A case study on the exploration of Blockchain potential

Master thesis submitted to Delft University of Technology

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in **Complex Systems Engineering and Management**

Faculty of Technology, Policy and Management

by

Camilla Valeria Cavaliere

Student number: 4623126

To be defended in public on Month Day Year

Graduation committee

Chairperson	: Prof.dr. W.A.G.A. Bouwman, Section ICT
First Supervisor	: Prof.dr. W.A.G.A. Bouwman, Section ICT
Second Supervisor	: Dr. H.G. van der Voort, Section Organisation and Governance
External Supervisor	: mid-European Production Company, name known by the supervisors

A case study on the exploration of Blockchain potential

An exploratory research on the impact of the technology on business process and value configuration of a mid-European company

Master Thesis Proposal Camilla Cavaliere – 4623126 cavalierecamilla@gmail.com

Complex Systems Engineering & Management

Faculty of Technology, Policy and Management, Delft University of Technology

1st of August 2018

Abstract Since 2017 blockchain (BC) has been settling in the spotlight. Several industry fields could use the technology as part of the underlying infrastructure for registering and transferring any type of asset and optimize business processes. As of 2018, numerous blockchain initiatives are continuously developed, with global executives looking forward to start a blockchain project and successfully extract value out of it.

However, several factors aliment the uncertainty corporates experience when passing from discussion to actual implementation. Eventually the majority of firms simply waits for the technology to develop further, running the risk of being already too late to catch up when the technology takes off. Organizations need to assess how the technology can be integrated in the current business and how its introduction at the operational level alters how value is created, delivered and captured, thus the Business Model (BM) overarching the current process.

Therefore, a thorough literature review about the technology and the BM concept is conducted. Links and interrelations among the two concepts are drawn and organized in a conceptual framework. Finally, an exploratory case study is conducted to validate the insights derived from theory: first a mid-European company is chosen for BC application and its internal dynamics studied. Then a specific use case is selected, and it is envisioned a possible exploration of the BM-BC relationships that the company would conduct.

The suggested exploration is then proposed to the case company. The suggestions given well reflect the exploration the Group conducted in reality, confirming the validity of the study. In particular, the findings suggest that tradeoffs and limitations characterizing the specific BC use case actually played a role in determining how the exploration of BM changes was conducted by the company.

The research gives insights on how a specific company explored and prepared for changes at the BM level. At the same time, it suggests the need to assess better how technological tradeoffs characterizing cross-organizational use cases translate into changes at the BM level.

Key words **Blockchain, tradeoffs, business process, Business Model, exploration**

Contents

1 Introduction ... 5
1.1 Research background ... 5
1.2 Research problem ... 5
1.3 Literature review ... 6
1.4 Research objective ... 8
1.5 Research questions ... 8
2 Blockchain technology ... 10
2.1 Distributed database and distributed ledger ... 10
2.2 Bitcoin and blockchain ... 11
2.3 BC infrastructure ... 13
2.4 Permissioned/permissionless blockchains ... 14
2.5 Ecosystem ... 15
2.6 Technology components ... 15
2.7 Blockchain value proposition ... 17
2.8 Technical tradeoffs ... 20
2.9 Conclusions ... 21
3 Blockchain use cases ... 22
3.1 Blockchain in action ... 22
3.2 Cross-organizational processes ... 26
3.3 Conclusions ... 28
4 The Business Model and value configuration ... 29
4.1 Theory on Business Model (BM) ... 29
4.2 Theory on business process and Business Architecture (BA) ... 31
4.3 The relation between BM, strategy and business process ... 31
4.4 A combined picture ... 32
4.5 Conclusions ... 33
5 Tradeoffs impact on Business Model design ... 34
5.1 Service domain ... 34
5.2 Technology domain ... 35
5.3 Organization domain ... 37
5.4 Financial domain ... 39
5.5 The conceptual framework ... 41
5.6 Conclusions ... 44
6 Research methodology ... 45
6.1 The selection of the case company ... 45

6.2 The selection of a use case 46
6.3 Data collection 47
6.4 Conclusions 48
7 Implications for the choice of blockchain on the company's BM 50
7.1 The processes 50
7.2 Network participants involvement 51
7.3 Software provider collaboration 52
7.4 Services and target group 53
7.5 Monetization 54
7.6 Step-by-step development 55
7.7 Implications on Business Model 56
7.8 Road map 58
7.9 Conclusions 59
8 Validation, discussion, limitations and conclusion 60
8.1 Validation 60
8.2 Discussion 60
8.3 Conclusions, limitations and future research 61
Bibliography 64
Appendix A: CoSEM Scientific Article 70
1 Introduction 71
2 Literature review 72
3 Research methodology 77
4 Main Results 80
5 Validation and discussion 83
6 Conclusions and limitations 85

1 Introduction

1.1 Research background

Since 2017 blockchain (BC), the technology that enables Bitcoin, has suddenly started to be widely discussed. This could be due to the decreasing support obtained by the Bitcoin by being a “controversial currency” (Rampton, 2017) whose performances are slowly worsening (Frankel, 2018). At the same time, attention has been raised by alternative blockchain use cases that governments and finance organizations around the world are currently experimenting with.

Bitcoin is only one of the potential applications that the BC technology can support in diverse markets and industries, such as logistics, manufacturing, banking, etc. The way this peer-to-peer database technology is designed increases its potential to represent “a game-changing force in any venue where trading occurs, where trust is at a premium, and where people need protection from identity theft” (Plansky, O’Donnell, & Richards, 2016). Particularly in a corporate environment, the technology has huge potential for optimizing business processes by serving as infrastructure for registering and transferring any type of asset (Brenig, Schwarz, & Rückeshäuser, 2016), and by being part of the solution supporting applications such as the Internet of Things or decentralized data storage (Wang, Chen, & Xu, 2016).

1.2 Research problem

The recent hype has led the technology to be one of the hottest topic exciting the business world, with corporates increasingly tempted to start a blockchain project and successfully extract value out of it. However, excitement rapidly dies out when organizations switch from “blockchain discussion” to actual “blockchain implementation”. What are the reasons for this uncertainty?

First, corporates have hard time assessing which BC-enabled solution is the most beneficial for them. This is mainly because they are not fully aware of which problems BC solves, what is its value proposition, and which use cases make business sense and which do not. This could be due to the fact that most of use cases have been developed in the finance sector, using the technology as innovative solution for reducing costs of time-consuming and paper-based processes, such as clearing and settlement of financial assets and payment systems (Zhao, Fan, & Yan, 2016). The focus makes generalizations and best practices for all kind of different organizations difficult to be drawn. Moreover, the fact that financial use cases are deployed within one single firm or very similar companies (banks, FinTechs, insurance companies, etc.) distracts from realizing that BC “is an emerging technology for software applications in cross-organizational setting” of all kind (Rimba, Tran, & Weber, 2017, p. 257).

Secondly, firms are not completely aware of what “corporate deployment of blockchain” means, which role they should play along the project development and who they should involve to make sure the investment delivers value to the company and its ecosystem. The technology is still in the early stages of development, adoption and experimentation, mass market applications are few (as of 2018 only the Bitcoin one), and corporate use cases limited to Proof of Concepts and trials (Furlong, 2018). Moreover, most of BC alliances are protected by strict confidential agreements, so that almost no information are available on how other companies managed and steered BC projects.

As of today, some organizations have explored the technology within different (pilot) projects and have started with niche applications (Camerinelli, 2015). However, this push is often not in line with what the company or its ecosystem needs and results in wasted time and resources. Other firms’ failures are another major source of uncertainty, together with an unclear legal environment and the highly fragmented BC landscape, with several different protocols or frameworks for application development (Hileman & Rauchs, 2017).

Eventually the majority of corporates simply waits for the technology to develop further. At the same time, they run the risk of being already too late to catch up when the technology takes off. Never before there has been such an urgent need for organizations to evaluate which technology use case make sense deploying on a cross-organizational process, how BC can be integrated in the current business, and how its introduction alters where value is created, how it is delivered and captured.

1.3 Literature review

A literature review is conducted to sum up what has been researched and analyzed until now. Due to the novelty of the topic and the limited amount of real-world deployments of enterprise applications, research papers and valuable literature about blockchain were hard to find. Instead, collecting papers on the Business Model concept and its relation with business processes was relatively easy. For the project also not-academic documents were analyzed, such as white papers, blogs and websites, deemed more appropriate seen the dynamicity and fast evolution of the technology. Academic search engines such as Google Scholar, Springer Link or Research Gate were used inputting the words "blockchain" AND "applications", OR "use cases", OR "business perspective", OR "business challenges", OR "business model", OR "business process". Other sources were identified among the list of references reported in the analyzed literature.

1.3.1 The choice for a blockchain solution

Some literature allows organizations to assess whether the technology is a good fit for them by having a look at company's type and underlying processes. For example, Juniper Research (2017) considers the need for transparency in transactions, the dependency on paper-based legacy systems and the transmission of high-volume information as the key company requirements for benefitting the most out of the technology (Juniper Research, 2017). Companies can also analyze their environment and the network in which they operate. In this regard, Wang et al. (2016) propose an interesting framework for blockchain adoption that assess the maturity of the technology and list conditions that make blockchain a valid potential solution. These are multiple parties sharing and updating data, needing verification, and willing to remove external intermediaries leading to extra costs and complexity (Wang, Chen, & Xu, 2016). Literature exists also informing which BC is the most appropriate for the business, whether public or private, permissioned or pemissionless. The decision trees developed by Peck (2017) and Wüst and Gervais (2017) consider both company's requirements (ex. data to exchange) and ecosystem characteristics and inform on the kind of blockchain needed (if at all).

Genuine valuable use cases for which the technology makes more sense based on its characteristics are described in few papers and articles. Some deal with added value that might be extracted from BC functionalities for financial institutions (EVRY Financial Services, 2015; Hoffman, Strewe, & Bosia, 2018), or in general for all kind of industries (Greenspan, 2016; Morabito, 2017).

1.3.2 Blockchain corporate deployment

Regarding corporates' role when deploying blockchain, the paper from Brenig et al. (2016) explains the ecosystem that develops around a DCS, or Decentralized Consensus System. Companies are seen as actors providing complementary applications and services built on top of a DCS, or as end-users (in)directly using a DCS (Brenig, Schwarz, & Rückeshäuser, 2016).

As piece of software that allows for decentralizing record-keeping and computation (Rimba, Tran, & Weber, 2017), BC introduction represents an architectural choice that at first impacts organizations at the operational thus processes level. This might justify why literature about technical, computational and engineering limitations of the technology is abundant. The paper from Yli-Huumo et al. (2016) effectively summarizes all that has been researched from a technical point of view. The main issues with BC regard privacy, security, and scalability, including throughput and latency. Of the same kind is the overview presented by Zhao et al. (2017) that shows how current research has been focusing on how to improve system efficiency and security, and explore innovative applications. The article published by Haley and Whitaker (2017) effectively summarizes limitations specific to corporates in accordance to organization's requirements, such as enterprise security, transactions speed, stewardship and governance. All other aspects but technical ones, such as business and economics, together with laws and regulations, are often left outside the scope of technical papers (Yli-Huumo, Ko, Choi, Park, & Smolander, 2016), with only some calling for more research on the social and economic effectiveness of technology applications (Zhao, Fan, & Yan, 2016).

Some papers do recognize the importance of other factors than technical ones when deploying blockchain at the corporate level. For example, Plansky et al. (2016) stress on the importance of aligning the investment with the company's value proposition and have clear strategic goals. They suggest four steps to follow for gradually apply the technology within the organization. First the business should identify customer's pain points and start with projects that could strengthen core business processes. Second, companies should conduct a feasibility check, coming out with explicit hypothesis on how the technology can make business sense for the company, for example: increased transparency, reduced time needed for asset adjustment, etc. Following steps are about implementation, in particular developing a prototype and assessing how the way the company currently does business in the network changes. Iansiti and Lakhani (2017) give examples of BC applications, and develop a framework that classifies innovations based on novelty (how much the application is new to the public) and complexity (degree of network coordination required). They give general recommendations on how to guide BC investment and suggest managers how to anticipate challenges such as the level of collaboration and the regulatory efforts required to develop the technology in their organization.

However, authors admit that there is "still work to be done to build confidence in […] (the) identification of the richest opportunities to deliver business value" (Hileman & Rauchs, 2017, p. 4). Introducing innovations at the corporate's operational level does not only change how processes are run, but can also have consequences on how the entire business functions. See other innovative technologies before BC that entered the corporate reality: the Internet, the smartphone, or the 3D printer. These technologies have changed the way business was done till that moment and have become enablers of completely new Business Models (Holotiuk, Pisani, & Moormann, 2017). The same way, a BC-enabled process has the potential to imply changes in the entire value configuration of a firm and alter the current firm's Business Model, i.e. the logic that specifies how a company sustain itself and generates revenues, to which value creation, delivery and capture are strictly related (Al-Debei & Avison, 2010).

1.3.3 Value creation, delivery and capture, and the role of the Business Model

Literature is present regarding value creation and delivery coming along with the implementation of innovation in business. Chesbrough and Rosenbloom (2002) consider a company's business model as "mediating construct between technology and economic value" (Chesbrough & Rosenbloom, 2002, p. 532). The model they introduce considers technology performance and feasibility as technical inputs for shaping the BM that includes: technology value proposition, market segments addressed, value chain and value network, and revenues mechanism; value is then the economic output of the model. A unified framework for the Business Model concept, together with its relation to not only value (creation, delivery and capture), but also interactions with strategy, business process and Information System, is given by Al-Debei and Avison (2010).

In the blockchain domain papers about value and business model are fewer. Understanding how cryptocurrency companies create and deliver value through their digital business model is the topic of Kazan et al. (2015). They develop an analytical framework for analyzing use cases that considers value dimensions (value creation logic, value capturing mechanism, value delivery architecture, and value stakeholder network), Digital Business Model and value configuration. The research however is limited to crypto service and application providers, and analyses static BMs, nothing is said on the implications on BMs and value configuration from changing value dimensions. Brenig et al. (2016) propose instead a general framework for the evaluation of value created by BC services and application from both point of views of the providers and of the end-users. They apply the framework to the Bitcoin application, but admit the focus on payment might not be informative for all other kind of BC applications. They anticipate the framework might be used for the concrete assessment of BM for BC or BC-based services/applications providers, but do not elaborate further. Finally, an extremely interesting article by Holotiuk et al. (2017) recognizes the disruptive power of blockchain technology as an enabler of new Business Models and try to assess where the major changes in current and new BMs lie. The research only concentrates on the payments industry and does not mention other application fields. It calls however for deepening the research on how implications on BMs impact the underlying business process and the overlying business strategy (Holotiuk, Pisani, & Moormann, 2017).

The review conducted highlights some key points:

i. The technology and its limitations are widely discussed and generic recommendations are given on how to solve technical challenges that might derive. Some valuable use cases from a corporate perspective are described, but a summary of meaningful use cases to deploy within a cross-organizational environment is missing.
ii. There is the need for evaluating BC cross-organizational use cases against corporate's requirements and have a clearer idea on which tradeoffs each application implies.
iii. There is a general confusion about what "corporate deployment of BC" means and it is unclear where do the major changes in any firm's current BM are likely to lie due to the introduction of the technology.

1.4 Research objective

The research wants to understand better blockchain in a business context, in particular the steering and managing of a blockchain project by a leading firm aimed at cross-organizational deployment. The paper contributes academically by summing up the literature regarding BC and BMs, and at the same time by shedding a light on how these two concepts are interrelated. This becomes an appropriate topic for a CoSEM Master thesis, since the outcomes would give corporates willing to deploy the technology a clearer idea on how they should explore these links, prepare for step-wise changes in the current BM, and facilitate the adoption of the BC-enabled offering on both public (society and authorities) and private side (other organizations).

The project is developed during a 6 months internship at a mid-European company willing to assess the feasibility of the technology and explore new possibilities for BC applications. The first objective of the research is to determine which technology use case makes business sense for the case company and give deployment recommendations to the Group. However, the research intends to provide all companies willing to create a BC ecosystem and take active part in it with a comprehensive guide that would allow to take the first steps in expanding their current services and products with a BC-based offering. Research deliverables include:

- ➔ A list of valuable blockchain cross-organizational use cases that make the technology worth with respective tradeoffs and limitations in relation to corporate requirements.
- ➔ A conceptual framework that provides core concepts for analyzing and subsequently changing the current BM of the offering into a BC-enabled one. In particular, the model informs which BM components would be affected, how these would look like after BC implementation considering its tradeoffs and limitations and how companies should transit from actual to future situation.
- ➔ The results from framework application to the case company. A comparison between how the Group should explored the BC-BM relations based on theory and how it actually intends to move towards BC-enabled offering is provided.

1.5 Research questions

In particular, the research questions that the project aims to answer are:

- ***RQ1: What is the current state of the art with regard to Blockchain? Which are valuable cross-organizational use cases?*** The technology functioning is described together with its value proposition and limitations by means of literature review. Tradeoffs that the technology implies against corporate requirements are listed. Then the study identifies which BC use cases add genuine value to cross-organizational processes. Use case analysis allows to specify limitations and implications on corporate requirements for each application.
- ***RQ2: What is the current theory on Business Model? How does it relate to value creation, delivery and capture?*** A unique definition for BM is adopted and how the concept relates to value configuration (creation, delivery and capture) in a company is explored. The interconnections with company's value proposition, ecosystem, processes and business architecture are made explicit by means of literature review. Components to consider when analyzing and subsequently re-designing the current BM are specified.

- ***RQ3: How does a company explore the relation between BC potential and BM? How does a company prepare for change in BM?*** This constitutes the main contribution of the research. A conceptual model is created that, by linking theory on blockchain, BM and value configuration, assesses the potential impact BC implementation has on current Business Model. In particular, the implications that the technology tradeoffs and limitations have on each BM area are underlined. By helping focusing on subsequent analysis, the model is then applied to the case company, resulting in strategic recommendations to the Group on which process to start with and how.

To answer these questions, the research has been structured according to the following: a review on BC technology is conducted through Chapter 2 and Chapter 3. Chapter 4 summarizes the existing literature on the Business Model concept and the connecting links with business process and business strategy. The concepts and the interrelations among those are made specific for blockchain technology in Chapter 5, and organized within a conceptual framework that helps further analysis focusing. The research methodology is explained in Chapter 6 together with the introduction of the case company and the BC use case that is deployed. Chapter 7 describes the results of the exploration conducted at the case company. Validation of the exploration, discussion, research limitations and conclusions are found in Chapter 8.

2 Blockchain technology

By now, you have for sure heard about Bitcoin and how it is promising to revolutionize the finance world as we know it. Few people, however, are aware that this cryptocurrency is just one of the infinite possible applications allowed but its underlying technology, the **blockchain**. Among those who came across the word "blockchain", only some truly understand how the technology works. Surprisingly, even less know how to program and implement it: in mid-2016 only "5,000 developers (were) dedicated to writing software for cryptocurrency, Bitcoin, or blockchain in general" (Mougayar, 2016). For the purpose of this research, it makes sense understanding how the technology works in a broad sense in order to classify the use cases introduced later. Therefore, too technical details of the technology are not discussed because out of scope. Let us start from the basis.

2.1 Distributed database and distributed ledger

You most likely have a computer at home where you saved the pictures of your last trip. These data are stored in a central disk, your database. You only have that specific database for that specific computer, meaning that you are running two major risks: first, in case you drop your pc and break it, your data get lost because physically linked to your computer that unfortunately just passed. Second, if a hacker accesses your computer and steals your data or modifies the records, you would not notice the change because you do not have any record of how it was your database before and after the attack. Now imagine you allow some of your friends to have a look at the pics stored in your database: you send a link (directory) through which they can access your data and have a look at it (*shared read*). In case a friend of yours wants to add some pictures, you delimitate the power of your friend: she can add pictures, but cannot delete any or save them on her computer. A *shared write* database is then possible by applying restrictions on other users' accounts (Greenspan, Private blockchains are more than "just" shared databases, 2015).

After few weeks, you have shared the same link with several friends of yours. Each of them is adding so many pictures, that the database is neither under yours or your friends' control anymore. This can be modified by anyone of you, but still has to be trusted by everyone. In this case, a **trusted intermediary** is necessary that manages who has access to the database and checks changes to the information happen according to the rules. However, a third person controlling changes to the database is expensive to maintain, so you and your friends decide to take the third party out of the equation. You replicate the image of your database on all your friends' computers, or servers, and agree on maintaining a meaningful view of the database state (meaning, none will delete all pictures, or add completely random data). You created a **distributed database**, with the major benefit of being **fault resistant**: by replicating the same image on many nodes, the system increases its resilience and it is not affected by the collapse of one single node. If your computer dies, you can ask your friends to send you back the pictures you lost.

Now, let us assume not all the people you allowed to access your database through the nodes are honest and might want to modify the information to damage you. Then, what you would need in case some nodes are acting dishonestly is a distributed database that is still able to synchronize and run, known also as "Byzantine fault-tolerant" (Hileman & Rauchs, 2017). Corrupting the system becomes more difficult because all database copies need to be attacked simultaneously for the attack to be successful (Eaton & Blycha, 2017). With "attack", it is meant either a dishonest entity getting large influence on the network by creating several fake identities and changing simultaneously information in all the nodes (also known as "Sybil attack", Wikipedia (2018)); or controlling at least 51% of the computing power of the entire system (called "51% attack", Du (2016)). Thanks to the Byzantine fault-tolerance, each of the nodes can independently verify and validate transactions updating the database state and recreate the entire transaction history (**who changed what and when**). This is what a **distributed ledger** is, a subcategory of distributed database whose nodes do not trust their peers by design. The way information and transactions are made public to everyone in this peer-to-peer network eliminates the need for data intermediation and validation before being trusted, i.e. the presence of a centralized authority.

Now the other peers in the network have a unique view on the data you reported and cannot change them arbitrarily. Leaving the pictures example behind, this characteristic becomes particularly important with assets transactions: the system has to make sure you do not spend the same amount of money twice, sending it to both Friend A and Friend B.

2.2 Bitcoin and blockchain

What has just been described is known as the **double spending problem**: a digital asset is copied, one copy is sent, the other is retained for further use (Hoffman, Strewe, & Bosia, 2018). Bitcoin was originally introduced to solve this specific issue (Nakamoto, 2008). In a centralized system, we normally find a trusted third party that timestamps the transaction and only keeps which came first. Instead, we deal with a system where no intermediary exists and all participants have potentially three "access rights":

- *Read access*: to view the transactions being recorded on the ledger;
- *Write access*: to ask the network to record transactions (write data) on the ledger;
- *Commit access*: validate input transactions and make changes to the ledger by timestamping transactions.

Note that each network participant can have from one to all access rights.

2.2.1 Writing process

Writers can have their transactions validated by the network if these respect the rules embedded in the shared database. For now, leave aside the term "bitcoin" as a currency, but think of it as a set of rules that controls which digitalized asset is allowed to be transacted or not. **Bitcoin transactional model** is a set of rules embedded in the shared database restricting which operations are permitted and automatically identify and solves conflicts between transactions: if someone adds information in one node, within a certain amount of time the system checks the input is not in contracts with any other output in all other nodes. It does so by constraining input transactions based on output transactions (ex. you were left with €30 in your account after last transaction, so now you cannot input two transactions transferring to other accounts €20 + €20 = €40), and verifying the assets you are addressing actually belong to you (Christidis & Devetsikiotis, 2016). Demonstrating the authenticity of the network participants (i.e. that they are the true owners of the addressed assets) still ensuring their anonymity is made possible thanks to **encryption**. As participant of the network, you are assigned to a private key (known only by you!), with which you sign the message sent to the receiver of the digital money. The receiver uses the public key address that uniquely identifies the node from which money are sent (known by the entire network) to verify if the public and private key actually correspond. In this way, the network verifies both assets balance and ownership.

2.2.2 Committing process

The question now is: among who has commit rights, who should validate (timestamp) the transactions? I.e., how to give incentives to the peers in order to update the ledger state? Adam Ludwin (2017) excellently explains the breakthrough enabled by the Bitcoin application: to let all the peers in the network compete for timestamping the transactions. Differently from distributed ledgers, the acceptable transactions are broadcasted simultaneously to all participants of the network that get to choose independently which one they want to validate. Bitcoin validators (or committers) are called "Miners". For example, Miner 1 chooses to timestamp transactions A, B and D, while Miner 2 wants to validate transactions B, C and D. The bundle of transactions is assigned to a **block**, or smaller dataset, with its own name: Miner 1 calls it "8CF"; Miner 2 names it "6GV". Transactions are officially validated and timestamped only when the block they belong to connects to the previous block and becomes the last ring of the chain. Therefore, the new block (batch) of transactions attaches to the previous one only if it explicitly refers to it.

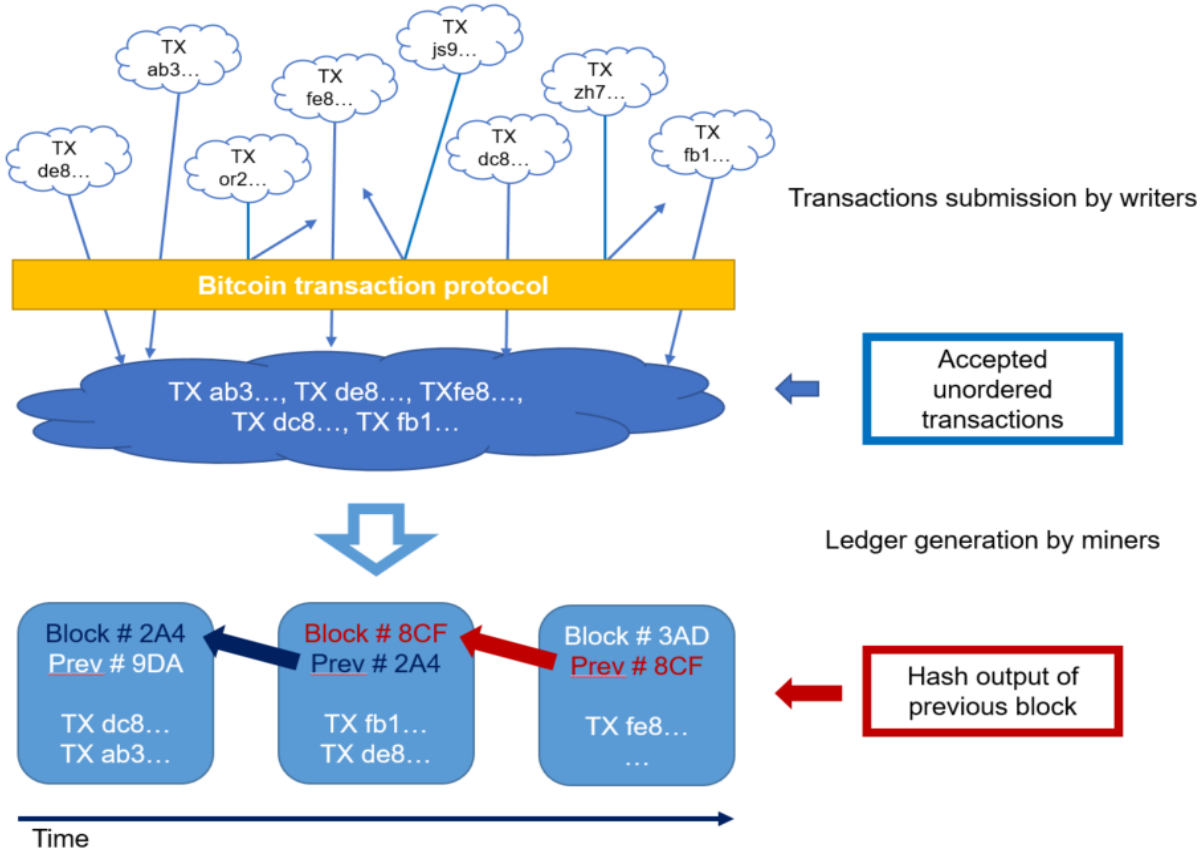

Figure 1 Generation of blockchain, adapted from Crosby et al. (2016), p. 11

In order to connect the last batch of announced transactions, both Miner 1 and Miner 2 need to find a **random number** generated by the network. Where does this random number come from?

A **hash function** is a one-way function whose inputs are known, but outputs are always random. Participants in the mining contest input the timestamp, the transactions that they want to batch together, the hash of the previous block and a random number called 'nonce' (Nakamoto, 2008). A good nonce gives an output value that begins with many zeroes, and it is found by iterating multiple times the hash function. You can imagine miner 1 and miner 2 each of them in front of 2 screens: one displaying which transactions are available to be timestamped, the other in which they are repeatedly running the function to finally find the nonce. However, the process requires your computer lot of time, computational power and energy. Why is that?

The procedure to timestamp the transactions must be time and energy consuming, so that participants of the network are discouraged from running a 51% attack, that would require an extremely big effort. This is why the nonce in the Bitcoin network is also called **Proof of Work** (PoW), proving the miner has actually spent time and energy to find such a number. Miner 1 finds the nonce first, and broadcasts it to the entire network. If the majority of nodes confirms the validity of the number, Miner 1 is elected as the "winner" and timestamps the batch of transactions (A, B and D). At this point, the block of transactions is accepted, added as last ring of the chain and the mining goes on.

Latest Blocks

Height	Age	Transactions	Mined by	Size
514358	5 minutes ago	1186	BTCC Pool	636578
514357	14 minutes ago	282	AntMiner	95477
514356	17 minutes ago	2257		956033
514355	35 minutes ago	1704	AntMiner	643612
514354	an hour ago	710		769299

See all blocks

Latest Transactions

Hash	Value Out
e970c6adf8a9bbffd870bc83c4d76b3e3e2eac7870a2...	0.0120377 BTC
48d963dfa15fc4cf23e05b5dd8e582c889f49319433c...	0.10204688 BTC
552c8d06f6c1ae3327b62254dc2d542b4dc431baeb3...	2.07892768 BTC
3daafff526638802783f15adc55708c207c71f3d0374...	0.02989371 BTC
cb3a17ccad888921a6796d937da5ff457770cc7a1f68...	0.00303075 BTC

Figure 2 Latest blocks and transactions added to the Bitcoin BC (from https://blockexplorer.com/, 20th March 2018, 8:49AM)

Miner 2 cannot timestamp transaction B and D anymore, but can still try to add to the chain transaction C through the same process. The confirmation process (agree on which transactions are valid and their order) is called “**consensus mechanism**”. The winner gets bitcoins as reward, in an amount that covers the real financial cost she has incurred (computing plus electricity) and includes a transaction fee sent by the owner of the transactions (the writer or sender) (Ludwin, 2017).

In the end, all data regarding Bitcoin transactions is contained in a chain of block of information. “The algorithms and the computational infrastructure of creating, inserting and using the blocks are considered as the **blockchain** technology”, which derives the name from its characteristic data structure (Zhao, Fan, & Yan, 2016, p. 1).

