Legal Recognition of Blockchain Registries and Smart Contracts*

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CONTENTS

1 INTRODUCTION

The interrelatedness between computer systems, networks, code, and traditional law and legal frameworks continues to pose a number of important and vexed questions. This report will consider one area of the relationship: legal recognition of distributed ledger technology (DLT) or blockchain applications[1]. Specifically, registers appended to blockchains (thereby creating "blockchain registries"), and "smart contracts" executed on blockchains[2].

Blockchains could shape law as much as law shapes them[3]. The balance between the two may change as so-called 'blockchain tourism' abates and 'practical business applications' start to appear, albeit in reduced or refined numbers[4]. Yet, a key question remains of whether or not existing legal and regulatory frameworks are capable of comprehending let alone absorbing a wide variety of blockchain applications, concepts, and use-cases without the need to create tailored blockchain laws or standalone blockchain legislation[5]. This issue affects common and civil law jurisdictions alike and is particularly acute regarding traditional contract and property laws and theories, where the latter, in particular, is challenged by the development of novel and tailored blockchain-based assets in the form of *tokens*[6].

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[1] An assumption is made of a general familiarity with blockchain technologies and, therefore, this report will not provide a single definition of DLTs or blockchains.

[2] Smart contract is in quotations here due to the debate over what precisely to call this application. For present purposes the nomination "smart contracts" will be used because it is the most common and familiar terminology.

[3] This echoes Kevin Werbach and Nicholas Cornell's view on smart contracts: 'Smart contracts may or may not transform the world, but they provide real benefits and seem likely to enjoy significant adoption over time. They represent the mature end of the evolution of electronic agreements over several decades' (Kevin Werbach and Nicolas Cornell. 2017. Contracts Ex Machina. 67 *Duke Law Journal* 313, p.317). Beyond educational initiatives designed and run by legal services to inform and ensure states of preparedness for entrepreneurs, businesses and governments regarding the potential legal risks surrounding blockchains, there is little evidence that blockchain use-cases are actually transforming legal practices or, more importantly, the formation of laws in many of the jurisdictions in which the technology is presently being explored. The exception to this rule is Estonia, a country that has achieved unprecedented levels of digital infrastructure relying in large part on the Guardtime KSI blockchain and technology stack. See: https://guardtime.com/technology (accessed 15 November 2018)

[4] Deloitte. 2018. *Breaking blockchain open: Deloitte's 2018 global blockchain survey*. https://www2.deloitte.com/global/en/pages/energy-and-resources/articles/gx-innovation-blockchain-survey.html (accessed 12 November 2018), p.5

[5] This report will, in part, argue that standalone or tailor-made legislation and regulations is not necessary at present, although greater regulatory monitoring and oversight is required.

[6] Tokens and the process of tokenization are both central to the operation of smart contracts and blockchain-based registers. Tokens provide a means of *representing* different forms of property and assets, and whilst they echo cryptocurrencies in the sense of computationally enabling users to transact on blockchains, they are not generalized mediums of value of exchange or obvious analogues of fiat currencies. In short, unlike cryptocurrencies, a broader idea of tokens does not simply see them as an alternative to cash. Instead, tokens are often tailored to very specific settings (digital environments, communities, or industries), and thus any inherent value a token has for its holder or user is realised *within* that particular setting.

Tokens play an extensive and critical role in many if not all DLT arenas and applications. Like discussions of smart contracts relative to traditional contracts, tokens require thorough and detailed analysis relative to property law and theory – something that is not possible within the scope of this report. Similarly, pressing questions concerning the regulation of initial coin offerings (ICOs) that enable the development of growing number of blockchain-based applications by, in essence, crowdfunding projects through mass token sales, will not be addressed here, but remain a major concern for lawmakers across different jurisdictions[7].

For present purposes three comments on tokens, including the role they play in facilitating Decentralized Autonomous Organizations (DAOs), will provide a backdrop to the report, although it is important to note that all three are contestable in many respects. Rachel Botsman focuses on the relationship tokens have to the fundamental ideals blockchains promise, notably the possibly for post-trust transacting: 'a digitally decentralized, shared ledger that relies on users to power the network by confirming transactions […] means that people who have no particular confidence in or knowledge of each other can exchange all kinds of assets without having to go through a trusted third party such as a lawyer or bookkeeper'[8]. For Michael J Casey and Paul Vigna tokens are the fuel powering blockchain implementations and a means of redefining and recalibrating existing global economies. The 'real power of tokens', claim Casey and Vigna, is that they 'offered a way to redefine and revalue the very exchange of resources around which economies function'[9]. In contrast, David Golumbia both highlights the risk of fraudulent behaviour and scams that token economies may facilitate, and the possibilities for erosion of democratic oversight if DAOs, underpinned by blockchain tokenization, proliferate without reasonable government regulatory oversight[10].

Returning to issues of legal recognition, evidence from the United States shows a greater number of legislative amendments to State legislation to address blockchains than standalone blockchain legislation, suggesting existing regulatory and legal parameters are, at least for the time-being, proving sufficient[11]. But, the general lack of specific blockchain laws also means less law to test and refine[12].

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[7] See, for example: https://www.fca.org.uk/news/statements/initial-coin-offerings (accessed 3 December 2018)

[8] Rachel Botsman. 2017. *Who Can You Trust? How Technology Brought Us Together – and Why It Could Drive Us Apart*. London: Portfolio Penguin, p.221

[9] Michael J. Casey and Paul Vigna. 2018. *The Truth Machine: The Blockchain and the Future of Everything*. London: HarperCollins, p.92

[10] David Golumbia. 2016. *The Politics of Bitcoin: Software as Right-Wing Extremism*. Minneapolis: University of Minnesota Press, pp.64-72

[11] A trackbill.com search returns 63 Bills referencing blockchain presently working their way through State and Federal levels in the US. The 63 Bills are originating in approximately 10 States, including Illinois, Arizona, Vermont, Wyoming, and Hawaii, with 7 individual pieces of legislation at the Federal level. Of the 10 States occupied with drafting blockchain related legislation, the Illinois General Assembly appears to be the only one creating standalone legislation, namely the *Blockchain Technology Act* (IL-HB5553). (accessed 13 November 2018)

[12] Out-of-court settlements in cases involving blockchains and cryptocurrencies also play a significant role here, because interpretations of existing laws and to a large extent new laws themselves will only emerge from judicial testing and review. See, for example, the settlement decision between the Securities and Exchange Commission (SEC) and Zachary Coburn of EtherDelta, which the SEC deemed to be operating as an unregistered

This could prove to be a vicious circle in which the opportunities and challenges that blockchain implementation and use pose in many private and public sectors remains undefined and poorly interpreted due to a lack of case-law able to structure and maintain developments.

It may be realistic to assume that blockchains are the next step in the mass socio-economic digitisation that has been underway since the mainstream adoption of the Internet and World Wide Web in the mid to late 1990s, at least in Western countries and the global north. Potentially providing the 'economic layer the Web never had'[13], blockchain-based applications expand the capabilities of the Internet stack and refocus the energies of existing network technologies and electronic working practices. A reasonable legal response is to do exactly the same: to build on and refine the stack of laws already instituted to deal with network technologies, communications, and electronic working practices, as well as, and this is important regarding smart contracts and blockchain registers, testing the authenticity of the law-like effects produced by blockchain applications[14].

Central to the ongoing uncertainty surrounding the overall "legality" of blockchains is a lack of robust judicial testing of blockchain-based practices and contexts. As a consequence, the nature of *blockchain conduct* is not well understood or defined at present[15]. It will be argued here that in order for legal recognition of blockchain smart contracts and registers (as well as other blockchain-based or decentralized client applications) to satisfy more than minimum or basic legal and regulatory standards, these applications must be tested via detailed analyses of existing laws[16]. Where lacuna appear in existing rules and principles by virtue of law's exposure to blockchain, laws pursuant to the specificities of blockchain and blockchain conduct will inevitably take shape.

2 STAKEHOLDERS

The focus of this report is on legal recognition of smart contracts and blockchain registers within the EU and UK. The globalizing nature of DLTs means, however, that the following discussion will not be limited to those jurisdictions alone.

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exchange and charged Coburn accordingly: https://www.sec.gov/litigation/admin/2018/34-84553.pdf (accessed 17 November 2018)

[13] Melanie Swan. 2015. *Blockchain: Blueprint for a New Economy*. Sebastopol: O'Reilly, p.vii

[14] Legal novelty in the sense of entirely new laws to deal with blockchains is an extreme and unnecessary suggestion. New laws are always created within heterogeneous environments, and blockchains are, therefore, not in a privileged position legally. The matter is arguably different from the point of view of economics. Blockchains may be no more useful or effective than existing ways of working with respect to contracting or registers, but the novelty of the technology creates new markets and thus fosters and drives economic interests.

[15] "Blockchain conduct" describes forms of autonomous, or quasi-autonomous behaviour, or methods of management and governance, all of which are produced by or are attributable to blockchain-based applications and implementations. Within this definition of conduct are a range of legal principles, including: performance, duty, obligation, and control.

[16] Regarding smart or technological contracts in particular, it is clear that the technology and conceptual developments fall far short of the level of detail necessary to make smart contracts a legitimate and viable contract type.

DLTs and associated applications are being explored, implemented and, therefore, to varying degrees, impacting upon a wide variety of civic (public) and private institutions, markets and sectors. Individual and collective stakeholders for whom legal recognition of blockchain applications is a concern are many and varied, including: governments, international financial and legal services, large corporates, small and medium enterprise (SMEs), entrepreneurs, and individual citizens and communities within the UK, EU member states and internationally.

Individual commercial actors and consortia such as R3 are the driving force behind many blockchain projects[17]. Governments and public sector operations and services may choose (or find necessary) in the near future to adopt blockchain-based registers or smart contracts[18]. While a number of governments, in the UK, US States and Federal level, and EU, are gathering evidence from commercial and academic communities in order to determine a way forward for blockchain initiatives, there is no parity between the public sector and private interests when it comes to research and development of blockchain technology. Yet governments remain the ultimate lawmakers within nation-states and arbiters of legal recognition of information and communications technologies (ICTs), including blockchains, especially where these are shown to have a broad socio-economic reach and impact.

It is vital, therefore, for governments acting in the public interest to establish *ex ante* regulatory frameworks through which new technologies such as blockchain registers and smart contracts can emerge and develop. Claims that regulations will stifle innovation need only consider whether innovation has, until now, been stifled by existing laws and regulations, with smart regulation that works closely with innovation as the bare minimum standard required[19].

3 THEMES

The report will cover three main themes:
- Legal recognition

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[17] As a measure of burgeoning commercial interest in enterprise blockchains, venture capital spending on blockchain and cryptocurrency projects has more than tripled during 2017/18 from $1Bn to $3.9Bn. See: 2018. Venture Capital Firms Go Deep and Wide with Blockchain Investments. *Diar*. Vol. 2, Issue 39 (October). https://diar.co/volume-2-issue-39/ (accessed 14 November 2018)

[18] In the EU there has been, for several years, the desire to harmonize Member State contract laws in order to improve the efficiency of the internal market. Solving the fragmentation and accompanying costs of mismatched approaches to contracting was a central aim of the now abandoned Common European Sales Law (CESL). However, key features relating to the legal basis for a CESL have been reformatted in the Directive on certain aspects concerning contracts for the supply of digital content (COM/2015/0634), in which it is stated that: 'The existing and upcoming fragmentation creates obstacles for businesses to sell cross-border because they have to incur contract law-related costs. Businesses are also uncertain about their rights and obligations. This has a direct effect on the establishment and functioning of the internal market and negatively affects competition. Given the heterogeneity of the online market for digital content it would be difficult for the market to overcome this fragmentation'.

[19] For more on existing and potential regulatory models that might be applied to blockchain see: Robert Herian. 2018. *Regulating Blockchain: Critical Perspectives in Law and Technology*. London: Routledge

- Smart Contracts
- Registers

Each of the core themes will be illustrated with examples relevant to blockchains (also see Appendix). Further, each will be considered in light of the influence on UK and EU law, as well as broader legal and regulatory frameworks.

The well-spring of contemporary blockchains included an ideological conjunction of anarcho-capitalist and libertarian projects. In a short space of time, however, patterns of blockchain research, development and use have become increasingly normal economically and commercially-speaking[20]. On that basis, blockchains ought to be subject to normative assessments of legal viability and legitimacy in the first instance, rather than assuming disruption or alienation of existing legal frameworks[21].

4 OPEN QUESTIONS

The following 'open' questions both reflect the content of the report and lay the foundations for it. Endeavours are made throughout to address if not precisely or always answer the questions, which continue to reflect unresolved or evolving issues and concerns confronting smart contacts and blockchain-based registers, as well as wider legal questions that DLTs and decentralized modes of governance pose.

- Are existing legal and regulatory frameworks capable of absorbing a wide variety of blockchain applications, concepts, and use-cases without the need for tailored blockchain laws or standalone blockchain legislation?

