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How Blockchain interrelates with trust in the supply chain context: insights from tracing sustainability in the metal industry

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Purpose: *Blockchain technology (BCT) is argued to deliver a trustless system where trust is driven by technology rather than individuals or organizations. This paper studies this claim using insights related to tracing sustainability features in the metal industry.*

Methodology: *The results of this study are based on multiple case studies of two supply chains (steel and copper) piloting a traceability solution for tracing metal sustainability throughout the supply chain. The data are collected and analyzed from multiple actors using sources such as interviews and secondary documents.*

Findings: *The study empirically supported that even if the BCT is applied, there will be a need for: benevolence, integrity, ability, and credibility dimensions of trust. Hence, a trustless system is still not yet applicable. Moreover, to remove the need for the trusted third party certificates, there are boundary conditions such as governance structures and standardizations that must be addressed first.*

Originality: *The concept of trust in the novel phenomena of the BCT was investigated from different point of views, such as the supplier and the buyer views. Moreover, different contexts were examined such as the commercial and the sustainability contexts. Therefore, this paper is among the first to handle the issue of trust from these regards.*

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1 Introduction

In today's business, inter-organizational interactions rely on unattached, multiple, and centralized systems across the supply chain (SC). That set-up requires much trust, harmony and coordination with participants to ensure unsafe, forged or fraud transactions do not occur anywhere in the network (Falcone et al., 2020). Therefore, many inter-organizational transactions are conducted through third parties or so called intermediaries, such as brokers or banks, who take on the potential risk of managing the transactions for an agreed price and sometimes a share in governance (Falcone et al., 2020; Lacity 2018).

Blockchain technology (BCT) is a distributed ledger in which all SC partners are given access in a peer-to-peer network to simultaneously exchange immutable records. This removes the need for central parties as it allows for a single trusted and visible source of information through the BCT (Francisco and Swanson, 2018; Wang et al., 2019). This could create a trustless system or a digital trust where trusting SC partners may be "not needed" given that the trust has been "programmed" into the BCT through its consensus mechanisms (Collier and Sarkis, 2021; Saberi et al., 2019). For example, in the metal industry, it is very difficult to trust other partners on the sustainability of their metals. This is because metals come from many different suppliers and countries and then they are melted, mixed and merged during the supply chain. However, with the help of the BCT, it became possible to have a trusted "eco-label" on metals to trace their sustainability features which facilitated the supply chain management (SCM) process (Svemin, 2019).

Saberi et al. (2019) speculated that BCT's trustless system can aid and support in solving many SCM problems related to environmental, economic and social aspects. Yet, great ambitions comes with great complexities. Indeed, there is a disagreement to wither the BCT is truly "trustless" as claimed by Saberi et al (2019), or a trustless system is a "myth" as described by Bratspies (2018). The problem lies in the nature of trust being a multidimensional, intangible concept that need to be operationalized into its underlying dimensions to be fully understood (Fawcett et al., 201). Now, trust became even more ambiguous due to the novelty of the BCT technology and the hypes surrounding it.

Therefore, some researchers suggested that trust will simply shift from intermediaries towards the technology itself and its governance process, but further research is needed to investigate such claims (De Filippi et al., 2020; Gucluturk 2018).

So the purpose of this paper is to explore the BCT and its trustless system in the SCM context. We endeavor to do this by exploring the current trust practices through close interactions with the individuals to capture their perceptions of trust as a concept. Insights from steel and copper supply chains are used to answer the following research questions:

- How is trust perceived with regards to SC partners and the BCT itself?
- To what extend the BCT's trustless system is applicable in the SCM?

2 Theoretical background

In this section, we follow a logical sequence to explain the BCT first. Then we explain the trust concept especially in the SCM literature. Finally, we link between trust and BCT to understand the "BCT based trust" in the context of SCM.

2.1 Blockchain technology

The BCT is defined as "a digital, decentralized and distributed ledger in which transactions are logged and added in chronological order with the goal of creating permanent and tamperproof records" (Treiblmaier, 2018). The technology basically depends on unique features that defines it. These unique features are best described by Falcone et al. (2020) as: first being a distributed ledger technology (DLT) and second is the peer to peer network (P2P). Indeed, DLT and P2P are not new features to the information technology world, but what makes it truly unique is the novel combination of these two features with the utilization of advanced cryptography and consensus mechanisms to guard the whole process. (Falcone et al., 2020; Francisco and Swanson 2018; Kuhn et al. 2019).

