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Blockchain's disruptive effects on International Trade

Theoretical analysis

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“The algorithms are more trustworthy than the humans” – Antony Pompliano

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1. Introduction

The world has experienced a drastic increase in trade flows following the beginning of globalization and the invention of containers. The sector is gaining an increasing importance in the gross domestic products of countries, especially for small open economies mostly relying on their exports. As data from the World Bank shows, trade in percentage of GDP for the whole world skyrocketed from 24,1% in 1960 to 57,85% in 2017 with a spike at 60% in 2008 just before the crisis¹. However, even though the exports of goods and services have a positive annual growth ever since 1971 except for 1975 and 2009, the processes have not evolved much and are still mainly paper-intensive, requiring costly and time-consuming manual checking. Moreover, the paper nature of the procedures entails major inefficiencies in terms of speed, visibility and security.

Therefore, questions about the possibility to get rid of the paper nature of those systems via its digitalization naturally arose. However, before the creation of Bitcoin in 2008 and consequently of the blockchain technology, there was no technology able to both digitalize data into a platform and guarantee its immutability without a third party involved. The need of a trusted third party to preserve information and to transfer either data or money constituted a major point of failure for both the security and the veracity of the data. In the case of blockchains, no third party is required to store and safe keep the data as the system is maintained by all the computers connected to the network. Consequently, the technology analyzed in this thesis could enable the proper digitalization of paper-based procedures and help to gather multiple parties into a similar platform without the need of a third party, possibly inducing disruptive effects in multiple sectors.

The digitalization of international trade processes by the use of blockchain-based systems could also enable their automation via the use of smart contracts and IoT devices. This enhancement should reduce both costs and risks taken by all agents throughout the current complex supply chains. The gathering of agents involved in the international trading of goods into common blockchain-based platforms, including governmental agencies and banks, could allow those stakeholders to acquire a visibility and auditability level never obtained before at all the stages of exportation.

¹ The World Bank (2019), *Trade (% of GDP)*. Retrieved from <https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS> on 18 May 2019.

This work intends to spot and highlight the disruptive effects that blockchain could bring to international trade via both trade finance, supply chain management and cross-border procedures.

The paper will be structured as follows: section 2 will first introduce the blockchain technology by defining it theoretically and describing the different possible types of structures. Then we will distinguish its features and explain the concept of smart contract; section 3 introduces trade finance processes, their pain points and the possible solutions brought by blockchain; section 4 aims to explain supply chain management and to describe its current pain points and the solutions to those problems; section 5 points out the possible applications of blockchain to cross-border procedures both for business-to-government and government-to-government relations; section 6 highlights the different limitations to the technology's full implementation; section 7 is a personal analysis of the disruptive effects by regions and their differences; section 8 concludes the work by resuming the impacts of the blockchain technology.

2. Blockchain

“A lot of people automatically dismiss e-currency as a lost cause because of all the companies that failed since the 1990’s. I hope it’s obvious that it was only the centrally controlled nature of those systems that doomed them. I think this is the first time we’re trying a decentralized, non-trust-based system” – Satoshi Nakamoto

2.1. Introduction to blockchain

Following the 2008 crisis, Satoshi Nakamoto, an anonymous person or entity, created Bitcoin². A digital currency and online peer-to-peer payment system, operating independently of any central bank in which encryption techniques are used to define the money creation system and verify transfer of funds. Through the creation of Bitcoin, Nakamoto also designed the technology studied in the thesis, the Blockchain, solving for the first time the problem of double spending on digital currencies without the need of a trusted third party. Indeed, the blockchain is the underlying technology of all cryptocurrencies, including Bitcoin. We can define it as a peer-to-peer database of all transactions made on a network organized in blocks chained to each other using cryptography. Each block containing a cryptographic hash of the precedent block, a transaction data and a timestamp.³

² Satoshi Nakamoto. (2019), “Bitcoin: A peer-to-peer electronic cash system”.

³ Casey, Michael, et al. (2018), “*The Impact of Blockchain Technology on Finance: A Catalyst for Change.*”, ICMB, International Center for Monetary and Banking Studies.

A ledger, according to the Oxford Dictionary, is “a book or other collection of financial accounts”. Those types of classic ledgers have existed for hundreds of years to keep record of transactions, especially when people started trading goods and services. However, it has not evolved much since then. Indeed, such type of ledger is still organized and kept by a centralized system and maintained in the information system of an organization. The most common ledger to everyone is a bank account record in which every transaction made by the customer, either credit or debit, is recorded by the bank. Therefore, clients trust the ability of the bank to maintain a proper record of all transactions safe and secure. That is referred as a double-entry bookkeeping system.

Thanks to the blockchain creation, we are now able to have a “distributed ledger” system which is collectively maintained by each system participant, also called nodes, instead of relying on a central entity. The nodes are the participants’ computers, which are each keeping, updating and validating simultaneously a complete set of transaction records to prevent a single point of failure. As every connected computer has a copy of the ledger and maintains it, there is no central entity verifying the validity of the transaction such as in a simple ledger; therefore, we can call it a “distributed” ledger.⁴ Using this technology, we go from a double-entry bookkeeping system to a triple entry accounting where any entry involving an outside party is cryptographically sealed by a third entry.

As in a classical ledger, the distributed ledger is updated whenever a new transaction occurs. However, when using a blockchain or distributed ledger technology (DLT), the previous information is not being overwritten by the new one such as in a conventional ledger but instead the new information is exchanged between nodes and added as a new entry. “Thus, the blockchain provides an immutable data storage, which only allows inserting transactions without updating or deleting any existing transaction on the blockchain to prevent tampering and revision.”⁵ In order to add this new entry, nodes need to reach consensus among themselves. To do so, they have to complete two important steps: Validation of the transactions and broadcast of the validated transactions to other nodes.⁶ Underneath is a visual representation of a money transfer, in the form of cryptocurrency, using a blockchain. The transfer could also consist of contracts, records, property titles or other information instead of cryptocurrencies.

⁴ HKMA. (2016), “*Whitepaper on Distributed Ledger Technology.*”, 9-11

⁵ X. Xu *et al.* (2016), “The Blockchain as a Software Connector”, *2016 13th Working IEEE/IFIP Conference on Software Architecture (WICSA)*, Venice, Italy, 182-191.

⁶ *Ibidem.*

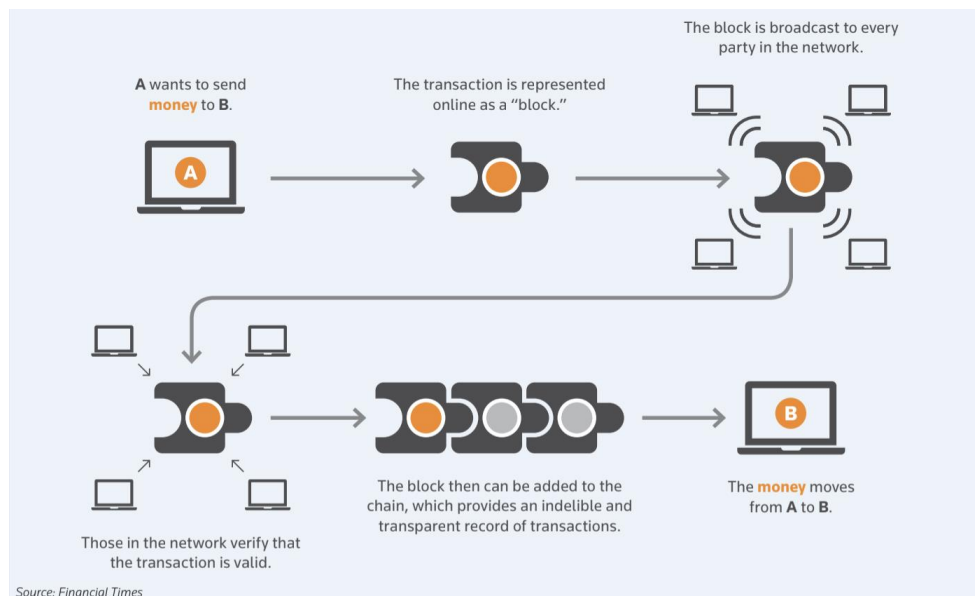


Figure 1: Money transfer using blockchain⁷

As mentioned, there is a need to reach consensus among nodes on the validity of transactions. Depending on the type of DLT, the process might differ completely. The first form of consensus reaching method was designed by the Bitcoin blockchain and uses the so-called “Proof-of-Work” mining process. In this setting, validating nodes compete among each other “to perform a computationally demanding calculation. The first node to solve the computational problem then helps to build a transaction block.”⁸ However, such type of consensus reaching method turns out to be problematic if certain ledgers need to be scaled to a very high number of transactions per second. Firstly, as the process requires very high computer power to perform the calculations, participants will need incentives to invest in such resources. Secondly, whenever a validating node is attempting to add a set of validated transactions to the block, it cannot process another set of transactions into a new block, possibly slowing down the process.⁹ This kind of problem has given rise to other types of blockchains and consensus reaching methods such as “Proof-of-Stake”, described further on.

To illustrate the transaction broadcast and validation by nodes, we will take the example of a property transaction including a property title transfer. In an ordinary property transaction, such as the selling of a real estate good, agents have to trust a central authority, such as a government, for the transfer of the property rights and usually a bank for the money transfer from the buyer to the seller. Government and banks may seem to be trustworthy agents in a

⁷ M. RENNOCK, A. COHN, J. BUTCHER (2018), “Blockchain technology and regulatory investigations”, The Journal.

⁸ HKMA *op. cit.*,

⁹ *Ibidem.*

developed country with a relatively low level of corruption. However, it might not be the case in developing countries suffering from high levels of government corruption. Therefore, using a DLT to increase visibility and trust in such a set up might be worth implementing as records are immutable.

Let's suppose that Manuella, client of bank A, is selling her flat to David, bank B's client, for \$1million. Once the purchase agreement is signed and David gets his mortgage, bank A will broadcast the transaction to all the other nodes, so that any of them can validate it. Indeed, as each node has a local copy of the ledger, they are able to track the property right among the set of previous transactions to check the validity of the transaction, in this case if Manuella has effectively the property right of her flat. During the validation period of the transaction, it can occur that another person, Malaika, is buying a property from Nicolas, settling payment from Bank C to bank D. Therefore, nodes will group all the newly made transactions that have not been recorded yet into the ledger and compile them into a block. A validating node will broadcast the transaction block to all the other nodes once the compiling is done. The consensus process allows nodes to communicate among themselves and verify if the agreed transactions can be added to the ledger. In the case of a blockchain type of DLT, the new block will be added to the existing ones making it permanent and unalterable. Once the operation is added, the process starts again. Considering the money transfer included in such a transaction, it can be made either outside the blockchain network using a separate payment system or in the same blockchain system through the recording of a digital currency movement.

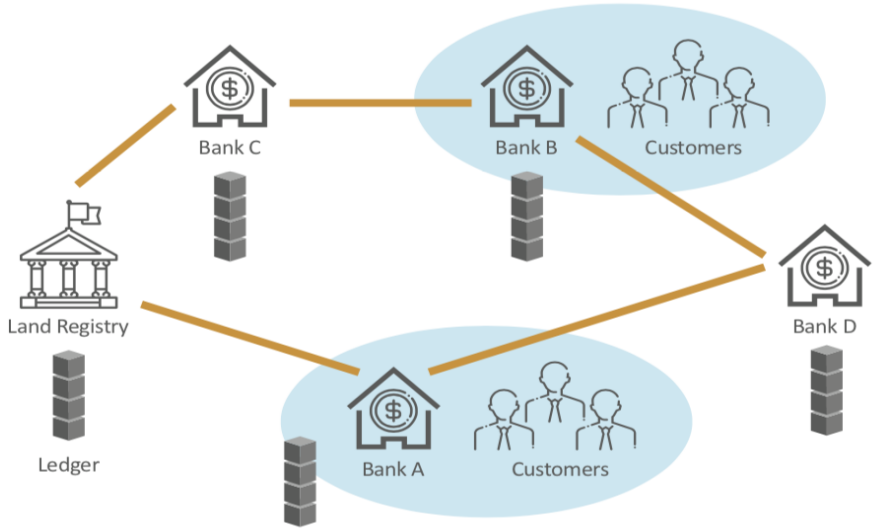


Figure 2: DLT system in which the Land Registry and banks maintain replicated copies of the ledger¹⁰

¹⁰ Ibidem.

There are two ways to encrypt transactions, either by a symmetric or an asymmetric encryption. In the first case, person A encrypts a message using a key which will be transferred to person B to decrypt the data sent. This method presents security risks as hackers can get their hands on the key during its transfer in order to compromise the data. In the asymmetric encryption case, two different keys are used, both a public key and a private key. In this method, both agents A and B generate one public and one private key when creating their wallet. Whenever agent A wants to send an encrypted message to person B, he will have to use agent B's public key to encrypt the message. Once the message is sent, its data will only be accessible by logging in the network with agent's B private key. A loss of the private key induces the loss of the corresponding wallet. Public keys, used to encrypt and transfer data to one another, could be compared with a bank account's number, while private keys are a means to connect to the wallet and decrypt the data, and could be compared with the bank account's password. Most systems such as Bitcoin or Ethereum use this asymmetric encryption method to securely send transactions throughout the network.

Finally, the current literature often misuses the words Blockchain and DLT by lack of understanding. Every blockchain is a distributed ledger technology (DLT) but not every DLT is a blockchain. On the one hand, the different data recorded on a blockchain are grouped together and organized in blocks which are linked one to another and secured using cryptography. On the other hand, DLT are not always designed in blocks and therefore can't be called blockchains. We will mostly refer to blockchains in this thesis as it is, in my opinion, the actual best form and the most common design of DLT created.

2.2. Types

There are three possible types of blockchain architecture options available which all have their advantages depending on the use case objective.¹¹

2.2.1. Permissionless or public Blockchains

In a public or permissionless blockchain, anyone can freely join or leave the network both as a reader and a writer at any time. Therefore, these are open-source networks where no central entity manages the membership, implying that any peer can read a written content making it a decentralized system. Moreover, each node can be part of the consensus process to check the validity of transactions. Such types of blockchains often offer economic incentives to those securing the network.

¹¹ Wüst Karl and Arthur Gervais. (2018), "Do you need a Blockchain?.", In 2018 Crypto Valley Conference on Blockchain Technology (CVCBT), 45-54. IEEE. In this sense too, M. RENNOCK, A. COHN and J. BUTCHER *op cit*;

The first ever blockchain created was a public or permissionless blockchain called Bitcoin. One advantage of such type of blockchains is that users are pseudonymous and highly resilient. As no agent singularly owns the ledger, such type of methodology would be more suitable for censorship resistant applications. A major drawback of such an architecture is usually the low scalability of the transactions.

