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WHY DO BLOCKCHAINS EXIST?

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to my brother,

This Master's Thesis along with my studies in Law and Economics program of the University of Macedonia and the Aristotle University of Thessaloniki, would both be impossible if it weren't for my parents.

May this piece of work please their faith in me.

ABSTRACT

The word “technology” always follows the word “Blockchain”. Either perceived as a technological achievement or a general purpose technology, one thing should be taken for granted: Blockchain challenges the way people and firms interact. This paper analyzes the institutional capacity that Blockchain technology carries and presents these distinctive attributes with which Blockchain wishes to claim its thesis in the economic arena. It is argued that coordination mechanisms through smart contracts and reputation tools running on Blockchain can cultivate clusters of efficient cooperation among people, firms and organizations. Subsequently, these clusters can work as a paradigm-shifter for neighboring and competitive markets causing the further proliferation of this new way of definite coordination. Finally, this paper attempts to reply to the existential question “Why do Blockchains exist?” because it is the author’s belief that such a response is a *sine qua non* condition for the institutional character that Blockchain wishes to secure.

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A.INTRODUCTION

1. What is a blockchain?

The ledger of John Smythe, a merchant lived in Bristol in the 1500s, is a large leather-bound volume originally fastened with a strong buckle and strap. The ledger has three hundred folios with the watermark "J.Nivelle" which shows that paper was manufactured at Troyes, in north-eastern France, where the paper may have been made and then exported to England. The first folio records that *"This boke of accowmptes aperteymith to Johne Smythe marchant of Bristowe''* and carries a mark which seems to be a monogram of Smythe's initials with a cross superimposed. Each folio is headed with a cross and, occasionally having dispatched a particularly consignment, Smythe adds "God sent hit saff".

John Smythe's ledger is considered as one of the most well-preserved book records in trade history and is kept in the Bristol Archives Office as a real treasure. It remarkably captures the nature of Bristol trade and it has served ever since as a source of historical knowledge. The transactions recorded in his ledger serve as a mine of information about the status of trade not only in Bristol but in the neighboring cities and countries as well. One thing we receive by reading these pages is that the largest share of Bristol trade was associated with soap-making, beer-brewing, tanning and point making. There were also smiths, rope-makers, bakers and shoemakers. John Smythe seems to have been one of the few merchants to export cloth. Much of this cloth was originated from the villages of Somerset and Witlshire and his main supplier was John Yerbery of Bruton in Somerset.

Back then, the only element able to verify that you have the capacity to make a transaction were simply the money in your pocket. Now, for the sake of this paper, travel back in time and imagine every single merchant in Bristol keeping in his ledger a copy of the list of every transaction that was conducted by the rest of the merchants in the history of Bristol and the neighboring villages. Then picture the moment when a cloth merchant from Somerset, say Mr. John Yerbery of Bruton, decides to buy some soap from Bristol. He rides his horse and heads to Bristol with no money in his pocket. He asks the soap maker to give him some soap and but instead of money he offers him the value created from a specific transaction he had previously performed when he sold cloth to a merchant called John Smythe. The soap-maker then leaves his shop, goes down the stone-built path to the town's square asking every single merchant to check his ledger to identify the specific transaction that John Yerbery told him about. He further asks every single one to use their dusted magnifying glass to identify John Smythe's monograms and his established inscription "God sent hit saff". Several hours later, he returns to his shop, he apologizes to John Yerbery from Somester for having him waiting and he delivers him the soap without receiving any money. He then returns back to every merchant of Bristol to inform them about the transaction. After that, he goes to the baker's to buy a loaf of bread with no money in his pocket. He just informs the baker about a previous transaction he had conducted with John Yerbery of Bruton in Somester. Same story, different time. Endlessly.

It is needless to say that the construction of such an economic system would be ridiculously ineffective for Bristol in the 1500s. Today though, things seem to have changed a little bit.

The term "Blockchain" is used to refer to a data structure consisted of blocks (the descendants of Smythe's folios) of transactions (i.e one purchase of cloth, one purchase of soap and one purchase of a loaf of bread) chronologically recorded in a network of computers. Every block in a blockchain, once approved by a certain and predefined procedure, is "chained" back to its previous block, by creating a cryptographic hash of the representation of the previous block and embodying it to its structure. No new block is added to the sequence of blocks unless the computers of the network (the merchants of Bristol) reach consensus as to the validity of the transaction (Wright & Filippi, 2015). Once added to the blockchain, a transaction record encrypted in the annexed block demands a tremendous amount of difficulty and energy so as to be altered or erased. This allows blockchains to become a ledger, whose immutable and public character render them transparent and accessible to anyone with the appropriate permissions. Thus, by allowing people to transfer a unique piece of digital property or data to others, in a safe, secure, and immutable way, the technology can create: digital currencies that are not backed by any governmental body; self-enforcing digital contracts (called *smart contracts*), whose execution does not require any human intervention; decentralized marketplaces that aim to operate free from the reach of regulation; decentralized communications platforms that will be increasingly hard to wiretap; and Internet-enabled assets that can be controlled just like digital property (called *smart property*) (Wright & Filippi, 2015).

