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Smart Contracts Through the Lens of Institutional Economics

Introduction

Smart contracts are a relatively new method of structuring agreements which may alter our view of exchange from an Institutional Economics standpoint. This technology, utilising automated scripts to execute contracts, changes various costs within a transaction. Since the outcomes of a contract are distinctly stipulated *ex ante*, including any potential penalties in case of deviation, the firm is assured parties will hold up their end of the agreement. Parties may also construct disclosure procedures or mechanisms which avert hold-up problems. Such technology could make for more efficient contracting, and potentially reduce the size of firms. However despite their usefulness I do not suggest smart contracts can by any means supplant their traditional equivalents. Original smart contracts cannot be renegotiated. Such obvious lack of flexibility may incur costs in other areas and impede complex agreements. Smart contracting becomes tremendously complex the further it is explored. For the sake of brevity, I intend to explicate basic smart contract transactions and their implications for transaction costs and participant behaviour. Institutional economics may help us understand why companies were so excited about smart contracts in the first place, and how they may change the nature of transaction costs within the firm.

What is the blockchain and what are smart contracts?

Smart contracts are a method of executing agreements utilising computer code. Unlike their non-smart counterparts, which require a certain measure of trust between parties, digitised agreements are trustless and automatic. Terms are digitised and translated into a coding language, and stored on blockchain platforms. (In this paper I refer specifically to smart contracts which are based on the Ethereum network[1], a mainstream decentralised programmable blockchain[2].) The network enables peer-to-peer interaction without a central authority and verifies smart contracts. This technology has considerable appeal due to its immutable nature, i.e. once a smart

[1] See the Ethereum Whitepaper for a more technical understanding of Ethereum. Buterin, Vitalik. "Ethereum Whitepaper." *Ethereum.org*, 2014, ethereum.org/en/whitepaper/.

[2] A blockchain is a form of digital recordkeeping. It is an immutable, distributed ledger that stores data in "blocks". A blockchain network can be used to build apps, organisations, or holding assets. For a more detailed idea of what blockchains are and how they work, see Sinclair Davidson, Primavera de Filippi, Jason Potts. *Blockchains and the economic institutions of capitalism*. Journal of Institutional Economics, 2018, 14 (4), pp. 639 - 658. 10.1017/S1744137417000200. hal-01850927.

contract is published to the network, it cannot be changed or taken down. Moreover, once a code is written, it is located on a ledger which is accessible to anyone who wishes to view it. The code is replicated across the blockchain and profits from the protection such tech offers. Parties involved within a particular transaction may indicate (or fail to indicate) certain parameters have been met; the code thus executes subsequent steps.

Smart contracts were developed thanks to the efforts of computer scientist Nick Szabo, who published a paper in 1994 on their concept and applications:

> A smart contract is a computerized transaction protocol that executes the terms of a contract. The general objectives of smart contract design are to satisfy common contractual conditions (such as payment terms, liens, confidentiality, and even enforcement), minimize exceptions both malicious and accidental, and minimize the need for trusted intermediaries. Related economic goals include lowering fraud loss, arbitration and enforcement costs, and other transaction cost[3].

What must be appreciated here is that contracts are "smart"—but hardly intelligent entities capable of highly sophisticated transactions. Szabo famously uses the example of a vending machine to illustrate the simplicity of this technology[4]. Much like an automated dispenser, smart contracts adhere to a set of preordained rules which trigger predefined responses, corresponding to an obvious *if-then* logic. Such conditional programming requires all outcomes to be explicitly stated; the same output will always be produced. In this sense, smart contract theory is somewhat elementary.

Smart contracts are able to execute transactions without any need for human intervention once they have been deployed (which affects the enforcement costs in traditional Transaction Cost Economics, a topic I will come to later). There is no one size fits all framework when it comes to smart contracting. Smart contracts are primarily recognised as single binding agreements between two parties but they may also accompany a traditional paper contract and merely exist to facilitate certain actions (such as transferring funds). For us to better comprehend the implications for such technology, we must turn to institutional economics.

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[3] Nick Szabo, "Smart Contracts," www.fon.hum.uva.nl, 1994, https://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart.contracts.html.

[4] Nick Szabo. "The Idea of Smart Contracts." www.fon.hum.uva.nl, 1997. https://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/idea.html.

Transaction costs economics and the role of the firm

Ronald Coase argues that firms arise in an effort to mitigate cost, presumably achieved through internalising some tasks instead of outsourcing them[5]. Transaction costs associated with hiring out could be too high due to information, bargaining and policing costs. Therefore companies continue to grow as long as internalising matters, or vertical integration, makes things cheaper; size is determined by reckoning between countervailing external and internal costs. Firms also seem to emerge when short-lived contracts are unsatisfactory. By allowing some kind of authority (entrepreneur) to direct the flow of resources, an organisation may reach higher levels of efficiency and save considerable time and money.