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[20] Cryptocurrencies such as Bitcoin are exemplars of the mainstreaming of blockchain technologies. While cryptocurrencies remain unstable, largely unregulated marginal economic forms relative to fiat currencies and other commodities, their use nevertheless mirrors and arguably aspires to normative market conditions. Further, the focus of higher education on cryptocurrencies in terms of future employability and economic trends shows the normalization of DLTs in critical and system thought and practice. The Independent reports that, 'An analysis of the top 50 universities in the world also found that 42 per cent offer at least one class on blockchain or cryptocurrency, with the majority of courses in the US' (Anthony Cuthbertson. 2018. Bitcoin is on its way to becoming a mainstream currency, study suggests. *The Independent*. 30 August. https://www.independent.co.uk/life-style/gadgets-and-tech/news/bitcoin-adoption-cryptocurrency-mainstream-study-coinbase-facebook-a8514431.html#comments (accessed 14 November 2018)

[21] There is some evidence that cryptocurrencies, although not necessarily broader blockchain applications such as registers or smart contracts, are subject to normative legal approaches despite an ongoing lack of international consistency in adopting regulatory measures (See, for example: Zhuling Chen. 2018. How should we regulate blockchain? It depends which country you ask. *Fortune*. 25 June. http://fortune.com/2018/06/25/blockchain-cryptocurrency-technology-regulation-bitcoin-ethereum/ (accessed 14 November 2018). An early focus by HM Revenue and Customs (HMRC) in the UK and the U.S. Securities and Exchange Commission has been to assume cryptocurrencies, in particular in terms of their status as 'assets' and in relation to value added tax (VAT), do fit existing legal frameworks. See, for example: HMRC. 2014. *Revenue and Customs Brief 9: Bitcoin and other cryptocurrencies*. https://www.gov.uk/government/publications/revenue-and-customs-brief-9-2014-bitcoin-and-other-cryptocurrencies/revenue-and-customs-brief-9-2014-bitcoin-and-other-cryptocurrencies (accessed 14 November 2018)

- What combination and balance of legal and technological criteria is necessary for legal recognition to occur?
- Should the development of novel laws occur if and when the relevance of existing legal measures have been exhausted or shown to be inadequate?
- Ought blockchains to be subject to normative assessments of legal viability and legitimacy in the first instance, rather than assuming disruption or alienation of existing legal frameworks?
- Will present tensions between nationalist and transnational political agendas pose significant obstacles to the likelihood of coordination in order to foster a harmonious, global blockchain ecosystem; or will blockchains be weaponized as part of defensive national measures and strategies?
- Is there a risk that smart contracts will undermine the validity and integrity of contract law by construing contracts *only* in terms of complete and fixed arrangements?
- How might "post-trust" electronic agreements influence social relations more widely?
- Who or what is ultimately responsible (liable, duty-bound) for ensuring the integrity and efficacy of the content (data) in blockchain registries, and how can the problem of rubbish in and rubbish out be mitigated?
- Does the (re)introduction of mediatory mechanisms in the form of decentralized arbitration reveal a level of critical inflexibility, especially in smart contracts, which cannot or will not be sufficiently overcome?
- How does the *tokenization* upon which smart contracts and blockchain-based registers largely rely ultimately fit into traditional property law and theory in both common and civil law jurisdictions?
- Is the influence and impact of artificial intelligence (AI) and quantum computing sufficiently accounted for in present blockchain development and implementation?

5 LEGAL RECOGNITION

5.1 INTRODUCTION

In this section a number of perspectives on the nature of legal recognition will be offered. Smart contracts or blockchain registers will not be dealt with expressly, instead a broader notion of legal recognition will act as a primer for the remainder of the report.

Before examining legal recognition it is important, briefly, to explore the idea that blockchain applications may not require or, indeed, eschew legal recognition. Notwithstanding this report's stated aim is to provide insight *into* legal recognition and, therefore, to extensively argue otherwise would be an exercise in arguing a negative, the grounds from which notions of *non*-legal recognition stem are vital to the overall picture and, therefore, necessary to address.

For present purposes this report will offer two possible, dialogic routes to the conclusion of non-legal recognition of blockchain applications, although it must be stated that both turn upon a very narrow definition of legal recognition as that

which derives *only* from formal judicial systems of state[22]. Firstly, it is entirely possible that thorough analyses would conclude that legal recognition is not relevant or necessary in some or most instances of blockchain applications, and alternative methods of self-regulation and enforcement should be allowed to evolve where appropriate, ultimately, to achieve dispute resolution. Secondly, and perhaps more realistically, the decentralized and autonomous (machine-to-machine) capabilities of blockchains negate an *a priori* requirement for legal recognition.

A key example of the latter is arbitration conducted either within or alongside blockchain applications, including smart contract platforms. Embedded or 'decentralized' arbitration would enable disputes over particular blockchain transactions to be resolved without traditional legal procedures, frameworks or remedies. OpenCourt, an initiative developed by OpenLaw – a predominately smart contract focused business (see Appendix for details) – aims to provide 'the first comprehensive step towards [...] an end-to-end commercial transaction that incorporates a smart contract powered arbitration system'[23]. OpenLaw underscore their vision of a specific form of smart contract arbitration based on the following rationale:

> Agreements incorporating smart contracts will not be immune to disputes and legal challenges. Parties will disagree about the terms governing their performance and disagree on how the smart contract was intended to operate. There also could be bugs in the smart contract itself, creating complications or misaligned incentives. The risk of mistake becomes magnified as smart contracts increasingly interact with outside data provided by trusted oracles like ChainLink but also require humans to perform their terms[24].

Many of the points raised above will be covered in depth later in this report. It is important to note that, whilst OpenLaw describe a decentralized form of arbitration, their vision does not appear to defeat, nor explicitly want to defeat, the notion of legal recognition formally defined. Rather than disavow legal systems, and by extension the legal recognition those systems facilitate, OpenLaw state that:

> blockchains hold out hope to power global universally available judicial systems that deliver low cost and high-quality dispute resolution services online. If implemented, the end result would be game-changing—a globally accessible "online court" where people have an equal opportunity to receive low cost, sophisticated, and transparent justice regardless of their location or creed[25].

What OpenLaw appear to propose, therefore, is a form of *private arbitration* conducted on the blockchain, and an analogue of existing off-chain and even off-

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[22] The counter argument, and the broader definition being, that legal recognition is not necessarily defined in and by state legal systems, but is an outcome of extensive and robust forms of social ritual, convention, and governance, although this does not detract from the law-making authority states alone ultimately hold.

[23] OpenLaw. 2018. *OpenCourt: Legally Enforceable Blockchain-Based Arbitration*. 18 October. Available at: https://media.consensys.net/opencourt-legally-enforceable-blockchain-based-arbitration-3d7147dbb56f (accessed 27 November 2018)

[24] OpenLaw, 2018

[25] OpenLaw, 2018

line private arbitration frameworks, including those services described under the umbrella of alternative dispute resolution (ADR)[26]. Notwithstanding the role blockchain plays in facilitating the type of arbitration OpenLaw envision, there is nothing fundamentally new about the proposal on offer, only a recalibration of existing methods and working practices[27]. Moreover, there is nothing new about the desire to deliver dispute resolution that is more efficient and cost-effective than existing court systems are able to achieve[28]. Perhaps more importantly, as ADR frameworks generally demonstrate, this form of arbitration does not defeat legal recognition, but is simply an alternative route to it.

5.2 SETTING THE SCENE

Law is a product of social relations and a longstanding mediator of disputes, transactions, and agreements. Legal recognition is an ancient and deeply-held philosophical and structural ideal necessary for achieving and maintaining justice between parties (individuals, communities, nations, etc.). Legal recognition both informs and stems from settled jurisprudence, governance models and procedures, as well as sustained conventions, traditions, practices and ethical frameworks, howsoever those come to be defined by an individual state or jurisdiction.

For law to be socially effective it must be able to comprehend (make sense of), and recognise (including the convenience of categorizing) a variety of individual rights, collective enterprises and organisations. In most societies and jurisdictions legal comprehension and recognition of the subject (citizen, claimant, defendant, etc.) or object (database, asset, fund, etc.) involves records, forms, documents, and other material artefacts[29]. A subject's rights are not necessarily or always granted using written or pictographic standards such as identity cards, licences, wills or contracts, but are invariably evidenced by them for the purposes of legal procedure. Comprehension and recognition of a subject or object often only occurs satisfactorily in the eyes of the law, therefore, when the ethereality of a right is made manifest in the materiality of an (evidentiary) record. For example, I am born a British citizen and can enjoy the rights and freedoms that entails because I have a birth certificate to prove it.

Similarly, an object is recognised legally if, for instance, and notwithstanding a subject's claim of a right over it, it meets prescribed legislative definitions or

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[26] The European Commission, for example, provide an extensive list of online alternative dispute resolution forums in each of the member states:
https://ec.europa.eu/consumers/odr/main/?event=main.adr.show (accessed 27 November 2018).

[27] This point is important because it could arguably apply to a wide range of blockchain use-cases. As a consequence the use of blockchain could be seen as gratuitous and premised only on *inter alia* ideals of greater security, immutability and transparency of data and transactions without reasonable explanation as to how or why these attributes are either relevant or desirable.

[28] In the UK, for example, there have been a number of damning reports in the last thirty years concerning the problems of inefficient and costly justice. See, for example: Jackson, R. 2016. Civil Justices Reform and Alternative Dispute Resolution. Judiciary of England and Wales, 20 September. Available at: https://www.judiciary.uk/wp-content/uploads/2013/03/lj-jackson-cjreform-adr.pdf (accessed 27 November 2018)

[29] See, for example: s. 64, *Law of Property Act* 1925 c.20, which deals in-depth with the production and safe custody of documents, concerns which are highly relevant in the context of blockchain registries.

regulatory standards pursuant to its type, operation or purpose[30]. While new technologies have enabled inroads into the digitization of bureaucratic processes (notably the advent of electronic signatures as legally enforceable[31]), there remains a significant amount of, not to mention reliance upon, off-line processes and, perhaps more importantly, paper in maintaining the evidentiary standards necessary for legal recognition. Jean-François Blanchette, for example, maintains that 'paper records (and paper work) form the material foundation on which the legitimacy and the day-to-day operation of the nation-state rests'[32]. The fact that something as *fundamentally non-digital* as a paper record continues to thrive in international bureaucratic processes of all kinds (legal, commercial, financial, etc.) is clearly a major obstacle to the proliferation of systems and networks that rely on digital artefacts.

Legal recognition always involves key externalities, most notably shifts in political and economic climates, or, as in the present instance, the impact of novel technological innovations. Political, economic or technological externalities are invariably reflected in the subsequent formation of legal principles, rules and conduct, but not always in an entirely coherent or obvious way. Hence, law often appears to lag behind or out-of-step with technologies. Gaps (*lacunae*) in legal knowledge open-up, which in turn fosters uncertainty. A symptom of the lack or failure of legal comprehension and recognition is informal, although not *de facto* illegal, modes of administration and governance. To be clear, this does not mean that laws do not apply, and the freedom to operate unfettered by the constraints of laws and regulations is often limited for two main reasons.

Firstly, formal law may well apply in such contexts, but can only be described *ex post*, such as in determinations of illegality. Secondly, communities or systems operating outside of the immediate influence of the formal law nevertheless create and adopt juridical principles, codes of conduct, and methods of arbitration able to perform the formal law *in absentia*. This includes, for instance, communities or systems that are auto- or self-regulating (autopoietic), where development and

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[30] For example, a "database" is described in s.3A of the *Copyright, Designs and Patents Act* 1988 c.48 as meaning:
a collection of independent works, data or other materials which—
(a) are arranged in a systematic or methodical way, and
(b) are individually accessible by electronic or other means.
[31] EU Directive 1999/93/EU provides a Community framework for electronic signatures. As Massimiliano Granieri maintains, however, 'the Directive does not cover aspects related to the conclusion and validity of contracts or other legal obligations where there are requirements, as regards form, prescribed by national or European Union law, nor does it affect rules and limits, contained in national or European Union law, governing the use of documents (art. 1(2)). In this respect', Granieri concludes, the impact of Directive on electronic contracting 'is limited' (Massimiliano Granieri. 2017. Technological Contracts. *Comparative Contract Law*. Edited by Pier Giuseppe Monateri. Cheltenham: Edward Elgar Publishing Ltd., p.419, fn.34)
[32] Jean-François Blanchette. 2012. *Burdens of Proof: Cryptographic Culture and Evidence Law in the Age of Electronic Documents*. Cambridge: The MIT Press, p.4. This bureaucratic reliance on paper is particularly acute in the world of off- and onshore 'tax havens', and a significant problem for regulators and tax authorities wanting to ascertain inter alia accurate lists of asset ownership and tax liabilities. See: Andres Knobel. 2017. Technology and online beneficial ownership registries: easier to create companies *and* better at preventing financial crime. *Tax Justice Network*. 1 June. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2978757 (accessed 14 November 2018)

evolution of prescriptive and proscriptive measures limits and checks ideas, practices or conduct that offends against the general will of a community or system in which the idea, practice or conduct has originated or to which it has spread.

Legal recognition involves the granting of rights, such as to property, foreshadowed by principles of enforcement (including determinations of illegality and criminality) and mechanisms for restitution or remedy. The conjoined granting and enforcement of rights is a longstanding basis upon which laws rest. Without mechanisms of enforcement and remedy, legal recognition would be a weak and ineffectual principle. Legal recognition can be illustrated in two longstanding and internationally recognised jurisdictions.

Firstly, the settlement of disputes between parties and enforcement of rights. In 'private law' dispute resolution, legal recognition turns on the provision and disclosure of documentary and evidentiary standards by parties to a dispute for the purposes of adjudicating rights claims and providing a remedy. Remedies take the form, first and foremost, of damages (money), but also performance (especially in the case of breach of contract), and restitution (returning the parties to the state they were in prior to an agreement).

The outcomes of adjudication further inform and shape the evolution of frameworks for predicting, determining and influencing future conduct and obligations, including offering a means for preventing or dis-incentivizing further disputes. This can occur both through the establishment of formalized, reported precedents, or frameworks and rules for (out of court) settlements. Legal recognition combines settled and agreed principles and rules, with an ability for the laws to react and bend to novelty and contingency within heterogeneous environments. In the context of Australia, Canada, the United States and England and Wales, the latter describes the function of equity and the equitable jurisdiction of Chancery.

Secondly, an act that offends against normative community standards and values prompting a community response in the form of a fine or imprisonment. Like dispute resolution, criminal law does not simply process criminal activity when it occurs, but aims to develop models of prevention as well as cure.

The aim of blockchain registers and smart contracts, like many technologies, should not be to "reinvent the wheel", that is, to seek to fundamentally remake law, legal practice and frameworks in the image of the electronic or digital. Instead, the aim should be to demonstrate and justify to communities and society at large that electronic alternatives to existing forms and practices are capable of at least meeting the same standards of authenticity, integrity, and legitimacy provided for by prevailing legal standards. Existing legal forms and practices are far from perfect, but they have been hard-won and thoroughly tested. Moreover, they are often highly complex precisely because they have been shaped over generations to meet the dynamism of *all* social conditions.

