The Drivers Behind Blockchain Adoption: The Rationality of Irrational Choices

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Abstract. There has been a huge increase in interest in blockchain technology. However, little is known about the drivers behind the adoption of this technology. In this paper we identify and analyze these drivers, using three real-world and representative scenarios. We confirm in our analysis that blockchain is not an appropriate technology for some scenarios, from a purely technical point of view. The choice for blockchain technology in such scenarios may therefore seem as an irrational choice. However, our analysis reveals that there are non-technical drivers at play that drive the adoption of blockchain, such as philosophical beliefs, network effects, and economic incentives. These non-technical drivers may explain the rationality behind the choice for blockchain adoption.

Keywords: blockchain, distributed ledger, technical drivers, non-technical drivers

1 Introduction

Blockchain technology has received a huge interest ever since its inception in the cryptocurrency Bitcoin [22]. Indeed, on a global scale companies and governments [27] are looking for applications of this technology [13]. Cryptocurrencies, in particular Bitcoin, are the best-known and most successful scenario where blockchain technology has been adopted, but many other applications of blockchain have been proposed, such as supply chain management[28], identity management[15], and smart energy grids [29].

However, the justification for using a blockchain in many of these scenarios is unclear. Indeed, many papers have argued that using a blockchain is not the best – or not even a good – solution for particular scenarios [17]. This has led to the proposal of methodologies for deciding if blockchain is an appropriate solution for a given scenario, from a technical point of view [25,39]. However, non-technical drivers are not typically discussed in most of the computer science literature. In this paper we try to look beyond this technical view, and we also consider the non-technical drivers behind the choice for blockchain in real-world scenarios.

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To do this, we consider in Section 3 three real-world scenarios in which blockchain technology is used, namely, the cryptocurrency Bitcoin, the identity management solution uPort, and a supply chain scenario for agricultural products, namely table grapes. Here we also identify and analyze the drivers behind the adoption of blockchain for these scenarios. We distinguish four categories of drivers: technical properties, philosophical beliefs, network effects, and economic incentives. Furthermore, we discuss the appropriateness of blockchain technology for each scenario. We argue that using a blockchain is not an appropriate solution for some of the scenarios if we only take a technological perspective. This may seem that using blockchain in these scenarios is an irrational choice. Based on this analysis, Section 4 discusses the non-technical drivers that may explain blockchain adoption. Here we argue that there is a rationality behind blockchain adoption if we also take non-technical drivers into account. Section 5 discusses related work, Section 6 future work, and Section 7 summarizes our conclusions.

2 Background

This section provides a generic description of blockchain technology and introduces the decision model by Wüst and Gervais [39] for determining if blockchain technology is appropriate for a particular scenario.

The novel part of blockchain technology is having a consortium of unknown participants to reach consensus [26]. Typically, participants in blockchain technology consist of users and miners. At any time, a user may propose a new state of the ownership of a token by means of a transaction. A transaction, contains at least the sender's account, the receiver's account, the number of tokens transferred, a timestamp and a signature of the sender.

Miners propose new ledger states, but only after having solved a cryptographic puzzle. The idea here is to prevent multiple, different ledger states being proposed. The participant who first solves the puzzle is allowed to propose a new state of the ledger. Miners propose new ledger states by collecting user transactions and proposing these as a set, called a block. Since the unique identifier of the previous block is included in the new proposed block, a chain of blocks is created, hence the term blockchain.

Blockchain may be useful in a scenario which contains certain properties. Therefore, to determine if blockchain is an appropriate technology for a particular scenario, several blockchain decision models have been proposed.

2.1 Blockchain Decision Models

Wüst and Gervais [39] proposed a model to determine if blockchain technology is appropriate for a particular problem. Several such models have been proposed, as discussed by, for example, Meunier [20]. We chose the model of Wüst and Gervais because it provides a detailed description of the decisions that have to be made, leaving less room for misinterpretation. Their model consist of a decision tree based on the following scenario properties:

(a) *Storing state.* Refers to the need of storing data that may change both in volume and in content over time.
(b) *Number of writers.* Multiple writers (also known as miners) must be present, that have a common interest in agreeing on the validity of the stored state.
(c) *Is there a Trusted Third Party?* A Trusted Third Party (TTP) is a centralized entity that could manage changes and updates the state. A TTP, if present, may also control who can read the state stored.
(d) *Are all writers known?* This refers to knowing the identity of all writers.
(e) *Are all writers trusted?* When writers are trusted, they are expected not to behave maliciously. When writers are not trusted, they may behave maliciously.
(f) *Public verifiability of state.* This property determines who may read the state stored on the blockchain, and verify the integrity of the ledger.