2.2.2. Permissioned or private blockchain

A central entity allocates the rights to read and write operations on the blockchain therefore limiting the access to the distributed ledger. Permissioned blockchains do not rely on anonymous nodes to validate transactions, as only authorized nodes can do that. This architecture is better suited for use-cases needing simplicity, speed and transparency. Indeed, even if companies might want the benefits of using a blockchain technology, they will still need to keep some privacy concerning sensitive data, which will lead them to choose a private blockchain. However, a possible drawback is the loss of immutability of such a system, because the rights to read and write are concentrated in few hands who could be able to tamper the ledger. That is why such types of blockchain are often designed by private companies for their personal commercial uses.

2.2.3. Consortium blockchain

Hybrid or consortium blockchains have characteristics of both public and private blockchains. Indeed, they have a set of permissions such as in private blockchains, but they differ in that they are controlled by a group of organizations instead of by a single organization. It could, for example, be a consortium of 20 partners where 15 of the 20 nodes need to validate the transactions of a block for the block to be integrated into the blockchain. Those architectures can be useful when a set of companies or organizations do not want anyone with an internet connection to be able to review their transactions but at the same time still want a minimum of decentralization in the process rather than having one single organization validating the blocks. They offer the advantages of efficiency and privacy of transactions incorporated in private blockchains. Consortium blockchains are often used by groups of companies such as big banks, for example R3.

Table 1: Taxonomy of blockchain systems¹²

<i>Property</i>	<i>Public blockchain</i>	<i>Consortium blockchain</i>	<i>Private blockchain</i>
Consensus determination	All miners	Selected set of nodes	One organisation
Read permission	Public	Could be public or restricted	Could be public or restricted
Immutability	Nearly impossible to tamper	Could be tampered	Could be tampered
Efficiency	Low	High	High
Centralised	No	Partial	Yes
Consensus process	Permissionless	Permissioned	Permissioned

2.3. Features

2.3.1. Immutability

As mentioned previously, a blockchain is composed of different blocks, each one displaying a set of transactions linked to each other by cryptographic techniques such that none of them are possibly erasable. The immutable nature of a blockchain is therefore made possible thanks to both cryptographic technologies and proof systems. However, as shown in subsection 2.2, depending on their type all blockchains are not totally tamper-proof. Indeed, when considering a public blockchain using a “Proof-of-work” consensus such as the Bitcoin, the only possible breach in the immutability aspect of it is that an agent or a group of agents have more than 51% of the total computing power of the network enabling them to modify an entry made on the blockchain and start double spending. With this in mind, we could say that such a blockchain is “Mutable-by-Hashing-Power”.¹³ Yet, nobody has ever succeeded to reunite such an amount of computing power, making the Bitcoin blockchain totally immutable for now. Therefore, as it is almost impossible to tamper such a blockchain, we can assess that it is immutable.

However, when considering consortium or private blockchains, the argument does not stand anymore. In fact, to reach consensus determination the former uses a selected set of nodes and the latter one single organization. Thus, the control over the immutability of the distributed ledger is only in a limited set of hands, allowing a party, especially a totally private blockchain, to change the record at will. Nevertheless, according to the use cases of such distributed ledgers,

¹² Zheng, Zibin, et al. (2018), "Blockchain challenges and opportunities: A survey.", *International Journal of Web and Grid Services* 14.4, 352-375.

¹³ Daniel Conte de Leon, Antonius Q. Stalick, Ananth A. Jillepalli, Michael A. Haney, Frederick T. Sheldon. (2017), "Blockchain: properties and misconceptions", *Asia Pacific Journal of Innovation and Entrepreneurship*, Vol. 11 Issue: 3, 286-300.

the possibility to tamper with a blockchain should not be a concern as there should be only trusted parties involved in such configurations.¹⁴

2.3.2. Transparency¹⁵

In most blockchains, linking a public address to the individual behind it is very hard, as the identity of the user is protected by powerful cryptography. Therefore, we may wonder if a blockchain is transparent or not and if it is not simply an opportunity for thieves to hide behind a public address. The transparent aspect of a blockchain is the ability to view, on most blockchains at least, the holding and transactions of each public address without the need of consent from the owner. Such type of transparency has never existed in any financial system before.

In the past and, surprisingly, even today, large financial institutions are able to handle their customers' funds as they please without any customer knowing what is done with them, the 2008 financial crisis being a perfect example of the consequences of this issue. To solve this issue, blockchain platforms enable large and small businesses to act with transparency and integrity towards their community and customers.

This property of the blockchain platforms can be of great use; consider a supply chain management for example: transparency will allow businesses and customers to know exactly what they buy and consequently what they eat with the certainty that the data is immutable.

2.3.3. Real-time record

As explained previously, every node on the blockchain has an up-to-the-moment record of all the transactions ever made on the distributed ledger. This means that whenever a transaction occurs on the system, every copy of the distributed ledger kept by the network participants is automatically updated in real time so that each node keeps an up-to-date record. This property of the system reduces opportunities to defraud and generates cost savings, every party has its own version of the truth constantly updated.

2.4. Smart Contracts¹⁶

Contracts have always been of a crucial importance in trade as it is the only legal binding document which can compel someone to honor his agreement to do or not do something in exchange for something else. However, such types of binding agreements often end in disputes

¹⁴ Wüst, Karl and Arthur Gervais *op cit*;

¹⁵ Lisk. (2019). *Blockchain Transparency Explained*. [online] Retrieved from <https://lisk.io/academy/blockchain-basics/benefits-of-blockchain/blockchain-transparency-explained> on 19 February 2019. In this sense too, Wüst, Karl and Arthur Gervais *op cit*;

¹⁶ SWAN M. (2015), "*Blockchain: blueprint for a new economy.*", Beijing, O'Reilly, 13-18.

as one party might not be willing to fulfil his obligation or might consider that the obligations of the other party have not been met. Indeed, contract disputes account for 44% of the total litigations in the United States and for 57% in the United Kingdom¹⁷. One possible solution could be to automate the system of contracts such that once a condition is met, it will trigger the execution of the rest of the contract. To do so, we can use Smart Contracts based on blockchains which “feature the same kind of agreement to act or not act, but they remove the need for one type of trust between parties. This is because a smart contract is both defined by the code and executed (or enforced) by the code, automatically without discretion”¹⁸.

Smart contracts are characterized by three properties: autonomy, self-sufficiency and decentralization. Autonomy in the sense that once the contract is launched, there is no further need for the parties to stay in contact as the contract will automatically honor the obligations, such as payments for example, once the conditions have been met. Secondly, smart contracts are self-sufficient in their “ability to marshal resources”¹⁹. Thirdly, they are decentralized in that they are distributed across the network nodes and therefore not kept in one single centralized server.

Yet, smart contracts will not make possible anything previously impossible possible, but they allow parties to solve common problems with a minimum need of trust. Without a doubt, taking human judgment out of the contract and allowing complete automation will make things more convenient and allow minimal trust in the process. A basic example is an inheritance gift which becomes available once the grandchildren are eighteen or the grandparents die. A contract initiating the transfer only when certain events occur could be created on a blockchain.

In this example, the program will fix the date of execution of the transaction on the grandchild’s 18’s birthday and will check if the transaction has not been executed yet. The second condition, that is the grandparent’s death can be set up by implementing a program which scans the online death registry database to assess that the grandparent is effectively dead. This is only one possible easy to understand use case but there are thousands of other possible applications such as automatic payments for betting, pledge systems like Kickstarter where funds could be more easily tracked by the contributor and many other fields.

¹⁷ *Ibidem.*

¹⁸ *Ibidem.*

¹⁹ *Ibidem.*

Still, there is huge concern about the need for new regulations and a body of laws that could be able to distinguish “between technically binding code contracts and our more flexible legally binding human contracts”²⁰. Indeed, it could be almost impossible to enforce smart contracts with the currently enacted legislation as such contracts are automatic and potentially unstoppable once codes are executed. A solution presented by Melanie Swan is to allow parties contracting a smart contract to integrate the legal framework of their choice into the code. Therefore, a legal framework could be chosen as a feature of the contract among a multiplicity of legal frameworks allowing the parties to incorporate the best fitting one.

Finally, if a smart contract incorporates a property title transfer, it would be much easier if this precise property title was encoded into the blockchain. In fact, it would be possible to automatically transfer on the blockchain the ownership of the property from one party to the other once the payment is made. This is the concept of smart property: transacting property in a blockchain-based model. The previously mentioned property could be either tangible such as a home or a car or intangible such as stock shares and copyrights. Once an asset is registered on the blockchain, its ownership will be controlled by who has the private key. Therefore, the owner, by transferring his private key to another party, will be able to sell directly on the blockchain. “The key idea of smart property is controlling ownership and access to an asset by having it registered as a digital asset on the blockchain and having access to the private key”²¹.

We can imagine a smart contract which would automatically transfer the property title of a car from the financing company to the owner of the car once its loan has been paid back. The key aspect of all this is the trustless feature of the blockchain technology enabling anybody to transfer to any other person without having the need to know and trust each other or to have a third trusted party to check the transaction. Making property smart will allow people to trade with each other with much less need of trust reducing fraud and mediation fees in addition to the increase in total trades. For example, I could lend my money over the Internet more easily by taking as collateral the other person’s smart property possibly making the lending industry more competitive, thus reducing the cost of credit.

However, it is important to note that everything cannot be modelled in a smart contract. Indeed, as in a classical form of contract, every situation that can occur between both contractors is not specified in the binding contract. Thus, whenever one of the unspecified conditions occurs, no repercussion will be triggered as it was not mentioned when the contract

²⁰ *Ibidem.*

²¹ *Ibidem.*

was coded. Therefore, some kind of flexibility in the execution of smart contracts will be required to keep the ability to add and execute previously unspecified conditions.

3. Trade Finance

“I know what I have given you... I do not know what you have received.” — Antonio Porchia

3.1. Explanation

International trade has become a major driver of the gross domestic products of open economies during the last few decades. Statistics from the World Bank show that exports of goods and services in percentage of GDP has evolved between 1960 and 2017 from 37,8% to 85,05% for Belgium and from 4,97% to 11,89% for the USA²² showing how important trade is for some countries. Thus, it is becoming vital for those countries to lubricate trades with others to maintain a viable growth rate. Nevertheless, as shown during the 2008 crisis, financial instability can trigger dips in international trades as trust in the banking system shrinks, creating struggles for open economies to finance their deficit.

Moreover, trade financing often seems normal in developed countries because the financial intermediaries backing the importers and exporters are already very mature, but it is not necessarily the case in developing countries where the access to financing is harder. As numbers show, the shortage of trade finance in Africa amounted to \$120 billion in 2012 when taking a conservative estimate²³ while it is estimated to be of US\$ 692 billion in developing Asia in 2016²⁴ (including India and the People’s republic of China).

Even in developed countries, it can be difficult for small and medium-sized businesses to obtain financing “because they typically have less collateral, guarantees and credit history than larger companies”²⁵. Therefore, it is important to describe how international trades occur in our current world and use available technologies to improve certain aspects of the actual system.

3.1.1. Inter-company credit

Whenever two agents want to trade with each other, the payment timing has always been a point of disagreement. Two thirds of global trade transfers are financed using inter-firm trade credit²⁶ such as Open accounts or Cash-in-Advance. The problem arising from such transactions is that

²² The World Bank (2019), *Exports of goods and services (% of GDP)*. Retrieved from <https://data.worldbank.org/indicator/NE.EXP.GNFS.ZS?locations=BE-US> on 5 March 2019.

²³ WTO. (2016), *Trade Finance and SMEs: Bridging the Gaps in Provision*, WTO, Geneva, 21.

²⁴ ADB. (2016), *2016 Trade finance gaps, growth, and job survey*, ADB BRIEFS NO. 64.

²⁵ WTO *op. cit.*, p9.

²⁶ Bank for International Settlements. (2014), “Trade finance: Developments and issues”, Committee on the Global Financial System (CGFS) publication no. 50 by Clark, J., Basel: BIS.

on the one hand, the exporter wishes to be paid upon shipment to make sure that he will effectively be paid by the receiver whereas on the other hand, the importer would prefer to pay upon receipt to be able to check the quality of the good before effectively paying.

Therefore, in the case of open account trades, the risk will be buried by the exporter who will have to finance in advance the required working capital and trust the importer to make the payment once the merchandise has been received. To cover all or part of this risk, the exporter can contract a trade credit insurance, therefore transferring the risk from the exporter to the insurer²⁷. When considering cash-in-advance methods, the risk will be on the importers' shoulders as he will have to trust the exporter to effectively deliver the goods in good condition. Hence, long-lasting relationships creating trust between the agents can lead the parties to choose such types of transactions settlements instead of bank-intermediated financing as it is less costly and faster.²⁸

3.1.2. Bank-intermediated finance

To solve those international trade risks, trade finance products have been created to provide insurance, credits and payment guarantees to both importers and exporters. It is often referred to as short-term maturity bank products linked to specific international trade transactions that help manage international payment risks. The maturity of those products can be of a longer term, depending on the nature of the traded products; however, most trade flows are short-term. The market of trade finances, when considered in its widest definition, represents above US\$ 12 trillion annually out of US\$ 18 trillion of exports according to the Bank of International Settlements (BIS)²⁹. Furthermore, when only considering bank-intermediated short-term trade finance, its total amounts to US\$ 6.5-8 trillion including US\$ 2.8 trillion in letters of credit during 2011.³⁰ Additionally, the world trade volume growth has been slightly positive³¹ ever since, making the market even bigger nowadays.

There are two major types of bank-intermediated finance products, letter of Credits (LC) and Documentary collection (DC), the first one being the most commonly used product. A LC is a commitment by the buyer's bank to pay the seller's bank as soon as the previously contracted agreements are reached. Once the seller and buyer agreed on a contract, the importer

²⁷ Niepmann, Friederike, and Tim Schmidt-Eisenlohr. (2017), "International trade, risk and the role of banks.", *Journal of International Economics* 107, 111-126.

²⁸ WTO (2016). *op. cit.*,

²⁹ Bank for International Settlements. (2014), "Trade finance: Developments and issues", Committee on the Global Financial System (CGFS) publication no. 50 by Clark, J., Basel: BIS.