5.3 LEGAL "INTERFACE"

A *legal interface* bridges on- and offline networks and systems, marrying the real world to virtual digital worlds, and enabling at once negotiation, guidance, regulation, and, where necessary, enforcement[33]. As computer protocol a legal

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[33] In what they call an *Integrated Deal-Design Framework*, Daniela Alina Plewe and Robert de Rooy consider something akin to a legal interface and its role described here:

interface provides a 'technique for achieving voluntary regulation within a contingent environment [...] a distributed management system that allows control to exist within a heterogeneous material milieu'[34].

The concept of a legal interface echoes the role of an "oracle" insofar as it consolidates information and data. It is vital, however, that an interface is also able to process data against programmed sets of rules relevant to contexts in which the data is being applied. Short of the entire legislative roll of an individual jurisdiction being available for the task of cross-referencing - something that may become possible with artificial intelligence – the legal interface would require a more modest set of rules. There are two possible forms these programmed rules might take. Firstly, a uniform code, such as civil procedure rules used for governing legal proceedings[35]. Secondly, a constitution, which can, as Vernon Bogdanor maintains, be further interpreted in two ways:

> The first and most obvious meaning of the term refers to a selection of the most important legal rules regulating the government and embodied in a document promulgated at a particular moment of time, such as the American constitution of 1787 or the French Fifth Republic constitution of 1958. There is, however, a second sense of the term 'constitution'. A society is distinguished from a mere conglomeration of individuals in that it comprises a group of people bound together by rules; and a constitution is nothing more than a collection of the most important rules prescribing the distribution of power between the institutions of government – legislature, executive and judiciary – and between the individual and the state[36].

A legal interface, like the constitutional format embodied by Bogdanor's notion of 'a collection of the most important rules prescribing the distribution of power', provides a framework for shaping ideas and concepts prior to or in conjunction with implementations to ensure, *inter alia*, that minimum standards of conduct are met by users and participants, and limitations are placed on the exercise of power. To paraphrase Alexander Galloway, a legal interface *qua* constitution is how legal control exists after decentralization[37]. In that sense the interface is not merely legal or technological, but political. Moreover, it is an arrangement that enables a political solution to the paradoxical intermingling of decentralizing technologies and centralized nation-state sovereignty and jurisdiction.

'Recent developments in the field of legal technology tend to focus on the actual practice of creating contracts, for example, smart contracts [...] a particularly broad view on the context of contracting would be beneficial to such approaches. We firstly propose to consider "high level goals" or "values" of the parties per se, in other words, preferences disconnected from any specific negotiations. These high level concepts serve as regulative ideas providing guidance for the more specific steps in the negotiation'. (Daniela Alina Plewe and Robert de Rooy. 2016. Integrative deal-design: Cascading from goal-hierarchies to negotiations and contracting. *Journal of Strategic Contracting and Negotiation*. Vol. 2 (1-2), pp.19-20)

[34] Alexander R. Galloway. 2004. *Protocol: How Control Exists After Decentralization*. Cambridge: MIT Press, pp.7-8

[35] See, for example: https://www.justice.gov.uk/courts/procedure-rules/civil/rules (accessed 27 November 2018)

[36] Vernon Bogdanor. 2009. *The New British Constitution*. Oxford: Hart, pp.8-9

[37] Galloway, 2004, p.8

In order to provide a universalizing legal recognition of decentralized transactional models and working practices, the type of constitutionalism inherent in a legal interface could mirror that of approaches to Internet 'digital constitutionalism' defined as: 'a common term to connect a constellation of initiatives that have sought to articulate a set of political rights, governance norms, and limitations on the exercise of power on the Internet'[38]. Constitutionalism of this sort is not necessarily settled in or by ecosystems of self-regulating commercial actors. Governments in different parts of the world, New Zealand and Italy for example, have shown competence in developing constitutional frameworks for digital practice, which has led in some instances to hybrid constitutionalism[39].

Governments, as Santaniello *et al* point out, 'have been seeking to perform the fundamental functions of classical constitutionalism in the Internet sub-system, by producing acts directed to the establishment and protection of digital rights, the limitation on the exercise of power on and through digital networks, and the formalisation of governance principles for the Internet'[40]. It is important to note that, as a universal set of rights enforcement criteria, this type of digital constitutionalism maps across existing international human rights law, rather than interlinking with domestic law in any one nation-state[41].

Given the history of Internet regulation and coordination principles being dominated by the United States, ICANN for example, the emphasis on wider international participation and, above all, input into constitutional aims tailored to the likes of blockchain conduct and working practices is welcome. A key question remains, however, of whether the present tensions between nationalist and transnational political agendas pose significant obstacles to the likelihood of coordination in fostering a legal interface *qua* digital constitutionalism of this sort?

6 SMART CONTRACTS

This section explores aspects of smart contracts and examines their legitimacy *as* contracts by looking at key features of traditional contract formation and use[42].

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[38] Dennis Redeker, Lex Gill, and Urs Gasser. 2018. Towards Digital Constitutionalism? Mapping attempts to craft an Internet Bill of Rights. *The International Communication Gazette*. Vol. 80(4), p.303

[39] Mauro Santaniello, Nicola Palladino, Maria Carmela Catone and Paolo Diana. 2018. The language of digital constitutionalism and the role of national parliaments. *The International Communication Gazette*. Vol. 80(4), p.321 and p.332

[40] Santaniello *et al*, 2018, p.321

[41] Further to this point, it is also worth noting that, as the two predominant legal systems globally, common and civil law transcend domestic jurisdictions, as a legacy of imperialism and colonialism during the last 400 years. Commonalities prevail between common law jurisdictions such as the UK, US, Singapore, Australia, New Zealand, and Canada despite national constitutions, as they do between a variety of codified civil law jurisdictions such as Brazil, Germany, France, South Africa, Norway, and Russia. Both types of legal system, therefore, already enable a degree of *legal interoperability* between individual nations by virtue of shared juridical histories.

[42] UK common law will be the lens through which contract formation will be considered in this instance, although many of the rules discussed apply in civil law jurisdictions. In EU terms it is important to note a variety of legislation that has impacted upon electronic contracts, although note smart contracts *per se*: Directive on electronic signatures (1999/93/EC); Directive on electronic commerce (2001/31/EC); Directive on contracts

6.1 DEFINITIONS

Traditional contracts can be described as agreements creating obligations enforceable by law[43], or as the law 'based on liability for breach of promise'[44]. These definitions crystallize traditional contract law and, importantly, show that contracting does not simply involve creating obligations, it provides a mechanism for situations in which promises fail to materialize or are not performed, or expectations based on a promise are not met.

Do definitions of traditional contract law reasonably or suitably describe smart contracts as we find them today? Contrast traditional definitions with one found in a new blockchain Act presently working its way through the Illinois General Assembly, in which a smart contract is defined as, 'a contract stored as an electronic record which is verified by the use of a blockchain'[45], a definition which at first blush suggests that a smart contract is nothing more or less than a traditional contract written to and executed on a blockchain. In other words, the blockchain transforms or translates the traditional into the smart through a process of hybridity. Ethereum founder Vitalik Buterin, speaking in 2016, maintained that: 'a smart contract is a computer programme that directly controls some digital asset'[46], a definition that draws on the sort of seamless causality notable in algorithms ("if x, then y"), a causality that is arguably unfamiliar to traditions of contract as well as property law and theory, however, where heterogeneity and contingency form the backdrop to contractual processes[47].

The wording applied by the Arizona State Legislature is more rigorous: '"Smart contract" means an event-driven program, with state, that runs on a distributed, decentralized, shared and replicated ledger and that can take custody over and instruct transfer of assets on that ledger'[48]. Norton Rose Fulbright, a global legal services firm who have positioned themselves at the forefront of legal considerations of smart contracts in recent years, add a further dimension: 'Smart

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negotiated away from business premises (85/577/EEC); Directive on distance selling (97/7/EC); Directive on consumer rights (2011/83/EU).

[43] The definition echoes that set out in the Proposed Regulation on a Common European Sales Law, which defines 'contract' as 'an agreement intended to give rise to obligations or other legal effects' (*Chitty on Contracts*, 2018, at 1-025)

[44] H.G. Beale, W.D. Bishop, and M.P. Furmston. 2008. *Contract Cases and Materials*. 5th Edition. Oxford: Oxford University Press, p.3

[45] *IL-HB553 Blockchain Technology Act*. http://www.ilga.gov/legislation/ (accessed 9 November 2018)

[46] Vital Buterin. 2016. "Panel 1: Law 2.0 Understanding Smart Contracts". *Chamber of Digital Commerce*. 8th November. https://www.youtube.com/watch?time_continue=463&v=ZuHZOryZ_f0 (accessed 9 November 2018)

[47] A case in point are 'incomplete contracts'. Complete contracts are 'contracts where everything that can ever happen is written into the contract. There may be some incentive constraints arising from moral hazard or asymmetric information but there are no unanticipated contingencies. Actual contracts are not like this, as lawyers have realized for a long time. They are poorly worded, ambiguous, and leave out important things. They are incomplete' (Oliver Hart. 2016. *Incomplete Contracts and Control*. Nobel Prize Lecture. 8 December. https://www.nobelprize.org/uploads/2018/06/hart-lecture.pdf (accessed 16 November 2018), pp. 372-373)

[48] Title 44 – Trade and Commerce, Chapter 26: Electronic Transactions, Article 5, 44-7061. *Arizona Revised Statutes*. https://www.azleg.gov/arsDetail/?title=44 (accessed 9 November 2018)

contracts will often be used to document bilateral obligations between a User and a Counterparty. Smart contracts inherently deal with issues of evidence and intention that are behind some formality requirements – but, until legal systems add rules dealing specifically with smart contract, these formalities will still need to be satisfied'[49].

Initial conceptualizations of smart contracts maintained that the two variations, smart and traditional, were not necessarily supposed to do or perform the same tasks and, therefore, achieve the same legal outcomes[50]. This raises three fundamental issues: firstly, if smart contracts are not challenging, or are incapable of challenging, traditional contract law and theory, then what is the point of them? Secondly, smart contracts may be little more than a niche intervention that will improve cost effectiveness and efficiency in a limited array of contractual scenarios. Massimiliano Granieri claims that, 'the massive emergence of technology in the realm of contracts and contract law has been interpreted mainly in terms of transaction costs reduction, since technology is instrumental to form agreements in a more expeditious way, regardless of the distance between contractors', and in this respect 'the advent of technology in contract law has too often and too simplistically been considered the same as e-commerce'[51]. Thirdly, if smart contracts are not doing what contract law does then isn't it about time to stop calling them "contracts"?

6.2 FIRST THOUGHT, BEST THOUGHT?

Lawyer and technologist Nick Szabo's elegant introduction to smart contracts relied on the simple mechanism of a 'humble vending machine'[52]. In that scenario the contract is a straightforward transaction. Let's briefly revisit the scenario. The role of the purchaser using the vending machine is two-fold: they select a desired product and insert money to cover its advertised price both as payment but more importantly in order to satisfy the necessary stage of contracting known as consideration. At which point the vending machine accepts and processes the payment, and where the payment matches the advertised price releases the product selected to the purchaser, in doing so the vending machine completes performance of the contract. Vending machines perform simple, automated and often seamless transactions. Yet such transactions leave open questions of enforcement if and when the machines fails to convey the product selected by a purchaser. The elegance of the vending machine contract model can only really account for unproblematic transactions and contracts properly performed, not instances of mistake, failure or breach that require a variety of dispute mechanisms and remedies.

Moreover, the vending machine (smart contract) model ignores a truism at the heart of contract law and theory: property does not contract, people do. To embed

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[49] Adam Sanitt and Ian Grigg. 2018. Legal analysis of the governed blockchain. *Norton Rose Fulbright.*
http://www.nortonrosefulbright.com/knowledge/publications/167968/legal-analysis-of-the-governed-blockchain (accessed 9 November 2018)
[50] Nick Szabo. 1997. Formalizing and Securing Relationships on Public Networks. *First Monday*, Vol. 2, No. 9 (September).
https://firstmonday.org/ojs/index.php/fm/article/view/548/469-publisher=First (accessed 12 November 2018)
[51] Granieri, 2017, p.408
[52] Szabo, 1997

contracts in digitally controlled property as both Szabo and more recently Buterin suggest might presume that breach of contract cannot occur. Equally, it obfuscates and renders uncertain the possibility that parties will receive a remedy in the event a breach does occur or a dispute arises. This potentially changes what Kevin Werbach and Nicolas Cornell have called 'the posture of litigation'[53]. 'Rather than complaining parties seeking fulfilment of alleged promissory obligation', Werbach and Cornell explain, 'complaining parties will seek to undo or reverse completed transactions'[54]. As such, smart contracts do not defeat grounds for remedies in contractual disputes, only shift the emphasis of the remedy from, for example, performance to restitution, thus potentially heralding a rise in restitutionary claims, damages, and overall litigation.

Szabo's account further concludes that: 'Smart contracts go beyond the vending machine in proposing to embed contracts in all sorts of property that is valuable and controlled by digital means. Smart contracts reference that property in a dynamic, often proactively enforced form, and provide much better observation and verification where proactive measures must fall short'[55]. The major caveat in Szabo's account is the need for property to be 'controlled by digital means'. This raises the question of how effective smart contracts can be in a world where property is either not controlled by digital means at all, or not by digital means that are compatible or interoperable, or where there is a clear disjuncture between on- and off-line activities or motivations.

These concerns form part of the 'oracle problem', relating to the legitimacy and viability of various data sources as well as mechanisms for gathering and consolidating data such as the readings and outputs from ambient or atmospheric sensors (e.g. a meteorological station). The oracle service ChainLink describe their role in providing 'secure middleware' for smart contracts as, 'Building a truly valuable smart contract requires the use of multiple inputs to prove contractual performance, as well as multiple outputs to affect outside systems and/or send payment to complete the smart contract[56].