2. Types of blockchain

The main categorization of blockchains is based on a) whether a blockchain system is accessible to anyone or demands prior permission for a node's entry and b) whether every node can participate in the verification process of a transaction or only a preselected group of nodes can undertake this procedure of key importance.

a. Public and Private Blockchains

Public Blockchains such as Bitcoin, are decentralized networks where everyone can have access at any level, read and conduct transactions. Public blockchains are always run through a specific token.

Private Blockchains are smaller networks of a predefined size and closed membership status. They are usually restricted to users within an organization or consortium (*consortium blockchains*) where the exchange of information and data is considered confidential. The distinction between the consortium and the private blockchains has been emphasized by Vitalik Buterin since the former consists a hybrid between the "low-trust entity" provided by public blockchains and the "single highly-trusted entity" model of private blockchains, whereas the latter can be more accurately described as a traditional centralized system with a degree of cryptographic auditability attached (Buterin V., 2015).

b. Permissioned and Permissionless Blockchains

Bitcoin is a *permissionless* network. Permission refers to the authorization for verification, and in Bitcoin-style platforms anybody can join the network to be a verifier without obtaining any prior permission to perform such network tasks. Because these verifiers are vital to the operation of the network, their participation is encouraged (and indeed incentivised) through the issuance of new currency that is paid to them once they have verified a block of transactions, the so called 'Proof-of-Work' concept to be discussed below.

Permissioned blockchains have a set of trusted parties to carry out verification, and additional verifiers can be added with the agreement of the current members or a central authority (Gareth & Panayi, 2016). Permissioned blockchains are intended to be purpose-built, and can thus be created to maintain compatibility with existing applications (financial or otherwise). They can be fully private (i.e. where write permissions are kept within an organisation), or consortium blockchains (where the consensus process is controlled by a pre-selected set of nodes) (Buterin, 2015). In fact, permissioned blockchains allow us to do things we already do in a fundamentally better way by offering us the advantages of blockchain technology without the troublesome openness of the Bitcoin network where anyone can be a node on the network anonymously (Szabo, 2015). It's worth mentioning that Barclays, Credit Suisse, KBC, SIX, Thomson Reuters and UBS are currently looking at ways to automate MiFIDII regulatory requirements aiming at strengthening investors' protection, through a permissioned blockchain. The collaboration, tests the quality of counterparty reference data through anonymous reconciliation with industry counterparts, run on a permissioned blockchain on the Microsoft Azure cloud platform (Allison, 2017).

3. Smart Contracts

Now, picture again the old Bristol of 1500s. Imagine that John Smythe meets his main cloth supplier, John Yerbery of Somester, and proposes him the following deal:

"John Yerbery of Somester, every weekday, at 15:00, no matter where you are and what you do I will be granting you the value of a loaf of bread in exchange for the respective value of your cloth. The deal will be written down on every single copy of our common ledgers in Bristol. The baker will be able and obliged to recognize the value you claim before him but beware because once we sign this deal you cannot exit it unless 90 days pass". John Yerbery agrees and afterwards decides to pay a visit to the baker's to propose him the following deal:

"Baker of Bristol, every weekday, at 15:01, I will be in your baker's. I will be granting you the value of a loaf of bread in exchange for a loaf of bread. The deal will be written down on every single copy of our common ledgers in Bristol. Beware though, because once we sign this deal you cannot exit it unless my previous contract with Johne Smythe expires. Please also note that the days when the road from Somester to Bristol is inaccessible due to weather conditions, they will not count and thus the amount of loafs will be increased respectively the next available day”. The baker agrees and thus everyday 2 transactions (one including mere value and one including property) will be being carried out autonomously, self-sufficiently and in a decentralized way.

The idea of smart-contracts originates from Nick Szabo (Szabo, 1997) and it stems from the use of the vending machine but goes well beyond that. What’s new about Smart Contracts? What is the structural difference between them and the already existent automated contracts? Blockchain can be regarded as a “paradigm-shifter” in the sphere of contracting: *it allows us to automate the process of performance contractual process of both parties*. Old-school vending machines automate performance only of one party, requiring at least some personal involvement on the other side (e.g. coin insertion or application of a banking card). When both parties’ performance can be fully automated a new quality of contract occuers, even triggering a question, whether there is still a contract in a legal sense and not some other kind of phenomena (Savelyev, 2016). Szabo’s theories may have seemed unrealistic until recently due to the inexistence of a technological platform to house these smart contracts. However, the emergence of the blockchain technology relaunched his ideas.