Based on these six properties, the model determines one of four possible solutions as the best solution for the scenario:

1. *Permissionless blockchain.* Anyone may join the network and read from the state stored, and write to the blockchain.
2. *Public permissioned blockchain.* A limited set of participants may write to the blockchain. Anyone may join the network and read the state.
3. *Private permissioned blockchain.* A limited set of participants may join the network, and write a new state. Only this set can read the state.
4. *Don't use blockchain.* This end state is reached when one of the properties (a), (b), (c), or (e) above is not met.

3 Scenarios

The following paragraphs present three scenarios in which blockchain is used. We chose these for two reasons. First, these are real-life and representative scenarios where a blockchain is used. Second, these scenarios are generally well known to be related with blockchain technology. For each scenario we propose a set of blockchain adoption drivers (see Table 1, page 4) and we group these drivers into:

- *Scenario properties.* These drivers, (a)-(f) above, focus on the rationale for using blockchain from a technological perspective.
- *Philosophical beliefs.* These drivers focus on the rationale for using blockchain based on the participants' beliefs.
- *Network effects.* Here we propose drivers where existing participants influence new participants in using blockchain technology.
- *Economic incentives.* These drivers are based on financial gain, or preventing potential financial losses, by one of the parties involved in the scenario.

The scenario properties are inherent characteristics of a scenario, which we consider *technical properties.* The other three driver categories are more about preferences or motivations of the participants, which we consider *non-technical properties.* This categorization is important because it allows us to determine what drives blockchain adoption.

Table 1. Blockchain technology adoption drivers

Category	Drivers	Bitcoin	uPort	Supply Chain
Scenario properties	Storing state	•	•	•
	Multiple writers	•	•	•
	Can not use TTP	•		
	Writers unknown	•	•	
	Writers untrusted	•		
	Public verifiability	•	•	•
Philosophical beliefs	Will not use TTP	•		
	Decentralization need	•	•	
	Enhanced privacy	•	•	
	Alternative system	•	•	•
	Political reasons	•		
Network effects	Driven by community	•		
	Curiosity	•	•	•
	Cool to use	•	•	•
Economic incentives	Marketing product		•	•
	Selling mining equipm.	•		
	Selling consultancy	•		•
	Charging for platform			•
	FOMO	•		•
	Alternative investment	•		

3.1 Scenario 1 - Bitcoin

Scenario description. In Nakamoto's work [22] a decentralized payment system is envisioned. The essence is to have a consortium of unknown participants achieve consensus [26]. To achieve this, Bitcoin uses a public permissionless blockchain, allowing anyone to participate.

Each participant owns one or more Bitcoin accounts. An account is identified by a public cryptographic key, and managed by the corresponding private key. Each account may hold a number of tokens, which represent a value, and can be seen as 'coins'. Coin ownership can be transferred by transactions. A transaction, in principle, contains the account of the sender, the account of the receiver, the number of coins transferred, and the signature of the sender. Transactions created by participants are collected by other participants called miners. These miners independently solve a moderately-hard cryptographic puzzle. The miner that solves the puzzle first, obtains the privilege to propose a new state of accounts, based on the transactions collected. A miner proposes a new state by presenting a sequence of transactions called a block. Note that only miners may write to the blockchain. Each block holds the hash of its previous block, linking all blocks into a block-chain.

Scenario properties. This scenario has all the properties for the use of blockchain to be the right solution according to the scheme of Wüst and Gervais: we have to store state, there are multiple writers, there is (by design) no Trusted Third

Party (TTP), the writers are unknown and untrusted, and the state should be publicly verifiable. In other words, the properties of this scenario provide a clear technical rationale to use blockchain.

