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A non-contractual approach to smart contracts

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Abstract:

This article adds to the debate on what, legally speaking, smart contracts are and what they should be. Currently, much of this debate focuses on the relationship between smart contracts and legal contracts, overlooking that other legal categories may also be appropriate. This article suggests that the concept of abandonment can be fruitfully applied to smart contracts. Using the concept of abandonment has the advantage of allowing smart contracts, as close as legally possible, to be utilized as machines (or using the terminology suggested by Vitalik Buterin, founder of Etherium, as a 'persistent script'). It would also make other issues, like the interpretation of smart contracts, easier to deal with. The argument is not that smart contracts can never be legal contracts; rather, it is suggested that, prima facie, users should have the choice of utilizing smart contracts as legal contracts or as machines.

Keywords: abandonment, blockchain, contract formation, distributed ledger technology, DLT, smart contracts

Introduction

Smart contracts have generated a considerable amount of debate in legal academia and among practicing lawyers.[1] This paper will focus on one particular aspect of the debate, namely what in the eyes of the law a smart contract is. Much of the discussion of this aspect of the smart contract debate focuses on the question if, and under what conditions, smart contracts are legal contracts. Although it is too soon to call it a consensus, a commonly held view is that there is no principal reason why a smart contract cannot fulfil the standard criteria of a legal contract, and if a smart contract meets these criteria, then it is a legal contract.[2] According to this paradigm, from a legal point of view, there are two options: smart contracts are either legal contracts or nothing

[1] For an overview of some of the arguments, see, for instance, Daniel Drummer and Dirk Neumann, 'Is Code Law? Current Legal And Technical Adoption Issues and Remedies for Blockchain-Enabled Smart Contracts' (2020) 35 JILT 337.

[2] This view is, for instance, expressed by the UK Jurisdiction Task Force, in 'Legal Statement on Cryptoassets and Smart Contracts' (2019) <https://lawtechuk.io/explore/cryptoasset-and-smart-contract-statement"https://lawtechuk.io/explore/cryptoasset-and-smart-contract-statement> accessed 11 January 2023; see also, the Law Commission of England and Wales, for England and Wales in 'Smart legal contracts Advice to Government' (2021) Law Com No 401 <http://www.lawcom.gov.uk/project/smart-contracts/#related"www.lawcom.gov.uk/project/smart-contracts/#related> accessed 10 January 2023. Also, Rizos argues: 'With respect to their use in a legally relevant context, one could distinguish between smart contracts, which are not used for purposes of performing agreement a legally relevant and those which are used for such purposes and could be described as legally relevant smart contracts The stricto sensu legally relevant smart contracts are the ones that have mostly drawn the attention of the legal scholarship and this article focuses on them.' (Italics in original, internal footnotes omitted) Evripidis Rizos, 'A Contract Law Approach for the Treatment of Smart Contracts' "Bugs"' (2022) 5 ERPL 775.

at all—or maybe 'what Roman lawyers called pacta nuda'[3] and what common law lawyers may call a nudum pactum.[4]

This article suggests that this approach overlooks all the other categories that may be applied to smart contracts. In particular, the argument will be made that the concept of abandonment can be applied fruitfully to smart contracts, ie a smart contract can be seen as a way for a user to abandon property and another user to claim the said property. The concept of abandonment is helpful because it enables property rights to be altered unilaterally, ie all that is needed for abandonment to be effective is for a person to intentionally commit the act of abandonment. This is useful because it is as close as legally possible to utilizing smart contracts as machines (or, as it has been suggested as a persistent script[5]). This article does not suggest that there is something inherently wrong about considering smart contracts as legal contracts or that smart contracts can never be legal contracts. The suggestion is merely that users should have a choice to either use smart contracts as legal contracts or to apply the concept of abandonment. Note that this article does not deal with the regulatory aspects of smart contracts. It may be that smart contracts create too much systemic risk or facilitate illegal activities to such an extent that regulating (or even banning) smart contracts becomes necessary. These issues lie outside the scope of this article, suffice to say that whether smart contracts are regarded as legal contracts or the concept of abandonment is applied, this does not impact the regulatory debate.

What are smart contracts?

A common way of starting an analysis, especially a legal analysis, is by providing a definition of the subject matter. However, applying this strategy to smart contracts immediately creates a problem, because the term 'smart contract' seems to imply that there is a contract, not necessarily a legal contract but a contract or an agreement of some sort.[6] Therefore, to suggest a non-contractual approach to smart contracts may seem like a contradiction in terms. However, this is merely a semantic issue. To deal with this issue, for the purposes of this article, the term 'smart contract' is not used as a definition but rather as a name that refers to all the things that the term 'smart contract' commonly refers to. This approach is echoed by the UK Jurisdiction Task Force (UKJTF) in its 'Legal statement on crypto assets and smart contracts'.[7] Rather than defining smart contracts, the UKJTF seeks 'instead to identify what it is about [smart contracts] that may be legally novel or distinctive'.[8] This is a sound approach, which will be followed in this article.

One feature that is distinct about smart contracts is 'automaticity',[9] which simply means that smart contracts are performed automatically. A standard contract written in natural language, in contrast, may create an obligation; however, the contract still needs to be performed. Another distinct aspect of smart contracts is that they are usually expressed through the use of computer code and are usually performed by a computer or network of

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[3] Filatova writes: 'Although a lot of scholars admit their contractual nature, currently smart contracts mostly remain what Roman lawyers called pacta nuda'. (internal reference omitted) in Nataliia Filatova, 'Smart Contracts from the Contract Law Perspective: Outlining New Regulative Strategies Smart Contracts from the Contract Law Perspective: Outlining New Regulative Strategies' (2020) 28 IJLIT 217.

[4] A possible exception may be to consider the possibility to see smart contracts as a form of self-help (see Max Raskin, 'The Law and Legality of Smart Contracts' (2017) 1 Geo. L. Tech. Rev. 305). Another option may be to consider them as a form of escrow Werbach and Cornell consider these options (self-help and escrow) but reject them. Kevin Werbach and Nicolas Cornell, 'Contracts Ex Machina' (2017) 67 Duke LJ 313, 344–348. For the purposes of this article, what matters is that both escrow and self-help are based on the concept of agreement. For there to be an escrow there has to be an agreement first. For there to be self-help, there also needs to be an agreement first, which the 'self-help' mechanisms seek to protect. (See also Werbach and Nicolas Cornell (n 4), 346–348.)

[5] Vitalik Buterin, Twitter (2018) <https://twitter.com/vitalikbuterin/status/1051160932699770882?lang=en> accessed 11 January 2023.

[6] Werbach and Cornell make a similar point in relations to contracts more general. Werbach and Cornell (n 4) 338.

[7] The UKJF states that "it is difficult, and unlikely to be useful, to try to formulate a precise definition of smart contracts". In UK Jurisdiction Task Force (n 2) 31.

[8] ibid.

[9] ibid.

computers.[10] The qualifier 'usually' is used because conceptually it is perfectly possible to imagine an automated contract implemented other than through computers. For instance, Nick Szabo, who coined the term smart contract, argued that a vending machine 'is a primitive ancestor of smart contracts', suggesting that an automated contract does not necessarily have to be in digital form.[11] Note, however, that, as will be argued below, the phrase 'expressed in code' is actually misleading because one may use code to create a smart contract and the code does not express anything. Nonetheless, as a first approximation, the phrase 'expressed in code' will suffice. Furthermore, this article will only consider smart contracts that utilize distributed leger technology (DLT). Using the DLT has the effect of making smart contracts '(almost) immutable'.[12] While smart contracts may have other distinctive features that ought to be analysed, these are the features that this article will focus on.

Before starting the analysis, it is worth clarifying some of the terminology used in this article. Contracts that automate performance may come in three distinct forms. First, the parties may agree to a standard legal contract expressed in natural language but decide that the contract shall be performed automatically through computer code. This type of contract is sometimes referred to as 'automated natural language contracts'.[13] Second, the parties may agree to a standard contract, which contains some code. Such a contract is sometimes referred to as a 'hybrid smart contract'.[14] Third, a smart contract may consist of nothing but code. This is sometimes referred to as a 'solely code smart contract'.[15] The focus of this article is predominately on solely code smart contracts and unless otherwise stated, or obvious from the context, as used herein the term smart contract refers to a 'solely code smart contract'. Occasionally, this article will use the expression 'solely code smart contract' to provide additional clarity. By 'legal contract' this article means a contract recognized as such by the law. The term 'standard contract' refers to any legal contract, other than a smart contract (be it automated natural language, hybrid or solely code smart contract). The term 'agreement' is used in its everyday sense. An agreement may be in the form of a legal contract but also includes agreements not recognized by the law as legal contracts. Finally, the term 'transaction' is used as a generic term referring to any situation in which people deal with each other; this may be through contracting or through other means like abandoning property.

What are the potential benefits of smart contracts?

Now that some terminology has been sorted out, the next issue that needs to be considered is what advantages smart contracts may have over standard contracts. This is not supposed to be an exhaustive list of all possible benefits of smart contracts and the reason for making the comparison is not to analyse whether smart contracts are superior to standard contracts from a business perspective. The point of making the comparison is to analyse whether there are certain 'things' smart contracts can do that standard contracts cannot (or can only achieve in a more costly manner). Whether these 'things' are worthwhile from a business perspective lies outside the scope of this article. However, it is important to understand what these 'things' are because if a legal classification of

[10] The term smart contract was coined by Nick Szabo in 1994. Szabo stated that '[a] smart contract is a computerized transaction protocol that executes the terms of a contract', Nick Szabo, 'Smart Contracts', 1994 <https://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart.contracts.html<www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart.contracts.html> accessed 10 January 2023.