In simple terms, a smart contract is a written contract that has been translated into code and build as complex *if-this-then-that* statements. The contract can self-verify that conditions have been met to execute the contract. It does so by pulling trusted data from outside sources (i.e. the Global Forecast System). And once there is a condition to which certain legal consequences are attached, the smart contract executes the corresponding statements and any other potential contractual consequences. Smart contracts in blockchains are typically programmed in a procedural language in that the programmer writes an explicit sequence of steps that are executed to produce what has to be done (Idelberger et al., 2016). On the platform Ethereum, for instance, developers can encode smart contracts in a procedural language called *Solidity*. Smart Contracts can be built around many different types of ideas and do not need to be financial in nature. Smart contracts can do all this while remaining tamper resistant from outside control. Blockchain technology allowed smart contracts to come into existence because smart contracts offer the permanence and corrupt resistances that were once provided only by paper, ink, and a trusted authority to enforce it all (Laurence, 2017).

Smart contracts are deterministic by nature. Same input will always generate the same output. If one writes a non-deterministic contract, when it is triggered it will execute on every node on the network and may return different random results, thus preventing the network from reaching consensus on its execution result (Christidis & Devetsikiotis, 2016). Contrary to the permissionless Bitcoin-style blockchains where nodes conduct mere asset transfers, smart contracts enable blockchains to foster a plethora of "interactions" between its nodes. More specifically, a member in a smart-contract based blockchain can (a) inspect the code and identify its outcomes before deciding to engage with the contract, (b) have certainty of execution since the code is already deployed on a network that neither of them controls fully, and (c) have verifiability over the process since all the interactions are digitally signed. The possibility of a dispute is eliminated (when all possible outcomes are accounted for) since the participants cannot disagree over the final outcome of this verifiable process they engaged in (Christidis & Devetsikiotis, 2016).

Smart contracts are also legally blind. They are egalitarian by their nature and thus they neither shelter weak parties nor take into account the principles of lawfulness and fairness. Once a smart contract enters into force, its uninterrupted execution is inevitable because the parties are even deprived from the right to legally breach it. Furthermore, smart contracts in combination with the immutable nature of blockchain platforms can foment illegal activity (Bloomberg, 2017). These special traits along with their innate characteristics of automation and self-sufficiency create a *sui generis* field for their cultivation. The emerging field of Smart Contracts could be envisaged somewhere among the boundaries of law, economics, sociology and informatics. As a result the very first step that needs to be taken towards the domestication of this fierce technology is the understanding of its utility.

B. A NEW INSTITUTION IN THE ECONOMIC ARENA

1. *Not just a #technology*

The word “technology” has always been standing next to “Blockchain”. Having been the institutional background of Bitcoin revolution, led many people to consider Blockchain as a powerful helping-hand for platforms and applications due to its capacity on information and data processing. Firms and organizations could reduce their production costs associated with any endeavor to produce a particular output, by taking advantage of blockchain technology and its effect on marginal factor productivity.

With the historical role of Blockchain technology being the extinction of the middleman and the substitution of the ledgers, the discussion was at first focused on the potential decentralization that Blockchain technology could have over centralized solutions. Blockchain’s trustless character enables them to disrupt any centralized system so that they run down three exponential cost curves:

(1) Moore’s law (cost of processing digital information, i.e. speed, halves every 18 months);

(2) Kryder’s Law (cost of storing digital information, i.e. memory, halves every 12 months); and

(3) Nielsen’s Law (cost of shipping digital information, i.e. bandwidth, halves every 24 months) (Wiles, 2015)

As such, the future of Blockchain technology was at first envisaged through cost curve diagrams. It was exactly this curve’s downward trend that disseminated the belief that Blockchain technology is about to become the next opponent of the traditional centralized ledger and maybe someday the technological substitution of the latter. This technological approach to the economics of Blockchain suggests that blockchain is in the early disruptive phase of a Schumpeterian process of ‘creative destruction’ that will likely be unfold along a logistic adoption-diffusion trajectory. This is the model of an evolutionary process of market and industrial dynamics - in which blockchains constitute new species of the 'technium'—eventually forming a new techno-economic paradigm (Davidson, Primavera, & Potts, 2016).

In the meantime, during the heated debate on Bitcoin and cryptocurrenices another approach to Blockchain technology emerged. It was an approach which examined the blockchain from a different, more revolutionary perspective. In fact it could be stated that these discussions on the revolutionary character of the Blockchain technology came as a "fork-event" in the ongoing series of events of the global perspective that lead to the belief that Bitcoin will someday "rule the world".

While blockchains can certainly be understood as a new general purpose information and computation technology, there are those who claim that it should be better understood as a revolutionary new institutional technology for economic coordination (Davidson, Primavera, & Potts, 2017) (Wright & Filippi, 2015). Due to the power of decentralization that blockchains brought, the scope of its potential analysis was rapidly expanded. Blockchain technology was not only considered as a way to minimize costs and facilitate market transactions. It was rather obvious that it wasn't just a technology for reducing production costs. On the contrary, blockchain seemed to be more of a General Purpose Technology over time. Its potential to disrupt the very notion of human organizations and shift the balance of power away from centralized authorities in the field of communications, business, and even politics or law (Wright & Filippi, 2015), has gradually altered the way people think and talk about blockchain.