³⁰ *Ibidem.*

³¹ WTO (2017). *Trade recovery expected in 2017 and 2018, amid policy uncertainty*. Retrieved from https://www.wto.org/english/news_e/pres17_e/pr791_e.htm on 12 March 2019.

will apply to his bank for a letter of credit which will thereafter be sent to the exporter’s bank with notification to the seller. As soon as the shipment of the product is achieved, the exporter will have to provide shipping documents, most of the time consisting in bill of landing, commercial invoice and certificate of origin to its advising bank to prove the effective delivery of the good. Even if the importer’s bank defaults, the exporter will still be able to get paid by his local bank thanks to the LC. Thus, this financial product allows to substitute the creditworthiness of the importer by the exporter’s bank.³²

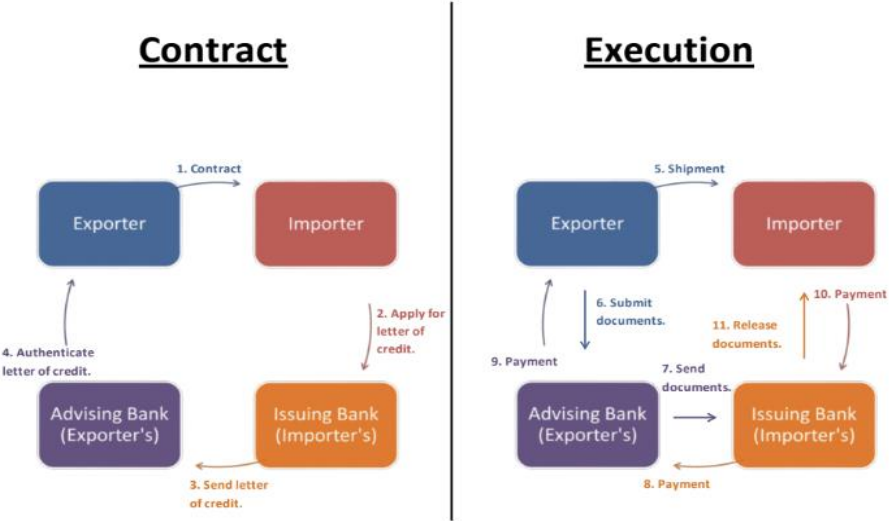


Figure 3: Letter of credit scheme³³

While letters of credit are often used in trade finance, documentary collection is less common. The main difference is that DC does not include payment guarantees as LCs. In this case, the advising bank will send the shipping and ownership documents to the issuing bank which will forward them to the importer upon payment of the goods. Therefore, the exporter will be paid only if the importer honors his commitments to his bank. In conclusion, bank-intermediated finance increases the importer’s incentives to pay, hence reducing the risks of such transactions.

However, the issuance and verification process of LCs is very costly and time consuming, making it unattractive for trading parties compared to open-account trades. This is reflected by the growing decline in the volume of MT700s, accounting for 90% of LC transactions. In fact, according to the International Chamber of Commerce, the use of MT700s has decreased by 9,07% between 2013 and 2016³⁴. This phenomenon highlights the need for

³² Niepmann Friederike and Tim Schmidt-Eisenlohr *op. cit.*,

³³ *Ibidem.*

³⁴ ICC. (2017), 2017: *Rethinking Trade and Finance*, International Chamber of Commerce, 90.

financial intermediaries to innovate in the LC process in order to cut the costs and the time needed to complete such operations, possibly making it attractive to businesses again.

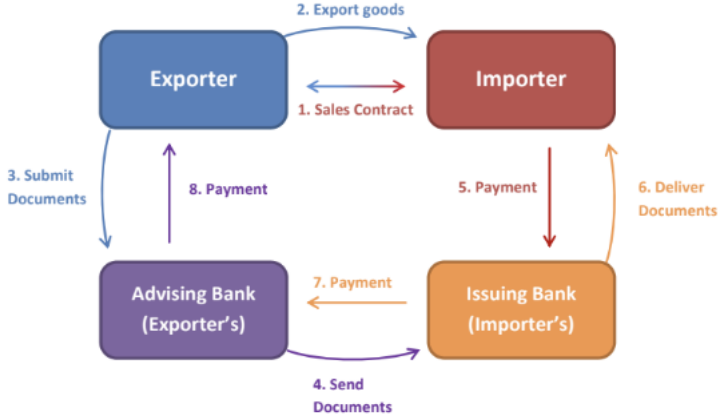


Figure 4: Documentary collection scheme³⁵

3.2. Pain points and solutions

The trade financing industry has not evolved much since the time it appeared, even with the massive growth in global trades. In this world of technological progress, many pain points of the present system could be resolved by technological improvements. Indeed, a lot of the process is still paper based and opaque and thus subject to falsification and fraud. Those problems are emphasized by the lawsuit against Citigroup accused by the Oceanografia’s investors of conspiring with Oceanografia about falsified work estimates which caused the loss of at least US\$ 1.1 billion to Rabobank Groep’s investors and to the creditors of the Mexican firm, Oceanografia SA³⁶.

Likewise, according to a survey by the International Chamber of Commerce, there has been an increase in both court injunctions against banks and issues of allegations of fraud over the last few years.³⁷ We will describe most of the solvable pain points. Then, we will further develop the possible solutions made available by the blockchain to solve these problems.

The basis of all solutions could consist in modelling a LC as a smart contract on a blockchain involving the seller, the different banks engaged in the transactions and finally the

³⁵ Niepmann Friederike and Tim Schmidt-Eisenlohr *op. cit.*,
³⁶ The Business Times. (2016). *Citigroup faces fraud suit claiming US\$1.1b in losses*. Retrieved from <https://www.businesstimes.com.sg/banking-finance/citigroup-faces-fraud-suit-claiming-us11b-in-losses> on 12 March 2019.
³⁷ ICC. (2016), *2016: Rethinking Trade and Finance*, International Chamber of Commerce, 16.

other trade partners. This smart contract would be a guarantee from the financier to pay the supplier if all the merchandise is effectively delivered to the buyer and the conditions mentioned in the contract are met. Doing so would enable everybody to monitor the transactions and their status in real-time while storing all the data immutably on the blockchain as the only version of the truth. This allows the importer to draw the LC conditions directly on the blockchain as a draft, making it visible first to his bank, which allows this agent to review and possibly change some of the LC applications where needed before digitally signing it. Once checked and confirmed by the issuing bank, the digitalized LC can be successively checked and confirmed by the other agents, which are the participating bank and the exporter in this simple case. Everybody with the correct access rights to the blockchain is able at any time to check and submit updates or amendments to the documents stored. Once changes are submitted to the different parties, a multi-signatory mechanism will be needed to trigger the changes, avoiding anyone to change terms on his own.

Of course, the participant must have approval and viewing permissions in order to participate in the multi-signatory mechanism. This allows the administrators, mainly in the case of a private blockchain, to exclude from voting the parties that are not concerned by the modifications.

Modelling a LC as a smart contract on a blockchain will also allow to automatically trigger payments once the buyer confirms that the conditions specified in the smart contract are fulfilled, thus reducing the delays between delivery and payment.

3.2.1. Contractual ambiguities

Pain point

The fulfilment of the letter of credit's legal term is often left to the discretion of the bank if not clearly written. Indeed, some conditions can be unclearly formulated in the contract, making it hard to assess if they have effectively been respected. For example, the condition of the shipment date can be noted as "Beginning of the month", which is vague, thus possibly creating a difference in interpretation between the bank and the seller. The seller could think that the beginning of the month consists in the first week, weekend included, whereas the bank could interpret it as the first five days. Those divergences in interpretation can lead to payment disputes or denial of the LC despite the correct fulfillment of the sales' contract requirements.

Furthermore, banks often apply strict compliance standards in the LC conditions; if they only checked for reasonable compliance, they could possibly accept a deviating behavior of the

seller leading to a failure of their obligations towards the buyer. Some estimates show that 80% of the LCs presented to banks contain potential ambiguities upon first presentation³⁸. Hence, it would be interesting to implement an automated verification system replacing the discretionary determination of the bank. Such system could possibly resolve ambiguities by clarifying the conditions.

Solution

As the LC is designed as a smart contract, the terms mentioned should be logical and verifiable. This implies that the specifications about time, place, manner of shipment and other terms should be precise and exact, excluding any discretionary decisions taken by the banks. We previously took the example of time with the sentence “Beginning of the month” to illustrate how it could be perceived differently by the bank and the exporter. In a smart contract design, such types of conditions would be replaced by discrete-time specifications, which are easily checkable by the different parties on the blockchain, removing the ambiguities and therefore the discretionary decisions by banks about delivery or payment time limits.³⁹

Moreover, it would also be possible to model as a smart contract the sales contract made between the buyer and the seller on the same blockchain as the LC agreement between the buyer and the issuing bank, avoiding even more data discrepancies. Indeed, key data elements such as the correct names of the goods can be directly copied from the sales contract and included in the LC smart contract. This method would ensure uniformity in the data across the different contracts dropping data errors.⁴⁰

3.2.2. Amendment cost

Pain point

On top of ambiguities, LCs can present discrepancies or data mismatches. Indeed, the buyer can be forced to reject discrepancies due to spelling, grammar or punctuation errors. For example, if the importer’s name is mentioned as “Nicolas & Co Limited” instead of the actual company name “Nicolas Co. Limited”, the LC can be considered as containing unacceptable discrepancies. Such types of data mismatches can also occur for instance if the name reference of the product is not the same in the shipped consignment and the inspection documents. In such cases, the buyer will have to give his approval to waive the discrepancy. This waiving process can take time, possibly delaying the delivery of the products. According to an ICC

³⁸ Mark Hayward. (2011), “The Top Five Problems with Letters of Credit,” Strong & Herd.

³⁹ Rashi Goyal and Lata Varghese part 2 *op. cit.*

⁴⁰ *Ibidem.*

study, around 60% to 70% of LC evaluation are disallowed on first presentation because of those types of discrepancies⁴¹.

Moreover, some discrepancies cannot be resolved easily and need amendments to be made either in the LC contract or the sales contract or both. Such an amendment could consist in the change of address of one party for example. If this occurs, all the modifications must be done before the expiration date of the LC, which requires the process to be fast. Yet, “an average LC easily costs several hundred dollars and requires seven to 10 days after documents are submitted for processing and payout”⁴². Any modification will represent an additional cost, both in money and time to the already expensive LC, possibly making the process unprofitable, especially for small transactions or time-sensitive shipments.

Solution

As explained, some discrepancies or data mismatches require amendments by the concerned parties. Those amendments are nowadays very costly in term of time and money, that is why it would be useful to digitalize the different contracts in a blockchain to allow the parties to check and modify specific data in real time. Indeed, when modelled into a smart contract on a blockchain, the LC and the sales contracts are visible to all the concerned parties, making the contracts' discrepancies quickly visible and identifiable. Once an amendment is needed in one of the agreements, the changes can be directly made using a multi-signatory mechanism even before presentment to the issuing bank. This multi-signatory mechanisms allows all concerned parties to approve or reject the updates, making them instantly visible to everyone in real time. Therefore, this technique will enable discussions and decisions to be made before the presentment of the documents to the issuing bank, avoiding unnecessary rejections and resubmissions. This multi-signatory mechanism allows to reduce the bank's evaluation time and speeds up the delivery time which will in the end help the seller to free the funds needed for the working capital.

Moreover, the increase in visibility of all parties in the validation process of documents is of a great help in the risk management and internal forecasting.

In fact, Barclays, in partnership with the fintech startup Wave, conducted the first ever trade finance deal on a blockchain using a permissioned ledger in 2016. They handled the Letter of credit between Ornuva and Seychelles Trading Company on the Wave platform with fund

⁴¹ Rashi Goyal and Lata Varghese (2017), “Blockchain for Trade Finance: Payment Method Automation (Part 2)”, Cognizant, 7

⁴² *Ibidem*.

sent via Swift. The total quantity transferred was about US\$ 100 000 worth of Cheese and Butter. According to Barclays, by using the blockchain technology, they managed to reduce the letter of credit process from around seven to ten days to less than four hours.⁴³ This first proof-of-concept is a major step in showing how this technology can be used and how it will impact the operational costs of banks, exporters and importers in terms of time, money and risks.

Such types of initiatives are more than needed to increase the number of trade transactions using letters of credits. Indeed, as the time taken for the completion of the entire process is still long nowadays, most of the intra-regional trades in the European union are made using supply chain financing instead of LCs. The most important reason is that the time elapsed between the submission, issuing and approval of the LC is longer than the shipping time of the goods itself, leaving little interests in such operations. Therefore, reducing the process from days to hours could have a significant impact on the use of LCs and thus on the security of those transactions.

3.2.3. Documentary inefficiency

Pain Point

Traditional trade finance has not been much digitalized yet; thus, most of the process is still labor- and paper-intensive, leading to costly and laborious procedures. Consequently, processing trade paperwork is still very costly, elevating at US\$ 420 billion per year⁴⁴ and up to 5% to 10% of the trade value. In fact, according to the Boston Consulting Group, a single trade finance operation unites more than 20 agents throughout the process, with data spread over 10 to 20 documents summing up the total data field interactions to approximately 5000 with only 1% of the interactions creating value.⁴⁵

In addition to being costly and laborious in coordinating all the parties involved in a transaction, the current state of trade financing is subject to much fraud. Indeed, the relatively high level of fragmentation in interactions between stakeholders, the variations of regulations and trade procedures between countries and finally the lack of security and common standards are the main reasons why it is relatively easy for fraudsters to take advantage of the system. Moreover, the decision-making process is mainly reliant on the document trail of alterable papers making it vulnerable to forging or altering.

⁴³ Barclays (2016), The Blockchain Revolution in Trade Finance, September 2016. Retrieved from <https://www.barclayscorporate.com/insights/innovation/blockchain-revolution-in-trade-finance/> on 03 April 2019.

⁴⁴ Dixon, Mark & Glasson, Bernard (2019), "Electronic Payment Systems for International Trade."

⁴⁵ Boston Consulting Group (2017), Digital Innovation in Trade Finance: Have We Reached a Tipping Point?, October 2017. Retrieved from https://www.swift.com/news-events/news/digital-innovationin-trade-finance-have-we-reached-a-tipping-point_ on 26 March 2019.

In fact, there are four main categories of documents required in an international trade transaction. The first one contains the documents related to the commercial transaction itself, such as the sales contracts. The second one concerns the trade financing aspect, for instance, letters of credit. In the third one, we have transport documents and in the fourth one the border procedure papers such as certificates of origin, sanitary and phytosanitary certificates, certificates of conformity, export/import licenses, custom declarations and customs inspection documents. Considering that almost all those processes are paper intensive, we can surely assess that it increases the administrative and coordination costs, and more importantly, the probability of errors, losses and frauds.⁴⁶ For instance, a person could forge a bill of lading and claim the good at the port by submitting the fraudulent document before the importer can do it.

Another common type of fraud in this sector is duplicate financing. It happens whenever different parties simultaneously finance the same payment receivable or trade collateral. Controlling for those illegal activities requires availability of trade information, which is relatively poor nowadays partly due to the paper intensive characteristic of the sector.

Moreover, when added to the lack of data and the high level of reliance on documentary proofs of trade, the high level of resource needs borne by banks for manual screening makes them vulnerable to deviations implying business risks, possible reputational damages and very expensive fines⁴⁷.

