Perceived Trust in Blockchain Systems: An Interview-based Survey

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ABSTRACT

Blockchain systems have received increased interest over the past few years, and several new fields of use, such as supply chain systems, are being investigated. Since blockchain is still a new technology, various papers have explored how to apply it to support use cases outside the limited scope of digital currencies. Systems require solid technological implementation and perceived trust among users to ensure their interests and successful usage in practice. This study aimed to understand what graphic user interface (GUI) elements of a blockchain-based system make users trust that their best interests, such as security and privacy, are maintained in the systems. As a case study, we developed a few blockchain-based supply chain GUI mockups with different elements that reflect the security and privacy features of the system. We then conducted 30 interviews in Norway and China to collect the users' opinions on whether the information presented in the GUIs helps them trust the system. The results show that users want access to as much information and data as the system can provide. The users' trust in the system increases if the GUI features give users the impression that the inner workings of the blockchain-based system are transparent. However, users prefer the information presented as more conceptual than technical in the first place. However, users appreciate the possibility of clicking on the conceptual explanation and getting more in-depth blockchain-related technical information if needed.

KEYWORDS

Blockchain, Perceived trust, Semi-structured interview, Security, Privacy

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1 INTRODUCTION

The use of blockchain has been widely adopted in recent years. One of the most important reasons for this increase in use is the fact that blockchain networks do not require a centralized trusted party to operate [14]. Another essential aspect of blockchain networks is the immutability of data, which means that the data stored on the blockchain are practically infeasible to modify [14]. These properties make blockchain systems suitable for digital currency schemes [4] and other use cases. Researchers have looked at the possibility of using blockchain technology in supply chains and other systems in recent years.

As detailed in [13], food traceability and transparency are issues that could potentially be related to the concept of decentralized blockchain networks [2]. Currently, consumers either have little to no information on the origin of the food they consume or have to trust a third-party system or organization, such as Fairtrade [8]. This is potentially a field where a decentralized network could link consumers more closely with producers and workers producing groceries. Decentralization, along with the immutability aspects of the data of blockchain networks, seems particularly useful for this specific case. However, questions arise as to whether consumers and producers trust these systems and their willingness to use them to their full potential.

Complicated technology, such as blockchain and various cryptography methods, being introduced to the public also creates new research possibilities regarding perceived trust [5, 12]. **Perceived trust refers to the user experience of trust when using a system.** The perceived trust is related to, for example, whether a user trusts the information provided by the system or trusts that the system owner or operator does not sell their personal data. It is essential that users trust the systems and feel confident that the technology works in their best interest. Blockchain technologies are relatively new, and the public is most familiar with them as digital currencies. How this translates to other systems and applications, such as supply chains, is underexplored.

The study aims to understand users' perceived trust [5, 12] in secure and privacy-preserving blockchain systems because security and privacy are the key aspects that differentiate blockchain-based systems from other types of systems. Motivated by our goals, we first developed GUI mockups of a blockchain-based supply chain web application containing different information related to blockchain, e.g., the hash of the data in the system and zero-knowledge proof technology. Then, we conduct a series of semi-structured interviews with 30 potential system end users in Norway

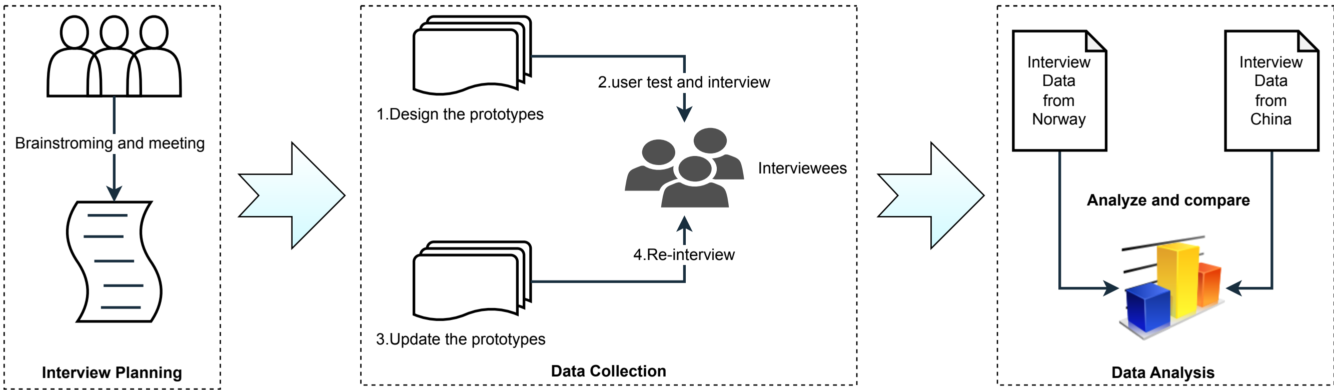


Figure 1: Research design

and China. We presented the GUI mockups to them and asked what elements in the mockups affected their perception of trust in the blockchain-based systems and what could be done to increase their trust.