[11] Nick Szabo, 'The Idea of Smart Contracts' (1997) <http://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/idea.html> accessed 01 August 2023. Further, apparently, automated contracts were already considered by the philosopher Leibniz in the 16th century long before the invention of modern computers. See Ali Newhard, Jacqui Frank and Sara Silverstein, 'How Smart Contracts Will Work' *Business Insider* (2018) <"http://www.businessinsider.com/how-smart-contracts-can-work-2018-10"www.businessinsider.com/how-smart-contracts-can-work-2018-10> accessed 01 August 2023.

[12] Rizos (n 2) 782. Also, a so-called hard fork may be used to de facto undo a smart contract, See the discussion of TheDAO hack.

[13] This classification is similar to the classification used by the Law Commission (n 2) vii.

[14] ibid.

[15] ibid.

smart contracts prevents an important benefit of smart contracts from being achieved, then this may provide a reason for using another legal classification.

The automaticity of smart contracts is thought to have several advantages. First, it means that there is no need to have an enforcement mechanism, which, in turn, means that parties can transact with each other without relying on the coercive power of the state for enforcement. Some commentators even go as far as to argue that smart contracts 'may operate without any overarching legal framework. De facto, they represent a technological alternative to the whole legal system'.[16] One reason why not relying on the coercive power of the state may be considered an advantage is because the parties may have anarchic sympathies[17] and do not want to engage with the state for ideological reasons. Another reason may be that the parties lack access to a functioning legal system.[18] It may also be the case that the parties view a particular judicial system as unjust, or a party may be concerned that the other side has more resources available (to pay for lawyers, experts and so on) and, therefore, is likely to prevail in a court action.

On the other hand, engaging in a transaction without using the coercive power of the state may have significant disadvantages. For instance, the parties may prefer to have their contracts based on the legal system rather than code because they believe that this will ensure justice. Although the liability under contract law is strict, there are a number of doctrines (e.g, duress, unconscionability, undue influence, frustration, mistake, misrepresentation and so on) to ensure a just outcome, and all these doctrines are very difficult (if not impossible) to put into code. More importantly, if the courts face a truly novel situation, they have the power to develop the existing doctrines to ensure a just outcome. It is very difficult for code to deal with unforeseen circumstances because for a specific circumstance to be provided for in code it usually needs to be foreseen.

Another reason why not relying on the legal system may be an advantage is because the legal systems may be viewed a costly and time consuming. One argument may be that the legal system 'is inherently prone to errors or human biases and is highly inefficient, with court decisions often taking years'.[19] Thus, the parties may regard smart contracts as quicker and cheaper, e.g. because smart contracts do not require resources for enforcement. It is important to note, however, that smart contracts involve costs that standard contracts do not have. For instance, smart contracts need to be coded and hosted on a network.[20] Furthermore, just because smart contracts are not based on natural language does not necessarily mean that lawyers will not be needed. As the parties may want to engage lawyers to check that the contemplated transaction complies with existing laws and regulation. Furthermore, if smart contracts are treated as legal contracts, then lawyers may be needed to advise on the contract law aspects of the smart contract and disputes may arise regarding these aspects. Therefore, whether smart or standard contracts are more cost-effective depends on the specifics of the situation.

Apart from dispensing with the need for enforcement, automaticity is also thought to reduce counterparty risk, i.e. the risk that the counterparty will not perform its obligation. It is important to note that smart contracts do not eradicate counterparty risk completely. For instance, if the counterparty has insufficient funds to complete a transaction, the counterparty will default even if a smart contract is used. However, the automaticity of smart contracts makes wilful default by a counterparty less likely or maybe even impossible.[21] The reason is simply

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[16] Alexander Savelyev, 'Contract Law 2.0: "Smart" Contracts as the Beginning of the End of Classic Contract Law' (2017) 26 ICTL 116, 132.

[17] For instance, JG Allen in analysing smart contract makes reference to the so-called California ideology, stating that '…the so-called "Californian ideology" [is] to substitute human-controlled public institutions with automated digital processes within which individuals can order their private affairs'. JG Allen, 'Wrapped and Stacked: "Smart Contracts" and the Interaction of Natural and Formal Language' (2018) 14 ERCL 307, 333.

[18] People may not have access to a functioning legal system because they are based in a place where no such system exists. Alternatively, it may be that the legal system excludes them either because the parties belong to a group the legal system wants to exclude from contracting (eg certain groups like women may be excluded from accessing the courts) or because the contract is used for illegal purposes (eg people cannot use the courts for criminal activities).

[19] Daniel Drummer and Dirk Neumann (n 1) 341.

[20] Savelyev (n 16) 127.

[21] As stated above, smart contracts, which are based on distributed ledger technology, are often thought of as essentially immutable. However, there is the possibly of a 'hard fork' or providing in the code that the smart contract may be changed.

that, assuming that once a smart contract is started it cannot be stopped, a party cannot choose not to perform.[22] In contrast, in a standard contract, the counterparty has the option to breach the contract. This will entitle the innocent party to damages usually to the extent to restore the innocent party to the position she would have been in had the contract been performed and in limited circumstances, the remedy of specific performance may also be available. However, neither damages nor specific performance will usually fully compensate the innocent party for the loss incurred.[23] This does not mean that reducing the possibility of wilful default is always beneficial. For instance, according to the law and economics idea of efficient breach, breaching a contract may be the economically efficient thing to do.[24] A more general aspect of counterparty risk (or the lack thereof), which, while obvious, is worth noting is that the possibility of the counterparty not performing is a detriment for one party but is a benefit for the other party. Therefore, reducing counterparty risk through automated performance is not an unequivocal advantage. However, smart contracts give parties the option of reducing counterparty risk if they so choose.

Another important aspect of smart contracts being performed automatically is that it reduces the scope of dynamic (or strategic) interaction between the parties after the contract has been concluded. To illustrate, consider the so-called holdup problem.[25] The holdup problem is a direct consequence of the fact that the award for breach of contract does not usually fully compensate the innocent party. This often gives the party who has yet to perform her obligation some bargaining power over the other party. A typical example is a contractor threatening to breach a contract to get a higher contract price after the project has begun when it is difficult for the counterparty to find an alternative contractor. If contractual damages would fully compensate the innocent party then the innocent party would be indifferent between the contractor breaching or fulfilling her obligation. However, because contractual damages usually do not fully compensate the innocent party, the contractor has some bargaining power. While smart contracts may be a way to deal with the holdup problem, there may be considerable practical problems in using smart contracts in these situations. However, the point is that, because smart contracts are performed automatically, they reduce the way a party can behave strategically after the smart contract has commenced. This may allow the parties to do things they could not do with standard contracts because the possibility of ex post strategic behaviour may prevent the parties from entering into a transaction ex ante. One problem with recognizing smart contracts as legal contracts is that it gives a party more options to behave strategically after the smart contract has started.

A related advantage of automaticity is that in a standard contract, a counterparty may delay performance or perform inadequately in a situation where it is not worth suing the party and it may not even be worth stopping doing business with the counterparty. A typical example is paying invoices late. Unpaid invoices may cause serious cashflow problems to a business, and businesses spend considerable time and resources chasing unpaid invoices. The core of the problem is the following. If a counterparty does not perform its obligation or performs its obligation inadequately like paying an invoice late, the innocent party has several options of how to respond: it can sue the counterparty, it can refuse to contract with the counterparty in the future, it can give the counterparty a bad rating and so on. However, many of these options will involve a cost to the innocent party, and if the costs of reacting to the breach are higher than what the innocent party expects to gain, the rational strategy for the innocent party is not to use such option. If the counterparty knows that the innocent party will not react (or react in only in a minor way, e.g. by sending a reminder), the counterparty may take advantage of this to the detriment of the innocent party. It may be thought that this problem can be solved through contractual provisions, e.g. stipulating contractually that time is of the essence or providing for interest to accrue on late

[22] The extent to which smart contracts truly cannot be stopped is a matter of debate. Nevertheless, even if is theoretically possible to stop smart contracts, it is usually considerably more difficult to do so than the wilfully default on a standard contract than on a smart contract and the rest of this article will proceed on this assumption.
[23] For an overview of the relevant issues, see, for instance, Omri Ben-Shahar and Oren Bar-Gill, 'The Law of Duress and the Economics of Credible Threats' 33, no. 2 (2004) J. Legal Stud. 391.
[24] For an overview of the relevant issue, see, for instance, Gregory Klass, 'Efficient Breach', in Gregory Klass, George Letsas and Prince Saprai (eds), The Philosophical Foundations of Contract Law, (2014 Oxford University Press, Oxford, 362.
[25] See Ben-Shahar and Bar-Gill (n 23).

payments.[26] This may work in specific instances; however, it does not deal with the core of the problem. The problem is that as long as the innocent parties incurs some costs in dealing with a breach, there will always be some 'small' breaches for which it is unprofitable to react. This will be referred to as the problem of small breaches.