Importantly, the oracle problem poses questions of who or what ultimately controls and manages vital and potentially valuable input data in these instances. The earlier discussion on the legal interface addressed the same issue to some extent. Realistically, however, there are three common and largely unsurprising options: public state control; private individual or commercial control; or hybrid private/public control. Blockchains do hold the key to further options, namely via decentralized autonomous organizations (DAOs) or corporations (DACs), although both are still, in essence, modes of private, that is, non-state, control.

6.3 ARE SMART CONTRACTS SOPHISTICATED ENOUGH?

The smart contract definitions cited above describe an ideal type of contract. But they also represent gross oversimplifications that belie the significant complexities of contract law and theory, including the actuality of incompleteness and role of orality in contract formation. For instance, it is not immediately apparent if or how something as basic as the translation of express terms in oral agreements and

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[53] Kevin Werbach and Nicolas Cornell. 2017. Contracts Ex Machina. 67 *Duke Law Journal* 313, p.376

[54] Werbach and Cornell, 2017, p.376

[55] Szabo, 1997

[56] https://chain.link/features/ (accessed 30 November 2018)

reasonable intentions of the parties feature in smart contracts[57]. We will return to this matter again shortly. What is more, an ideal always fails to account for flaws, and in smart contract design bugs pose, what Werbach and Cornell call, 'significant limitation in replacing human enforcement of agreements with software running on the blockchain'; things as they rightly say 'simply do not always go according to plan'[58].

Is there a risk that smart contracts will undermine the validity and integrity of contract law by construing contracts only as complete and fixed arrangements? Fundamentally this assumption misses the significance of contractual variations at law and judicial interpretation, as well as key performative and remedial processes such as rescission and rectification that enable the unwinding of agreements[59]. In other words, it is wrong to view contracts as immutable and for smart contracts to do so, especially with regard to one of the most significant consequences of rescission, namely, treating the contract as though it never came into existence[60], clearly undermines contract law.

As an institution, contract law helps parties distribute or allocate risk by remaining flexible and contingent, and much of this has to do with an ability to: change contracts (rectification); unwind agreements made, *inter alia*, under duress or because of unconscionable bargains (rescission); put parties back in a position that they would have been in but for the agreement (restitution); or enforce, by order of the court, performance of a contract (specific performance). As previously suggested, restitution is a vital part of the suite of remedies contract law provides, and based on Werbach and Cornell's claims regarding the future posture of litigation under smart contracts, there is every chance that more not less restitution will be demanded by parties to a dispute in a future of smart contracts.

Many remedies are accompanied by damages relating to the breach of contract, as well as costs for litigation. But the equitable dimension of performance – that an agreement is performed as promised – is a longstanding principle of contract law that reveals agreements are not simply cold, hard transactions between parties freely contracting at arm's length, but morally binding promises. To undermine or negate remedies for breach of contract is a significant risk to the integrity of smart contracts as contracts, but also disturbs the moral basis upon which much of contract law and theory is predicated, by effectively removing the human element from promissory obligations.

In order to address this issue it is necessary to explore ways in which smart contracts can be more flexible. Ongoing initiatives, for example the *ERC1538: Transparent Contract Standard* developed by Ethereum smart contract designers, addresses the general inflexibility of smart contracts and seeks to create conditions

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[57] In the broader case of electronic contracts, attempts have already been made to ensure that oral preconditions in contract formation can survive technological change in the form of non-oral modification clauses (NOM). The validity of such clauses has recently been affirmed in the UK by the Supreme Court in *Rock Advertising Limited v MWB Business Exchange Centres Limited* [2018] UKSC 24

[58] Werbach and Cornell, 2017, p.365

[59] Cardozo J in his judgement in the New York Court of Appeals in *Beatty v Guggenheim Exploration Co* (1919) 225 NY 380 maintained: 'Those who make a contract, may unmake it. The clause which forbids a change, may be changed like any other. The prohibition of oral waiver, may itself be waived. Every such agreement is ended by the new one which contradicts it'.

[60] As per Lord Wilberforce in *Johnson v Agnew* [1980] AC 367

whereby variations in contract terms ("functions") are possible[61]. Addressing the vexed issue of smart contract immutability *qua* flexibility is vital if they are to better align with traditional contract law[62]. But it is also clear that in changing the fundamental immutability of smart contracts a desirable aspect of them, namely the ability for parties or individuals to execute contracts without having to trust one another, is eroded. As the author of the Standard maintains:

> Immutable, trustless contracts cannot be improved, resulting in increasingly inferior contracts over time. Contract standards evolve, new ones come out. People, groups and organizations learn over time what people want and what is better and what should be built next. Contracts that cannot be improved not only hold back the authors that create them, but everybody who uses them. In some cases immutable, trustless contracts are the right fit. This is the case when a contract is only needed for a short time or it is known ahead of time that there will never be any reason to change or improve it[63].

Mistakes, as they say, do happen. But in contract law mistakes assume particular significance with regard to contract frustration[64]. Courts (and the common law more generally) aim to uphold contracts when and where possible, but this is not always possible or desirable on the facts. Such mechanisms and processes demonstrate that contract is, however, flexible, contingent, and, perhaps above all else, a reflection of the inherent messiness of human enterprise. This, for some technologists, may be reason enough to find a "solution" to the "problem" of traditional contract law.

But, it is incumbent on smart contract designers to remember that contracts do not only exist in an immature state such as vending machine transactions. Nor is it desirable for contracts to do so if a balance between the express and consensual execution of rules-based agreements and the moral obligation of promise and performance are to remain intact[65]. Put another way, contract is a legal norm that

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[61] Nick Mudge. 2018. *ERC1538: Transparent Contract Standard #1538*. 31 October. https://github.com/ethereum/EIPs/issues/1538 (accessed 17 November 2018) – *This standard addresses the following technical issues:*
  - *A way to add, replace and remove multiple functions of a contract atomically (at the same time).*
  - *Standard events to show what functions are added, replaced and removed from a contract, and why the changes are made.*
  - *A standard way to query a contract to discover and retrieve information about all functions exposed by it.*
  - *Solves the 24KB maximum contract size limitation, making the maximum contract size of a transparent contract practically unlimited. This standard makes the worry about contract size a thing of the past.*
  - *Enables an upgradeable contract to become immutable in the future if desired.*

[62] Jeremy M. Sklaroff. 2017. Smart Contracts and the Cost of Inflexibility. *166 University of Pennsylvania Law Review 263*

[63] Mudge, 2018

[64] See, for example: *Great Peace Shipping Ltd v Tsavliris, The Great Peace* [2002] 4 All ER 689

[65] This points to the role of laws of equity and restitution, especially within Anglo-American common law jurisdictions, both of which work in and around the law of contract in order to ensure *inter alia* that a fair and reasonable balance is maintained between the bargaining powers of parties and that grounds for unjust enrichment or unconscionable bargaining are mitigated.

has successfully underwritten and influenced many social structures, not just the individual transactions to which they referred. Therefore, the question of how "post-trust" electronic agreements might influence social relations more widely is one that ought to be taken seriously.

6.4 NATURAL VS COMPUTER LANGUAGE

From the point of view of legal services, but also wider business interests, the key to the legitimacy and scalability of smart contacts turns on the matter of contractual language. In particular, the relative legibility and accessibility of natural language contracts (English as a common standard for international trade and consumer contracts for example), compared with the computer language or code of smart contracts. Under s. 7 of the *Unfair Terms in Consumer Contracts Regulations* 1999 (SI 1999, No. 2083), for instance, written contracts must be expressed in plain, intelligible language, and "coded" smart contracts do not necessarily meet this requirement[66].

Recall the Illinois General Assembly's definition of smart contracts: 'a contract stored as an electronic record which is verified by the use of a blockchain'[67]. In this example it is entirely possible for a traditional, natural language contract to form the basis of the electronic record, in the form of, for example, a scanned paper contract or PDF. In this case the natural language of contract is not disturbed by the intervention of smart protocols, and retrieval and interpretation of the contract could still remain a familiar task to the lawyer or paralegal.

Compare this to Vitalik Buterin's definition: 'a smart contract is a computer programme that directly controls some digital asset'[68]. In this case, no documentary form of a contract exists outside of the electronic environment purposefully established for its execution. The smart contract is either embedded in the property being conveyed or is formed at the moment of transaction and "written" in code. Whilst this may cause potential problems of contract legibility and intelligibility for the parties subject to it, smart contracts do appear to satisfy another key stage in traditional contract formation, namely, by establishing an enforceable *pre-written* promise[69].

Usually promises are binding if made orally or reflected by a particular form of conduct that evidences the promise or intentions of the parties to form a contract. In the case of smart contracts as defined by Buterin, however, a promise (or even an effective agreement) exists (latently) in the property subject to transaction, and as such the promise exists not unlike implied terms or clauses in traditional

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[66] Also: Directive 93/13/EEC on unfair terms in consumer contracts [1993] OJ, L95/29

[67] *IL-HB553 Blockchain Technology Act.* http://www.ilga.gov/legislation/ (accessed 9 November 2018)

[68] Buterin, 2016

[69] In the common law context it is especially important that this aspect of smart contracts is tested with regard to a variety of remedial actions, notably resulting and constructive trusts and estoppel. Resulting and constructive trusts, for example, have proven to be important safeguards in cases where a contract was obtained by fraudulent misrepresentation (*Lonrho plc. v Fayed* (No. 2) [1992] 1 WLR 1; *El Ajou v Dollar Land Holdings plc* [1993] 2 All ER 717)

contracts[70]. Instead of *ex post* adjudication in order to interpret and expressly define an implied term, that is, a term that was always already in the agreement, a smart contract executes on the basis that the agreement is always already valid.

The pre-written stage in contract formation raises one final important question: the ability of smart contracts to mirror good faith principles and the reasonable expectations of parties. As computer code or script, smart contracts do, by their very nature, privilege the written or documentary form as evidence of contract formation. Yet the matter of oral agreements (promises made) as binding based on evidence of the intention of the parties is a long settled and general rule applicable to most types of property. How can smart contracts ensure this rule remains in place, including associated considerations of good faith[71]?

If the answer is that oral agreements or good faith can be "coded" into smart contracts by, for example, a lawyer or notary trained in smart contract formation, then, once again, it must be asked whether this can be considered an improvement upon existing practices or a mere reinvention of them. Moreover, there is specific tension that arises between good faith principles or requirements, as a standard for fair dealing within contractual contexts, and the promise of smart contracts (and blockchains more generally) to foster *trustless* or post-trust transacting regimes. If smart contracts negate good faith by design, this places a heavy burden on smart contracts to maintain conditions in which good faith is no longer necessary. This presupposes that smart contracts can radically alter conduct in ways that continue to reflect good faith even in the absence of the principle.

6.5 CONCLUSIONS

An increasing number of peer-to-peer, domestic and international agreements, modes of exchange and transaction are being explored in light of smart contract compatibility and viability[72]. It has been stated that a successful smart contract regime requires and insists in equal measure on the digitization of property, notably, as discussed earlier, via tokens[73]. Without this state of affairs smart contracts cease to offer an autonomous technological solution that is wide-ranging. Instead, and as present conditions dictate, smart contract use must accommodate off-line, real-world legal conditions that accordingly satisfy normative standards of contact formation, performance, and remedial action in order to have any real value. Smart contracts are presently viable in tandem with existing contractual regimes, resulting in hybrid and concomitant (traditional and smart) contracting regimes. Like traditional contracts or other promissory formats and systems (fiat

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[70] Implied terms are distinguished from express terms. Express terms are 'actually recorded in a written contract or openly expressed at the time the contract is made. But there are cases in which the law implies a term in a contract although it is not expressly included therein by the parties. An implied term may be a condition, a warranty or an intermediate (innominate) term' (*Chitty on Contracts*, 2018, at 14-001).

[71] For example, in the UK, s. 53 of the *Law of Property Act* 1925 c.20 stipulates that written agreements must be used to create or dispose of an interest in land; to declare a trust of land; or in dispositions of equitable interest under a trust.

[72] For a detailed overview of some of these concept and use cases please see the Appendix.

[73] From the first inception of the smart contract concept to one of the latest statements of a viable commercial form, the need to change not only the nature of contract but also property has been identified as a critical factor in enabling smart contracts to operate in a practicable way. See, for example: Szabo. 1997; Mattereum. 2018. *Mattereum Protocol: Turning Code into Law*. https://www.mattereum.com/ (accessed 12 November 2018)

currency for example), the ultimate value of smart contracts will only really derive from the belief that others will accept them as part of a process of transaction or exchange.

Further, contrary to the notion of smart contracts "disrupting" existing contract law and theory, they must instead satisfy a high level of interoperability with the processes and procedures of verification defined by traditional contract law and theory. As Beale *et al* explain: 'contract law' is used to mean the whole collection of rules which apply to contracts, and these may include many rules that are not 'contractual' in the sense of being based on a promise to do something'[74]. This forms part of the determination of legal recognition that smart contacts must meet if they are to be legitimate, and whilst the dynamic nature of contract means it is 'always developing ad sometimes changing rapidly as new problems confront the courts and legislature'[75], a transition to smart contracts, if and when it occurs, is unlikely to sweep away all vestiges of traditional contract law.