The BCT has two types: permissionless (public) and permissioned (private) blockchains. In public blockchain, the digital ledger is completely decentralized and can be accessed

by any Internet user, which may put sensitive information at risk of exposure. On the other hand, private blockchain allows only a set of preselected participants to be authorized to use the ledger. In a fully private blockchain, entries are monitored by a central authority which can decide to accept new members into the network and determine their level of access (Treiblmaier, 2018). Moreover, an optional feature called the smart contract allows transactions to be triggered autonomously based on the trusted data of the distributed ledger. This has a great potential in terms of automation and artificial intelligence (Iansiti and Lakhani 2017).

2.2 Trust in the context of supply chain management

A highly cited definition of trust is "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (Mayer et al., 1995). In the literature, trust has been heavily discussed from different disciplines such as: psychology, sociology, economics, marketing, and SCM. This makes the topic of trust more complex rather than being simpler, since each discipline used its own lenses to explore it (McKnight and Chervany, 2001).

The SC literature defined trust in many ways. For example, Chan (2003) defined trust in SCM as the "reliability and consistency between different levels of the supply chain". Poppo et al., (2016) identified two main frameworks for trust, the first is calculative trust and the other is the relational trust. Indeed, Trust became even more complex in the context of SCM as it involves multiple inter-organizational relationships by nature (Arvidsson 2020 and Melander; McKnight and Chervany, 2001)

Batwa and Norrman (2021) argued that trust in SC partners can have dimensions like benevolence, credibility and openness of information sharing. These dimensions goes in line with some of the dimensions suggested by Fawcett *et al*. (2012; 2017) and Seppänen et al. (2007). Moreover, some other older and widely cited researches such as Mayer et al. (1995) have argued for alternative dimensions like integrity, ability and benevolence. Table 1 summarizes trust dimensions, its definitions and their references.

In this article, all the above dimensions are considered, whereas similar terminologies are grouped together. Indeed, the literature have many synonyms for trust dimensions, for example, Seppänen et al. (2007) mentioned more than 20 dimensions. But they can be grouped into few dimensions that depends on how broad or limited the definitions are. In this article, we focused on the most dominant dimensions in the SCM according to Fawcett et al. (2012; 2017), Seppänen et al. (2007) and Mayer et al. (1995).

Table 1: Dimensions of trust in SC partners

Trust dimensions	Definitions	References
Benevolence or goodwill	The mutual expectation between two parties that each will do good to the other	Fawcett et al. (2012; 2017); Seppänen et al. (2007) Mayer et al. (1995)
Openness	Transparency in sharing information and values	Seppänen et al. (2007)
Credibility	The confidence that each party in a relationship will perform as promised	Fawcett et al. (2012; 2017);
Ability or competence	The group of skills and competencies that enable a party to have influence	Mayer et al. (1995)
Integrity	The trustor's perception that the trustee adheres to a set of principles that the trustor finds acceptable.	Mayer et al. (1995)

2.3 Blockchain based trust

The BCT features that drives digital trust can be summarized in five points as mentioned by Lacity (2018) and cited by Falcone et al. (2020):

- "BCT allows participants to interact directly instead of through a third party
- BCT eliminates the need for reconciliation due to a shared, time-stamped, and immutable ledger of transactions,
- BCT instantly provides transparency and provenance of transaction's data
- BCT settles transactions faster and cheaper by automating the transaction and removing third parties
- BCT creates a data structure that is fault-tolerant, resilient, and persistently available to all participants in the network". (Falcone et al., 2020)

Batwa and Norrman (2021) proposed that trust is still needed for applying BCT. Therefore the influence between trust and BCT can have a reciprocal nature, i.e. trust can be both an antecedent for applying the BCT and a consequence. Moreover, trust can be seen with regards to two objects: trust in the SC partners and trust in the technology itself (Figure 1).