It may also be thought that smart contracts are less risky than standard contracts. However, care must be taken with this statement because if risk is understood to mean the risk of the smart or standard contract working differently from the way the parties intended, then it is not necessarily true that smart contracts are less risky than standard contracts.[27] A piece of code may behave very differently than was intended (this may be referred to as 'code risk').[28] The platform hosting the smart contract may stop working or work differently than expected (this may be referred to as 'platform risk'). Of course, an obligation expressed in natural language may also turn out differently from the way the parties intended.[29] However, at least with a standard contract expressed in natural language, there is a connection between intention and obligation because natural language is supposed to represent the intentions of the parties. This remains the case even if the intentions of the parties are assessed objectively, as it is the case in common law interpretation of contracts.[30] Therefore, in the case of smart contracts, the parties take a risk on the code, whereas in the case of obligations expressed in natural language, the parties take a risk on natural language. This means that smart contracts are not necessarily less risky than standard contracts. However, the important point is that the risk profile of smart and standard contracts is different and, given the situation, the parties may prefer one over the other. For instance, a party that is more confident in her coding than in her drafting abilities may prefer code to natural language.

A related issue is that natural language is nuanced whereas code is not, and there may be some advantages as well as disadvantages to code not being nuanced. Regarding the advantages, an obligation expressed in natural language may give the person who has to perform the obligation some leeway in exactly how to perform the obligation, and the person may perform it in such a way that benefits her the most, and this may be to the detriment of the person who is supposed to receive the benefit.[31] Smart contracts ensure that there is no discretion on how an obligation is performed. As smart contracts are performed automatically and expressed in code, this allows transactions to be executed without any debate about the meaning of natural language. Again, it is important to stress that it is not suggested that this means that a smart contract will perform exactly as the parties intended. It only means that there is no uncertainty regarding the meaning of natural language and the parties will have no discretion in how to perform the contract.

However, there are also several disadvantages to smart contracts being expressed in code. Terms like 'reasonable', 'satisfactory' and 'adequate', that are often used in standard contracts, are very difficult to express in code.[32] Apart from the problem that not everything can be expressed through code, the parties may prefer the flexibility provided by natural language. Even if vague terms like 'reasonable' could be expressed in code, the parties may prefer not to use code. For instance, if an obligation is expressed in code, the parties must decide at the time of coding how to handle a situation that may arise in the future. However, the parties may prefer there to be some discretion in how to deal with a situation when it arises and, therefore, prefer to express the obligation

[26] However, care must be taken that this clause is not construed as a penalty clause, which is unenforceable under English law. Cavendish Square Holding BV v Talal El Makdessi [2015] UKSC 67.
[27] See, eg Savelyev (n 16) 126, For a discussion of trust in smart contracts see also Eliza Mik, 'Smart Contracts: A Requiem' (2019) 36 JCL 5.
[28] Rizos states that an 'empirical studies, [found that] 99.82% of the researched smart contracts contained at least one bug, albeit the number of bugs that could actually lead to an unintended or undesired allocation of resources is significantly lower'. Rizos (n 2) 783.
[29] See, for instance, the English law case of Arnold v Britton [2013] EWCA Civ 902.
[30] See Lord Hoffmann in Chartbrook Ltd v Persimmon Homes Ltd [2009] UKHL 38, [2009] 1 AC 1101, para 14, affirmed by Lord Neuberger in Arnold v Britton (n 27) para 15.
[31] This is, of course, not a new problem. Business, as well as courts, have known for a long time that without the right incentives, a counterparty often does not perform adequately, even if there is a contractual obligation to do so.
[32] See discussion in Agata Ferreira, 'Regulating Smart Contracts: Legal Revolution or Simply Evolution?' (2021) 45 Telecommun. Policy 3. See also Mik (n 27) p 18.

in natural language.[33] Again, the point is not that smart contracts are better or worse than standard contracts, only that smart contracts offer different possibilities.

Smart contracts as a way to coordinate actions without agreement

There is an even more profound difference between smart contracts and standard contracts, namely that smart contracts may be used as a way to coordinate actions among actors which is not based on the concept of agreement. This may sound strange because one may think that coordinating actions among different actors ipso facto implies that there is an agreement. However, there are two different ways to look at agreements, namely as a unilateral act or a bilateral act.

As a unilateral act, an agreement functions as a method whereby a person voluntarily restricts her options for acting, and this allows two or more actors to coordinate their actions. A helpful way to illustrate how to think of an agreement as a unilateral action is by considering how the philosopher Philippa Foot thought about promising.[34] She proposes a thought experiment in which a drug is available, that if taken at time t1 will make the person do at a later time t2 what the person at time t1 said she would do. Foot argues that promising fulfils the same function as this drug. Promising ensures (of course, not perfectly) that at time t2 the promisor does what she said she would do at time t1, even if she no longer wants to. Foot's argument can easily be extended to apply to agreements. If persons A and B agree at t1 that at t2 A will do x and B will do y, the agreement is merely a device to ensure A will do x and B will do y, and this may be used by A and B to coordinate their actions (e.g. A might not do x unless A has assurance the B will do y.)

On the other hand, Immanuel Kant famously argued that a transfer of property is not a series of unilateral acts.[35] If it were a series of unilateral acts, then a transfer of property would consist of the transferee giving up her title to the property and the transferor claiming title to the abandoned property. One problem is that there is the risk that in the short time span between the property being abandoned and taken up by the transferee, a third party could claim the property.[36] Kant suggests that a property transfer is a bilateral act, jointly performed by the transferor and transferee, where the transferor gives and the transferee takes. However, this can only be the case if there is an agreement between the parties. Arthur Ripstein, a modern-day interpreter of Kant, suggests that there is a difference between people making 'matching' choices and 'joined' choices.[37] He argues as follows:

> The fact that I have decided to do something, even decided to do something involving you, is not equivalent to my having consented to doing that thing with you. The fact that you have decided to permit me to do something does not amount to your having consented to that thing unless something transpires between us. Neither your desire that I do some act x, my true belief about that desire, nor the combination of the two suffices for consent. Instead of merely matching, our choices must be joined.[38]

The way people react in traffic is an example of matching actions. For instance, a driver signalling left indicates to other road user that she will perform a left turn. Other drivers may react to this signal by slowing down and giving way to the signalling driver. In turn, the driver who indicated may react to this by turning left. In this case, the road users are reacting to each other; however, the drivers did not enter into an agreement, let alone a legal contract. Thus, according to a Kantian understanding, an agreement is something that creates a joined action, and it is in this sense that smart contracts enable the coordination of actions without agreements.

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[33] For instance, an obligation that a task has to be performed in a reasonable manner, gives some discretion to the party who has to perform the task but also provides some boundaries as to how the task is to be performed.
[34] Philippa Foot, Natural Goodness, (Oxford University Press, 2001, Oxford) p 45, referrred to in David Owens, Shaping the Normative Landscape (Oxford University Press 2012, Oxford) p 241 and following.
[35] See Kant Immanuel, Groundwork of the Metaphysics of Morals. For an analysis, see, Stephane Serafin, 'Transfer by Contract in Kant, Hegel, and Comparative Law' (2018) 31 Can. J. Law Jurisprud. 151, or Arthur Ripstein, Force and Freedom: Kant's Legal and Political Philosophy (Harvard University Press 2009, Cambridge) ch 5.
[36] Ripstein (n 35) 113 and following.
[37] Ripstein (n 35) 109.
[38] ibid. (italics in original)

Although it is outside the scope of the paper, to fully articulate the difference between joined and matching actions, two aspects are important to note. First, it is important to note that an agreement is something that is based on act of communication between the intended participants of the joined action. The act of communication may be in the form of natural languages like English or Mandarin; however, an agreement may also be based on something like a nod, a wink, a handshake and so on. Nonetheless, a gesture can only form the basis of an agreement if the gesture is taken as communicating something. For instance, it is not the physical effect of the nod that is important, but the fact that a nod may communicate something like acceptance. This does not mean that matching actions cannot be based on communication, e.g. person A shouting 'watch out' and person B reacting to it. However, in joined actions, the communication defines the parties' obligations, whereas, in matching actions, it does not. For instance, a driver indicating a left turn may be seen as an act of communication (what is being communicated is that the driver intends to turn left). A left signal may create certain obligations on other road users (e.g. not to overtake the person who intends to turn). However, these obligations are not defined by what the left signal communicates, they are defined by rules of road usage.

Second, an agreement creates forward-looking obligations. Prima facie, if persons A and B enter into an agreement and A does not do what was agreed, A has wronged B. Matching actions, however, do not create forward-looking obligations. Assume A and B drive towards each other on a narrow lane, and A swerves to her left indicating how she intends to pass B, and B swerves to her left indicating her intention how to pass A. Furthermore, assume that B then realizes that she forgot something at home and reverses back on the narrow lane. Person A cannot claim that B wronged her by not passing her on the left because a matching action does not create an entitlement to make another person do something.[39] It may be thought that coordinating actions through matching actions rather than joined actions is only a 'second-best' option. For example, one may argue that the reason why the rules of the road are not based on contract is that, due to transaction costs, it is impossible for all road users to contract with each other. However, as the example above demonstrates, matching actions are not always a second-best solution. For instance, road users may be more interested in matching their actions to other road users, rather than creating obligations that make other road users do certain things.

