Project Thesis

Blockchain enabled Trust & Transparency in supply chains

Anders V. Hua

Jørgen S. Notland

NTNU School of Entrepreneurship TIØ4530

NTNU – Autumn 2016

December 19th 2016

Faculty of Social Science and Technology Management Department of Industrial Economics and Technology Management.

Supervisors: Lars Øystein Widding & Donn Morrison

Abstract

The blockchain is a new groundbreaking open-source technology (Nakamoto 2008) which was initially released as the underlying technology for the world's first decentralized global digital currency, Bitcoin. The blockchain is an immutable and transparent distributed database, a ledger which has global consensus by all participants. This means that the things written in the ledger can't be edited and cheated, thus trusted if the writer is trusted.

The supply chains for commercial markets are opaque and complex, they can span over hundreds of production stages and several geographical locations so that the provenance and history of a product is usually unknown to upstream actors. Lack of transparency and trust in the supply chain lead to lack of information about the provenance and working conditions behind the product. There has been shown that some actors behave illegally and unethically.

This thesis' research purpose is to investigate the nature of trust in supply chains and if blockchain technologies can increase trust in supply chains. A theoretical framework involving trust and transparency in supply chains, blockchain and record keeping has been established.

Blockchain has its strengths and limitations: high integrity but unstable information reliability. How data is recorded on the blockchain is considered critical and require a trusted third party recording transactions to guarantee information reliability. The authors believes that if the problem of information reliability is solved, trust in blockchain implementations will increase.

The actors in the supply chain need an incentive and clear profit in order to have any motivation to implement the blockchain technology. A strong incentive and a method and specific steps for implementation still remains to be researched.

Table of contents

Acknowledgements

Special thanks to Lars Øystein Widding for providing valuable feedback for intertwining blockchain with business and management theory and to Donn Morrison for being a valuable technical supervisor and discussion partner.

1. Introduction

1.1 Blockchain

Blockchain was introduced to the world in 2008 in a whitepaper describing a new kind of electronic currency: Bitcoin. Later, several other use cases for blockchains has emerged. A blockchain efficiently records transactions between parties on a distributed ledger. The data recorded on a blockchain is immutable and instantly verifiable. A blockchain can also be programmed to automatically trigger transactions using smart contract technology.

Blockchain is a groundbreaking technology possibly representing a paradigm shift in how counterparties trust each other and how value is transferred globally. Although investments in the blockchain space has increased from 1 million dollars in 2012 to 475 million dollars in 2015 (KPMG & CB Insights, 2016) most blockchain solutions are at the Proof of concept, alfa or beta stage of development. This puts blockchain technologies in the early stages of the technology adoption life cycle (Moore 1991).

One major reason to why blockchain technology is so useful is because it solved the double-spending problem. If Alice emails a file to you, Alice will still have a copy of the file after she sent it. Unlike a file, value such as an apartment or a cryptocurrency such as bitcoin should only exist one copy of at the all times. If this is not the case, the apartment can be sold twice and the money can be spent twice, thus the term double spending. On a blockchain the double spending problem is solved by publicly announcing the transaction to all miners (see 3.5 Blockchain) in the blockchain such that all miners verify all transactions. The miners reach consensus on the current state of the blockchain, like for example who owns what house and how much bitcoin each address owns.

The underlying TCP/IP protocol in the internet has enabled anyone in the world with a computer/smartphone and a connection to the internet to freely share information with each other. In the internet of information, information flows freely and anyone can share (upload) or consume (download, copy) any digital content such as text or images. This is referred to as "the internet of information" where information is instantly accessible to all users once it is published. In a blockchain based system, transactions occur almost instantaneously and are settled instantaneously on the blockchain.

Transferring value between banks and countries takes several business days (Commonwealth Bank 2016) and in the shipping industry, settlement of a contract between two firms in the supply chain happens every 30. days. (Kavussanos & Visvikis 2006). With blockchain these settlement times can be significantly reduced. Economic value is unlocked by lowering both the time and cost of transferring value. Referred to as "the internet of value" where any business, organization or person can instantaneously transfer value directly to each other.

A limitation with blockchain technology is trust in the process of transaction records. Blockchain technology in itself does not address the reliability of its records. Reliability (in recording) is not a core part of blockchain technology.

1.2 The problem with supply chains today

A supply chain contains all of the links that are involved when manufacturing and distributing goods. In today's world, a supply chain can potentially involve hundreds of stages and dozens of geographical locations. Like for example the supply chain of Apple Computing whose suppliers employ over 1.6 million people in 20 countries (Apple 2016). This makes it very difficult to track events happening in a supply chain and investigate incidents. Because there are information losses and barriers in every step of the supply chain, the further away in the chain an incident is the harder it is to obtain any information on it (Cecere 2014).

Buyers and sellers have to have a reliable system for verifying and validating the true value of a product or service purchased. The endemic lack of transparency in supply chains effectively means that what we pay for a service or a product is often a wrong reflection of what the true cost of production is. There is for example no standard way to track the environmental damage that follows the manufacturing of goods for supply chains that are not fully integrated, which is the vast majority of goods.

When an actor in the supply chain conducts illicit activities, investigation becomes very hard and often no one is held accountable. This includes activities such as slavery, inhumane work conditions, counterfeiting and revenues being wired to fund criminal activity or war. An example is the Coltan Ore (Sutherland 2011), which is used in mobile phones and consumer electronics. It's mining has reportedly committed human rights abuses for several years in a row.

1.3 Research questions

The importance of trust in supply chains relationships and blockchain technologies nature to provide trust and smart contract capabilities has led to three research questions that the project thesis will seek to answer:

RQ1: What is the nature of trust in supply chains?
RQ2: Can blockchain tracking and information transparency increase trust in supply chains?
RQ3: Can blockchain automated smart contracts increase trust in supply chains?

To find answers to the RQ's, a literature review of existing research and papers on supply chain, trust and blockchain technology will be performed.

2. Methodology

This chapter presents the purpose behind the literature review within the field of research, the specific method and steps behind the literature search and data acquisition and finally a reflection and critique of the methodology.