2.3 BC infrastructure

The following discussion describes the basic architecture of a blockchain system, in order to explain what “blockchain application” means and make sense of the use cases introduced later in this research. Three layers compose the technology infrastructure:

- *The protocol layer*: Here is where the pure computer code resides and basic functionalities of the technology are built, such as data structures and consensus mechanism. It constitutes the fundamental infrastructure that gives sense of existence to the other two layers. In particular, network nodes use this to communicate with each other (Allison, 2015). However, it is difficult to monetize it as single component and adds almost no value without the network layer built on top.
- *The network layer*: “Where blockchains come to life” (Platt, 2017). This layer enables the actual peer-to-peer system, with nodes connecting to each other and sharing the same data. No one-to-one relationship exists between protocol and network layer, so that it is possible for one protocol layer to support several network layers simultaneously.
- *The application layer*: “Where blockchains become useful” (Platt, 2017). Here is where the appropriate logic for the business transactions is specified (Allison, 2015), and where business functions are executed, together with the development of the user interface and the delivery of the final products and services. According to Platt (2017), this layer will receive most of the attention in the future, with application users not even noticing that the system is built on top of a blockchain.

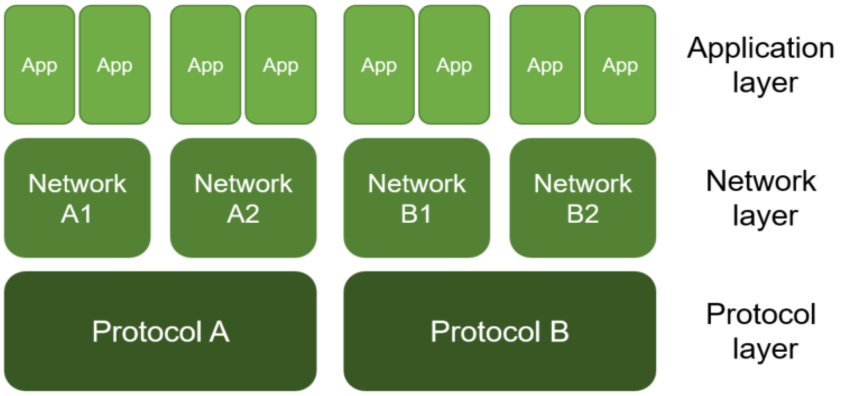

Figure 3 Blockchain technology layers, adapted from Platt (2017)

2.4 Permissioned/permissionless blockchains

Bitcoin application is a case of **permissionless** network, such as Litecoin and Ethereum. Any actor has all access rights: they can view the transactions recorded on the ledger (**read**), ask the network to validate input transactions (**write**), and validate "in line" transactions by timestamping them (**commit**). They can perform the three tasks even when completely unrelated to the network and with no previous interaction with it. However, depending on the use case or enterprise's requirements, this infrastructure might not be the most desirable one: any application built on top remains public, meaning all transactions happening between actors can be seen by anyone taking part in the network. Instead, anonymous users cannot modify permissioned (closed) blockchains.

If the network is permissioned, restrictions apply on the network participants' rights, and it's usually the network operator that puts the network in place and establishes who has access to what. In this case, the enterprise (or consortium of enterprises) functions as network operator, regulating the access to the system as well as deciding on the state of the ledger. They are divided in two categories:

1) **Consortium blockchains**: nodes are assigned to pre-selected and known participants, all or part of them controlling the consensus process. R3 Corda and EWF belong to this category.
2) **Private blockchains**: the organization itself decides who can do what (centralized control) (Hoffman, Strewe, & Bosia, 2018). Examples are Bankchain, Monax or Multichain.

			Read	Write	Commit	Example
Blockchain types	Open	Public permission less	Open to anyone	Anyone	Anyone	Bitcoin, Ethereum
		Public permissioned	Open to anyone	Authorized participants	All or subset of authorized participants	Sovrin
	Closed	Consortium	Restricted to an authorized set of participants	Authorized participants	All or subset of authorized participants	Multiple banks operating a shared ledger
		Private permissioned ('enterprise')	Fully private or restricted to a limited set of authorized nodes	Network operator only	Network operator only	Internal bank ledger shared between parent company and subsidiaries

Table 1 Main types of blockchain segmented by permission model, adapted from Hileman and Rauchs (2017), p. 20

It is true that the concept of a permissioned blockchain stands in contrast with the original disintermediated (free from single central authority) design of the first technology applications, such as Bitcoin, because of the presence of a system operator (see next section). However, as said by many authors (Gaur, 2016; Morabito, 2017; Hileman & Rauchs, 2017), closed BC are best suited for use cases deployed within corporate environment. In the end, corporate applications value other aspects of the technology, such as the possibility to speed up transactions reconciliation and increase transparency. Network and application performance are affected by how extended the network is, meaning how many nodes compose the network, and this is the topic of Section 2.8. From now on, it is assumed that only **permissioned BC** are used for corporate applications, and the consequences are analyzed further on.

2.5 Ecosystem

In the blockchain landscape, we witness different ways entities interact with permissioned blockchains:

- *Core infrastructure providers*: they install the protocol in the interested organization and put in place (deploy) the network. The infrastructure code can be open source or closed; an open source code gives external users more freedom to build their own customized network expanding it if necessary later on and their own applications.
- *Operators:* They design and run the network and the applications built on top of it.
- *Direct users*: either network participants or code users. The latter can provide services, making basic functionalities of the technology easier to use for network participants, or create applications (and services to enhance application use).
- *Indirect users*: they make use of the additional functionalities provided by direct users, either applications or services. Applications can be open access or closed access (Brenig, Schwarz, & Rückeshäuser, 2016).

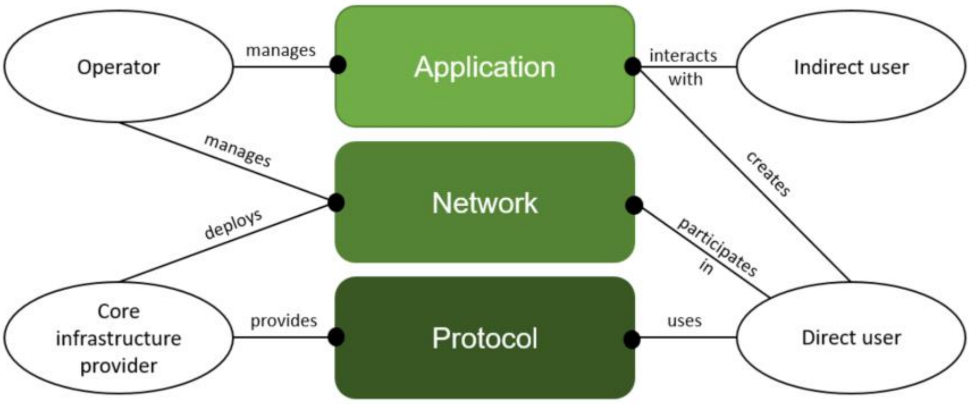

Figure 4 Blockchain ecosystem, adapted from Brenig et al. (2016)

The research focuses on corporate deployment of BC, so **organizations** are assumed to be **system operators**: they operate and manage the network (most likely inter-companies, thus a consortium) fully provided or built up with the support of one core infrastructure provider (Hileman & Rauchs, 2017). They as well build applications and services on top of the P2P network by means of application interface. When they take part in the network they operate, they also have the role of direct users.

2.6 Technology components

By means of literature review, the following five components (features) of BC were recognized:

- *Distributed ledger*. The distributed database lists all transactions and bundles them together in blocks linked one to each other by cryptography (Hileman & Rauchs, 2017). It contains the guidelines that each participant of the ecosystem must respect when connecting to the BC through a node, in particular restrictions on access rights (Gupta, 2017). In case of a permissioned network, access rights are assigned to network participants by the system operator.

- *Peer-to-peer network*. This is the network "for peer discovering and data sharing" (Hileman & Rauchs, 2017, p. 14), with no central point of control or failure (Greenspan, The Blockchain Immutability Myth, 2017). It consists of computers, or nodes, hosting the information added to the blockchain through transactions (Wiese, 2017). We deal with a **true P2P system** when all nodes perform the same tasks (permissionless network) or with a **merely decentralized system** when some nodes have more power and additional tasks (permissioned network) (Mainelli & Smith, 2015).

- *Consensus mechanism*. The hashing algorithm that allows the P2P network to agree unanimously on the current state of the ledger, even if not all nodes are acting honestly. Different types of mechanism exist; for a good overview on the most common consensus mechanisms, refer to Verhoelen (2017). In general, consensus mechanism constitute the part of the blockchain that adds most of the complexity, influencing the system throughput, i.e. "how many state updates a system can handle in a given amount of time" (Wüst & Gervais, 2017, p. 2). Indeed, the more the system grows and expands, the more the technology is likely to show a decrease in performance. In particular, **scalability** problems manifest in terms of increasing time it takes to both put a transaction in a block and to reach a consensus (Rosic, Blockchain Scalability: When, Where, How?, 2017).

- *Cryptography*. It constitutes the **authoritativeness source** supporting all transactions in the network, allows managing communication security and verifying nodes authenticity (Christidis & Devetsikiotis, 2016). As one of the most common privacy enhancing techniques, it enables encryption of on-chain data and involves the use of "cryptographic one-way hash functions, Merkle trees and public key infrastructure (private-public key pairs)" (Hileman & Rauchs, 2017, p. 14). Parties can communicate directly with each other and share data openly, improving communication and guaranteeing authenticity (assets ownership). In particular, in a distributed system in which transactions are disclosed to all network participants, cryptography allows for public verifiability and better transparency, without compromising users' privacy (Wüst & Gervais, 2017).

  It is important to keep in mind that user control over the secured assets or data fundamentally relies on the secrecy of the **private key**, used for network participants' authentication. Losing control over the private key or compromising it automatically means losing your assets and it might give the way for malicious attackers to freely transfer your assets or attack the network. Therefore, securing private keys represents a crucial matter regarding user's interaction with any blockchain. Moreover, it is true that blockchains help reduce the need for trust, but they do not eliminate it completely. "At the bare minimum, trust must be placed in the underlying cryptography" (Hileman & Rauchs, 2017, p. 17). Thus, a solid and verified cryptography system coming from a **reliable provider** is needed for the system to obtain basic consideration.

- *Validity rules*. These are norms contained in the database regulating the network functions and interactions with the ledger and constitute the key innovation characterizing shared distributed databases. In a centralized system, a trusted authority checks at every single point in time if the database state is valid and updates the interested parties. Validity rules for a decentralized system instead compare the database state before and after a transaction occurs and "**restrict the transformations** that a transaction can perform" (Greenspan, Private blockchains are more than "just" shared databases, 2015).

  Two dominant methods are used:

  a) **Bitcoin method**: as previously explained, it compares which database entry the incoming transaction is deleting with the one that it is creating. Particularly suited for transfer and tracking of digital assets (Christidis & Devetsikiotis, 2016). It enables a limited amount of functionalities, but transactions can be run in parallel without interfering with each other since each of them modifies only a limited amount of data locally and clearly reports which information are changed (Allison, 2015).

b) **Smart contracts**: "A smart contract is a piece of code that is stored on a blockchain, triggered by blockchain transactions and which reads and writes data in that blockchain's database" (Greenspan, Why Many Smart Contract Use Cases Are Simply Impossible, 2016). The term was coined by Szabo back in 1994 (Szabo, 1994), but remained unused because of lack of technology that could allow parties to program deals and transactions autonomously (Morabito, 2017). Their introduction in the blockchain world is recent and comes together with the further development of the technology, now able to run functionalities that are more complex. What are they used for?

   As the bitcoin transactional model does, they reside at the protocol level. However, these pieces of code enabled by the Ethereum open source technology, are best suited for the movement of different assets than digital money, such as stocks, bonds, licenses, documents, certificates, etc. (Hoffman, Strewe, & Bosia, 2018). For this kind of transactions more conditions must be verified than simply confirming the authenticity of the node where the asset comes from.

   Smart contracts represent the evolution of traditional legal contracts to automatically trigger and control the transfer of assets when specific conditions are met or services are fulfilled. They make sure the terms of a contract are executed and rules are enforced without the need of a trusted intermediary. This in the "blockchain jargon" translates to: start when a transaction addresses the specific smart contract, run the transactions specified in the piece of code, and update the state of the ledger by recording the transactions just validated in every node in the network. In this way, the level of automation in settling decentralized agreements of any kind is increased.

   However, the code running them is closed, so that they cannot run in parallel because they might interfere with each other without you even knowing it. This might lead to scalability problems.

To conclude, basic components of the technology are combined in different ways and give raise to an **infinite number of potential applications**, among which Bitcoin is only one example.

2.7 Blockchain value proposition

Literature is scarce about how value is created for the providers and users of a blockchain system and what is the technology value proposition for the different parties (Brenig, Schwarz, & Rückeshäuser, 2016). What does "**Value Proposition**" (VP) mean? It is usually a statement used by business marketing to convince a consumer to buy a product or use a service because better than other available substitutes (Investopedia, 2018). Hoffman et al. (2018) use the term to indicate blockchain key technical aspects, such as "peer-to-peer value exchange system" or "group consensus mechanism" (Hoffman, Strewe, & Bosia, 2018). In this case, VP refers to the additional functionalities the technology offers compared to any centralized solution.

2.7.1 Blockchain functionalities

After breaking down the technology into its basic features, it is useful to describe the respective functionalities and finally identify added value (the benefits) and limitations of each of them. Pay attention on the subtle but consistent difference between "features" and "functionalities" or "functions": features are tools used to accomplish functions, with one feature potentially enabling more than one functionality. For instance, the battery of your phone is a feature (or tool) that allows it to receive calls (the enabled function).

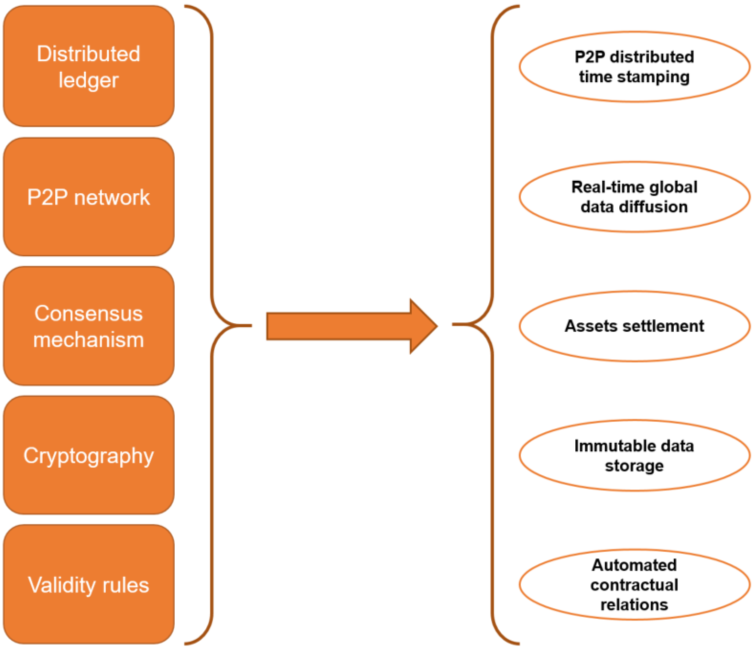

Figure 5 Blockchain features enabling functionalities

The following functionalities derive from Hoffman et al. (2018), but report respective benefits and limitations as well, with specific focus on permissioned blockchain:

- *P2P distributed time stamping*: the algorithm behind the consensus mechanism makes sure all transactions registered in the ledger are automatically timestamped and validated, so that who accesses information can be certain about date and time reported on it (Hoffman, Strewe, & Bosia, 2018). This reduces the risk of tampering and increases the certainty about reported data, even without an intermediary (a **notary** in this case). This function is particularly effective against the double spending problem, for which the Bitcoin was originally introduced (Nakamoto, 2008). By timestamping the entire history of transactions, it becomes theoretically impossible to copy the asset and send it twice, because the ledger reports that a transaction of that asset has happened already in previous time.
  Limitations: The immutability of the blockchain system has proofed to be a myth. All nodes in the network have to agree upon the state of the ledger simultaneously. However, each node acts independently, so if more than 51% of the nodes decides to change the rules and behave dishonestly, they can arbitrarily change the image of the system and possibly reverse transactions or even invalidate them. This is called the "**51% attack**" (Du, 2016, p. 214) and eliminates the chances for any blockchain to be truly and absolutely immutable. The more the network extends, the higher the amount of computing power needed to reverse the system, making this type of attack unlikely. Instead, the more the network reduces, the least the effort needed to manipulate the ledger.

- *Real-time global data diffusion*: data is broadcasted simultaneously to all nodes in the network "in a gossip-like way" (Greenspan, The Blockchain Immutability Myth, 2017; Rosic, 2017), so that every peer keeps a complete transactions history and is real-time updated on the state of the ledger. The horizontal communication allowed by the technology increases the transparency, enhances system monitoring and drastically reduces the time to get an answer from the system.
  Limitations: global data diffusion entails every node in the network receiving the same information of anyone else. Even if anonymous, when transmitted to the entire network some transactions might put in danger the full **privacy and security** of the transacting parts and expose them to unnecessary risk. Indeed, it is possible for a participant of the network to associate a specific user to a traded asset by monitoring the transactions happening through a node (Du, 2016). However, **confidentiality** represents one of the biggest value to safeguard in

corporate reality (Greenspan, Four genuine blockchain use cases, 2016). Where data diffusion of some network participants represents a sensible topic, multichannel data diffusion or selective disclosure might me more appropriate: transactions are disclosed only to selected parties involved in the specific trade (Hileman & Rauchs, 2017).

- *Assets settlement*: transaction time (when a transaction is recorded) and settlement time (when a transaction is executed) coincide because real-time validation takes place just after transactions are broadcasted to the network in order to complete the trade. Clearing, "the procedure by which an organization acts as an intermediary and assumes the role of a buyer and seller in a transaction to reconcile orders between transacting parties" (Investopedia, 2018), is not needed anymore because of the decentralized nature of the system. By removing the two post-trade steps of confirmation and central clearing, the settlement cycle time is shortened, fastening the end-to-end trade process overall. At the same time, by automating the settlement process, the amount of data errors and reconciliation lags reduces, leading to cost reduction. This functionality is particularly helpful when numerous parties must verify assets changes but are distributed across siloed systems, so that executing the process takes a long time (Haley & Whitaker, 2017).
  Limitations: in a decentralized system without any central authority, trading assets other than cash becomes cumbersome. Indeed, "blockchains are […] well suited for transfer of assets or data native to the respective blockchain (e.g., bitcoin)", whereas difficulties arise for off-chain assets (Hileman & Rauchs, 2017, p. 18). The blockchain can settle and reconcile the digital representation of the asset, but cannot verify **input validity** and assure that what is reported on the ledger actually corresponds to reality. It is fundamental to find a way to back the assets reported on the blockchain in such a way that they can be claimed in the real world (Greenspan, Avoiding the pointless blockchain project, 2015).

- *Decentralized immutable data storage*: cryptography and the P2P network make it possible storing data and recording the complete log of transactions on a blockchain in such a way that it can hardly be modified or deleted after validating a certain number of transactions (Greenspan, The Blockchain Immutability Myth, 2017). This characteristic differentiates the technology from a regular database, in which information can be replaced or destroyed as the database owner wishes. In this way, the tampering risk reduces and transparency increases.
  Limitations: About immutability, the same valid for timestamping applies here as well. Moreover, the possibility to store data and documents is defined by the **block size** (Hoffman, Strewe, & Bosia, 2018), meaning there is a limit to the amount of transactions that can be added to a block. Block size depends on the blockchain on which the application is run, but in general the bigger the size, the higher the computational (hardware) requisites to add blocks to the chain (Madeira, 2018).

- *Automated contractual relations*: The introduction of smart contracts serve as a powerful tool to automate the creation, transmission and validation of specific transactions. They make particular sense when it comes to process decentralized agreements, from setting off contracts among parties when specific conditions are met, to enforcing laws along the way and on the outcomes. Increased automation reduces risk in trading relationships, improves coordination, and fastens the process while reducing costs.
  Limitations: As a consensus based system, blockchain works only if the entire network validates every input data. Parties need to agree on an authoritative record on which smart contracts run (Hoffman, Strewe, & Bosia, 2018). However, if smart contracts retrieve data from external sources, this happens independently and separately in each node, and does not imply that the entire system has the same image of that data. "Perhaps the source will change its response in the time between requests from different nodes, or perhaps it will become temporarily unavailable" (Greenspan, Why Many Smart Contract Use Cases Are Simply Impossible, 2016). A **validation oracle** (internal or external) serves as a trusted party that adds the required data

to the BC by creating a transaction, substituting the smart contract. Similarly, when it comes to qualifying the outcome of a contract the oracle tracks the state of the system and responds with certain actions (Morabito, 2017).

In a permissioned network, in the mini-database that each smart contract contains are stored data that cannot be accessed by another smart contract or by the network. However, the smart contract withdrew those data from the ledger, whose image is stored in each node of the chain, so that anyone can still read the information from their own system. In this way, smart contracts are not the solution for hiding **confidentiality data**.

2.8 Technical tradeoffs

After reviewing the components and functionalities of the technology, some important considerations are drawn. The P2P network behind the solution can be made up of only few validating nodes (reduced network) controlled by major organizations. Or it can be larger, including several actors playing even marginal roles (extended network) resembling more a pemissionless network.

The more the system is **decentralized**, the more replicas of the ledger exist that more peers can access to verify the state. This means the system increases its robustness, because if the system goes down in one node, this could still recover the entire transactions history as soon as it comes back to functioning. At the same time this means a decrease in **performance** and an increase in average time needed to confirm a transaction. Indeed, when the network involved in the validation process reduces the consensus mechanism speeds up and requires way less computing power and time than extended blockchains: no miners competing, no Proof of Work needed. An extended network hinders the possibility for corporates to process a high volume of transactions and **scale up** the system according to their needs when later expansion (more nodes joining, more transactions performed, and longer transactions history) is needed (Hileman & Rauchs, 2017). Technical solutions are available to solve the scalability issue, but in general enterprises deploying blockchain should decide **who to involve** and **how many nodes** to deploy, and should plan a growth path in case of system expansion (Haley & Whitaker, 2017).

Corporations can hardly leave **governance** behind, because of the reputational and legal consequences this might have. Thus, companies deploying permissioned BC take the role of system operators that by governing the network and running the applications also ensures a better **safeguard**. Some functionalities of the technology requiring a trusted third party in place are facilitated in a reduced network. For example, off-chain assets such as bonds and securities can be transferred and settled more easily. Also the validity of outcome of smart contracts can be verified faster. However, the higher the degree of governance, the higher the chances for information asymmetry (Morabito, 2017) and the easier for specific nodes in the network to modify the records at their will and hamper the **immutability** of the technology. Thus basic trust must be put in the operators and validators responsible for the network that they do not change data arbitrarily. In this way, it results fundamental for companies deciding **what can involved people do**, the **power** they have, and stipulating off-chain legal contracts and agreements among actors to discourage misbehavior and punish it accordingly.

The last tradeoff results to be the most important when building a BC network within companies that might even be competitors. **Disintermediation** refers to the ability to have multiple parties sharing a single database and achieving a single view of the truth, without any party in charge of the database but still making sure everything is consistent. On the other hand, the more the system is disintermediated, the more information is spreading far away, with all participants in the network seeing that a specific transaction between two parties has taken place (Greenspan, Video talk: Blockchains vs databases, 2017). **Privacy** issues might arise more easily in extended networks due to the revealing of personal data (Peck, 2017). Also, since extended blockchain networks could present scalability and capacity problems, organizations might be forced to store data outside the BC. In that case, when blockchain accesses external data storages, companies must encrypt the **off-chain data** before disclosing them to the distributed network. Indeed, even with a permissioned system, the node where data is accessed from are still vulnerable and might be accessed by malicious actors. Some of the best encryption techniques help mitigating this issue. However, actors' requirement for **confidentiality** must be carefully addressed, so that companies must assess **which data are shared** within the network and with whom.

The following tradeoffs are derived by comparing the key functionalities of the technology to usual corporate requirements.

Table 2 Blockchain technology tradeoffs

The more…	**The less…**
Decentralization = how many nodes is the network composed of & **Robustness** = how many replicas of the ledger exist	**Performance (speed)** = how many transactions the system processes within a certain time & **Scalability** = possibility to expand system
Immutability = how likely it is that information reported cannot be modified	**Governance** = degree of ruling power of pre-assigned participants & **Safeguard** = how easy it is to intervene in case something happens
Disintermediation = level of absence of any authority	**Privacy/confidentiality** = level of data secrecy

2.9 Conclusions

To conclude, the review conducted has explained how blockchain technology works and what permissionless or permissioned blockchains are. In particular, they are both used to build applications, but applications built on top of a permissionless network make the solution public, i.e. anyone accessing the network can see transactions going on between business actors. According to several authors (Gaur, 2016; Morabito, 2017), **permissioned networks** offered by known infrastructure providers are **preferred in a corporate reality**, where legal and reputational aspects must be handled carefully (Hileman & Rauchs, 2017). Therefore, it has been assumed for the remaining research that the organization choses to build on top of a permissioned network and becomes the **system operator**. In case it does not exist already, the firm has the freedom to form the ecosystem, or the **blockchain network** of validating nodes that will make sense of the BC-enabled solution.

The review has highlighted how the company integrating BC in their current business process and designing a new blockchain network has to deal with the tradeoffs listed in Section 2.8. Depending on the blockchain network topology that supports the solution, the final blockchain application changes the value that it can deliver to the users: if the network is less extended speed, scalability, governance and confidentiality are best respected. However, decentralization, disintermediation and immutability, considered as the key elements of the technology Value Proposition, are left apart, becoming important again only when the network expands. In the following chapter examples of blockchain in action in several fields are given to clarify what could be potential applications of the technology. Then, specific use cases that make sense in a cross-organizational setting are described together with characteristic tradeoffs and limitations.

3 Blockchain use cases

Considering the key features and functionalities of the technology, it is easy to understand the reason for financial institutions to be particularly interested in the potential of blockchain. It is also clearer why in all papers describing meaningful applications of blockchain, the stress is always put on financial institutions and the benefits they might get from blockchain introduction. In particular, thanks to the opportunity of automating and speeding up back-office transactions handling (such as assets clearing and settlement, payment systems, Know Your Customer (KYC) procedures, etc.), BC could save financial institution up to “$20 billion annually in settlement, regulatory, and cross-border payment costs” (Fanning & Centers, 2016, p. 56). However, the trade and exchange of assets happens in all kinds of industries, where transactions modify the state of not only financial, but any type of goods or services. The same features and functionalities that might add value in the financial domain can be recombined to originate valuable applications in any type of sector, from healthcare, to logistics, telecommunication, insurance, and so on (Morabito, 2017). These were identified in the previous chapter and are **P2P distributed time stamping, real-time global data diffusion, assets settlement, decentralized immutable data storage, and automated contractual relationships**. The following sections report first some examples of blockchain in action in every type of industry. Then blockchain use cases for specific cross-organizational setting are listed together with characteristic limitations.

3.1 Blockchain in action

Hereafter are listed thirteen use cases benefitting from the BC functionalities listed before in different ways: some mainly use it as an immutable and decentralized data storage (for example the healthcare industry), others enjoy the fast and quick assets settlement that the technology allows (for instance inter-companies solutions such as lightweight financial systems), still others benefit from the improved automation of contractual relationships (for example, supply chain use cases). The following discussion describes some use cases that have been developed in all kind of industries and wants to trigger ideas on how the technology could be helpful in a business environment.

3.1.1 Mobile payments

The very first applications of the technology, cryptocurrencies are not issued by any bank or public authority and are not necessarily attached to a fiat currency, but transacting parties belonging to the blockchain network use it as a mean of exchange (EVRY Financial Services, 2015). Their value is completely bonded to their native chain, meaning what is exchanged has no physical representation in reality but belongs completely to the respective virtual network, that can transfer, store or trade it in digital format exclusively. Cryptocurrencies can be used for transfers, payments, tips and crowdfunding (Morabito, 2017, p. 32). Mobile payment is indeed an application that cryptocurrencies have facilitated in several projects (Zago, 2018). For example, a Japanese consortium of 61 banks plans to enable instant domestic payments through an application built using Ripple’s technology (Zuckerman, 2018).

Ripple in particular offers a blockchain-based global **payment and settlement network** that enables banks to settle cross-border payments with end-to-end tracking, payment providers to reduce capital requirements for liquidity and all users to send payments globally. As of today the company includes in the network banks, payment providers, digital asset exchanges and corporates, with the latter benefitting mainly from payment tracking, capital efficiency and rich data transfer (Ripple, 2018).

3.1.2 Energy distribution

The energy industry is increasingly trading surplus supply and at the same time it need to ensure distribution happens efficiently throughout the entire supply chain. This requires a record keeping that cannot be failed, the distribution of information across several data points, and tight cooperation between all parties involved in trading and distribution. Thus the blockchain can actually help the **real-time tracking** of resources between energy suppliers and continuously maintaining **data confidentiality** (Zago, 2018). In this regard, a test project is currently developed by Essentia, a company developing a modular and decentralized framework for data interoperability and management (Essentia, 2018). For this project, they intend to include in the underlying network several of the major energy suppliers, even though the countries of provenance of these suppliers are not disclosed.

3.1.3 Border control

Another project lead by Essentia sees the Dutch government creating a blockchain based system for speeding up border control procedures (Bitcoinist, 2018). The solution proposed would reduce the control checks that nowadays travelers have to go through at multiple points when travelling between Amsterdam and London. This is made possible by **securely and immutably storing** passengers' data and **real-time sharing** them with both Dutch and English authorities in order to be easily audited, ensuring that none could tamper the data (Zago, 2018).

3.1.4 Supply chain

Supply chain management most likely represent one of the most beneficial blockchain use cases since good are passed from one hand to the other, with processes spanning across regions and involving several stakeholders (Wüst & Gervais, 2017; Zago, 2018). Interesting supply chain BC initiatives have been developed as of 2018 in the food industry to improve food tracking and safety and involve some of the biggest food processors and distributors. A consortium of six leading food companies including Nestlé, Walmart, Costco, Golden State Foods, McCormick and Co., and Tyson Foods has been established in collaboration with IBM. The group intends to study BC-based solutions that would increase supply chain visibility and traceability by improving **information accessibility and availability** for all participants of the network (Aitken, 2017). When actors connect to the blockchain, they have a **complete overview** on what is going on along the food chain and can more easily identify the source of contamination, reduce waste and avoid costly recalls.

Mars Food as well is trying to trace its global rice supply chain with the help of Transparency-One supply chain management solution. The solution is provided by SGS, one of the biggest auditors worldwide (SGS, 2017) and builds on Microsoft Azure cloud space (Microsoft, 2018). The BC-based solution helps Mars Food reducing food fraud risks, improves **supply chain efficiency** and builds consumer's confidence about food practices.

Finally, Louis Dreyfus Corporation, one of the major food traders, has also started a blockchain project in collaboration with Dutch and French banks. The pilot involved the tracking of a soybean shipment from the US to China and saw the blockchain being used as useful tool for **settling transactions** and **matching data in real-time**, reducing to a fifth of the time the document processing (Hoffman & Munsterman, 2018).