North asserts that transaction is costly precisely because of the considerable resources required to "define and enforce exchange agreements". The bottom line is that "costs arising from transacting are a fundamental influence on economic activity[6]". Transacting takes up resources, but the cost is amplified in the face of individual wealth maximising behaviour and asymmetric information. Enforcing the agreements is also a costly endeavour, even more so with the exchange of multidimensional goods. This creates dilemmas of cooperation. With large groups of people, where information is lacking and there is a lower degree of trust, sustaining cooperation becomes much more difficult. Through institutions, it is possible to reach successful solutions. Institutions have the ability to create conditions whereby those involved may raise benefits for cooperation and create undesirable consequences for reneging.

Smart contracts also promote cooperation and prevent backtracking on agreements. In fact, participants are aware from square one the terms of the agreement and consequences of delusive conduct. They know there is no way of violating the terms of the agreement without facing the clearly stipulated consequences. In a payment situation, if the contractee fails to send money or there is no money in his digital wallet, he will not have access to the product or service he desires. Szabo provides an interesting example using car loans: when a customer fails to make payments on his car (assuming forgiveness clauses have also been breached), the car will be rendered inoperable. In such a case the consumer has no access to the car whatsoever and cannot

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[5] Ronald H. Coase, "The Nature of the Firm," *Economica* 4, no. 16 (November 1937): 386–405, https://doi.org/.

[6] Douglass C. North, *Institutions, Institutional Change and Economic Performance* (Cambridge: Cambridge University Press, 1990), 244.

continue using it while evading his creditors[7]. Ergo, repossession agencies no longer have to pay for policing agents.

Williamson similarly argues that economising is the core problem of economic organisation. He characterises the so-called "contracting man" as an individual who is especially prone to self interest seeking behaviour. Keen awareness of such opportunism creates a kind of checks and balances environment which prevents modes of contracting from falling at either of the two extremes. They refocus attention, distinguishing between the feasible and infeasible. Transaction cost economics hinges upon uncertainty arising from random acts of nature and unpredictable changes in consumer preference (reliable fulfilment) or incomplete contracting. Williamson's point that all contracts are in sooth incomplete reinforces the notion that organisations are needed.

Smart Contract Technology in the Firm

In North's example of residential property exchange[8], he admits that though institutions lower transaction costs, they are also a "mixed bag" and may also do quite the opposite. Barriers to entry, useless inspections, and intentionally obfuscating details of a transaction are a few instances where unnecessary costs inhibit productive interactions. I argue that *the writing* of smart contracts themselves reduces risk for the seller, and uncertainty on both sides. The unambiguous nature of this technology forces both parties to explicate terms of the agreement to the nth degree from its inception. Firms are thereby forced to adhere to a certain standard, even if the agreement is not wholly digitised. Not only do both parties know exactly what is expected of them, but smart contracts may also unmask fine print actions which may be hidden from buyers during a transaction. One such case is grocery store checkout machines[9]. When making purchases, customers are entirely unaware if their names are being linked to this activity in a database. Through "hidden actions" of checkout software which has been designed to obscure important information about the transaction, customers may be handing out sensitive personal data without being any the wiser.

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[7] Some other examples from the Ethereum whitepaper: "*For example, you could write a smart contract that holds funds in escrow for a child, allowing them to withdraw funds after a specific date. If they try to withdraw the funds before the specified date, the smart contract won't execute. Or, you could write a contract that automatically gives you a digital version of a car's title when you pay the dealer*."

[8] North, 248-9.

[9] Szabo,1994.

Other costs result from human failure or subjective judgements. A traditional contract is liable to personal interpretation, wily manoeuvring, or unforeseen obstacles which result in conflict. Smart contracts "execute precisely based on the conditions written within the contract's code. This precision means that given the same circumstances, the smart contract will produce the same result[10]." A need for trusted individuals strains traditional contracts. The possibility of deviating from contract terms necessitates maintenance and enforcement so that the firm ensures all participants perform. This possibility is eliminated on the blockchain.

Parties cannot merely refuse to pay out. Thus all who partake can rely on blockchain to assure contractual obligations *will* be performed. Thus we see how smart contracts can 1) facilitate auditing, as contracts are located on a public blockchain and asset transfers/other information are easily tracked. Anyone can scrutinise this data. 2) Create more transparency in terms of the bargain. Visible terms allow participants to check what is in the contract before signing it and lends control over knowledge of terms. Firms can check who is sending money to their address if such an action has transpired. 3) Lack of discrimination against one party. Contracts are automated and not subject to human prejudice. 4) Protect privacy, since transactions are tied to a cryptographic address, not a legal name.