In this context, the institutionally focused analysis of this new coordination technology was concentrated on a different aspect, namely a foundational technology for new forms of governance providing rule-governed economic orders. In this governance-centred view, blockchains compete with firms and markets, as institutional alternatives in coordinating the economic actions of groups of people (Davidson, Primavera, & Potts, 2017). Thus Blockchains' potential moved well beyond the value and prospect of Bitcoin revolution and monetary efficiency. In a sense, the Blockchain technology transformed the tug of war between markets and firms into a three-way battle. A new player had thus emerged in the economic institutions' arena.

2. *The economics of Blockchain*

The Blockchain is *ab initio* a technology of decentralization and disintermediation. Decentralized ledger technologies "combin[e] peer-to-peer networks, cryptographic algorithms, distributed data storage, and [ ] decentralized consensus mechanisms" to enable "people to agree on a particular state of affairs and record that agreement in a secure and verifiable manner." In other words, decentralized ledger technologies create "online lists, maintained by no one and available to everyone, [and] are maintained by a consensus protocol" (Reyes, 2016). Blockchain technology enables users to verify, send and/or receive information through a specific protocol instead of using centralized networks or electronic platforms such as Google Drive or Gmail. Blockchains' truth is built block by block through consensus mechanisms which demand the prior consent of the "chains". Thereby, distributed ledgers, such as blockchains, are a technology for manufacturing consensus. Facts that are instrumental for the economic coordination, a role historically dominated in market capitalist economies by governments, large firms and middlemen, are just a matter of a digital protocol running in Blockchain (Davidson, Primavera, & Potts, 2017).

Looking back in history, we can recall that firms emerged because of their comparative advantage to reduce transaction costs. Ronald Coase, author of "The theory of the firm", tried to explain the ratio of the firm by answering the *quasi* existential question of "Why do firms exist?". Therefore the basic insight of the institutional economics (also known as transaction cost economics) was to ask why do some transactions occur in firms (hierarchies) rather than in markets (Davidson, Primavera, & Potts, 2017). The answer was that because of transactions costs in dealing with uncertainty, asset specificity and frequency of dealings, some transactions are more efficiently conducted in hierarchies rather than markets (Williamson O. , 1985). In this context, if Blockchains are willing to have a place in an arena historically dominated by markets and firms, they must provide a solid response to the question "Why do blockchains exist?"

a) Coordinating People

In the Williamson (Williamson O. , 1985) operationalization of Coasian transactions cost analysis, a hierarchical organization is a method for controlling opportunism in the presence of bounded rationality and asset specificity. The need for protection against opportunism and the quest for a way to build trust led to the creation of hierarchical organizations such as the firms. Hierarchy is not merely a contractual act but is also a contractual instrument, a continuation of market relations by other means (Davidson, Primavera, & Potts, 2017).

Cooperation and trust have always been spontaneous and scarce in the markets. On the contrary, firms provided a framework of intended cooperation and *quasi* imposed trust. The value of such cooperation was first introduced by Chester Barnard, an executive with great impact on academia, and was defined as "*that kind of cooperation among men that is conscious, deliberate, purposeful*" (Barnard, 1938). Blockchains now face the challenge of setting the condition of trust in a whole new framework.

Within a Blockchain, coordination and trust construction work by enabling a spot market exchange to carry forward indefinitely a pure promise. In reality, its radical public transparency in combination with its crypto-consensus mechanisms, executed automatically with smart contracts, are the critical features which blockchains aim to disrupt the economic arena with.

Transparency means that "what is written in a blockchain cannot be erased". Transactions conducted using blockchain are viewable by the public and cannot be altered, thus, their integrity and transparency are guaranteed (Morabito, 2017). By setting up such an immutable public record, blockchain technology sets the foundations for a society of checks and balances since everyone's activity, either he is an individual or a transnational organization, will be accessible and viewable by everyone. This is precisely the sort of core infrastructural element that could allow humanity to scale up to orders-of-magnitude-larger progress with truly global organizations and coordination mechanisms (Swan, 2015).

However, no system, albeit its transparent character, would be credible without having its inputs reviewed and its accuracy tested. One implication of transferring value with blockchain-based smart networks instead of relying on human-based institutions is that the traditional intermediaries responsible for verifying and validating transactions may become obsolete (Swan & Primavera, 2017). In blockchain, the question on how to reach consensus among the untrustworthy nodes is a transformation of the Byzantine Generals (BG) Problem (Laport, Shostak, & Pease, 1982). In BG problem, a group of generals who commanded a part of the Byzantine army, circle the city. The attack would fail if only one part of the generals entered the city. Generals needed to communicate and reach an agreement on whether to attack the city or not. However, there might have been traitors amongst the generals. A traitor could send different message with decisions to different generals. This is an untrustworthy environment. How to reach a consensus in an environment similar to that is a challenge. It is also a challenge for Blockchain as the Blockchain network is distributed. In Blockchain, there is no central node that ensures ledgers on distributed nodes are all the same (Zheng et al., 2017). The procedure or agreement-system that enables blockchain to verify the validity of every single block (data, transaction etc), that aims to be “chained” in its sequence, is called *consensus* and its goal is to ensure that the blockchain ecosystem remains immutable and self-sufficient.

