanism whereby a smart contract stops and refers the matter to a human (who holds a key to reinitiate the process). We might call this a 'semantic oracle', as it would mirror the use of so-called 'oracles' as external sources of data relating to the conditions of contract performance.[89] Most oracles are algorithms that provide third party information such as weather data or stock prices scraped from some database, but there is no reason why a human institution could not perform a similar function in giving semantic content to difficult terms—especially when circumstances have changed in unpredictable ways.[90] The result of such an approach would not be a techno-libertarian post-law utopia, but it would be a much 'smarter' smart contract.

### (v) Keeping contracts based in relationships between (human) agents

Donald Robertson stresses the importance of flexibility in international contracts, and in particular the principle of 'good faith' as a basis on which to adjust the operation of a contractual relationship after the event.[91] Parties actually value relationships, which endure beyond transactions, far more than some innovators seem to recognise. Accordingly, it is important for lawyers (who do appreciate this fact) to consider how smart contracts might be used to structure long-term relational contracts, instead of just trying to obviate the need for a meaningful relationship between the parties.[92] Robertson argues that good faith and fair dealing are the essential features of international contract law, especially in the context of the adaptation of contractual obligations once a contract has become 'executive' and performance initiated. It is noteworthy that smart contracts occupy the same space between regimes of national law, but purport to deal with the problem of uncertainty and risk in exactly the opposite manner.

### (vi) Textualism and contextualism (in a new context)

The formal nature of smart contracts adds a new dimension of complexity to existing controversies about the 'formal' *versus* 'contextual' interpretation of

**89** I thank Miëtek Bak for suggesting this nomenclature.

**90** See Vitalik Buterin, 'Ethereum and Oracles' (Ethereum Blog, 22 July 2014), https://blog.ethereum.org/2014/07/22/ethereum-and-oracles/ (accessed 22 November 2017).

**91** See Donald Robertston, 'Contracts in Crises' [2014] *AMPLA Yearbook* 221.

**92** See generally Alan Cunningham, 'Decentralisation, Distrust & Fear of the Body – The Worrying Rise of Crypto-Law' (2016) 13(3) *SCRIPTed: A Journal of Law, Technology and Society* 235.

contractual language.[93] Take, for example, Lord Hoffmann's fifth principle in *ICS* (above), i.e. that, if we conclude from the background that something must have 'gone wrong with the language', we should not impute to the parties an intention which they plainly could not have had. This, and related principles, have given rise to complex discussions about what context is relevant and about what evidence of context is admissible. The present status of this principle, and of the so-called 'contextual' approach to contractual interpretation generally, is currently being undermined in the jurisprudence of the UK Supreme Court, and is generally in a state of flux across the Commonwealth jurisdictions.[94]

The alternative to Lord Hoffmann's contextual approach looks at the 'natural' or 'ordinary' meaning of contractual language in the first instance, and only looks to context if there is ambiguity in the contractual language. (The *ICS* approach looks first at the context to determine what the words mean, and therefore whether there *is* any ambiguity in the first place.) The textual approach may prove itself to be problematic where the content of a contract is determined in whole or in part by a code-based instrument. The problem, as I see it, is this: If code is capable of execution, it would appear to be (by definition) clear in meaning and not ambiguous; if ambiguity is prerequisite for context to play a role in interpretation and/or construction, the court will never get to the point of asking whether the algorithm's product is really what the human parties intended—even in perverse cases. For example, the Supreme Court recently held in *Arnold v Britton*[95] that a clause containing a simple mathematical formula should be interpreted to require lessees of some holiday shacks to pay £1,025,004 per year for garden maintenance in the 99th year of a lease while others, with a slightly different version of the contract, would pay only £1,900 for the same services.[96]

Things can go wrong with the drafting of smart contracts, too. A prominent example is the incident involving an entity called 'The DAO'.[97] The smart contract

**93** See e.g. Zhong Xing Tan, 'Beyond the Real and the Paper Deal: The Quest for Contractual Coherence in Contractual Interpretation' (2016) 79(4) *Modern Law Review* 623.