Solution

As explained previously, a traditional trade finance operation can involve more than 20 agents throughout the process, most of them acting in a sequential matter whereas records, not only trade financing ones, are often kept separately, making them subject to fraudulent alteration as there is no single version of the truth accessible to all agents at all times. While, when using blockchain-based processes, records are kept and shared with everybody in real time on a common platform and are almost impossible to modify, the difficulty of tampering depending on the type of blockchain and consensus implemented. Therefore, a solution to the alteration problems of paper-based documents could be their digitalization. Still, even though the theoretical part of the digitalization looks like a good solution, previous attempts have not been very successful.

⁴⁶ Emmanuelle Ganne. (2018), *Can Blockchain revolutionize international trade?*, World Trade Organization, Geneva, 18-20.

⁴⁷ Rashi Goyal and Lata Varghese. (2017), "Blockchain for Trade Finance: Payment Instrument Tokenization (Part 4)", Cognizant, p6.

Indeed, the implementation of Bank payment Obligations (BPO), a conditional payment guarantee made by one bank to another using electronic data-matching, launched by the SWIFT in 2013 was a first unsuccessful attempt to digitalize LCs. This technology has only been used in a limited scope although cheaper and quicker than LCs. The facts that “each party to the transaction had to be BPO-enabled, investing in the technology could be costly, and moving to BPO required an overhaul of traditional and well-established processes and a change in culture”⁴⁸ are among the reasons why there was a lack of interest in this new way to improve trade finance flows. The blockchain solutions could suffer from the same kind of barriers to implementation possibly slowing down the adoption process.

Thus, questions could be raised about the revolutionary aspect of the blockchain’s implementation in trade finance. On the one side, many praises the benefits in cyber-security, transparency, payment automation, audibility, immutability, visibility of real-time transactions and finally the ease with which we can add newcomers into the system. Those advantages are all very important to transform the current paper intensive system into a digitalized one.

On the other side, many also point out that documentation checking will still be needed, even if we manage to implement a totally blockchain-based system. Indeed, using this technology makes tampering with documents almost impossible, thus solving such types of fraud. Yet, most sources of fraud are related to the issuance of false documents rather than to tampering with valid ones. Hence, even when using a blockchain-based system, the latter cannot automatically prevent false documents to be issued, the technology being unable to detect if the information is correct. Consequently, manual checking of documents entries will remain important and irreplaceable for now.

Nonetheless, it is possible to get rid of at least part of the factoring frauds. Factoring is a way for firms to get financing by selling their account receivables at a discount to a bank for instance, called the ‘factor’, and receiving cash in exchange. Once the debtor has paid the invoice to the factor, he will reimburse the rest of the receivables minus fees to the creditor.⁴⁹ There are many types of factoring including different modalities fitting best according to the needs. It is a great way, especially for small-and-medium sized businesses, to get early payments on their invoices in order to unlock their working capital. Even though it is great to get financing, many use that service in a fraudulent way to get more cash. Indeed, it is possible,

⁴⁸ Emmanuelle Ganne *op. cit.*, p25-26.

⁴⁹ Klapper, L. (2005), “The Role of Factoring for Financing Small and Medium Enterprises”, The World Bank, p3.

when checkings are not done properly, to finance the same invoice multiple times by presenting it to unrelated factors. As the different banks have limited resources to check the veracity of the documents, they most often accept invoice factorings of already financed bills of credit.

Presently, the blockchain technology can become the best way to digitalize invoices. As those payment instruments are essentially based from credit instruments arising on trade transactions, we can directly issue those credit instruments on a distributed ledger as a native asset and link them to their underlying trade transaction in an immutable and verifiable manner. This process requires the digitalization of the receivables on a blockchain network. By doing so, participants can track the ownership and value of the asset issued. Moreover, as the receivable assets are issued on the blockchain, any transfer will be immutably recorded on the ledger, making duplicate financing impossible and thus avoiding any possible double spending transfers.

Consequently, financiers are able to spot if a receivable has already been financed by another agent thanks to the decrease in transaction reconciliation costs between and within banks. Some matters of confidentiality could be raised here if the financiers were able to check confidential attributes of the assets. Nevertheless, it is possible to hash the transactions on the blockchain and mask the confidential data.⁵⁰

However, problems could still arise if the interoperability issues of blockchains are not fixed. Indeed, if all the different available blockchains are not sufficiently connected to each other through interoperability mechanisms, a receivable asset could be issued on two distinct blockchains gathering different financiers, who would not be able to check on the other ledger if the same receivable has already been financed. Such possible problems point out the importance of interoperability between blockchains and the need to achieve milestones in the matter to decrease even more the possible ways of fraud, thus making the technology more attractive.

Even though some types of fraud are not avoided, the numerous advantages presented are attracting many corporations and countries to develop projects. For instance, the Hong Kong Monetary Authority, in collaboration with five leading banks in Hong Kong, has developed a Proof-of-Concept (PoC) of a blockchain-based trade finance platform⁵¹. The design of the platform aims to achieve four important features. First of all, all the participants along the process should share the status of the transactions. Secondly, system alarms should be created for duplicated financing to avoid frauds. Thirdly, smart contracts should be incorporated to

⁵⁰ Rashi Goyal and Lata Varghese part 4 *op. cit.*

⁵¹ HKMA *op. cit.* p6.

automate manual processes and reduce human efforts in invoice reconciliations. Finally, access to certain data should be granted to a selected number of participants only and customers' business information and privacy should be protected from the other stakeholders of the system.

While developing this project, they announced in November 2017 a joint project with the Monetary Authority of Singapore to create a global trade connectivity network aiming at digitalizing trade and trade finance between both countries, using a blockchain-based cross-border infrastructure which is expected to go live in 2019. Their first aim is to implement the technology between both countries, then to expand it in the region and finally all over the globe.

3.2.4. Information asymmetry

Pain Point

Whenever a bank projects to grant financing, it must check the credit ratings of the borrower to assess the risks taken. However, such data on past performances are not available for all agents. In fact, a great part of this information is only publicly available for large companies keeping a record of their past activities while very hard to find for small and medium-size enterprise (SME). Therefore, when SMEs try to get a loan to finance their international activities, they will have to provide enough data, such as past performances, payment history and possibly other financial health indicators to assess their solvency; otherwise they simply will not get any financing. Indeed, the asymmetry of information between the bank and the SMEs about the creditworthiness of the latter tend to exclude those small players, leaving the best financing terms to the big corporates, especially in developing countries.

Moreover, banks may be keen to opt for credit rationing to mitigate their risks, reducing yet more the financing of SMEs, even those who are ready to pay high interest rates.⁵² Consequently, SMEs' last option is to borrow from the market at higher interest rates, increasing their business cost and thus reducing their margins.

Furthermore, banks are often unwilling to start Know-Your-Customer (KYC) processes of potential new SMEs clients due to the low profitability of their transactions. This low profitability combined with the lack of financial records makes it hard to assess their creditworthiness and tends to decrease the probability of credit guarantees' extensions.⁵³

To put this effect in perspective, numbers shows that SMEs' trade finance applications are rejected in 56% of the cases while they are only rejected in 34% and 10% of the cases for

⁵² *Ibidem.*

⁵³ Asian Development Bank (2017), 2017 Trade Finance Gaps, Growth, and Jobs Survey, ADB Brief N. 83.

large corporates and multinational corporations⁵⁴. Those rejections create a credit gap which is estimated, when only considering both formal and informal SME, to amount up to US\$ 2.6 trillion⁵⁵. Considering the size of the unmet demand, a solution to increase the visibility and transparency of information about enterprises, allowing to decrease the financial information asymmetry between SMEs and banks, could represent a major financial gain for both banks - through better credit risk assessing, and businesses - through a better and cheaper access to financing.

Besides, credit reports containing the credit managing history of an individual, are often handled by Credit Bureaus as called in the US or Credit Reference Agencies (CRA) in the UK. Those companies collect credit data and help lenders make decisions about extending credits or not⁵⁶. Those agencies, handling the sensitive data of hundreds of millions of people, must respect laws and regulations about privacy and fair treatments of individuals. However, many problems still arise from that data management.

Firstly, those databases are only updated once a month and an update can take up to seven days as those agencies do not receive daily information from creditors and other sources⁵⁷.

Secondly, identification problems can arise when the data received do not include proper information about the identity of the creditor⁵⁸. Moreover, identity theft can influence the collected data negatively.

Thirdly, credit data are often valid for only one jurisdiction, limiting the access to foreign credit information. Therefore, whenever an individual moves to another country or continent, his credit record is erased.

Fourthly, as data can be stored by different CRAs, some inconsistencies or contradictions can arise, possibly leading to a denial of credit access.⁵⁹

Finally, data breaches or unauthorized access to the data base of CRAs are major concerns as the sensitive data are kept in a single location or by a single entity. In 2017, sensitive

⁵⁴ ADB (2016), "2016 Trade finance gaps, growth, and job survey", ADB BRIEFS NO. 64.

⁵⁵ John Owens and Lisa Wilhelm. (2017), "Alternative Data Transforming SME Finance," International Finance Corp.

⁵⁶ Goharshady, A. K., Behrouz, A., & Chatterjee, K. (2018). "Secure credit reporting on the blockchain.," arXiv preprint arXiv:1805.09104.

⁵⁷ R. B. Avery, P. S. Calem, G. B. Canner and R. W. Bostic (2003), "An overview of consumer data and credit reporting," Federal Reserve Bulletin, vol. 89, p. 47

⁵⁸ Consumer Federation of America and the National Credit Reporting Association (2002), "Credit score accuracy and implications for consumers", Tech. Rep.

⁵⁹ *Ibidem*.

information of about 143 million people was stolen by hackers in the US from the Equifax company.⁶⁰

Solution

By bringing together both the SMEs and the financiers on the same blockchain, such as explained previously with the example of the receivables, the latter have a better insight into both the receivables and their related trade transactions, the payment history and the credentials of the SMEs. By enabling a transparent insight of the financier into the trade transactions and payments of the SMEs, the lenders can assess in a faster and better way the creditworthiness of the borrowers.⁶¹

Moreover, thanks to the increase in credit history transparency, lenders can offer more competitive financing rates as they are able to properly assess the risks taken. This can help SMEs reduce their costs of financing, which are most of the time very high due to the lack of information about their activities or the lack of collateral at their disposal.

This increase in visibility for the financier into both credit history and supply chain cash flow also increases the easiness of KYC processes. Those KYC procedures are crucial in the financial world to identify if the persons behind the SMEs are fraudulent or not.

The Chinese Central bank is developing a trade finance platform to offer supply chain finance across Guangdong, Hong Kong and Macau Bay area. The first aim of the project is to help small and medium businesses secure financing from financial institutions by improving the available data on credit accumulation of those businesses. They also emphasize that such “system could prevent the same accounts being used to maliciously obtain multiple loans from different institutions”⁶² thus both increasing data availability and decreasing the probability of loan frauds.

Likewise, the We.trade platform, powered by the Hyperledger Fabric, is a supply chain finance platform accessible from any connected device. It completed its first operations the 3rd of July 2018, which involved five major banks and twenty companies. They aim to streamline trade finance procedures particularly for SMEs. This platform includes managing, tracking and securing trade transactions.⁶³

⁶⁰ Federal Trade Commission (2017), “The equifax data breach: What to do”. Retrieved from <https://www.consumer.ftc.gov/blog/2017/09/equifax-data-breach-what-do> on 8 April 2019.

⁶¹ Rashi Goyal and Lata Varghese part 4 *op. cit.*

⁶² Huillet, M. (2018), “China: Central Bank’s Blockchain Trade Finance Platform Pilots in Shenzhen”, Cointelegraph. Retrieved from <https://cointelegraph.com/news/chinas-central-bank-backed-blockchain-trade-finance-platform-pilot-kicks-off-in-shenzhen> on 03 April 2019.

⁶³ Suberg, W. (2018), “IBM-Powered Blockchain Platform Completes First Live Trades Via Five Major Banks”, Cointelegraph. Retrieved from https://cointelegraph.com/news/ibm-poweredblockchain-platform-completes-first-live-trades-via-five-major-banks?utm_source=newsletter1&utm_medium=email on 9 April 2019.

Finally, in their paper about credit reporting, Goharshady, Behrouz and Chatterjee proposed a solution to the Credit Reference Agency's problems. They suggest removing CRAs from the lending process and replace them with smart contracts on the Ethereum blockchain hence removing third parties. This allows to update data in only a few seconds instead of days, to avoid identification problems, to remove inconsistency, to make the credit reports globally usable and, lastly, to secure all sensitive information with cryptography, avoiding any possible data breaches. In their contribution, they managed to give some individuals full control over their credit history while keeping the record correct and not editable by those individuals.

4. Supply chain management

“Almost all quality improvement comes via simplification of design, manufacturing, layout, processes, and procedures.” – Tom Peters

4.1. Explanation

Since the beginning of the 2000s, the term Supply chain management (SCM) has become widely known across the corporate and academic world; yet, no real consensus has been reached on its definition and the different challenges it still faces nowadays. Only two cross-functional, cross-firm, process-based frameworks have been successfully implemented in major corporations⁶⁴: The Supply Chain Operations Reference (SCOR) and the SCM framework developed by Lambert and Cooper in their article “Issues in Supply Chain Management”⁶⁵. More recently, Lambert and Cooper updated their SCM definition firstly developed in their 2000 article and defined the SCM as “the management of relationships in the network of organizations, from end customers through original suppliers, using key cross-functional business processes to create value for customers and other stakeholders”⁶⁶.

In their 2000 article, they based their writings on the idea that competition was not between companies anymore but between different supply chains. Indeed, they argued that supply chains were now composed of suppliers-brand-stores that competed against other suppliers-brand-stores instead of being two companies challenging each other. Based on that, the success of a company was dependent on the ability to integrate the different levels of the chain to smoothen the business relationships. However, the authors did not consider back then

⁶⁴ D.M. Lambert, S.J. García-Dastugue, K.L. Croxton (2005), *An evaluation of process-oriented supply chain management frameworks*, Journal of Business Logistics, 26 (1), p 25-54

⁶⁵ Douglas M. Lambert, Matias G. Enz (2000), *Issues in Supply Chain Management*, Industrial Marketing Management, Volume 29

⁶⁶ Douglas M. Lambert, Matias G. Enz (2017), *Issues in Supply Chain Management: Progress and potential*, Industrial Marketing Management, Volume 62, p5.

that it is common for two competing brands to have the same suppliers and retail customers, thus removing the concept of cross supply chain competition. For instance, Coca-Cola Company and PepsiCo Inc. both have Cargill and Graham Packaging Company as suppliers of sweeteners and packaging. Thus, the competition is not about supply chain A versus supply chain B but about the management of relationship of two competing firms with the same suppliers and sellers. Therefore, if Coca-Cola Company manages their relationship with Cargill and Graham Packaging Company in a better way than PepsiCo Inc., they will certainly win the competition.⁶⁷

A basic version of a supply chain is composed of a company, its suppliers and the customers to which the company is selling. However, things can get very complex when other parties step in to play a role. Indeed, heavily developed structures include many suppliers and suppliers' suppliers as well as numerous customers and customers' customers, or final clients. On top of that, there are all the organizations needed to deliver the products to the customers such as logistic providers, financial organizations and software vendors. This large network is interrelated rather than linearly chained. Therefore, an event occurring in one part of the globe can influence the management of products on the other side of the world, possibly creating major disruptions.