For the analysis of smart contracts, this means the following. If we take the term 'agreement' in the Kantian sense, as creating joined actions, then there are two options. First, smart contracts may be used to create agreements. There is no reason why code cannot be used for the purpose of communication. However, in that case, what matters is not what the code does but what it represents, ie what it communicates. For instance, person A encounters a piece of code created by B, which purports to 'transfer' a non-fungible token (NFT) to A's digital wallet provided that A sends digital currency to B's digital wallet. This may be understood as an offer by B to A to sell an NFT for some digital currency. What defines the obligation is what has been communicated between A and B. That is, if A accepts the offer and sends digital currency to B, prima facie B is under an obligation to transfer the NFT to A, and if the code does not do that, then B will be in breach of the agreement. If a solely code smart contract is used in this way, then, in a certain sense, it will turn the solely code smart into a hybrid smart contract or automated natural language contract. As the code is not solely used as code but also as a mean of communication. The code creates an obligation, which is defined by what the code communicates, ie there is an agreement, and this agreement is performed through the code. This is very similar to a hybrid smart contract or automated natural language contract.

A similar argument can be made in relation to the analogy between smart contracts and vending machines. As stated above, Szabo suggested that vending machines are a 'primitive ancestor of smart contracts'.[40] However, the way vending machines are typically treated in law is more akin to automated natural language contracts or hybrid smart contract. Vending machines often display the price of the items on offer as well as terms and conditions. This can be seen as a contractual offer, which is accepted by inserting the required money into the

[39] Nevertheless, this analysis should not be taken as an argument for why the contractual measure of damages is expectation loss rather than reliance loss. Although it may inform this debate, the debate about the 'correct' measure of damages in contract deals with somewhat different issues. This is a longstanding debate in contract law, which lies outside the scope of this article. For an overview of the issue, see, for instance, Perter Benson, 'Contract' in Dennis Patterson (ed), A Companion to Philosophy of Law and Legal Theory (Blackwell Publishing 2010, Oxford).
[40] Szabo (n 11).

machine.[41] The vending machines, once activated, perform the contract. Even in the rare case where no prices or terms and conditions are displayed, one could make the argument the items insight the vending machines are offered at the price equivalent to the amount of money that needs to be inserted into the machine to activate the mechanism to dispense the item. Again, this is more akin to an automated natural language contract or a hybrid smart contract.

However, because smart contracts are performed automatically, there is also the possibility to use them to coordinate actions without an agreement, used in the Kantian sense, and this enables smart contracts to be treated like machines. The legal scholars Werbach and Cornell put it like this:

> The smart contract is not fulfilled by some further action of a contracting party, but rather by the completion of this mechanical process. As an analogy, if Bob balances a pail of water on top of a door, he does not promise to drop water on whoever next opens the door. Rather, he has merely set up the mechanical process by which that will inevitably happen. In a similar way, a smart contract to transfer one Bitcoin upon such-and-such event occurring is not really a promise at all.[42]

Ultimately, Werbach and Cornell reject the view of smart contracts as machines because 'smart contracts are voluntary mechanisms that purport to alter the rights and duties of the parties.'[43] Nonetheless, matching actions may also be used to 'alter the rights and duties of the parties'. For instance, a driver signalling left may alter the rights of the driver signalling left and of other road users, e.g. the driver may now have the right to turn left, and other road user may have to give way. An even more obvious example, which will be discussed further below, is the concept of abandonment. If person A abandons property x, then this will change 'rights and duties' of others, e.g. another person B now may appropriate property x, without violating A's rights, yet this does not mean the abandonment is a contract. Note further that coordinating actions through a machine or other device does not mean that the coordination is based on physical restraints, it may be based on legal restraints but this in itself does not turn it into a contract. For instance, a turning signal does not physically restrain other road users but it still can be used to coordinate actions.

For the purposes of this article, the important point is that all the aspects that make smart contracts distinct from standard contracts can be achieved if smart contracts are seen as machines. Seeing smart contracts as machines allow people to coordinate their actions in a fashion not based on language, in the sense that language does not define the obligations. Furthermore, treating smart contracts as machines increases the certainty of the performance of the smart contract. Certainty in this context does not mean that the performance of smart contract will closely correspond to what the parties intend, but almost the opposite, namely it is independent from the intentions of the parties. Arguably, seeing smart contracts as machines is closer to the concept of smart contracts as envisaged by some of the developers working in this field.[44] Ethereum, a major player in the smart contract sphere, states in a white paper:

> Note that 'contracts' in Ethereum should not be seen as something that should be 'fulfilled' or 'complied with'; rather, they are more like 'autonomous agents' that live inside of the Ethereum execution environment, always executing a specific piece of code when 'poked'[45]

Vitalik Buterin, one of the founders of Ethereum and sometimes described as its inventor,[46] stated: '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"'.[47] Note, not all the benefits of smart contracts will disappear if they are seen as agreements. For instance, as was highlighted above, smart contracts may be

[41] See, for instance, Thornton v Shoe Lane Parking Ltd [1971] QB 163.
[42] Werbach and Cornell (n 4) p 340.
[43] Werbach and Cornell (n 4) p 341 and following.
[44] Werbach and Cornell (n 4) p 340.
[45] Ethereum Whitepaper <"https://ethereum.org/en/whitepaper/"https://ethereum.org/en/whitepaper/> accessed 11 January 2023.
[46] For a description on the Buterin's role in the creation of Ethereum, see, for instance, Klint Finley, 'Out in the Open: Teenage Hacker Transforms Web Into One Giant Bitcoin Network' Wired (2014) <"https://www.wired.com/2014/01/ethereum/"https://www.wired.com/2014/01/ethereum/> accessed 31 July 2023.
[47] Buterin (n 5).

effective in dealing with the problem of 'small breaches'. This benefit would persist, even if smart contracts are seen as agreements. Also, it is not suggested that smart contracts should always be seen as machines, it is only suggested that there are certain benefits of using smart contract as machines.

What are the relevant legal questions?

The next question that needs to be answered is what are the relevant legal issues in relation to smart contracts. This is an important question because, as stated above, smart contracts are performed automatically, which is thought to make it unnecessary to rely on the coercive power of the state to enforce the contract. This in turn, it is thought, allows for smart contract to be 'outside' the legal system.[48] This could mean that smart contracts do not raise any legal questions as they are outside the purview of the law. A common reply to the claim that smart contracts are outside the law is that, rightly or wrongly, the law does not give people the right to unilaterally declare that they are outside the law.[49] There are, of course, large parts of human life where people are free to act as they please. However, the point is that the law defines what these aspects are. Also, it does not mean that the law is able to exercise effective control over people's lives. There is plenty of criminal and other illegal activity where people act in ways not sanctioned by the law. However, these activities still raise legal questions because the law still claims dominion over these activities.

Nevertheless, the question of whether the law has effective control over smart contracts should not be dismissed that easily. If it is really the case that the law cannot effectively control smart contracts, either because they cannot be stopped or because the parties often are anonymous, or for some other reason, then even if the law claims dominion over smart contracts, it may make little difference in practice. By analogy, from an English law point of view, the UK Parliament may be able to revoke US independence and declare that all UK laws shall apply to the USA. However, from a US law point of view, this probably will make not much difference. Whether it makes a difference in practice will probably come down to whether the UK can effectively enforce its laws in the USA.

However, the claim that the state cannot have any effective control over smart contracts is probably overblown. The servers on which smart contracts run and the people who use them are located in the 'real' world (as opposed to the digital world), and states can usually exercise some, albeit imperfect, control over people and servers. The often-cited example of the so called 'TheDAO' may be used to illustrate this point.[50] TheDAO was a decentralized autonomous organization, which raised money for venture capital (VC) investments. However, different from normal VC funds, the intention was not to have a fund manager or even a fund. Instead, investments would be voted on by members of TheDAO and the fund would be replaced by a series of smart contracts. TheDAO managed to raise over US$160m. However, 'hackers'[51] discovered a bug in the code and appropriated around US$50m. What is interesting about this case is that the hackers claimed not to have done anything illegal and released a statement threatening legal action against anyone trying to deprive them of their gains. The issue was eventually resolved by Ethereum engaging a 'hard fork' thereby restoring the money to the original owners.[52] For the present purpose, it is important to note that the hackers threatened legal action. Therefore, it seems that, as far as the hackers were concerned, they believed that the law is relevant in relation to smart contracts. Thus, even if it is difficult for the state to control smart contracts, this does not mean that they are outside of the law.

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[48] Savelyev (n 16).
[49] Daniel Drummer and Dirk Neumann (n 1) 341, 342.
[50] For an overview of TheDAO case, see, for instance, Adam Kolber, 'Not-So-Smart Blockchain Contracts and Artificial Responsibility' [2018] STLR 198. N??ote that different commentators refer to the organization in different ways e.g. 'TheDAO', 'The DAO' or 'DAO'. This paper follows Kolber's usage by using the name 'TheDAO'.
[51] As will be detailed further below whether they actually were hackers is a matter of debate. For the purpose of this article, the term hacker is used in value neutral way, simply referring to the persons who appropriated the monies.
[52] A hard fork is a change in the network's protocol. See eg Lucianna Kiffer, Dave Levin and Alan Mislove, 'Stick Fork in it: Analyzing the Ethereum Network Partition' (2017 November) Proceedings of the 16th ACM Workshop on Hot Topics in Networks.