The problem of bridging real and virtual worlds (the oracle problem), as well as bringing laws of contract and property into *digital harmony*, remain major obstacles for smart contract design and implementation within domestic jurisdictions and internationally[76]. Moreover, the question of whether smart contracts ought to be construed as or considered contracts *simpliciter* remains highly contentious[77]. Instead, smart contracts might best be understood as a new *type* of contract within an overall suite of contract law, rather than an alternative to or replacement for traditional contracts. It is clear from a legal standpoint that smart contracts do not provide a wholly viable alternative to existing forms of contract, nor, indeed, pose a threat[78]. Smart contracts are an immature judicial

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[74] Beale *et al*, 2008, p.3

[75] Beale *et al*, 2008, p.8

[76] See, for example: Jerry I-H Hsiao. 2017. Smart Contract on the Blockchain-Paradigm Shift for Contract Law, *14 US-China Law Review 685*.
Test cases for smart contract viability have tended to rely on tokenization of non-physical property that is amenable to digital exchange and transaction, such as financial products or intellectual property, and this trend has not changed in recent years despite some high-profile attempts to demonstrate that both chattels and real estate can be conveyed using smart contracts. See, for example: John Ream, Yang Chu, and David Schatsky. 2016. Upgrading blockchains: Smart contract use cases in industry. *Deloitte Insights*. 8 June. https://www2.deloitte.com/insights/us/en/focus/signals-for-strategists/using-blockchain-for-smart-contracts.html (accessed 12 November 2018); Aleksandra Dikusar. 2017. Smart Contracts: Industry Examples and Use Cases for Business. *XB Software*. 17 October. https://xbsoftware.com/blog/smart-contracts-use-cases/ (accessed 12 November 2018); Sudhir Khatwani. 2018. These are The 5 Best Use Cases of Ethereum Smart Contracts. *Coin Sutra*. 22 May. https://coinsutra.com/ethereum-smart-contract-usecases/ (accessed 12 November 2018);

[77] See for example: Werbach and Cornell, 2017; Max Raskin. 2017. The Law and Legality of Smart Contracts. *Georgetown Law and Technology Review*. Vol. 1, Issue 2 (April), pp.305-341; Scott A. McKinney, Rachel Landy, and Rachel Wilka. 2018. Smart Contracts, Blockchain, and the Next Frontier of Transactional Law. 13 *Washington Journal of Law, Technology & Arts* 313. In a Twitter exchange between Ethereum founder Vitalik Buterin and publishers of the Crypto Law Review, CleanApp.io, Buterin admitted: 'To be clear, at this point I quite regret adopting the term "smart contracts". I should have called them something more boring and technical, perhaps something like "persistent scripts"' (@VitalikButerin. *Twitter*. 6.21PM. 13 October 2018).

[78] For example, *Chitty on Contracts* (a vital reference work on contract law) does not mention smart contracts in the latest (October 2018) edition, only electronic documents

form incapable of fulfilling most of the conditional requirements of traditional contract law and theory. Although complacency on the part of lawyers is unwise and potentially misguided.

Smart contracts may provide corresponding opportunities and create markets for a small number of specialists. It is important, therefore, to recognise the rhetoric and especially hyperbole surrounding smart contracts, and subject lobbying interests to reasonable scrutiny. Smart contracts may serve special interests, but not a wider public interest upon which centuries of contract theory is built. Put another way, is there enough firm evidence that contract law needs to be, or actually will be, "disrupted" by smart contracts? Furthermore, can this be achieved without corresponding and far reaching changes to property law and cultures of ownership?

7 REGISTERS & REGISTRIES

An existing web of legislative and regulatory provisions and procedures, rules and principles command a wide range of transnational and trans-jurisdictional registration practices[79]. The promise of greater network decentralization offered by blockchain, allowing for simultaneity in information and data sharing between jurisdictional authorities may alter and, indeed, improve the ways in which registry systems operate in the future. Decentralization may improve trans-jurisdictional collaboration but it does not automatically negate the necessity for a high degree of centralized control of registries within individual jurisdictions, nor allow for an abdication of responsibility for maintaining robust and reasonable audit practices. The key role of state maintained blockchain registers would be to ensure *sticky ownership* notifications that fix (time-stamped and immutable) to commodities, assets, funds, investments, indeed anything subject to registration for the purposes of administrative oversight. Further, this once again focuses attention on the matter of tokens as the basic asset class available to blockchain registries.

7.1 A HYPOTHETICAL TAX LIABILITIES REGISTER
Imagine a register that auto-defines and enforces the tax liabilities of individuals or corporations either domestically or trans-nationally. Appended to a specified blockchain registry[80], the register would enable a direct link to be maintained between a specific token or asset and either the legal or beneficial owner of that

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and deeds with regard to provisions in land registration legislation for e-conveyancing measures (Hugh Beale (ed.) 2018. *Chitty on Contracts*. 33rd Edition. London: Sweet & Maxwell, at 1-123)

[79] The following EU regulations provide examples of registers that may be attractive options for translation onto blockchain, primarily due to the transnational and trans-jurisdictional nature of the regulatory subject matter: Regulation aiming to establish a common framework for business registers (No. 177/2008); Regulation concerned with the registry of ships, or rather the transfer of them between registers (No 789/2004); Regulation No. 166/2006 is concerned with the establishment of a European Pollutant Release and Transfer Register; Directive 2017/1132 has a section on company registers; Trade mark Directive 2015/2436 refers to registers but not a specific system; Insolvency regulation refers to the requirement of publicly accessible registers (2015/848)

[80] The type of blockchain (public, private, permissioned, permissionless, hybrid, etc.) required for such a registry would need to be decided.

asset for the purposes of tracking tax liabilities. Liabilities would auto-enforce based on a range of events, including conveyance by sale or gift, or transfer of ownership as part of a will or in trust. Echoing tokenization, as the digitisation of all property types required for the successful scalability of smart contracts, a tax liabilities register would run smart contract-like scripts that could identify, collect and enforce a quantum of liability associated with specific assets according to a prescribed tax code.

Can a register of this sort have legal force, and, importantly, who or what is ultimately responsible (liable, duty-bound) for ensuring the integrity and efficacy of the content on electronic registers in blockchain registries, and how to avoid the problem of rubbish in and rubbish out? Governments rely upon the competencies of centralized departments, institutions and agencies, such as Her Majesty's Revenue and Customs (HMRC) in the UK, to ensure databases and registers such as the one described above offer an effective means of combating tax evasion and avoidance and safeguarding the collection of vital revenues.

Decentralizing these responsibilities using blockchains, in the sense that the tax code would be embedded within the asset, could prove more efficient and secure than existing methods. Transparency with regard to certain liabilities could also be maintained, although this would not necessarily require a public blockchain. Transparency, in this instance, would engender a two-way street: honest and fair dealing of assets on the part of the legal or beneficial owner of the asset, and honest and fair calculation of liabilities on the part of tax authorities.

7.2 DIFFERENT BUT THE SAME

The effectiveness of a tax liabilities register, as noted above, relies on much the same principles required for the scalability and efficacy of smart contracts. Smart contracts in conjunction with blockchain-based registers, therefore, could help make individuals and businesses economically expedient, and keep them honest. In an honest tax regime individuals and corporations would choose to navigate ownership of fluid property and assets, including deriving rental income from those tokenized assets, using smart contracts, whilst simultaneously enabling an index of tax codes to read the status of a particular asset and collect revenues accordingly. Formalized association of the two regimes, in other words, is technologically possible, but it must also be desirable to enforce that association politically as well as legally, and the primary aim of doing so would be to affect a particular mode of *blockchain conduct*.

Concomitance of smart contracts with smart contract enabled registers in the hypothetical example of collecting and enforcing tax liabilities echoes real-world systems of provenance, attribution and enforcement in present use-cases found, for example, in the arts and music. Accurate and fair attribution of intellectual property using blockchain is seen as a significant step forward in protecting the rights of artists, and allowing artists to create opportunities to generate and derive reasonable income and royalties from their work[81]. Registers that clearly define

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[81] There are various discussions and perspectives on the relationship between blockchain and art. See, for example: Ruth Catlow, Mark Garrett, Nathan Jones, and Sam Skinner (Eds.) 2017. *Artists Re:Thinking the Blockchain*. Torque Editions & Furtherfield. http://torquetorque.net/wp-content/uploads/ArtistsReThinkingTheBlockchain.pdf (accessed 13 November 2018); Laura Lotti. 2018. Financialization as a Medium: Speculative Notes on Post-Blockchain Art. *MoneyLab Reader 2: Overcoming the Hype.*

ownership and provide regulatory oversight are entirely practicable and merit consideration in an array of public (civic) and private (commercial) contexts.

In order to escape niche implementation only, blockchain-based registers, like smart contracts, require a general reappraisal and potential revision of normative cultures of property ownership in order to be scalable and effective as autonomous systems. The alternative is a patchwork of hybrid forms involving existing, non-blockchain-based systems, tokens, assets, and databases that will at best dilute and at worst undermine or negate any gains that blockchain systems promise. It is possible that small-scale blockchain projects are able to start necessary paradigm shifts required in different sectors, but this will not be a short-term measure[82]. Furthermore, the likelihood that blockchains, as a technological *tour de force*, are superseded in the interim cannot be discounted.

A major factor concerning blockchain-based registers is the ability to erase appended records and data, especially in jurisdictions where data subjects have a so-called 'right to be forgotten'. In particular, the General Data Protection Regulations (GDPR) could prove highly problematic for public registers but not necessarily for private registers appended to permissioned blockchains. Of the new rights under GDPR, the right to be forgotten (Art. 17) is one which does not sit comfortably with what for many stakeholders are core and desirable features of blockchain, namely the ability of 'immutability' to create 'transparency' in order to foster 'trust'. It is important to note that 'erasure' is not an absolute right to be forgotten under the terms of the legislation however, and if, for example, the data involves defence of a legal claim or has overriding public interest then a data controller can refuse to comply with the right. Maxwell and Salmon describe the issue as follows:

> One of the design features of blockchain architecture is that transaction records cannot be changed or deleted after-the-fact. A subsequent transaction can always annul the first transaction, but the first transaction will remain in the chain. The GDPR recognises a right to erasure. The broad principle underpinning this right is to enable an individual to request the deletion or removal of personal data where there is no compelling reason for its continued processing. What constitutes "erasure" is still open to debate. Some data protection authorities have found that irreversible encryption

Edited by Inte Gloerich, Geert Lovink, and Patricia de Vries. Amsterdam: Institute of Network Cultures, pp.87-100; Maecenas, a blockchain-based art auction site offering shares in fine art - https://www.maecenas.co/ (accessed 13 November 2018)

[82] An analogy can be drawn here with internet retail or e-commerce versus offline retail, and blockchain-based registers versus off-chain 'electronic records' and databases or even paper-based registries. In the US in 2017 e-commerce accounted for only 9% of all retail sales. Whilst this figure is increasing (12.4% expected by 2020) and has made a number of e-commerce companies such as Amazon very wealthy and powerful, it has taken more than 20 years to reach this relatively modest market share. The retail culture in the US is, in other words, not yet dominated by e-commerce and will not be dominated by it for several years to come based on present projections, despite the relative maturity of today's digital infrastructure compared with 10 years ago. The change is occurring, but only very steadily because the major shift required is not technological, it is cultural.

constitutes erasure. In a blockchain environment, erasure is technically impossible because the system is designed to prevent it[83].

The right to be forgotten linked to the erasure of personal data strikes at the heart of the immutability of blockchain-based registers. Following the logic above, once immutability falls due to mechanisms for undoing or unwinding chains, does this bring into question the level of transparency and the ability to foster trust that the promise of blockchains rests on?

8 OBSTACLES

The aim here is to briefly outline known and unknown obstacles facing smart contracts and blockchain-based registers. The obstacles described also reflect on DLTs more broadly and thus potentially capture a variety of applications that use DLTs beyond those explicitly discussed in this report.

8.1 KNOWN

A number of key issues relating to blockchains have emerged following the relative maturation and pervasive use of cryptocurrencies, as well as tokens that enable tangible and intangible property to be represented on the blockchain, exchanged and transacted, globally. Three main obstacles can be highlighted here (in no particular order).

Firstly, issues of cost, speed, scalability and ultimately, the long-term security of blockchains. The IOTA Foundation's development of a rival to the blockchain called the *Tangle* is predicated on the notion that blockchains are slow, expensive, and, as a consequence, will not scale sufficiently for commercial or civic purposes[84]. *Cryptokitties,* a very popular game based on the Ethereum blockchain, also revealed problems with both speed and scalability of the blockchain as it struggled to support a huge growth in users[85]. Further, while the cryptography underlying blockchains is seen as one of its strongest attributes compared with traditional or existing data storage, rapid developments in quantum computing are likely to undermine the robustness of blockchain architectures[86].

Secondly, the environmental and climatic costs due to a massive growth in computing power needs. Mass cryptocurrency mining, notably in China, has revealed that stringing together multiple computers in order to enable blockchain-based applications to operate on an industrial scale uses (much like many

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[83] Winston Maxwell and John Salmon. 2017. A guide to blockchain and data protection. *Hogan Lovells*. September. https://www.hlengage.com/_uploads/downloads/5425GuidetoblockchainV9FORWEB.pdf (accessed 17 November 2018), p.15

[84] https://www.iota.org/research/meet-the-tangle (accessed 16 November 2018)

[85] https://www.cryptokitties.co/ (accessed 3 December 2018)

[86] See, for example: Emerging Technology from the arXiv. 2018. If quantum computers threaten blockchains, quantum blockchains could be the defense. *MIT Technology Review*. 1 May. Available: https://www.technologyreview.com/s/611022/if-quantum-computers-threaten-blockchains-quantum-blockchains-could-be-the-defense/ (accessed 27 November 2018)

conventional means of production) a great deal of electricity and energy[87]. If blockchain-based systems and projects are to be or remain environmentally sustainable, therefore, a significant priority must be to ensure infrastructure developments do not augment and contribute to deteriorating global environmental conditions[88].

Thirdly, issues of interoperability and a general fluidity and harmonization across a range software (and hardware) has long plagued digital network design and scalability, and the same fate confronts blockchains. Arguably, the matter has been tackled on the Internet to a large extent by economic means rather than technological solutions, namely via monopolisation (centralized control) of different digital methods, platforms, and artefacts (including data). The role monopoly plays is economic, but it equally affords a sense and utility of harmony between methods, platforms, and artefacts previously seen as divergent by virtue of competition - the consolidation and proliferation of Google services is an example of this[89]. Ethereum have been significant in addressing issues of blockchain interoperability by providing designers with an opportunity to develop decentralized applications (dApps), including smart contracts using a uniform token standard that can represent different assets, whether fungible or non-fungible (most recently ERC-1155[90]), which bridge and enable interactions between the blockchains and other, conventional (off-chain), technologies and properties.