4.2. Pain points and solutions

Creating trust and automation in the network is becoming increasingly important since supply chains are getting more global and complex with connections all over the world. However, due to several reasons, it is still difficult to create trustful relationships between the multiple agents involved in complex supply chains due to several reasons. We will describe the main pain points making trust between agents required and figure out solutions.

4.2.1. Visibility and auditability

Pain Point

Most supply chain agents lack visibility in the in-transit shipment status, which prevents them from having information about the estimated delivery date and about possible delays or damages to the goods. Such a lack of information can have important consequences on the buyer's side, as it can become difficult for the importer to honor downstream obligations if the shipment faces problems. In fact, if the imported goods are a key input for the buyer and the shipment is delayed or the merchandise is damaged, the merchant can be prevented from delivering the promised goods to his clients. If, for instance, the buyer had a way to increase

⁶⁷ *Ibidem.*

his visibility into the process and to anticipate possible delays or damages, he would be able to renegotiate with his own clients even before delivery date.

On top of that, it is still hard for buyers to monitor the conditions of shipment. Indeed, some products, such as perishable or temperature-sensitive goods, need certain conditions during transport to avoid any prejudice. However, it is costly and time-consuming nowadays to assess at what point of the transport chain the goods have suffered inappropriate conditions. Goods are inspected at the port of origin and given a sanitary certificate if they are effectively free from diseases before shipment⁶⁸. In the same way, a control is organized at the port of destination. Still, it is very difficult to evaluate the long-term effect of inappropriate shipment conditions on the healthiness of the product. Indeed, the products, fruits for instance, could be in a relatively good shape once received at the port of destination but could perish faster than expected due to improper transport conditions. Moreover, if that is the case, the buyer will not have any information about whom he should sue for the improper state of the goods as he would have no clue at which moment the conditions were not optimal. Such issues arising from a lack of visibility and transparency create trust problems between supply chain actors, especially within multi-tier supply chains, that can only rely on intermediaries such as banks and stamped documentations⁶⁹. Building trust within supply chains often requires businesses to develop long-term relationships and financial commitments between each other.

Furthermore, data within a specific supply chain is often fragmented in “silo” by the different agents involved in the process and kept separately. This specificity creates massive information asymmetries as there is very little interoperability of the data between silos. Thus, information held by one stakeholder is not transferred to the other ones, or at least very little of it, making the integrity of the product harder to protect along the supply chain. This type of behavior increases the vulnerability to fraud of the records as data can be added or altered by any party without notification to the others. As there is no continuity in the collection of data from one end to the other of supply chains, every stakeholder must reconcile data himself to guarantee accuracy. Hence, as the information about products is relatively hard to get for the businesses involved, it is even worse for the consumers of those products, who are increasingly willing to know where and how their product was cultivated, transported and modified.

⁶⁸ Emmanuelle Ganne. (2018), *Can Blockchain revolutionize international trade?*, World Trade Organization, Geneva, 35.

⁶⁹ Kembro, J., Näslund, D., Olhager, J. (2017), *Information sharing across multiple supply chain tiers: a Delphi study on antecedents*, Int. J. Prod. Econ. 193,77–86.

Solution

Considering the low level of transparency in the in-transit shipments and the difficulty to get an overall picture of the transactions made within the chains, implementing a blockchain-based system in combination with IoT devices could become of great use. Indeed, the information about transactions is often stored in different locations and accessible by specific entities, which makes a clear view into the supply chains' actions and their impacts.

Therefore, gathering every stakeholder of a supply chain including customers onto a common blockchain-based platform can enable them to transparently and immutably track products and transactions made by each agent throughout the whole shipment process. The level of visibility into the transactions and their authors can be reduced for some stakeholders depending on the authorizations granted through the smart contract. The possibility to restrict the visibility of some participants is crucial as some transfers require data privacy.

Practically, goods are possessed by a large variety of agents throughout their life cycle, going from producers to end consumers and many others in between. In the first step to digitalize the current system, stakeholders would have to create their profile on a platform upon registration, displaying, if not anonymized, some of their information such as their location, their certification and their association with products⁷⁰. Each participant would be allocated both a public and a private cryptographic key when registering on the platform. The former would be used to identify himself within the network, the latter to authenticate himself when interacting with the system⁷¹. All products registered on the platform would be attached with an information tag such as a QR code to easily consult information related to them on the platform.

Once this has been done and the products are ready to be exported, an asset token would be created on the platform representing one unit of the goods exported and would be transferred from one stakeholder to another during shipment. Throughout the whole process, only the possessor of the asset token can add data about the product or initiate a transfer. Consequently, whenever a trade is occurring, both parties must sign a digital contract triggering the transfer of both the asset and its token. A network consensus must be achieved to immutably store the transfer of the token. In addition to that, IoT sensors could be installed in the different locations of the transit to automatically and immutably record data about the product and its environment on the blockchain-based system, generating a digital history of the product accessible to all

⁷⁰ ABEYRATNE, S.A. and MONFARED, R.P. (2016). Blockchain ready manufacturing supply chain using distributed ledger. *International Journal of Research in Engineering and Technology*, 05(09), pp. 1-10.

⁷¹ *Ibidem*.

participants. Pushing things even further, those sensors could also be implemented in the soil where products are actually grown and harvested to check the soil conditions, its Ph levels, how much rain fell that season, etc. Once those sensors are correctly implemented into the supply chain, we can start to automate insurance and have real-time insurance depending on the conditions captured by the sensors where payments can get automated and made in real-time. Therefore, instead of paying a fixed premium calculated on the limited information held by the insurance company, they could charge a variable amount which would be defined by the conditions captured by the IoT sensors.

For instance, the figure below represents an end-to-end supply chain using the blockchain technology to improve its traceability process. In this simple version, once the producer has harvested or shaped his product, he will enter specific data about it on the blockchain through its platform user interface and will sign the digital contract to transfer his ownership to the processor.

Secondly, the processor will enter data about the time of arrival, the processing and shipping methods and other information if needed on the blockchain while processing the product, pork in this case.

Thirdly, once the pork has been processed, a smart tag such as a QR code is added to the packaging to easily access historical data by scanning it with a smartphone app for example.

Then, the good is transferred from the processor to the transport company using the digital contract while data about conditions, time and location are continuously being recorded by IoT sensors onto the blockchain.

Finally, the transport carrier would transfer the good and the token related to it to the final store. Both the store and the final customer would have all the information needed about the product thanks to the smart tag placed on the packaging. The consumers would be able, if allowed so to do by the stakeholders of the platform, to track the journey of the product they want to buy from the farmer to the final store including all the relevant data about storage conditions, origin, etc. A more complex example is represented in annexes.

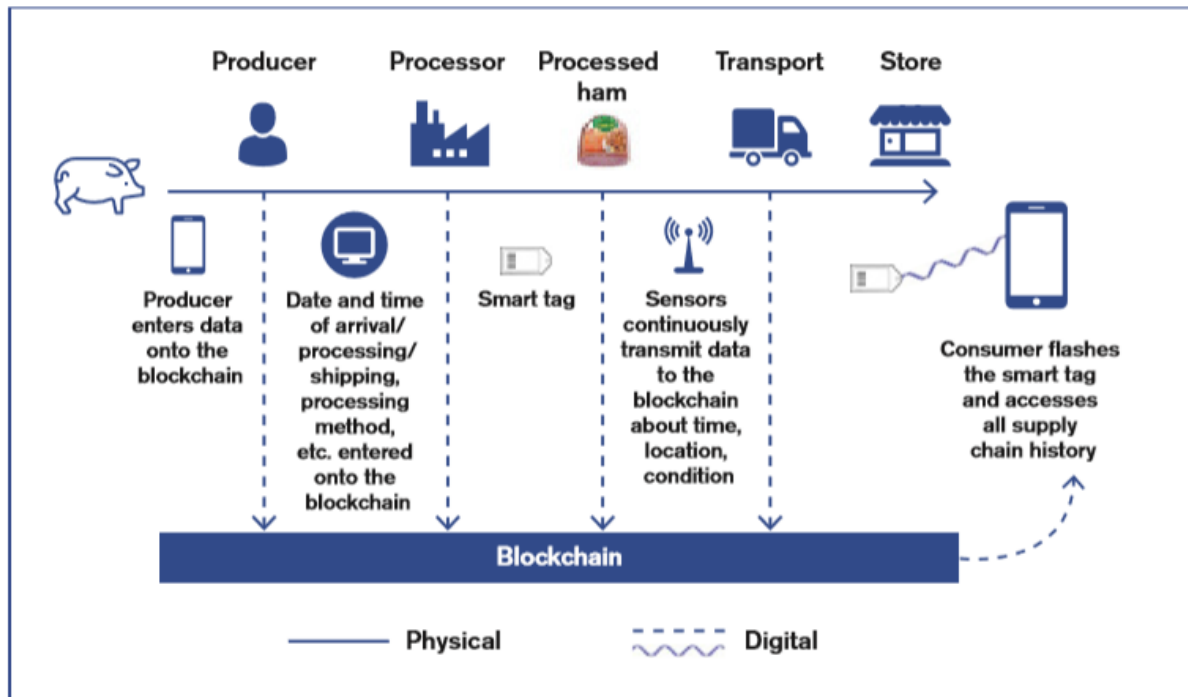


Figure 5: Traceability of products⁷²

Many companies are currently putting their goods on different blockchains to increase their traceability. For instance, Bumble Bee Foods, a San-Diego based seafood giant is using a private distributed ledger called “multichain”, based on a blockchain tech developed by SAP, to trace yellowfin tuna from harvesting to selling in the stores. Their packagings are equipped with a QR code scannable by consumers, allowing them to consult information about the origin of the fish and how it got to be fair trade certified⁷³.

Maersk also developed in collaboration with IBM a blockchain-based global trade platform called TradeLens⁷⁴. With over 90% of internationally traded goods carried by sea⁷⁵, maritime transporters are one of the most important players in global trade. Maersk being one of the leading maritime carriers, they aim to implement cutting-edge technologies in their activities to generate cost reduction and competitive advantages against competitors. The TradeLens platform intends to connect parties involved in international trade, including governmental authorities, and digitalize the end-to-end supply chain without compromising details, privacy and confidentiality. After piloting the platform for several months, they

⁷² Emmanuelle Ganne *op. cit.*, p78.

⁷³ Robert Hackett (2019), “Bumble Bee Foods Aims to Put All Its Fish on a Blockchain. It's Starting With 'Fair Trade' Tuna.”, Fortune. Retrieved from <http://fortune.com/2019/03/08/tuna-blockchain-bumble-bee-sap/> on 15 May 2019.

⁷⁴ See <https://www.tradelens.com/>

⁷⁵ Emmanuelle Ganne *op. cit.* p42.

officially launched it in August 2018⁷⁶ and managed to sign up 234 marine gateways, two other ocean carriers, customs brokers, several freight forwarders and different customs authorities in Singapore, Peru, the Netherlands, Saudi Arabia and Australia⁷⁷. They also developed a trade document module on the platform called Clearway. This module allows importers, exporters, customs brokers and trusted third parties like government agencies and customs to automate various business processes, import and export clearance for example, via smart contract. It also enables those stakeholders to collaborate in cross-organizational business processes⁷⁸.

Finally, IBM partnered with Walmart and the Tsinghua University in Beijing to track pork across China using their blockchain. The platform documents “the origins and batch number of the product, the information on the plant and on processing methods, the expiration dates and details on retailing steps”⁷⁹ enabling Walmart to guarantee the origin of the product and track the source of contamination if some pigs are found sick. They also ran this project using mangoes instead of pork and managed to reduce the time needed to track the goods from days to seconds⁸⁰.

Following the success of the pork and mangoes trials, Nestlé, Walmart and eight other companies joined the IBM Food Trust blockchain platform to track food across the planet⁸¹. This permissioned blockchain aims to improve the accountability and visibility of the supply chain and offers the stakeholders a record of the origin, processing data and shipping details of the food as well as other elements. It will integrate growers, processors, wholesalers, distributors, manufacturers and retailers at least⁸².

4.2.2. Risk management

Pain Point

Supply chains are becoming worldwide networks of suppliers and sellers with multiple connections among all participants. This large amount of inter-connected networks creates a great number of uncertainties for the different companies involved. Thus, one role of supply

⁷⁶ Wass, S. (2018), “Maersk and IBM go live with global blockchain trade platform TradeLens”, Global Trade Review. Retrieved from <https://www.gtreview.com/news/fintech/maersk-and-ibm-go-live-with-blockchain-supply-chain-platform-tradelens/> on 15 May 2019.

⁷⁷ See IBM press release: <https://newsroom.ibm.com/2018-08-09-Maersk-and-IBM-Introduce-TradeLens-Blockchain-Shipping-Solution>

⁷⁸ Emmanuelle Ganne *op. cit.* p42.

⁷⁹ Emmanuelle Ganne *op. cit.* p79.

⁸⁰ Higgins, S. (2017), “Walmart: Blockchain Food Tracking Test Results Are ‘Very Encouraging’”, Coindesk. Retrieved from <https://www.coindesk.com/walmart-blockchain-food-tracking-test-results-encouraging/> on 15 May 2019.

⁸¹ Giles, F. (2018), “Is Blockchain the Future of Food Safety?”, Growing Produce. Retrieved from <https://www.growingproduce.com/fruits/blockchain-future-food-safety/> on 15 May 2019.

⁸² Emmanuelle Ganne *op. cit.* p79.

chain management is to reduce this risk by investigating into its connections. According to Svensson, sources of supply chain risks are categorized to be either atomistic or holistic⁸³. The former can be dealt with by checking a selected and limited part of the supply chain. This method is best suited for goods with low value, easily available and not complex. The holistic source of risk on the other hand can be dealt with by analyzing the overall supply chain to assess the present risks. This method is more adapted to rare and complex components with high value⁸⁴.

A relational risk is among the most common risks faced by companies involved in complex supply chain. It can consist in a business partner's engagement in opportunistic behavior⁸⁵ such as cheating or distorting information to gain a possible competitive advantage or to gain bargaining power.