Philosophical beliefs. Bitcoin's pseudonymous inventor Nakamoto states that 'What is needed is an electronic payment system based on cryptographic proof instead of trust' [22]. Clearly, Bitcoin is specifically designed not to have a TTP. Also, many of its participants are motivated by political reasons to use Bitcoin [30]. For example, when national governments prevented WikiLeaks from receiving donations by blocking credit card transactions [33], Bitcoin could be used as an alternative payment system to circumvent these restrictions. Furthermore, given the pseudonymous nature of all accounts in Bitcoin, payments are more privacy-friendly than centralized bank payments.

Network effects. Bitcoin has received considerable media attention in the last few years [13,21,37]. This causes a network effect, where people consider Bitcoin 'cool to use' [3]. Also, at this point in time several issues remain which hinder global adoption, such as scalability [4], high transaction fees, price volatility and energy consumption [23]. These problems are hard to solve, which has led to a growing academic interest in blockchain technology to tackle them [32,40].

Economic incentives. Several companies have a direct economic interest in the success of Bitcoin. As miners nowadays need special dedicated hardware, hardware vendors supplying this hardware have a clear economic interest in the success of Bitcoin. Furthermore, many companies, including established firms and young startups [35], offer blockchain consultancy services, some of which are related to Bitcoin. These companies also have a strong economic incentive, namely to sell consulting services.

Finally, given the broad global attention to blockchain technology, there is the fear of missing out (FOMO) [34]. This may lead to that some parties buy bitcoins, as well as other cryptocurrencies, to mitigate the risk of having missed the bandwagon when it turns out the technology becomes a success. For example, public media has extensively reported on the rise of the value of Bitcoin. This triggered other, new participants to also invest in Bitcoin, as these participants also hope for a profitable investment in Bitcoin. Indeed, uninformed participants consider Bitcoin as an alternative investment [13]. However, as Bitcoin is not backed by any government nor gold, these investments are fueled largely by speculation.

3.2 Scenario 2 - uPort

Scenario description. This second scenario addresses an identity management solution. Such solutions aim to facilitate the management of identifiers, authentication, personal information, and the presentation of this information to other parties. Typically, in these solution schemes, a trusted identity provider such as a government, issues attributes to a participant. These participants store their attributes on their mobile device. This allows a verifying party such as a retailer, to verify the validity of the attributes issued.

Several companies (e.g. Consensys, Evernym, and IBM) advertise their blockchain-based identity solution. Here we focus on uPort [36] by Consensys. uPort is an identity management solution that uses the Ethereum blockchain [38] for so-called account recovery. In this account recovery process the user reclaims ownership of a unique number, called a persistent identifier (PI). This then allows participants to easily (re-)obtain attributes from issuing parties, by proving ownership of this PI.

The uPort app allows a device, such as a smart phone, to connect to a specific smart contract on Ethereum. This contract contains a unique number represented by the PI, which is linked to the participant's public key. When, for example, the device holding the attributes and private key is lost, a participant may prove to be the owner of the PI. Ownership of this PI is proven by requesting multiple trusted parties to state that, indeed, the participant is linked the unique number, after which the user can link a new public key to the PI. Currently, uPort seems to be the only identity management solution that offers recovery of a PI.

Scenario properties. In this scenario, state in the form of a smart contract is stored on the publicly verifiable Ethereum blockchain. From a participant perspective, all writers to the contract holding the persistent identifier are known, since these are the parties (e.g. friends or government) trusted by the participant. In this scenario the owner of a smart contract, including its trustees, can write to the contract. Furthermore, a centralized party, for example the issuing party of the attributes, could store the unique number related to the attributes of a participant. Therefore, following the model of Wüset and Gervais, there is no technical rationale to use blockchain technology in this scenario as all writers are trusted.

Philosophical beliefs. The mission of uPort states that "we believe that everyone has the right to control their own digital identity" [36]. Blockchain technology offers a platform that can be used by everyone and, therefore, using a blockchain is in the interest of uPort. From a company perspective, offering such a platform is based on principles that drive uPort, such as company purpose, economic principles, and social impact. However, from a technical perspective there is no need to use blockchain for the unique number recovery, as explained above.

Network effects. Blockchain technology offers multiple functionalities, such as storing of data, reaching consensus, and an audit trail. As companies often wonder how blockchain functionalities can benefit their company, curiosity may have played a role in blockchain adoption in this scenario.