2.1 Purpose of Literature Review

The purpose of the literature review was first and foremost to look deeper into the literature of the supply chain and trust in order to answer the research questions. It helped the researchers understand the nature of trust in supply chains and developed a frame of reference for the discussion in this paper. Because blockchain is still in it's young days (released in 2008), emerging from the open web and not in an academic environment, there has yet not been established academic literature spanning the whole field. The authors has gained an overview of the existing research within the field of supply chain and trust, including what is missing. As Yin (2014) argues, the literature review's purpose is to develop sharper questions and more insights within the area of investigation.

2.2 Data Acquisition

The authors started the project thesis with a broader perspective on blockchain and how it would be commercialized. The authors mapped out the themes of blockchain related conferences from around the world to get an overview of the space [Appendix A]. To keep up to date with the latest advancements in the industry the authors subscribed and followed several online weekly newsletters [Appendix B]. Supply chain was identified as one of the main potential benefactors of blockchain technology, thus the thesis was narrowed down to blockchain and supply chain. After narrowing down the scope, the authors started looking deeper into potential use cases for blockchain in the supply chain and started acquiring relevant academic sources. The search for academic literature started by searching for supply chain. The search *supply chain definition* on Google Scholar led to several definitions of supply chain from the first page. A definition of trust was found by searching for *trust definition* on Google Scholar. Transparency articles were found using the keywords *transparency, information sharing and supply chain* on Google Scholar.

A search using the keywords *trust* and *supply chain* lead to the article "Understanding trust in supply chain relationships" (B.S. Sahay 2003) which is an comprehensive article covering supply chain relationships and trust. This article was used to review article citations to discover new sources and the authors systematically looked into the citations of the cited sources. This method is referred to as snowballing (Streeton et al 2004). This method provided access to other relevant and useful articles.

2.3 Reflection and Critique

The authors recognizes that the data acquisition should have been recorded more thoroughly. The inconsistency in recordkeeping of sources has resulted in incomplete records in subchapter 2.2 Data Acquisition.

2.3.1 Snowballing

The authors have favored the method of snowball sampling instead of a fully structured search limited to one academic database. Snowballing has it's limits, as it is a less structured method and relies more on other authors and the directions they point you within the literature, which may result in less credible sources being selected. The exact number of articles and papers are also not determined by the researchers themselves. Second, replicating snowball sampling naturally results in less structure and an exponential growth in numbers of papers, where the authors are forced to choose which papers to cut off, which emphasizes the importance of clear cutoff criteria, such as a certain number of citations. The authors may have missed important articles due to the chosen method. The search strings and phrases matter less when snowballing, but is still important.

On the other hand, given the difficulty in finding relevant and good search terms, snowballing has an advantage in collecting relevant sources and expand the scope of the literature review compared to structured search.

3. Literature review

In this section the authors give an overview of supply chain literature and traditional supply chain relationships. Trust and transparency in supply chain relationships will be reviewed in depth. Lastly blockchain technology literature including smart contracts will be reviewed.

3.1 Supply chain

La Londe and Masters has proposed that a supply chain is a collection of businesses passing material forward. They argue that normally there are several independent companies that are involved in the manufacturing of a product and eventually reselling it to the end user of a supply chain. Their definition says that all these companies including firms producing raw material and components, product assemblers wholesalers, retailers and transportation firms are members of a supply chain (La Londe & Masters, 1994). Lambert, Stock and Ellram similar definition of a supply chain states that the supply chain is the alignment of firms that bring products or services to market. Both of these concepts of supply chain include the final customer as a part of the supply chain (Lambert et al. 1998)

Another supply chain definition notes that a supply chain is the network of organizations involved in upstream and downstream linkages where they perform activities and processes that produce value. This value produced in the form of products and services and are ultimately delivered to the end customer (Christopher, 1992). Thus a supply chain contains several firms, both upstream (i.e., supply) and downstream (i.e., distribution), and ultimately the end customer.

With these three definitions given, and for the purpose of this paper, a supply chain is defined as: A group of two or more entities (individuals or organizations) whom are directly involved in the down and upstream exchange of information, products, services and finances from a source to the end customer.

3.1.2 The traditional adversarial relationships

The traditional approach in supply chain relationships was more in the nature of a confrontationist negotiation based relationship seeking competitive terms and conditions, as a part of the effort to build economic efficiencies through cost, quality and other such considerations. Hacker et al. (1999) says that in the past, customers relied upon their leverage to give business or to take it away in supplier relationships, often creating a win-lose situation. There has been a common practice to keep multiple suppliers, with a threshold for certain efficiency to keep up the relationship. The mindset of the customer is to keep the suppliers competing. The relationship(s) perseveres with a mindset of confrontation and not a collaboration (Welty and Bercerra-Fernandez, 2001). In such cases, the mutuality that enhances the value of the exchanges may be missing because of the focus on getting quality at reduced costs rather than creating greater value in the exchange through a full exploration of what each partner has to offer to the exchange and value creation process (Lockamy III and Smith, 2000). As a result, an adversarial atmosphere is frequently developed.

3.1.1 The emergence of long-term relationships

A combination of rapid globalisation, internationalisation, deregulation and advanced scientific and technical innovations are all a part of the underlying factors that has pushed the emergence of the relationship paradigm for creating long-term relationships among customers and suppliers in the supply chain (Zineldin & Jonsson 2000; Chandra & Kumar 2000). Because of an increasing global competitiveness, a lot of companies focuses on their core-business and outsources the sub-processes. A consequence of this is that companies have realized the importance of maintaining long-term relationships between customer and supplier (B.S Sahay 2003).

3.1.2 Long-term relationships means collaborative relationships

Customers and manufacturers, distributors, retailers and a host of service organisations have become more aware of a mutually beneficial reasons based less on power play and more on value exchange is necessary in order to survive. Relationships based on this new paradigm enhance value two ways: collaboration changes the working relationships in ways which enhance the value derived from each other. They also allow lower costs and risks, and synergies, so that the net value delivered through this value chain is much higher than others in the industry. Collaborative relationships require trust, commitment and a willingness to share risks in order to achieve a beneficial long-term cooperation (Sahay and Maini, 2002). Trust is a complex concept both in the literature and the real world, but it plays a key role in in supply chain relationships.

3.2 Trust in the supply chain

In this paper the authors define trust as: *"Willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or confront that other party."* (Mayer et al. 1995)

Thus, trust is extremely important in supply chains because there is always the expectation of another party performing a particular action important to the trustor. When a party in a transaction has been paid to provide a goods or service, the paying party expects the goods or service provider to perform a particular action. Inter-firm trust levels has been shown to be a central part of supply chain relationships (Kannan & Tan 2006).