Thus far, it has only been shown that the law claims dominion over all aspects of people's lives and that the state has the power to enforce its laws even over smart contracts. However, this does not mean that the state will insist that there can be no other forms of transaction other than legal contracts. Yet, this is what sometimes seems to be argued. One commentator puts it as follows: 'Nation states will always have a natural reflex to defend their power and influence. [...] They won't just surrender.'[53] It is a fair assumption that the state will not give up its power to enforce its laws. For instance, if smart contracts are used for criminal activities, then the state will probably take steps to prevent this. However, this is not the issue. Smart contracts offer the possibility of engaging in transactions without relying on the coercive power of the state, and prima facie there seems to be no reason why the state would not allow this. It may be the case that smart contracts enable illegal activities to such an extent that states may consider banning them, or maybe smart contracts create a systemic risk to such an extent that states may consider regulating (or banning) them. However, apart from these and similar issues, there seems to be no reason why states should have any interest in not allowing their citizen to engage in transactions not based on legal contracts. By allowing smart contracts, the state does not give up its power.[54] Contracts are voluntary obligations (ie people can opt to use contracts or not) and the state already allows people to enter into agreements that are not enforceable in court, for instance by stating they are 'binding in honour only'. Similarly, many legal systems allow parties to choose the law that governs their contracts and the forum to resolve disputes, including the option for disputes to be resolved through arbitration rather than litigation. Far from having a 'natural reflex' to defend their dominion over how people engage in transactions, states are usually willing to give people a choice in this area. In fact, states may even welcome this to relieve some of the pressures on the court system.

Yet, there is another problem with the idea that people can simply decide to use an alternative to the legal system to arrange transactions. The problem is that technology alone is unlikely to stop the parties from seeking the assistance of the legal system to get a remedy ex post, even if this is what the parties intended ex ante. To illustrate, assume that persons A and B resolve to use a smart contract whereby A will transfer digital asset x to B. If the law does not recognize smart contracts as a legitimate way to affect property rights, then if A is unhappy with how the transaction turned out, and wants to 'undo' the transaction, then A may try to use the law to get x back. For example, A may bring a proprietary claim; a claim of unjust enrichment or a claim in the tort of conversion, to mention just a few options. By not recognising B as the rightful owner, the law gives A the option to reclaim the asset and to de facto undo the contract. It is very unlikely that technology alone is able to give people the possibility to credibly commit not to use the courts to try to impugn the transaction ex post, even if that is what the parties wanted ex ante. Again, TheDAO case may be a good illustration of this point. Before using TheDAO, users had to consent to a disclaimer that read as follows:

> The terms of The DAO Creation are set forth in the smart contract code existing on the Ethereum block-chain at 0xbb9bc244d798123fde783fcc1c72d3bb8c189413. Nothing in this explanation of terms or in any other document or communication may modify or add any additional obligations or guarantees beyond those set forth in The DAO's code.[55]

From this, one may conclude that the parties intended that TheDAO is exclusively governed by code and that none of the parties would use the courts to enforce their rights. However, this did not stop the hackers from threatening legal action, i.e. using the law.

The issue is that the parties alone cannot decide to exclude the use of the courts. This is not so much because the state does not allow the parties to exclude the use of the court system. Although this may also be a problem, as explained above there are plenty of examples where the law declares that people can arrange their affairs as they want and that this cannot be reviewed (or can only be reviewed in limited circumstances) by the courts.[56]

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[53] Drummer and Neumann (n 1) 341, quoting Filby, 'Code Is Law: Assessing Architectural File Sharing Regulation in the Online Environment' (2013) 8 J ICL T 81, 103

[54] Similarly, by allowing citizens to have burglar alarms to state does not give up its power over criminal matters.

[55] Kolber (n 50) 218.

[56] An example may be referees or umpires in sport. States usually do not see it as a way to undermine their authority to allow referees or umpires to make certain calls. The state usually also grants educational institution a wide discretion for academic issues. Students are usually expected to have exhausted the internal appeals procedures of the institutions

The problem is that as long as the parties have the option to use the courts, they cannot credibly commit not to use them. If the parties intend that a transaction will be 'governed by code', then the parties need assistance from the law, in the form of an assurance that the law will not allow itself to be used to 'undo' the transaction.[57] A similar dynamic can be seen in arbitration. Arbitration is an alternative way to resolving disputes using arbitral tribunals rather than courts, and many legal systems allow for this option. However, simply allowing arbitration is not sufficient to establish arbitration as a genuine alternative to litigation; the law must also provide that it will not 'undermine' the outcome achieved by arbitration. The problem is that an arbitration agreement (or arbitration clause) is simply a contract.[58] A party unhappy with the outcome of the arbitration could bring a contractual claim in a court and have the arbitration agreement, process or outcome reviewed on the basis of the principles of contract law. Therefore, a party could de facto relitigate the arbitration and thereby undermining the whole point of arbitration. For arbitration to be an effective alternative to litigation, the law must not only allow for arbitration, the law must also provide that the courts cannot be used to undermine arbitration. Therefore, it is usually the case that legal systems that provide for arbitration also provide that arbitration can only be reviewed by the courts on very narrow grounds.[59]

For smart contracts, this means that the relevant question is as follows: Assuming that we want people to use smart contracts as machines if they so choose, what legally needs to be in place to enable people to use smart contracts in this way? The obvious next question is why should the state do anything to help smart contracts? One answer might be in the spirit of what Sir Geoffrey Vos stated in relation to smart contracts:

> We should try to avoid the creation of a new legal and regulatory regime that will discourage the use of new technologies rather than provide the foundation for them to flourish.[60]

Therefore, unless smart contracts facilitate criminal activities to such an extent that they should be outlawed or they create so much systemic risk that they should be regulated, the law should, as far as reasonably possible, provide for ways that people can arrange their affairs in any way they please. The reader may disagree with this. In this case, the reader is invited to treat the rest of this article as a hypothetical analysis rather than a recommendation.

How should the law react?

The sections above argue that there is the possibility to see smart contracts not as agreements but as machines, but it was also argued that the law must provide some recognition of smart contracts. The challenge is to find the appropriate legal category that allows the law to recognize smart contracts as machines. In particular, this

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before appealing to the courts. Again, the state usually does not see this as undermining the power of the state. This may be 'silly' example, however, it just goes to show how commonplace these examples are.

[57] A similar problem may also arise for people who do not have access to a functioning legal system. Let us say both parties live in a lawless society and one party is a poor and powerless and the other is a powerful warlord in command of a small army. The warlord wants the poor person to perform some coding for her and tries to assure the poor person that she will get paid because as soon as the coding is done a mart contract will transfer a digital asset into the poor person's digital wallet. The problem is that the warlord cannot assure the poor person that she will not use her soldiers to take away the digital currency from the poor person ex post.

[58] See, for instance, Hiro N Aragaki, 'Arbitration: Creature of Contract, Pillar of Procedure' (2016) 8 Yearbook on Arbitration and Mediation 2.

[59] See, for instance, the UK Arbitration Act 1996, Sections 66–70. Another example where this dynamic can be seen is that courts are generally reluctant to interfere with bona fide decisions of sporting officials, even if wrong. (See GM Kelly, 'Prospective Liabilities of Sports Supervisors' (1989) 63 Aust. Law J. 669). There may be 'solid' legal reason for this (see John O'Brien, 'Don't Argue With the Ref!—Legal Liability for Incorrect Decisions of Sports' Officials' (2014) ANZSLJ 159. However, if every decision by a sporting official could be reviewed by the courts, professional sports would be very different and probably a lot less interesting. This does not mean that sports take place in an 'anarchic' environment outside of the law. It simply means that the law recognizes that for sports to function as it does now, the parties should only have limited possibility to use the courts to challenge decisions by sporting officials.

[60] The Law Commission (n 2) para 127.

means that one needs to find a legal category that enables smart contracts to affect property rights or in case of services make it so that the service is legitimately received.

It may be thought that viewing smart contracts as machines immediately rules out regarding smart contracts as legal contracts. As legal contracts are enforceable agreements, and the point of regarding smart contracts as machines is that they are not agreements. However, there is the possible objection that this conclusion is 'pedantic', overlooking the inherent flexibility of the common law, and its ability to deal with new situations pragmatically. Therefore, one may argue that the common law could pragmatically extend the concept of legal contracts to cover the idea of smart contracts as machines?[61]

This may not be as farfetched as it sounds because there is the possible argument that legal contracts are not actually agreements, in the Kantian sense, but rather a method to voluntarily restricting one's future options for the purpose of coordinating actions with other actors.[62] The question of what legal contracts really are is a long-running debate in contract law theory. Fortunately, for the purposes of this article, it is not necessary to settle this debate. For the purpose of this article, the following is sufficient. Even if legal contracts are simply a voluntary restriction on one's future options, it would still be the case that legal contracts would be the wrong category if smart contracts are to be viewed as machines. One reason is that legal contracts are based on communication. That is clear in the case of written or oral contracts, but even if a contract is based on a nod or wink, what defines the obligation is what is being communicated.

Furthermore, the way the law operates makes it unlikely that contracts are simply a method to restrict one's options for the purpose of coordinating actions.[63] First, language and phrasing used in contract law suggest that contract law is concerned about joint actions. For example, expressions like 'a meeting of minds', 'mutual agreement' or 'consent' to name just a few, only make sense in relation to joined actions.[64] Second, many contract law doctrines like duress or misrepresentation are difficult (if not impossible) to explain if contract law is only concerned about restricting future behaviours. For instance, for both duress and misrepresentation, it is crucially important that the person who committed the duress or misrepresentation is a party to the contract. If the contracts are essentially something unilateral, then this should not matter. Third, if it were true that contract law is only concerned about restricting future actions, then legal contracts that do not involve future performance should not count as contracts because a simultaneous exchange does not involve a future obligation. Yet simultaneous and instantaneous exchanges can be regarded as contracts.[65] Fourth, if contract law is based on the notion of restricting the future self, then it should be possible for a person to contract with herself only.[66] However, under English law this is not possible.