3.1.5 Fishing Industry

Illegal fishing and human right abuses represent two major problems affecting the industry and hampering the realization of sustainable practices. A project lead by the UK-based company Provenance intends to provide the technology for empowering actors along the chain to **verify and prove the origin** of the fish, the processing it went through and where it was sold (Zago, 2018). The use case they developed until 2016 tracks tuna fish through the Indonesian supply chain, from catch to consumer, testing Provenance chain-of-custody application (Provenance, 2016). In particular, Provence is a platform that allows businesses to create applications to improve supply chain transparency by tracing back the origin and the steps the product went through. The way they make sure steps are authenticated and properly represented online is by mean of software programs they deploy in the company (Provenance, 2015).

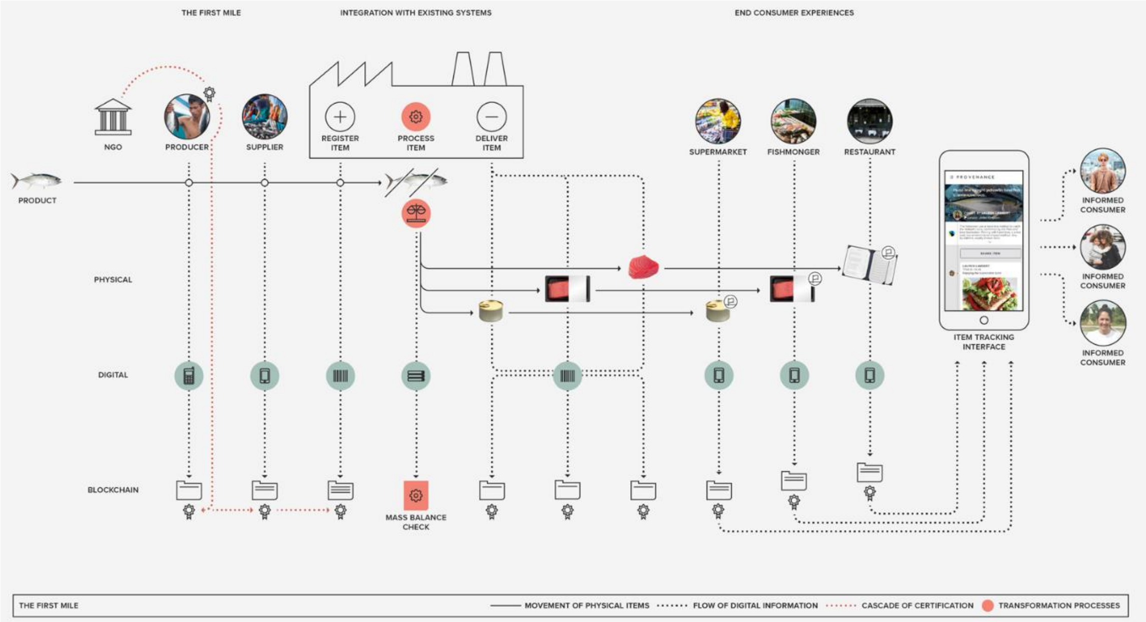

Figure 6 Blockchain integrated fish supply chain, Provenance (2016)

3.1.6 Enterprise

Enterprise software vendors can provide Blockchain as a Service (BaaS) so that businesses can "access to smart contracts and blockchain applications in a secure hosted environment" (Zago, 2018). Microsoft offers the cloud computing services of Azure to access the Ethereum blockchain and build decentralized applications on top of it. Their intent is to enable corporates to create their own public, private or consortium blockchain and **streamline cross-organizational processes** like settlement (Gray, 2015).

Another major player working on its own blockchain based technologies to support its cloud business is Google (Zago, 2018). In particular, Google would make use of blockchain to **securely store transaction and process data** over the Internet, and in this way reassure users of its cloud services that information are kept secure in the supporting computers (Kharif & Bergen, 2018).

3.1.7 Catastrophe bonds

This type of bond is used as a debt instrument linked to insurance activities and raises money in case a catastrophe (such as a hurricane or a tsunami) actually happens (Investopedia, 2018). Their nature is parametric, meaning they are paid out when the catastrophic event happens between the parameters of the bond. So settlement happens without need for claim or investigation, unlikely insurance contracts, and the blockchain can add value in this regard. Indeed, the technology enables a **quick and transparent settlement** between parties without the need for an intermediary, with the settlement being triggered directly by the parameters of the bond when these are met (Bullard, 2017).

Solidum Partners, an investment advisory company specialized in catastrophe bonds, has also benefitted by the use of blockcahin technology. Usually a trusted intermediary holds the bonds and facilitates the trade getting a fee on the service. Solidum recently got rid of the intermediary, issued on a Multichain permissioned blockchain $15 million catastrophe bond and dollar denominated tokens for allowing the network to transact. Now network participants can **directly exchange** dollars and bond units with each other by accessing their own BC node and having **full control over their on-chain assets.** Moreover, Solidum does not pay any extra fee to the middleman and fully controls who has access to the network. The solution has been provided by Multichain, an open source platform that provides the core protocol for building on top of it any type of network and service. Similar to Corda, it is a permissioned blockchain, or better, it supports consortium and private blockchains, but it is not specialized in the finance domain, so that any organization can build and deploy any type of application at their wish. The company has several platform partners that are building blockchain applications on Multichain, mainly IT consulting firms (MultiChain, 2018).

3.1.8 Health care and medical

Hospitals and clinics are often working with records about patients that are incorrect or miss some information. This derives from patients moving between providers, but not being followed by consistent data handling processes, so that this leads to dispersed and wrong medical records. The blockchain in this case can be used as effective mean for **facilitating data sharing** across medical departments, but still ensuring authentication and information confidentiality (Zago, 2018). MedRec consists of a distributed system that makes use of blockchain technology to unify access and validation of data across disparate providers (MedRec, 2018). By using the blockchain as a **decentralized immutable data storage**, critical patient data can now be immediately accessed from any geographical area. In this way, other two major issues affecting the medical environmental are solved as well: the consequences deriving from hackers' attacks and the current fragmentation problem. Indeed, even when record are digitized, these are kept in a centralized solution that is prone to hackers' strikes and does not allow hospitals to communicate with each other because of different Electronic Healthcare Records (EHRs) being used. When the same record system is replicated across multiple nodes and equally used by all participants, these last two issues can be mitigated.

MedRec

3.1.9 Luxury

Blockchain results to be an extremely helpful ally when it comes to maintain forever without tamper possibilities a **digital record** of the **provenance and change of ownership** of some high value items. Two good examples are the diamonds and art industry. The first application field is characterized often by the uncertainty about diamonds source, their ethical (or less) origin (often from conflict areas), and their handling, resulting often in stones being substituted for less valuable ones along their journey (Zago, 2018). The De Beers Group is indeed using blockchain technology as an **immutable record** over which each diamonds are registered for reassuring customers and industry players (Open Access Government, 2018). Provenance and authenticity of the good are particularly important also for fine pieces of arts, for which the technology can be applied for authenticating the previous owner, but also tokenize them and conduct and **easy trade and exchange** from any part of the world without physically transfer them from a secure storage (Zago, 2018).

3.1.10 National security

The blockchain technology can be used not only to store but also to transmit securely any type of data (Zago, 2018). This is what the US Department of Homeland Security (DHS) intended to do in 2016: **securing the storage and transmission** of several data coming from security cameras, sensors and other internal databases (Young, 2017). The infrastructure is meant to be efficient, immutable and transparent and takes care of encrypting and storing the data retrieved using blockchain as solution for reducing data breaches. The solution is provided by Factom, a collaborative open source platform running on Bitcoin's blockchain. Factom provides products and services to enterprises and governments for handling and authenticating data, documents or other types of records in a secure manner. The data-layer solution they offer integrates with current legacy system and helps organizations streamlining data integrity, audit, and compliance (Factom, 2018). Moreover, Factom protocol and network serve as a public utility that can be used for building **auditable and immutable record systems**, together with several other applications, such as "trustless audit chains, record keeping for sensitive personal, medical and corporate materials, and identity management as a KYC solution" (EVRY Financial Services, 2015). So users can either use their apps, join their networks or build their own.

FACTOM

3.1.11 Shipping

The shipping industry is characterized by goods passing continuously from hand to hand and being followed by extremely long paper work: bureaucracy cannot be avoided and represents the most time consuming and prone to error process coming along with international trade (Zago, 2018). By implementing BC technology, traditional trade finance documents would be stored on the BC as smart contracts and **get updated by transactions** as they move through the trade process. A transaction refers to a digital asset stored at a specific address, that is simply a secure identifier from which funds can be accessed, something similar to a bank IBAN (Rosic, Blockchain Address 101: What Are Addresses on Blockchains?, 2017). This is accessed by private owners by using their private key and finally transferred to another address by means of private and public keys combination (EVRY Financial Services, 2015).

The improved transparency and the **automated filling of documents** has been at first experimented by Maersk with IBM support. They were the first pioneers in digitizing the global trade by introducing blockchain as part of a trade platform connects all actors along the supply chain. In particular, it provides end-to-end visibility by allowing parties to **exchange shipment events** in a secure and real-time manner, and it digitize and automate the paper work filling across boundaries with the use of smart contracts (White, 2018).

Another attempt for simplifying the overseas shipping industry has been carried on by ZIM by implementing BC-based paperless Bill Of Lading (BOL). By updating data instantaneously and increasing the transparency over the control mechanism, the technology could be used also in this case for tracking shipments, reducing control times and risk of counterfeited goods entering the market (UseTheBitcoin, 2017)

3.1.12 Insurance

Typically dealing with high-value assets and requiring collaboration between multiple parties, the industry is however characterized by inefficient tracking mechanisms based on paper, siloed information and several datasets, and lack of real-time visibility on asset location and condition (Microsoft, 2018). The introduction of blockchain simplifies operations and improves **data visibility** by providing a single source of truth, and this is what the pilot conducted by the Insurer American International Group Inc intend to demonstrate (Zago, 2018). By partnering up with International Business Machines Corp, they carried on a project supported by IBM for implementing a “smart contract” multi-national insurance policy “that uses blockchain to manage complex international coverage” (The Business Times, 2017). In particular, the solution allows for policies issued at the headquarter to be **real-time shared** with all affiliates and insurers, and it also notifies all actors about payments.

3.1.13 Smart cities

The possibility for BC to be integrated combined with sensors technologies such as the IoT has been mentioned by several authors (Hoffman, Strewe, & Bosia, 2018; Wüst & Gervais, 2017), in particular for assuring the origin and authenticity of the data collected by the sensors (Morabito, 2017) and storing them in an **immutable way**. Smart cities project making use of the functionalities of blockchain are becoming a reality: Taipei has partnered up with IOTA for creating cards assigned to each citizen that would not only store their ID and allow them to vote, but would also detect light, temperature, humidity and pollution by means of sensors (Buck, 2018). In particular, IOTA is a German non-profit foundation that delivers the Tangle, an open-source distributed ledger that empowers specific IoT applications and ensures data integrity for machines embedded with sensors (IOTA Foundation, 2018).

3.2 Cross-organizational processes

The previous examples demonstrate the nature of blockchain as a technology that impacts processes spanning across multiple companies, geographies, and involve several actors. The intrinsic and key value of the technology is to allow a database to be shared (read + write possibility) between different actors that by assumption do not trust each other, meaning they would not allow any of them to singularly take care of the database, but still do not need or want to put any single party in charge. Indeed, the blockchain itself enables actors in the network to independently “achieve real-time reconciliation of validated, authenticated and timestamped transactions, without the cost, hassle and risk of relying on a trusted intermediary. The chain provides meaningful value when it’s maintained by consensus between multiple nodes, each of which is controlled by a party with different interests” (Greenspan, Three (non-pointless) permissioned blockchains in production, 2017). This also confirms and supports the cross-organizational nature of the technology (Rimba, Tran, & Weber, 2017). This section focuses on general uses cases that see BC adding value specifically to cross-organizational processes involving several organizations. Limitations are also specified for each use case.

3.2.1 Instant payment networks

These could be both **domestic and international** (EVRY Financial Services, 2015) between multiple companies and/or financial institutions. Each participating organization runs a node on the BC and they are all connected to each other in a P2P way. Money in some form (shares, bonds, regular cash, etc.) is issued on the BC as a token representing ownership of that asset, most likely by a bank. Tokens are exchanged in the network with any metadata attached to those (ex. Scans of contracts, messages, images, etc.). Settlement happens in matters of second once consensus is reached among nodes, reconciliation takes place automatically in real-time. Businesses can easily manage asset exchange, receive and make payment faster and timely. Regulators have a positive approach as well, because they can run a read-only node on the BC and see everything that's happening without asking for reports when things don't quite correlate. However, the biggest problem is **confidentiality**: every participant in the network can see not only their own transactions, but also what all others are doing, and often participants are even competing among each other's. Several cryptographic techniques exist that could partially or almost completely solve this problem, but this still refrains actors from taking part in this kind of network (Greenspan, Video talk: Blockchains vs databases, 2017). Also ensuring the performance of the solution is essential: the larger the underlying network, the slower the transactions processing.

3.2.2 Lightweight financial system

This consists of a financial system where stakes or number of participants are low. It is also considered as a quick and dirty financial system with participants coming together on assets for which confidentiality is not an issue, such as loyalty points, gift cards, alternative financial instruments.

3.2.3 Shared customers' metadata

Also intended as decentralized data storage. Many companies are connected to each other, but they are not moving assets, rather they are trying to share data and record them on the BC. Each piece of data entering the BC is digitally signed so that everyone knows where that piece of data comes from, and it is timestamped so that everybody agrees on what time something happened. Moreover, **immutability** guarantees that information cannot be changed or corrupted unless the majority of validating nodes decides to maliciously collude, a stronger concept than trusting one single organization to keep the records that can make changes in the database at their will. Confidentiality is ensured by encryption that can be used quite freely to unlock data content for only specific participants, people can see transactions but need encryption keys to see which data are actually being transacted (Greenspan, Video talk: Blockchains vs databases, 2017).

3.2.4 Intra-company clearing and settlement

According to Greenspan (2017) this is the only meaningful use case deployed internal to a single organization. Often a company has several subsidiaries considered as separate legal entities, and each needs to maintain control over their own assets. In such a non-competing environment, BC characteristic of settling assets within seconds can genuinely add value (Greenspan, Video talk: Blockchains vs databases, 2017), thus **performance** and speed of the system is more important than for other use cases.

3.2.5 Supply chain management and provenance tracking

These most likely represent the most beneficial blockchain use cases (Wüst & Gervais, 2017; Zago, 2018). There is a process that spans across multiple companies and multiple geographies, with goods passed from hand to hand, but still all companies need to agree with each other. When a centralized database is in place it is difficult to decide where the database is going to sit and who keeps track of what's happening to the item. Also, which organization is responsible for running that database and under which legal and regulatory regime does that organization sit? Blockchain adds value by enabling a shared ledger tracking movements and critical documents coming along with the items, in particular high-value items that are subject to counterfeit and theft along long (time and distance) supply chains. A high-value item is created, a trusted entity (can be the manufacturer itself) issues a digital token on the BC authenticating the origin of the item. After that, each time the item moves from one hand to the other, the ownership of the digital token changes as well. The final point of the chain receives the physical items and can verify the chain of custody the good went through since the point of origin. Benefits are for both final consumer that can trace back chain of custody, and for all parties involved in the chain management that can verify and control the state of the chain (Greenspan, Video talk: Blockchains vs databases, 2017). In this way, blockchain is a valuable part of a solution for supporting financial, document and provenance flow along any supply chain and make them fully transparent to whoever joins the network. The challenges lie in assigning the role of the registrar to a valid entity that would register the supply chain actors and confirms item's attribute such as Fair Trade, GPS, etc. Also, other authoritative parties are needed to make sure the link between physical and digital representation of the asset is conserved. **Governance** of the system becomes then the most important point to address to make sure as well the system is **immutable**. Finally, for what concerns data input, interoperability issues can arise since data might be collected from different sources, or not even collected in some point of the supply chain.

3.3 Conclusions

It has been shown how different fields make use of blockchain to securely store and transfer data, to fasten the settlement of assets, or to automate contractual relationships. This has helped the discussion focusing only on use cases that make sense deploying within companies, listed in Section 3.2. The ecosystem that develops around each of the listed BC-enabled use cases enjoys **reduced transaction time and costs**, **improved visibility and transparency**, and the guarantee of an **immutable and tamperproof data storage**. For each use case it was mentioned how the extension of the network behind influences how efficiently the solution creates and delivers value to the user of the service. Equally, it likely impacts the value that the company deploying BC can extract out of service or product offering. Thus, from being introduced at the operational level, BC is likely to have an impact on the entire Business Model, i.e. the logic that specifies how a company sustain itself and generates revenues, to which value creation, delivery and capture are strictly related (Al-Debei & Avison, 2010).

However, understanding the implications BC has from the operational to the strategic level is not trivial, particularly in case of such an immature technology for which only technological challenges have been underlined so far. Therefore, the next Chapter wants to understand the relationships and influences between business process, BM and business strategy in a general business environment. These concepts are then made specific for blockchain technology in Chapter 5, which informs companies on how to explore the transition towards a BC-enabled BM considering the tradeoffs in Section 2.8. Then in Chapter 6 a use case from those reported in Section 3.2 is chosen for the case company and analyzed in terms of tradeoffs (ex. Is for this application speed more important than robustness?).

4 The Business Model and value configuration

The literature review conducted hereafter serves as starting point for the construction of the conceptual model after being combined with literature about BC technology. Three main concepts are tackled: business strategy, Business Model (BM) and business process. These are described according to what the literature says, and the intersections among those defined. Once relationships among elements are clearer and how the technology works is sound, assumptions can be made on how the introduction of the technology in a corporate reality would first shape the business process, then impact design of BM and finally strategy.

4.1 Theory on Business Model (BM)

First, let's have a brief look on **business strategy** and how it differentiates from the Business Model concept. Few authors argue that business strategy and BM are not the same, even if the two concepts are related (Al-Debei & Avison, 2010) and BM can be a powerful source of firm's differentiation and competitive advantage (Zott, Amit, & Massa, 2011). The review conducted by Zott et al. (2011) highlights how a BM does not specify firm's positioning (differentiator or cost leader), firm's business areas, or firm's internal organization. Moreover, the BM does not emphasizes that much value capture and sustainability, or financial issues as strategy does (Chesbrough & Rosenbloom, 2002). Chesbrough and Rosenbloom (2002) particularly focus on the knowledge possessed by a firm: while constructing a BM, knowledge limitations are deliberately considered. In particular, attention is put on previous successes of the firm and how these influence the creation of a new model. Strategy instead "assumes that any cognitive limitations on the part of the firm are of limited importance" and bases choices on the available information (Chesbrough & Rosenbloom, 2002, p. 535). Therefore, the two concepts do present differences and are to be kept separate, and it is important to underline that strategy planning precedes the creation of the BM (Al-Debei & Avison, 2010), concept explained further.

Before strategy used to be directly implemented in processes that were simpler, more static and experienced less pressure from stakeholders. In this increasingly digitized society driven by telecommunications, globalization and continuous market changes, a gap formed between business strategy and business processes. This gap is today filled by the **Business Model** that guides strategic choices towards their implementation not only in the company, but also among stakeholders by means of process and information system design (Al-Debei & Avison, 2010). However, even recognizing the fundamental importance of the BM for any organization, a solid, concrete and unified definition of it lacked since the coming of the Internet in the mid-1990s, with academics and business actors describing the concept in disparate and siloed ways (Zott, Amit, & Massa, 2011). As of 2018, two papers have carried on an extensive review of the literature concerning the BM concept: Zott et al. (2011) and Al-debei and Avison (2010).

Zott et al. (2010) identifies three areas of interest of the researches conducted about BM, in particular e-business and how companies use ICT, issues related to strategy and innovation and technology management. They highlight that no analysis is conducted on how business model components relate to each other, how BM is differentiated from strategy concept and how it stands between the input resources of a firm and the market outcomes. Technology is seen as one of the possible inputs, a kind of an "enabler" of the BM concept. This idea has been first suggested by Chesbrough and Rosenbloom (2002) that defined the BM as a "mediating construct between technology and economic value" (Chesbrough & Rosenbloom, 2002, p. 532). In synthesis, the BM is a concept that spans among the firm and the network in which it operates, does not only include *what* the business does, but also *how* it does it, and it is a conceptualization of activities performed by the company, its suppliers, partners and customers (Zott, Amit, & Massa, 2011).

The second paper mentioned here is from Al-debei and Avison (2010), and although less recent than Zott et al.'s one (2011), it is argued to be more complete, clear and precise. It indeed provides a unified framework of the BM concept highlighting its primary dimensions or constitutive elements, its modeling principles, how it interacts with strategy, business processes and Information System. Finally its main functions and why companies should pay attention to it. Four elements must be considered when designing, evaluating and managing any BM, to make sure the desired value is delivered and economic value is captured when the company provides a service or a product. These are:

- **Value proposition**, demonstrating how the company creates value for customers or involved parties by offering products and services that solve target segment's needs;
- **Value architecture**, specifying the technological architecture of a company and the organizational structure that enables product and information flow, including also company's access to resources, their configuration and core competencies;
- **Value network**, describing how a company makes use of coordination and collaboration to enable transactions among parties, specifying its position in the value system and its relationship with stakeholders (suppliers, partners, distributors, intermediaries, competitors, public organizations, customers, etc.);
- Value finance, describing issues related to costing, pricing and revenue mechanism (Al-Debei & Avison, 2010).

The paper of Al-debei and Avison (2010) is extremely helpful to get an overview on the concept and gives some guidance on which are the BM components responsible for value creation, delivery and capture. However, there is the need to know how these concepts relate to each other and which implications they have on BMs design. How to effectively design BMs for services to be widely accepted and used is the topic of Bouwman et al. (2008). They argue that to offer value to customers and allow the service provider to capture value as well, the Business Model must specify its components, in particular customer value proposition, together with technical, organizational and financial arrangements. Thus they propose the STOF model, a conceptual framework useful for analyzing (and subsequently re-designing) the elements that constitute any business model (Bouwman, De Vos, & Haaker, 2008). These are:

- *Service*: starting point of the approach are service definition and its **value proposition**. Value is intended as the comparison the target customers draws between what they receive and what they give up when becoming owners of the product or service. In providing this value, a company must be more efficient and effective than its competitors either proposing new content (a new product or service), a new context (how a company offers it, for example through mobile app), or a new infrastructure (a new way in which transactions occur, for example self-service). Also, value changes notation based on who offers it or who receives it: the value the provider wants to offer (intended value) and the value it is actually delivered might be the same, but mismatch the perceived value from customer or end-user side because dependent on user's preferences and behavior.
- *Technology*: this is the "driver for new innovative services and business models (push-model)", still seen only as an enabler from a customer's point of view (Bouwman, De Vos, & Haaker, 2008, p. 37). Functional requirements that specify what the product or service should do are originated in the service domain and determine the technical architecture. Some technical issues to be addressed for any application running on a network and offered to customers are users authentication, user profiles management and level of security, a critical factor on which the success of the service depends.
- *Organization*: institutional design is related to technological design in terms of defining how actors regulate "their relationships, tasks, responsibilities, allocation of costs, benefits and risks" (Bouwman, De Vos, & Haaker, 2008, p. 49). Value chain concept leaves space to value web or **value network** idea, in which structural, contributing or support partners add differently to the final value delivered to customers and have more or less important roles in the network. This value-creating network is aligned to customer's needs, sees actors engaging in a "collaborative, system-wide communication and information management" and it is scalable to respond to changes in an agile way (Bouwman, De Vos, & Haaker, 2008, p. 53). The focal firm in particular has to manage wisely its resources and capabilities, and guide activities to get access to resources it does not have (could be organizational processes, information, etc.) to finally offer a product or service with unique value proposition. Indeed, a key element to consider when deciding who to incorporate in a value web is access to critical resources.
- *Finance*: resources in this domain are often the most important to acquire, and the two main issues to consider are investment decisions and the revenue structure. Included here are costs (particularly transaction costs, i.e. "the costs of planning, adapting, executing and monitoring

task completion"), revenue sources, risks (such as investment risks, standards, path dependency, etc.) and pricing (Bouwman, De Vos, & Haaker, 2008, p. 58). It also specifies how these are shared among the actors in the value network.

A small remark is made on **value configuration**, a notion that derives from Strategic Management literature and specifies how a firm creates, delivers and captures value (Kazan, Tan, & Lim, 2015). In their paper, Kazan et al. (2015) present three generic value configuration: value chain, value shop and value network. The latter sees firms co-creating and capturing value by linking stakeholders with complementary business interests by means of a "mediating (IT) artifact" (Kazan, Tan, & Lim, 2015, p. 5). Finally, they specify the core elements of a digital BM (value creation logic, value capturing mechanism, value delivery architecture, and value stakeholder network) and argue that digital BMs and value configurations are synonyms.

4.2 Theory on business process and Business Architecture (BA)

Since we intend the BM as "an intermediate layer between business strategy and business processes including their supportive IS", it is necessary to define what a business process is and what supporting systems are (Al-Debei & Avison, 2010, p. 365). A business process allows an enterprise to provide a specific outcome (product or service) by combining activities or sets of activities according to a structure that specifies the logical order and dependencies of the elements (Aguilar-Savén, 2004). Along the process, people might interact with Information Technology (IT) systems that are made up of devices (software, hardware, and other accessories). The Information System (IS) instead originates from how the users make use of the IT system associated with the process and it continuously evolves and adapt (Paul R. J., 2007).

Accurate and functioning business process and the underlying IS should be derived directly from the BM (Al-Debei & Avison, 2010) or from the Business Architecture (BA) (Versteeg & Bouwman, 2006). Differently from Enterprise Architecture, that generally indicates any architecture extended over the enterprise, BA "specifically […] structure(s) responsibility over (business and) economic activities by multiple organizations (supply chain level), by one organization (enterprise level) or by part of an organization (business unit level)" (Versteeg & Bouwman, 2006, p. 92). In particular, main elements of a BA are "business domains" that perform specific activities and work together as specified by business process models to achieve organizational goals. Business domains become clusters of activities over which meaningful accountability can be taken, where activities are a bundle of business functions and related objects (high-level data description). In this way BA stands as a tool that facilitates the analysis, design and implementation of organizational, processes and IT structure (Versteeg & Bouwman, 2006). They then have a look at how the BA model supports the translation of business strategy into "functional, information, process application architectures, and […] into the way ICT-governance is shaped" (Versteeg & Bouwman, 2006, p. 97). To sum up, Business Architecture is typical of a big enterprise with several processes that can be divided into units of analysis and replicated in many other business processes.

4.3 The relation between BM, strategy and business process

Keeping up with the idea of the BM as intermediate layer between strategy and processes as suggested by Al-Debei and Avison (2010), we know briefly discuss the relationship among these elements, in particular what their overlap signifies. At the intersection with BM, the organization becomes more specific on how it wants to achieve strategic goals and objectives previously defined and starts defining better value propositions, enterprise architectures, needed cooperation and financial arrangements. At this point the BM still strongly depends on business strategy (Al-Debei & Avison, 2010).

For what concerns different processes together with their supportive IS, according to Al-Debei and Avison (2010) the BM gives origin to a range of design options, but does not precisely define how these are run or their settings. This is the trigger for the research conducted by Solaimani and Bouwman (2012): there is the need for creating a model that would allow for processes and procedures of different actors in the value network to be operationally aligned and sustain the overall BM. Indeed, the literature as of 2012 lacks on two points: theory on which elements should be considered when aligning BM and business processes, and a generic approach valid for all actors independent of the process modeling tools they used. Therefore, they propose the VIP framework that allows for extracting "the necessary insights from the upper level BM in a generic way, and transform them to the information that is needed to generate and model BPs in many (if not all) possible ways" by means of interaction components (Solaimani & Bouwman, 2012, p. 663). The model includes three layers:

- **Value exchange (V)**: in this phase actors and requirements analysis is conducted to identify the actors, money and goods flows (value objects), their roles (value activities), (value) goals and (value) dependencies, or interactions they must carry on to obtain tangible value objects from each other.
- **Information exchange (I)**: already mentioned as one of the main "areas of accountability" specified in Business Architecture (BA) (Versteeg & Bouwman, 2006), in this layer actors' interactions and dependencies are made more obvious by specifying which data, information and knowledge is exchanged. In here are also included information flow, information authorization (access), and trust dependencies, specifying which activities are carried on by actors to ensure trust (intangible good) is exchanged.
- **Primary business Processes (P)**: after clarifying actors and information, primary activities (for the physical creation of the product of service) performed by each actor are represented from both a functional (what is being done) and behavioral perspective (how it is being done). Moreover, process boundaries and dependencies (which processes need to be performed before others) are also specified.

For each layer, representation methods and tools are suggested as well, such as the e^3-value model or the use-case diagram for the Value layer, WebML+ or DFD graphic technique for the Information domain, and BPMN, UML and ArchiMate for modeling processes form a behavioral point of view (Solaimani & Bouwman, 2012). Finally, the VIP framework is practically applied on a pharmaceutical project in a study case conducted by Solaimani et al. (2018).

4.4 A combined picture

After conducting a thorough literature review, a general overview is extracted that is first explained and later used for the creation of the conceptual framework.