Solution

By integrating blockchain-based solutions into their supply chains, companies could address their holistic source of risk. Indeed, the increase in visibility about all stakeholders throughout the supply chain allows to more precisely assess the risks taken thanks to an overall picture of the network and the interdependences between the different agents.

Moreover, blockchain-based systems would ensure that the software files downloaded by the stakeholders have not been breached. As every participant must identify himself to enter the database, involved parties, depending on the smart contract's authorizations, could check what has been done by whom to reduce cyber-security risks and increase their trust. Finally, the database can only be accessed and used by validated identities. Therefore, transactions can only be made by parties mutually accepted in the network⁸⁶. James Regenor, the Moog's additive manufacturing and innovation unit director, put this into perspective by saying "How can the maintenance crew on a U.S. aircraft carrier have absolute confidence that the software file they downloaded to 3D print a new part for a fighter jet has not been hacked by a foreign adversary?"⁸⁷. The answer may well be the blockchain.

Note that in the case of permissioned blockchains, which would certainly be the appropriate type of blockchain for such use cases, the number of stakeholders, and therefore of

⁸³ Svensson, G. (2000). *A conceptual framework for the analysis of vulnerability in supply chains*. International Journal of Physical Distribution and Logistics Management, 30(9), 731–749

⁸⁴ *Ibidem*.

⁸⁵ Nir Kshetri (2017), *1 Blockchain's roles in meeting key supply chain management objectives*, International Journal of Information Management, Volume 39, 80-89.

⁸⁶ Nir Kshetri *op. cit.*

⁸⁷ Casey, M. J., & Wong, P. (2017). Global supply chains are about to get better, thanks to blockchain. Harvard business review. Retrieved from <https://hbr.org/2017/03/global-supply-chains-are-about-to-get-better-thanks-to-blockchain> on 7 May 2019.

nodes in the system is limited to the number of participants granted access, contrary to permissionless blockchains such as Bitcoin, where everyone can freely access and make transactions. Therefore, blockchains with limited access lose part of their decentralized nature as the data is spread among a smaller number of nodes than public blockchains making breaches into the systems possible by hacking some of the participants, the number required to alter the ledger depending on the consensus method implemented.

5. Cross-border procedures

International trade transactions often require cross-border procedures to reach an importer. Those border procedures involve data and document exchanges between businesses (transportation, exporter, importer, logistic and banks) and government authorities. While national Business-to-Government (B2G) and Government-to-Government (G2G) procedures are increasingly done electronically, cross-border B2G and G2G procedures are still mainly paper-intensive and consequently complex. Considering the automation possibilities of smart contracts and the secured way of exchanging information between parties in real time, Blockchain could diminish the coordination costs and delays of the present system and boost the efficiency of processes, both B2G and G2G⁸⁸. Thus, we will describe the possible use cases of the technology and their impact on different fields, firstly B2G and thereafter G2G.

5.1. Business-to-Government procedures

5.1.1. Certificates and licenses

Sanitary and phytosanitary certificates as well as certificates of origin and conformity assessment certificates are documents distributed by trusted authorities and are needed to assess the fulfillment of certain requirements by the goods exported. An importer or a competent authority will require those documents as an assurance of validity that the goods meet those specific criteria. However, those certificates often take time to get and are not always valid for all types of operations.

Shipments having received a phytosanitary certificate cannot be fragmented into multiple shipments and sent with this single certificate even though the products and the destination have not changed. To be allowed to fragment a shipment, the exporter has to go back to the issuer of the certificate and ask for a replacement certificate, which is a time-consuming procedure⁸⁹. While using blockchain, new transactions are linked to the previous

⁸⁸ *Ibidem.*

⁸⁹ *Ibidem.*

one by a cryptographic hash possibly allowing exporters to avoid the need of a replacement certificate, simplifying the life of traders and certifying agencies⁹⁰.

Furthermore, businesses are required to have import and export licenses to start international trade. Those licenses are only valid for a certain period and need to be kept into a safe place. However, such permits are easily forgeable and may lead agents to fake permits. Storing those certificates on a blockchain eliminates the possibility of fraud and avoids the need for a secure place for the certificates, the technology providing a secure and trusted ledger.

Moreover, smart contracts can allow the automated cancellation of import/export certificates upon the date of expiration avoiding the recycling of expired permits to smuggle goods into a country such as happened in the Philippines in 2016.⁹¹

Furthermore, blockchain technology can be used to certify the authenticity of the certificates of origin and to assess if they have not been tampered with. However, as the technology does not have a function to detect the effective origin of the products registered on its ledger, its only role would be to safeguard the inputs made by the Chambers of Commerce.

Nonetheless, an Indonesian project was launched in 2016 by Provenance, a UK-based startup, to track the fair-trading practices and ethical claims, such as slavery-free production. Fishermen must send messages to register their product on the blockchain specifying their respective catches. Thereafter, the information is transferred to the supplier until the end user. While using this process, consumers can access information about the origin and the journey of the products bought with their smartphones⁹². This could be a great way to help small-and-medium sized businesses prove the origin and quality of their goods, especially in developing countries where small farmers do not have the power and information to negotiate prices with the middlemen.

Similarly, the paperless trade platform provider essDOCS has launched new features for their electronic certificates of origins (eCO) called essCert. They now incorporated blockchain technology options enabling Chambers of Commerce to include their eCO data to IoT devices and blockchain platforms to increase the verification of origin⁹³. Moreover, the Singapore International Chamber of Commerce has developed, in collaboration with the fintech company

⁹⁰ *Ibidem*.

⁹¹ Fortune, A. (2016), "Philippines takes on meat import fraud through permit recall", GlobalMeat News. Retrieved from <https://www.globalmeatnews.com/Article/Philippines-import-permit-recall> on 23 April 2019.

⁹² Provenance (2016), "From shore to plate: Tracking tuna on the blockchain". Retrieved from <https://www.provenance.org/tracking-tuna-on-the-blockchain> on 20 April 2019.

⁹³ essDOCS (2018), "Introducing essCert – a next generation eCO solution", essDOCS News. Retrieved from <https://www.essdocs.com/blog/introducing-esscert-next-generation-ecosolution> on 29 April 2019.

vCargo Cloud, a permissioned blockchain platform incorporating eCOs. They intend to decrease the level of fraud and the cost of verifying certificates of origin⁹⁴.

However, when used in this context, a blockchain can only guarantee that the data has not been tampered with, thus third-party checks on the validity of the asserted information are still required. Therefore, verifications about the concordance of off-line events and their online records is key. Those checkings could be made by IoT sensors, automating the procedure. However, the combination of IoT and blockchain would not solve the problem if those IoT sensors could be tampered with. For example, an IoT thermometer used by freight carriers of fruits could be placed in a different location than the goods in the purpose of recording fake temperatures. Nevertheless, if controls are done properly, the use of such devices could automate the system and record much more data.

Besides, the possibility to track the origin of products and their journey toward the end consumers could also help fight counterfeits. Indeed, an artist or patent owner could register his property on the blockchain, by either hashing its digitizable intellectual property work or by adding a QR code to its physical good giving access to its history. Therefore, a brand could add its specific QR code on each of its products or on its packaging and notify customs and enforcement agencies that all its products contain such mechanisms. Consequently, if a product does not contain its tag or if it carries a false one, it can easily be spotted and categorized as counterfeit. In fact, multiple projects have emerged to fight counterfeit and stolen products. Blockverify is one of them, specialized in pharmaceuticals, luxury items, diamonds and electronical products. They assert to be able to verify any counterfeit product, diverted good, stolen merchandise and fraudulent transactions.

5.1.2. Customs clearance

In our current international trade system, trade documents are often transferred separately from the flow of goods, possibly locking the goods at the carrier's, for example when bills of lading are delayed. Moreover, customs must check the exactness of the import declaration by cross-validating the information with other trade documents. For instance, they can compare the invoice value mentioned on the import declaration with the pro forma invoice value which is

⁹⁴ Execassist (2018), "Singapore International Chamber of Commerce and vCargo Cloud Launch World's First Blockchain-Based e-Certificate of Origin ("eCO")". Retrieved from <https://aseantechsec.com/singapore-international-chamber-of-commerce-and-vcargo-cloud-launch-worlds-first-blockchain-based-e-certificate-of-origin-eco/> on 29 April 2019.

the original document specifying the value of the invoice⁹⁵. However, those cross-validating processes are still manually done even when the documents are electronically exchanged. For instance, the Netherlands performed around 180 million declarations annually which is a very time-consuming bureaucratic work⁹⁶. Considering that those numbers should increase in the years to come with the rise of e-commerce businesses, a solution to automate the cross-validating process is vital and should decrease document fraud, costs and lead times⁹⁷.

For a buyer the lock up of a cargo, due to slow validating processes, causes an increase in costs and risks⁹⁸. However, as explained in section 3.3.3, a great part of the paperwork volume could be digitalized and registered on a “distributed ledger” enabling possible efficiency gains both for trade finance operations and trade of goods.

Another gain from the digitalization process explained previously is the increase in visibility throughout the supply chain. Indeed, by reuniting both suppliers, buyers, freight forwarders, custom brokers, banks and assurance companies on the same permissioned blockchain, all of them would have an appropriate insight into the documents and the journey of the traded goods. Such visibility increase into the supply chain would give customs a better insight into all the accurate and necessary data, such as a proof of purchase or bills of landings, without the need of manual verifications⁹⁹. Moreover, licenses and certificates, often needed during the customs clearance process, could be added to this permissioned blockchain, speeding up even more the clearance of goods and consequently reducing the end-to-end lead time¹⁰⁰.

In addition to the increase in availability of the data, we shall also notice the increase in their accuracy. Indeed, by reuniting all the stakeholders into the same permissioned blockchain, inaccurate data inputs made by one node should be automatically detected by the rest of them as they all have access to the immutable distributed ledger. Consequently, customs and regulatory authorities would be guaranteed to have access to the right information given by the appropriate sources, allowing customs to have a more data-driven approach and to optimize their risk assessment. Such improvement could let customs automatically clear goods that have

⁹⁵ Lennard Segers (2019), *The use of a blockchain-based smart import declaration to reduce the need for manual cross-validation by customs authorities*, Delft University of Technology.

⁹⁶ *Ibidem*.

⁹⁷ *Ibidem*.

⁹⁸ Rashi Goyal and Lata Varghese (2018), “Blockchain for Trade Finance: Trade Asset Tokenization (Part 3)”, Cognizant.

⁹⁹ Emmanuelle Ganne *op. cit.*

¹⁰⁰ Yotaro Okazaki (2018), *Unveiling the Potential of Blockchain for Customs*, WCO Research Paper No. 45, 16-20.

already been screened by themselves using the available information on the “distributed ledger”, thus enabling a reallocation of their resources toward other categories of trade¹⁰¹.

Finally, the use of the blockchain could help tackle trade-based money laundering (TBML). In fact, criminals use trades to disguise their illicit activities by false reporting, for example by over or under valuating traded goods in order to transfer funds and whitewash them. Therefore, creating a network between customs, anti-criminal and revenue collection authorities, intelligence agencies and financial service providers using the blockchain technology could be a good way to record and share the sensitive information needed to resolve such complex cases. The integration of financial institutions into the network would be of great help to spot illicit financial flows, especially if they manage to create a paperless working environment for trade finance and other services. Moreover, the cooperation between customs and financial institutions could enable them to spot differences between the trade data submitted by operators and the capital flows recorded by the financial institutions, possibly helping to find clues of criminal acts¹⁰².

In fact, the Korea Customs Service (KCS) developed a pilot project with multiple e-commerce companies to test and conduct transactions on the ICON foundation’s loopchain which allows to restrict the access to certain information on the permissioned blockchain to only authorized entities throughout the process¹⁰³. Their goal is to test the possible applications of the technology into e-commerce customs clearance and improve their related laws and systems. This pilot could include up to 50 domestic businesses involved in exports and up to 10 foreign companies for the import side¹⁰⁴.

On top of that, the KCS also partnered with Samsung SDS to develop a blockchain-platform on the Nexledger for their customs clearance system. The platform is designed for organizations dealing with export activities. It will allow them “to streamline and secure documents sharing at each stage, from customs declarations of the exported goods to the delivery, in addition to detecting and preventing the use of forged documents.”¹⁰⁵

¹⁰¹ *Ibidem*.

¹⁰² Yotaro Okazaki *op. cit*.

¹⁰³ ICON Foundation (2018), “loopchain technology to be applied to Import Customs Clearance Procedure for the Korea Customs Service”, Medium. Retrieved from <https://medium.com/helloiconworld/loopchain-technology-to-be-applied-to-import-customs-clearance-procedure-for-the-korea-customs-9a7572b3c484> on 29 April 2019.

¹⁰⁴ Samburaj Das (2018), “Korea Customs Service to Pilot Blockchain-Based Import Customs Platform”, CCN. Retrieved from <https://www.ccn.com/korea-customs-service-blockchain-customs-clearance-platform> on 29 April 2019.

¹⁰⁵ Ana Alexandre (2018), “Korea Customs Service Partners with Samsung SDS to Build Blockchain Customs Platform”, Cointelegraph. Retrieved from <https://cointelegraph.com/news/korea-customs-service-partners-with-samsung-sds-to-build-blockchain-customs-platform> on 29 April 2019.

5.1.3. Revenue collection

The technology could be used by Tax authorities in parallel with customs administrations to decrease the gap between the expected value-added taxes (VAT) collected and their effective collection. As the technology immutably records all the information about the transactions and the goods in the network in a transparent way, it is possible to track where the VAT has been paid. However, such a system would be hard to implement as it would require every person accountable for VAT to give their information, even those without computers or internet connection¹⁰⁶.

However, with smart contracts, we could automate the payments of customs duties according to an “if... then...” formula embodied into the smart contracts. We could imagine a formulation such as “if the goods arrive at the customs administration on the importing side, then the payment of duties is automatically generated”.

Another solution to automate the revenue collection of customs could be to integrate smart contracts with IoT sensors. Indeed, the IoT sensors placed into the trucks would detect whenever the vehicle crosses a border and would thus trigger the execution of the duty payment condition included in the smart contract.¹⁰⁷

5.2. Government-to-Government procedures

The G2G procedures mostly consist in sensitive data shared between different governmental agencies and/or organizations using internet. The main goal of G2G is to help B2G initiatives by enhancing better communication and data sharing between involved entities. However, multiple issues can arise from such activities.