How smart contracts fit into this framework: dApps

DApps (decentralised applications) operate upon blockchains and through the use of smart contracts. Open source and run without required human intervention, these applications are also not owned by any single entity—instead ownership is decentralised and spread among all users. DApps can be fitted to a variety of purposes[11]. Let us examine something that is already familiar to us: a marketplace. Much like in the traditional financial world, there are also exchanges housed on the blockchain. Uniswap[12] is among the most popular of these crypto exchanges, utilising smart contract technology to enable seamless peer-to-peer transactions. The platform lists hundreds of crypto tokens to choose from. If one desires to purchase a particular coin on Uniswap, the transaction is executed by automated means. Once a desired token is selected, one simply "swaps" the ETH tokens in one's wallet in exchange for the token in a matter of seconds. The app checks the exchange rate, and tells you how much ETH the token will cost. Then,

[10] Ethereum.org. "Smart Contracts." ethereum.org, 2022. https://ethereum.org/en/smart-contracts/.
[11] Crowdfunding, lending apps, insurance, decentralised trading—to name a few.
[12] https://uniswap.org/.

Uniswap verifies if the funds are available in your wallet. If the funds are there, the app withdraws and uses them to purchase the desired token, which is deposited back in your wallet. The cost of this transaction is calculated before the swap occurs, known as a "gas fee". Any transaction which occurs on the Ethereum network has this fee[13].

The important thing to note here is that there are no centralised databases or servers required to support the application[14]. There is no need to research other participants to ascertain whether or not they will realise the agreement. We hereby observe the costs incurred within a transaction may change the way firms operate. If a firm were to utilise some kind of dApp to facilitate certain internal or external interactions, it would not need to operate a database to keep exhaustive records. Nor would the firm rely on expensive, powerful servers to store this data. Further, keeping such data on a decentralised network increases transparency and thwarts potential below-board activity, thereby reducing policing costs.

Behavioural Incentives and the Commitment Problem

To quickly touch upon collective concerns and governance[15], we look to Ostrom. If participants are acting under contract, they are incentivised to maximise profits per the wishes of the firm and complete their side of the agreement as best possible. More specifically, a firm may try to ensure participation by creating a number of contracts with the participants. These agreements direct the participants to act in a coordinated manner; they will voluntarily choose to join the firm under some set of conditions. Hence there is a voluntary non-exploitative quality since agents freely decide whether to accept the contract. Changing a group from one acting independently to one which acts with a great level of coordination comes with a high cost according to Ostrom[16]. Monitoring must be supplied to ensure conformation to agreements. However with smart contracts monitoring is far less frequent and ensuing costs are greatly reduced.

According to Ostrom, individuals are more willing to cooperate if they observe a majority doing so. If organisations require a minimum amount of participation from a certain number of people,

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[13] "*In short, gas fees help keep the Ethereum network secure. By requiring a fee for every computation executed on the network, we prevent bad actors from spamming the network. In order to avoid accidental or hostile infinite loops or other computational wastage in code, each transaction is required to set a limit to how many computational steps of code execution it can use.*"
https://ethereum.org/en/developers/docs/gas/ .

[14] Data is stored on a distributed ledger—in our case Ethereum network.

[15] Smart contracts certainly coincide with the CPR issue, but I will refrain from talking about this extensively, as it goes beyond the scope of this paper.

[16] Elinor Ostrom, *Governing the Commons* (Cambridge: Cambridge University Press, 1990), 40.

they are able to acquire greater willing contribution from the rest of the group. This type of behaviour is called frequency-dependent behaviour. Another means of changing outcomes and level of coordination is by bolstering the amount of information available to members. Implementing a set of incentives/consequences for particular outcomes is also an effective way of promoting cooperation. It seems such goals are met in part by smart transaction protocols for reasons hitherto explained[17].

How smart contracts change the economy and the firm

North argues that ability to "enforce contracts across space and time" differentiates economies from one another and is a pivotal determining factor in performance[18]. In this sense, perhaps smart agreements could provide underdeveloped countries with greater power and capacity to bolster economic performance.

Williamson voices concerns that monopoly sellers will expropriate buyers when follow on orders are placed, after the buyer has made durable investments that cannot be deployed without sacrifice of productive value[19]. It is possible to introduce a mechanism that addresses this, and if done with smart contracts there is some assurance that the seller will not engage in such hazardous behaviour. Also, contractual clauses or protocols can be embedded in the technology which cause contract breaches to be too expensive to contradict.