It may be thought that one solution is for the parties to enter into an agreement that the code alone shall govern the transaction. The problem with this suggestion is that there is still an agreement. Thus, all the contractual doctrines like misrepresentation, duress, mistake and frustration would still apply. Furthermore, as Kolber demonstrated, an agreement that the code shall govern the transaction can give rise to complex interpretational questions[67] and this may be exactly what the parties are seeking to avoid. Another option may be that the parties 'agree expressly that a smart contract is not legally binding'.[68] However, apart from the issue that there is still an agreement, which may be as fiercely litigated as any other agreement, more importantly, this solution does

[61] That the courts may be willing to take a 'pragmatic' approach in this area may be seen in the decision in AA v Persons Unknown, [2019] EWHC 3556 (Comm).
[62] Randy Barnett, may be seen as possible exponent of this view. See Randy E Barnett, 'Contract Is Not Promise; Contract is Consent' (2011) Georgetown Law Faculty Publications and Other Works 615. See also Werbach and Cornell (n 4) 358–360.
[63] See also James E Penner, 'Voluntary Obligations and the Scope of the Law of Contract' (1996) 2 LEG 325, 327 and following.
[64] Of course, it has to be said what exactly a 'meeting of minds' is and what role it plays in contract law is obscure at best.
[65] James Penner, The Idea of Property in Law (Oxford University Press 1997, Oxford) ch 5.
[66] As a person, may have an interest in restricting his future action purely for its own sake. For instance, a person who wants his future self not to smoke could 'contract' that he has to donate $1000 to charity for each cigarette he smokes.
[67] Kolber (n 50).
[68] UKJTF (n 2) 31.

not deal with the question of how the smart contracts affect property rights. It says what a smart contract is not but it does not say what a smart contract is.

Another possibility is to argue that a person entering into a smart contract is making a gift.[69] The problem is that gifts are commonly thought of as bilateral not unilateral acts (ie a gift to be effective must be given as well as received). This would mean that a gift requires an agreement between a donor and a donee, although this agreement is not a contract. Arguably under the English law, a gift may be considered as unilateral act,[70] as the law 'presumes a donee's assent until disclaimed'.[71] However, it is doubtful that this means that under English law a gift is really a unilateral act. Note that the law only presumes that a donee assents to the gift until it is disclaimed. This presumption is based on the idea that usually a reasonable person will assent to a gift[72] (ie a gift is still a bilateral act, albeit the law presumes assent). The even more fundamental problem is that making a gift requires communication, ie the mere intention to make a gift is not enough to create a gift, the intention must be expressed, and it is the communication that defines how the rights of the parties are changed. Therefore, to conceive of smart contracts as a way to make a gift does not lend itself to the view of smart contracts as machines.[73] Another option may be to consider smart contracts as a form of estoppel.[74] Recall that estoppel does not create an agreement between the parties so it may be a useful tool. It may be argued that, if A uses a smart contract to transfer an NFT to B, A represents to B that B is the new owner of the NFT and if B relies on this representation to B's detriment (e.g. by transferring another crypto asset to A) this could give rise to claim of estoppel. However, the problem is that estoppel is based on communication. This is clear in the case of promissory estoppel that requires a promise. However, other forms of estoppel, like proprietary estoppel, also require that a person gives assurance to another person.

Another possibility is for the law to create a specific regime to deal with smart contracts as machines. There are two basic requirements that such a regime would need to fulfil. First, by using a smart contract a party relinquishes legal ownership of an asset, and the counterparty gains legal ownership of the asset. Second, this legal effect is based on unilateral not bilateral actions by the parties, and it is not based on communication. The drawback of a specific regime is that to create such a regime would probably require legislative intervention and, importantly, a legal concept already exists that potentially fits these requirements, namely the concept of abandonment. It may be thought that using the concept of abandonment has a fatal flaw, namely that it only deals with property, and smart contracts may also be used for services. Yet, the analysis can easily be extended to services. For brevity's sake, the rest of this article deals only with property; however, the arguments apply equally to services. The next section will explain in more detail how the concept of abandonment can be applied to smart contracts.

The abandoned property approach

The idea behind using the concept of abandonment is to do exactly what Kant said should not be done, namely 'transferring' property through the unilateral acts of abandoning and claiming property. Legally abandonment may be 'defined as the voluntary giving up of possession without possession being transferred to another person

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[69] For example, when A sells an NFT to B in exchange for cryptocurrency, A gifts B an NFT and B gifts A cryptocurrency.
[70] See also James Penner, 'Voluntary Obligations and the Scope of the Law of Contract' (1996) 2 Legal Theory 325, 329.
[71] Neville Crago, 'Principle of Disclaiming a Gift' (1999) 65 UWALR 65.
[72] Neville Crago, 'Principle of Disclaiming a Gift' (1999) 65 UWALR 65.
[73] NB the creation of an express trust also requires communication, although not necessarily communication to the beneficiary. Therefore, a solution based on trusts would not work either, apart from being far too complicated.
[74] This could either be classified as a promissory estopped see <"https://en.wikipedia.org/wiki/Hughes_v_Metropolitan_Railway_Co" \o "Hughes v Metropolitan Railway Co"Hughes v Metropolitan Railway Co <"https://www.bailii.org/uk/cases/UKHL/1877/1.html"[1877] UKHL 1, 2 App Cas 439, (1876–77) LR 2 App Cas 439> <https://en.wikipedia.org/wiki/Central_London_Property_Trust_Ltd_v_High_Trees_House_Ltd" \o "Central London Property Trust Ltd v High Trees House Ltd" Central London Property Trust Ltd v High Trees House Ltd [1947] KB 130) or proprietary estoppel (Dillwyn v Llewelyn (1862) 4 De GF&J 517, or the Australian case Waltons Stores (Interstate) Ltd v Maher (1988) 164 CLR 387.

by way of sale or gift'.[75] Crucially, abandonment is not based on communication. This follows ipso facto from the fact that it is a unilateral act. This is also explicitly recognized in case law, where it was held that abandonment '… may arise when the owner with the specific intent of desertion and relinquishment casts away or leaves behind his property … '.[76] Thus, to abandon property all that is required is that the person intentionally commits the act of abandonment. The basic idea is that if a person uses a smart contract, the person abandons property and another person claims the abandoned property. Legally there is no agreement, and the assurance that the 'correct' person appropriates the abandoned property and that this person fulfils her obligations is (primarily) based on technology not law. This will be referred to as the abandoned property approach.

From an intuitive point of view, the abandoned property approach seems like a workable solution, unfortunately, legally it may not be quite as simple. Different to many civil law jurisdictions, which see no problem with the idea of abandoning property,[77] English law has struggled (and some argue is still struggling)[78] with the concept. Still, it seems quite clear that English law does recognize the possibility of abandoning property,[79] and the debate centres more around the question of whether English law embraces a bilateral or unilateral divestment view.[80] The bilateral divestment view was held by commentators like Sir Frederick Pollock who argued that 'abandonment is […] merely a licence to the first man who will take the goods for his own, which taking will be justified and will finally change the property'.[81] On the other hand, Sir William Blackstone argued for an unilateral divestment view, namely that an act of abandonment means that the property 'becomes, naturally speaking, publici juris once more, and is liable to be again appropriated by the next occupant'.[82] There is judicial support for both views.[83] However, it seems that modern commentators favour the unilateral divestment view.[84] Regardless, for the abandoned property approach, it does not matter whether the bilateral or the unilateral divestment view is correct, as both are compatible with the abandoned property approach.

A further question is whether the intention to abandon the property is to be judged subjectively or objectively. In relation to abandonment generally, both approaches have benefits and drawbacks.[85] Nonetheless, with regards to abandoning property through smart contracts it is preferable to judge the intention objectively unless the person claiming the property had subjective knowledge that the person did not intend to abandon the property. The reason is that smart contracts are usually used in a business context and an objective standard will increase predictability. From a practical point of view, it may be difficult to distinguish using a smart contract with the intention of creating a legal contract from using a smart contract with the intention of abandoning property. Therefore, it is advisable to expressly declare that the intention of the party is to abandon property. It may be thought that this contradicts the idea of affecting property rights without communication. However, in this case, communication is not used to define rights or obligations but as a way to evidence that a person had the relevant intention.