Results of the study show that: there are many and varied answers to what affects a user's trust in the system. The visual components, such as logos, branding, and third-party endorsements, are the most important factors. The results also show that the more transparent a system is in its inner workings, the more trustworthy users perceive the system since they do not feel anything is hidden from them. However, there is a potential for information overload for the users. So, there is a preference for what can be referred to as layered information, meaning users prefer first to be presented with a brief overview and then to be able to click on it to get more in-depth information if needed.

The main contributions of this study are as follows: i) We identified several GUI elements of a blockchain-based supply chain system that affect the perceived trust of security and privacy for a user and how these elements can be improved to increase the perceived trust; ii) We uncovered the preferred way to present and explain to a user how the blockchain and zero-knowledge proof system works and why the technologies used are beneficial.

The rest of the paper is organized as follows. Section 2 presents the design and implementation of the study. Section 3 shows the answers to the research questions. Section 4 discusses our findings. Section 5 describes related work. Section 6 draws the conclusion and outlines future work.

2 RESEARCH DESIGN AND IMPLEMENTATION

We aim to understand the perceived trust of potential users of a blockchain-based system who are not blockchain technology experts. We decided to use a blockchain-based supply chain system as the case study because such a system is among the most popular applications of blockchain technologies, and most of the users of such systems are not experts in blockchain technology. We focus on answering the following research questions:

***RQ1:* What is important to a non-technical user when evaluating whether a technical system is trustworthy in terms of security and privacy?** In this study, one of the goals is to identify which factors are important to users when determining whether a system is trustworthy or not. Based on these factors, we want to know what can be done to enhance trust. Trust is, in this study, limited to a user's trust in a system to provide security and privacy according to their expectations.

***RQ2:* What is the best way to explain a technical system to a user, to convince them that their security and privacy are preserved when using the system?** This study will investigate the best way to explain a technical system based on blockchain and zero-knowledge proof technologies to a user that is not familiar with these technologies, to enhance their trust in the system.

***RQ3:* Does the perceived trust vary in different cultures and social contexts?** We assume people in different cultures and societal contexts may have different opinions on perceived trust. This study will compare users' opinions on perceived trust from countries with different cultural and societal contexts to understand whether the results of RQ1 and RQ2 can be generalized.

2.1 Research design

The overall research design is shown in Figure 1. To answer RQ1 and RQ2, we first identified the elements and information related to the blockchain that may be relevant to perceived trust in the security and privacy of supply chain systems. Then, we designed and implemented prototypes, which are basically GUI mock-ups of a blockchain-based coffee supply chain and the corresponding blockchain elements and information, which include two steps.

Step 1: We developed in total ten prototypes in Step 1, where there are four prototypes (1.1-1.4) for the provider of the goods or services, who are often also the data provider. Six prototypes (2.1-2.6) are for the consumer of the goods or services, who are often the data consumer in the supply chain. The prototypes contain different features to investigate what could impact the users' trust. The different features of these ten prototypes are shown in Table 1 and Table 2. We assume the blockchain-based supply chain is developed using Hyperledger (https://www.hyperledger.org/) technologies like Sawtooth. Thus, the logos and technology explanations are based on them. The URLs of the publicly available prototypes are in the Appendix.

Based on these prototypes, we conducted semi-structured interviews, which are explained in Section 2.2. The interviews aimed to talk to potential end users of a blockchain-based system and attempt to understand better what type of information and trust signals they would need to trust that their security and privacy are preserved.

Step 2: A re-interview of the same users to collect their feedback on two new prototypes that have been updated based on the finding in Step 1. Here, there was one prototype for the data provider (prototype 1.5) and one for the data consumer (prototype 2.7) in the supply chain. The goal of this round of interviews is to check if the improved prototypes based on the findings of Step 1 actually increased the trust in the interview object.

To answer RQ3, we carried out the same study in Norway and China and compared the results of the interviews. The reason for choosing Norway and China is due to convenience and the belief that the culture and societal contexts of the two countries are possibly different because one is in the western part of the world and another is in the eastern side.