Every blockchain has its own way of reaching consensus, as there are many ways of reaching consensus within a society. The text of the rules applied for the verification of the one and only true version of a blockchain is called *Consensus Protocol* or *Consensus Mechanism* and shields the credibility of the transactions within a Blockchain. There are plenty of mechanisms which differ in terms of who validates an input, how and why. In public blockchains every node can join the consensus process, while in the permissioned blockchains only certified nodes can undertake and accomplish this procedure. In fact, the consensus protocol embodies these principles of cooperation that each blockchain wishes to carry. Hence a further elaboration on them would be worth doing:

Proof of Work (or PoW) is the most famous consensus mechanism in Blockchain technologies since it determines the function of the Bitcoin platform. The creation or verification of a new block in the *Proof of Work* ecosystems depends on the computational power of the *miners*, a group of computers who compete to solve an extremely difficult cryptographic puzzle. The reason why miners spend tremendous amount of energy in such a “race” is the prize, as the miner who solves the puzzle receives tokens and transaction fees as a reward.

Proof of Stake (or PoS) is the most common alternative to the proof of work mechanism. Unlike the miners’ race in the Proof of Work system, the validators and creators of a new block in the *Proof of Stake* systems are chosen in a deterministic way based on their wealth and/or luck. Thus, *Proof of Stake* naturally aligns the incentives of digital currency holders in the blockchain with the good operation of the blockchain (Xu, et al., 2017).

Delegated Proof of Stake (or DPOS) is the more representative democratic alternative to the *Proof of Stake System*. In this the generators and validators of new blocks are elected by the stakeholders of a blockchain. The credibility of these “delegates” is assured through the fear and the easiness of being voted out. *DPOS* has already been implemented as the blockchain on which BitShares is running.

There are numerous alternative consensus mechanisms such as the *Byzantine Fault Tolerance Protocol*, the *Proof of Activity*, the *Proof of Burn* etc. Some of them have unique characteristics while others combine characteristics of the aforementioned protocols. Thus, from the very first day of its existence and despite the chosen protocol, every blockchain maintains a holy book describing in a crystal clear way how it functions.

At the end of the day though, the fate of every consensus mechanism is ultimately determined by their members’ incentives to act in prudent or malicious manner and by their willingness to cooperate. In this context, some examples of protocols punishing bad actors started to appear in consensus mechanisms. *Casper protocol*, for instance, achieves economic finality by requiring validators to submit deposits in order to participate, and taking away their deposits if the protocol determines that they acted in a way that violates some set of rules. This *quasi* legal norm which runs in Casper Protocol is called *slashing condition*, a term introduced by Yoichi Hirai (Hirai, 2018) and elaborated on by Vitalik Buterin (Buterin, 2017) , the co-founder of Ethereum platform. “Crypto-Economics”. As a consequence of the above mentioned, a scientific area to study the incentives within a blockchain has appeared and has recently gained much attention (Buterin, 2018). Coding behaviors of individuals and organizations in a “smart” environment consists a brand new and troublesome challenge for traditional programmers. The ratio of this challenge is based on the nature of the coding “needs”. A group of researchers (Delmolino et al., 2015) shared their experience of their efforts to teach “smart programming” to a group of students in a cryptocurrency Lab. “Smart contract programming requires an “economic thinking” perspective that traditional programmers may not have acquired” they concluded. Contracts must be written to ensure fairness even when counterparties may attempt to cheat in arbitrary ways that maximize their economic gains”. As a consequence, if blockchains wish to set up a field of effective people’s coordination, a deeper understanding of their cornerstone is essential.

b) “Smart” is the new black

Human involvement in the drafting and the implementation of contracts has been remarkably minimized during the last decades. Today, the vast majority of market transactions are executed through standardized terms with little or no negotiation background. People can purchase a product at a click of a button by giving their consent in an agreement whose terms are well predefined. Information society will try to go further by minimizing human involvement not only in defining the contractual terms but also in their enforcement. Besides, new types of agreements may be also concluded without direct human involvement, by electronic agents. “Smart” contracts are a good example of the development of contracting procedure towards this direction (Savelyev, 2016).

By buffeting the tectonic plates of contracts, automation in agreements may come to its completion with smart contracts. Naturally, this shift will trigger further fundamental changes in the very vital principles of the economic system. Mostly, smart contracts aspire to challenge the most primitive and dynamic characteristic that contracts ever carried: their incompleteness.

The creeping uncertainty that "tailgates" almost every transaction has been the cornerstone of the development of our economic system. Although, current legal structures establish a framework of regulation for the uninterrupted and consistent implementation of a contract, there has always been an elephant in the room, meaning the possibility of a sudden termination for which the contractual parties would never speak a word. Contractual incompleteness has thus become the origin of the study of economic organization and governance.