The blockchain attributes of decentralization, disintermediation and distribution are all powerful ideals which ought, at least in theory, undermine monopoly and discourage monopolistic interests. The reality, however, is somewhat different. The fundamental issue at hand is that there is not a single, uniform blockchain. Since the contemporary emergence of DLTs in the form of the Bitcoin blockchain in 2008 - a public blockchain predicated on ideals of post-trust transparency and true peer-to-peer functionality – there has been a significant expansion of both public (permissionless) and private (permissioned) blockchains organized around similar but not the same principles or aspirations. Decentralization, in this sense, begins to look like fragmentation based on a wide variety of different interests[91].

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[87] Alex Hern. 2018. Bitcoin's energy usage is huge – we can't afford to ignore it. *The Guardian*. 17 January. https://www.theguardian.com/technology/2018/jan/17/bitcoin-electricity-usage-huge-climate-cryptocurrency (accessed 16 November 2018)

[88] For a further discussion on the relationship between blockchain and climate change, see: https://unfccc.int/news/how-blockchain-technology-could-boost-climate-action (accessed 3 December 2018)

[89] For a more thorough examination of these arguments see: Nick Srnicek. 2017. *Platform Capitalism*. Cambridge: Polity

[90] https://github.com/ethereum/eips/issues/1155 (accessed 3 December 2018)

[91] The present development of different blockchains echoes the evolution and fragmentation of the Internet. Milton Mueller has argued that Internet fragmentation has largely been driven by a 'mismatch' between cyberspace ideals of unfragmented space and the real territorial demands of nation-states and legal jurisdiction. For Mueller this is best illustrated in the field of cybersecurity where jurisdiction has been forced upon an otherwise unfragmented space in order to ensure the integrity of national interests are secured and maintained. Whilst Mueller is correct in his assessment of jurisdiction in this regard, the idea that cyberspace is *a priori* unfragmented is not true. This is because it fails to account for the role and equally fragmentary influence of commercial, private interests defending commercially lucrative digital territories. See: Milton Mueller. 2017. *Will the Internet Fragment?* Cambridge: Polity

8.2 UNKNOWN

By their very nature pin-pointing and even describing unknown obstacles or, similarly, unintended consequences is harder than the inverse. As Chris Reed suggests with regard to the 'law of unintended consequences' that shadow ICT legislation and regulation, the 'tendency to concentrate on the intended consequences of regulation often means that it potential to produce *unintended* consequences is overlooked'[92]. Therefore, this sub-section will simply and briefly list some potential unknown obstacles, especially with regard to legal services as facilitators of frameworks and mechanisms governing legal recognition.

- Minimum requirement/level of combinatory techno-legal skills and the impact on employability
- Adjusting entrenched law and procedural frameworks to new technological methods.
- Adjusting for technology incompatibilities and inconsistencies within legal services and beyond.
- Mid to long term impact on legal education and services.
- Mid to long term impact on business and society from shifts in practices and principles of contract and property law and theory.

9 CONCLUSIONS

'Blockchain technology is a highly reliable witness to ideas and events, in that sense it bears no relation to the fallibility of human memory whilst maintaining an inescapable dialogue with it. Blockchain records and (re)presents data, appends and witnesses, (de)materialises and (re)configures, and does so in ways that both reflect existing Internet capabilities and intensifies them, for purposes that are primarily economic, but nevertheless result in social, cultural and political consequences'[93].

Blockchains offer trans-national and trans-jurisdictional ways of working, including the possibility of machine-to-machine "invisible" functionality, fully autonomous systems underpinned by tokens and self-executing code (DAOs or even decentralized commons[94]), perpetual scripts (smart contracts?), the Internet of Things ("IoT"), artificial intelligence (AI), or a combination of all of these. Problems persists however. In jurisdictions such as the UK and EU (as a Union and individual member states) there is lingering uncertainty over blockchains due to an overall lack of jurisprudence (i.e. case-law, legislation, regulations or directives), and a lack of focus on or understanding of *blockchain conduct.*

Blockchain conduct requires lawmakers to focus not on the technology or applications alone, but on those who engage with or rely on them (developers, designers, users, consumers, 'prosumers', data providers, data managers, etc.).

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[92] Chris Reed. 2007. The Law of Unintended Consequences – Embedded Business Models in IT Regulation. *Journal of Information Law and Technology*. Issue 2. Available at: https://warwick.ac.uk/fac/soc/law/elj/jilt/2007_2/reed (accessed 3 December 2018)

[93] Herian, 2018, p.31

[94] The idea of Decentralized Autonomous Organizations (DAOs) famously devalued in 2016 when a hack exploiting a software vulnerability drained a fund of approximately $50 million in cryptocurrency. From a legal standpoint the 'theft' from the fund did not arguably breach any rights (was not, therefore, a *de facto* fraudulent act) because the smart contract at the heart of the organization executed as it was supposed to.

Generally-speaking it is correct to assume that technology does not break laws, breach contracts or contravene rights, people do. This means lawmakers must remain in-step with conduct produced by technologies such as blockchains and not allow legal recognition to lag behind.

Legal or, more specifically, regulatory lag can be attributed to a number of factors, some of which are more obvious than others. For example, whilst the agility of innovationism versus the grinding gears of legal evolution is often cited as a main reason for regulatory lag, the predominance of self and smart regulatory measures, including "wait and see" and "wait and monitor" provisions in the EU context, that aim to give space to innovation and not stifle entrepreneurial enterprise, are arguably also contributing to a failure for public, regulatory bodies to remain fully engaged and thus not simply keep pace but potentially set it[95].

"Wait and see" might satisfy economic demands, as well as ideological ones, in the immediate term, but is not a reasonable measure in the medium to long-term without suitable mechanisms in place to guarantee actual implementations based on legal recognition, oversight, and certainty. This is especially the case where risk and public interest intersect in public expenditure initiatives to support innovation. Innovation conducted on a basis of civic benefit or improvement (for example, blockchain-based registers of patient records[96]), ought to be accompanied by legal certainty, not only to guide implementations, but more importantly offer informed redress in the event of a dispute, fault or breach.

At present it is not viable for smart contracts and blockchain-based registers to act autonomously. Instead, a high level of hybridisation is necessary in order to surmount a disjuncture, most notably, between technological aspirations and legal (property, contractual, etc.) norms and cultures. This means smart contracts working in tandem with on- and offline, and on- and off-chain, transactional modalities. Further, it means blockchain-based registers acting like, rather than superseding, traditional databases or similar electronic archives. As a consequence, significant new laws and regulations tailored to smart contracts and blockchain-based registers are yet to emerge. When they do, however, the rules and principles that underpin them must be well informed, robust, and equitable.

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[95] The EU seem to be moving towards regulatory standards interlinked with technical standards. In a recently adopted EU non-legislative resolution on DLTs and blockchains, the Commission and the national competent authorities are encouraged to 'swiftly build up technical expertise and regulatory capacity, allowing for rapid legislative or regulatory action if and when appropriate' (John Salmon. 2018. EU adopts non-legislative resolution on DLTs and blockchain. *Hogan Lovells*. 8 November. https://www.hlengage.com/eu-adopts-non-legislative-resolution-on-dlts-and-blockchains (accessed 15 November 2018)

[96] See, for example: https://medicalchain.com/en/ (accessed 19 November 2018). Use cases such as medical records stored on blockchain emphasise individual control over data. At first blush 'taking back control' may seem an incontestable good, but the ramifications to the individual are, I suggest, far from conclusive and may even assume, incorrectly, a high level of expertise and knowledge, as well as psychological competence to individually or personally administer massive amounts of personal data.

*APPENDIX**

1 LEGAL "INTERFACE"

- Constitutional format
- Embedded jurisdiction
- Granting "contextualized" legal rights
- Enforcement/control procedures and mechanisms
- Automated/hybrid regulation
- Importance of defining a vocabulary

OPENLAW website
https://openlaw.io/

Stanford Journal of Blockchain Law & Policy
https://jblp.scholasticahq.com/
https://stanford-jblp.pubpub.org/

It's Blockchain your Honour
October 23, 2018
https://www.lexology.com/library/detail.aspx?g=8ad7a2de-a76b-4caf-858f-8d7c996dcde8

Blockchain Technology & Malta's Regulatory Framework
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https://www.bmmagazine.co.uk/business/blockchain-technology-maltas-regulatory-framework/

Blockchain State Legislation
July 10, 2018
http://www.ncsl.org/research/financial-services-and-commerce/the-fundamentals-of-risk-management-and-insurance-viewed-through-the-lens-of-emerging-technology-webinar.aspx

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European Parliament calls for progressive regulation on blockchain technology
October 15, 2018
https://www.linklaters.com/en/insights/blogs/fintechlinks/2018/october/european-parliament-calls-for-progressive-regulation-on-blockchain-technology

1.1 BLOCKCHAIN CONSTITUTION

What could a blockchain Constitution look like? (Steemit Article) - EOS
2017
https://steemit.com/eos/@dantheman/what-could-a-blockchain-constitution-look-like

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How to create a meaningful Blockchain Constitution (Steemit Article) - EOS
2016
https://steemit.com/eos/@dantheman/how-to-create-a-meaningful-blockchain-constitution

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Ideas Behind Eos Blockchain Governance and Constitution PT. 2 (Steemit Article) - EOS

2018
https://steemit.com/eos/@champagnecrypto/ideas-behind-eos-blockchain-governance-and-constitution-pt-2

Why every Blockchain needs a Constitution (Steemit)
2016
https://steemit.com/blockchain/@dan/why-every-blockchain-needs-a-constitution

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Blockchain Australia: The genesis of blockchain discovery, policy and implementations
https://www.blockchainaustralia.org/consititution/

Blockchain and Buchanan: Code as Constitution (paper - Shruti Rajagopalan)
September 5, 2018
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3238472

Blockchain: 1st Amendment Protections (Hackernoon article)
November 24, 2017
https://hackernoon.com/blockchain-1st-amendment-protections-85c2190d2062

1.2 BLOCKCHAIN GOVERNANCE

The Three Branches of Blockchain Governance (Medium article)
August 23, 2018
https://medium.com/digitalassetresearch/the-three-branches-of-blockchain-governance-75a29bf98880

Blockchain Governance: Programming Our Future (Medium article)
November 27, 2017
https://medium.com/@FEhrsam/blockchain-governance-programming-our-future-c3bfe30f2d74

Solving Decentralized Blockchain Governance Is Key to the Future of Crypto (coincenter article)
August 1, 2018
https://coincentral.com/solving-decentralized-blockchain-governance/

2 REGISTRIES

- Business/Corporate
    - Corporate/companies (e.g. Companies House)
    - Financial Services
    - Trusts/beneficial ownership
    - Insolvency
    - Shipping
    - Charity
- Individual/Citizen
    - Civil registration
    - Births/Deaths/Marriage
    - Immigration/emigration
    - Insolvency
    - Trusts/beneficial ownership
    - Wills
    - Virtual land/property

2.1 BUSINESS/CORPORATE

2.1.1 Corporate/companies
The Emergence of Blockchains as Activity Registers (CoinDesk article)
August 13, 2016
https://www.coindesk.com/emergence-blockchains-activity-registers
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Blockchain could clean up messy shareholder registers (FT article)
September 11, 2017
https://www.ft.com/content/f5cf21f6-935a-11e7-a9e6-11d2f0ebb7f0

Proxeus enables first business to be legally registered using blockchain (article)
April 10, 2018
https://proxeus.com/en/proxeus-enables-first-business-to-be-legally-registered-using-blockchain/
https://www.trustnodes.com/2018/04/09/ibm-others-legally-register-company-3-hours-blockchain
http://uk.businessinsider.com/swiss-using-blockchain-to-refine-clunky-business-incorporation-2018-5
Partner: IBM

Dubai Launches Blockchain Business Registry to Ease Market Entry (cointelegraph article)
MY 02, 2018
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https://www.dsoa.ae/en/news/ded-and-dsoa-unveil-blockchain-commercial-registry-project-for-improved-ease-of-business/
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Tech Partner: IBM

Canada: Making the Blockchain Real for Corporate Registries (pdf)
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https://e-estonia.com/solutions/business-and-finance/e-business-register/

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August, 2018
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Blockchain and its competition law risks
August 1, 2018
https://www.tltsolicitors.com/insights-and-events/insight/blockchain-and-its-competition-law-risks/

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Global Debt Registry taps blockchain for loan registry

June 27, 2018
https://www.finextra.com/pressarticle/74488/global-debt-registry-taps-blockchain-for-loan-registry

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Blockchain in financial services
https://www.pwc.com/us/en/industries/financial-services/research-institute/top-issues/blockchain.html

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Blockchain and Its Coming Impact on Financial Services
Summer 2018
http://jwm.iijournals.com/content/21/1/124

Applications of blockchain to financial services: three banking use cases
May 10 2018
https://finsia.com/insights/news/news-article/2018/05/10/applications-of-blockchain-to-financial-services-three-banking-use-cases

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How is the UK approaching financial blockchain regulation? (Computerworlduk - article)
July 17, 2018
https://www.computerworlduk.com/security/how-is-uk-approaching-financial-blockchain-regulation-3680781/

Blockchain in financial services: birth of the hybrid FinTech lawyer
June 2018
https://www.taylorwessing.com/download/article-blockchain-in-financial-services.html

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Around the world in Blockchain Regulations
June 1, 2018
https://medium.com/edchain/around-the-world-in-blockchain-regulations-e077d9a2a535

Blockchain in the financial services sector: what's on the regulator's agenda?
January 3, 2018
http://www.osborneclarke.com/insights/blockchain-in-the-financial-services-sector-whats-on-the-regulators-agenda/ which discusses:
FCA - Distributed Ledger Technology: Feedback Statement on Discussion Paper 17/03
https://www.fca.org.uk/publication/feedback/fs17-04.pdf

2.1.3 Shipping
Blockchain Is About to Revolutionize the Shipping Industry (Bloomberg - article)
April 18, 2018
https://www.bloomberg.com/news/articles/2018-04-18/drowning-in-a-sea-of-paper-world-s-biggest-ships-seek-a-way-out

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How can the Shipping Industry take advantage of the Blockchain technology? (Opensea article)
https://opensea.pro/blog/blockchain-for-shipping-industry