Table 1: Features of Prototypes 1.1-1.4

Prototypes	Brief explanation	Logos	Graphical explanation	Written explanation
Prototype 1.1	-	-	-	-
Prototype 1.2	Yes	Yes	-	-
Prototype 1.3	Yes	Yes	Yes	-
Prototype 1.4	Yes	Yes	-	Yes

Table 2: Features of Prototypes 2.1-2.6

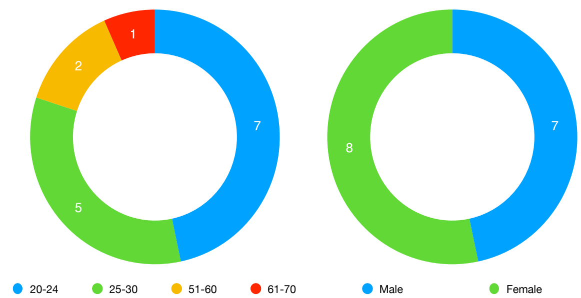
Prototypes	Brief explanation	Logos	Graphical explanation	Written explanation	Blockchain hash value	Blockchain transaction
Prototype 2.1	-	-	-	-	-	-
Prototype 2.2	Yes	Yes	-	-	-	-
Prototype 2.3	Yes	Yes	Yes	-	-	-
Prototype 2.4	Yes	Yes	-	Yes	-	-
Prototype 2.5	Yes	Yes	-	Yes	Yes	-
Prototype 2.6	Yes	Yes	-	Yes	-	Yes

2.2 Semi-structured interviews

The interviews were conducted in person and in digital meetings using video and shared screens. There are no video or audio recordings of the interviews, but notes were taken throughout the interviews. After the interviews, these notes were presented to the interviewees to ensure that the notes recorded were reflective of the information and responses they gave during the interviews.

2.2.1 *Interviews based on the first version of the prototypes.*

The interviews were designed for the interviewees to click through the ten prototypes and talk more or less freely about the interview topic. Each interview took 45-60 minutes. Finally, participants were asked to rate the most to least trustworthy prototypes.



(a) Age ranges of the interviewees (b) Gender of the interviewees

Figure 2: Age and Gender of the interviewees in each country

2.2.2 *Re-interview based on the improved prototypes.*

The format was a short interview for about 15 minutes in which two new prototypes were presented: one for the data consumer and one for the data provider. The main question to be answered was whether they found these two updated prototypes more trustworthy than the previous ten prototypes. Follow-up questions were added when needed, including why, what they found more trustworthy, what they found less trustworthy, and so on.

2.3 Data Analysis

Data analysis was performed using MS Word to identify the codes in the results. Researchers from Norway and China separately collected and analyzed data for their own interviews using the same interview guide. The results are then consolidated and compared.

3 RESULTS

In this section, we first present the profile of the interviewees. Then we explain the results of the research questions. The results of RQ3 are embedded in the presentation of the results of RQ1 and RQ2 because the purpose of RQ3 is to compare whether the results of RQ1 and RQ2 are different in Norway and China.

3.1 Profile of the interviewees

We conducted interviews with 30 respondents, 15 of them in Norway and 15 in China. The same sampling method was used in China or Norway to draw the 15 respondents. As shown in Figure 2, in each country, seven of the interviewees were between 20-24 years old, five were between 25-30 years old, two were between 51-60 years old, and one was between ages 61-70 years old. Seven of the interviewees were male, and the other eight were female. Seven of the interviews were conducted in person, while the remaining eight were conducted over video meetings. All interviewees had a limited understanding of blockchain technologies. This was intended since the goal is to understand what non-technical individuals need to trust a technical system in general and the blockchain-based system in particular.

3.2 Rating of the Prototypes

After each round of interviews, the interviewees were asked to rate the prototypes for both the data provider and the consumer.