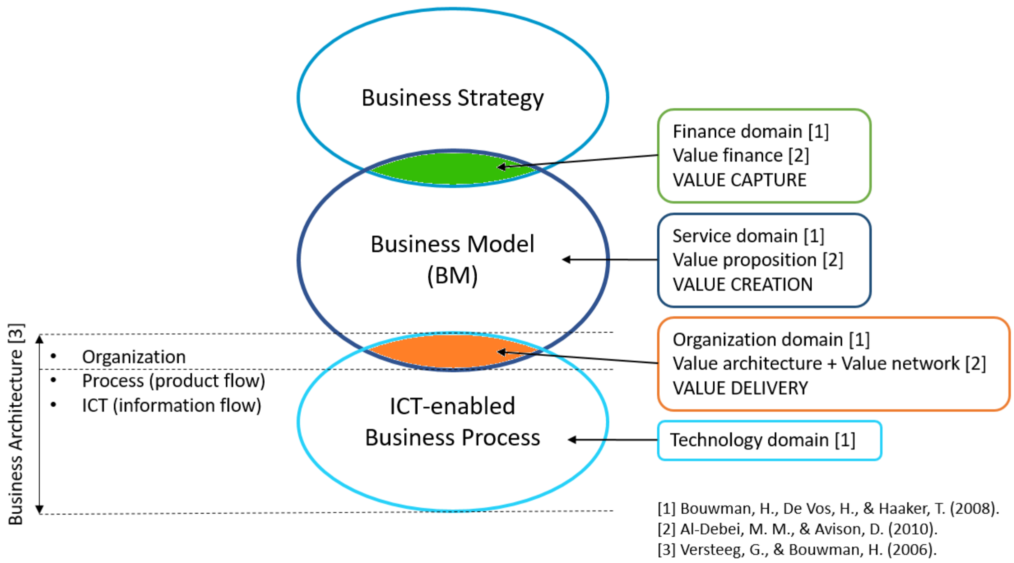

Figure 8 Figurative sum-up of literature review with authors' contribution

The circles in the picture together with their intersections represent the elements previously identified and described. The squares on the right contain the design elements addressed by each of the conceptual areas:

1) Define the offered **service** or product, then describe the value proposition for each of the identified target groups. What the company is offering must satisfy the needs of some entity or group of entities (target groups), which have either expressed clearly their request or are potential sources of undiscovered needs. Making this specific entity satisfied with that specific offering is the company's goal, but it is not limited to that. The company wants their customers to be not only satisfied, but also happy about its products, in particular happier than with the same product offered by a competitor. This is why the company strives to offer value on top of the basic functionality of the product. Value does not originate out of thin air, but derives from companies' effort to coordinate and exploit their resources and knowledge to make their product stand out for newness, performance, design, convenience, etc. This is why in this domain **value creation** resides: the mechanisms used to create value are identified and entailed in the company's value proposition, making its definition extremely important.
2) Explore the potential of the **technology** at hand as enabler of new innovative services and structure the technical architecture that allows for "service development, creation, discovery, delivery, bundling, control and management" (Bouwman, De Vos, & Haaker, 2008, p. 46). Having a clear idea of the technology value proposition (which problems is it solving? Which are its characteristics?) and the tradeoffs it implies it's an important initial step because it helps anticipating several designing issues, such as security or scalability. In this phase business processes and supporting ICT infrastructure are analyzed, with particular focus on **product and information flow**.
3) Analyze product and information flows to support the identification of activities that if performed correctly (i.e. in a structured and ordered way) enable the service. Activities as mere bundles of functions and objects cannot operate alone, so divide and assign roles to activities to fulfill the specified functions. In this respect, **Business Architecture** supports the assigning of responsibilities over business domains by reducing them into bundles of activities (Bouwman, De Vos, & Haaker, 2008). The **value architecture** can then come to life, by having specified both "technological architecture and **organizational** infrastructure that allows the provisioning of products and services in addition to information flows" (Al-Debei & Avison, 2010, p. 366). Resources and capabilities are needed for those in charge of activities to orchestrate product and information flow in a meaningful way. However, sometimes the company alone does not have the right resources of capabilities, so it needs to collaborate and coordinate with several actors in the value network. Thus, on top of assigning roles to business domains, come up with a network strategy that describes which transactions are enabled within the **value network** to make critical resources available. **Value delivery** is the appropriate definition for this intersection, defining how the company configures resources and capabilities within the network to deliver the product or service (Kazan, Tan, & Lim, 2015).
4) Specify how each participant of the network extracts economic (more specifically, monetary) value from value creation and delivery. Accordingly, this area of the picture is where **value capture** lies. **Financial** arrangements typically describe how investments, costs, revenues, and risks are distributed among actors, and the final outcome goes on offer pricing and fees charged at different levels of the network. This domain is attributed to the intersection between strategy and BM, because when deciding on this type of arrangements, the company should keep in mind the firm's strategy and be inspired by it.

4.5 Conclusions

In general, theory about BM, business processes and business strategy is abundant. Papers summarizing the state of the research have been an extremely helpful input for this chapter. The final overview given wants to be an additional summary and contains elements from several papers that were considered important for the subsequent conceptual model creation. Design factors and conditions included in each area of Figure 1 (Service, Technology, Organizational and Finance domain) are derived from Bouwman et al. (2008) and made specific for blockchain, considering technology Value Proposition and tradeoffs. For example in the Organization domain, factors such as "partner selection" will become "BC provider selection" in the BC environment. Concepts are then organized in a conceptual framework reported in Section 5.5 that is used to focus the analysis of the case company later on.

5 Tradeoffs impact on Business Model design

In the previous chapters blockchain technology has been described in its functioning, value proposition (VP), technical tradeoffs and meaningful use cases. Corporate's roles as operators (network operator and participant + application developer and operator) has been clarified. The literature review conducted in Chapter 4 about BM and business process has described the elements and highlighted the relationships and influences between the domains.

It is assumed here that the reason for the business to introduce BC lies in strengthening those capabilities that differentiate the company in the market (Plansky, O'Donnell, & Richards, 2016). Thus, the process enabling the product or service delivery on which blockchain is deployed represents a core business process for the company, which decides to offer the technology as an extension of the product or service. In this way, the value delivered by the current offer is enhanced by leveraging the typical characteristics of the technology. Thus, when modifying the current BM of real use cases, it is important to keep in mind that the Service Domain or Value Proposition of the offering gets enhanced by blockchain VP. Other changes in the BM happen in the Technology Domain (how to make sure the technology is properly integrated and supports the final service), in the Organization Domain (how to make sure critical business actors are involved and can coordinate to enable the offering) and in the Finance domain (how to make sure the network is motivated and rewarded). The Service-Technology-Organization-Finance (STOF) model proposed by Bouwman et al. (2008) is argued to give a comprehensive and substantial method for analyzing and subsequently design BMs for digital services and reflects the subdivision highlighted in Section 4.4. The following discussion in particular specifies the Critical Design Issues (CDIs) for BC technology. To be precise, CDIs are design variables considered important to ensure the BM under evaluation results to be viable and sustainable (Bouwman, De Vos, & Haaker, 2008). Finally it is necessary to identify the activities that allow the identified changes to actually become reality and give raise to the new BC-enabled BM. The entire discussion is then summarized in the conceptual model proposed in Section 5.5.

5.1 Service domain

As previously said, the substance of the offering remains the same, but its embedded value is augmented by the technology VP. The core established service (or soon-to-be service according to business strategy) represents the starting point, and BC serves as support or auxiliary service that improves customer value.

- *Targeting.* The main target for a company being the BC system operator are end-users, either network participants or application users. The former run a node on the blockchain (read or write/commit) and are considered **direct users** forming the blockchain network (Brenig, Schwarz, & Rückeshäuser, 2016). Their direct participation makes them critical actors of the blockchain network and their selection is better explained in *Partner Selection*.

  An application user is instead any entity that connects to a specific application and interacts with the BC network through the app interface (Hileman & Rauchs, 2017); they are considered **indirect users** (Brenig, Schwarz, & Rückeshäuser, 2016). A choice is to disclose that the service is based on blockchain. However, it is unlikely that users would value the new version of the product or service more only because it is said to be "integrated with blockchain technology". Thus, it is necessary to instruct the users on how the technology works and what its added value is. In this way, it is recommended to target a **niche market**, such as a technological-savvy group of consumers or businesses, or a wealthy part of the population potentially willing to pay more for enhanced product or service features.

  If the targeted market instead is the mass market, it becomes unfeasible to teach how BC works. At that point, blockchain properties must emerge spontaneously and immediately from the usage of the service, without necessarily revealing to end-users that the solution is built on BC technology.
- *Creating Value Elements.* Once the target group is clear, it is time to identify for which reasons they would choose the new BC-enabled version of the service or product. When direct users interact with the BC-enabled service, the main added value is the enhanced **trust** among peers

that do not have to rely on third parties to run transactions. Trust is considered a fundamental value element (Bouwman, De Vos, & Haaker, 2008). However, the object of trust varies depending on the network topology. The more the network is extended, the more participants associate trust with the consensus mechanism in place, that guarantees the integrity of the information reported on the ledger. If a service is built on top of such a network, however, value elements such as privacy and confidentiality, as well as speed and performance are badly affected. So when designing services based on extended networks, providers should stress on the guaranteed immutability and warn users on the possible drawbacks, even if solutions are in place to mitigate the issues. Instead, when the number of validating nodes reduces, service users have to trust the reliability of the actors managing the nodes. In this case, it is fundamental to highlight how the "mutability risk" is compensated by improved privacy, better application performance and increased transparency. Direct users also benefit from **accessibility** and **censorship resistance**, i.e. anyone allowed can access the network from anywhere and verify or run transactions (Ludwin, 2017); and **redundancy**, meaning all participants conserve a copy of the ledger.

Other value elements that blockchain can deliver to indirect users are **newness** (as a new extremely hyped technology), (transactions) **cost reduction** and business efficiency (trusted transaction storage, Wang et al., 2016), and **automation** (by means of smart contracts).

- *Branding.* Using well-known brands supporting the BC solution can help increasing visibility of the product and attracting the targeted group. To convince users that key issues related to the technology are addressed (see speed, privacy and security, etc.), reliable and trustworthy BC providers should be chosen, possibly with years of experience in the software development field. In general, collaborating partners for the deployment of the solution should be chosen in such a way that their value proposition is clearly stated, and it aligns with the VP of both the technology and the company deploying BC.

5.2 Technology domain

The following CDIs are usually addressed by BC providers or application developers, but it is responsibility of the system operator making sure they are properly tackled.

- *Security.* For any service developed, security refers to two features: access to the service and how information are communicated and stored (Bouwman, De Vos, & Haaker, 2008). For blockchain this means handling public and private keys of direct users, and making sure data are transmitted along the network in a secure way, are registered on the ledger and never changed again. The former represents a major human-dependent issue: regardless of how the service is designed, if direct users lose control on their **private key**, this automatically means losing control over network access and personal assets, and it might lead to severe security breaches. This is why several BC providers offer to handle and keep secure their customers' private keys in offline storage devices, or key stores (Yadav, 2017). To mitigate this problem, the service should be designed in such a way that users are informed on the importance of keeping their private key secure, even if this means adding more steps when registering or accessing the BC-based service.

The second issue deals with making sure that the data recorded on the ledger cannot be changed over time and it derives from **consensus mechanism** governing the network. Contrary to common services, security is not more easily realized in a BC closed environment: indeed, it is easier to guarantee data security in a public and open network such as Bitcoin, than in a private one. When the service is based on a permissioned BC, users should be given the possibility to refer back to the nodes responsible for the ledger state, usually the network operator and the validating nodes, in case of security issues. So potentially all users can have anonymous access but validating nodes that must be clearly recognizable by all direct or indirect users.

In addition to this, it is important to reason whether the use case has to comply with **data protection regulations**, such as in the healthcare and financial sector (Cocco & Singh, 2018). Based on the regulations, it might be necessary to inform users on the identity of all other network members and the data they have access to. Finally, contracts must be stipulated among network operator and validating nodes to make clear which consequences actors not respecting the rules are going to face, and contracts must be disclosed to service users to reassure them on the rules governing the network.

- *Quality of Service*. For a service based on BC, a critical technical functionality to deliver is transaction **processing speed**. This highly depends on the consensus mechanism in place, that itself depends on the mode of peer participation, permissioned or permissionless (Sandner, 2017). Services built on private network can run faster that those built on top of public ones: from the 10 minutes required to mine one bitcoin block (Du, 2016), down to the 10-19 seconds of Ethereum block time (Blocksplain, 2018) or the 4 seconds in the Ripple network (Schwarz, 2018). Thus, if the quality of the service depends on speed it is better to build on top of a private blockchain, so that the network-loading problem can be addressed better (Wang, Chen, & Xu, 2016).

  Availability of the service also plays an important role: the global reach as BC property guarantees transactions can be run from anywhere in the world without affecting transaction speed (Hileman & Rauchs, 2017).

  Finally, **scalability** can largely affect the quality of the service and prevent the company to offer the BC-enabled product or service to a wider costumer base than the niche market targeted at the beginning. Thus, companies should pay extreme attention and plan for scaling up the service since the very beginning.
- *System Integration*. The BC-based service increases its value if it can be easily integrated with the existing technical infrastructure of both the company and the direct or indirect users. It is then important to make sure that the blockchain and the current enterprise architecture are not stand-alone systems but can share information and at the same time are integrated with "several other systems, communication protocols and technologies in real time" (Shadab, 2018). What is needed is a blockchain **proxy layer**, or an integration layer, that allows the installed blockchain to communicate not only with existing enterprise applications (back-end legacy system, i.e. ERP, CRM, etc.), but also with any other blockchain (Shadab, 2018). This results to be extremely useful in allowing organizations to participate in multiple blockchains, and overcome the **fragmentation problem** that sees an increasing number of corporates testing with BC, but all with different protocol frameworks, standards and networks built on top (Hileman & Rauchs, 2017).

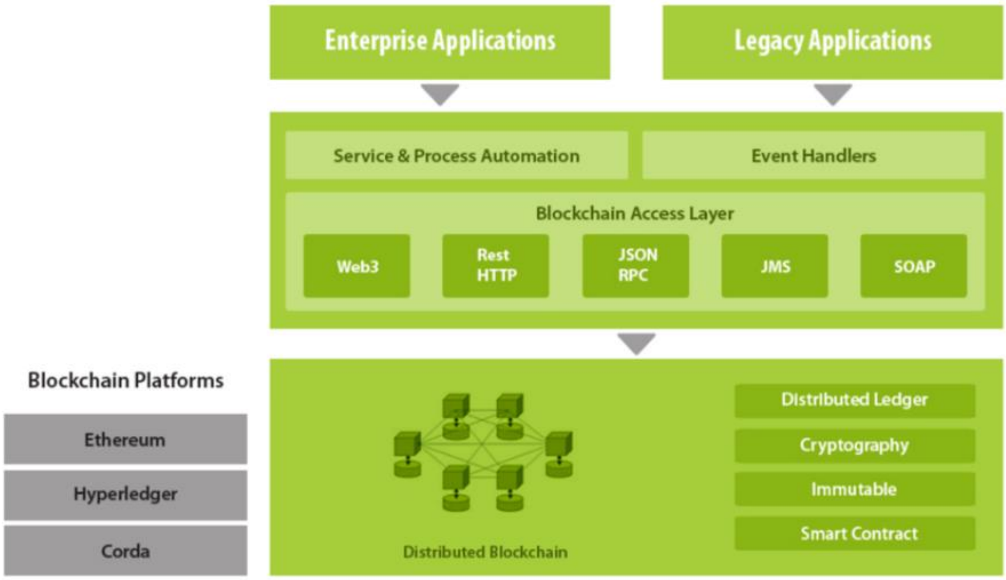

Figure 9 Blockchain integration layer, adapted from Shadab (2018)

However, an integration task that requires some attention consists in importing into the blockchain systems the previous transactions (Wang, Chen, & Xu, 2016). When deploying the

BC-based service is then important to carefully assess which data are required by the applications and where these are coming from.

- *Accessibility for Customers*. Accessibility is here interpreted as how easily end-users interact with the blockchain network or the blockchain-enabled service. From a technical point of view, it is important to choose BC providers that would take care of deploying a proxy layer for allowing a seamless integration of company's BC-enabled service and customers' devices.

  Often, however, accessibility is not hampered by technical features, but by **specific capabilities** that end-users need to acquire to make the most out of the service value elements (Bouwman, De Vos, & Haaker, 2008). Direct users have to be instructed on how to handle their private key, on how the consensus mechanism works, what are the rules of the network, etc. Thus, to attract users it is important to find mechanisms for educating them about the technology, so they can clearly see the advantages (Milano, 2018). As the technology works on the Internet, companies have to make sure the service is made available to end-users on devices that can connect to the Internet and that the geographical area where the service is used is Internet-enabled.
- *Management of User Profiles.* Direct users get assigned to a pair of private and public keys automatically generated by the system and must be informed on the importance of safely storing them. When the application runs on a permissioned network, users' profiles can contain more information than the public key, for example what are users' roles and what type of data they have access to. In that case, a **registrar** is needed "that provide(s) credentials ad unique identity to actors (e.g. an accreditation service)" (Provenance, 2015). This actor links the real-world identity of the participants with their digital identity so that they can interact with the blockchain. Moreover, it can also verify actors' identity and record the results on the BC, so that anyone can inspect them (Provenance, 2015). Thus it is important that the registrar it is a reliable authority and that its identity is disclosed to end-users. More about this topic is discussed in *Network Governance*.

5.3 Organization domain

As already mentioned in Section 2.5 it is assumed companies deploying BC applications would outsource the system development to one BC provider since it does not belong to their main competencies. Indeed, building a blockchain in-house requires software development skills that organizations do not usually possess: it would be similar to coding part of your computer Operating System (OS) by yourself instead of buying an off-the-shelf solution such as Windows from Microsoft. With "deploying the blockchain" it is meant that the platform provider **installs a piece of software** on the company's servers and takes care of the initial configuration of the network. Further discussion on the point is found in *Network Governance*. This part of the BM relates fundamentally to how the company chooses **network participants** (or direct users) and how it handles them.

- *Partner Selection*. A fundamental factor to consider when designing a new BM is choosing who to get on board to acquire specific resources and capabilities that the company currently does not have (Bouwman, De Vos, & Haaker, 2008). The stakeholders potentially interested in or affected by the development of the solution are many, but some critical ones need to be involved before than others to favor and strengthen the environment in which it will be offered. Regarding BC, partner selection is intended as: first, choosing an appropriate BC core **infrastructure provider**; second, involving aligned **key network participants**.

  The blockchain provider is usually a software vendor or a platform operator that offers blockchain solutions on top of their usual corporate offerings (Hileman & Rauchs, 2017). It is seen here as a **critical actor** providing an indispensable and irreplaceable resource (the BC itself) (Bouwman, De Vos, & Haaker, 2008). Companies should check which is their OS provider and if this has BC offerings already in place. If this is not the case, then choose a provider whose protocol is wide spread, on top of which several networks are already running. Indeed, the provider should be knowledgeable about developing customized network (check use cases already developed) or offer a modular development environment with BC toolset to support the creation of networks by the company itself. Also, make sure the provider can help addressing CDIs in the Technology Domain, such as system integration, upgrade and maintenance.

Upgrading is particularly cumbersome when it comes to BC since the technology lives on the Internet and cannot be upgraded as other existing enterprise software (Wang, Chen, & Xu, 2016). Also, the provider might be chosen based on the network that wants to be deployed or joined. Network can be industry-specific (ex. All actors belonging to financial domain), use case-specific (ex. Food supply chain) or enterprise-specific (Hileman & Rauchs, 2017). BC providers differentiate themselves also for the networks they are good in building: for instance, R3 Corda excels in building networks and applications in the financial domain, while Hyperledger is really good at supply chain use cases.

Network participants are instead interpreted as both **critical and supporting resources** (Bouwman, De Vos, & Haaker, 2008). Critical are the very first ones involved that allow the network to come to life, usually validating nodes that offer computing power and make sure the state of the ledger is updated. Supporting partners are involved in a second phase, are usually peripheral or non-computing nodes, maybe with only-read capabilities. Once the business process to be embedded with BC has been selected, a thorough stakeholder's analysis (in particular the information flow occurring) must be conducted to clarify company's and actors' roles in the ecosystem. Fundamental is to sketch in details the **information flow** of the process. The company must search for an **access point**, i.e. a critical partner (or two at most) which to start with. There is no correct one, but company's position plays an important role in guiding the decision. The company is recommended to have complete or overall good control over the digital or physical asset that is transacted. Between the company and the partner(s) there must be tight integration, standard processes and data sharing, or enabling them in the short future time is feasible. **Data sharing** is fundamental: critical partners are sources of data that the company can collect and process to extract value of any kind. The company might even consider to buy a company that gives access to critical data. Finally, it is recommended to choose a partner over which regulatory pressure and/or demand for transparency is increasing.

- *Network Openness.* This usually "indicates the degree to which new business actors can join the value network and are allowed to provide services to customers" (Bouwman, De Vos, & Haaker, 2008, p. 79). For the BC, this refers to deciding not only **network topology**, i.e. whether it is an extended or reduced network, public (open) or private (closed) blockchain, but also application topology, with **open or closed access**. As already said, for industrial applications it makes more sense to engage with permissioned blockchains, so that it is possible to identify the people in charge of ledger state and update. Moreover, a closed model in which only specific partners can collaborate (Bouwman, De Vos, & Haaker, 2008) helps knowing who did what and when and managing better the value network forming around the solution. However, this might limit the data collection possibility, forcing people interested in contributing to the network to ask for obtaining access. Also, it might affect the "transparency" value element. Making the permissioned network public, i.e. open for anyone to see what is happening, might compensate for the transparency loss.

  When it comes to applications running on BC, it is important noticing that they can be permissioned or permissionless regardless whether they run on public or private networks. When targeting a niche market, it is possible to put in place a closed access that follows the "walled garden model", making sure only people complying with certain fixed rules can use the service (Bouwman, De Vos, & Haaker, 2008, p. 79). If instead the service wants to have a wide customer reach, it is recommended to make the application accessible to anyone, so that data collection and sharing widens up. However, at that point it is recommended to set up mechanisms that would assure the quality of the provided content is respected.
- *Network governance*. For a decentralized system that (in theory) none fully owns, this becomes a particularly critical point. It is intuitive that the company that deploys the permissioned blockchain (and pays for software license) should play a dominant role in the blockchain network and consequently manage it. The same company is in charge of selecting partners (network nodes), clarifying consensus mechanisms and legal consequences for compromising the system, and monitoring everyone complies with these rules. In particular, since all peers taking part in the consensus must know the identity of the other peers, the initial configuration of the network is fundamental. Thus some trusted party, called "**gatekeeper**" or "**administrator**", has

to authenticate the identity of the participants, issue private-public keys and give them access to the network based on what they can do in it (Hileman & Rauchs, 2017, p. 61). Usually it is the BC provider giving the possibility for the company to choose the gatekeeper, which can be the company itself or even a consortium or federation of selected entities (Hileman & Rauchs, 2017). So before building up their own network, a company should make sure a network similar to the one they envision does not already exist, and in case they should join it.

The gatekeeper in a permissioned environment can optionally cover also other roles that facilitate network governance. Maintaining and upgrading the system are usually responsibilities of the software vendor, whereas the one in charge of approving the updates is the system administrator, which can ask network participants to vote and express their opinion on software updates (Hileman & Rauchs, 2017). Thus, when setting up the network, it is important to address these points and ask network participants what they think about it. Also, it is possible to co-maintain the software together with the provider, but it is suggested only if the company has enough software-related knowledge. The administrator can also take care of solving or arbitrating disputes arising between involved parties. Now, disputes can arise either because the validating nodes reverse the system, or because of token issuance claims. Regarding the former, BC technology allows for knowing who did what, so it is possible to identify the malicious nodes in a closed system and punish them according to contracts stipulated among actors. The latter instead regards the issuance of new digital assets on the BC (ex. A bond), or tokenization process, by which a physical asset gets digitally represented and then traded through transactions on the BC. There is again the need for a trusted third party that not only allows the entity to issue the token on the BC, but then also backs the asset with existing assets and that is legally accountable (Hileman & Rauchs, 2017). This can be a single actor, for example the system administrator, as long as it has overview on the asset movements. Otherwise, other actors should play the role of the "granting" trusted party, depending on which part of the process they supervise. It is then recommended again to clearly **set rights and obligations** of each participants at the very beginning.

- *Network Complexity.* In a BC network, this refers to the number of critical (validating) nodes that the company decides to install and collaborate with, and the difficulty in managing technical architecture, i.e. grating system integration and accessibility (see *System Integration* and *Accessibility for Customers*). At the beginning, it is recommended to keep network complexity as low as possible, involving other 2 or maximum 3 validating nodes (upstream/downstream actors), and grating only-read access to few other parties (ex. Regulators). This allows for testing system performance and expand it later on when the functioning is clearer.

5.4 Financial domain

The Financial Domain is by far the **most uncertain and unclear**. Blockchain providers inform about few developed applications but do not go into details about financial aspects. Corporates engaging with BC projects instead only report BC networks under construction, but most of the leave unclear which applications are developed on top and how they envision to make money out of it. The issue however is particularly compelling, since it is about capturing value from a service that originates from a distributed technology.

Pricing entails ways for evaluating how much is correct to charge the service users, but for BC products suggestions are still far to come. Questions are rather: who is going to get charged exactly? And who decides on how much to charge? Direct users could be charged for getting access to the network, gaining either write/commit rights, or read-only access. Indeed, there could be actors with high interest in getting to know what is happening inside the network, for example regulators. Indirect users instead could be charged for the improved value proposition of the service, for example increased transparency or accessibility. The price should be decided by the system operator, or the company deploying BC, preferably in collaboration with main partners in the blockchain network, those providing fundamental access to resources and capabilities.

Division of Investments and Risks and *Division of Costs and Revenues* are closely related, meaning it is intuitive that actors who made the major investment and took the biggest risks are also capturing more of the value created and delivered. How these factors are split depends on the individual access actors have to resources and how much those are valued, i.e. how critical these are (Bouwman, De Vos, & Haaker, 2008).

Valuation of Contribution and Benefits is probably facilitated by the underlying technology because it is clearer who did what and when. It is related to putting in place effective mechanisms for rewarding the people taking part in the network. If the BC application is backed by the introduction of a cryptocurrency circulating in the network this becomes easier. If the network does not allow for such a thing, it is important to find effective ways to convince network participants to share resources and highlight related business benefits.

In the next Section, the latest concepts are organized in a framework that recognizes implications for each of the Domains in case the blockchain network is less or more extended, according to the technical tradeoffs mentioned in Section 2.8.

5.5 The conceptual framework

Links and interrelations among BC and the BM concept have been drawn and organized in the conceptual framework presented below. CDIs in the STOF model represent the rows of the model, while columns report the process enabling the offer **as-is, to-be**, and the recommended **transition** from one to the other. On how to guide transition, the BM roadmapping approach from Reuver et al. (2013) is followed. Particular stress is put on how an extended or reduced network implies technical tradeoffs and influence differently changes at the BM level. Indeed, the to-be process changes depending on the extension of the blockchain network, similarly does the transition to follow. Finally, the writing « “ ” » means the right column should report the same as the left one but it is not reported for sake of simplicity.

Table 3 Conceptual framework summarizing theory

		Process	To-be		Transition	
Domain	CDI	As-is	Reduced network	Extended network	Reduced network	Extended network
Service	*Target*	Actual service users	Niche market (direct and indirect users)	Mass market (indirect users)	Instruct users on how BC works and added benefits (address *Network Openness*)	Technology characteristics emerge from service usage (address *Quality of Service*)
	Value Elements	The service would benefit from:				
		Immutable tamperproof data storage	Database trustable because of business actors’ reliability	Database trustable because of consensus mechanism (immutability ✓)	Get on board reliable and well-known business actors, disclose writing/committing actors’ identity to end-users (address *Partner Selection*)	Stress on guaranteed immutability
		Improved visibility and transparency	Asset movements and ownership change visible to few actors (confidentiality ✓)	Asset movements and ownership change visible to many actors	Design data diffusion and stipulate legal contracts among actors for data breaches (address *Network Governance*)	Deploy multi-channel data diffusion (address *Security*)
		Reduced transaction time	Medium transaction speed (performance ✓)	Slow transaction speed	Only transactions that do not require high processing speed (address *Quality of Service*)	Only transactions that do not require medium processing speed
		Reduced transaction costs	Reduced transaction fee (more difficult)	Reduced transaction fee (less difficult) (performance ✓)	Decrease transactions fee	Eliminate transactions fee
		Improved accessibility and censorship resistance	All users can access from anywhere	“ ”	Service is accessible through nodes (address *Accessibility for Customers*)	“ ”
		Improved automation	Contractual relationships are managed by smart contracts	System activities are performed by smart contracts	Translate real-life contracts into smart contracts (assess *Network Governance*)	Assess smart contracts limitations, ensure and verify access to data sources

	Branding	Actual partners collaborate in delivering solution	Competent and well –known BC provider, application developer and network participants support the BC-enabled service	" "	Align partner's value proposition, communicate partnership to end-users (assess *Partner Selection*)	" "
Technology	*Security*	Access to service regulated by service provider with usual credentials Information stored on central database	Few users are assigned to public-private keys pair, low exposure of keys (privacy ✓) Data transmitted along network are registered on each replica of the ledger	Many users are assigned to public-private keys pair, high exposure of keys Data transmitted along network are immutably registered on each replica of the ledger (immutability ✓)	System operator/registrar creates and assigns keys, inform users on private key importance Disclose writing/committing actors' identity to end-users	System automatically generates key pairs, extend service with secure key stores, inform users on private key importance Verify encryption of data transmitted
	Quality of Service	High processing speed not critical Possible to scale up the system Service available to users	Medium transaction speed possible High possibilities to scale up the system, service can be offered to a wider market All users can access from anywhere	Slow transaction speed possible Difficult to scale up the system and expand to wider target " "	Only transactions that do not require high processing speed Plan system scale up since the very beginning Provide Internet-enabled devices in Internet-enabled areas	Only transactions that do not require medium processing speed Mitigate problem with technical solutions " "
	System Integration	Enterprise system and BCs are stand-alone systems Previous data are not on the BC	Legacy and BC systems are integrated, few other actors join the BC and share information (less difficult, low fragmentation possibilities) Previous transactions are imported on the BC (less difficult)	Legacy and BC systems are integrated, many other actors join the BC and share information (more difficult, high fragmentation possibilities) Previous transactions are imported on the BC (more difficult)	Choose competent software vendor, make sure a blockchain proxy layer is introduced Assess which data are required by applications and where are coming from	" " " "
	Accessibility for Customers	Users access the normal service	Users access the blockchain network or interact with the BC-enabled service	Users interact with the BC-enabled service	Introduce a blockchain proxy layer, instruct users on private key handling, make clear network rules, provide Internet-enabled devices in Internet-enabled areas	Introduce a blockchain proxy layer, provide Internet-enabled devices in Internet-enabled areas
	Management of User Profiles	Handled by a single party, stored in central database	The registrar generates and manages personal keys, roles, access to data	Public-private keys are generated and assigned automatically by the system	The system operator is also the registrar that provides, verifies and records identities	Put in charge a reliable registrar or automatically done by the system
Organization	*Partner Selection*	The offering is provided by the company in collaboration with its partners	The company as system operator expands its current ecosystem and choses critical actors:	The company as system operator expands its current ecosystem and choses critical and supporting actors:		

			The BC provider installs the software and enables the network Few key network participants or stakeholders join the network and contribute with their data	The BC provider installs the software and enables the network Several network participants or stakeholders join the network and contribute with their data	Check about BC provider: use cases developed, capable of addressing CDIs in Technology Domain, network type Assess company's market position and identify access point, clarify actors' and company's roles in the blockchain network, assess information flow and data sharing	" " No need to clarify all roles, partners selected based on standard criteria they respect
	Network Openness	Actors interested in adding value to final product or service can join the offering. The company ultimately decides who can access	Network participants are selected, few critical actors can ask permissions for joining the network and get assigned specified roles, system operator has decision power and checks content BC-based application can be closed access (niche-market)	The access is standardized, actors having specific characteristics can directly join the network without system operator's permissions BC-based application can be open access (mass-market)	Get in direct contact with network participants, clearly explain them roles and activities they are required to carry on, highlight importance of keeping network reduced, compensate restricted access to the system with increased transparency	Impose standard rules dictating who can access the service and what content is accepted, put in place control and punishment mechanism, set up feedback system
	Network Governance	The company has control on service or product offering and who contributes to it	The company becomes the gatekeeper/system administrator/system operator and manages the solution	The system operator can be a consortium of companies, governance less tight and more distributed, each participant responsible for part of process they supervise	Set rights and obligations for each network participants at the very beginning with legal contracts, approve system maintenance and upgrade by asking network participant to vote, arbitrate disputes between parties	Set up scheduled system maintenance and updates, leave disputes resolution to system itself (ex. Smart contracts)
	Network Complexity	The network includes the company and its collaborators	Low (only critical partners)	High (critical and supporting partners)	Involve 2-3 validating nodes and reading nodes	Involve more people, open up system
Finance	*Pricing*	The offer is priced as usual	Embedment of technology in product leads to extra price decided by system operator in collaboration with main partners	Embedment of technology in product leads to extra price chose by voting among many network participants	Direct users are targeted as payers of the service for getting access to it	Direct users and indirect users are targeted as payers of the service for improved Value Proposition
	Division of Investment and Risks / Costs and revenues	Money invested and risks are split among current business actors based on their contribution to service offering	Network participants that contributed the most with resources (mostly data access) also get back more money and share more risks	Investment of resources is voluntary and revenues automatically assigned by the system based on who contributed more	Establish roles since the beginning, monitor and make clear to all network participants investment steps that led to service offering	
	Valuation of Contribution and Benefits	Who contributed most to service offering is also rewarded more	The underlying technology allows for knowing who did what and when and system operator takes care of redistributing benefits	The underlying technology allows for knowing who did what and when and system automatically redistributes benefits	Stipulate contracts among actors deciding amount of reward based on contribution	Put in place rewarding mechanisms (ex. cryptocurrency)

As it was already anticipated in Section 2.8, depending on how extended the computing blockchain network behind the solution is, the value that the BC-enabled process can deliver to final user changes. Some areas in the BM are not impacted by these tradeoffs, for example *Branding*: the choice is in the hand of the company offering the blockchain solution and does not depend on the underlying blockchain network. Areas that are instead impacted significantly are others. *Value Elements* delivered to the target group are performance and confidentiality in case the network is reduced, but switch more into immutability and transparency when this expands. This impacts *Security* and *Quality of the Service* in different ways: when the network is reduced, handling private keys is relatively easier, and the service benefits from improved speed and scalability. *Integration* as well becomes slightly easier when less people join the blockchain network: the smaller the network, the least fragmentation problem and easiness in importing previous data on the new system. However, a reduced network implies decentralization and disintermediation to almost fade away: much power is given in the hands of the system operator, i.e. the company deploying the blockchain network and solution. In the Organization Domain, several areas are influenced by the choice for a reduced network: *Network Governance* sees the system operator being in charge of assigning roles to all network participants, becoming the registrar that manages personal keys, roles, and access to data. *Participant Selection* is critical when the network is small: the system operator has to wisely choose both BC provider and the very first business partners that take part in the network with the company. As long as *Network Complexity* increases, *Network Governance* gets slightly looser and *Network Openness* improves, with the system operator leaving the task of assigning roles to a specifically selected registrar, or installing a standardized procedure that checks participants' compliance to network requirements. *Participant Selection* becomes automatic when the system expands including not only critical actors but also supporting ones. Finally, also financial mechanisms of costs and benefits split are difficult to control by system operator when the network expands because of redistribution of roles and powers (actors contribute in the same way to the system). In that case, the system itself redistributes benefits with some type of automatic mechanism in place, for example cryptocurrencies.