**94** See Sir Geoffrey Vos, 'Contractual Interpretation: Do judges sometimes say one thing and do another?' (2017) 23 *Canterbury Law Review* 1; see e.g. Paul S. Davies, 'Interpretation and Rectification in Australia' (2018) 76(3) *Cambridge Law Journal* 483.

**95** [2015] UKSC 36.

**96** See *Arnold v Britton* [2015] UKSC 36.

**97** See David Siegel, 'Understanding The DAO Hack' (Coindesk, 25 June 2016), https://www.coindesk.com/understanding-dao-hack-journalists/. The acronym stands for 'Decentralised Autonomous Organisation', essentially a body without human organs. The legal cognoscibility of entities of this kind is another question for an independent examination. See Alan Cunningham, 'Decen-

governing this entity allowed investors to pool their money into an investment vehicle that would operate without human organs. Naturally the code allowed for investors to withdraw their funds. However, the code also allowed users to exercise the removal function recursively, that is to make repeated withdrawal requests, without checking whether the requests exceeded the investor's original contribution. Intuitively, this would appear as a bug, rather than a feature, of the software. A certain user (or users) discovered this function and used it to remove about US $50m (of a total fund of about US $150m) into a so-called 'child DAO' hived off from the parent fund. The DAO community responded to this action as a 'hack' rather than the legitimate use of a feature. The 'hacker(s)' claimed rightly that the terms of the smart contract excluded any extrinsic material as an aid to interpreting the code's functioning. The majority of The DAO community took a different view, however, and in the end a group of insiders short-circuited the consensus mechanism in the (supposedly immutable) code to perform what is called a 'hard fork' in the blockchain—effectively, they colluded to wind the clock back and start a new chain of transactions. There are now two competing records of the events, each claiming to be authoritative.

Because so many smart contracts are being drafted with the intention of excluding context entirely, principles of contextual interpretation will be even more difficult to apply. The DAO incident again demonstrates that inferences drawn from the context (including the background intention of the parties, and the background intention of those who drafted the formal language) are crucial to the interpretation of smart contract code. Contract law will have to develop an appropriate response.

#### (vii) An evolving canon of interpretation

By its very nature, a formal language may do unexpected things from the point of view of a human observer. For example, the problem with The DAO appears to have been one of language *design*, not just language *use*.[98] This opens a debate about the intended function of the whole language, not just that of a portion of code written in it. The semantic content of a formal language is informed by the question of what the language itself was intended to do. Unlike natural lan-

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tralisation, Distrust and Fear of the Body: The Worrying Rise of Crypto-Law' (2016) 13 *SCRIPTed: A Journal of Law, Technology and Society* 235.

**98** See Nicola Atzei, Massimo Bartoletti, and Tiziana Cimoli, 'A Survey of Attacks on Ethereum Smart Contracts (SoK)' in Matteo Maffei and mark Ryan (eds), *Principles of Security and Trust: POST 2017 Proceedings* (Springer 2017), 164.

guages, formal languages are created rather than evolved. For example, the programming language Simplicity is presented as a 'new language that maintains or enhances the desirable properties that Bitcoin Script has while adding expressiveness', and its creators name five 'design goals'.[99] The legal meaning of a phrase in Simplicity could therefore plausibly be informed by the stated intention to improve on its predecessors. The law may have to develop its traditional canons of interpretation based on this feature of formal languages. It may be necessary, in due course, to use documents such as this as we would use a dictionary or grammar. Again, this will entail discussion (in a meta-language) about the developer's intended meaning at the time of drafting. But it will be difficult to determine the status of this or that statement in the canon of interpretation, especially in the context of open-source languages on which a large number of programmers have collaborated, over many versions and over a long period of time.