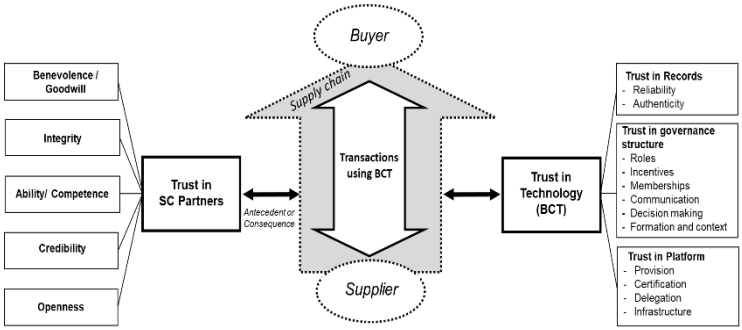

Figure 1: Framework for BCT based trust, adopted from Batwa and Norrman (2021)

After describing the dimensions of trust in SC partners, we now describe trust in the technology. Based on Lemieux (2016), Grandison and Sloman (2000), and Mak (2014), Batwa and Norrman (2021) proposed that this is perceived through two dimensions: trust in the records and trust in the platform. Other researchers such as Pelt et al (2021) and De Filippi et al. (2020) recently argued that confidence in the BCT depends fundamentally upon its underlying governance structure, this is also considered in this study (Table 2).

Table 2: Dimensions of trust in the technology (BCT)

Trust in BCT dimensions	Sub-dimension	Description
Trust in the records (Lemieux, 2016)	Reliability	The process of record creation: who creates the record and how they go about creating it
	Authenticity	Establishing and preserving the identity and the integrity of a record after its point of creation
Trust in the governance structure (Pelt, et al., 2021)	Roles	Describe observable hierarchical structures of participants
	Incentives	Motivational factors involved for the specified roles
	Memberships	The way participation are managed for the available roles.
	Communication	The formal and informal ways of communication between the stakeholders of the blockchain
	Decision making	How decisions are made, monitored and agreed upon
	Formation and context	The purpose of using a blockchain, and the type of the license used
Trust in the platform (Grandison and Sloman, 2000)	Provision	Trusts to let the trustee implement the service
	Certificate	A belief that the trustees' identity is claimed, based on certifications
	Delegation	To let trustee make decisions on the trustor's behalf,

Trust in BCT dimensions	Sub-dimension	Description
	Infrastructure	Trust in the related hardware and software to establish the BCT

3 Methodology

In this research, we are exploring the well-known trust concept but in the context of a novel phenomenon that is the BCT in the SCM. Since the context is intrinsic to the phenomenon, and since this phenomenon is complex and not yet fully understood, then it is very good match to use the qualitative research strategy (Golicic et al., 2005). This research depends on established trust concepts that can be used to approach the empirical context. The empirical data would lead into more insights to previous trust concepts in the novel context of BCT and therefore this research can be seen as a theory elaborating rather than theory generating research. (Ketokivi and Choi, 2014).

In terms of the research design, several researchers (e.g. da Mota Pedrosa et al., 2012; Voss et al., 2012; Yin, 2014) suggested that case research is an appropriate research method for exploring a phenomenon that we have limited understanding about. Furthermore, in this study we aim to capture trust aspects from close up interaction with the respondents to understand the underlying concepts of trust (Easton, 2007). Hence, case research was selected in this article as it fit the purpose of the study.

Multiple cases were used in terms of data collection. The reason for that is the nature of the supply chain context, for example, the settings for a dyadic relationships can be different than the relationship with a second or third tiers in the supply chain either upstream or downstream. The studied cases in this paper were copper and steel chain (Figure 2). In the steel supply chain, the blockchain pilot project involved a direct relation between the iron mines and their manufacturer of the steel. But in the copper chain, the blockchain project involved a second tier relationship between the copper mines, the copper wire manufacturer and the copper buyers that is a large electronic company. However, the manufacturer in the copper chain had a minor involvement in the

blockchain project and therefore it was not included in the interviews. The unit of analysis is trust in the context of different supply chains that applied at least a pilot blockchain project. One research institute has managed both cases where a pilot blockchain project has been applied separately for each case.

The main data collection method was a semi structured interviews to capture the related trust aspects (Easton, 2007). In total, 8 interviews were carried out. The interviews were done with key employees in each company who were involved in the blockchain pilot project including one interview with the project manager in the research institute who lead the two pilot blockchain projects. On average, the interview length was about one hour and 25 minutes per person. The median time is 75 minutes. All interviews were done through online meetings due to current Covid-19 restrictions. The interviews were recorded and transcribed using a transcription software with the author review and corrections, and with the permission of the respective interviewee. Additionally, we used published secondary documents by the research institute leading the two pilot blockchain projects.