The study found that inter-organizational trust exhibits a robust and rather strong relationship with a number of different outcome variables under different conditions. This provides quantitative evidence across a wide range of studies for the contention that inter-firm trust is central to supply chain relationships

The awareness of trusts role in supply chains emerged in the 1990s and mid through the 1990s the concept of trust and collaboration started to challenge transaction cost theory's explanatory power (Ghoshal & Moran 1996) (Chiles & McMackin 1996). It became obvious how important trust was as a precondition for sharing information and assets, which then again was essential for the success of a strategic partnership. They argued that trust when gained through efficient communication can create resources which lead to competitive advantages. In the end of the 1990s (Peters & Hogensen 1999), (Monczka et al. 1998) and (Chandra & Kumar 2001) argued that collaboration and trust were emerging as more prevalent factors in supply chain relationships due to their ability to lower uncertainty.

Having a long lasting and stable supply chain relationships shifts a suppliers interest more towards final customers needs (Zineldin & Jonsson, 2000). They reduce the amount and grasp of formal contracts (Larson, 1992) and facilitate resolution of disputes (Ring & Van de Ven, 1994). Benefits gained from the relationship itself in the business conducted is also seen as an important benefit of trust (Gulati, 1995; Madhok, 1995). The main factor determining a relationship's length is commitment. Commitment is only present where there is trust. I.e. trust is an essential pre-condition for the long-term commitment of supply chain partners (Morgan & Hunt, 1994)

Still, every partnership dynamic changes can have an effect on the relationship if one party sees the other as opportunistic and undynamic (Argandona, 1999). When a partner relationship with another firm is not working well, trust is said to be the number one concern (Lewis 2000). To keep a partner relationship stable and thus transaction costs down, partners need to square up in misconstructed and negative perceptions and trust each other. Many studies say that these relationships depend on relational exchange forms having high levels of trust involved (Richards, 1995; Volery & Mensik, 1998; Handfield & Nichols, 1999; Olorunniwo & Hartfield, 2001).

It is also worth mentioning that all customers does not want to purchase the highest quality service no matter what. Some customers rather want someone whom can be trusted to provide a certain degree of service (Olshavsky, 1985).

3.3 Trust in records

The discussion about trusted records mainly boils down to the two interlinking concepts of reliability and authenticity (Mak 2014). Reliability in records is defined as how trustworthy a record is based on: The controls on its creation, the completeness and the competence of the author (Duranti & Rogers 2012, 525). Also referred to as validity in other contexts (Merriam-Webster 2015). Reliability is more linked to how records originate and who originated them than how subsequently the records are maintained.

Documentary truth or juridical truth (Duranti 1990) is the trustworthiness of a record as a record in itself. This is the authenticity of the identity of the record in relation to what it purports to be, the identity of the record. It is also the integrity of the record, has is been tampered with or corrupted (interPARES 2015). Authenticity is closely linked to how records are preserved over time (Lemieux 2016).

3.3.1 Reliability

The ISO 15489 standard mandates the standards for current record management. ISO 15489 (2001) states:

"A reliable record is one whose contents can be trusted as a full and accurate representation of the transactions, activities or facts to which they attest and can be depended upon in the course of subsequent transactions or activities".

ISO 15489 acknowledges that a record recorded at the time or soon after an incident or a transaction by an individual that has direct knowledge of facts or by an instrument used to conduct the transaction are more reliable (ISO 2001, 13). The history of the context of records should be retained to enable reliability auditing (ISO 2001, 18). Also systems must capture and organize the records. The records must be protected from unauthorized tampering and must serve as the primary source of information about documented actions while providing ready access to all metadata and records. (ISO 2001, 14).

3.3.2 Authenticity

Authenticity of a record relies upon establishing and preserving the records identity from its creation on thereafter (Rogers 2015). Authenticity is also mandated by ISO 15489 (2001). The system that generates a record establishes the identity of a record and classifies it by linking it to related records that are related to the same function. Measures like user verification, access control, audit trails, documentation of the system, frequent upgrades and regular maintenance assures integrity in such systems (ISO 2001).

3.4 Transparency in the supply chain

Developing broad and clear communication lines in the supply chain is important (Mohr and Spekman, 1994; Frankel et al., 2002) to breed sharing of information and creating a shared understanding (Stank et al., 1999; Ireland and Bruce, 2000). Instead of single points of contact there must be developed broad interfaces between organizations. This it to overcome potential lack of internal communication and to foster culture where an innovative mindset is supported (Barratt and Green, 2001). Organizations also need to avoid scenarios where a relationship is jeopardised if one person whom is the single point of contact leaves. (Frankel et al., 2002).

Although communication is important, sharing information within the scope of a supply chain poses certain challenges:

- Confidentiality of information
- Issues with incentives
- Reliability of information technology
- Cost of information technology
- Accuracy of information
- Development of capabilities that allows firms to utilize the shared information effectively

(Lee and Oakes 1996) (Khurana et. al 2011) (Lee and Whang 2000)

Several authors has shed light on the basic need of information sharing if supply chains are to increase their performance. (Stank et al., 1999; Lambert & Cooper, 2000; Lau & Lee, 2000). "Information enrichment" or the instantaneous sharing of data from the marketplace with all actors in the supply chain (Mason-Jones & Towill 1997) argues is not only desirable, but obligatory. In a process integration scenario where reaching the "seamless" supply chain is the goal where all “players” act and think as one. “Information enrichment” must first be achieved (Towill, 1997).

A barrier of interpersonal sharing of information in supply chains are concerns about information privacy, the question of what information can be shared with third parties or not. To foster interpersonal information exchange in the supply chain, a trusted network where individuals can share information should be built (Razavi & Iverson, 2006).

3.5 Blockchain

A blockchain is essentially a public ledger that contains information on every transaction made using the blockchain. A blockchain system is not based on trust but cryptographic proof. This allows conductions of direct transactions between to consenting parties instead of trusting a centralized institution such as a bank to handle the transaction (Nakamoto 2008).

Blockchain can be viewed as a gigantic google doc spreadsheet that represents a registry of intangible and intangible assets like for example currency, documents or physical property. In the essence a blockchain is a distributed ledger which cannot be changed and can be audited by anyone. The technology can be used for monitoring and tracking assets, information sharing, communication and executing conditioned and long-term contracts (Swan 2015).