5.6 Conclusions

To conclude, if the use case that the company wish to deploy requires more speed, governance and confidentiality, the firm as system operator must deploy a reduced network at first, wisely choosing critical actors that would give access to important data resources. Then, it has to manage closely the network by assigning roles, controlling which data are shared by whom and intervening in case something goes wrong. Also, it must make sure that network participants are instructed on how BC works, what the system rules are, and what are legal consequences in case these are not followed. Finally, it must underline to the users how the quality of the service is increased and compensate for the loss in immutability by revealing the identity of the network participants to the entire ecosystem. For sake of confidentiality and privacy of the network participants, this could imply that the solution is offered to a niche market instead of a mass market. When the network expands instead, the solution gains in disintermediation, decentralization and immutability, and the system operator can delegate some of its responsibilities to other participants or the network itself. In the next Chapter, the research methodology is explained, the case company is introduced, and one of the use cases mentioned in section 3.2 is selected. Finally in Chapter 7 the framework is applied to the use case chosen.

6 Research methodology

By now blockchain technology has been understood in its functioning, valuable use cases have been identified and the firms' role as system operators (and direct users) has been clarified. The aggregated literature about BM-business process-strategy concepts and relations has been combined with the knowledge about the technology, its value proposition, limitations and tradeoffs in order to originate the conceptual framework reported in Section 5.5. This step needed to be completed before analyzing any company's use cases, and see how BC introduction in firms impacts their operational and strategic level. To validate the insights derived from theory it was deemed appropriate to conduct a case study that would allow to understand better how a company in real world analyzes the current BM of the offering and modifies it into a BC-enabled one.

As of now, no theory exists that relates the implementation of BC in corporate environment with the expected changes at the Business Model level. Literature is scarce or inexistent about how the firm deploying BC manages to create, run and maintain the network with its partners. Even less is said about application creation on top of the network and financial exploitation. It can be firmly stated that the topic of BC in a corporate environment and its comings is not at all explored and the problem needs to be studied more clearly. Therefore, it was deemed appropriate to maintain an **exploratory approach**. Exploratory research helps gaining familiarity with the phenomenon that is still not well known and formulating a more precise problem by accumulating experience (Wikipedia, 2018). The research indeed does not aim to give specific answers to the problem, but rather to highlight key issues and to suggest topics for further research (Dudovskiy, 2017). An **exploratory case study** in particular helps answering *how* and *why* a specific event has happened, in this case how a company explores the BC-BM relationship, how it prepares for changes in the BM, and why it gives more importance to specific BM areas along with the exploration. Hereafter it is explained how the exploratory case study has been conducted.

6.1 The selection of the case company

First a company has been selected for BC application. The Group established in a mid-European country more than 150 years ago and has expanded its global presence over 140 countries. As of 2017, the Group has reached a total of almost 11,000 employees. The Group is mainly a B2B (Business to Business) corporation, and their expertise includes mechanical and thermal processes engineering. Their expertise is applied mainly in the **fast-moving consumer industry**, such as cereals, rice, and coffee processing, targeting any kind of food and feed manufacturing industry. Values such as quality and safety drive the business, which aims at **increasing efficiency**, **improving traceability** and reducing food loss along the process. The Group is also active in the automotive and chemical industry, including inks and pigments processing. They provide comprehensive solutions inclusive of machines and systems, and on top of that several services (installation, maintenance, repair), training courses, application centers (where they come up with and test solutions with customers), and consulting assistance.

6.1.1 Core competences and strategy

In general, being process expert and integrated solutions provider, the Group core competences are:

- Reproducing machines that can be customized around the process based on customers' needs and requirements, to offer fully tailored experience;
- Collecting data coming from process and machines and analyze it, to allow the creation of innovative services such as predictive maintenance;
- Training customers on how process and machines work, to put them in full control of the process, so they can optimize it and improve performances.

In particular, the data collection and analysis business has recently become solid part of their strategic framework, strongly facilitated by the increasing trend of digitalization in industry. The Group sees **digitalization** as a powerful tool for controlling process quality, enhancing transparency along the value chain and improving machines and systems efficiency. Moreover, the trend allows the Group to better comply with one of the main company's characteristics in doing business: to continuously focus on customers. Indeed, digitalization allows customers to reduce costs by monitoring better the process, thus reducing energy use, improving quality, increasing differentiation, and reducing downtime. Following this commitment, the focus on Industry 4.0 has steadily increased recently going towards IoT development.

Together with digitalization, another main pillar of the Group strategy is **sustainability**, achievable not only by improving machines' performances, but rather by integrating value chains across entire systems according to the Group. The company follows a **product differentiation** strategy: the Group gains competitive advantage by enhancing the perceived value of its own products and services by assuring high quality and offering full customization to their customers.

6.1.2 Ecosystem and trends

For what concerns the food industry, the Group provides partial or complete solutions (including machines and services) to raw material stockers and food processors. These constitute only two of a vast range of actors that are active in the food supply chains all over the world, and includes farmers, transporters and carriers, wholesalers, retailers, and final consumers. The entire chain is supervised and closely controlled by regulators appointed by governments and authorities making sure food supply chain steps occur according to standards set by standards organizations, such as certifiers, inspectors and auditors. The digitalization effort particularly interest this business, following the increased demand for transparency and traceability required not only by final consumers, but from all intermediate actors along the supply chain. Indeed, who bears the majority of the risk in terms of reputation and then revenues when food does not meet quality or safety standards are those in direct contact with final consumers, i.e. retailers (supermarkets) and restaurants, food chains, etc. Other parties involved are intermediaries such as banks and insurance companies. Also the general public and academics keep an eye on the Group development and businesses.

To conclude, the company has made food safety and transportation sustainability its main focuses and was chosen for several reasons. First, the Group has established in time **solid partnerships** and has built a strong reputation among ecosystem actors as reliable and trustworthy. This grants them the possibility to be system operators, establish and run the blockchain network and get access to (critical) business data that might add value to several actors along the value chain. Second, considering the nature of the business, in particular its size, its interactions with suppliers, clients and general public, its business areas dealing with high-value commodities that are at the same time likely subject to fraud, the company would benefit from **increased transparency** along their processes, streamlined interactions and **information exchange** seen the extension of the networks the operate in, and in general improved synergies across value chain. Finally, the area in Europe in which they operate sees companies experimenting with latest innovations and making them source of competitive advantage; the Group itself has been massively digitizing in the last half decade.

6.2 The selection of a use case

A specific cross-organizational use case that the Group could benefit from was selected after conducting an interview with the company's CTO and proposing the use cases already mentioned before, in particular Instant payment networks, Lightweight financial system, Shared customers' metadata, Intra-company clearing and settlement, and Supply chain management and Provenance tracking. The Group is in need for driving new Business Models and exploring possibilities for expanding the service offering that has already established. This is why **Supply chain management and Provenance tracking** use case was selected. In particular, the discussion interested since the beginning the food processes rather than the automotive and chemical ones, because of clear benefits that the **food supply chain** could derive from BC applications, such as **transactions efficiency**, better **risk management** and improved **transparency**. It is believed that blockchain could represent a key part of a solution improving the food chain traceability, thus grating better food safety.

The CTO was asked to evaluate the tradeoffs reported in Section 2.8 and give his opinion on how the supply chain solution would have looked like. He observed that actors that are going to deal with the supply chain use case value the **performance** of the underlying system in terms of transactions speed: events regarding assets movements must be sent to the network and timestamped immediately to allow a real-time visibility on what is going on. **Scalability** as well must be granted: the system must efficiently work even when it expands including new actors and cannot experience huge decrease in performance. Network participants clearly care about the system to be immutable, but they also have the necessity to refer back to established authorities that would help solving issues as long as they come out. Business contracts characterize any corporate reality, so he considered the establishment of **legal agreements** between network participants (in the end, other organizations) a feasible solution for grating ledger immutability. Finally, **confidentiality** represents a sensible topic in any business environment, so data sharing would happen only when people supporting the BC solution well know each other and are confident about the identity of other network participants.

6.3 Data collection

Information about the company's processes, ecosystem, partnerships, products and so on have been collected during a 6-month internship conducted at the case company's site. In particular, data have been collected by means of:

- *Participant observation*. This represents a powerful tool for collecting information as business insider about company's people, processes and culture in qualitative research studies. Particularly important was to report impressions by taking part in the firm's activities, such as meetings, conferences, etc. The most important input came from the Innovation Day held 3 months after the start of the internship. This constitutes a one-day long conference in which all people from the company involved in some type of digitization project (ex. IoT platform, digital services, etc.) meet and discuss the current situation and the strategic initiatives of the Group. Importantly, it was confirmed the ongoing partnership with the current software vendor and the intention to build on top of their cloud several services, among which also blockchain initiatives. In general, participant observation is recognized as a way to increase the validity of the study, that further improves when it is supported by other strategies such as "interviewing, document analysis, or surveys, questionnaires, or other more quantitative methods" (Kawulich, 2005).
- *Face to face discussion (internal)*. The opinion from key business people, such as the company's CTO, data and IT expert, strategic managers and financial people supported the analysis. Indeed, the biggest contribution of the study comes from unstructured interviews, conferences, panel discussions, and small talks conducted with company ecosystem actors. In particular, topics of discussion were how the identified process works, who is involved, how do information and product flow work, what is company's position in that ecosystem and how the ecosystem would react to planned changes in the current service offering. The following actors were consulted along the research and they are listed in order of frequency (the higher, the most frequently interviewed):
  - ➢ D.B.: The former project manager assigned to BC research represented a fundamental input. He updated on the research conducted till the start of the internship, what were challenges faced till that moment and gave recommendations on how to proceed. Also, important suggestions on use cases, weak/strong point of each use case, and potential technical partners to involve was also his input.
  - ➢ I.R.: The Group's CTO was helpful in understanding better the company's strategy, why they wanted to develop blockchain and in how long. Meetings for updating him on the research development were held every month. These meetings served as approval for continuing the research in the same way, or for modifying the focus of the research.
  - ➢ S.B.: The Group's Digital Officer focused on a more operational level than the CTO and was consulted to get a better overview on development possibilities, i.e. how the company would have seen better the BC development also in relation with the digitization push that came out in the last years.
  - ➢ One data scientist and one master data manager were asked about the data situation of the company, how data were collected, managed and further used. They were interviewed for knowing about integration possibilities.
  - ➢ Two process engineers were interviewed to understand better how the current processes of the company work and what were pain points the Group's customers along each process.

- One data scientist and one research engineer were asked about other digital services that the company offers or intends to offer. They were asked about digital Business Models and data sharing challenges that the company met already and which solutions were put in place.

- *Corporate documents*. The company's Intranet and website were important sources of documents that complemented the analysis, such as:
  - Monthly reports: these informed about the overall strategy of the Group and development path intended to be followed.
  - PPT presentations from Business Units: these reported the specific strategy of and the processes belonging to each business unit, together with name of reference people responsible for each department.
  - Fliers targeting clients: these were helpful to have a look at offered products, value proposition and intended target.
- *Face to face discussion (external)*. Others actors external to the company and already involved in the technology implementation were interviewed, such as technology experts or blockchain solution providers in the food industry.
  - Gideon Greenspan, CEO of Multichain. He was interviewed one months after the start of the internship (20/03/18) to consult about meaningful BC use cases and deployment challenges regarding permissioned blockchains. In particular, he clarified the role of the system operator and gave recommendations on network participants' involvement.
  - The BC fair held in the Netherlands (Amsterdam, 27-28/06/18) was extremely helpful to have a look at BC providers, integration possibilities, use cases, collaboration incentives, data sharing challenges, etc. In general, it gave a much clearer understanding about the current landscape with BC for business and enterprise.

When studying a specific phenomenon indeed it is important to use two or more methods of data collection so that the same result obtained by using different information sources becomes stronger and more credible. A useful way to check whether results correspond and data collected are valid is *triangulation*, a method that helps researchers capturing different dimensions of the same unit of analysis (Write, 2018). In particular, the approach followed here is *methodology triangulation*: different methods are used to collect data (ex. Unstructured interviews and Intranet reports) and the information gained are compared to check if they complement each other (Write, 2018).

6.4 Conclusions

To conclude, the company has made food safety and transportation sustainability its main focuses and sustains its competitive advantage by selling its know-how, by being in contact with a wide customers' network, and by offering cutting-edge solutions to its business areas. In this context, it was deemed appropriate for the Group to be chosen as case company several reasons. First, the Group has established in time **solid partnerships** and has built a strong reputation among ecosystem actors as reliable and trustworthy. This grants them the possibility to be system operators, establish and run the blockchain network and get access to (critical) business data that might add value to several actors along the value chain. Second, the company would benefit from **increased transparency** along their processes, streamlined interactions and **information exchange** seen the extension of the networks they operate in, and in general improved synergies across value chain. Finally, the area in Europe in which they operate sees companies experimenting with latest innovations that become source of competitive advantage. After consulting with the company's CTO, the use case Supply chain management and Provenance tracking has been chosen as application to be deployed on food processes. It is believed that blockchain could represent a key part of a solution improving the food chain traceability, thus granting better food safety.

Finally, data collection methods have been listed. The most important have been unstructured interviews with key management and process engineers in the company. Participation in internal and external conferences has allowed for clarifying better company's role and the environment in which they operate. Unstructured interviews and face to face talks have been useful as well for exploring blockchain deployment possibilities in the food industry and use cases already deployed within the market.

In the next Chapter it is envisioned the exploration the company might conduct when changing the current BM and moving towards a BC-enabled one. The exploration is derived from theory and supported by the conceptual model reported before. In particular, recommendations are given on which could be the underlying software provider to partner up with, the BC network to set up and the services to build on top. Finally, suggestions are compared to how the exploration was actually performed by the company, what was done differently from the theoretical exploration and which impact technical tradeoffs had on BM exploration.

7 Implications for the choice of blockchain on the company's BM

Once the company has been analyzed, it becomes clear the potential the Group has to enhance with BC introduction the value proposition of the services it already offers along the food chain and support them with modified or completely new Business Models. The second step was about selecting the product or process to embed with BC technology. Then it comes the assessment of the validating ecosystem, the choice of the software provider, the selection of target group and the value proposition offered, including rewarding and paying mechanisms for both direct and indirect users. The following chapter describes in detail the steps that the case company was suggested to follow when exploring the relationship between BC and BM.

7.1 The processes

First, it was identified which food supply chain would benefit most from the technology characteristics. The high-value items that the company processes through its machines that were considered valuable for a BC application were **coffee**, **chocolate** and **nuts**. These three processes present some similarities. In general, at the very beginning it is identified a collection point: the harvest, i.e. cocoa beans, chocolate beans and nuts, is picked from different farmers and collected in one centralized point. From that moment on the rough produce passes from trader to trader (exporters/importers) that serve as link between the farmer and the very first processing point. Some preliminary processing steps, such as cleaning and sorting, are usually carried on already by the traders as first screening to remove major imperfections. After the trading, the produce reaches a stock point at the food processor site and waits to be further processed. This point can be physically located in the country of origin or in the destination country, depending on the processor's logistics. The actual process that the case company is able to control starts only now, when the rough material has already passed from hand to hand and it is now owned by one company (or the first in the value chain) that will industrially treat the rough material to obtain the final product that is sold to distributors and retailers.

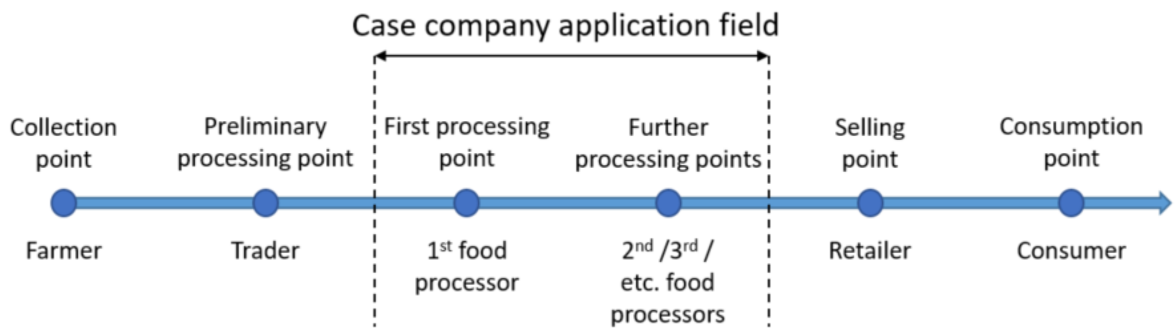

Figure 10 Case company value chain

When analyzing the product and information flow that characterize the processes, it can be noticed that independently of coffee, cocoa or nuts, three major problems affect these specific food value chains:

- ➔ It might be that the information on the country and the region of origin, together with the certifications earned by the farmers, passes on till the consumption point. However, information about the farm of origin and how much each farmer contributed to the total harvest is firmly kept by traders and gets lost before reaching the final consumer. Once the total produce has been collected, traders pay farmers a price that is convenient to them and then resell the total amount to other traders or to the first food processor at a price that largely benefits them. Obtaining a **proof of provenance** together with a proof of fair **working conditions** would give retailers and consumers more confidence in the food source. Moreover, the farmers would benefit as well from owning data that testify how much they produced of the total harvest.
- ➔ The visibility on what happens to the harvest from collection to first industrial processing point is definitely reduced. While it passes from hand to hand, the produce usually gets stolen,

counterfeited, diluted, etc.: who manages the harvest has almost complete decision right on the produce's destiny. However, very first food processors suffer from the lack of information on **product journey**. Indeed, what they strive to know is the change in weight that the product went through, so they do not pay extra money for both buying and processing a product of lower quality than they expected. The information they miss it's the total amount of product a certain farmer or group of farmers declared to have produced, so they can check whether the amount (in weight) they are processing is far or close to the declared one.

➔ Finally, some steps that food processors perform are particularly critical for granting the quality of the product: these are **sorting and debacterisation**. Information on the actual realization of these processes according to standards is of particular interest for retailers that usually bear all the risk when products are recalled from the market for safety reasons. Being able to monitor the conditions under which the product went through would allow retailers to efficiently spot fault points along the process where conditions were not met and solve disputes faster.

7.2 Network participants involvement

Once the potential value chains were selected, it was necessary to identify critical partners that the company would involve in the network. Key participants had to be interested in adding data in an immutable way, checking what happens along the value chain and which transactions are sent to the network. Six actors were identified along the food supply chain, together with characteristics they should have and examples (whenever possible):

- **Farmers:** they own their data about total harvest and keep information in a secure and immutable database. They also get certifications testifying their farming practices and improve their credibility in front of food processors.
- **Food processors**: they want to get recognition and market advantage compared to competitors for following certifiable and ethical sourcing practices. They also want downstream actors to know that certain critical process steps have been followed without the need for long auditing steps and checks from authorities. How to choose them:
  - ✓ They already had food safety issues and could not recognize the source of disease outbreak;
  - ✓ The raw material passes through several steps that need to be checked before reaching them.
  - ➔ Examples: Nestlè, Mars Food
- **Retailers**: they bear the risk for any problem happening upstream and need to protect both consumers and their brand. By joining a BC network as validating nodes, they benefit from the improved transparency and monitoring, reduced risk, faster checking and dispute resolution time. How to choose them:
  - ✓ They already had their image impacted from lack of transparency on the food they sell or had to run massive product recalls;
  - ✓ They have already experimented with BC, are soon going to do that, or at least are familiar with the technology.
  - ✓ They get products from food processors equipped with the case company's machines;
  - ➔ Examples: Coop, Walmart
- **Regulators**: by viewing all the information on the shared ledger, they ensure food safety and immediately recall impacted products. The "access the ledger by running a node themselves (…), or (…) obtaining selective disclosure into some agreements" (Hileman & Rauchs, 2017, p. 64). In this way monitoring and auditability happens real time and in an easier way. How to choose them:
  - ✓ They suffer from paper-based and time-consuming checking and auditability processes;
  - ✓ They have already experimented with BC, are soon going to do that, or at least are familiar with the technology.
  - ➔ Examples: SGS

- **NGOs**: as supporting entity, they might be interested in getting an overview on practices followed along the supply chain, in particular in terms of working conditions and process sustainability. They as well can run a node on the blockchain and benefit from the increased transparency gained along the process.
- **Final consumers**: they increasingly demand detailed information about what they buy and need to have confidence in products. Also, they want to make sure they only support brands that align with their own value and that make their practices transparent.

Considering the CTO's opinion reported in Section 6.2, it was deemed appropriate to have a **reduced network** supporting the Supply chain use case, at least at the beginning, with the Group playing the role of the system operator. Therefore the most appropriate **access point** to start with were considered **food processors**. In particular, the case company should choose a food processor that has a good overview on the good movements and that is currently using their machines along most of the process. Close and long-lasting collaboration and tight process integration is what would guarantee the Group a convenient access to process data and in general favor data sharing.

7.3 Software provider collaboration

It is important to underline the ongoing partnership and collaboration the Group maintains with a well-known Software Vendor (from now on called SV) and the digital services they are already building on their cloud. In particular, SV's cloud computing, networking and storage services facilitate the creation of scenarios and applications on three of the most famous blockchain platforms, R3 Corda, Hyperledger Fabric and Ethereum. The solution SV provides is a piece of software that once installed deploys the network, consisting of a set of transaction nodes, with which an application or user interacts to submit transactions, or mining nodes to record transactions on the ledger. Let's first explain the differences between the three platforms and which one could be the most appropriate for the case company.

Most of Corda's use cases are applied in the financial services industry. This is mainly thanks to the already established network they formed since 2014 that allows them to build several applications on top of it. So Corda it is not chosen as blockchain provider in this case. The choice has to fall on Fabric or Ethereum. Fabric can develop use cases for several industries by providing "a modular and extendable architecture" (Sandner, 2017). Ethereum is a generic BC platform as Fabric is, but better known for the freedom it guarantees in building any type of application and use any type of transaction. Moreover, Ethereum supports an easy development and embedment of smart contracts on the BC. Another difference between the two is that Ethereum runs a permissionless network that anyone can join, while Fabric builds on top of a permissioned one. It is important to notice that applications can run on top of both permissioned or pemissionless network and still be open or closed access. However, applications running on Ethereum might have issues of transactions processing performance and privacy, problems that are avoided with Fabric. Particularly because with Ethereum anyone can join the network, become a computing node and assume all roles, while these are differentiated in Fabric based on whether they are clients (or writers), peers (or committers) or orderers (ordering transactions received by clients and forwarding them to peers). This allows for "fine-grained control over consensus and restricted access to transactions which results in improved performance scalability and privacy" (Sandner, 2017). Another difference lies in the fact that use cases can be developed with Fabric without the need for a cryptocurrency to be deployed within the network since nodes do not reach consensus via mining. It is however possible with Fabric to develop a native currency or tokenize assets and create digital tokens (Sandner, 2017).

Thus, the most appropriate BC development space would be **Hyperledger Fabric**: only specific business actors join the network and have assigned roles and responsibilities. In particular Hyperledger platform has already been used for the deployment of food chain use cases, such as the tracking of tuna fish from bate to plate (Paul M. S., 2018). Instead, if the information reported want to be public and be accessible to a wider network that also includes the final consumers on a later stage, the best choice becomes the Ethereum platform (second phase service, see Section 7.6).

7.4 Services and target group

Services that could solve the issues mentioned in 7.1 are **provenance attestation**, and **environmental and process monitoring**, created in collaboration with the SV using the Hyperledger toolkit.

7.4.1 Provenance attestation

The case company identifies a region where there are multiple coffee, cocoa or nuts producers serving as input for the food processors that the Group serves with its machines and makes sure each of them have earned specific certifications, for example Organic or Fair Trade. Only when farmers prove to be certified, the case company provides each of them with access credentials for registering on the ledger how much product they harvested, when and at which collection point they delivered it. It also makes sure that the harvest from each producer is put in special bags allocated to each famer and traceable by means of sensors and labels.

When the rough material arrives at the factory, the food processor easily verifies from which exact piece of land the product comes from by comparing the bin label with the info reported on the BC. Moreover, she is sure that the farmer was certified for inputting data on the blockchain. If the product respects quality standards expected by the food processor, famers get direct credit for their farming practices. If the product it is of lower quality than expected, the processor easily recognizes a possible source of fault.

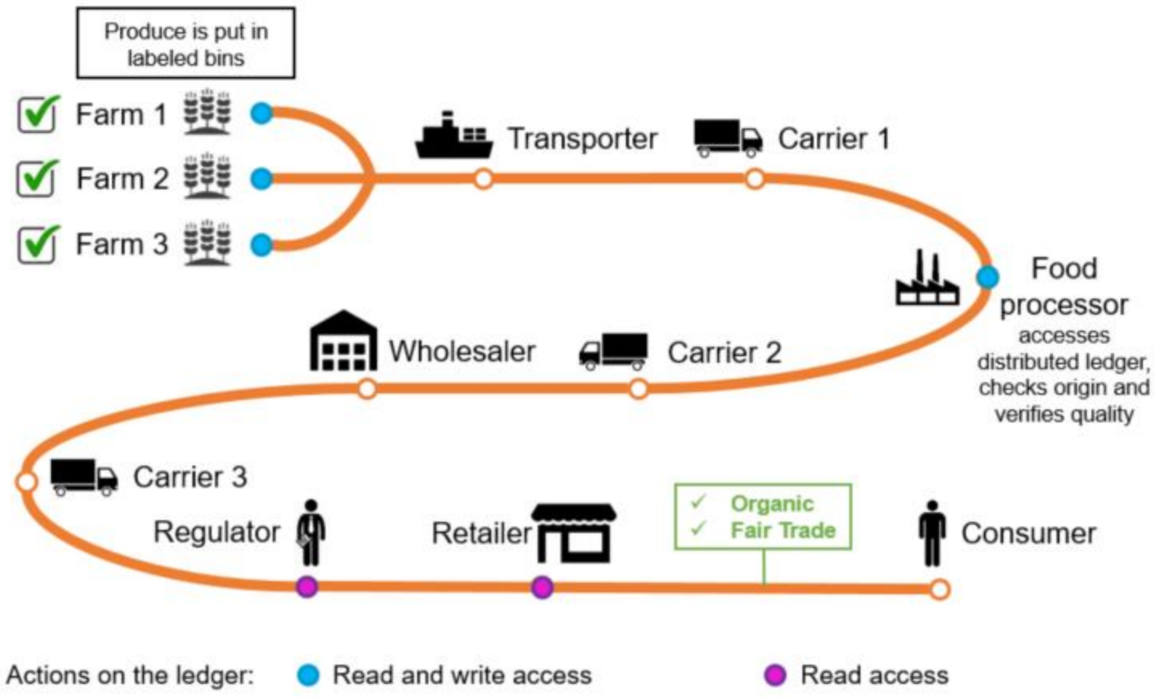

Figure 11 Provenance attestation service and actors' access rights

7.4.2 Environmental and process monitoring

Assigning traceable bins to each farmer allows the factory to do more than precisely identify the source of produce. In case the Group would embed bags with sensors monitoring state and environmental conditions, it becomes possible to add to the ledger information such as bins' weight, temperature and humidity changes experienced during transportation. The factory processes the rough material through the Group sorting machines that are embedded with sensors and send to the ledger information on the amount of food that has arrived to be processed. Any addition or loss or weight is confirmed and the exact point in which foreign material was added or removed can be clearly identified. Temperature and humidity instead help the food processor identifying possible faulty points along the supply chain that could explain the lower quality of the product. Thus the second input on the BC is added by the food processor that specifies how much product has been processed in total and how much discarded.

The food processor is now responsible also for the third input in the ledger, i.e. confirming that the debacterising process has been conducted on all the produce according to regulations. Again, the Group debacterising solutions embedded with sensors send to the ledger the amount of produce that has passed through. Both regulators and retailers can then check the sorted and debacterised amount correspond. However, the main benefit that regulators and retailer obtain from monitoring environmental and processing conditions is an easier auditability and dispute resolution. Indeed, retailers can spot fault points and enforce contractual penalties, whereas regulators are sure the process has been conducted with the Group's machines that automatically ensure quality and safety of the products they process. By means of smart contracts the process is even easier and faster: the system notices almost real-time if conditions are not met, stores immutable information for everyone to audit and check, and automatically imposes fines to supply chain actors.