Table 3 gives the details of the companies, the respondents, and the interviews. Due to confidentiality reasons, the companies and the respondents are given alias names. The letter S refer to “supplier” while the letter B refers to “buyer”. Moreover, the roles indicated two contexts: commercial context which is related to commercial activities such as sales or purchasing. And sustainability context that is covering environmental and social activities.

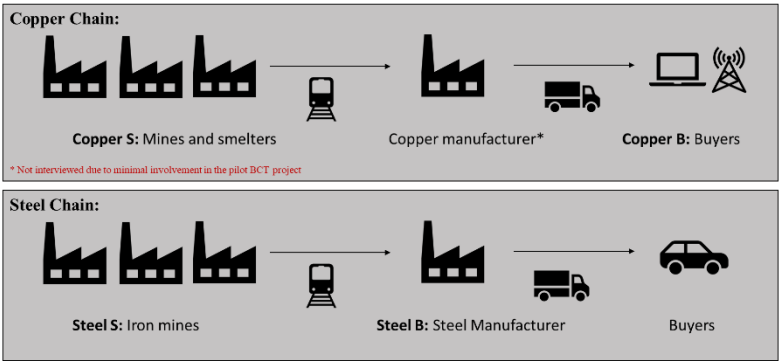

Figure 2: Copper and steel supply chains

Table 3: Respondents roles

Cases	Companies	Respondents	Respondent Alias	Interview length
Copper SC	Copper S	Sales director	Co-S-Sales	75 Min
		Sustainability advisor	Co-S-Sustainability	75 Min
	Copper B	Account manager (purchaser)	Co-B-Purchasing	120 Min
Steel SC	Steel S	Sales director	Stl-S-Sales	60 Min
		Purchaser	Stl-S-Purchasing	75 Min
		Sustainability director	Stl-S-Sustainability	75 Min

Cases	Companies	Respondents	Respondent Alias	Interview length
	Steel B	Sustainability director	Stl-B-Sustainability	120 Min
Projects leader	Research institute	Project leader	The project leader	90 Min

Following an abductive reasoning, we used iterative open and axial coding for the data analysis. In the open coding, the data from the different respondents was broken down to be analyzed, conceptualized, and categorized (Ellram, 1996; Yin, 2014). Then axial coding (pattern analysis) was used to make preliminary connections among the categories developed in open coding (Ellram, 1996). It is important to mention that analysis has been conducted in parallel with the data collection rather than a sequential process.

4 Cases introduction: the need for traceable sustainable metals

Due to the way metals has been traded in the global market, it was almost impossible to put an "eco-label" on metals to trace back its sustainability features. This is because metals are mixed and merged during the supply chain which puts the traceability of the chain of custody on the wish-list for decades, especially for mining companies with high environmental standards. However, in the last few years, things have started to change positively due to: legislation initiatives, development of new chain of custody (CoS) models and most recently the development of new technologies that allowed for real time traceability such as BCT (Svemin, 2019).

Indeed, "the need for sustainable metals and minerals will grow substantially as a result of a growing world population, increasing living standards and, not least, the transition to a climate neutral society. In this context, certification of metals and minerals could

contribute to meet sustainability challenges of increased resource use" (Svemin, 2019). According to Svemin (2019), Chain of custody models are different based on different needs. It could be for example:

- Identity preservation: in which the product can be traced back to the original source.
- Segregation: in which only products or materials from equivalent sources will be mixed in the production.
- Mass balance: in which the identity preservation and segregation are lost due to mixing of sustainable material with non-sustainable material.
- Certificate trading: in which sustainability claims are traded as certificates or credits. It is an approach to reward responsible production when it is difficult or impossible to trace products or material in the supply chain.