3.5.1 Research maturity

The Blockchain protocol was invented by an anonymous person with the alias “Satoshi Nakamoto” and released as an underlying technology for enabling a new kind of digital currency called Bitcoin. A research paper was sent to a cryptography mailing list called "Bitcoin: A Peer-to-Peer Electronic Cash System".

The design of Bitcoin was adopted into an open-source project. Developers from around the world built the currency together and 3 months after Satoshi sent the email Bitcoin was released to the public. Everyone with an internet connection could now store value in bitcoin and use it for transactions.

A blockchain requires computational power to process transactions in blocks of X amount of transactions. These blocks with transactions are then chained together forming a blockchain. A miner which can be anyone with access to a computer with processing power and internet connection processes transactions and are usually rewarded with a cryptocurrency linked to the value of the blockchain it is mining. For example, bitcoin is rewarded for miners spending computational resources processing transactions on the bitcoin blockchain. A miner mines by adding encrypted transaction records to a blockchains ledger, past transactions or "chain of blocks containing transactions". A miner confirms new blocks of transactions published by the network in addition to publishing new blocks of transactions himself. This is so the blockchain can identify legitimate blockchain valid from faulty transactions..

Blockchains is an emerging technology at its early stage. Startups are leading the charge and academic peer-reviewed sources and general research is in scarcity and does not span the whole field yet. There is a low number of high quality publications on the journal publication channel level. Most of the academic research up to now has been focused mainly on narrow technical areas within the bitcoin blockchain (Yli-Huumo et al 2016).

Much of the information in the blockchain field is released via white papers, yellow papers, conferences, workshops. These papers emerge from blockchain organizations and interest such as the ethereum foundation, blockchain symposiums, blockchain conferences and startups. The papers are often not peer reviewed by academic standards, but by an online communities of blockchain enthusiasts and experts. (Yli-Huumo et al 2016)

3.5.2 Smart contracts

A smart contract is a piece of computer code that executes on a blockchain. It is a digitally signed agreement that includes two or more parties. On a smart contract, the terms of the contract are defined by computer code as a set of instructions (Blockchain Technologies 2016). It is characterized by being autonomous, self-sufficient and decentralized (Swan, 2015).

A smart contract has the capability to facilitate, execute and enforce the performance of negotiation of a contract. The entire lifecycle of a smart contract is automated and can provide valuable as a complement to or substitute to a legal contract (Walport, 2016).

Smart contracts can for example enable a fully automated self-owning vending machine. The vending machine automatically ejects an item when a digital currency such as bitcoin is sent to the blockchain address of the machine's smart contract. If the vending machine runs out of items it can use the value stored in the smart contract from sales to a refill of items from a blockchain-enabled business that accepts digital currencies.

4. Analysis and discussion

This chapter analyses discusses the literature review from the previous chapter, first trust and transparency. Thereafter the authors discuss blockchain in the supply chain and how it would apply to transactions. In the end an analysis of the technology's limitations and strengths is discussed.

4.1 Trust

The 2017 Edelman trust barometer discovered that trust in institutions including NGOs and corporations has in 2016 declined to trust "lows" similar to trust levels during the financial crisis. 85% of respondents indicated that do not "trust the system". And only 52% of the respondents trust in businesses (Edelman 2017).

How do we regain trust? Blockchain guarantees trust in a system using mathematics, code and decentralized verification of transaction. Blockchain can solve the issue of multiparty contention without having to involve a human. Parties that has different sets of interests will probably relax contention when untrusted systems and processes are replaced by blockchain implementations because blockchains are self-administered, self-executing and administrator-free. Instead of a system involving an authority that can control and corrupt the system. Blockchain creates a trusted, decentralized way of managing who owns what, or "the current state of the world".

When parties have differing sets of interest concerning who owns what, contention arises. Who owns what money? How will this transaction be settled? These contentions are today mainly resolved by distrusted authorities such as banks and clearinghouses. With blockchain dependence and trust to a third-party is no longer needed as the trust is integrated into transactions. Trust is no longer placed in individuals and central institutions, but rather distributed across the population. Central authorities are replaced by communities of peers in the form of peer-to-peer networks. No single entity had the capability to unilaterally taking actions on behalf of the community. In a democratized context like this, corporations cannot unilaterally defy the community and break the rules of the system, thus increasing the trustability of the system itself (Sun et al 2016).

4.2 Transparency

The authors believe blockchain technology can increase transparency in supply chains. This is possible using it's decentralized ledger that can track and record movement of goods through supply chains from end to end. Tracking goods using blockchain technology enables a capability to directly validate an item's provenance and authenticity. Every actor within a blockchain network has a complete and constantly updated copy of the ledger. This enables them to use the ledger for real time monitoring of their supply chain.

A smart-contract based corporate identity solution can reduce concerns about information privacy. A secure access-controlled environment where every person has a corporate identity that is given permission to access specific pieces of information from actors in the chain. Then information is regulated by a smart contract owned by the actor and no administrator or 3rd party can access information set as private by an actor. Also actor-agnostic and role-specific identities (i.e. CTO) can be issued with specific permission. This creates a more trusted network for sharing information due to the lack of central authorities with access to the information in the network and the actors control of access to the information.

A blockchain implementation can register the handling of items through the whole supply chain. This can enable customers with the information about the provenance of suppliers product. Information such as how it has been transported, what it is made of and if the workers downstream in the supply chain are slaves or employees. In a blockchain enabled supply chain buyers might require suppliers to be active on the blockchain because the buyer is running a brand based on guaranteed slavery-free supply chains and needs to prove it to her customers. Thus utilizing blockchain technology for tracking of a firm's internal operations could insinuate that a supplier fulfils standards that are expected from suppliers upstream in the supply chain. In the future having implemented blockchain technology might also yield a competitive advantage as consumers become more aware of the provenance of products and working conditions. If blockchain expansion prevails customers has the option to disregard all suppliers that are not blockchain enabled. Customers might suspect that they have something to hide considering the provenance of the product or working conditions.

4.3. Blockchain in supply chains

"Supply chains will certainly evolve into supply blockchains in pharma, finance, public sector, mining exploration, and retail" - Andrew Keys, head of global business development at consensus systems.