The advantage of the abandoned property approach is that it is as close as possible to allowing one to view smart contracts as machines. As there is no agreement, there can be no debate about whether the smart contract fulfilled

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[75] Janine Griffiths-Baker 'Divesting Abandonment: An Unnecessary Concept?' (2016) 36 CLWR 16, 18; referring to Golding (Inspector of Taxes) v Kaufman, [1985] STC 152.
[76] Simpson v Gowers (1981) 121 DLR (3d) 709 at 711 in Cheng Lim Shaw, 'The Law of Abandonment and the Passing of Property in Trash' (2011) 23 SAc LJ 145, 148.
[77] Konstanze von Schütz, 'Keeping It Private: The Impossibility to Abandon Ownership and the Horror Vacui of the Common Law of Property' (2021) 66 MLJ 721, 745 and following.
[78] von Schütz (n 77) 750 and following.
[79] For example, James Penner writes: 'Although the legal view [eg in Haynes's Case (1614) 77 ER 1389] respecting title might suggest; otherwise, it is submitted that we do have the right to abandon the property. It is surely part of a right to determine how a thing is to be used that one may make no use of it at all, forevermore'. In Shaw (n 76) fn 63.
[80] Griffiths-Baker (n 75) 18 and following.
[81] Arrow Shipping Co Ltd v Tyne Improvement Commissioners [1894] 10 LQR 293, in Shaw (n 76) 155.
[82] Sir William Blackstone, Commentaries on the Laws of England, Book 2 (Clarendon Press, Oxford 1766) ch 1, p 9, in Shaw (n 76), 156, 157.
[83] Inter alia, Haynes's Case (1614) 77 ER 1389 is often cited in support of bilateral divestment view. Arrow Shipping Co Ltd v Tyne Improvement Commissioners (The Crystal) [1894]. AC 508 is often cited in support of the unilateral divestment view.
[84] See Shaw (n 76), 157 and following.
[85] See discussion by Griffiths-Baker (n 75) 19.

the agreement or how to interpret the agreement and because there is no contract contractual doctrines like, duress, unconscionability, undue influence, frustration, mistake, misrepresentation and so on do not apply either.[86] Nevertheless, it is important to point out that the abandoned property approach does not enable smart contracts to be completely treated as machines. As there are still questions that can only be settled by the law and not by a technology, e.g. questions like whether a person had the right to abandon the property, whether the person had the relevant intention or to what property exactly the intention relates.[87] The abandoned property approach should not be thought of as a way of avoiding legal disputes altogether. As stated above, smart contracts need the assistance of the law to be effective, and as such, it is impossible not to have any legal questions in relation to smart contracts. Ultimately, this means that it is not possible to treat smart contracts completely like machines; however, the abandoned property approach is as close as legally and conceptually possible to the treatment of smart contracts as machines.

Solely code smart contracts are seldom used in practice so why bother?

At this point, the reader may ask why bother with the abandoned property approach or even with an analysis of solely code smart contracts because, currently, it seems that solely code smart contracts are seldom used in practice.[88] It goes beyond the scope of this article to fully analyse the question of why this is, nevertheless it is an interesting question for further research. However, one possibility is that if the only options are to treat smart contracts as legal contracts or nothing at all, then solely code smart contracts do indeed not make much sense. As users get all the downside of not having a natural language contract and few of the upside of there not being a legal contract. However, if it is possible to use smart contracts as machines, then users may find it beneficial to use solely code smart contracts.

It has also been argued that it is 'unwise' to use solely code smart contracts,[89] and that the parties are usually better off using an automated natural language contract or a hybrid smart contract. One reason why it may be unwise to use solely code smart contracts is that code is often difficult to understand and, therefore, it is better to have a natural language version of the smart contract. That code is difficult to understand is certainly true for object code, which is generally not understandable by humans. However, even for source code, which may be understandable to humans, it will often be very difficult to predict how the code will react. Thus, it seems natural to want to create a natural language representation of the code upon which people can rely. If this is so, then it would seem that solely smart contracts will rarely be used, and the abandon property approach would be largely useless.

There are a number of possible responses to this. First, although it is true that it may be difficult to predict how a piece of code will react in certain circumstances, often people will have a fair idea how the code will react. If this was not the case, people would never use code for anything. Second, using smart contracts as machines does not mean that there can be no natural language explanation of how the code is supposed to operate. Like any other machine, a solely code smart contract may come with instructions and a description of how it will function. If the instructions or description of the smart contract turn out to be wrong, then the victim may sue the person responsible for the instructions and description in the tort of negligence.[90] However, this does not mean that thereby a legal contract is created between the parties to the smart contract.

Another argument for why treating smart contracts like machines may be problematic is that contract law doctrines like duress, frustration or undue influence will be unavailable, and it may be thought of as unwise to enter into a transaction without the possibility of recourse to these doctrines. Yet, it is important to remember that people engage in many activities where contract law doctrines are not available (e.g. building a house,

[86] The reason is obvious because contract law doctrines only apply to contracts. However, note that similar doctrines may apply, eg misrepresentation may not be available but negligent misstatement might be.
[87] A person may claim that it intended to abandon property x but mistakenly abandons property y.
[88] Law Commission (n 2) para 2.83 and following.
[89] The UKJTF seems to make this suggestion. UKJTF (n 2) para 136.
[90] Provided the victim suffered damages that are recoverable in law, the person responsible acted negligently and owed the victim a duty of care.

choosing a career and so on). This does not mean that it is unreasonable to engage in this activity. Moreover, there are also many other systems, which were created specifically such that a transaction cannot be unwound. These systems are so familiar to us that we may not even notice how they function. A prime example is fiat currency. Even if a person is deprived of fiat currency unfairly (e.g. it was lost or stolen), the person cannot go to the relevant monetary authorities and ask to be issued with new currency to replace the lost or stolen currency. The only person who needs to make restitution is the person who appropriated the currency. Bearer bonds may be another example. One could imagine a system, in which bearer bonds are replaced if lost or stolen and some jurisdictions provide that this may be possible in very limited circumstances.[91] However, there is nothing inherently unwise with a system where this is not possible. Bearer bonds are of course not very common these days. Particularly, in the USA, where they were effectively eliminated due to 'regulatory' concerns because the anonymous nature of bearer bonds was thought to facilitate tax evasion and money laundering.[92] Fiat currency and bearer bonds are, of course, not a perfect analogy for treating smart contracts like machines. The point is merely that the systems of fiat currency and bearer bonds were designed in such a way as to put a lot of emphasis on the finality of a transaction and there is nothing obviously unwise about that from the perspective of users. There are legitimate regulatory concerns about bearer bonds (as well as maybe about cash) and regulatory concerns may also apply to smart contracts but this does not make using solely code smart contracts unwise.

Furthermore, note that just because contract law doctrines are not available if one regards smart contracts as machines, this does not mean other legal doctrines are not available. For instance, if the smart contract was induced by an untrue statement, one cannot use the doctrine of misrepresentation, if the smart contract is treated as a machine. However, one may be able to use the doctrine of negligent misstatement.[93] Similarly, the doctrine of duress is not available if smart contracts are treated as machines, but depending on the form of the coercion used, the victim may still be able to bring a claim for compensation against the coercer. Furthermore, if a party intended to abandon one piece of property but mistakenly abandons another, this party may be able to bring a claim similar to a unilateral mistake in contract.[94] As the party may be able to argue that the party who appropriated the abandoned property, knew or should have known, that the person who abandoned the property did not have the relevant intention. Even, a claim in unjust enrichment may be possible. Assume that party A uses a smart contract to abandon property x intending (or hoping) that it will be appropriated by B but mistakenly A uses the smart contract in such a way that C appropriates x (ie de facto A 'transfers' x to the wrong person). One problem in bringing a claim in unjust enrichment is that the defendant's enrichment must be at the expense of the claimant. Arguably, if the unilateral divestment view of abandonment is correct, then at the time the defendant was enriched that the claimant did not own the property anymore, and therefore, the enrichment was not at the expense of the claimant. If the bilateral divestment view is correct, then this problem does not arise. Thus, a claim in unjust enrichment may be possible. However, it is important to point out that when smart contracts are treated like machines and the courts are asked to consider a claim for negligent misstatement, mistake or unjust enrichment the courts need to be mindful not to allow these claims to undermine the notion of treating smart contracts as machines.

How to deal with hacking cases?

Another possible concern with the abandoned property approach is that it cannot satisfactorily deal with cases of hacking, like TheDAO hack. Yet, the abandoned property approach is actually better equipped to deal with hacking than a contractual approach to smart contracts. One of the challenges in analysing hacking is to define

[91] U.S. Treasury, 'Loss, Theft, or Destruction of United States Bearer or Registered Securities Assigned As Payable To Bearer' (2007) <"http://www.treasurydirect.gov/forms/sec3987.pdf"www.treasurydirect.gov/forms/sec3987.pdf> accessed 21 January 2023.

[92] See, for instance, Frank Gogol, 'Complete Guide to Bearer Bonds' Stilt (2022) <http://www.stilt.com/blog/2021/04/bearer-bonds/"www.stilt.com/blog/2021/04/bearer-bonds/> accessed 21 January 2023.

[93] Caparo Industries PLC v Dickman [1990] UKHL, Hedley Byrne & Co Ltd v Heller & Partners Ltd [1964] AC 465.

[94] Recall the unilateral mistake is when one party is mistaken as to the terms of a contract. See, for instance, the Singaporean case Chwee Kin Keong v Digilandmall.com Pte Ltd [2005] 1 SLR(R) 502 but contrast with the other Singaporean case of Quoine Pte Ltd v B2C2 Ltd [2020] SGCA(I) 02.

what a hack is. As a first approximation, the term 'hack' means to use code in a way which was clearly not intended, and which causes harm to other users (ie a person deliberately exploits a weakness or bug in the code). It may be thought that hacking is a problem for the abandoned property approach because if A abandons property x hoping B will claim it, but C finds a weakness in the code and is able to claim x, prima facie neither A nor B has a claim against C. A contractual approach may seem to provide a better prospect to deal with hacking cases. For instance, A may be able to claim that if the smart contract is construed properly, the contract does not give C a right to exploit the bug. Alternatively, A may make a claim similar to unilateral mistake, ie by offering a code with a bug, A offered the wrong terms and C knew, or ought to have known, that A offered the wrong terms.[95]

However, for both contractual claims to be assessed, it is necessary to first interpret the smart contract.[96] To interpret a smart contract, it has been suggested to use a 'reasonable coder test'.[97] For instance, in the UK, the Law Commission states:

In our view, interpretation of a coded term should be determined by asking what the term would mean to a reasonable person with knowledge and understanding of code—that is, a "reasonable coder". The answer to this question will be determined by reference to what the code, in that person's reasoned opinion, appeared to instruct the computer to do.[98]

The Law Commission further elaborates that the reasonable coder test could be applied similarly to the Bolam test in the tort of negligence.[99] The Bolam test asks 'whether the defendant's actions were in accordance with a practice accepted by a responsible body of professional opinion'.[100] Bolam was modified by Bolitho[101], which held that the courts are not bound to follow the Bolam test if the 'professional opinion "cannot be logically supported at all"'.[102] Thus, a solely code smart contract means what a reasonable coder thinks it means unless this interpretation 'cannot be logically supported at all'.