1. *Efficient Breach*

According to Black's Law Dictionary, efficient breach theory is *"the view that a party should be allowed to breach a contract and pay damages, if doing so would be more economically efficient than performing under the contract*." Richard Posner defined the *efficient breach* in the most succinct way and laid the foundations for one of the most dominant ideas of Law and Economics.

[I]n some cases a party [to a contract] would be tempted to breach the contract simply because his profit from breach would exceed his expected profit from completion of the contract. If his profit from breach would also exceed the expected profit to the other party from completion of the contract, and if damages are limited to loss of expected profit, there will be an incentive to commit a breach. (Posner, 1977).

The theory of efficient breach has added an additional burden of uncertainty in contracts. Moreover, efficient breach often leads to inefficient outcomes because the compensation may be smaller than the expectations of the promisee, or has diminished due to supplementary costs such as delay, lawyer's fees and uncertainty about the court's verdict. Apart from assuming empirical facts that are difficult to observe, the theory of efficient breach has also received criticism based on moral rules. Efficient breach is thus considered as distortive to the notion of "obligation" because it adds the element of will to the contractually fundamental duty of "keeping your word". However, despite the criticism, efficient breach has been a theory that historically followed the signing of a contract by reflecting the freedom of the parties to decide whether or not to fulfill the obligations deriving from it. The non-performance decision of a contractual party may be based on changing of the conditions that occurred or on a possibility of better allocation of resources. For example A promises to sell a property to B and the next day receives a proposal from C that it is sufficient enough both for satisfying A and compensating B. Rendering such a capability impossible will be economically irrational.

In the digital world of blockchain there is no room for "efficient breach". In fact there is no room for "breach" at all. Judicial enforcement is thus less needed in a system controlled by self-executing contracts, as the manner in which the rules have been defined in the code matches exactly the manner by which they are enforced (Morabito, 2017). Thereby, smart contracts are technically binding for all the parties to it, they are no longer dependent on any human intermediary. In the meantime, a subsequent change of circumstances, or the intent of the parties towards such a change, is irrelevant (Savelyev, 2016). The only modifications that can be made to smart contracts are those that were built into the original contracts as dormant alternatives (Marino & Juels, 2016). The other side of the coin says that it is exactly this smart contract's clarity that may work as a deterrent factor. Indeed, the contractual parties' inability to exit a smart contract provoked many reservations against their adoption and it cannot be doubted that their inflexibility may further lead to inefficiencies. Computer code must be precisely and completely defined, because at root it is a series of if–then instructions that must all be resolvable by a computer. A smart contract cannot contain a term that has one meaning at the time of execution and takes on another meaning later (Sklaroff, 2018). This inflexibility is yet regarded as a problem only under the perception that smart contracts and blockchains are inventions aiming at replacing markets and firms. However the scope of this paper is to demonstrate that blockchains and smart contracts are not the deterministic future of transactions that will darwinically set aside markets and firms. On the contrary, they should be considered nothing more than an emerging third way of coordinating people's interactions, with its pros and cons. And still, this is revolutionary.

2. *Reputation matters*

Bounded rationality, eloquently captured in the widely cited prisoner's dilemma, implies that individuals will act as profit maximizers if the breach of a contract offers more profit than its preservation.

As described above, the termination of a contract is preferable to its maintenance when the short-term gains override the future gains. Performance, on the other hand, is assured when:

1) W1 < W2

W2, the capital cost of the expected lost future profit stream that is imposed upon a nonperforming transactor when the relationship is terminated,

2) $W2 = \Pi 0 * + \frac{\Pi 1}{1+r} + \frac{\Pi 2}{1+r} + \cdots$

is called the transactor's reputational capital. The magnitude of each transactor's reputational capital determines, according to (1.), the efficacy of the self-enforcement mechanism (Klein, 2000).

In our daily life we rarely know the person with whom we interact in economic terms. Thus we base our trust in our instinct or knowledge about his reliability. Our instinct is guided and our knowledge is enhanced through one's reputation. Agents with an intact reputation successfully advance the aims of their organisation (functional reputation), they act responsibly (social reputation) and they have a profile that clearly delimits them from the competition (expressive reputation) (Klewes & Wreschniok, 2009).

Now, imagine a community of traders where reputation matters in every single transaction. In such a community, improved reputational effects attenuate incentives to behave opportunistically in trade, since the immediate gains from opportunism in a regime where reputation counts must be traded off against future costs (Williamson O. E., 1991). Blockchain ecosystems can become such communities.

Blockchain entrepreneurs will quickly determine, via the destruction of early platforms at the hands of bad actors, how important reputational guidelines are within their blockchain networks—guidelines that go beyond the simplistic "average score" method and attend to the following issues:

- **Collusion**—Shilling Attack, where malicious nodes submit dishonest feedback and collude with each other to boost their own ratings or bad-mouth non-malicious nodes

- **Reputation Cashing**—Agents cashing in on their good reputation to carry fraudulent transactions with higher gain
- **Strategic Deception**—Establishing initial trust for new agents more dynamically (using reputation on other networks, feedback from agents that they have transacted with)
- **Faking Identity**—Agents faking identities within social impact networks to steal disbursed, charitable resources (Greenfield, 2017).