Blockchain being a technology that ensures a trusted, secure and transparent technology has the potential to fix some of the current problems with supply chains today. An example is an blockchain implementation that registers all transactions of goods on a blockchain: The parties involved, date, price, location, state and quality of the product and other information that is relevant to management of the supply chain.

The Blockchains implementations public availability means that it will be possible to track every step in the supply chain of every product. In a supply chain that has implemented blockchain, everyone can potentially trace a product back to the raw materials used to produce it. With the blockchain being decentralized, consisting of miners all over the world it is considered nearly impossible for an attacker or "hacker" to take ownership of the blockchain and the data stored there to manipulate it to their own advantage. Also, the immutable and cryptographically secured nature of operations on the blockchain makes it nearly impossible to compromise or "hack" the blockchain.

In a blockchain implementation, a blockchain based smart contract can trigger automatic value transfers based in conditions. Imagine a GPS tracker in a ship that triggers a payment that is instantly settled on a blockchain once the GPS location of the ship proves that the ship has reached the destination a buyer.

4.3.2 Transactions

Lower trust is now needed to contentiously interact with a third-party. Blockchain technology is ideal for transaction of value in between two parties or more in a secure, open, peer-to-peer and auditable way.

Paper-based and electronic banking systems has been created to move large amounts of value around from owner to owner, but maintaining trust by managing and recording transactions is inefficient using banks and double-entry accounting compared to the capabilities of blockchain technology. When trading in the supply chain, fiat currencies traded on an non-blockchain banking infrastructure are inefficient and value moves in terms of every month. Also in current systems records of transactions are recorded asymmetrically resulting in information asymmetry and record tampering.

Buying an item using cash is simple. An actor can just hand the cash over and receive the item in return instantly in a peer-to-peer fashion. You don't have to give up any personal information to a central institution, there is an instant settlement between buyer and seller when handing over the cash. In blockchain implementations, value is also traded in an peer-to-peer value. In addition to being instantly visible to all actors every actor has a record containing a full auditable history of all the transactions of value every conducted on the blockchain implementation. Using blockchain technology, counterparties in a transaction can cheaply and independently transact and verify the transaction on a blockchain. The transactions settle almost instantly and are secured by the decentralized nature of the blockchain.

Transactions in the supply chain often requires third party institutions such as banks and clearinghouses. These are normally brokers and middlemen who are paid a fee and trusted to manage or process a transaction. Blockchain implementations has the potential to provide automatic blockchain-based smart contract systems that receives a higher degree of trust than these brokers and middlemen. The brokers and middlemen might lose their competitive advantage of trust to a blockchain implementation that is more trusted and does the job more efficient. Especially now in January 2017 when trust in businesses is considered to be very low (Edelman 2017).

4.4 Limitations and strengths of blockchain systems

Blockchain technology in itself does not address the reliability of its records. Reliability (in recording) is not a core part of blockchain technology. Often a person acting as a trusted third party records the information on the blockchain. In the case of tracking slavery or other unethical business practices an individual can simply enter into the blockchain system that the business is legitimate and upstream actors can thus be fooled. A GPS tracker set to release a payment upon arrival can be hacked to send a faulty location to a smart contract and trigger the payment of the goods without actually delivering it. The authors thus considers assuring record liability the major limitation of blockchain systems (Lemieux 2016).

The authors believe that maintaining the authenticity and integrity of records is the core capability of blockchain technology. This is considered the major opportunity blockchain technology promises to deliver. The technology's capability of maintaining authenticity of records depends on how secure the system is (Lemieux 2016). Blockchain is not 100% secure from all attacks even though it is one most secure protocols ever designed (Nakamoto 2008).

5. Conclusion

The nature of trust in supply chains, as asked in RQ1, is covered in the chapter of literature review. It is obvious and naturally an advantage to have trust in relationships, also in the supply chain. We also learned of the growing awareness of its importance how this has become increasingly relevant in today's emerging relationships.

To address information integrity and transparency issues, blockchain technology can be used to build open, secure and trusted systems assuming that the infrastructure processing and recording transactions is secure and properly managed. In terms of RQ2 and RQ3, the answer is yes, blockchain tracking, information transparency and automated smart contracts can increase trust in supply chains.

The technical challenge is that blockchain technology does not have the capability to guarantee information reliability in the recording. Thus blockchain implementations could face several limitations and might require a trusted third party or a very secure tracking device to maintain the trustworthiness of records. The authors believe that if the problem of information reliability is solved trust in blockchain implementations will increase.

Another challenge is a non-technical. The question is if it would be perceived as profitable for the one concerned to implement blockchain technology. If you run a sweatshop in your supply chain, what incentive would you have to open your doors for everyone? And if you are the end customer, would you want to know your products provenance, if this spills your consciousness and the alternative is more expensive. If you are not the end customer, your reputation could be damaged by this information. Hence, the conclusion here is that there must be some clear incentive for all parties to be transparent. You could argue that the transparency would increase trust in the relationship, and as shown in the literature: Trust in relationships increase performance, synergies and overall success. Even though, this is not immediate and clear profitable effects. Profit is easy to measure, while trust and relationship management is more intangible and much harder to measure.

6. Further research

The researchers have established that there is a clear necessity for trust in the supply chain in order to have successful and productive long-term relationships. Blockchain technology can provide this required trust with transparent transactions in addition to a record of the product, so that the customer know the true value of the product.

Further research would need to explore and find the incentives for the actors in the supply chain to implement such a technology. The research would have to present clear gains and profits for the actors themselves by having such transparency. If this can not be found, the researchers would have to explore alternative solutions, e.g. a forced implementation from the government.

There is also a need to see how the technology would be implemented in detail to a specific supply chain, especially the recording. This paper does not contain research questions concerning the implementation of the blockchain technology, but has rather shown that it is wise and possible to do it if an increase in transparency and trust is wished.

References

BlockchainTechnologies (2016). The ultimate guide to blockchain smart contracts. Avaivable at: http://www.blockchaintechnologies.com/blockchain-smart-contracts [Accessed 12.01.2017]

KPMG & CB Insights (2015). 'The Pulse of Fintech'. Available at: https://home.kpmg.com/xx/en/home/insights/2016/03/the-pulse-of-fintech-q1-2016.html [Read 11.11.2016]

Moore G. (1991). Crossing the chasm. 3rd ed. New York: Harper collins. pp. 11-17

Szabo, N. (1997). Formalizing and securing relationships on public networks. First Monday, 2(9).