Economic incentives. The uPort app points to a perceived single source of truth, the blockchain. When more participants would adopt the uPort app, uPort would gain more exposure, recognition, and funding. Still, the need for blockchain technology can be questioned. Ethereum, despite its novel design, currently contains several issues such as scalability [4], energy consumption [23], and lack of decentralization[12]. Instead, an independent group of trusted third parties could be used to manage the unique identifier of the smart contract. However, blockchain technology is also a marketing tool to arouse interest in a product [3] which in this scenario is the identity solution, or to arouse interest in an organization [1] [2].

3.3 Scenario 3 - Agricultural Products Supply Chain

Scenario description. In this third scenario a public permissioned blockchain called Hyperledger Fabric by IBM [5] is used. This blockchain tracks certificates in a supply chain of table grapes. In this scenario [11], a farmer in South Africa produces organic grapes, and presents such a claim to a certification authority. This authority issues a certificate to the farm, allowing the farm to certify its grapes. Grapes are stored in boxes, which are identified by a unique barcode.

To ensure a correct certification process, certification authorities are accredited by an accreditation authority. The certification authority stores the certificate it receives from an accreditation authority on the blockchain. Additionally, details of the certification authority are stored on the blockchain, so that anyone may see which party certified a farm. This entire process is audited. An auditor may revoke the certificate issued by the certification authority, for example, after the discovery of unauthorized pesticides [31] being used in the production of the fruits. An auditor also may revoke accreditations made by the accreditation authority. Here, both revocation types are recorded on the blockchain.

The grape boxes are shipped to resellers in Europe, after which the grapes are sold to supermarkets, and eventually to customers. Since it is unknown who may purchase the grapes, public verifiability is required. This allows all parties involved to query the blockchain for the validity of the organic certificate. Also, change of ownership is recorded in the blockchain, and provenance of the labeled boxes can be determined. From this description we observe that there are multiple, known writers. However, these writers are not trusted, as can be observed from the cascading audit trail from farmer to auditor.

Scenario properties. In this scenario the origin and background of the grapes are stored on the blockchain. Furthermore, multiple writers are present, such as certificate authorities and auditors. Finally, the state stored must be publicly verifiable, as consumers verifying the grape origins must read from the blockchain. Furthermore, in this scenario it is clear that writers are not trusted, because there exists an extensive audit trail. However, blockchain technology does not replace the audit trail. In this scenario blockchain technology introduces a decentralized administrative system in which audit findings are stored. In fact, even with blockchain technology, audits still must be performed to ensure that each party involved follows the regulations. Although blockchain technology may offer insight in the entire audit trail, a shared centralized database could achieve the same. This database could be managed by the highest auditing authority in this grape scenario, as this is the final trusted party in the supply chain. Therefore, as there may exists a TTP, according to Wüst and Gervais [39], there is no technical rationale to use a blockchain in this scenario.

Philosophical beliefs. In this scenario, blockchain technology is used as an alternative to a centralized solution. However, in any solution for this supply chain scenario, some form of trust is third parties is unavoidable, because trust has to be placed in auditors that audit the entire certification process. Furthermore, there is also trust in the shipping company for not changing the content of the grape boxes. For example, it would be feasible to exchange the contents of the boxes containing organic grapes with those boxes containing non-organic grapes during transport. Therefore, in essence, trust is placed in the integrity of the information stored on the blockchain. All participants rely that the information on the blockchain is correct only by trusting the auditors.

Network effects. As blockchain is a complex technology, companies may experiment with it by creating proof of concepts. Indeed, the aim of the original scenario [11] was to provide a proof of concept based on blockchain technology. As other technologies, such as a centralized database, seem not to be considered, we assume that the use of blockchain technology is also driven by curiosity.

Economic incentives. It benefits the technology supplier (here IBM) to use blockchain in this scenario, as it may provide related consulting services. Furthermore, the successful implementation of its technology serves as a platform for future scenarios. In such scenarios both the technology as well as consultancy may be provided. We therefore argue that in this scenario blockchain adoption is also driven by company principles.

Furthermore, in this scenario FOMO may also be a driver for blockchain adoption. Here, FOMO applies to all parties involved considering the potential of blockchain technology. However, as other technologies are not considered in [11], only blockchain seems to offer a solution to track certificates.