Maersk, IBM Launch Blockchain Shipping Supply Chain Platform (cointelegraph - article)

August 9, 2018
https://cointelegraph.com/news/maersk-ibm-launch-blockchain-shipping-supply-chain-platform
Tech Partner: IBM

Can Blockchain Technology Bring Smooth Seas to Global Shipping?
September 14, 2018
https://worldview.stratfor.com/article/can-blockchain-technology-bring-smooth-seas-global-shipping

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Blockchain technology set to renew and ease ship registration (Danish Maritime Authority - article)
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British Maritime Society Builds Blockchain Tool for Ship Registration (CoinDesk article)
September 4, 2018
https://www.coindesk.com/british-maritime-society-builds-blockchain-tool-for-ship-registration

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May 14, 2018
https://cointelegraph.com/news/scandinavian-start-up-to-track-worlds-shipping-containers-through-blockchain

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Lloyd's Register Develops Blockchain Platform for Ship Registration (BitcoinExchangeGuide - article)
September 5, 2018
https://bitcoinexchangeguide.com/lloyds-register-develops-blockchain-platform-for-ship-registration/
Tech Partner: Applied Blockchain - https://appliedblockchain.com/

Lloyd's Register's digital shift: new digital twin, blockchain and compliance projects (article)
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https://www.marinemec.com/news/view,lloyds-registers-digital-shift-new-digital-twin-blockchain-and-compliance-projects_54125.htm

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Tech Partner: Blockchain Labs for Open Collaboration (BLOC) - https://www.un-bloc.com/

Blockshipping's world-first registry to have 'huge impact' on container management
May 29, 2018
https://www.containerst.com/news/view,blockshippings-worldfirst-registry-to-have-huge-impact-on-container-management_51949.htm

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https://www.thirdsector.co.uk/edward-harvey-blockchain-charity-sector-future/digital/article/1487721

Losing the Middle but Keeping the Heart: Blockchain, DAOs and the future decentralisation of charity
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Block and Tackle: Using blockchain technology to create and regulate civil society organisations (report)
July 2016
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Blockchain charity donation platform launched (Charity Digital News - article)
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https://www.charitydigitalnews.co.uk/2018/04/20/blockchain-charity-donation-platform-launched/
Tech: AidChain - AidCoin https://www.aidcoin.co/?lang=en
Blockchain: Ethereum
Tech: Promise: https://www.promisegiving.com/

Binance Explains How the Blockchain Charity Foundation Will Work (BitcoinExchange - article)
October 9, 2018
https://bitcoinexchangeguide.com/binance-explains-how-the-blockchain-charity-foundation-will-work/

Australia Gets First Blockchain Charity
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https://probonoaustralia.com.au/news/2018/07/australia-gets-first-blockchain-charity/

Chinese Ministry Eyes Blockchain to Boost Trust in Charities (CoinDesk - article)
September 11, 2018
https://www.coindesk.com/chinese-ministry-eyes-blockchain-tech-to-boost-trust-in-charity-sector

2.2 INDIVIDUAL/CITIZEN

2.2.1 Civil registration

Estonia: identity management - http://fortune.com/2017/04/27/estonia-digital-life-tech-startups/ and their own page https://e-estonia.com/solutions/e-identity/id-card/

Developers of e-Identity

These e-Identity solutions are provided by the following Estonian companies:

- **SK ID Solutions** ID-card, Mobile-ID, Smart-ID, digital signature [Visit website](#)
- **Raul Walter** ID-card [Visit website](#)
- **SignWise** digital signature [Visit website](#)
- **Politsei- ja Piirivalveamet** ID-card [Visit website](#)
- **Telia** Mobile-ID [Visit website](#)
- **Nortal** Mobile ID, eID Lifecycle Management, Public Key Infrastructure, digital signature, eID Authentication, Data encryption with eID [Visit website](#)

Find out more about the services and know-how of the [Estonian IT sector](#)
Book a Visit to talk about Estonia blockchain tech: https://e-estonia.com/showroom/#booking
Tech: KSI Blockchain - Guardtime (https://guardtime.com/)
Maturity: Deployed

E-Estonia: Blockchain – security control for government registers
August 2017
https://e-estonia.com/blockchain-security-control-for-government-registers/

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Switzerland - Zug: https://medium.com/uport/zug-id-exploring-the-first-publicly-verified-blockchain-identity-38bd0ee3702 - Dec 7th 2017

Using uPort - says their system is GDPR compliant. Trial Done.

"In the coming months the City of Zug is planning to organise workshops with the public to determine what the first use case implementations will look like. One possibility may be to conduct public surveys ("Umfrage") on general topics, which constitute a crucial part of the Swiss political process and an important first step in how uPort could be used for systems like e-voting."

Tech Company: Consensys - uport.

India: https://www.wisekey.com/press/wisekey-and-the-government-of-andhra-pradesh-india-announce-collaboration-to-bring-security-to-block-chain-and-fintech-projects/

"Geneva, Switzerland – September 6, 2017 – WISeKey International Holding Ltd (SIX: WIHN), a leading Swiss cybersecurity and IoT company announced today a collaboration agreement with the Government of Andhra Pradesh, the seventh largest state in India, to explore implementation of blockchain technology POCs as pilot projects in various departments. "... "The WISeKey Platform can be used to enhance the security of Citizens' Identity, position citizens at the center of gravity of Government services using the WISeKey PKI based Blockchain technology as the solution to secure government-recorded data."

"WISeKey Digital Identity BlockChain Platform selected by BBC as one of the Five African tech trends to look out for in 2018" - (https://www.wisekey.com/press/wisekey-digital-identity-blockchain-platform-selected-by-bbc-as-one-of-the-five-african-tech-trends-to-look-out-for-in-2018/)

Maturity: Pilot - announcement (https://globenewswire.com/news-release/2017/09/06/1108031/0/en/WISeKey-and-the-Government-of-Andhra-Pradesh-India-announce-collaboration-to-bring-Security-to-Block-Chain-and-Fintech-Projects.html)

Tech Company: WISeKey Blockchain (https://www.wisekey.com/the-wisekey-blockchain/)

2.2.2 Digital Identity

Blockchain to the Rescue Creating a 'New Future' For Digital Identities:
https://www.forbes.com/sites/rogeraitken/2018/01/07/blockchain-to-the-rescue-creating-a-new-future-for-digital-identities/#1625e8225492

Microsoft - Decentralized Digital Identities and Blockchain – The Future as We See It:
https://cloudblogs.microsoft.com/enterprisemobility/2018/02/12/decentralized-digital-identities-and-blockchain-the-future-as-we-see-it/

The future of public service identity:
http://www.reform.uk/wp-content/uploads/2017/11/The-future-of-public-service-identity-blockchain.pdf

Transforming digital identity into trusted identity:
https://www.ibm.com/blockchain/identity/

Sovrin™: A Protocol and Token for Self Sovereign Identity and Decentralized Trust:
https://sovrin.org/wp-content/uploads/2018/03/Sovrin-Protocol-and-Token-White-Paper.pdf

Estonia e-identity:
https://e-estonia.com/solutions/e-identity/id-card/

IBM and Maersk Are Creating a New Blockchain Company:
http://fortune.com/2018/01/16/ibm-blockchain-maersk-company/

Everledger Diamond Tracking:
https://diamonds.everledger.io/

Big banks and telcos backing $185 M supercluster bid for national digital identity system:
https://www.itworldcanada.com/article/big-banks-and-telcos-backing-supercluster-bid-trying-to-revamp-identification-system/396894

Canadian banks are building a digital identity tool:
http://www.tearsheet.co/data/canadian-banks-are-building-a-digital-identity-tool

Open Identity System for the Decentralized Web uPort:
https://www.uport.me/

ConsenSys explains self-sovereign identity on Ethereum at the United Nations:
https://www.ibtimes.co.uk/consensys-explains-self-sovereign-identity-ethereum-united-nations-1607068

Blockchain Identities for Lost Citizens:
https://media.consensys.net/blockchain-identities-for-lost-citizens-708e486ca24c

Blockchain identities should mix legacy data; don't ignore it, import it:
http://qed-it.com/2017/08/blockchain-identities-should-mix-legacy-data-dont-ignore-it-import-it/

Two Blockchain Use Cases for Self-Sovereign Digital Identities:
https://www.ictworks.org/blockchain-use-cases-self-sovereign-digital-identities/#.Ws8dDMgh3MU

2.2.3 Digital Identity Solution Providers

Gravity - KYC Compliant Digital Identities with Gravity - https://www.gravity.earth

BanQu - Economic Identities for Smallholder Farmers - http://www.banquapp.com/

Civic App - https://www.civic.com/

SecureKey (backed by Canadian Banks - see above) - https://securekey.com/

ID2020 (Microsoft, Accenture, Rockefeller Foundation) - https://id2020.org/

MONI (asylum seekers in Europe) - https://moni.com/

2.2.4 Births/Deaths/Marriage
Illinois Launches Blockchain Pilot to Digitize Birth Certificates (CoinDesk article)
August 31, 2017
https://www.coindesk.com/illinois-launches-blockchain-pilot-digitize-birth-certificates
https://illinoisblockchain.tech/illinois-partners-with-evernym-to-launch-birth-registration-pilot-f2668664f67c
https://illinoisblockchain.tech/
https://faizod.com/blockchain-based-birth-certificates-free-society/

Tech Partner: Evernym https://www.evernym.com/
Blockchain technology: Hyperledger Indy
https://www.hyperledger.org/projects/hyperledger-indy

Indian State Government Will Issue Birth Certificates on a Blockchain (ccn article)
August 28, 2018
https://www.ccn.com/indian-state-government-will-issue-birth-certificates-on-a-blockchain/
https://www.newsbtc.com/2018/08/22/indian-municipal-corporations-issue-birth-certificates-blockchain/

Tech Partner: Lynked World https://lynked.world/

Get Married on the Blockchain (service)
https://smartvows.com/
Tech: Ethereum

'Get married on the blockchain if your country won't let you', says Björn Borg campaign (article)
June 11, 2018
https://www.campaignlive.co.uk/article/get-married-blockchain-country-wont-let-you-says-bjorn-borg-campaign/1484621

Marriage Unblocked (service)
https://marriageunblocked.com/

Getting Married and Divorced on the Blockchain (article)
October 9, 2018
https://www.libertarianism.org/building-tomorrow/getting-married-and-divorced-blockchain
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Reno aims to make marriage blockchain official (article)
May 2018
https://thenextweb.com/insider/2018/04/27/reno-aims-to-make-marriage-blockchain-official/

Tech Partner: Tital Seal https://titanseal.com/
Blockchain: Ethereum

2.2.5 Immigration/emigration
How blockchain can create a more humane process for refugees (article)
July 13, 2018
https://bigthink.com/reuben-jackson/how-blockchain-will-help-refugees-and-migrants
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Microsoft and Accenture Unveil Global ID System for Refugees (article)
June 19, 2017
http://fortune.com/2017/06/19/id2020-blockchain-microsoft/
Partner: Accenture https://www.accenture.com/gb-en/company
Tech: ID2020 https://id2020.org/

Finland Solves Refugee Identity with Blockchain Debit Cards (issued to asylum seekers
and immigrants) - https://cointelegraph.com/news/finland-solves-refugee-identity-with-
blockchain-debit-cards
https://medium.com/world-economic-forum/finland-has-created-a-digital-money-system-
for-refugees-ba1fe774ee1c (14th Sep 2017)

How Blockchain can benefit migration programmes and migrants (article)
February 22, 2018
https://migrationdataportal.org/blog/how-blockchain-can-benefit-migration-programmes-
and-migrants

ImmiCoin: Powered by Blockchain, the New Cryptocurrency Takes Immigration to the
Next Level (article)
June 13, 2018
https://medium.com/@immicoin/immicoin-powered-by-blockchain-the-new-
cryptocurrency-takes-immigration-to-the-next-level-510741403074

The First Revolutionary Immigration Network
https://immi-coin.io/

Here are three ways blockchain can change refugees' lives (World Economic Forum -
article)
June 25, 2018
https://www.weforum.org/agenda/2018/06/three-ways-blockchain-change-refugees-lives/

Bitnation is a blockchain startup helping refugees to obtain digital ID documents
https://tse.bitnation.co/

DLT in Migration Policy: How Blockchain Can Help Both Refugees and Host Nations
(cointelegraph article)
September 19, 2018
https://cointelegraph.com/news/dlt-in-migration-policy-how-blockchain-can-help-both-
refugees-and-host-nations

2.2.6 Wills / Estate Planning

Wills and Testaments on the Blockchain- Blockchain Estate Planning (article)
https://medium.com/@vishnu_3187/wills-and-testaments-on-the-blockchain-crypto-wills-9d2be9171a7d

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Will and Testament Coin
http://watc.io/
Blockchain: Ethereum

Can you write your will onto a blockchain? – Smart contracts (RocketLawyer article)
October 25, 2018
https://www.rocketlawyer.co.uk/blog/can-you-write-your-will-onto-a-blockchain/

Inheritance & Estate Planning Meets the Blockchain—Heir.io Reveal (Medium article)
May 6, 2018
https://medium.com/@heir/inheritance-estate-planning-meets-the-blockchain-heir-io-reveal-cdbd0fed57e8
Company: heir - https://heir.io/

How Blockchain Technology Is Influencing the Estate Planning Process (Ettinger Law Firm article)
June 16, 2018
https://www.newyorkelderlawattorneyblog.com/how-blockchain-technology-is-influencing-the-estate-planning-process/
'When the New York legislature referred Bill AB8780 to government task force operations "to determine the impact of cryptocurrencies on the financial markets" January 1, 2018, the bill revised the state's technology law defining "blockchain technology" and "smart contract." New York law currently recognizes the Commodity Futures Trading Commission (CFTC) definition of cryptocurrencies as "commodities" — fiat currency exempt from the current definition of "money" where transmissions are concerned (*Application of the Definition of Money Transmitter to Brokers and Dealers in Currency and other Commodities, FIN-2008-G008, Sept. 10, 2008*).'