Cecere L. (2014) Supply Chain Visibility in Business Networks. Supply Chain Insights LLC. Avaivable at: http://supplychaininsights.com/wp-content/uploads/2014/03/Supply_Chain_Visibility_in_Business_Networks-11_MAR_2014.pdf [Accessed 11.11.2017]

Rogers, C. (2015), "Virtual authenticity: authenticity of digital records from theory to practice", unpublished PhD dissertation, University of British Columbia. Avaivable at: https://open.library.ubc.ca/cIRcle/collections/ubctheses/24/items/1.0166169 [Accessed 11.12.2017].

ISO (2001). ISO 15489-1:2001 – Information and Documentation – Records Management –Part I: General. Geneva: ISO.

Lemieux V. (2016). Trusting Records: Is Blockchain Technology the Answer? Records Management Journal. 26(2), pp. 110-139.

Swan, M. (2015). Blockchain: Blueprint for a New Economy. O'Reilly Media, Inc.

Kannan, V. & Tan, K. (2006) Buyer-supplier relationships: the impact of supplier selection and buyer-supplier engagement on relationship and firm performance. International Journal of Physical Distribution & Logistics Management. 36(10), pp. 755-75.

Sun J., Yan J. & Zhang K. (2016) Blockchain-based sharing services: What blockchain technology can contribute to smart cities. Financial Innovation 26(2).

Goldacre B. (2014) Bad pharma: how drug companies mislead doctors and harm patients. London: Fourth Estate.

Deloitte (2016) Tech Trends 2016 Innovating in the digital era, Blockchain: Democratized trust. Available at: https://documents.dupress.deloitte.com/TechTrends2016 [Read: 5.11.2016]

Nakamoto S. (2008) ‘Bitcoin: A Peer-to-Peer Electronic Cash System’. Available at: https://bitcoin.org/bitcoin.pdf [Read 5.10.2016]

Yin, R. (1998/2014) Case Study Research. 4th/5th edition. London: Sage Publications Ltd.

Streeton, R., Cooke, M. & Campbell, J. (2004) Researching the researchers: using a snowballing technique. Nursing Research, 12, pp. 35-46.

Yli-Huumo J, Ko D, Choi S, Park S, Smolander K (2016) Where Is Current Research on Blockchain Technology?—A Systematic Review.

Commonwealth Bank (2016) How Long Does It Take To Transfer Money? Available at: https://www.commbank.com.au/support/faqs/572.html [Accessed 09 Jan. 2017]

Kavussanos M. & Visvikis I. (2006) Shipping freight derivatives: a survey of recent evidence, Maritime Policy & Management: The flagship journal of international shipping and port research, 33(3), pp. 233-255.

Ewan Sutherland (2011) Coltan, the Congo and your cell phone. Available at: http://web.mit.edu/12.000/www/m2016/pdf/coltan.pdf [Accessed 19 Jan. 2017]

Sahay, B. & Maini, A. (2002) Supply chain: a shift from transactional to collaborative partnership, Decision, 29(2), pp. 67-88.

B.S. Sahay (2003) Understand trust in supply chain relationships, pp. 553-557

Bernard J. La Londe and James M. Masters (1994) Emerging Logistics Strategies: Blueprints for the Next Century

Lambert, D., James R., & Lisa M. Ellram (1998) Fundamentals of Logistics Managemen., Boston, MA: Irwin/McGraw-Hill, Chapter 14.

Lambert, D. & Cooper, M. (2000) Issues in supply chain management. Industrial Marketing Management, 29(1), pp. 65-83.

Christopher, Martin L. (1992) Logistics and Supply Chain Management. London: Pitman Publishing.

Hacker, S., Israel, J. & Couturier, L. (1999) Building Trust in Key Customer-Supplier Relationships. The Performance Center and Beaverton and Satisfaction Strategies. Portland, OR.

Welty, W. & Bercerra-Fernandez, I. (2001) Managing trust and commitment in collaborative supply chain relationships. Communications of the ACM, 44(6), pp. 67-73.

Archie Lockamy III & Wilbur I. Smith (2000) Target costing for supply chain management: criteria and selection

Zineldin, M. & Jonsson, P. (2000) An examination of the main factors affecting trust/commitment in supplier-dealer relationships: an empirical study of the Swedish wood industry. The TQM Magazine, 12(4), pp. 245-66.

Larson, A. (1992) Network dyads in entrepreneurial settings: a study of the governance of exchange relationships. Administrative Science Quarterly, 37(l), pp. 76-104.

Ring, P. & Van de Ven, A (1994) Developmental processes of cooperative interorganisational relationships. Academy of Management Journal, 19, pp. 90-118.

Gulati, R. (1995) Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. Academy of Management Journal, 38(1), pp. 85-112.

Madhok, A. (1995) Opportunism and trust in joint venture relationships: an exploratory study and a model. Scandinavian Journal of Management, 11(1), pp. 57-74.

Morgan, R., & Hunt, S. (1994) The commitment: trust theory of relationship marketing. Journal of Marketing, 58, pp. 20-38.

Argandona, A. (1999) Sharing out in alliances: trust and ethics. Journal of Business Ethics, 21(2), pp. 217-28.

Richards, L (1995) Empowerment and trust key to partnerships. The TQM Magazine, 7(1), pp. 38-41.

Volery, T. & Mensik, S. (1998) The role of trust in creating effective alliances: a managerial perspective. Journal of Business Ethics, 17, pp. 987-94.

Handfield, R. & Nichols, E. (1999) Introduction to Supply Chain Management. NJ: Prentice Hall.

Olorunniwo, F. & Hartfield, T. (2001) Strategic partnering when the supply base is limited: a case study. Industrial Management & Data Systems, 101(1), pp. 47-52.

Mohr, J. & Spekman, R. (1994) Characteristics of partnership success: partnership attributes, attributes, communication behaviour, and conflict resolution techniques. Strategic Management Journal, 15(2), pp. 135-52.

Olshavsky, R. (1985) Perceived quality in consumer decision making: an integrated theoretical perspective. in Jacoby, J. and Olson, J.C. (Eds). Lexington, MA: Perceived Quality, Lexington Books.

Frankel, R., Goldsby, T. & Whipple, J. (2002) Grocery industry collaboration in the wake of ECR. International Journal of Logistics Management, 13(1), pp. 57-72.