In the two studied cases of copper and steel chains, a mass balance approach was used. For each case, a pilot BCT project was applied using a private BCT system that was developed specifically to meet these two requirements for both cases:

- Implement an immutable and traceable mass balance chain of custody on a BCT database system
- Develop a certified declaration and tracking for mainly (1) carbon footprint and (2) recycled content of metals

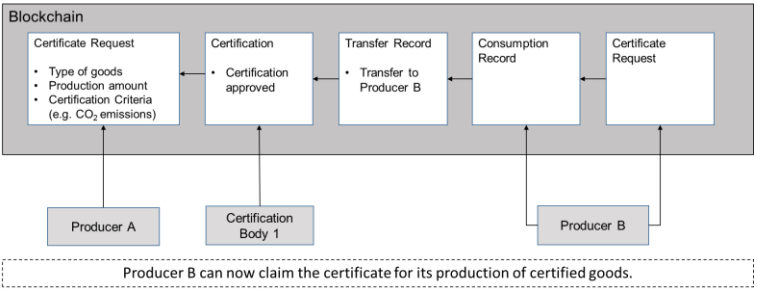

Figure 3: Explanation of how BCT certificates work

According to the project leader, it was useful to apply BCT in tracing the sustainable metals especially to meet the mentioned requirements. However, it came with some challenges related to the confidentiality, governance, correctness, and technical issues

such as energy consumption and node operations. A limitation is that the pilot projects were not implemented in full scale but only tested few times. Thus, the practicality and scalability of the BCT could not be deeply investigated. Furthermore, smart contract features were not used as it was not necessary needed to meet the two requirements.

5 Cases insights

For capturing how trust is perceived related to BCT, trust needed to be operationalized to its dimensions for developing a better understandings. Each trust dimension will now be explained based on the insights from the cases.

5.1 Trust in SC partners dimensions

Five dimensions were discussed through the interviews which are benevolence, integrity, ability, credibility and openness.

Benevolence or goodwill

All the respondents from the buyer and the supplier views said that no obvious opportunistic behavior with related to tracing CO2 emission and sustainable content materials. This indicates that maintaining a goodwill is a common practice in relation to sustainable context in the metal industry. However, Co-S-Sustainability from Copper S mentioned they face some altered information during the complex process of exchanging assays (i.e. quality documents for metal or ore). This practice make them benefit from reduced metal value which can be considered an opportunistic behavior that goes against benevolence. Despite this, benevolence is considered an important aspect of trust and it couldn't be replaced by the BCT as it goes beyond the opportunistic behavior into more productive collaboration as per Co-S-Sales S and Stl-S-Sales opinions.

Integrity

One example of integrity can be the adherence into the principles for reducing CO2 emissions among all the respondents. This can be justified as only a small number of actors were interviewed and sustainability issues was one of the main project aims.

However, integrity in other contexts is not as much agreed upon as reducing CO2 emissions. For example, Co-S-Sales stated that “the system without sanctioning capabilities basically doesn't provide any security for us“. If agreements must be “enforced” to be applied, this means a lack of trust in terms of integrity.

In terms of BCT and integrity, trust in other SC partner’s integrity is important for BCT to success and to avoid conflict on interests. Simply, the project leader indicated “it will be difficult to put many people in one room to implement a collaborative project if they don’t trust each other”. Hence, trust in other’s integrity remains important despite BCT implementation.

Ability or competence

In the two studied cases, a sort of consensus formed with regards to the ability dimension. All the respondents pointed out they generally trust their partners’ abilities. This is because they carefully picked them in the first place. Moreover, they cannot see how BCT would influence any partner’s power that is gained based on a specific ability or competence. Therefore, Trust in other’s abilities to fulfill the requirements is irreplaceable by BCT as it is embedded in the skills and competences of the core business.

Credibility

The respondents Co-S-Sustainability, Stl-S-Sustainability, and Stl-S-Sales from both sustainability and sales departments tied credibility with transparency. For example, Co-S-Sustainability stated “credibility to carry out the agreement is often related to what issues do they have at the production plant and if they are transparent with that, then it's easier for us to reach an understanding”. Stl-S-Sustainability stated that “if you have full transparency in the value chain, you will be able to monitor this (credibility) and you will see who is better than others”.

Yet, credibility is not all about transparency and visibility. Others pointed out that it can be developed over time such as the respondents Co-S-Sales, Co-B-Purchasing, and Stl-S-Sales. Besides that, all other respondents also pointed out that personal relationships are very important to develop confidence in an organization and they don’t see that a technology could replace experience or personal relationship aspects.