Writing an Estate Planning Contract (Program the Blockchain article)
February 20, 2018
https://programtheblockchain.com/posts/2018/02/20/writing-an-estate-planning-contract/
Example smart contract for a Blockchain based Will.

Blockchain Technology, Estate Planning and Resting Place Management (Nasdaq article)
May 30, 2018
https://www.nasdaq.com/article/blockchain-technology-estate-planning-and-resting-place-management-cm970777

Considerations in Estate Planning for Bitcoin, Ethereum, and other Crypto-Currencies
April 26, 2018
https://www.cstaxtrustestatesblog.com/2018/04/articles/estate-planning/considerations-estate-planning-bitcoin-ethereum-crypto-currencies/

2.2.7 Registries - Land Registry

Website for videos, info about blockchain based land registries

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https://blockchainland.org
First story below comes from this site, but there were many others.

Kenya: Blockchain on Kenya Land Registry System
November 25, 2017
https://wn.com/blockchain_on_kenya_land_registry_system

Britain: Will HM Land Registry be revolutionised by blockchain?
August 1, 2018
https://www.roydswithyking.com/will-hm-land-registry-be-revolutionised-by-blockchain/

Britain: HM Land Registry to explore the benefits of blockchain
October 1, 2018
https://www.gov.uk/government/news/hm-land-registry-to-explore-the-benefits-of-blockchain
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Ghana: Real Estate Land Title Registration in Ghana
http://bitlandglobal.com/
http://landing.bitland.world/

New Zealand: NSW Land Registry announces blockchain trial
November 2, 2018
http://idm.net.au/article/0012262-nsw-land-registry-announces-blockchain-trial
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British Columbia: LTSA and ChromaWay Assessing Blockchain Technology for Registry Solutions
October 29, 2018
https://ltsa.ca/news/ltsa-and-chromaway-assessing-blockchain-technology-registry-solutions
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Sweden: Land Registry -
MAR 07, 2018 Swedish Government Land Registry Soon to Conduct First Blockchain Property Transaction: https://cointelegraph.com/news/swedish-government-land-registry-soon-to-conduct-first-blockchain-property-transaction
"Sweden's land-ownership authority, the Lantmäteriet, is soon expected to conduct their first Blockchain technology property transaction after two years of testing"...
"Lantmäteriet first started testing Blockchain technology in 2016, completing their second stage of trials in March 2017. By July 2017, the Swedish land registry was using Blockchain to register land and properties on the Swedish Blockchain startup ChromaWay's private Blockchain network, albeit on a *"small scale,"* according to Snäll."
Maturity: Pilot project - Testing started 2016 - soon to be used for first 'volunteers'
Tech: Using ChromaWay's (https://chromaway.com) private blockchain technology which they call Postchain (https://github.com/chromaway)

UK: UK Land Registry Plans to Test Blockchain in Digital Push
https://www.coindesk.com/uk-land-registry-plans-test-blockchain-digital-push/
https://hmlandregistry.blog.gov.uk/2017/12/18/world-leading-through-digital-transformation/ (18th Dec 2017)

Verifying a secure digital mortgage service:
https://hmlandregistry.blog.gov.uk/2017/7/28/verifying-secure-digital-mortgage-service/

GOV.UK Verify overview:

https://www.gov.uk/government/publications/introducing-govuk-verify/introducing-govuk-verify

Maturity: Planning a trial

Ukraine: Ukraine Moving Land Ownership Records onto Blockchain Platform to Fight Corruption (4th Oct 2017) https://cryptovest.com/news/ukraine-moving-land-ownership-records-onto-blockchain-platform-to-fight-corruption/

The Ukrainian government will begin blockchain land registration trials in October (6th Jan 2018)
https://www.coinmis.com/the-ukrainian-government-will-begin-blockchain-land-registration-trials-in-october/

Tech Company: BitFury Group Ltd https://bitfury.com/
Maturity: Pilot

India: https://www.cnbc.com/2017/10/10/this-indian-state-wants-to-use-blockchain-to-fight-land-ownership-fraud.html
https://www.coindesk.com/andhra-pradesh-partners-with-chromaway-to-develop-blockchain-land-registry/
"The Indian state of Andhra Pradesh is working with startup ChromaWay on a land registry pilot that uses blockchain to track the ownership of property." (Oct 10, 2017)

https://analyticsindiamag.com/how-andhra-pradesh-is-emerging-as-indias-blockchain-hub/ (2018 article)

Maturity: Pilot (only articles relating to the announcement of the pilot so probably yet to run)
Tech Company: ChromaWay (https://chromaway.com)

Brazil: Ubitquity Used to Test Pilot Blockchain Land Registry in Brazil: (27th Jan 2018)
https://www.bitsonline.com/ubitquity-test-blockchain-land/
"The University of British Columbia's research program on blockchains, released a study that analyzed a test pilot they conducted on blockchain tech with respect to land registry. The case study was performed in Brazil with the help of Ubitquity, a startup that specializes in blockchain solutions for real estate."
Maturity: Pilot - completed? - Study released by University of British Columbia analysing the pilot.
Tech Company: Ubiquity (https://www.ubitquity.io) which use Bitcoin "Our blockchain in use is Bitcoin, however we're 100% compatible with Ethereum, Hyperledger, and MultiChain in an effort to remain fully blockchain-agnostic." i.e. my guess is they are just creating hashes.

Vermont City Pilots Land Registry Record with Blockchain Startup (23rd Jan 2018)
https://www.coindesk.com/vermont-city-pilots-land-registry-record-with-blockchain-startup/
Blockchain Is Gaining Ground on Land Registry Systems (25th Jan 2018)
https://bitrazzi.com/blockchain-gaining-ground-land-registration-systems/
"- Sweden, Brazil, India, and now Vermont: Blockchain-based land registry is common to all"
Maturity: Pilot
Tech: Public Ethereum - provided by Propy (https://propy.com/) - documents refer to Smart Contracts

Challenge: "This pilot will push the limits of blockchain technology as it applies to secure and efficient means for real estate transactions with the added layer of storing land management data affordably. Lowering cost was a big incentive for the city of South Burlington to evaluate blockchain technology and run this pilot."
(https://blog.propy.com/propy-announces-first-us-pilot-with-vermont-23ec0b2d3b11)

Honduras Land Registry - "Honduras: end of land title fraud, thanks to blockchain technology." - https://medium.com/@BCDiploma/honduras-end-of-land-title-fraud-thanks-to-blockchain-technology-fc7aede49998
Maturity: Pilot - stalled (according to https://www.newamerica.org/international-security/future-property-rights/blog/blockchain-for-property-rights-georgia/)
Tech: Bitcoin - using Factom, an open source decentralized ledger which is secured by the Bitcoin Blockchain (https://s3.amazonaws.com/ipri2016/casestudy_collindres.pdf)

Georgia: Land Registry on the blockchain - https://www.forbes.com/sites/laurashin/2017/02/07/the-first-government-to-secure-land-titles-on-the-bitcoin-blockchain-expands-project/#1784b21e4dcd
Maturity: Pilot moving now to proper implementation.
Tech: Via company called Bitfury (http://bitfury.com) - private blockchain whose transactions are publically secured on Bitcoin
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Ghana: Land ownership - https://www.forbes.com/sites/rogeraitken/2016/04/05/bitlands-african-blockchain-initiative-putting-land-on-the-ledger/#20ebc6187537
Maturity: Pilot
Tech: OpenLedger blockchain (https://openledger.info/) - employed by Bitland (www.bitland.world)
Contacts: http://www.bitland.world/contact-bitland/

Russia: Russia's Government to Test Blockchain Land Registry System (20th Oct 2017) https://www.coindesk.com/russias-government-test-blockchain-land-registry-system/
Maturity: Planned Pilot in July 2018

Japan: Japan Could Place Its Entire Property Registry on a Blockchain (22 June 2017) https://www.ccn.com/japan-place-entire-property-registry-blockchain/
Maturity: Trial in summer 2018

Dubai: Dubai Land Department becomes world's first government entity to conduct all transactions through Blockchain technology; move part of 'Dubai Blockchain Strategy' launched by Shaikh Hamdan bin Mohammed and led by Smart Dubai (2nd May 2018) https://gulfnews.com/business/property/dubai-has-world-s-first-government-entity-to-conduct-transactions-through-blockchain-network-1.2101819
https://www.coindesk.com/dubai-land-department-launches-blockchain-real-estate-initiative/
Maturity: Production?

3 SMART CONTRACTS

- Problems of definition: are smart contracts really contracts?
- Fundamental nature of smart contracts in contrast to existing modes of contract
- Electronic signatures
- Electronic records
- Incomplete contracts?

3.1 PROBLEMS OF DEFINITION: ARE SMART CONTRACTS REALLY CONTRACTS?

Can Code Really Be Law? New Report Clarifies Smart Contract Misconceptions (Forbes article)
September 27, 2018
https://www.forbes.com/sites/astanley/2018/09/27/can-code-really-be-law-new-report-clarifies-smart-contract-misconceptions/

Smart contracts - can code ever be law? (Ashurst law firm - article)
March 1, 2018
https://www.ashurst.com/en/news-and-insights/legal-updates/smart-contracts---can-code-ever-be-law/

Should Smart Contracts Be Legally-Enforceable? (Blockchain at Berkeley - article)
February 28, 2018
https://blockchainatberkeley.blog/should-smart-contracts-be-legally-enforceable-599b69f73aea

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R3 & Norton Rose Fulbright, "Can smart contracts be legally binding contracts?" (whitepaper)
http://www.nortonrosefulbright.com/files/r3-and-norton-rose-fulbright-white-paper-full-report-144581.pdf

contains:
Country analysis: do smart contracts have legally binding contractual effect?
(England, United States of America, Australia, Canada, China, France, Germany, South Africa)

3.2 EXAMPLES: SMART CONTRACT BASED BLOCKCHAIN PLATFORMS

Ethereum: https://ethereum.org/

Rootstock: https://www.rsk.co/

Codius: https://codius.org/

Hyperledger Fabric, Sawtooth, Burrow, Iroha https://www.hyperledger.org/

ChainLink: https://chain.link/

Corda: https://www.corda.net/

Lisk: https://lisk.io/

Steem: https://steem.com/

EOS: https://eos.io/

Chainledger: https://chainledger-systems.com

3.3 Smart Contracts and Law - general references

Contract law 2.0: Smart contracts as the beginning of the end of classic contract law (paper - pdf)
April 7, 2017
https://www.hse.ru/mirror/pubs/lib/data/access/ram/ticket/37/15428985020b92028d1adf841bdd357c1a67d65188/Savelyev_Contract%20law%202%200%20Smart%20contracts%20as%20the%20beginning%20of%20the%20end%20of%20classic%20contract%20law.pdf
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Law and Autonomous Systems Series: How to Resolve Smart Contract Disputes - Smart Arbitration as a Solution. (University of Oxford: Faculty of Law - article)
June 1, 2018
https://www.law.ox.ac.uk/business-law-blog/blog/2018/06/law-and-autonomous-systems-series-how-resolve-smart-contract-disputes
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Smart Contract Relations in e-commerce: Legal Implications of Exchanges Conducted on the Blockchain
October 2017 (Technology Innovation Management Review - article - pdf)
http://www5.austlii.edu.au/au/journals/UTSLRS/2017/24.pdf

SMART CONTRACTS (Code vs Contract)
an overview of blockchain technology and legal implications of smart contracts from a Turkish Law perspective
January 3, 2018
https://talkingtech.cliffordchance.com/en/tech/smart-contracts--code-vs-contract-.html
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Smart legal contracts: How the law benefits with blockchain (IBM blog)
June 27, 2018
https://www.ibm.com/blogs/blockchain/2018/06/smart-legal-contracts-how-the-law-benefits-with-blockchain-2/

Smart Contracts: Legal Agreements for the Digital Age (pdf)
November 2017
https://talkingtech.cliffordchance.com/content/micro-cctech/en/tech/smart-contracts/_jcr_content/text/parsysthumb/download/file.res/Smart%20Contracts.pdf
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Smart Contracts: Is the Law Ready? (whitepaper)
September 2018
https://digitalchamber.org/smart-contracts-whitepaper/
https://digitalchamber.org/policy-positions/smart-contracts/
https://digitalchamber.org/policy/
https://digitalchamber.org/policy/chamber-reports/
The white paper presents twelve smart contract use cases across a range of industries and topics, including:

- Land title recording
- Mortgages
- Digital identity
- Supply chain
- Financial data recording
- Over-the-counter derivatives
- Auto insurance
- Records
- Securities

- Trade finance
- Drug discovery in cancer research
- Clinical trials

Smart contracts: a boon or bane for the legal profession? (Taylor Vinters law firm - article)
24 Sep 2018
https://www.taylorvinters.com/article/smart-contracts-a-boon-or-bane-for-the-legal-profession/

UK Begins Research on Law Reform for Use of Blockchain Smart Contracts (CoinDesk - article)
Jul 20, 2018
https://www.coindesk.com/uk-begins-research-on-law-reform-for-use-of-blockchain-smart-contracts

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Law and Autonomous Systems Series: What is a Smart Contract? (Oxford Faculty of Law - article)
09 Jul 2018
https://www.law.ox.ac.uk/business-law-blog/blog/2018/07/law-and-autonomous-systems-series-what-smart-contract

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Law and Autonomous Systems Series: Defining Smart Contracts - The Search for Workable Legal Categories (Oxford Faculty of Law - article)
25 May 2018
https://www.law.ox.ac.uk/business-law-blog/blog/2018/05/law-and-autonomous-systems-series-defining-smart-contracts-search

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Tennessee became the second state to go out of its way to legally recognize smart contracts:
(State of Tennessee Public Charter No.591 - pdf)
March 2018
https://publications.tnsosfiles.com/acts/110/pub/pc0591.pdf

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Law Commission to look at English laws that apply to smart contracts (Linklaters law firm - blog)
https://www.linklaters.com/en/insights/blogs/fintechlinks/2018/july/law-commission-to-look-at-english-laws-that-apply-to-smart-contracts