Stank, T., Crum, M. & Arango, M. (1999) Benefits of inter-firm coordination in food industry supply chains. Journal of Business Logistics, 20(2), pp. 21-41.

Ireland, R. & Bruce, R. (2000) CPFR: only the beginning of collaboration. Supply Chain Management Review, September/October, pp. 80-8.

Barratt, M. & Green, M. (2001) The cultural shift: the need for a collaborative culture. Conference Proceedings of Supply Chain Knowledge 2001, Cranfield School of Management, November

Lambert, D. & Cooper, M. (2000) Issues in supply chain management. Industrial Marketing Management, 29(1), pp. 65-83.

Lau, H. & Lee, W.B. (2000) On a responsive supply chain information system. International Journal of Physical Distribution & Logistics Management, 30(7/8), pp. 598-610.

Mason-Jones, R. & Towill, D. (1997) Information enrichment: designing the supply chain for competitive advantage. Supply Chain Management, 2(4), pp. 137-48.

Towill, D. (1997) The seamless supply chain: the predator's strategic advantage. International Journal of Technology Management, 13(1), pp. 37-56.

Lee G., Oakes I. (1996) Templates for change with supply chain rationalization. International Journal of Operations & Production Management, 16(2), pp. 197-209.

Lee H., Whang S. (2000) Information sharing in a supply chain. International Journal of Manufacturing Technology and Management, 1(11), pp. 79-93.

Khurana M., Mishra P., Singh A. (2011) Barriers to information sharing in supply chain of manufacturing industries. Int. J. Manufact, Syst. 1(1), pp. 9-29.

Peters, J. & Hogensen, A. (1999), New directions for the warehouse. Supply Chain Management Review, Global Supplement, Spring, pp. 23-5.

Monczka, R., Morgan J., Trent, R. & Handfield, B. (1998) Purchasing and Supply Chain Management. South-Western: Cincinnati, OH.

Chandra, C. & Kumar, S. (2001) Enterprise architectural framework for supply-chain integration. Industrial Management & Data Systems.101(6), pp. 290-304.

Mayer, R., Davis J. & Schoorman F. (1995). An integrative model of organizational trust. Academy of Management Review. 20(3), pp. 709-734.

Ghoshal, S. & Moran P. (1996) Bad practices a critique of the transaction cost theory. Academy of Management Review, 21(1), pp. 13-47.

Chiles, T. & McMackin, J. (1996) Integrating variable risk preferences, trust, and transaction cost economies. Academy of Management Review, 21(1), pp. 73-99.

Razavi M., Iverson L. (2006) Grounded theory of information sharing behavior in a personal learning space, Proceedings of the ACM CSCW '06 Conference on Computer Supported Cooperative Work, pp. 459-468.

Duranti L., Rogers C. (2012) Trust in digital records: An increasingly cloudy legal area, Computer Law & Security Report Vol. 28, No. 5, pp. 522-531

Mak, B. (2014) Authenticity, in Duranti L. and Franks P., Encyclopedia of Archival Science, Rowman & Littlefield, NY.

Merriam Webster (2015), Trust, Merriam Webster Online Dictionary, accessible at www.m-w.com

Duranti L. (1990), Diplomatics: New Uses for an Old Science (Part III), Archivaria 30, pp. 4-20

InterPARES (2015), "Terminology Database", accessible at http://arstweb.clayton.edu/interlex/

Yeo, G. (2013), "Trust and Context in Cyberspace", Archives and Records Vol. 34, No. 2, pp. 214-234.

Apple (2016). Supplier Responsibility 2016 Progress Report. Avaivable at: http://images.apple.com/supplier-responsibility/pdf/Apple_SR_2016_Progress_Report.pdf [Accessed 03.01.2017]

Fiks: https://www.edelman.com/trust2017/

Appendix

Appendix A: Blockchain conferences

Capital markets blockchain conference
http://digitalcurrencysumm.it/london-capital-markets-blockchain/

- How different blockchains are re-inventing financial services
- Challenges for industry wide adoption of DLTs
- Current initiatives and proof-of-concept projects

"blockchain-applied solutions could used to bridge the gap between distributed ledger systems and the world of mainstream financial infrastructure."

Capital Markets Blockchain 2016
Hong Kong

- Bitcoin and banks
- Current status and future of blockchains in fintech
- Fintech & blockchain hong kong
- Assets on the blockchain (Internet of value)
- Hiring tech in banks
- Integrating blockchain with banking systems
- Fintech/blockchain in emerging/mature markets

http://kyc-chain.com/

Finance 2.0/Crypto 16'
Zurich Switzerland

- How Blockchains can unleash new global value and relevance in Art and Music
- Business applications for private and open chains
- Legal implication of DAOS and smart contracts
- Cybercrime
- International settlements

Blockchain world congress
http://infocastinc.com/event/blockchain-world-congress/
New york

- How will blockchain influence global payments?
- Regulatory issues
- Who will survive in fintech after blockchain is adopted?
- Use cases beyond finTech
- An investor's perspective
- Smart contracts & implications
- Identity & security
- E-stonia
- Blockchain in (Insurance, Healthcare, Public Sector, Supply Chain, Entertainment)

- Blockchain for energy
- Real estate
- Future of blockchain

Devcon 2
https://ethereumfoundation.org/devcon/?page_id=14
- Dapps and regulations
- Ethereum
- Future of Dapps
- http://raiden.network/
- FROM Web 3, from LAMP to Ethereum & IPDS
- Blockchain in state channels
- Technical talks
- Ethereum security
- Ethereum in different languages
- How to build ethereum
- IPFS
- Decentralized git
- Dns with ethereum
- Identity on the blockchain: uPort
- Ethereum in our daily lives
- Decentralized collaborative web. Web 3.0

International blockchain week Shanghai
- IBM + hyperledger (hyperledger = blockchain backend for banks (evil))
- Blockchain without bitcoin
- Microsoft keynote
- Demo day
- Hosted by: Wanxiang Blockchain Labs (non-profit)

The Internet of Value
Blockchain and Financial Services Innovation
https://www.eiseverywhere.com/ehome/188629/427232/
- http://agriledger.com/ blockchain solutions for poor farmers
- A vc that only invests in blockchain
- Digital asset trading platform https://www.blockex.com/about
- Regulations
- Risks and opportunities of the Blockchain revolution
- how are digital currencies and distributed ledgers changing the marketplace?
- Capital Markets and Custody