Indeed, the first main issue is the low level of security and integrity when manually processing the sharing of sensitive information. In fact, as there is no common platform with immutable properties available for data sharing, multiple points of failure appear and hackers can penetrate governmental databases to either collect or alter the data. With a blockchain-based platform, governmental entities can share their information on a permissioned ledger with immutable properties allowing for no single point of failure. This means that even if one computer of the network is successfully attacked, the remaining nodes in the network are still active to spot any inappropriate entry made by the corrupted node. Thus, migrating confidential data onto a blockchain-based platform with specific privacy protection could enhance security.

¹⁰⁶ PwC (2017), How blockchain technology could improve the tax system, PwC UK (161205171727-LL-OS), retrieved from <https://www.pwc.co.uk/issues/futuretax/howblockchain-technology-could-improve-tax-system.html> on 28 April 2019.

¹⁰⁷ Emmanuelle Ganne *op. cit.*

Furthermore, G2G procedures can include the sharing of data concerning authorized economic operators (AEO). AEO are, according to the UK Government, “an internationally recognized quality mark that shows your:

- role in the international supply chain is secure
- customs controls and procedures are efficient and meet EU standards”¹⁰⁸.

When enrolled as an AEO, the operator has a quicker access to simplified custom procedures and even the possibility to use “fast-track” safety and security procedures speeding up the custom clearance. Regardless of its size, any business active in international trade activities involving customs, can apply for this status. However, the enrolment procedure can take up to 120 days and mutual recognition agreements (MRA) need to be reached between countries to apply this AEO status¹⁰⁹. Therefore, we can spot the same security risk as mentioned previously concerning the exchange of sensitive data between customs. Reuniting all the countries involved in the MRA of AEO on a similar blockchain-platform could ease up and secure the way customs exchange data.

Moreover, the blockchain technology could help entities trace back the data at their disposal as every transfer, monetary or informational, made on the ledger is recorded immutably. It makes the data transfers totally transparent for the stakeholders granted permissions into the permissioned blockchain, allowing agents to establish the provenance of the data and ensure their integrity. In addition to the traceability aspect, the technology could help customs and governmental entities secure their access to confidential information.

Finally, a blockchain-based platform could enable customs and other public entities to act in real time on their issued AEO. Indeed, it could, for example, allow to react immediately whenever a suspension occurs instead of having to wait, for month sometimes, just for the data to be transferred between customs. For instance, if an exporter had transgressed EU standards in terms of customs control and procedures, customs would be allowed to suspend the process and communicate their action in real time to the other countries involved in the MRA. This sharing process of AEO data across the network of MRA could therefore be automated in real time and in a secured manner.

One of the first pilot projects to create a common platform for EAOs management has been launched in March 2018 by Mexico, Peru and Costa Rica in collaboration with Microsoft and the IADB. This pilot project called Cadena ensures that customs administrations engaged

¹⁰⁸ Gov.UK (2019), “Authorised Economic Operator for imports and exports”. Retrieved from <https://www.gov.uk/guidance/authorised-economic-operator-certification> on 30 April 2019.

¹⁰⁹ *Ibidem*.

in MRA can all view the status of a delivered AEO certificate in real time, while keeping a certain level of security, traceability and confidentiality of the data. It also allows the private sector to view their AEO information on the blockchain, thus increasing the trust and the participation of the private sector. In addition to that, the platform also embodies the use of smart contracts to automate even more the validation of AEOs under an MRA¹¹⁰. Preliminary results from the pilot project show an increase in the efficiency and effectiveness of MRA management as well as an improvement in the transparency of the certificates' information¹¹¹.

A table can be found in the annexes resuming the importance of digitalization in the topics studied and the necessity of blockchain in the digitalization process to improve the current pain points of Trade Finance, Supply chain management and cross-border procedures.

6. Limits to implementation

Considering the previous sections, we can already spot that the analyzed technology can have huge influence on the current processes of Trade Finance, supply chain management and cross-border procedures. However, to get the most out of the technology, barriers to implementation need to be taken down. Yet, a lot of those barriers are still present and slowing the development of both platforms and smart contract applications.

6.1. Internet Connection

First and foremost, to use the blockchain technology, participants must have an internet connection to access the platforms. Therefore, some developing parts of the world could be left behind if we do not manage to provide them with a basic internet connection to start with and afterward with a proper bandwidth allowing faster connections. To put things into perspective, close to eighty percent of the Europeans have access to internet compared to twenty percent of the Africans according to ITU/ICT indicators. More worrisome, the digital gap between the OECD countries and the LDCs has been growing ever since the beginning of the century with a small exception in 2013.¹¹² In a similar vein, the bandwidth gap is also increasing, leaving the few LDCs with poor bandwidth speed.

If not solved, this unequal accessibility to internet could grow disparities even further as SMEs in developing countries will not have the technical capacity to participate in the

¹¹⁰ Sandra Corcuera Santamaria, "CADENA, a blockchain enabled solution for the implementation of Mutual Recognition Arrangements/Agreements", Inter-American Development Bank. Retrieved from <https://mag.wcoomd.org/magazine/wco-news-87/cadena-a-blockchain-enabled-solution-for-the-implementation-of-mutual-recognition-arrangements-agreements> on 30 April 2019.

¹¹¹ *Ibidem*.

¹¹² Emmanuelle Ganne *op. cit.*

deployment of blockchains. Subsequently, SMEs in the OECD countries will have the capacity to expand their technological development, allowing them to decrease costs and increase efficiencies for the reasons mentioned in previous sections, while SMEs in LDCs will possibly suffer from the increased competition of the SMEs from OECD countries. Moreover, evidence shows that SMEs are already lagging behind as regards adoption of new technologies¹¹³, making the problem even worst.

Moreover, many supply chain actors are located in those developing countries lacking the computerization levels required to implement the technology. Thus, it will not be possible to exploit the full potential of the technology in supply chains solutions until those countries provide sufficient infrastructure to connect their producers to blockchain-based solutions¹¹⁴.

6.2. Scalability and energy consumption

The scalability and energy consumption problems are particularly true as regards public blockchains such as the Bitcoin but much less for private or consortium blockchains. Indeed, when considering scalability, public blockchains are often only able to handle only a small amount of transactions per second. Bitcoin, for instance, can only process seven transactions per second on average¹¹⁵ when using its first layer while Ethereum is able to make twice as much transactions per second¹¹⁶. In comparison with the 2000 transactions per second on average for the mainstream Visa¹¹⁷, a big time lag is still present between the future, blockchains and the present, centrally controlled payment systems. Furthermore, the number of users of both Bitcoin and Ethereum is constantly increasing, making the blockchains even more congested and delaying even further the validation of transactions. Such scalability limits can become a major problem if the number of corporations on the network skyrockets, leading to slower transactions and therefore lower efficiency. Many solutions to this problem have already been explored and tested, some successfully, such as the Lightning Network on the Bitcoin blockchain, which allows to make faster and cheaper transactions using off-chain payments¹¹⁸.

Thankfully, the most used type of blockchain in international trade is the consortium blockchain, which does not face the same kind of scalability problems. For instance, the

¹¹³ Organisation for Economic Co-operation and Development (2017), “Enhancing the Contributions of SMEs in a Global and Digitalized Economy”, Proceedings of the Meeting of the OECD Council of Ministerial Level, Paris: OECD.

¹¹⁴ Nir Kshetri *op. cit.*

¹¹⁵ <https://www.blockchain.com/fr/charts/transactions-per-second?timespan=1year>

¹¹⁶ <https://etherscan.io/chart/tx>

¹¹⁷ Croman, K. and al (2016), “On Scaling Decentralized Blockchains”, Position Paper.

¹¹⁸ J. Poon, T. Dryja (2016), “The Bitcoin Lightning Network: Scalable Off-Chain Instant Payments”.

Hyperledger Fabric can process up to 3500 transactions per second¹¹⁹. Unlike a public blockchain, a consortium blockchain has control over all the nodes on their network, allowing them to guarantee correct internet bandwidth levels and high computer power over all nodes. Besides, plenty of projects such as the Ethereum 2.0 are developing scalable public blockchains using “proof-of-stake” consensus mechanisms allowing dapps and businesses requiring thousand of transactions per second to be implemented on those platforms.

On the energy consumption side, according to O’Dwyer and Malone, the Bitcoin blockchain consumed as much energy as Ireland in 2014, an estimated 3 GW¹²⁰, in its process of validating blocks. Indeed, some blockchains, depending on the consensus implemented, have computationally intensive validation processes which requires lots of energy. This issue can raise many questions as the technology already consumes an enormous amount of energy although it has not been implemented at its fullest. Therefore, we can wonder how much energy this technology will consume once it will be used massively. However, much of this debate arises from the sole high level of energy consumption of the Bitcoin blockchain. Indeed, permissioned blockchains use another consensus mechanism which is much lighter in energy consumption. Moreover, more energy-efficient technologies such as IOTA are being developed to avoid any excess in energy usage. Most of those projects are using “proof-of-stake” consensus mechanism or some derivatives of it to solve the problem of energy consumption of “proof-of-work” based blockchains such as Bitcoin. A table comparing cryptocurrencies on energy consumption and other elements such as transactions per second can be found in annexes.

6.3. Interoperability

The Interoperability issue of blockchains is another major obstacle to the full implementation of the technology. This term refers to the capacity of different systems to exchange information among each other and make use of the data. This problem arises from the multitude of isolated blockchains developed and the difficulty to connect them one to another. Those interoperability problems may have a negative impact on the implementation of the technology as agents involved in international trade, going from the exporter to the government agencies, must be able to communicate some of their information to other participating entities. However, if two governments or agents involved in the same supply chain or trade finance ecosystem do not use

¹¹⁹ Androulaki, E. and al. (2018), “Hyperledger fabric: a distributed operating system for permissioned blockchains”, Proceedings of the Thirteenth EuroSys Conference, Porto, Portugal.

¹²⁰ O’Dwyer, K., and Malone, D. (2014), “Bitcoin Mining and its Energy Footprint”, National University of Ireland Maynooth, Working Paper.

the same blockchain to process their transactions and if the two ledgers are not interoperable, they will not be able to transfer data or cryptocurrencies from one system to another without the help of some centralized third-party such as a centralized trade platform.

However, different scenarios can arise depending on the interoperability level of the blockchains. In the following figure, the scenarios are developed for two different countries, thus involving G2G cross-border operations. Nonetheless, those representations can also be used to include non-government agents.

In the best possible scenario, both countries involved in cross-border transfers are using the same single blockchain meaning that no interoperability is needed. Consequently, data transfers could be done directly from country A to country B without any reconciliation needed. Additionally, smart contracts would also be written in the same computer language and could be designed to share only selected data with the other platform's participants. An example of such scenario is the Singapore Declaration initiative developed by IBM and the Singapore customs. This project allows to send custom declarations from one end of the world to the other through a blockchain-based customs portal¹²¹. Yet, such an approach will certainly be limited to some custom authorities across the globe with a multitude of other platforms running alongside.

In scenario 2, both the importer's and exporter's government authorities are using the same blockchain technology but on two different platforms. Therefore, platform interoperability, also called "intra-ledger interoperability" would be required. Such as in the previous scenario, smart contracts would be designed to reveal a certain amount of data to specific participants. A lot of work is currently being done on the platform interoperability issue. For instance, the Enterprise Ethereum Alliance released back in 2018 an open-source cross-platform framework intended to allow interoperability between permissioned blockchains developed on the Ethereum public blockchain¹²².

In our third case, both government authorities would be on two different platforms based on different blockchain technologies. In our previous case, they shared the same technology on different platforms which allowed them to use intra-ledger interoperability. In this case, they both have different technologies and platforms meaning that they must have some inter-ledger

¹²¹ Emmanuelle Ganne *op. cit.*

¹²² Higgins, S. (2018), "Enterprise Ethereum Alliance Unveils Common Blockchain Standards", Coindesk. Retrieved from <https://www.coindesk.com/enterprise-ethereum-alliance-unveils-common-blockchain-standards> on 03 May 2019.

interoperability to exchange data. In other words, data bridges must be created between blockchains such as currently being developed between Hyperledger and Ethereum¹²³.

In our final scenario, the importing and exporting government authorities would keep part or all their activities off-chain and would connect with a blockchain-based trade platform using APIs (an application to extract data from one system to another), if the trade platform's smart contracts are API compatible. Such type of setting would not improve cross-border G2G operations which would operate in the same way prior the technological introduction. The only difference arising from this scenario is the introduction of API mechanisms which could help authorities to extract information from the platforms to speed up their custom clearance.

The last two scenarios are the most likely to happen. Indeed, it is hard to imagine every customs authority joining the same single blockchain on either the same platform or on different ones such as in scenario 1 and 2. Actually, most of them are developing their own platforms with different enterprises exploiting different systems. Therefore, unless interoperability solutions are developed, enabling the different technologies and platforms to interact in a more fluent way, the presented solutions to G2G cross-border transactions and international trade transactions in general will not have much impact on the total value traded.

¹²³ Hyperledger (2018), "The Dutchess Project: A Tale of True Interoperability Between Multiple Blockchains". Retrieved from <https://www.hyperledger.org/blog/2018/04/26/the-dutchess-project-a-tale-of-true-interoperability-between-multiple-blockchains> on 03 May 2019.