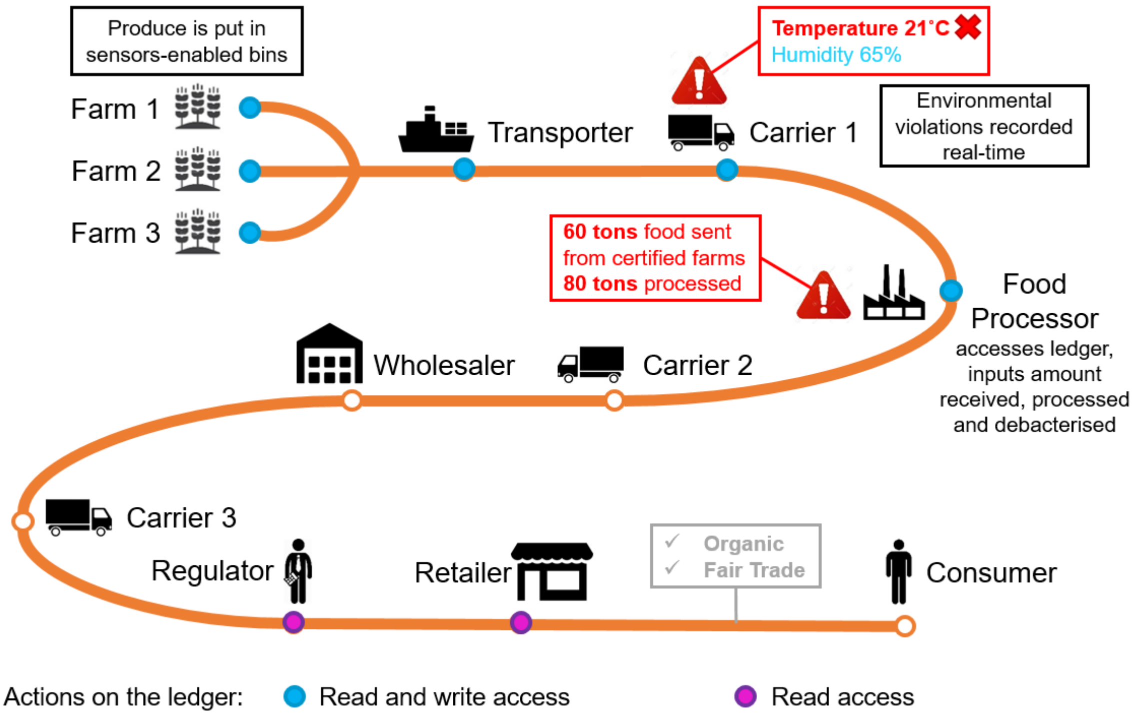

Figure 12 Environmental and process monitoring service and actors' access rights

The main users and data contributors of both services would be farmers and food processors. Added value for farmers comes from owning their data about total harvest and keeping information in a secure and immutable database. Moreover, they get certifications testifying their farming practices and improve their credibility in front of food processors. These instead enjoy the enhanced service offered by the case company that now allow also them to own their data, minimize risks and improve their image with retailers. Indeed, now they can testify they access to ethical sources, they strictly follow processing practices and they delivered in time and in-full.

7.5 Monetization

The last issue to address regards the Financial Domain, in particular, how does the case company make money on top of the BC-enhanced service that it offers. To motivate the ecosystem in validating and timestamping transactions, a symbolic token must be deployed among nodes. The network will see exchanges of tokens that correspond to a real fiat currency. At this point it is important to make a distinction between customers and end-users: customer is the one that pays for the service, end-user is the person that actually uses the service (Bouwman, De Vos, & Haaker, 2008). For the previously described services the main customer is identified as the food processor: she pays for using the machine and with it being able to input data on the blockchain. Optionally, retailers can also be customers in case they would pay a fee for getting access to the network. The money flow deriving from the food processor (and the retailer) directly reaches the farmer, which gets paid based on amount of harvest declared. Assuming that each machine the Group provides is linked to a symbolic asset on the BC that corresponds to a real-life asset (ex. A bank deposit), several pricing mechanisms can be imposed by the case company, some examples are given below:

- Money are detracted at the end of each month or year based on usage fee and occurred maintenance or repair expenses. The extra harvest that the farmers didn't declare but the factory processes is paid more, but normal usage fee is kept low;
- Same as before, but normal usage fee is higher because extra harvest is processed at the same price of declared one;
- Independent of usage, a fixed asset is paid upfront by customers each month or year. The case company amortizes changes in usage and presence of extra harvest.

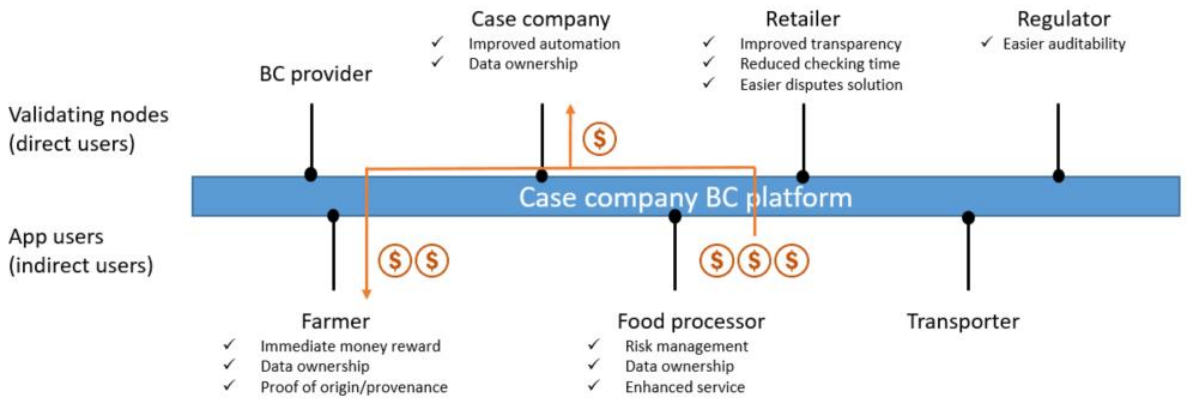

Figure 13 Monetization mechanism

Food processors are however also end-users of the service, together with farmers, retailers, regulators, and the case company. The case company gets a commission on the transactions happening between the food processor and the farmer as legitimate validating node and network operator.

7.6 Step-by-step development

The BC deployment in the case company is likely to follow a step-by-step approach that sees the BC solution being first offered to the previously mentioned actors, and only on a later stage being expanded to transportation and final consumption part of the food supply chain. In particular, final consumer might be able to access the service and vote for product quality, with the farmer getting a direct reward and the Group getting again a fee for every vote or based on how much the consumer rewards the farmer.

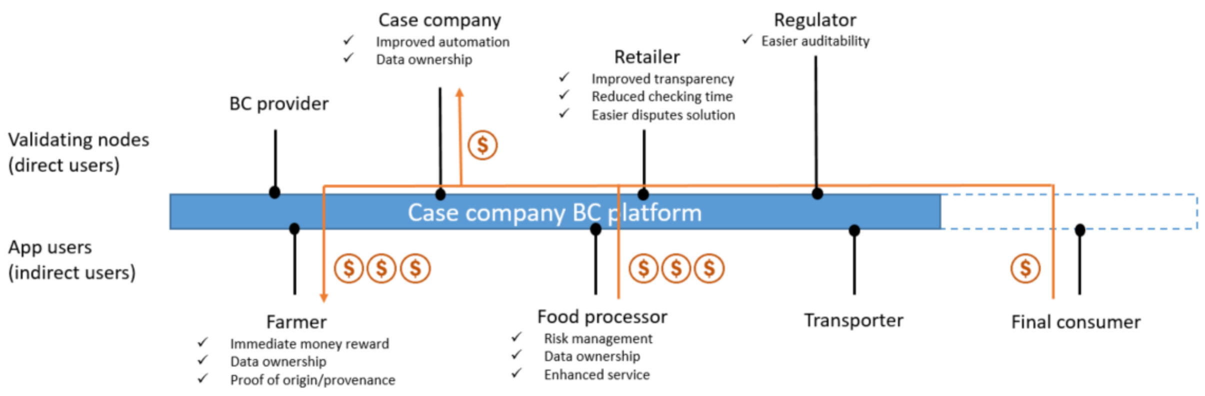

Figure 14 Monetization mechanism, second phase

7.7 Implications on Business Model

A reduced framework is introduced to analyze better which implications BC introduction would have on the current BM of the case company. Again, the computing network behind the supply chain use case would be a reduced one, with food processors and farmers as very first key network participants. Others joining the network with read-only access could be regulators and retailers.

Table 4 Reduced framework applied to case company

		Case company process	To-be	Transition
Domain	CDI	As-is	Reduced network	Reduced network
Service	*Target*	Food processors	Food processors + farmers + regulators + food retailers	Instruct actors on how BC works and added benefits
	Value Elements	The service would benefit from: Improved visibility and transparency Reduced transaction time Improved automation	Material movements and ownership change visible to few actors (confidentiality ✓) Medium transaction speed (performance ✓) Contractual relationships are managed by smart contracts	Design data diffusion and stipulate legal contracts among actors for data breaches (in particular farmers and food processors) Supply chain transactions that do not require high processing speed Translate real-life contracts into smart contracts
	Branding	Actual partners collaborate in delivering solution	Network participants support the BC-enabled service built on Hyperledger Fabric	Align partner's value proposition, communicate partnership to end-users
Technology	*Security*	Access to service regulated by service provider with usual credentials Information stored on central database	Few users are assigned to public-private keys pair, low exposure of keys (privacy ✓) Data transmitted along network are registered on each replica of the ledger	Case company as system operator creates and assigns keys, informs users on private key importance Disclose writing/committing actors' identity to end-users
	Quality of Service	Possible to scale up the system Service available to users	High possibilities to scale up the system, service can be offered to a wider market including final consumers All users can access from anywhere	Plan system scale up since the very beginning Provide Internet-enabled devices in Internet-enabled areas, particularly first mile (i.e. farmers)
	System Integration	Enterprise system and BCs are stand-alone systems Previous data are not on the BC	Legacy and BC systems are integrated, few other actors join the BC and share information (low fragmentation possibilities) Case company helps network participants importing previous transactions on the BC	Make sure a blockchain proxy layer is introduced Assess which data are required by applications and where data are coming from
	Management of User Profiles	Handled by a single party, stored in central database	The registrar generates and manages personal keys, roles, access to data	The case company is also the registrar that provides, verifies and records identities
Organization	*Partner Selection*	The offering is provided by the company in collaboration with its partners	The case company as system operator expands its current ecosystem and choses critical actors: The BC provider installs the software and enables the network Few key network participants join the network and contribute with their data, in particular food processors and farmers	Check about Hyperledger: use cases developed, capable of addressing CDIs in Technology Domain, network type Assess company's market position and identify access point, clarify actors' and company's roles in the blockchain network, assess information flow and data sharing
	Network Openness	Actors interested in adding value to final product or service can join the offering. The company ultimately decides who can access	Network participants are selected, few critical actors can ask permissions for joining the network and get assigned specified roles, system operator has decision power and checks content	Get in direct contact with network participants, clearly explain them roles and activities they are required to carry on, highlight importance of keeping network reduced, compensate restricted access to the system with increased transparency

	Network Governance	The company has control on service or product offering and who contributes to it	The company becomes the gatekeeper/system administrator/system operator and manages the solution	Set rights and obligations for each network participants at the very beginning with legal contracts, approve system maintenance and upgrade by asking network participant to vote, arbitrate disputes between parties
Finance	*Division of Investment and Risks / Costs and revenues*	The case company invests more money and gets more risk, all other actors contribute with data	Network participants that contributed the most with resources (mostly data access) also get back more money and share more risks	Establish roles since the beginning, monitor and make clear to all network participants investment steps that led to service offering
	Valuation of Contribution and Benefits	Who contributed most to service offering is also rewarded more	The underlying technology allows for knowing who did what and when and case company takes care of redistributing benefits	Stipulate contracts among actors deciding amount of reward based on contribution

The very first changes happen in the Organization Domain. The Group would become the system operator (also registrar) and expand the ecosystem around the coffee/cocoa/nuts process by involving not only their established clients, i.e. the food processors. The case company would need to involve the food processor's ecosystem made up of farmers, regulators and retailers. It becomes fundamental to clarify the new roles and activities of the case company and of all actors taking part in the BC network. Information flow would now be different, with the case company interacting with new actors that didn't have to share their own data with the Group before. The increased power and information access that the Group would get should be regulated by legal contracts that would report rights and obligations of each participant and the consequences of not respecting the contracts. To motivate stakeholders in taking part in the network, the Group should conduct several group sessions in which it is explained how BC works, what are public and private keys and how to use them, and which are the benefits of the BC-enabled solution. In particular, it should be highlighted the importance of keeping the network reduced and the gain in process visibility and transparency such a choice implies.

Together with addressing the Organization Domain, the Group should take care of the Technology Domain. Indeed, the company should make clear the drawbacks of a reduced network, such as reduced disintermediation with most of the power in the hand of the system operator, the possibility for the system to be not completely immutable, etc. At the same time, it should show them as solvable problems because of addressing technology limitations by partnering up with a competent software provider. The partnership with such a provider and the building of the solution on a known BC platform should reassure ecosystem actors that while integrating BC in the current process, public-private keys are kept safe, privacy issues are addressed, that a BC proxy layer is in place, that data in the legacy systems are safely transmitted and stored in the new BC system, etc. Also, it should be highlighted the effort the Group puts in maintaining the solution and taking care of disputes resolution still giving the entire network the possibility to express their opinion through voting. The translation of multiparty agreements into smart contracts results to be a delicate issue. Indeed, this would mean clearly assign responsibilities to all network participants and subdivide the process in areas of accountability. It should become clear who does what, when and how, and actors can agree on automatic fines (who pays how much in case of what). Partnership with the BC provider is particularly important when smart contracts must be coded and the source from which they retrieve data must be established and agreed upon.

Once critical partners are on board, the Group should be able to practically show which changes happen in the Service Domain. The same service that the company offered so far would be now improved by involving a larger ecosystem in which information sharing happens real-time and in a transparent way, but still ensuring good performances and data confidentiality. In particular now the company should continuously communicate its value proposition, its intention in offering such an enhanced service and should stress the possibility for network participants to refer back to them whatever would happen with the BC-enabled solution.

Finally, changing roles and responsibilities of each actor around the process impacts the Finance Domain as well. In particular, by becoming the system operator, the case company would see an increased responsibility and risk in managing the system. On one side, this could be a convincing motivation for actors to join the network: less power, less risk, less costs. However, this might lead to problems whenever the BC-enabled offering has to be priced or revenues have to be split. Again, legal agreements should be stipulated in real life to make sure problems that might arise between network participants are anticipated or avoided.

7.8 Road map

To pass from the first (business process "as-is") to the second column (business process "to-be") of the model it is also necessary to carefully plan business activities that would allow such a transition. Indeed, the switch from the existing BM to the desired technology-enabled version of it has to be gradual, particularly if the technology introduction impacts resources configuration (De Reuver, Bouwman, & Haaker, 2013). To structure and analyze better the path the case company intends to follow, the Business Model Roadmapping approach proposed by De Reuver et al. (2013) is proposed:

1. The major **changes in the current BM** are identified, in particular the partnership with new business actors, the collaboration with a BC provider, and of course the implementation of blockchain technology in the current process.
2. **Impact of the changes** on other BM domains is analyzed, such as the need for imposing a new governance structure in which data collection and sharing happens differently from before, the enhancement of the original service Value Proposition, and the likely establishment of a different revenue stream.
3. Planned changes are translated into **specific business activities**, such as the wise selection of critical partners (BC provider and network participants), the introduction of an integration layer to make sure BC is integrated with the current systems and the service is made accessible to all users.
4. Once the needed actions are listed, these can be **visualized in a road map** that better shows dependencies between actions.

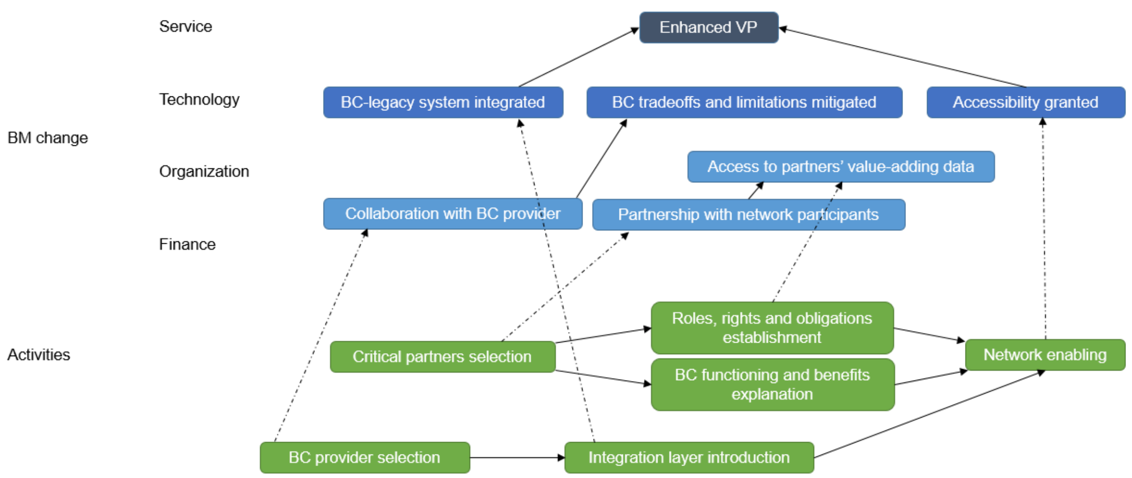

Figure 15 BM road map for BC-enabled offering

Domain	BM change	Explanation	Activities required to enable the change
Service	Enhanced Value Proposition	The Value Proposition of the current offering must be enhanced by BC Value Proposition and must clearly result from product/service usage	
Technology	BC and legacy system(s) are integrated	The company's and stakeholders' legacy systems need to communicate and exchange information with the BC seamlessly	Integration or proxy layer introduction

	BC tradeoffs and limitations are mitigated	BC issues have to be addressed or mitigated so that BC benefits are not badly affected	
	Accessibility is granted	The product/service must be made accessible to direct and indirect users by enabling the physical (devices and Internet) and technical (integration layer) infrastructure	Network enabling
Organization	Collaboration with BC provider	The company does not build in-house BC, so it needs a software vendor providing BC	BC provider assessment and selection
	Partnership with network participants	To enable the network and build applications on top the company needs to partner up and sustain relationship with actors that will join the network	Access point identification and partner selection
	Access to partners' value-adding data	Business data of some value need to be added to the BC	Rights, roles and obligations are clearly established

The roadmap proposed wants to be a figurative summary of what was already mentioned in Section 7.7 and make clearer the proposed order in BM exploration. The figure and the table were created by the author to be then presented to the CTO's of the case company to get an approval or a rejection of what was proposed. The full lines drawn in the picture establish dependence between activities. For example, it is not possible to access partners' data without establishing a partnership with network participants beforehand. Dotted lines instead connect activities influencing each other. For instance, the establishment of rights and obligations among actors it is supposed to facilitate the access the case company gets to partners' data.

7.9 Conclusions

To conclude, this chapter clarifies the case company's position and the processes proposed for developing the first instances of blockchain application, in particular, the **food supply chain** limited **from farmers to first food processors**. The process has then be described in terms of information and product flow, the major problems characterizing the flows, and the actors involved in such a process. In case the chosen BC provider would be Hyperledger, this would give the possibility to the case company to autonomously build their own BC network of validating nodes. These have been explained, together with the benefits each of them would get from a BC-enabled solution proposed by the case company. If instead the solution is built on Ethereum, this would stay public and allow a wider ecosystem to develop around the BC application, including final consumers. Services and applications that make sense integrating or extending with blockchain have been described together with target groups. These are provenance attestation and environmental and process monitoring. It is fundamental that the BC corporate deployment follows a step-by-step approach, with possible extension of service features in the future. Finally, the conceptual framework reported in Section 5.5 has been tailored on the supply chain use case for the Group and a general BM road map has been sketched to be proposed to the case company management.

8 Validation, discussion, limitations and conclusion

8.1 Validation

The analysis performed in Chapter 7 and the related recommendations have been checked by the case company's CTO and compared to the approach that the Group agreed to follow in partnership with the Software Vendor mentioned in Section 7.3. The CTO has approved the focus on the process of high value items such as the ones identified in Section 7.1 and the extension of the supply chain solution from farmer to first food processor. Moreover, he has confirmed the consolidation of the ongoing partnership with the current software provider and the use of its cloud services for building on top BC applications. He has as well affirmed that partner selection would have constituted the next step. In particular, the Group selected a food processor with a very good visibility on the process (from farmers to their facility including transportation) that also maintains a solid relationship with the Group since many years. This confirms the validity stakeholders' analysis performed in Section 7.2 followed by the suggested collaboration with BC provider in Section 7.3. However, since everything stays still at the network formation level and no BC application has been deployed yet in the case company, the services proposed and how to financially support those was not envisioned because too early. Thus, the following steps in which the value-adding services and the revenue mechanism are envisioned could not be confirmed because dependent on the partners' needs and pain points encountered along the process.

However, the BM road map proposed in Section 7.8 has been checked as well by the CTO and its validity confirmed. The most critical and time-consuming part has been recognized as the Technology field, in particular building the back-end infrastructure that would guarantee a sustainable BC solution in time. Once the integrator is installed and running, the second step is to choose a BC platform where to build the BC application. Critical actors taking part in the network are selected indeed for the access they guarantee to data, in particular for the higher integration level and visibility they assure on the process identified, i.e. from farmer to first food processor. The stipulation of legal contracts to get critical actors on board and the clear definition of roles, rights and obligations was deemed another fundamental activity to be carried on before enabling the full added value of the service.

8.2 Discussion

The following discussion serves as a reflection on the results found and their significance based on what resulted from the literature review, i.e. what was known about the original research problem, and how the exploration of the BC-BM relationship was conducted in the company. By describing how the relationships between blockchain technology and the current BM were explored within the firm in which the technology is introduced, the findings of this exploratory case study provide a different perspective to the literature on BMs analysis and change than what has been proposed so far.

Similarly to what is suggested in the literature (Plansky, O'Donnell, & Richards, 2016; Wang, Chen, & Xu, 2016), the Group started with identifying the processes and the related pain points that could be solved by BC implementation. This supports the concept of blockchain as a software choice for a company proposed by Rimba et al. (2017): at very first, BC corporate introduction impacts the operational or process level, in particular the way information flow happens.

Moreover, it is important to recall what the company's CTO stressed when first interviewed about the food supply chain use case. He underlined how the BC-enabled supply chain solution would need to perform efficiently in terms of transactions speed and to be scaled up and still function when it is expanded. He considered the establishment of legal agreements between network participants a feasible solution for granting ledger immutability. He also stressed the importance of allowing data sharing only when people supporting the BC solution would know each other for sake of confidentiality. By considering the tradeoffs that BC technology implies, a reduced network underlying the BC supply chain application could ensure speed (performance), governance and confidentiality. This could explain the importance the company gave to network formation and governance (i.e. Organizational Domain) when exploring the changes from current to BC-enabled BM. Also, by confirming the validity of the exploration conducted by the author, also the conceptual framework is validated, in particular the connections between Organization and Technology domain, and their implications on the Service one.

In particular, if the use case requires the formation of a reduced network the system operator must expect an expansion of the current ecosystem and the increased responsibilities coming along with it. The most important are motivating actors in joining the system, bearing most of the risk in case the solution is not successful, solving disputes when they arise, and maintaining and upgrading the system. To manage better and address these CDIs in the Organization Domain it seems fundamental to stipulate legal contracts between actors clearly explaining stakeholders' roles and responsibilities. On top of that, the system operator must make sure CDIs in the Technology Domain are addressed not only for them, but also for the network participants so that everyone can use the technology and access the BC-enabled service. The most delicate and critical activity to carry on is the translation of legal contracts into smart contracts: once roles and areas of responsibility are established, actors need to agree on smart contracts coding and must verify autonomously the data source smart contracts can access. All this is however feasible only when the network is reduced and the system operator can take care of stipulating specific contracts with each one of the network participants. When the system expands instead, it makes more sense to automate repetitive processes, such as checking actors' compliance for joining the network, instruct them on public-private key importance and usage, and specifying their roles and requested activities. To allow the automatic functioning of these processes, addressing the Technology Domain then becomes more important and sees the establishment of automatic mechanisms embedded in the blockchain.

In this way, a new light is shed on tradeoffs that the technology implies for each use case and how importantly they should be considered when changing from current to BC-enabled BM. Moreover, exploration order might change depending on the use case, or more importance might be given to other areas of the BM. It is argued here that there might be a relation between use case requirements and BM exploration. For this use case performance, governance, and confidentiality mattered, so it was better to assess first the Organization Domain. Differently, a use case for which speed and confidentiality are not important might care less about the Organizational Domain, and more about the Service or Technological one. Indeed, the research conducted by Holotiuk et al. (2017) represents the perfect example of how for payment system use cases the approach might be rather top-down than bottom-up: regardless of the underlying processes, first the Service Domain is affected with the introduction of BC-enabled services, then the financial structure changes and finally impacts are observable on entire BMs (Holotiuk, Pisani, & Moormann, 2017).

Finally, the research also suggests the need for moving away from mere technological discussion and step back having a look at the entire BM, in which there is also space for addressing technological challenges and even seeing them in relations with other domains.

8.3 Conclusions, limitations and future research

After conducting the literature review about BC technology and Business Models, and studying how the case company intends to integrate the technology in their current business processes, some conclusions can be drawn.

First, the current theory on blockchain technology widely discusses technological limitations and IT implementation challenges when it comes to corporate integration. Secondly, if other than technical aspects are considered, the focus is mainly on the financial sector. Thus, the current literature on blockchain has been reviewed to clarify the meaning of "BC deployment", and to list use cases that make sense deploying within a cross-organizational setting. Assuming the network on which a BC-enabled solution would be a permissioned one, the company plays the role of system operator: in case it does not exist already, the firm has the freedom to form the ecosystem, or the blockchain network of validating nodes that will make sense of the BC-enabled solution. Tradeoffs interesting a permissioned solution have been listed: when the network underlying the solution is reduced, the open and disintermediated nature of the technology is compromised to gain on solution performance, privacy and confidentiality. The review regarding BC use cases serves mainly to give companies examples of blockchains in action and summarize cross-organizational processes that make sense embedding with BC technology.

Moreover, the review conducted on BC highlighted the lack of research on the impact BC corporate introduction would have on other field than technological one. Knowing that BC is a software choice for a company, it was fair assuming that its introduction would have started at the operational level of an organization. Still, it was not clear how it would have impacted the entire value configuration of a firm due to its unique characteristics. Thus, the theory on the Business Model (BM) concept and its design components has been reviewed and the interrelations with company's processes (information and product flow), business architecture, ecosystem, and value proposition have been made explicit. Areas to explore when analyzing and then changing the current BM were the Service, Technology, Organization and Finance Domain. Critical Design Issues (CDIs) have become the unit of analysis and have been made specific for blockchain technology. The results of this part of the research have been summarized in a framework that reports concepts used to analyze and then change the current BM into the BC-enabled one. In particular, it resulted that addressing the tradeoffs of BC in a corporate environment is actually equivalent to addressing specific CDIs when changing from current to BC-enabled BM.

It was still unclear how a company would explore the relation between BC potential and BM, and how it could prepare for change in BM. This has been the motivation for analyzing a specific company and conduct an exploratory case study. The Group has been chosen for the industry in which they are active (food industry) and the digitization push that characterizes the market. The Supply chain management and Provenance tracking has been chosen as use case to deploy within the firm. Based on theory and Group's characteristics, it was studied an order that the case company should have followed during its exploration: first identify the processes and the related pain points. Then perform stakeholders' analysis and analyze possible partnerships with both network participants and BC providers. Finally, envision the services that could add value to the target groups identified and come out with a rough revenue mechanism as well. These suggestions have been proposed to the CTO of the company together with a high-level road map describing which business activities they should take care of when transiting from current to BC-enabled BM. The exploration order has been approved, confirming the validity of the research. It resulted that for the supply chain use case the most critical Domain to address was the Organizational one: indeed, the creation of the blockchain network by means of partnership with actors in the firm's ecosystem was fundamental and critical to make sense of a supply chain application built on top of it. Secondly, it was deemed fundamental making sure that CDIs in the Technological Domain were addressed.

This exploratory research wants to sum up the current situation regarding corporate deployment of blockchain and understanding better blockchain in a business context. In particular, the case study has been useful to see how technological tradeoffs translate into changes needed at the BM level. At the same time, it has been helpful for identify other areas of research that is worth and important exploring more than technological ones. For example, in the future it could be researched how the creation of a business ecosystem around the blockchain solution and the governance of it (particularly related to the financial aspect) changes depending on the use case deployed. Also, the study case warns firms from experimenting with blockchain solutions without strategically evaluating the value at stake or how feasible it is to capture it: in this way, several companies won't see a return on their investments. However, "companies can determine whether they should invest in blockchain by focusing on specific use cases and their market position" (Carson, Romanelli, Walsh, & Zhumaev, 2018).

Nevertheless, the research has some important limitations. The most important is that it only analyses the approach followed by one production company that went specifically for a supply chain use case. Thus it results difficult to derive generalizations for all other use cases mentioned in Section 3.2. For example, service companies might want to deploy completely different use cases and explore the needed changes in their BM with a different approach. More than the use case they chose, some additional factors might motivate the bottom-up approach they took, characterized by a "reflect and adapt" behavior, opposite to the more "think and act" way the top-down approach supports. The first condition that could influence such a development is the size of the corporation. With almost 11,000 employees, it is unlikely for such a big company to modify the usual revenues stream without first making sure the technology is well integrated with the current technical architecture and the solution gets a certain support from business partners. Secondly, the company is indeed moving towards increased digitalization, but at this stage for sure it cannot be considered a high-tech company. This might hamper the introduction of new technologies, or follow a slower path than the one followed by really high-tech firms. Finally, the uncertain environment that surrounds BC corporate development for sure favors a more cautious approach. As of 2018, very first projects are starting being disclosed, but few information is released, so that it is extremely difficult for the case company assessing whether it is necessary to set up their own network, or if it is possible to join an existing one. Therefore, smaller, more high tech companies might do differently, particularly in few years from now when the BC landscape will be much clearer. However, companies with similar characteristics to the case company and willing to deploy the same use case might experience a similar development path.

Other limitations of the research regard the methodology. Participant observation leads to data collection that is mainly dependent on the informants used along the research. In this case, mostly people from the business itself where interviewed, with only few data coming from external sources such as company's clients or BC experts. Having access to different people could have changed the results obtained (Kawulich, 2005). Still, another limitation comes from the researcher's bias: by being employed by the case company, it is possible that only positive aspects of the technology applied to the use case were reported.