4 Discussion

All technical conditions must be met to ensure the appropriateness of using blockchain, if we follow the scheme of Wüst and Gervais [39]. However, in the uPort and supply chain scenarios only some technical drivers are addressed. Indeed, blockchain is used in both scenarios, despite that there appears to be no technical rationale to use blockchain, according to Wüst and Gervais [39]. Clearly, the scenario properties suggested in [39] alone are insufficient in explaining blockchain adoption.

As can be observed from Table 1, the majority of drivers for blockchain adoption in each of the three scenarios is non-technical. However, the technology supports at least one underlying technical property in a scenario, such as storing of state. Therefore, we conjecture that blockchain adoption is driven by a combination of both technical and non-technical drivers.

Furthermore, we observe that in each scenario a TTP *could* be used. Therefore, blockchain technology is not needed for any of these scenarios, according to [39]. However, in the Bitcoin scenario there used to be an underlying academic problem, namely, how can a consortium of unknown participants reach consensus. Nakamoto [22] aims to answer that question by introducing blockchain technology. Therefore, a rationale exists to use blockchain in the Bitcoin scenario.

5 Related work

Although several models exists to determine technology acceptance, the Technology Acceptance Model [8] is most employed [7]. Blockchain technology and the Technology Acceptance Model (TAM) are discussed in, for example, [10], [3]. TAM is used to determine technology adoption based on two major considerations, *perceived usefulness* and *perceived ease of use* by the intended user. Depending on the research domain, TAM has been extended with other considerations such as 'perceived playfulness' for the web acceptance, and 'perceived user resources' in bulletin boards systems [14]. In our work we distinguish four considerations (i.e. the driver categories) for the adoption of blockchain.

Debabrata and Albert argue that blockchain may eliminate fraud in supply chain management [9]. However, eliminating fraud only by using a blockchain in the grape scenario is impossible. A TTP must remain present to verify the claims made by the farmers, certification authorities, and accreditation authorities. Here, blockchain cannot replace the trust in human observation of a complex process.

Seebacher and Schüritz propose that the qualitative aspects of transparency and autonomy play a role in blockchain adoption [24]. In addition to these two aspects, in our work we argue that blockchain adoption lies in both the technical and non-technical drivers, and we identified a total of 20 drivers.

6 Future work

In our work we have shown that technical and non-technical drivers exist for blockchain technology adoption. Various models have been suggested to support this decision making process, as discussed in Section 2. These models, however, do not mention alternatives to blockchain. A further analysis, and a possible extension of these models is needed to determine if blockchain is appropriate.

Also, trust in a third party appears to be a much broader concept than the trust a blockchain can offer. In fact, this technology appears to provide trust in integrity of the data recorded on the blockchain. However, we assume that the trust needed by a participant goes beyond integrity of data alone. Therefore, it is unlikely that blockchain can fully replace a TTP. Additionally, the concept of trust has been defined in many ways [19]. For example, one way of defining trust is the willingness to depend, meaning that you make yourself vulnerable to another person in a situation by relying on them [18]. However, these many definitions also makes that the concept of trust is diffuse, and it is unclear what is defined as a *Trusted* Third Party. How blockchain shifts trust, and which types of trust are affected by blockchain also seem interesting subjects for further explorationBlock.

Furthermore, additional scenarios that involve blockchain technology could be analyzed in order to determine the value of blockchain technology over alternative technological solutions. Here, possibly more drivers for blockchain technology adoption may be found. Also, extending this work by adding weights to the drivers may be part of future work. Adding weight to drivers allow for determining which driver influences blockchain technology adoption most.

7 Conclusion

Many people have questioned the rationale behind blockchain adoption [6,16]. To support such claims, methodologies have been proposed to see if blockchain suits a particular scenario [39,20]. Such methodologies are mainly based on technical drivers, which are properties inherent to a scenario. In real-life scenarios we see that sometimes a blockchain-based solution is chosen even if these methodologies would argue against that.

Given the inherent lack of technical drivers in some scenarios, the choice for blockchain technology may seem irrational. Our novel insight is that blockchain adoption may be explained by non-technical drivers, namely philosophical beliefs, network effects and economic incentives. These drivers may explain, after all, the rationale behind blockchain adoption. Our work can be generalized to other scenarios that involve cryptocurrencies, identity management solutions and supply chains, as it is likely that similar scenarios contain the same drivers.

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