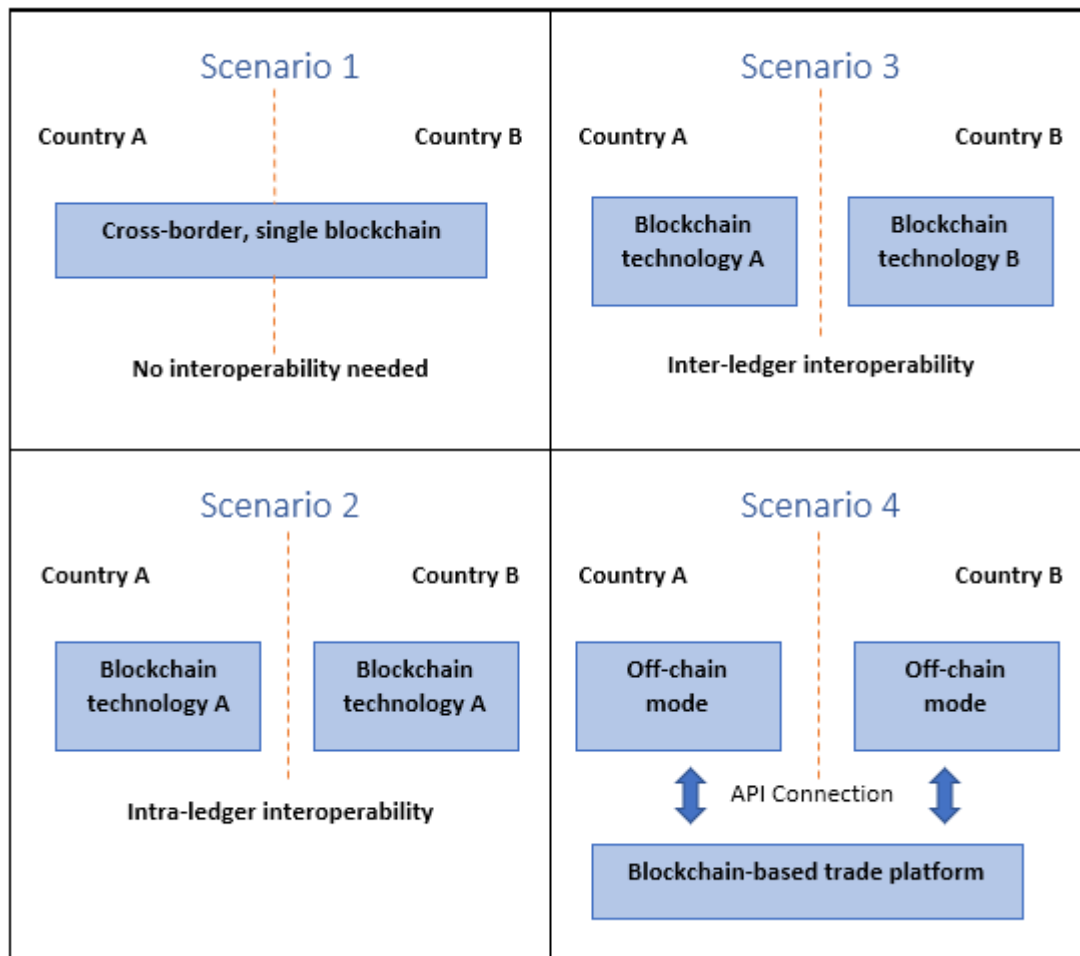


Figure 6: G2G Interoperability¹²⁴

Another interoperability issue is the coding language used in the different systems. Indeed, the coding language of smart contracts might differ across technologies, making the work of developers even harder. Therefore, some sort of language standardization may be needed to go one step further in developers' implication. Indeed, without standardization, two developers might be developing the exact same application on two isolated chains using different languages, which can be considered as a waste of resources. Bringing together all the developers on the same coding language, or at least reducing the number of different languages, could enable efficiency gains.

Similarly, IoT devices used for the tracking of goods must be able to register the data collected in different formats compatible with a multitude of blockchains. If not implemented that way, some sort of data transformation may be needed to transfer information from one system to another without compromising the data.

¹²⁴ Designed by Author. Inspired by Emmanuelle Ganne *op. cit.* p37.

6.4. Legal framework

While the digitalization of the actual paper intensive processes of international trades through the use of blockchain requires some degree of interoperability to be completely efficient, it must also embody a legal framework recognizing e-authentication methods as well as e-signatures, e-transactions and e-documents. Nowadays, most countries still request documents in paper format and only a few already recognize e-formats.

Moreover, countries must implement new national legislation to allow or ease the access and exchange of data with other administrations both nationally and internationally. Consequently, administrations should promote national recognition of electronic transactions and e-signatures on a first basis and afterwards on an international level¹²⁵. While national regulations could be adapted relatively rapidly, the recognition of other countries' e-documents would require case by case agreements¹²⁶.

The regulatory parameters allowing national data to be exchanged between countries still need to be defined; otherwise no country will join, by fear of sensitive data theft or lack of data confidentiality. However, the possibilities offered by smart contracts to hide specified data and limit accesses to authorized agents could be decisive for the creation of a trusted and secure environment to exchange information among both governmental entities and private actors if included.

Such trusted channels to exchange data only exist on a limited scale. For instance, the Netherlands have implemented paperless channels with China concerning the exchange of health certificates for dairy products and with Colombia for flowers' phytosanitary certificates. However, those channels take time to be fully functional as regulatory issues must be solved product by product¹²⁷.

Furthermore, supply chains are now operating all over the world with suppliers located on different continents. Whenever a product travels from Europe to the US, it goes through a complex range of regulations and laws such as maritime laws, commercial codes and laws related to ownership with multiple jurisdictions along the journey. Complying with all the old laws, institutions and customs managed by humans could be a hard task for blockchain-based solutions and smart contracts which are denationalized, automated and dematerialized¹²⁸.

¹²⁵ Emmanuelle Ganne *op. cit.*

¹²⁶ UNNExT, UNECE, UNESCAP (2012), *Electronic Single Window Legal Issues: A Capacity Building Guide*, United Nations Publication.

¹²⁷ Emmanuelle Ganne *op. cit.*

¹²⁸ Casey, M. J., & Wong, P. (2017) *op. cit.*

Therefore, a big part of the success to implement blockchain platforms into the current systems to exchange and process data between governments and private actors depends on the political powers in place. The current reserve of nations to exchange sensitive data via electronic channels might be disrupted by the increase in security brought by the blockchain technology which could possibly strengthen the political support required to create a legal framework adapted to paperless trade.

7. Developed versus developing countries

Throughout our work we have observed that major improvements can be achieved in many fields of international trade. However, those enhancements are dependent on several variables such as the level of the bandwidth and the legal framework in place, to mention just two examples. Those conditions required are rarely the same across all countries, surely making the adoption rate endogenous and dependent on those variables. Therefore, the aim of this section is to analyze the current differences between developed and developing regions and the possible implications of those divergences on the impact of the technology and its adoption rate.

First and foremost, trade finance improvements should favor both high- and low-income countries thanks to the means explained in section 3. Businesses in the developing and the least developed countries, especially the small and medium sized businesses, often have to struggle more to find financing, due to a lack of information about them; an enhancement of available data about their businesses and activities for the financiers should allow them to get better interest rates on their loans. This effect, combined with the reduction of amendment costs and of fraud risks could level the playing field for these developing countries often facing high levels of fraud. When only considering high-income countries, we can make the hypothesis that the impact will be greater for SMEs than for large corporations, the rejection rate of applications for financing being massively smaller for the latter.

Secondly, better supply chain management visibility and auditability will most likely bring positive effects on both developed and developing countries. However, those improvements will certainly not impact the same actors in developed and in developing countries. Indeed, on the one hand, activities in high-income countries most often belong to the second or third sector, meaning that they modify primary resources to create complex goods with high technological levels. When done on a large international scale, those types of activities require complex supply chains connecting multiple upstream and downstream producers with a multitude of different inputs and outputs. Therefore, visibility and auditability improvements of those complex supply chains will surely benefit big companies in developed

countries in the way that they should be able to manage their production and the related risks more efficiently and transparently. On the other hand, agriculture, fishing and forestry still represent a consistent percentage of the developing and least developed countries' GDP. Indeed, while those three activities only represented 1,3% of the high-income countries' GDP in 2016 and 3.6% for the whole world, it amounted to 25,1% of GDP for the low-income countries and 15,1% of GDP for lower middle-income countries in 2017¹²⁹. Consequently, we can think that supply chain management improvements through the use of blockchain will most likely impact first the primary sector in developing countries as it represents the major part of their activities. In fact, agents of the primary sector often lack platforms to communicate and prove the quality of their products to agents in developed countries reducing their market power when dealing with them. This could be fixed with a proper development of the technology in those regions, transforming the way those farmers deal with rich countries.

Thirdly, cross-border transactions include time consuming customs clearance processes. The time required to free a product from customs often varies between countries and regions. Indeed, border compliance can vary from 12,5 hours for OECD high income countries to 97,3 hours for sub-Saharan Africa¹³⁰. As we say, time is money, meaning that every hour spent at the customs represents a monetary cost arising to 605,8 USD for the Sub-Saharan Africa when only 139,1 USD for OECD high income countries¹³¹. Those statistics clearly emphasize the gap in trading costs between low- and high-income countries when only considering shipping products across borders. That being said, we can think that bigger improvements are possible in developing countries as they are already lagging far behind the others. Therefore, implementing such technology to boost cross-border procedures will most likely generate greater disruptive effects on developing countries than already developed ones and might also be easier to incorporate in current processes, as low income countries would almost start from scratch, whereas high income countries would have to replace existing habits and techniques.

Finally, we have emphasized that blockchain could help developing countries, more than developed countries, to achieve financial freedom, prove the quality of their products and ship them at lower cost. However, we have not yet included the difficulties of those countries to implement this technology. Indeed, as previously said in section 6, most developing countries still do not have performant internet connections, or even do not have any, forbidding those

¹²⁹ The World Bank, *Agriculture, forestry, and fishing, value added (% of GDP)*. Retrieved from <https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS> on 29 May 2019.

¹³⁰ The World Bank, *Trading across borders, Doing business*. Retrieved from <http://www.doingbusiness.org/en/data/exploretopics/trading-across-borders> on 29 May 2019.

¹³¹ *Ibidem*.

agents to connect themselves to the network. Therefore, implementing blockchain in those countries will be a real challenge as companies must first connect people to internet with enough speed before even thinking of incorporating blockchain into their habits. This process should be much faster in countries already having huge infrastructures and highly efficient connections. Moreover, in developing countries the legal framework is often unclear and slow to adapt, and it is hard to enforce rights in front of a court. Yet, the disruptive effects of the technology require some kind of adaptation of the current legal framework to be completely efficient. Consequently, improper adaptations of the laws to the technology could either slow the adoption process or even make the technology inefficient. This also goes for developed countries who must understand the technology and its implications to design appropriate legislations. In my opinion, developed countries will adapt much faster than developing countries, as they have more human capital able to understand and create or adapt laws.

Therefore, the final outcome of the technology will mostly depend on the ability of developing countries to adapt their current laws and infrastructures. If they manage to do so, they are the ones who might benefit the most from this technology. However, if they don't achieve those milestones, inequality levels between rich and poor countries may increase even further.

8. Conclusion

In the first part of the paper, we aimed to explain the core components of a blockchain system, differentiating between their types and features. Indeed, we used the simplest definition of a blockchain being a peer-to-peer database of all transactions made on a network organized in blocks chained to each other using cryptography. Each block is built with a cryptographic hash of the precedent block, a transaction data and a timestamp¹³². Next, we clearly described the immutability, transparency and real-time record characteristics of the technology as well as the different types of blockchains. The most worldwide spread type being public blockchains such as Bitcoin allowing anyone to join and make transactions on the network without any requirements. Then, private companies and banks started to develop private types of blockchain, restricting the access to authorized agents only with the goal to maximize the scalability and privacy components of the technology. Thereafter, consortium blockchains appeared, consisting in a mix of the private and public types in the sense that it is also mostly permissioned but handled by a group of people or entities instead of being governed by a single

¹³² Casey, Michael, et al. *op. cit.*

one. Finally, we explained the term smart contract in comparison to the current contracts. We described its form as a “if ... then” condition embodied into the codes of the contract developed on the blockchain-based platform. Therefore, once signed by both parties, the contract will execute in an automatic way when conditions are fulfilled.

In chapter 3, we introduced Trade finance by differentiating between inter-company credits and bank-intermediated credits while also describing the form and use of letters of credits and documentary collection. Once those terms well defined, we started to spot the different pain points that make the process inefficient and tried to find blockchain-based solutions. The two first pain points are relatively connected as contractual ambiguities (first pain point) often end up in amendment costs (second pain point) needed to modify the documents presented to either banks or customs. We developed a solution using smart contracts to keep the ability to modify whenever needed contract specifications with the consent of the other participants in the blockchain. Thereafter, we developed the problem of the documentary inefficiencies of the current system which are mostly due to its paper-intensive nature and we explained the consequences on the high level of fraud, the latter consisting mostly of forging of trade related documents or duplicating of receivables. We also described the information asymmetries between banks and their borrowers, which reduce the possibilities to get financing or increase their interest rates, especially when SMEs from developing countries are concerned. We emphasized the importance to digitalize the system using a blockchain-based platform in order to share all related documents among all the participants in real-time and immutably. If checking of the data entered is done properly, this could reduce the forging of documents and the frauds by factoring but also improve the quality of the available data.

Next, we introduced the term ‘supply chain management’ and developed its two major pain points, namely visibility and risk management. In the current system, most companies lack visibility over their complex supply chains and it is still very costly and time-consuming to track a product from seed to final product. This lack of visibility over the all of the supply chains and also on the in-transit conditions of the products makes the risk management even harder for those companies. For these reasons, we argued that gathering all the stakeholders in supply chains onto a common blockchain-based platform could enhance their visibility and auditability both into the different participants and the conditions of transportation of the products consequently improving their risk management.

Based on the solutions explained in the chapter on supply chain management, we discussed the current problems and solutions to both business-to-government and government-to-government cross-border procedures. In the B2G procedures, we developed solutions for

certificates and licensing, customs clearance and revenue collection. The solution consisted in gathering parties, both private and governmental, on a common blockchain-based platform to ensure an immutable and real-time record not only of the certificates but also of the documents relating to traded goods, which should improve the efficiency of the three areas mentioned above. We also suggested to incorporate smart contracts in the revenue collection methods to automatically perceive the VAT on traded goods. We also developed solutions in the G2G procedures to manage in a more efficient way the transfer of data between countries and authorized economic operators (AEO). In addition, the proposed solutions could help customs and governments to act in real-time on the issuance of AEO certificates and to communicate their actions more easily to other countries concerned with the mutual recognition agreement (MRA).

In the next chapter we introduced the four big limitations to the full implementation of the blockchain technology, being the internet connection, the scalability and energy consumption, the interoperability and the legal framework. The first one is pretty straight forward: as connecting to a blockchain network requires an internet connection, the widespread adoption of proper internet connections is required to include every person in the world. Secondly, the scalability and energy consumption of public blockchains are major issues pointed out by many. Indeed, a large-scale usage of the technology will require a high level of transactions per second and low levels of energy consumption; otherwise the network would be inefficient and not ecology friendly. However, those two issues are relatively easily addressed by private blockchains. Finally, the interoperability of blockchains and the legal framework must be improved to increase worldwide mass adoption of the technology. Indeed, if the legal framework is not clear enough, issues could arise when enforcing a smart contract in front of an incompetent justice. The same applies for interoperability issues: if these are not solved, data will continue to be operated in silos with very low communications.

In the last chapter we compared the magnitude of the effects and the adoption of the technology in both developed and developing countries. We argued that developing countries might benefit more from blockchain than developed ones, considering the low level of financing of the population and the cost of customs both in time and money to export or import. However, we also emphasized that developed countries are better prepared to adopt the technology than developing ones, considering their internet connections and legal framework. Therefore, the final effects of the technology on those countries might differ greatly depending on their ability to adapt.

Finally, the major flaw of this thesis is the lack of empirical analysis to confront the supposed benefits that the technology should bring with what it actually brings to businesses and governments. However, the lack of available data to conduct such an analysis left me no choice but to develop theoretical solutions without data backing my allegations. Therefore, trying to estimate the cost reduction and productivity gain generated by the blockchain technology on different sectors should be further explored by the literature.

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