Blockchain & Bitcoin Conference Kiev
http://bitcoinconf.com.ua/en
- Bitcoin & bitcoin safety
- Mining
- Crypto Trading
- Blockchain-based password-free authorization

- Bitcoin 2.0
- Trading platforms
- CHallenges for banks
- Capital markets + blockchain
- National crypto
- Exchanged
- Regulation
- Crypto shares
- Mining
- Investing with blockchain using it as an investment tool.
- The economics of interchange
- E-auctions
- E-democracy
- Smart contracts
- Land registry
- POS analysis
- Coin battles
- Develop a server-less app
- Securiy
- Ripple & stellar

Blockchain 360 & IoT Security Summit
https://tmt.knect365.com/iot-security/agenda/1

- Blockchain + iot benefits
- Blockchain uses
- Solar coin
- Electric Chain
- Company shared over bitcoin
- Singulardtv,
- Consensys
- Evolution media (blockchain for film/music)
- Integrating bitcoin into the real world of business
- Ethereum & IoT
- Blockchain in IoT http://www.blockchainofthings.com/
- Medical blockchain, patient journals
- Blockchain in energy
- Distributed electric grid
- Solar grid
- Renewable energy
- Blockchain in public sector: voting & crime prevention(?)

Crypto cannabis conference
https://www.cryptocannabisconference.com/

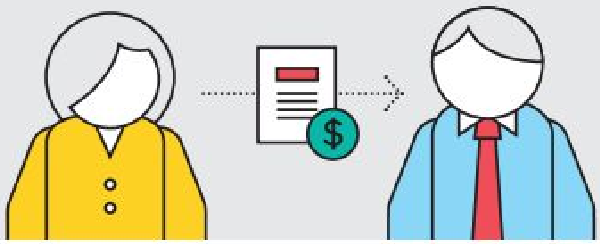
- Proof of Existence
- Security
- Branding business with BTC
- Legal

Distributed health
https://godistributed.com/health/
Healthcare meets blockchain

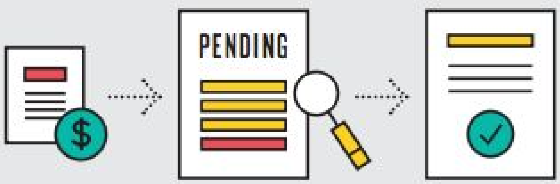
- Electronic medical records
- Pharmaceuticals
- Identity & trust
- Bitcoin, blockchain & the law
- Blockchain and insurance (HIPAA)
- Interoperability
- Supply chain & counterfeiting
- Customers

Appendix B: Blockchain newsletters

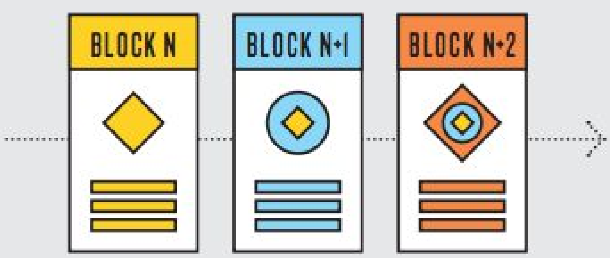
https://godistributed.com/ledger/
http://www.the-blockchain.com/newsletter/
https://consensys.net/
https://bitcoinmagazine.com/



1 **TRANSACTION** Two parties exchange data; this could represent money, contracts, deeds, medical records, customer details, or any other asset that can be described in digital form.

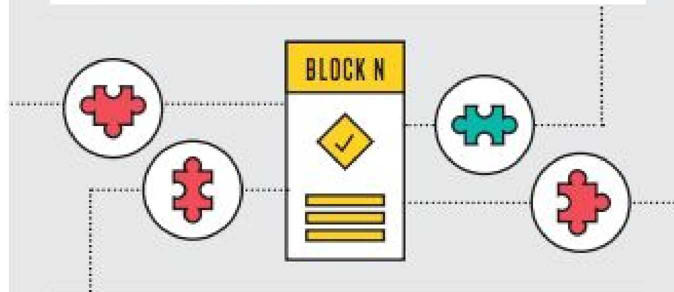


2 **VERIFICATION** Depending on the network's parameters, the transaction is either verified instantly or transcribed into a secured record and placed in a queue of pending transactions. In this case, nodes—the computers or servers in the network—determine if the transactions are valid based on a set of rules the network has agreed to.

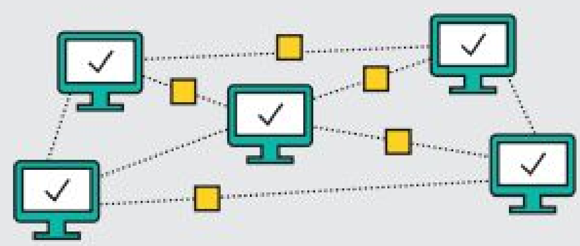


3 **STRUCTURE** Each block is identified by a hash, a 256-bit number, created using an algorithm agreed upon by the network. A block contains a header, a reference to the previous block's hash, and a group of transactions. The sequence of linked hashes creates a secure, interdependent chain.

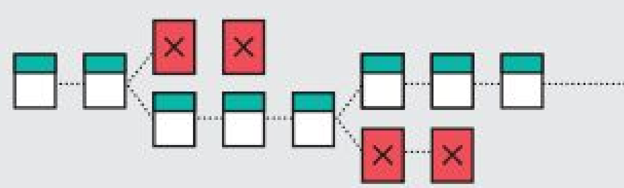
4 **VALIDATION** Blocks must first be validated to be added to the blockchain. The most accepted form of validation for open-source blockchains is proof of work—the solution to a mathematical puzzle derived from the block's header.



5 **BLOCKCHAIN MINING** Miners try to "solve" the block by making incremental changes to one variable until the solution satisfies a network-wide target. This is called "proof of work" because correct answers cannot be falsified; potential solutions must prove the appropriate level of computing power was drained in solving.



6 **THE CHAIN** When a block is validated, the miners that solved the puzzle are rewarded and the block is distributed through the network. Each node adds the block to the majority chain, the network's immutable and auditable blockchain.



7 **BUILT-IN DEFENSE** If a malicious miner tries to submit an altered block to the chain, the hash function of that block, and all following blocks, would change. The other nodes would detect these changes and reject the block from the majority chain, preventing corruption.