### (viii) Whither equity?

Finally, smart contracts will raise issues surrounding the equitable doctrines that do so much work in contract law—from estoppel to rectification to specific performance. While less pronounced in Civilian systems that have not, historically, had a dual system of law and equity, similar issues might arise in relation to functionally similar doctrines such as *culpa in contrahendo* or the notion of 'abuse of rights'. First, many of these doctrines intervene in the normal process actually set out in the words of the agreement. To the extent that an automated process is unstoppable, even in light of changes in the parties' legal relationship, smart contracts may therefore come into direct conflict with equitable doctrines earlier and more frequently than any other part of contract law. This also relates to the points made above about complete contingency drafting and the unknowability of the future. Secondly, the techno-libertarian ideology driving smart contract innovation is inherently antagonistic to the tradition of Aristotelian equity in English law. As Lord Ellesmere said the *Earl of Oxford's Case*,[100] chancery exists because our actions are so diverse and infinite that it is impossible to make any general law that will cover every interaction and not fail in some circumstances. Equity specifically involves a departure from parties' legal rights, including their

**99** See Russel O'Connor, 'Simplicity: A New Language for Blockchains' (Blockstream Blog, 30 October 2017), https://blockstream.com/simplicity.pdf .
**100** (1615) 1 Ch Rep 1.

contractual rights, based on very human considerations. Equity is peculiarly vulnerable in the context of smart contracts—but, paradoxically, the latter's rigidity calls out for more, rather than less, equitable supervision. So far, the interaction between smart contracts and equity seems to be entirely neglected in the literature.

# 5 Conclusion

Smart contracts are not business as usual, but they are not end of contract law as we know it, either. The normal mode of the law's development is the refurbishment of existing concepts and doctrines in the wake of social and technological change. The disruptive potential of smart contracts equals that of innovations in corporate organization and finance in the 18th and 19th centuries, and the pace of change is more rapid. The potential for disruption is particularly acute in the context of automated contractual performance, especially using tamper-proof processes that are unstoppable once initiated and cannot respond to changes in the state of the world or the legal position of the parties. Rather than focussing on the potential for disruption, however, lawyers, judges, and legal academics should look at the positive influence that smart contracts might have for legal theory and practice more generally. In particular, smart contracts could act as a catalyst for the increased formalisation of contractual concepts and the language used to express them.

In advance of any of issues coming before the courts, the legal academy has an important role to play in explaining the role of language in law and in computer science, and forging a common vocabulary with computer scientists. Much of the groundwork has already been laid in the philosophy of language, on which both disciplines already draw. I have stressed the importance of speech acts contained in documents, or document acts, in the construction of our social, economic, and legal world. This is essential to understand a world in which algorithms can interact with the information systems which maintain these domains. As a result, we need to engage actively and constructively with the computer science community whose innovations (and ideology) are, at present, marking out the field.

At the moment, conversations are still in progress regarding the syntactic structure and semantic content of smart contracting languages themselves. We need to ensure we take up a place at the table while the conversation is still in terms we can understand and to which we can contribute. The challenge is to ensure that parsing contractual language to be machine readable does not exclude too much of contract law, on the one hand, and on the other to ensure that

the strictures of received legal doctrine do not stifle worthwhile technical, business, and legal innovation. In particular, we need to reconsider current debates in the law of contract interpretation in light of smart contracts, and think carefully about how to preserve the operation of equitable doctrines that affect the parties' legal position pre-contract or mid-performance.

**Acknowledgment:** Thanks to Isak Herman, Miëtek Bak, Björn Scheuerman, Ingolf Pernice, Jörg Pohle, Philipp Hacker, Donald Robertson, Sir Geoffrey Vos, Gino Dal Pont, Andrew Halpin, Axel Metzger, Philipp Thurner, Gerhard Dannemann and James Scheibner for discussions on the subject and/or comments on the draft. Thanks also to Brendan Gogarty and the participants of a seminar held at the University of Tasmania School of Law in February 2018 for their insightful comments. All errors and mistakes are my own. All URLS last accessed 30 November 2017.