There are numerous blockchain platforms that have developed detailed reputational systems for reviewing the transactions' history of a member. *Repute* is such a decentralized autonomous platform for validating domain specific reputation (expertise). *Repute* includes 4 main components:

1) A dynamic list of system-generated sub-tokens, representing reputation/expertise in any domain.
2) The **forum** of expertises. For each expertise, there is a linked list of posts, where each list has a sub-token assigned to it, based on its root post, called the **expertise tag**. Each post can include opinions, evidence of work, evidence of expertise, policies, and contract templates. A **post** is a trivial smart contract on the Ethereum blockchain, typically a short text post.
3) The **bench** of anonymous experts/validators who stake their respective sub-tokens to answer validation requests or proclaim their availability for off-platform work.
4) The **validation pool**. Experts may stake their expertise-specific tokens in order to validate or invalidate posts through a betting pool. This is used to answer validation requests, set precedents, promote specialization and proficiency (Calcatera, Kaal, & Adrei, 2017).

Verify is a different example for calculating the rating history of a contractual party. The mechanism governing reputation calculation in the general case is described as follows:

1) Establish clear expectations from the parties engaging in the transaction. These expectations vary depending on the transaction, but an example may be:
    A. Buyer to pay a certain *amount* (in stablecoin)

B. Seller to provide *item* by *date* in *condition*. The item should be described in with as much detail as possible.

2) Buyer initiates the transaction by fulfilling their obligation and transferring the mutually agreed amount to the Verify escrow account.
3) A portion of the transaction amount is set aside as an "insurance fee" on the transaction and retained by Verify as company revenue. This amount must be settled in CRED tokens.
4) The remaining funds are stored in escrow until the transaction is completed (either through a confirmation from the seller or once the deadline has passed). When the transaction is closed, there are two possible outcomes:
   A. Buyer is satisfied: funds are immediately released to the seller in full.
   B. Buyer is unsatisfied: funds remain on hold, and the dispute resolution process is initiated (the exact process is discussed in Section 4.1.3).
5) Reputation is updated for both parties **simultaneously** (to prevent retaliatory attacks. The impact that a transaction has on each party's reputation is defined by application but consistently applied across all users of the application (Alirhayim, Mokdad, & Vorobyev, 2017).

Open Bazaar, a free online marketplace to buy and sell goods / services using Bitcoin, introduced the term of *decentralized reputation* in his effort to set up a protocol for reputation building within an ecosystem of pseudonymous decentralized market-place (OpenBazaarTeam, 2015).

Blockchains are thus developed to be reputation-friendly ecosystems and in the meantime specific protocol norms (i.e. *slashing conditions*) can render reputation capital a *sine qua non* condition for transacting within their ecosystem. As a result, reputational clarity along with smart contracts' capability of establishing uninterrupted and precise contractual relations among the parties, pave the way of an unprecedented way of people's, firms' and organizations' interaction.

c) Building global network pipelines

Today, interfirm networks of companies are proliferating all over the world. The scope of such alliances is primarily the knowledge sharing among its members.

Although there are these who believe that firms are unlikely to suspend self-interest in alliances and that trust may often be a result rather than a cause (Koza & Lewin, 1998), the growing knowledge-intensity of trade and services renders these alliances *quasi* essential for firms aiming to thrive in the world stage. One of the most effective ways of knowledge sharing has always been the direct communication of companies driven and facilitated by their proximity. Neighboring companies set up clusters within which the locally embedded knowledge is shared and exchanged by various methods. Porter (Porter, 2000) defines a cluster as 'a geographically proximate group of inter-connected companies and associated institutions in a particular field, linked by commonalities and complementarities', while also stating that the geographic scope of a cluster can 'range from a single city or state to a country or even a group of neighboring countries'. The operative event or the cement that holds a cluster still, is the willingness of suppliers to join an already existent a specialized industry cluster because they consist a valuable market. By locating near to these clusters they minimize the transaction and transportation costs thus gaining economies of scale.

However, as elaborated in *Bathelt et al* (Bathelt, Malmberg, & Maskell, 2004) "While a large number of studies in economic geography and related social sciences have emphasized the importance of local networking relatively few empirical studies have actually provided convincing empirical evidence of the superiority of local over nonlocal interaction, aside from some well-known case studies on industrial districts and creative milieus". Empirical work on regional linkage patterns has provided evidence that even in regions such as the San Francisco Bay area and Baden-Württemberg, which are often portrayed as prototypes of regional networking, internal transactions are by no means dominant over external relations. Not surprisingly, an increasing number of studies have begun to question the seemingly dominant character of local learning processes.