Last limitations derive directly from the nature and stage of development of the technology. As already said, blockchain technology is still largely being experimented: many other prototypes and trials are needed before assessing better the impact the technology can have on the way business is done. Moreover, corporate use cases are still highly dependent on the context and their deployment on the firm's characteristics. The literature review confirms that there are real constraints for launching BC mass market use cases today, mostly technological such as technology integration and the lack of a common standard. This is mainly because blockchain is still an immature technology, even though the community is addressing those constraints.

Bibliography

Aguilar-Savén, R. S. (2004). Business process modelling: Review and framework. *Production Economics*, 129-149.

Aitken, R. (2017, August 22). *IBM Forges Blockchain Collaboration With Nestlé & Walmart In Global Food Safety*. Retrieved from www.forbes.com: https://www.forbes.com/sites/rogeraitken/2017/08/22/ibm-forges-blockchain-collaboration-with-nestle-walmart-for-global-food-safety/#4d2c7a733d36

Al-Debei, M. M., & Avison, D. (2010). Developing a unified framework of the business model concept. *European Journal of Information System*, 359-376.

Allison, I. (2015, September 22). *Dr Gideon Greenspan: Blockchain design is academic work and shouldn't just be decided by banks*. Retrieved from www.ibtimes.co.uk: https://www.ibtimes.co.uk/dr-gideon-greenspan-blockchain-design-academic-work-shouldnt-just-be-decided-by-banks-1520754

Bitcoinist. (2018, March 04). *THE NETHERLANDS EXAMINING ESSENTIA'S PROPOSAL FOR BLOCKCHAIN-BASED BORDER CONTROL*. Retrieved from bitcoinist.com: https://bitcoinist.com/netherlands-examining-essentias-proposal-blockchain-based-border-control/

Blocksplain. (2018, February 28). *Blockchain speeds & the scalability debate*. Retrieved from blocksplain.com: https://blocksplain.com/2018/02/28/transaction-speeds/

Bouwman, H., De Vos, H., & Haaker, T. (2008). *Mobile Service Innovation and Business Models.* Springer.

Brenig, C., Schwarz, J., & Rückeshäuser, N. (2016). Value of Decentralized Consensus Systems – Evaluation Framework. *ECIS*.

Buck, J. (2018, January 31). *Taipei Partners With IOTA To Become A Blockchain-Powered Smart City*. Retrieved from cointelegraph.com: https://cointelegraph.com/news/taipei-partners-with-iota-to-become-a-blockchain-powered-smart-city

Bullard, N. (2017, August 14). *Blockchain Used as Settlement Mechanism for Cat Bond with Parametric Trigger*. Retrieved from www.insurancejournal.com: https://www.insurancejournal.com/news/international/2017/08/14/460989.htm

Camerinelli, E. (2015, November 25). *Blockchain Business Scenarios*. Retrieved from www.finextra.com: https://www.finextra.com/blogposting/11913/blockchain-business-scenarios

Carson, B., Romanelli, G., Walsh, P., & Zhumaev, A. (2018, June). *Blockchain beyond the hype: What is the strategic business value?* Retrieved from www.mckinsey.com: https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/blockchain-beyond-the-hype-what-is-the-strategic-business-value

Chesbrough, H., & Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. *Industrial and Corporate Change*, 529-555.

Christidis, K., & Devetsikiotis, M. (2016). Blockchains and Smart Contracts for the Internet of Things. *IEEE Access*, 2292-2303.

Cocco, S. W., & Singh, G. (2018, March 18). *Top 6 technical advantages of Hyperledger Fabric for blockchain networks*. Retrieved from www.ibm.com:

https://www.ibm.com/developerworks/cloud/library/cl-top-technical-advantages-of-hyperledger-fabric-for-blockchain-networks/index.html

De Reuver, M., Bouwman, H., & Haaker, T. (2013). Business Model Roadmapping: a practical approach to come from an existing to a desired Business Model. *International Journal of Innovation Management*, 1-18.

Du, M. (2016). Mastering Bitcoin. *Journal of World Trade*, 675-704.

Dudovskiy, J. (2017). *Exploratory Research*. Retrieved from research-methodology.net: https://research-methodology.net/research-methodology/research-design/exploratory-research/

Eaton, E., & Blycha, N. (2017, August 22). *Distributed Ledger Technology (DLT): DLT commonly known as Blockchain Technology is driving a new wave of innovation and productivity in the mining industry*. Retrieved from www.herbertsmithfreehills.com: https://www.herbertsmithfreehills.com/latest-thinking/distributed-ledger-technology-dlt-dlt-commonly-known-as-blockchain-technology-is

Essentia. (2018). *essentia - The Next Generation Layer of Interoperability and Data*. Retrieved from essentia.one: https://essentia.one/

EVRY Financial Services. (2015). *Blockchain: Powering the Internet of Value.* EVRY Financial Services.

Factom. (2018). *Factom Products*. Retrieved from www.factom.com: https://www.factom.com/products

Fanning, K., & Centers, D. P. (2016). Blockchain and Its Coming - Impact on Financial Services. *Corporate Accounting & Finance*, 53-57.

Frankel, M. (2018, January 24). *Bitcoin Is Losing Ground -- Here's the Coin That Could Take Its Place*. Retrieved from www.fool.com: https://www.fool.com/investing/2018/01/24/bitcoin-is-losing-ground-heres-the-coin-that-could.aspx

Furlong, J. (2018, January 29). *The Future of Blockchain for Business*. Retrieved from www.business.com: https://www.business.com/articles/future-of-blockchain-in-business/

Gray, M. (2015, November 9). *Ethereum Blockchain as a Service now on Azure*. Retrieved from azure.microsoft.com: https://azure.microsoft.com/en-us/blog/ethereum-blockchain-as-a-service-now-on-azure/

Greenspan, G. (2015, November 22). *Avoiding the pointless blockchain project*. Retrieved from www.multichain.com: https://www.multichain.com/blog/2015/11/avoiding-pointless-blockchain-project/

Greenspan, G. (2015, October 1). *Private blockchains are more than "just" shared databases*. Retrieved from www.multichain.com: https://www.multichain.com/blog/2015/10/private-blockchains-shared-databases/

Greenspan, G. (2016, May 10). *Four genuine blockchain use cases*. Retrieved from www.multichain.com: https://www.multichain.com/blog/2016/05/four-genuine-blockchain-use-cases/

Greenspan, G. (2016, April 17). *Why Many Smart Contract Use Cases Are Simply Impossible*. Retrieved from www.coindesk.com: https://www.coindesk.com/three-smart-contract-misconceptions/

Greenspan, G. (2017, May 4). *The Blockchain Immutability Myth*. Retrieved from www.multichain.com: https://www.multichain.com/blog/2017/05/blockchain-immutability-myth/

Greenspan, G. (2017, November 22). *Three (non-pointless) permissioned blockchains in production*. Retrieved from www.multichain.com: https://www.multichain.com/blog/2017/11/three-non-pointless-blockchains-production/

Greenspan, G. (2017, April 22). *Video talk: Blockchains vs databases*. Retrieved from www.multichain.com: https://www.multichain.com/blog/2017/04/video-difference-blockchain-database/

Gupta, A. (2017, May 23). *Blockchain Technology- Types and Components*. Retrieved from www.linkedin.com: https://www.linkedin.com/pulse/blockchain-technology-types-components-dr-anita-gupta

Haley, C., & Whitaker, M. (2017, November 28). *To Blockchain Or Not To Blockchain: It's A Valid Question*. Retrieved from www.forbes.com: https://www.forbes.com/sites/groupthink/2017/11/28/to-blockchain-or-not-to-blockchain-its-a-valid-question/#2fc2a335229d

Hileman, G., & Rauchs, M. (2017). *Global Blockchain Benchmarking Study.* Cambridge, United Kingdom: Cambridge Centre for Alternative Finance.

Hoffman, A., & Munsterman, R. (2018, January 22). *Dreyfus Teams With Banks for First Agriculture Blockchain Trade*. Retrieved from www.bloomberg.com: https://www.bloomberg.com/news/articles/2018-01-22/dreyfus-teams-with-banks-for-first-agriculture-blockchain-trade

Hoffman, E., Strewe, U. M., & Bosia, N. (2018). *Supply Chain Finance and Blockchain Technology.* Springer, Cham.

Holotiuk, F., Pisani, F., & Moormann, J. (2017). The Impact of Blockchain Technology on Business Models in the Payments Industry. *Internationalen Tagung Wirtschaftsinformatik*, (pp. 912-926). St. Gallen.

Iansiti, M., & Lakhani, K. R. (2017). The truth about Blockchain. *Hardward Business Review*, 1-11.

Inc. (2018). *High-Tech Business*. Retrieved from www.inc.com: https://www.inc.com/encyclopedia/high-tech-business.html

Investopedia. (2018). *Catastrophe Bond - CAT*. Retrieved from www.investopedia.com: https://www.investopedia.com/terms/c/catastrophebond.asp

Investopedia. (2018). *Clearing*. Retrieved from www.investopedia.com: https://www.investopedia.com/terms/c/clearing.asp

Investopedia. (2018). *Value Proposition*. Retrieved from www.investopedia.com: https://www.investopedia.com/terms/v/valueproposition.asp

IOTA Foundation. (2018). *What is IOTA?* Retrieved from www.iota.org: https://www.iota.org/get-started/what-is-iota

Juniper Research. (2017). Which industries are the best fit for blockchain? *Juniper Research*, 1-11.

Kawulich, B. B. (2005). Participant Observation as a Data Collection Method. *Qualitative Social Research*, 1-11.

Kazan, E., Tan, C.-w., & Lim, E. T. (2015). Value Creation in Cryptocurrency Networks: Towards a Taxonomy of Digital Business Models for Bitcoin Companies. *Pacific Asia Conference on Information Systems (PACIS).*

Kharif, O., & Bergen, M. (2018, March 21). *Google Is Working on Its Own Blockchain-Related Technology*. Retrieved from www.bloomberg.com: https://www.bloomberg.com/news/articles/2018-03-21/google-is-said-to-work-on-its-own-blockchain-related-technology

Ludwin, A. (2017, October 16). *A Letter to Jamie Dimon*. Retrieved from blog.chain.com: https://blog.chain.com/a-letter-to-jamie-dimon-de89d417cb80

Madeira, A. (2018, February 28). *What is the Block Size Limit*. Retrieved from www.cryptocompare.com: https://www.cryptocompare.com/coins/guides/what-is-the-block-size-limit/

Mainelli, M., & Smith, M. (2015). Sharing ledgers for sharing economies: an exploration of mutual distributed ledgers (aka blockchain technology) . *The Journal of Financial Perspectives: FinTech*, 1-47.

MedRec. (2018). *What is Medrec ?* Retrieved from medrec.media.mit.edu: https://medrec.media.mit.edu/

Microsoft. (2018). *5 ways blockchain is transforming Financial Services.* Microsoft.

Microsoft. (2018, June 27). *Mars Food uses the cloud to track rice from farm to fork*. Retrieved from customers.microsoft.com: https://customers.microsoft.com/en-us/story/mars-food-consumer-goods-azure

Milano, A. (2018, February 20). *Lisk Relaunches Blockchain Project With 'Accessibility' in Mind*. Retrieved from www.coindesk.com: https://www.coindesk.com/lisk-relaunches-blockchain-project-accessibility-mind/

Morabito, V. (2017). *Business Innovation Through Blockchain.* Springer International Publishing.

Mougayar, W. (2016). *The Business Blockchain.* Hoboken, New Jersey: Wiley & Sons.

MultiChain. (2018). *MultiChain Platform Partners*. Retrieved from www.multichain.com: https://www.multichain.com/platform-partners/

Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System.*

Open Access Government. (2018, January 25). *Blockchain technology used to track and authenticate diamonds*. Retrieved from www.openaccessgovernment.org: https://www.openaccessgovernment.org/blockchain-technology-track-authenticate-diamonds/41525/

Paul, M. S. (2018, April 30). *Hyperledger—Chapter 5 | Tuna Fishing Supplychain - Context*. Retrieved from medium.com: https://medium.com/swlh/hyperledger-chapter-5-tuna-fishing-supplychain-context-f593b03e2cf0

Paul, R. J. (2007). Challenges to information systems: time to change. *European Journal of Information Systems*, 193-195.

Peck, M. E. (2017, September 29). *Do You Need a Blockchain?* Retrieved from spectrum.ieee.org: https://spectrum.ieee.org/computing/networks/do-you-need-a-blockchain

Plansky, J., O'Donnell, T., & Richards, K. (2016, January 11). *A Strategist's Guide to Blockchain*. Retrieved from www.strategy-business.com: https://www.strategy-business.com/article/A-Strategists-Guide-to-Blockchain?gko=0d586

Platt, C. (2017, January 16). *Of permissions and blockchains... A view for financial markets*. Retrieved from medium.com: ///

Provenance. (2015, November 21). *Blockchain: the solution for transparency in product supply chains*. Retrieved from www.provenance.org: https://www.provenance.org/whitepaper

Provenance. (2016, July 15). *From shore to plate: Tracking tuna on the blockchain*. Retrieved from www.provenance.org: https://www.provenance.org/tracking-tuna-on-the-blockchain

Rampton, J. (2017). *5 applications for blockchain in your business* . Retrieved from economist.com: https://execed.economist.com/blog/industry-trends/5-applications-blockchain-your-business

Rimba, P., Tran, A. B., & Weber, I. (2017). Comparing Blockchain and Cloud Services for Business Process Execution. *2017 IEEE International Conference on Software Architecture (ICSA)*, (pp. 257-260).

Ripple. (2018). *Corporates - Simplify payments*. Retrieved from ripple.com: https://ripple.com/use-cases/corporates/

Rosic, A. (2017, June). *Blockchain Address 101: What Are Addresses on Blockchains?* Retrieved from blockgeeks.com: https://blockgeeks.com/guides/blockchain-address-101/

Rosic, A. (2017, October). *Blockchain Scalability: When, Where, How?* Retrieved from blockgeeks.com: https://blockgeeks.com/guides/blockchain-scalability/

Sandner, P. (2017, June 25). *Comparison of Ethereum, Hyperledger Fabric and Corda*. Retrieved from medium.com: https://medium.com/@philippsandner/comparison-of-ethereum-hyperledger-fabric-and-corda-21c1bb9442f6

Schwarz, M. (2018, May 24). *Transaction Speeds: Which Crypto is The Fastest?* Retrieved from www.abitgreedy.com: https://www.abitgreedy.com/transaction-speed/

SGS. (2017, June 13). *SGS, Transparency-One and Mars Food Launch Revolutionary Supply Chain Solution*. Retrieved from www.sgs.com: https://www.sgs.com/en/news/2017/06/sgs-transparency-one-and-mars-food-launch-revolutionary-supply-chain-solution

Shadab, M. (2018, January 23). *Integrating with Blockchain Technology*. Retrieved from adeptia.com: https://adeptia.com/blog/integrating-blockchain-technology

Solaimani, S., & Bouwman, H. (2012). A framework for the alignment of business model and business processes: A generic model for trans-sector innovation. *Business Process Management Journal*, 655-679.

Szabo, N. (1994). Smart Contracts.

The Business Times. (2017, June 15). *AIG teams with IBM to use blockchain for 'smart' insurance policy*. Retrieved from www.businesstimes.com.sg: https://www.businesstimes.com.sg/banking-finance/aig-teams-with-ibm-to-use-blockchain-for-smart-insurance-policy

UseTheBitcoin. (2017, November 28). *ZIM Shipping Company to Use Blockchain Technology for Product Shipping*. Retrieved from usethebitcoin.com: https://usethebitcoin.com/zim-shipping-company-use-blockchain-technology-product-shipping/

Verhoelen, J. (2017, October 17). *blockcentric #1: Consensus mechanisms of the blockchain*. Retrieved from blog.codecentric.de: https://blog.codecentric.de/en/2017/10/consensus-mechanisms-blockchain/

Versteeg, G., & Bouwman, H. (2006). Business architecture: A new paradigm to relate business strategy to ICT. *Inf Syst Front*, 91-102.

Wang, H., Chen, K., & Xu, D. (2016). A maturity model for blockchain adoption. *Financial innovation*, 1-5.

White, M. (2018, January 16). *Digitizing Global Trade with Maersk and IBM*. Retrieved from www.ibm.com: https://www.ibm.com/blogs/blockchain/2018/01/digitizing-global-trade-maersk-ibm/

Wiese, C. (2017, December 20). *3 Parts of a Blockchain*. Retrieved from www.factom.com: https://www.factom.com/university/tracks/fundamentals/3-parts-of-a-blockchain

Wikipedia. (2018, May 18). *Exploratory research*. Retrieved from en.wikipedia.org: https://en.wikipedia.org/wiki/Exploratory_research

Write. (2018). *Data Triangulation: How the Triangulation of Data Strengthens Your Research*. Retrieved from www.write.com: http://www.write.com/writing-guides/research-writing/research-process/data-triangulation-how-the-triangulation-of-data-strengthens-your-research/

Wüst, K., & Gervais, A. (2017). Do you need a Blockchain? *IACR Cryptology ePrint Archive*.

Yadav, G. (2017, July 11). *Cryptographic Key Storage Options & Best Practices*. Retrieved from www.globalsign.com: https://www.globalsign.com/en/blog/cryptographic-key-management-and-storage-best-practice/

Yli-Huumo, J., Ko, D., Choi, S., Park, S., & Smolander, K. (2016). Where Is Current Research on Blockchain Technology?—A Systematic Review. *PLoS ONE*, 1-27.

Young, J. (2017, January 15). *Homeland Security to Use Blockchain in Tracking Goods & People Globally*. Retrieved from cointelegraph.com: https://cointelegraph.com/news/homeland-security-to-use-blockchain-in-tracking-goods-people-globally

Zago, M. G. (2018, May 30). *50+ Examples of How Blockchains are Taking Over the World*. Retrieved from medium.com: https://medium.com/@matteozago/50-examples-of-how-blockchains-are-taking-over-the-world-4276bf488a4b

Zhao, J. L., Fan, S., & Yan, J. (2016). Overview of business innovations and research opportunities in blockchain and introduction to the special issue. *Financial Innovation*, 1-5.

Zott, C., Amit, R., & Massa, L. (2011). The Business Model: Recent Developments and Future Research. *Journal of Management*, 1019-1042.

Zuckerman, M. J. (2018, March 7). *Consortium Of 61 Japanese Banks To Release Instant Mobile Payment App Powered By Ripple*. Retrieved from cointelegraph.com: https://cointelegraph.com/news/consortium-of-61-japanese-banks-to-release-instant-mobile-payment-app-powered-by-ripple

Appendix A: CoSEM Scientific Article

A case study on the exploration of Blockchain potential

An exploratory research on the impact of the technology on business process and value configuration of a mid-European company

Master Thesis Proposal Camilla Cavaliere – 4623126 cavalierecamilla@gmail.com

Complex Systems Engineering & Management

Faculty of Technology, Policy and Management, Delft University of Technology

1st of August 2018

Abstract Since 2017 blockchain (BC) has been settling in the spotlight. Several industry fields could use the technology as part of the underlying infrastructure for registering and transferring any type of asset and optimize business processes. As of 2018, numerous blockchain initiatives are continuously developed, with global executives looking forward to start a blockchain project and successfully extract value out of it.

However, several factors aliment the uncertainty corporates experience when passing from discussion to actual implementation. Eventually the majority of firms simply waits for the technology to develop further, running the risk of being already too late to catch up when the technology takes off. Organizations need to assess how the technology can be integrated in the current business and how its introduction at the operational level alters how value is created, delivered and captured, thus the Business Model (BM) overarching the current process.

Therefore, a thorough literature review about the technology and the BM concept is conducted. Links and interrelations among the two concepts are drawn and organized in a conceptual framework. Finally, an exploratory case study is conducted to validate the insights derived from theory: first a mid-European company is chosen for BC application and its internal dynamics studied. Then a specific use case is selected, and it is envisioned a possible exploration of the BM-BC relationships that the company would conduct.

The suggested exploration is then proposed to the case company. The suggestions given well reflect the exploration the Group conducted in reality, confirming the validity of the study. In particular, the findings suggest that tradeoffs and limitations characterizing the specific BC use case actually played a role in determining how the exploration of BM changes was conducted by the company.

The research gives insights on how a specific company explored and prepared for changes at the BM level. At the same time, it suggests the need to assess better how technological tradeoffs characterizing cross-organizational use cases translate into changes at the BM level.

Key words **Blockchain, tradeoffs, business process, Business Model, exploration**

1 Introduction

Since 2017 blockchain (BC) technology has been widely discussed. As piece of software for decentralizing record-keeping and computation (Rimba, Tran, & Weber, 2017), BC introduction represents an architectural choice impacting organizations at the operational level. It has huge potential for optimizing business processes when used as part of the underlying infrastructure for registering and transferring any type of asset (Brenig, Schwarz, & Rückeshäuser, 2016), or when combined with other technologies, such as the Internet of Things (Wang, Chen, & Xu, 2016). Several industries around the world have all started experimenting with other blockchain use cases than cryptocurrencies, alimenting the hype. This has led the technology to be one of the hottest topic exciting the business world, with corporates increasingly tempted to start a blockchain project and successfully extract value out of it.

However, organizations' excitement rapidly dies out when switching from "blockchain discussion" to actual "blockchain implementation". First, corporates have hard time assessing which BC-enabled solution is the most beneficial for them, particularly because they are not fully aware of which problems BC solves, what is its value proposition, and which use cases make sense deploying within cross-organizational settings. Secondly, firms are unclear of what "corporate deployment of blockchain" means, which role they should play along the project development and who they should involve to make sure the investment delivers value to the company and its ecosystem. The technology is still in the early stages of development, adoption and experimentation, mass market applications are few (as of 2018 only the Bitcoin one), and corporate use cases limited to Proof of Concepts and trials (Furlong, 2018). Eventually the majority of corporates simply waits for the technology to develop further. At the same time, they run the risk of being already too late to catch up when the technology takes off.

Therefore, the research objective is to understand better blockchain in a business context, in particular how the technology can be integrated in the current business. The study shows how its introduction at the operational level alters how value is created, delivered and captured, thus the Business Model (BM) overarching the current process. Its practical relevance mostly lies in describing how a BC project is actually steered and managed within a firm. By doing so, the study aims to give some ideas to corporates on how to pass from discussion to actual implementation without focusing only on technical problems. The research represents a useful tool for companies to make sense of the extremely high expectations that have been surrounding the technology and steer the attention away from technical problems towards a wider vision that includes several domains of the BM.

At the same time, the research contributes to the scarce academic literature addressing other than technical challenges when it comes to BC corporate introduction. In particular, it sheds a light on the influence that technological tradeoffs have on several BM components, and how the impact likely depends on the use case developed. Finally, the study gives suggestions on future research that are worth developing.

A first thorough literature review is conducted to understand what is the current state of the art with regard to blockchain and which use cases add genuine business value. A second literature review summarizes what is the current theory on Business Model and how the concept relates to value creation, delivery and capture. Interconnections with company's value proposition, ecosystem, processes and business architecture are also highlighted. Links and interrelations among BC and the BM concept are drawn and organized in a conceptual framework summarized at the end of Section 2. Particular stress is put on how technology limitations and tradeoffs influence which changes at the BM level. Literature review and the creation of the conceptual model pave the way for answering the main research questions: *How does a company explore the relation between BC potential and BM? And how does a company prepare for change in BM?* Section 3 explains the motivations for conducting an exploratory case study. This is useful to validate the insights derived from theory: first a mid-European company is selected for BC application and its internal dynamics studied. Then a specific cross-organizational use case that the Group can benefit from is selected, and a possible exploration of the BM-BC relationships that the company would conduct is envisioned. Main results of the research are presented in Section 4, followed by Discussion in Section 5 and Conclusions and Limitations in Section 6.

2 Literature review

2.1 Blockchain technology

Both permissioned and permissioless blockchains are used to build applications. However, applications built on top of a permissionless network make the solution public, i.e. anyone accessing the network sees the transactions going on between business actors. According to several authors (Gaur, 2016; Morabito, 2017), **permissioned networks** offered by known infrastructure providers are **preferred in a corporate reality**, where legal and reputational aspects must be handled carefully (Hileman & Rauchs, 2017). Therefore, it has been assumed for the remaining research that the organization builds on top of a permissioned network and becomes the **system operator**. In case it does not exist already, the firm has the freedom to form the ecosystem, or the blockchain network of validating nodes that will make sense of the BC-enabled solution.

The P2P network behind the solution can be made up of only few validating nodes (reduced network) controlled by major organizations. Or it can be larger, including several actors playing even marginal roles (extended network) resembling more a pemissionless network. In general:

Table 5 Blockchain technology tradeoffs

The more…	**The less…**
Decentralization = how many nodes is the network composed of & **Robustness** = how many replicas of the ledger exist	**Performance (speed)** = how many transactions the system processes within a certain time & **Scalability** = possibility to expand system
Immutability = how likely it is that information reported cannot be modified	**Governance** = degree of ruling power of pre-assigned participants & **Safeguard** = how easy it is to intervene in case something happens
Disintermediation = level of absence of any authority	**Privacy/confidentiality** = level of data secrecy

The more the system is **decentralized**, the more replicas of the ledger exist that more peers access to verify its state. System robustness increases: if the system goes down in one node, this recovers the entire transactions history as soon as it comes back to functioning. At the same time **performance** decreases and the average time needed to confirm a transaction increases. Indeed, when the network involved in the validation process reduces, the consensus mechanism speeds up and requires way less computing power and time than extended blockchains. An extended network hinders the possibility for corporates to process a high volume of transactions and **scale up** the system according to their needs when later expansion (more nodes joining, more transactions performed, and longer transactions history) is needed (Hileman & Rauchs, 2017). In general enterprises deploying blockchain should decide **who to involve** and **how many nodes** to deploy, and should plan a growth path in case of system expansion (Haley & Whitaker, 2017).

Corporations can hardly leave **governance** behind, because of the reputational and legal consequences this might have. Thus, companies deploying permissioned BC take the role of system operator. This governs the network and runs the applications ensuring a better **safeguard**. Some functionalities of the technology requiring a trusted third party in place are facilitated in a reduced network. For example, off-chain assets such as bonds and securities can be transferred and settled more easily. Also the validity of outcome of smart contracts can be verified faster. However, the higher the degree of governance, the easier for specific nodes in the network to modify the records at their will and hamper the **immutability** of the data. Thus basic trust must be put in the operators and validators responsible for the network that they do not change data arbitrarily. In this way, it results fundamental for companies deciding **what can involved people do**, the **power** they have, and stipulating off-chain legal agreements among actors to discourage misbehavior and punish it accordingly.

Finally, **disintermediation** refers to the ability to have multiple parties sharing a single database and achieving a single view of the truth, without any party in charge of the database but still making sure everything is consistent. However, the more the system is disintermediated, the more network participants see that a specific transaction between two parties has taken place (Greenspan, Video talk: Blockchains vs databases, 2017). **Privacy** issues arise more easily in extended networks due to the revealing of personal data (Peck, 2017). Also, since extended blockchain networks usually present scalability and capacity problems, organizations might be forced to store data outside the BC. In that case, when blockchain accesses external data storages, companies must encrypt the data kept in offline databases before disclosing them to the distributed network. Some of the best encryption techniques help mitigating this issue. However, actors' requirement for **confidentiality** must be carefully addressed, so that companies must assess **which data are shared** within the network and with whom.

The same functionalities that add value in the financial domain can be recombined to originate valuable applications in any type of sector, from healthcare, to logistics, telecommunication, insurance, and so on (Morabito, 2017). These were identified as *P2P distributed time stamping, real-time global data diffusion, assets settlement, decentralized immutable data storage*, and *automated contractual relationships*. Five general uses cases that combine these functionalities were identified:

- *Instant payment network*. Each participating organization runs a node on the BC and they are all connected to each other in a P2P way. Money in some form (shares, bonds, regular cash, etc.) is issued on the BC as a token representing ownership of that asset. Settlement happens in matters of second once consensus is reached among nodes, reconciliation takes place automatically in real-time. Businesses can easily manage asset exchange, receive and make payment faster and timely. Thus the **performance** of the solution plays a key role. However, the biggest problem is **confidentiality**: every participant in the network can see not only their own transactions, but also what all others are doing, and often participants are even competing among each other's (Greenspan, Video talk: Blockchains vs databases, 2017).
- *Lightweight financial system*. This consists of a financial system where stakes or number of participants are low, also considered as a quick and dirty financial system with participants exchanging assets for which confidentiality is not an issue, such as loyalty points, gift cards, alternative financial instruments. Also, medium or low transaction speed is acceptable seen the non-critical nature of the data exchanged.
- *Shared customers' metadata or decentralized data storage*. Many companies are connected to each other, sharing data and recording them on the BC. Each piece of data entering the BC is digitally signed so that everyone knows where that piece of data comes from, and it is timestamped so that everybody agrees on what time something happened. **Immutability** guarantees that information cannot be changed or corrupted unless the majority of validating nodes decides to maliciously collude, a stronger concept than trusting one single organization to keep the records. Confidentiality is ensured by encryption that can be used to unlock data content for only specific participants, people can see transactions but need encryption keys to see which data are actually being transacted (Greenspan, Video talk: Blockchains vs databases, 2017).
- *Intra-company clearing and settlement,* the only meaningful use case deployed internal to a single organization. Often a company has several subsidiaries considered as separate legal entities, and each needs to maintain control over their own assets. In such a non-competing environment, BC characteristic of settling assets within seconds can genuinely add value (Greenspan, Video talk: Blockchains vs databases, 2017), thus **performance** and speed of the system are important.
- *Supply chain management and Provenance tracking*. Probably the most beneficial blockchain use cases (Wüst & Gervais, 2017; Zago, 2018). A process spans across multiple companies and multiple geographies, with goods passing from hand to hand, but still all companies need to agree with each other. When a centralized database is in place it is difficult to decide where the database is going to sit, who keeps track of what's happening to the asset, and which organization is responsible for running that database. In this way, blockchain is a valuable part of a solution for supporting financial, document and provenance flow along any supply chain and make them fully transparent to whoever joins the network. However, authoritative parties are needed to make sure the link between physical and digital representation of the asset along the chain is conserved. **Governance** of the system becomes the most important point to

address to make sure some parties are made accountable for solving problems in case something happens.

The five BC use cases mentioned see the technology adding value specifically to cross-organizational processes between several firms that should form the underlying blockchain network. The most important requirements are underlined for each use case (performance and speed for payment systems, governance for supply chain example). Finally, they have been used as general categories to propose to the case company's management when selecting a use case to deploy within the Group.

2.2 Business Model

As piece of software that allows for decentralizing record-keeping and computation (Rimba, Tran, & Weber, 2017), BC introduction represents an architectural choice that at first impacts organizations at the operational thus processes level. However, introducing innovations at the operational level does not only change how processes are run, but has also consequences on how the entire business functions. Look at other innovative technologies, such as the Internet, the smartphone, the 3D printer, etc. Similarly, a BC-enabled process has the potential to imply changes in the entire value configuration of a firm and alter the current Business Model, i.e. the logic that specifies how a company sustain itself and generates revenues, to which value creation, delivery and capture are strictly related (Al-Debei & Avison, 2010).