Openness or transparency

Many respondents perceive trust as a transparency in sharing information especially in the sustainability context. For example, Stl-S-Sustainability stated that ”my take on the term trust comes from a well, purely a sustainability perspective and to me, it equals transparency, which within sustainability is considered to be something that we strive for”. Stl-B-Sustainability stated that “Blockchain is all about the need for information sharing and a need to be transparent”. Co-S-Sustainability stated that “trust equals transparency: when we are transparent, we build trust”. Therefore, openness or transparency was the dominant perception among the dimensions of trust according to our interviews especially in the sustainability context.

However, to achieve transparency, many challenges come in the way. One major challenge is about setting up a standard way to calculate sustainability measurement criteria as it is not standardized among the SC partners neither in the copper nor in the steel case. Stl-B-Sustainability for example emphasized that “setting up standers is the most important challenge in the BCT implementation”. Others agree with him such as Stl-S-Purchasing and Co-B-Purchasing as well as the project leader.

Some cooperation was there between direct supplier-buyer relationships such as a project between both steel S and steel B as reported by both sustainability and sales respondents in both companies. This kind of cooperation was not visible in the copper chain since it has a multiple tiers relationship. Here, we quote from Co-B-Purchasing who stated that “I don't think blockchain will change the trust we have today towards the suppliers we work with directly, but it will increase the trust between the sub suppliers in the blockchain”

Other challenges related to openness is the confidentiality of sharing information. In terms of the sustainable context, CO2 emissions and sustainable materials content are not of course seen confidential. However, in the commercial context, many respondents find it difficult to share information like the origin and destination of the products, especially for the sales respondents due to reasons related to competitive advantages and negotiation of prices. This kind of issues has been technically discussed and it can be solved through DLT and P2P features of BCT at least on theory. So BCT based trust can

mainly replace the dimension of trust that is related to openness but some boundary conditions must be met first such as confidentiality and standards.

5.2 Trust in the technology dimensions

In this section, we will mainly discuss trust in the records as well as governance mechanisms. Since the two cases involved only pilot testing, it was difficult to draw conclusions related to trust in the platform and hence it would not be discussed.

Trust in the records

Trust in the records has two dimensions, first is the reliability and second is the authenticity. In terms of reliability, it relies on who created the records at the first place. Therefore, many respondents pointed out the need for a certified third party to validate the records before entering to the system. This finding comes from the suppliers' perspective as a competitive advantage to proof they are trustworthy. On the other hand, from the buyers' perspective, it is a condition prior to trusting the transactions. This can be interpreted into a lack of trust in the other SC partners, but also a common practice in the metal industry. In terms of authenticity, indeed all participants agreed upon the ability of BCT to provide a trusted data, which is related to maintain provenance records of the transactions. However, standardized process such as ISO are still required as suggested by some respondents.

To sum up the respondents opinion here: the records of BCT are trusted only if it is through a trusted third party specialized in providing such certificates. Once data entered into the BCT, it will be handled according to standardized methods and will be completely trusted. As an example: Co-B-Purchasing stated that ”If everybody will start to use some kind of certified method, then I believe, it is not so very difficult to get the trust between the actors within the blockchain. Because you can quite easily get that by forcing everybody to sign an NDA. If you sign a nondisclosure agreements for everybody, which is inside the certified blockchain, then you're forced to follow it, and then you're forced to trust the information you get”.

Trust in the governance structure

Governance structure has many dimensions and layers. However, as this was a pilot cases, it was difficult to capture all the dimensions with regards to BCT. However, respondents reflected mostly upon communication, roles, decision making and contextual factors for applying BCT.

Since the two cases are mainly related to sustainability context, free communication with agreed roles and decision making is not an issue at all, especially related to tracing CO2 emissions. However, some respondents speculated that if BCT is applied into other contexts, governance structures would be complex and would require a high cooperation to be agreed upon. For example, Co-S-Sales stated that “we are trying to figure out what is required to make it (BCT) a solution, which has a critical mass of governance structures, parameters and users” he also reflected on the contextual factors for applying the BCT since the current pilot was mainly to discover the potential benefits that might drive a competitive advantage for them, but the initiative was not based on an urgent need for solving a current problem within their business.

One way to remove the uncertainty and the mistrust regarding BCT governance structure is by relying on third party experts such as the technology providers or consultants to settle these issues. For example, Co-S-Sustainability stated that in terms of governance “I would rely on other experts to define if this is something we can trust or not. So I would rely on experts on the technology”

From the interviews, it can be seen that governance structures is a main source of uncertainty and it is not what companies needed at the moment. However, as many respondents pointed out especially in the steel SC, direct relationships helps in solving the boundary conditions but the true value of BCT comes with regards to trust in multi tiers partners. This also goes inline to what was said by Co-S-Sales.