Unfortunately, the reasonable coder test does not provide much help in hacking cases. Assume that the code of a smart contract contains a bug; however, the bug is fairly obvious such that a reasonable coder would have spotted it. Arguably this was the case with TheDAO hack, as before the hack there were multiple reports of weaknesses in the code.[103] Therefore, a reasonable coder if asked to determine 'what the code […] appeared to instruct the computer to do' may conclude that what the hackers did falls within that. It may be argued that the reasonable coder should not be asked what the code appears to instruct the computer to do but should be asked what in her reasonable opinion the people who wrote the code intended the code to do. However, if this is the case, then this takes the reasonable coder test considerably outside the traditional canons of contractual interpretation used in the common law, where it was traditionally held that a contract means what the words mean to a reasonable bystander with the relevant background knowledge not what the parties intended the words to mean.[104]

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[95] For unilateral mistake more general see, for instance, the Singaporean case of Chwee Kin Keong v Digilandmall.com Pte Ltd [2005] 1 SLR(R) 502.
[96] To be able to claim that a party offered the wrong terms, one needs to first know what the terms were.
[97] Law Commission (n 2) 84, ch 4, see also Sarah Green, 'Smart Contracts: Interpretation and Rectification' [2018] LM CLQ 234.
[98] Law Commission (n 2) 84, para 4.48.
[99] Law Commission (n 2) 84, para 4.43, and Green (n 97) 246, Bolam v Friern Hospital Management Committee [1957] 1 WLR 582.
[100] Law Commission (n 2) 84, para 4.43.
[101] Bolitho v City and Hackney Health Authority [1996] 4 All ER 771.
[102] Law Commission (n 2) 84, para 4.43.
[103] Nathaniel Popper, 'A Hacking of More Than $50 Million Dashes Hopes in the World of Virtual Currency' The New York Times (2016, New York) "http://www.nytimes.com/2016/06/18/business/dealbook/hacker-may-have-removed-more-than-50-million-from-experimental-cybercurrency-project.html"www.nytimes.com/2016/06/18/business/dealbook/hacker-may-have-removed-more-than-50-million-from-experimental-cybercurrency-project.html> accessed 21 January 2023.
[104] See, for instance, Arnold v Britton [2013] EWCA Civ 902.

The reason why the reasonable coder test is not appropriate to deal with hacks is because it is a test of interpretation. However, the underlying issue of hacks is not one of the interpretations but of how a person ought to act. For instance, Rizos argues that:

An example could be drawn by the 'DAO Hack' case, where obviously it would not have been possibly expected by any reasonable person that any member of the fund would have the capability to withdraw the whole capital.[105]

Rizos also uses a contractual approach to smart contracts. However, it is perfectly possible that a reasonable person would have expected the possibility to withdraw the entire capital, in the sense that a reasonable person may have spotted the weakness in the code, which allows the entire capital to be withdrawn by any member. What a reasonable person would not have done is to act in the way the hackers did and exploit the weakness in the code.

As all the reference to standards used in the tort of negligence (e.g. Bolam, Bolitho, reasonable coder) may indicate a better approach to hacking is by using the tort of negligence. It may be worth taking a step back and ask on a purely conceptual level, what, if anything, the hackers, did wrong. The hackers claim that they did nothing wrong. The declared intention of all the parties was that code alone should govern their interaction and the hackers acted in accordance with the code. It was also not an obvious case of mistake as to the terms because the people who created the TheDAO did not mistakenly use one piece of code rather than other. What the hackers did wrong is that they violated a community standard of how reasonable people ought to behave in this situation. Communities often set standards for how their members are expected to behave (e.g. doctors are held to a certain standard, accountants to another and so on). Such standards may be valuable because it allows for forward planning because people will know what to expect and often these standards tend to be economically efficient. Arguably, what the hackers did wrong was that they did not act in accordance with the standard promulgated by Lord Atkin in Donoghue v Stevenson namely that 'You must take reasonable care to avoid acts or omissions which you can reasonably foresee would be likely to injure your neighbour.'[106] Using Bolam, as modified by Bolitho, this means that the reasonable coder test should be used to determine whether the defendant's actions were in accordance with a practice accepted by a responsible body of professional opinion, i.e. the question is whether a reasonable user of smart contracts would have done what the hackers did.

This test may not seem very intellectually satisfying because it does not give a clear answer to the question of what hacking is or why it is wrong. However, this may also be seen as an advantage. Rather than trying to define hacking in the abstract (which is very difficult and the courts may be ill equipped for this task), one relies on standards set by the community of smart contract users unless that standard 'cannot be logically supported at all'. The appropriate standards set by the users of smart contracts is probably something like 'thou shall not unfairly take advantage of bugs in the code'. This standard is fair as well as efficient. If there were no limits on whether one can exploit bugs, then more resources would need to be spent on ensuring the code is bug free, or people would be reluctant to use code at all. However, if the standard was 'thou shall never take advantage of bugs in the code', this may incentivise sloppy coding and too many lawsuits, especially in relation to whether something is a bug or not.

If the tort of negligence is used to deal with hacks, then this can be applied in a straightforward manner to the abandoned property approach. Assume that a person appropriates a property in an unreasonable manner, by exploiting a bug in the code. This may cause harm to either the person who was supposed to appropriate the property, as he is deprived of the possibility to appropriate the property or the person who abandoned the property, as she may be deprived of the benefit that she expected to receive from abandoning the property. Provided the other elements of the tort of negligence (e.g. duty of care, loss not too remote and so on) are met, a claim may be brought.

A slight 'wrinkle' in this argument is that the loss suffered probably constitutes pure economics loss, which generally is not recoverable under English law. However, this problem should not be overstated. Arguably, the

[105] Rizos (n 4) 799.
[106] Lord Atkin in Donoghue v Stevenson [1932] A.C. 562.

main justification for the doctrine of pure economic loss is public policy, ie it controls the floodgates of litigation.[107] However, there are other ways to control the floodgates, and there is some judicial doubt as to the merits of the doctrine of pure economic loss.[108] Furthermore, pure economic loss was held to be recoverable in cases of negligent misstatement.[109] Nevertheless, it may require a 'pragmatic intervention' by the courts to extend the tort of negligence to make it applicable to hacking.[110] It may be possible to 'press' the above argument into a contractual framework. This may be easier in civil law jurisdictions, which have the doctrine of good faith, and it may even be possible in the common law by using the principle that a contract should be interpreted to give it business efficacy.[111] However, the point remains that the key issue with hacks is not about contractual interpretation but about how one ought to behave, and the abandoned property approach makes this clear.

Conclusion

This article suggests that it is possible to conceive of smart contracts as a genuine alternative to legal contracts, to view smart contracts not as contracts but as machines. It is important to emphasize one last time that the suggestion is not that smart contracts should never be used as legal contracts. The argument is merely that an alternative is possible and that prima facie people should have the choice of whether they want to use smart contracts as legal contracts or as machines. If the only option that the law recognizes is that smart contracts are either legal contracts or nothing at all, then it will be impossible to use smart contracts as machines. Therefore, this article suggests an alternative way for the law to treat smart contracts, namely as a way of abandoning and claiming property. This is, of course, only one of the issues surrounding smart contracts. This article did not analyse regulatory or related issues, e.g. the extent to which smart contracts may create systemic risk or may be used to facilitate illegal transactions. These are important issues, which need to be analysed further. It may turn out that smart contracts should never be used at all. However, until we have reached this conclusion, people should have the choice of how they engage in transactions, and smart contracts allow an alternative to legal contracts for people to engaging in transactions.

[107] See Lord Denning in Spartan Steel & Alloys Ltd v Martin & Co (Contractors) Ltd [1973] QB 27 For a discussion of economics loss, see for instance William Bishop, 'Economic Loss in Tort' (1982) 2 OJLS.
[108] See, for instance, Lord Roskill's comments in Junior Books Ltd v Veitchi Co Ltd [1983].
[109] Caparo Industries plc v Dickman [1990] UKHL 2, Hedley Byrne & Co Ltd v Heller & Partners Ltd [1964] AC 465.
[110] That the courts may be willing to take a pragmatic approach in this area may be seen in the decision of AA v Persons Unknown, [2019] EWHC 3556 (Comm).
[111] Attorney General of Belize v Belize Telecom Ltd [2009] UKPC 10, Marks and Spencer plc v BNP Paribas Securities Services Trust Company (Jersey) Ltd. [2015] UKSC 72.