Three main concepts were tackled during the second literature review: business strategy, Business Model (BM) and business process; they are represented as the circles in Figure 1. To offer value to customers and allow the service provider to capture value as well, the Business Model must specify its components such as customer value proposition, together with technical, organizational and financial arrangements (Bouwman, De Vos, & Haaker, 2008). The squares on the right contain the design elements addressed by each of the conceptual areas.

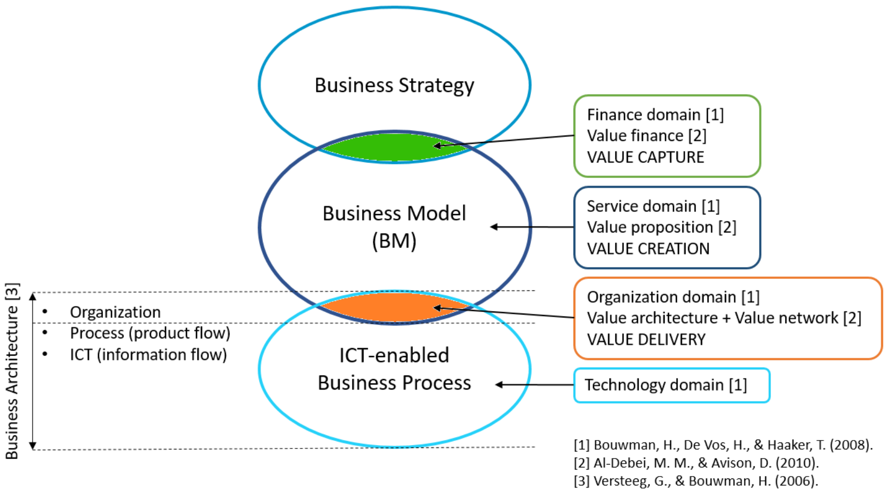

Figure 1 Figurative sum-up of literature review with authors' contribution

The goal of the *Service Domain* is to define the offered **service** or product, and to describe the value proposition for each of the identified target groups. What the company is offering must satisfy the needs of some entity or group of entities (target groups). Making this entity satisfied with that specific offering is the company's goal. However, the company also wants their customers to be happy about its products, in particular happier than with the same product offered by a competitor. Thus the company strives to offer value on top of the basic functionality of the product. Value derives from companies' effort to coordinate and exploit their resources and knowledge to make their product stand out for newness, performance, design, convenience, etc. **Value creation** resides in this domain: the mechanisms used to create value are identified and entailed in the company's value proposition.

The *Technology Domain* explores the potential of the **technology** at hand as enabler of innovative services and structures the technical architecture allowing for "service development, creation, discovery, delivery, bundling, control and management" (Bouwman, De Vos, & Haaker, 2008, p. 46). Having a clear idea of the technology value proposition and the tradeoffs it implies is an important initial step that helps anticipating several design issues, such as security or scalability. In this phase business processes and supporting ICT infrastructure are analyzed, with particular focus on **product and information flow**.

Information flows are analyzed in the *Organization Domain* to support the identification of activities that if performed in an ordered way enable the service. Activities as mere bundles of functions and objects cannot operate alone, so divide and assign roles to activities to fulfill the specified functions. **Business Architecture** supports the assigning of responsibilities over business domains by reducing them into bundles of activities (Bouwman, De Vos, & Haaker, 2008). The **value architecture** specifies both "technological architecture and organizational infrastructure that allows the provisioning of products and services in addition to information flows" (Al-Debei & Avison, 2010, p. 366). Resources and capabilities are needed for those in charge of activities to orchestrate product and information flow in a meaningful way. However, sometimes the company alone does not have the right resources of capabilities, so it needs to collaborate and coordinate with several actors in the value network. The goal of this domain is to come up with a network strategy that describes which transactions are enabled within the **value network** to make critical resources available. This intersection is called **value delivery,** specifying how the company configures resources and capabilities within the network to deliver the product or service (Kazan, Tan, & Lim, 2015).

In the *Finance Domain* it is specified how each participant of the network extracts economic value from value creation and delivery. Here is where **value capture** lies. Financial arrangements typically describe how investments, costs, revenues, and risks are distributed among actors, and the final outcome goes on offer pricing and fees charged at different levels of the network. This domain is attributed to the intersection between strategy and BM, because when deciding on this type of arrangements, the company should keep in mind the firm's strategy and be inspired by it.

The Service-Technology-Organization-Finance (STOF) model proposed by Bouwman et al. (2008) is argued to give a comprehensive and substantial method for analyzing and subsequently re-designing BMs for digital services and reflects the subdivision highlighted in the previous Section. In particular, specific design variables must be addressed to ensure each component of the BM under evaluation is finally viable and sustainable; these variables are called Critical Design Issues (CDIs) (Bouwman, De Vos, & Haaker, 2008).

2.3 The conceptual framework

After reviewing the technology value proposition, limitations and tradeoffs, it was possible to draw links and interrelations among blockchain and BM concepts and create a conceptual framework that sees Critical Design Issues (CDIs) being specified for BC technology. Interestingly, it turned out that discussing the tradeoffs reported in Section 2.1 was equivalent to discussing some of the CDIs in the STOF model. For example, one Critical Design Issue to consider when designing a service is *Value Elements,* i.e. what added value is delivered to the target group compared to a similar available service. For a BC-based solution, these become performance and confidentiality in case the network is reduced, but switch more into immutability and transparency when this expands. In a BC-enabled service, addressing this CDI impacts *Security* and *Quality of the Service* in different ways: when the network is reduced, handling private keys is relatively easier, and the service benefits from improved speed and scalability. *System integration*, i.e. making sure the BC and the current enterprise system share information seamlessly, becomes slightly easier to design when less people join the blockchain network: the smaller the network, the least fragmentation problem and easiness in importing previous data on the new system.

However, an application built on top of a reduced network loses some of the main technology characteristics, such as decentralization, immutability and disintermediation. Indeed, much power stays in the hands of the system operator, i.e. the company deploying the blockchain network and solution. When specified for BC technology several CDIs in the Organization Domain are influenced by the choice for a reduced network: *Network Governance* sees the system operator being in charge of assigning roles to all network participants, becoming the registrar that manages personal keys, roles, and access to data. *Participant Selection* is critical in a small network: the system operator has to wisely choose both BC provider and the very first business partners that would take part in the network with the company. As long as *Network Complexity* increases, *Network Governance* gets slightly looser and *Network Openness* improves, with the system operator leaving the task of assigning roles to a specifically selected registrar, or installing a standardized procedure that checks participants' compliance to network requirements. *Participant Selection* becomes automatic when the system expands including not only critical actors but also supporting ones. Finally, also financial mechanisms of costs and benefits split are difficult to control by system operator when the network expands because of redistribution of roles and powers (actors contribute in the same way to the system). In that case, the system itself redistribute benefits with some type of automatic mechanism in place, for example cryptocurrencies.

3 Research methodology

To validate the insights derived from theory a case study was conducted to understand better how a company in real world analyzes the current BM of the offering and modifies it into a BC-enabled one. However, since no theory exists that relates the implementation of BC in corporate environment with the expected changes at the Business Model level, it was deemed appropriate to maintain an **exploratory approach**. Exploratory research helps gaining familiarity with the phenomenon that is still not well known and formulating a more precise problem by accumulating experience (Wikipedia, 2018). In particular, an **exploratory case study** helps answering *how* and *why* a specific event has happened, in this case how a company explores the BC-BM relationship, how it prepares for changes in the BM, and why it gives more importance to specific BM domains along with the exploration.

3.1 The selection of the case company

The selected firm is a mid-European company that has made food safety and transportation sustainability its main focuses. The Group was selected because it is a global market leader in the supply of Fast-Moving Consumer Goods (FMCG) production plants and lines. Other reasons were the long-lasting partnerships it has established in time and the strong reputation it has built among ecosystem actors as reliable and trustworthy. This grants them the possibility to be system operators, to establish and run the blockchain network and to get access to (critical) business data that can add value to several actors along the value chain. Moreover, considering the extension of the ecosystem the case company operates in, they would benefit from **increased transparency** along their processes, streamlined interactions with clients and **information exchange**, and in general improved synergies across value chain. Finally, the geographical region in which they operate sees already several players experimenting with blockchain and using it as a source of competitive advantage.

3.2 The selection of the use case

A specific cross-organizational use case that the Group could benefit from was selected after conducting an interview with the company's CTO and proposing the use cases mentioned in Section 2.1. The Group is in need for driving new Business Models and exploring possibilities for expanding the service offering that has already established. This is why the choice has fallen on **Supply chain management and Provenance tracking** use case. In particular, the discussion interested since the beginning the food processes rather than the automotive and chemical ones, because of clear benefits that the **food supply chain** can derive from BC applications, such as **transactions efficiency** and improved **transparency**. The case company believes that blockchain represents a key part of a solution improving the food chain traceability, thus granting better food safety by identifying faster the source of illness before it spreads across the value chain.

The CTO was asked to evaluate the tradeoffs reported in Section 2.1 and give his opinion on how the supply chain solution would look like. He observed that actors that are going to deal with the supply chain use case value for sure the **performance** of the underlying system in terms of transactions speed: events regarding assets movements must be sent to the network and timestamped immediately to allow a real-time visibility on what is going on. **Scalability** as well must be granted: the system must efficiently work even when it expands including new actors and cannot experience huge decrease in performance. Network participants clearly care about the system to be immutable, but they also have the necessity to refer back to established authorities that would help solving issues as long as they come out. Business contracts characterize any corporate reality, so he considered the establishment of **legal agreements** between network participants (in the end, other organizations) a feasible solution for grating ledger immutability. Finally, **confidentiality** represents a sensible topic in any business environment, so data sharing would happen only when people supporting the BC solution well know each other and are confident about the identity of other network participants.

3.3 Data collection

Information about the company's processes, ecosystem, partnerships, products, etc. have been collected during a 6-month internship conducted at the case company's site. In particular, data have been collected by means of:

- *Participant observation*. This represents a powerful tool for collecting information as business insider about company's people, processes and culture in qualitative research studies. Particularly important was to report impressions by taking part in the firm's activities, such as meetings, conferences, etc. The most important input came from the **Innovation Day**, a one-day long conference in which all people from the company involved in digitization projects meet and discuss the current situation and the strategic initiatives of the Group. Importantly, it was confirmed the ongoing partnership with the current software vendor and the intention to build several services on top of their cloud, among which also BC-enabled services. In general, participant observation is recognized as a way to increase the validity of the study, that further improves when it is supported by other strategies such as "interviewing, document analysis, or surveys, questionnaires, or other more quantitative methods" (Kawulich, 2005).
- *Face to face discussion (internal)*. The opinion from key business people supported the analysis. Indeed, the biggest contribution of the study comes from **unstructured interviews**, conferences, panel discussions, and small talks conducted with company ecosystem actors. In particular, topics of discussion were how the identified process works, who is involved, how do information and product flow work, what is company's position in that ecosystem and how the ecosystem would react to planned changes in the current service offering. The following actors were consulted along the research:
    - ➢ D.B.: The former project manager assigned to BC research updated on the research conducted till the start of the internship, what were challenges faced till that moment and gave recommendations on how to proceed. Also, important suggestions on use cases, weak/strong points of each use case, and potential technical partners to involve was his input.
    - ➢ I.R.: The Group's CTO helped understanding better the company's strategy, why they wanted to go for blockchain development and in how long. Meetings for updating him on the research development and in case modifying the focus of the research were held every month.
    - ➢ S.B.: The Group's Digital Officer focused on a more operational level. He was consulted to get a better overview on development possibilities, i.e. how the company would have seen the BC development also in relation with the digitization push that came out recently.
    - ➢ One data scientist and one master data manager were asked about the data situation of the company, how data were collected, managed and further used. They were interviewed for knowing about integration possibilities.
    - ➢ Two process engineers were interviewed to understand better how the current processes of the company work and what were pain points the Group's customers along each process.
    - ➢ One data scientist and one research engineer were asked about other digital services that the company offers or intends to offer. They were asked about digital Business Models and data sharing challenges that the company met already and which solutions were put in place.
- *Corporate documents*. The company's Intranet and website were important sources of documents that complemented the analysis, such as:
    - ➢ Monthly reports: these informed about the overall strategy of the Group and development path to follow.
    - ➢ PPT presentations from Business Units: these reported the specific strategy of and the processes belonging to each business unit, together with name of reference people responsible for each department.
    - ➢ Fliers targeting clients: these were helpful to have a look at offered products, value proposition and intended target.

- *Face to face discussion (external)*. Others actors external to the company and already involved in the technology implementation were interviewed, such as **technology experts** or blockchain solution providers in the food industry.
  - Gideon Greenspan, CEO of Multichain. He was interviewed (20/03/18) to consult about meaningful BC use cases and deployment challenges regarding permissioned blockchains. He clarified the role of the system operator and gave recommendations on network participants' involvement.
  - The BC fair held in the Netherlands (Amsterdam, 27-28/06/18) was extremely helpful to have a look at BC providers, integration possibilities, use cases, collaboration incentives, data sharing challenges, etc. In general, it gave a much clearer understanding about the current landscape with BC for business and enterprise.

When studying a specific phenomenon indeed it is important to use two or more methods of data collection so that the same result obtained by using different information sources becomes stronger and more credible. A useful way to check whether results correspond and data collected are valid is *triangulation*, a method that helps researchers capturing different dimensions of the same unit of analysis (Write, 2018). In particular, the approach followed here is *methodology triangulation*: different methods are used to collect data (ex. Unstructured interviews and Intranet reports) and the information gained are compared to check if they complement each other (Write, 2018).

4 Main Results

4.1 The exploration

After collecting data about the Group's dynamics, a likely exploration of the BM-BC relationships that the company would conduct was envisioned. The analysis started with selecting the product or process to embed with BC technology. This was followed by the assessment of the validating ecosystem, the selection of the software provider, the description of the services offered, and finally rewarding and paying mechanisms for users.

The value chains chosen for developing the first instances of blockchain application were **coffee**, **chocolate** and **nuts** processing along the supply chain limited **from farmers to first food processors**. Three major problems result from analyzing the information flow of these food value chains:

- ➔ Obtaining information about the farm of origin and how much each farmer contributed to the total harvest is difficult. This hampers the possibility to provide downstream actors with a **proof of provenance** together with a proof of fair **working conditions**.
- ➔ The visibility on what happens to the harvest from collection to first industrial processing point is definitely reduced. Very first food processors suffer from the lack of information on **product journey** and they strive to know the change in weight that the product went through.
- ➔ Information on the actual realization of critical processing steps such as **sorting and debacterisation** are of particular interest for retailers that usually bear all the risk when products are recalled from the market for safety reasons.

People to involve in the network were most likely actors interested in adding data in an immutable way, checking what happens along the value chain and which transactions are sent to the network. Six actors were identified:

- **Farmers:** they own their data about total harvest and keep information in a secure and immutable database. They also get certifications testifying their farming practices and improve their credibility in front of food processors.
- **Food processors**: they want to get recognition and market advantage compared to competitors for following certifiable and ethical sourcing practices. They also want downstream actors to know that certain critical process steps have been followed without the need for long auditing steps and checks from authorities.
- **Retailers**
- **Regulators**
- **NGOs**
- **Final consumers**: they increasingly demand detailed information about what they buy and need to have confidence in products. Also, they want to make sure they only support brands that align with their own value and that make their practices transparent.

Considering the CTO's opinion reported in Section 3.2, it was deemed appropriate to have a **reduced network** supporting the Supply chain use case, with the Group playing the role of the system operator. Therefore the most appropriate access point to start with were considered **food processors**. In particular, the case company should choose a food processor that has a good overview on the asset movements and that is currently using the case company's machines along most of the process. Close and long-lasting collaboration is what would guarantee the Group a convenient access to process data and favor information sharing.

The Group collaborates with a well-known software vendor whose cloud computing, networking and storage services can be used to facilitate the creation of scenarios and applications on three of the most famous blockchain platforms, R3 Corda, Hyperledger Fabric and Ethereum. The most appropriate BC development space was selected as **Hyperledger Fabric** if the final consumers (general public) were not meant to be involved in the service provision. Only specific business actors would have joined the network and have assigned roles and responsibilities.

Services that were designed to solve the issues mentioned were **provenance attestation**, and **environmental and process monitoring**. The main customers of both services are farmers and food processors, very first key network participants. Others joining the network with read-only access are likely regulators and retailers.

4.2 Implications on the case company's Business Model

The very first changes happen at the Organization Domain. The Group becomes the system operator (also registrar) and expands the ecosystem around the coffee/cocoa/nuts process by involving the food processor's ecosystem (farmers, regulators and retailers). It becomes fundamental to clarify the new roles and activities of the case company and of all actors taking part in the BC network. Information flow changes, with the case company interacting with new actors that didn't have to share their own data with the Group before. The increased power and information access that the Group gets is regulated by legal contracts that report rights and obligations of each participant and the consequences of not respecting the contracts. To motivate stakeholders in joining the network, the Group conducts several group sessions in which it is explained how BC works, what public and private keys are and how to use them, and which benefits the BC-enabled solution brings. In particular, it is highlighted the importance of keeping the network reduced and the gain in process visibility and transparency such a choice implies.

In parallel the Group takes care of the Technology Domain. The company makes clear the drawbacks of a reduced network, such as reduced disintermediation with most of the power in the hand of the system operator, the possibility for the system to be not completely immutable, etc. At the same time, it shows them as solvable problems because of addressing technology limitations by partnering up with a competent software provider and by building on a known BC platform. Ecosystem actors are sure that while integrating BC in the current process, public-private keys are kept safe, privacy issues are addressed, data in the legacy systems are safely transmitted and stored in the new BC system, etc. Also, it is highlighted the effort the Group puts in taking care of disputes resolution still giving the entire network the possibility to express their opinion through voting. The translation of multiparty agreements into smart contracts results to be a delicate issue. Indeed, this means clearly assigning responsibilities to all network participants and subdivide the process into areas of accountability. It becomes clear who does what, when and how, and actors can agree on automatic fines (who pays how much in case of what). Partnership with the BC provider is particularly important when smart contracts are coded and the source from which they retrieve data is established and agreed upon.

Once critical partners are on board, the Group can practically show to service users which changes happen in the Service Domain. The service that the company offered so far involves a larger ecosystem in which information sharing happens real-time and in a transparent way, but still ensuring good performances and data confidentiality. The company continuously communicates its value proposition, its intention in offering such an enhanced service and stresses the possibility for network participants to refer back to them whatever would happen with the BC-enabled solution.

Finally, changing roles and responsibilities of each actor around the process impacts the Finance Domain as well. In particular, by becoming the system operator, the case company sees an increased responsibility and risk in managing the system. On one side, this is a convincing motivation for actors to join the network: less power, less risk, less costs. However, this leads to problems whenever the BC-enabled offering is priced or revenues are split. Again, legal agreements are stipulated in real life to make sure problems that arise between network participants are anticipated or avoided.

Planned changes in the current BM and their impact on other business domains are translated into **specific business activities.** Once the needed actions are listed, these are visualized in a **roadmap** that better shows dependencies between actions. The roadmap was created by the author to be presented to the CTO's of the case company to get an approval or a rejection of what was proposed.

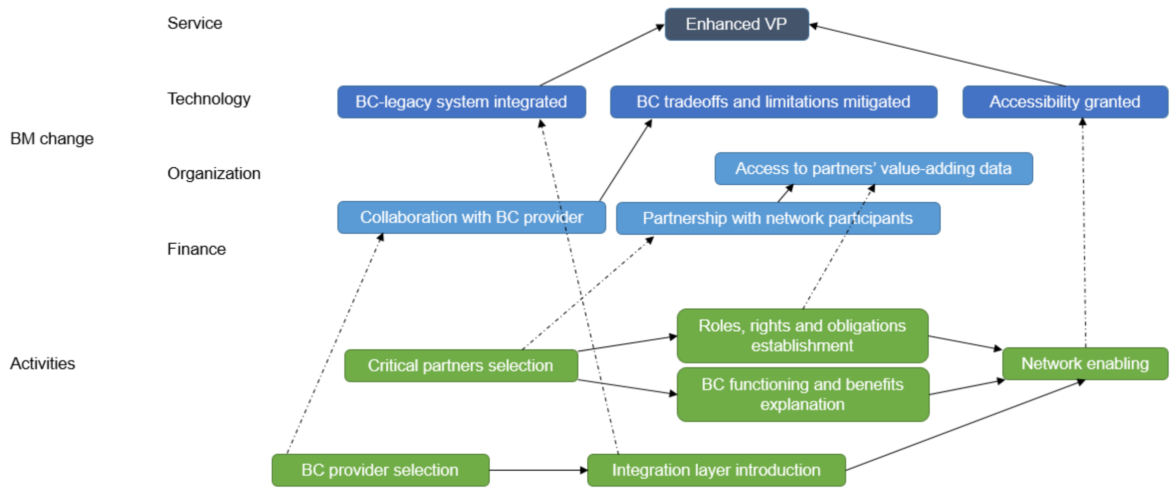

Figure 2 BM road map for BC-enabled offering

The full lines drawn in the picture establish dependence between activities. For example, it is not possible to access partners' data without establishing a partnership with network participants beforehand. Dotted lines instead connect activities influencing each other. For instance, the establishment of rights and obligations among actors it is supposed to facilitate the access the case company gets to partners' data.

5 Validation and discussion

5.1 Validation

The results presented in Section 4 were checked by the case company's CTO and compared to the approach that the Group followed in reality. The CTO approved the focus on the process of high value items such as the ones previously identified and the extension of the supply chain solution from farmer to first food processor. Moreover, he confirmed the consolidation of the ongoing partnership with the current software provider and the use of its cloud services for building on top BC applications. He as well affirmed that partner selection would have been the next step. In particular, the Group selected a food processor with a very good visibility on the process (from farmers to their facility including transportation) and maintaining a solid relationship with the Group since many years. This confirms the validity of the stakeholders' analysis performed in Section 4.1 followed by the suggested collaboration with BC provider. However, since no BC application has been deployed yet in the case company, the services proposed and how to financially support those was not envisioned because too early. Thus, the following steps in which the value-adding services and the revenue mechanism are envisioned could not be confirmed because dependent on the partners' needs and pain points encountered along the process.

However, the BM road map proposed in Section 4.2 was checked as well by the CTO and its validity confirmed. The most critical and time-consuming part is the Technology field, in particular building the back-end infrastructure that would guarantee a sustainable BC solution in time. Once the integrator is installed and running, the second step is to choose a BC platform where to build the BC application. Critical actors taking part in the network are selected indeed for the access they guarantee to data, in particular for the higher integration level and visibility they assure on the process identified (from farmer to first food processor). The stipulation of legal contracts to get critical actors on board and the clear definition of roles, rights and obligations was deemed another fundamental activity to be carried on before rolling out the service.

5.2 Discussion

The following discussion serves as a reflection on the results found and their significance based on what resulted from the literature review, i.e. what was known about the original research problem, and how the exploration of the BC-BM relationship was conducted in the company.

Similarly to what is suggested in the literature (Plansky, O'Donnell, & Richards, 2016; Wang, Chen, & Xu, 2016), the Group started with identifying the processes and the related pain points that could be solved by BC implementation. This supports the concept of blockchain as a software choice for a company proposed by Rimba et al. (2017): at very first, BC corporate introduction impacts the operational or process level, in particular the way information flow happens.

Moreover, it is important to recall what the company's CTO stressed when first interviewed about the food supply chain use case. He underlined how the BC-enabled supply chain solution would need to perform efficiently in terms of transactions speed and to be scaled up and still function when it expands. He considered establishing legal agreements between network participants the solution for giving actors more confidence in ledger immutability. He also stressed the importance of allowing data sharing only when people supporting the BC solution would know each other for sake of confidentiality. By considering the tradeoffs that BC technology implies, a reduced network underlying the BC supply chain application could ensure speed (performance), governance and confidentiality. This can explain the importance the company gave to network formation and governance (i.e. Organizational Domain) when exploring the changes from current to BC-enabled BM.

In particular, if the use case requires the formation of a reduced network the system operator must expect an expansion of the current ecosystem and the increased responsibilities coming along with it. The most important are motivating actors in joining the system, bearing most of the risk in case the solution is not successful, solving disputes when they arise, and maintaining and upgrading the system. To address these CDIs in the Organization Domain it seems fundamental to stipulate legal contracts between actors clearly explaining stakeholders' roles and responsibilities. Moreover, the system operator must make sure CDIs in the Technology Domain are addressed for all network participants so that everyone can use the technology and access the BC-enabled service. The most delicate and critical activity to carry on is the translation of legal contracts into smart contracts: once roles and areas of responsibility are established, actors need to agree on smart contracts coding and must verify autonomously the data source smart contracts can access. All this is feasible only when the network is reduced and the system operator can take care of stipulating specific contracts with each one of the network participants. When the system expands instead, it makes more sense to automate repetitive processes, such as checking actors' compliance for joining the network, instruct them on public-private key importance and usage, and specifying their roles and requested activities. To allow the automatic functioning of these processes, addressing the Technology Domain then becomes more important and sees the establishment of automatic mechanisms embedded in the blockchain.

A new light is shed on tradeoffs that the technology implies for each use case and how importantly they should be considered when changing from current to BC-enabled BM. Moreover, exploration order likely changes depending on the use case, or more importance is given to other domains of the BM. It is argued here that there is a relation between use case requirements and BM exploration. For this use case performance, governance, and confidentiality mattered, so it was better to assess first the Organization Domain. Differently, a use case for which speed and confidentiality are not important cares less about the Organizational Domain, and more about the Service or Technological one. Indeed, the research conducted by Holotiuk et al. (2017) represents the perfect example of how for payment system use cases the approach is rather top-down than bottom-up: regardless of the underlying processes, first the Service Domain is affected with the introduction of BC-enabled services, then the financial structure changes and finally impacts are observable on entire BMs (Holotiuk, Pisani, & Moormann, 2017).

Finally, the research also suggests the need for moving away from mere technological discussion and step back having a look at the entire BM, in which there is also space for addressing technological challenges and even seeing them in relations with other domains.

6 Conclusions and limitations

After conducting the literature review about BC technology and Business Models, and studying how the case company intends to integrate the technology in their current business processes, some conclusions can be drawn.

The review conducted on BC highlighted the lack of research on the impact BC integration potentially has on other fields than technological one. Knowing that BC is a software choice for a company, it was fair assuming that its introduction would have started at the operational level of an organization. Still, it was not clear how it would have impacted the entire value configuration of a firm due to its unique characteristics. Thus, the theory on the Business Model (BM) concept and its design components was reviewed and the interrelations with company's information and product flow, business architecture, ecosystem, and value proposition was explicated. Components to explore when analyzing and then changing the current BM were the Service, Technology, Organization and Finance Domain. Critical Design Issues (CDIs) became the unit of analysis and were specified for blockchain technology. Results were summarized in a framework that reports concepts used to analyze and then change the current BM into the BC-enabled one. In particular, it resulted that addressing blockchain tradeoffs in a corporate environment is actually equivalent to addressing specific CDIs when changing from current to BC-enabled BM.

It was still unclear how a company would explore the relation between BC potential and BM, and how it could prepare for change in BM. This was the motivation for analyzing a specific company and conduct an exploratory case study. The Group was selected for the industry in which they are active (food industry) and the digitization push that characterizes the industry. The Supply chain management and Provenance tracking use case was selected to be deployed within the firm. Based on theory and Group's characteristics, it was studied an order that the case company should have followed during its exploration: first identify the processes and the study the information flow. Then perform stakeholders' analysis and analyze possible partnerships with both network participants and BC providers. Finally, envision the services that add value to the target groups identified and come out with a rough revenue mechanism. Suggestions were proposed to the CTO of the company together with a high-level road map describing which business activities they should take care of when transiting from current to BC-enabled BM. The exploration order was approved, confirming the validity of the research. It resulted that for the supply chain use case the Organizational Domain is the most critical to address: the creation of the blockchain network by means of partnership with actors in the firm's ecosystem was fundamental and critical to make sense of a supply chain application built on top of it. Secondly, it was deemed fundamental making sure that CDIs in the Technological Domain were addressed.

This exploratory research wants to sum up the current situation regarding corporate deployment of blockchain and understanding better blockchain in a business context. In particular, the case study has been useful to see how technological tradeoffs translate into changes needed at the BM level. At the same time, it has been helpful for identifying other research areas worth exploring more than technological ones. For example, in the future it can be researched how the creation of a business ecosystem around the blockchain solution and the governance of it (particularly related to the financial aspect) changes depending on the use case deployed. Also, the study case warns firms from experimenting with blockchain solutions without strategically evaluating the value at stake or how feasible it is to capture it: in this way, several companies won't see a return on their investments. However, "companies can determine whether they should invest in blockchain by focusing on specific use cases and their market position" (Carson, Romanelli, Walsh, & Zhumaev, 2018).

Nevertheless, the research has some important limitations. The most important is that it only analyses the approach followed by one production company that went specifically for a supply chain use case. It is difficult to derive generalizations for all other use cases mentioned in Section 2.1. For example, service companies might want to deploy completely different use cases and explore the needed changes in their BM with a different approach. Some additional factors motivate the bottom-up approach they took, characterized by a "reflect and adapt" behavior, opposite to the more "think and act" way the top-down approach supports. The first condition is the size of the corporation. With almost 11,000 employees, it is unlikely for such a big company to modify the usual revenues stream without first making sure the technology is well integrated with the current technical architecture and the solution gets support from business partners in the ecosystem. Secondly, the company is indeed moving towards increased digitalization, but at this stage it cannot be considered a high-tech company. This can hamper the introduction of new technologies, or follow a slower path than high-tech businesses, such as Amazon, Intel, etc. (Inc., 2018). Finally, the uncertain environment that surrounds BC corporate development favors a more cautious approach. As of 2018, very first projects are starting being disclosed, but few information is released, so that it is extremely difficult for the case company assessing whether it is necessary to set up their own network, or if it is possible to join an existing one. Therefore, smaller, more high tech companies might do differently, particularly in few years from now when the BC landscape will be much clearer. However, companies with similar characteristics to the case company and willing to deploy the same use case are likely to experience a similar development path.

Other limitations of the research regard the methodology. Participant observation leads to data collection that is mainly dependent on the informants used along the research. In this case, mostly people from the business itself where interviewed, with only few data coming from external sources such as company's clients or BC experts. Having access to different people could have changed the results obtained (Kawulich, 2005).

Last limitations derive directly from the nature and stage of development of the technology. Blockchain technology is still largely being experimented: many other prototypes and trials are needed before assessing better the impact the technology can have on the way business is done. Moreover, corporate use cases are still highly dependent on the context and their deployment on the firm's characteristics. The literature review confirms that there are real constraints for launching BC mass market use cases today, mostly technological such as technology integration and the lack of a common standard.