Blockchain does not come without its downsides. Williamson offers bounded rationality and opportunism as tools which "distinguish between feasible and infeasible modes of contracting[20]". So far, I have established how smart contracts address problems of opportunism and endow greater conviction that economic agents will reliably redeem their promises. However on the other end, so-called "impossibly complex" incomplete contracting poses a serious matter of contention with blockchain technology. Williamson urges that the limitations of bounded rationality preclude the possibility of all-encompassing *ex ante* contracting. Undoubtedly, conditional agreements by their very nature render impossible any sort of amendatory supplement to the contract. Inconsistencies and incompleteness are not uncommon; institutional mechanisms exist for dealing with these issues, but code lacks absolute solutions.

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[17] It may also be compelling to further explore this line of thought with regard to various consensus mechanisms employed by blockchain networks. Ethereum specifically uses Proof of Stake, which allows users to stake assets to participate in verification processes.
[18] North, 247.
[19] Williamson, 163.
[20] Williamson, 139-40.

Williamson characterises effective and complete contract negotiation as a fiction, and he is not misled in saying so. Indeed, the idea of any comprehensive arrangement in nuanced situations is a foolish hope. Gap filling and certain types of dispute settlements can be attained through adding "layers" to the code or with special upgrade functions in coding language[21] to enable improvements. However, these solutions are no panacea. It is evident that smart contracts require a sizable amount of investment and effort at the outset, so as to create the most comprehensive negotiation possible. This inevitably incurs transaction costs in the bargaining stage.

Importance of flexibility in transactions is highlighted in Granovetter's *The Problem of Embeddedness*[22]. He highlights the central role social relationships play in any business agreement, especially between firms. Within smart transaction protocols, flexibility is dependent upon how the code was written. Nevertheless, it is important to make a distinction here. We must differentiate between relationship based, long term contracts and impersonal, trustless interactions. On the whole, smart contracts are often used in one time exchanges or payments. The contracts Granovetter discusses deal with navigating complicated personal ties, but not all transactions are created equal. Given their inherent constraints, smart contracts may be suited for highly standardised transactions with strangers (healthcare, financial, administrative transactions for example). I have mentioned before that smart contracts are often used in tandem with traditional paper agreements, and for many firms this is an ideal arrangement. The key here is to pinpoint where smart contracts can be applied so as to reduce enforcement costs while still maintaining low bargaining costs.

Scalability and future applications of smart contracts

Now it is clear that blockchain technology ushers a new set of rules to the table. It may be too soon to speculate what influence there will be, if any, on institutions. With networks such as Ethereum, decentralised autonomous organisations (DAOs) preponderate, and it may well be that the future will see further fortification and recognition of these types of non-traditional "firms". As smart contract tech burgeons, we will likely see a development of third party arbitration services that address dispute problems and are also native to the blockchain[23]. Future

[21] Massimo Bartoletti, Maurizio Murgia, and Roberto Zunino, "Renegotiation and Recursion in Bitcoin Contracts," *Lecture Notes in Computer Science* 12134 (June 10, 2020): 261–78, https://doi.org/.
[22] Granovetter, Mark (1985). 'Economic Action and Social Structure: The Problem of Embeddedness', American Journal of Sociology 91(3): 481-510.
[23] For an interesting example of a decentralised arbitration service, see the Kleros whitepaper: https://kleros.io/static/whitepaper_en-8bd3a0480b45c39899787e17049ded26.pdf.

development of smart property or synthetic assets are another area in which smart contracts may be applied.

Conclusion

A central purpose of the firm is to mitigate costs by internalising tasks. Transaction costs have diminished over the years thanks to better available technology. However smart contracts might further this endeavour by breaking down transactions into precisely defined lines of rational code—if they can be designed cheaply and executed correctly. Removal of the middle-man speeds up transaction processes and attenuates risk, including human error. Not only can the terms of the contract be clearly delineated, but the privacy of parties involved is tantamount. Terms are programmatically executed when met and stored as non-repudiable data, reducing monitoring resources on all sides. Indeed, there may be ample up-front costs, but these are subject to situation. It may be difficult to rationalise the two, as institutional economics generally emphasises the effectiveness of the firm by stressing the benefits of centralisation. In contrast, smart contracts (which are part and parcel of a larger community that prizes decentralisation and individual autonomy above all else) lighten the responsibilities of the firm, and perhaps diminishes its size in certain cases. Blockchain is a nascent field and extremely technical. The success of the technology is trustless, but ultimately depends on the deployability of the contracts and success in write-up periods. Smart transaction protocols do not by any means usurp existing institutions, but it seems a pluralistic approach is welcome. This topic poses some interesting food for thought when pondering the future of our institutions. Smart contracting may be able to make more transparent transactions within the healthcare system, other types of insurance, and financial services.

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