Setting up global pipelines has always been a burdensome procedure in that it demanded trust, time and money. However, such partnerships have always been offering a comparative advantage to firms due to the transmission of knowledge created in numerous parts of the world. Till today, communication processes in global pipelines have been contingent by nature and plagued by great uncertainty. Common institutions and procedural rules were established step by step, constantly being reshaped by experience. The establishment of such global pipelines could only be accomplished through a set of procedural rules involving a sequence of transactions and interactions wherein small risks are followed by larger ones and commitments progressively increase (Lorenz, 1999). Moreover, knowledge flows through pipelines were not automatic and participation was not free. The processes behind the establishment and maintenance of global pipelines must have been predesigned and planned in advance, and they required specific investments (Bathelt et al., 2004). There were two major challenges that demanded meticulous negotiations and excessive research: the selection of the partners and the development of shared institutional context.

Blockchains seem to have the potential to facilitate the trusting procedure between firms and organizations thus simplifying the creation of network pipelines. By establishing trustless systems of coordination through smart contracts, blockchains enable firms to come together via a digital form of trust to a new type of cluster in which geographical proximity stays out of the equation. Indeed, blockchains – especially private ones- can become the stepping stones of the aforementioned shared institutional context for interfirm cooperation and expand the light of the local clusters throughout the globe. Firms and organizations alliances can be established to run on Blockchains thus minimizing transaction costs and the chance of opportunism. In such a context, actors can overcome the identification advantage of local clusters and bridge the cognitive distance among its members by forming an automatic and predefined set of rules according to which the alliance will progress. The notion of proximity is consequently enriched in terms of cooperation in order to encompass not only the geographically neighboring actors but also the digitally connected ones.

In the meantime, apart from altering proximity's notion, blockchains can foster communities of long-term partnerships with standardized level of cooperation and blind trust. A burgeoning body of research shows that when firms need innovation and knowledge inputs from suppliers rather than just standardized commodities, no combination of strong hierarchical control and market discipline can assure as high a level of performance as trust-based community (Adler, 2001). Hierarchy and market are relatively more effective for the governance of low-knowledge–intensity transactions where efficiency, rather than innovation, is critical. Where knowledge management is the critical task, the more effective approaches rely on long-term partnership style relationships based on ‘‘goodwill’’ trust, as well as competence- and contract-trust (Sako, 1992) (Bensaou & Venkatraman, 1992). For trust to become the dominant mechanism for coordination *within* organizations, broadly participative governance and multi-stakeholder control would need to replace autocratic governance and owner control—even if hierarchy, in a high-trust form, continued to characterize large-scale enterprise. And, for trust to become the dominant mechanism for coordinating *between* organizations, comprehensive but democratic planning would need to replace market competition as the dominant form of resource allocation—even if market retained an important subsidiary role (Adler, 2001). Thereby, community becomes the most suitable institution beyond markets and firms to foster cooperation between and within firms. Subsequently, blockchains can become the fundamental institutional framework to cultivate partnerships within these communities through the implementation of well-programmed, self-sufficient and open smart contracts. The cultivation of such communities is also an endogenous procedure that may affect neighboring or subject to competition communities. It has been observed that a long term, trust-based partnership within a community can foster the necessity for serious, sustained, self-conscious efforts to create trust among neighboring or competitive actors (Sabel, 1993).

And thus, step by step, cluster by cluster and pipeline by pipeline, blockchains may fertilize a new form of trust and finally a new era of cooperation.

C. CONCLUSION

Blockchain is labeled as “technology” but it should not be perceived merely as such. On the contrary, it should be regarded as a socioinstitutional mechanism whose functionality is expanded well beyond the rest of the general purpose technologies mainly due to its ability to foster a new type of cooperation among people, firms and organizations. As a result, if we had to provide an answer to the *quasi* existential question of “Why do Blockchain exist?” we would choose to say: “because they render contracts complete”.

Indeed, through reducing the uncertainty of a transaction by making its breach impossible and the element of reputation important, Blockchains have the potential to cultivate communities where compliance is unavoidable and thus contracts are complete. Since Smart contract as described above, is having software code in its core, its terms are expressed in one of computer languages, which are rather formal languages in their substance: with strictly defined semantics and syntax. Computer language does not allow discretion in its interpretation by machine. Thus, the precision of programming languages is able to mitigate possible issues associated with unpredictable interpretation of contractual terms by the party to the contract or enforcement agency. Although ambiguity may exist in programming languages, these ambiguities are less than in the real world because there are simply fewer terms that a computer can recognize than a human can recognize. Smart contracts are thus threatening the domination of incomplete contracts in the economic system. Thanks to them, alliances of complete contracts running under pre-existing norms with immutable continuation in time and with crystal clear arrangements among its members are feasible. Such clusters of complete contracts have at the end, the ability to be gradually hatched and multiplied within a whole group of firms or people, the society and subsequently the world.

Will these elements push Blockchains to set aside markets or firms? No, Blockchain technology seems neither able nor willing to adopt such an ambition. By leafing through the pages of economic history though, we can witness that apart from these who avoid a contract's clarity, there are also those who are seeking it. Apart from these who favor a contract's flexibility, there are also those who prefer the one-shot solution. And apart from the moneylenders in the villages of India as we read in the conclusion of Akerlof's article "The Market for Lemons" (Akerlof, 1970), there were also banks.

Today, there are still banks in India.

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