6 Discussion and Conclusion

6.1 How is trust perceived with regards to SC partners and the BCT itself?

To answer the first research question, it has to be understood from two different perspectives. First is related to trusting other SC partners in the presence of BCT. In general, trust in the SC partner is perceived as openness in information sharing especially in the sustainability context. With this regards, BCT is perceived as a very promising technology. However, trust also perceived in other ways such as benevolence, integrity, ability and credibility. Indeed, in these aspects trust seems to be still needed even after applying the BCT, especially in the commercial context.

With regards to trusting the technology, the major perception is that there is a great trust in the records already tested in terms of authentication. For example the “eco labels” to trace the sustainability features of the products. However, there is less trust in the reliability or correctness of the data, i.e. garbage in garbage out problem. Therefore, the metal industry still relies heavily on third party certifications. Another important aspect of trust in the technology is related to trusting its governance structure and the different standards between the different companies. Indeed, one way to remove the uncertainty and the mistrust regarding governance structure and standardization is by relying on third party experts which contradicts a major goal of applying BCT and achieving a trustless system.

6.2 To what extend the BCT’s trustless system is applicable in the SCM?

With proper governance and standardization, we can say trust in a third party will be less needed. However, there will be a need for benevolence, integrity, ability, and credibility dimensions of trust. And hence, a trustless system is still not yet applicable in SCM. Table 4 summarizes the case insights that support this conclusion.

Table 4: Summarizing results and discussion

Trust objects	Trust dimension	BCT based trust	Context
Trust in SC partners	Benevolence	Required to avoid opportunistic behavior and for productive collaboration	Commercial contexts
	Integrity	Required to avoid conflict of interests	Commercial contexts
	Ability	Required to trust the ability that could be a core to the business even if the BCT is applied	Sustainability & commercial
	Credibility	It does not rely only on transparency, but time and personal relations as well, so it cannot be replaced by the BCT	Sustainability & commercial
	Openness	It can be replaced using the BCT if boundary conditions are met	Sustainability & commercial
Trust in technology	Trust in records	High trust in authenticity of the records, but not the reliability. The reliability would only be trusted if the records are entered through a trusted third party.	Sustainability & commercial
	Trust in governance	It could be trusted through technology provider or third party or if it is collaboratively developed	Sustainability & commercial

The above discussion is aligned with De Filippi et al. (2020) that suggested the BCT is not a trustless technology but rather a confidence machine, where confidence in the BCT depends upon its underlying governance structure. It also echoes Bratspies (2018) opinion that cryptography trustless is a myth.

7 Research contribution, limitation and future studies

This research helps in capturing the soft dimensions of trust in relation to the BCT, which contributes in appraising the potential benefits for this novel technology, despite the hype around it being a trustless system. In terms of the practical contributions, this research provided insights based on empirical data on the potential of applying the BCT to trace the sustainability of the metal industry. Indeed, the tractability of Co2 emissions and recycling contents in the metal industry can be achieved using the BCT although a complete trustless system is not yet achievable.

Future research is still needed for the BCT to seek solutions regarding the garbage in and garbage out problem. For example, using the BCT with internet of things (IOT) devices to capture inputs, and using smart contracts to trigger transactions. Indeed, the respondent Stl-S-Purchasing raised such questions but it remains for another research and another cases to study as it was not applicable in this paper. Moreover, this research could also be further studied using quantitative research strategies for generalizing its results and conclusions. The BCT indeed is a novel technology that is being considered by many businesses nowadays such as food chains and automotive industries. Therefore, the results of this study could be re-visited in the future with more cases other than the metal industry, and this would enrich the contribution and the value of this study.

The limitations of this study is that it only relied on a pilot project testing the BCT, and hence no conclusion could be driven on trusting the platform dimensions. Moreover, not all the companies in the supply chain were interviewed, mainly because of their minor contribution in the pilot projects, but yet this limits the conclusions for example with regards to the governance structure dimensions. However, interviewing employees from different contexts beside the projects leader helped in driving the conclusions of this paper.

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