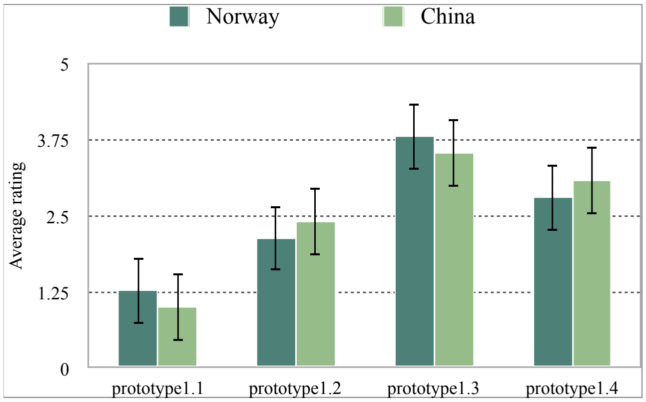


Figure 3: Average Rating of Data Provider Prototypes

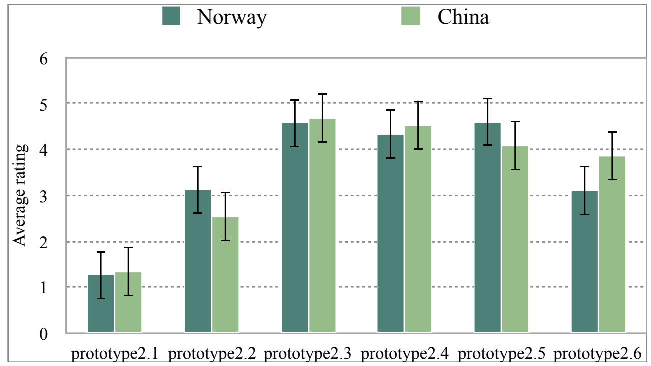


Figure 4: Average Rating of Data Consumer Prototypes

The rating of the prototypes provides a basis for answering both RQ1 and RQ2 since it provides an average rating for the prototypes presented to the interviewees. Although it is useful when discussing RQ1, it is more closely related to answering RQ2 since the rating was based on what the interviewees found the most trustworthy way of explaining the system details. An average of the rating score from the interviews in China and Norway is plotted in Figure 3 and Figure 4. The more trustworthy one prototype is, the higher the rating score.

3.2.1 *Average Rating of Prototypes for Data Provider*.

The rating was calculated based on giving a prototype score of four if the interviewee found it the most trustworthy, three for the second place, two for the third place, and one for the least trustworthy one. As shown in Figure 3, interviewees in China and Norway have similar opinions about the trustworthiness of these four prototypes. In particular, both rated prototype 1.3, which explains the blockchain system graphically, as the most trustworthy one.

3.2.2 *Average Rating of Prototypes for Data Consumer*.

The rating was calculated based on giving a prototype score of six if the interviewee found it the most trustworthy, five to the second place, four to the third place, three to the fourth place, two to the fifth place, and one to the least trustworthy one. The average rating score is shown in Figure 4. The prominent difference is that prototype 2.5, which tells users the hash value of their transaction, is the highest-scored prototype in Norway. However, in China, the most trustworthy turn out to be prototype 2.3, which has a graphical explanation of blockchain technologies.

3.3 Answers to RQ1: Elements that Enhance Perceived Trust

3.3.1 *Logos and Icons as Trust Signifiers*.

All prototypes except prototypes 1.1 and 2.1 had icons and logos. Prototypes 1.2, 1.3, and 1.4 all had an IBM logo with a link to an article written by IBM on zero-knowledge proof. We had the IBM logo because it is a company that contributed to the early development of Hyperledger. Prototypes 2.2-2.6 all had the Hyperledger Sawtooth logo and a logo from the Blockchain Council, which also said certified. In Norway, 11 of the interviewees said that icons and logos enhanced their perceived trust in the system on a general basis, while the remaining four said that logos and icons did not enhance or decrease trust. In China, all interviewees argued that the logos and icons of the authorities made the system more trustworthy. This means there was no negative impact on trust to add icons or logos on the GUIs of a blockchain-based system. The reasoning for this was mostly because the users felt that the brand on the logo somehow had endorsed the system and therefore made the technology more trustworthy. Therefore, logos and icons from trusted third parties might be important for users when determining how trustworthy they perceive a system.

3.3.2 *Other Findings*.

In the interviews conducted in Norway, 13 interviewees said that more details regarding the specific coffee and more explanations regarding the claim that the supply chain workers were paid fair wages would increase trust. Information about, such as the region of harvest, how much the farmer is paid, pictures of the farmer, how much is considered a fair wage, and how much coffee there was in this transaction would increase the trust of consumers. Also, seven of the Norwegian participants expressed that trust was increased by color, nice layout, or good user experience. Colors like green and blue increased the trustworthiness of a website, but red made it seem like it was an error. Ease of use also increased trust, along with what the interview objects called a professional look. Meanwhile, ten of the interviewees from China also expressed similar opinions about the system regarding the factors that could affect trust, such as the layout and color of the user interface. Six Chinese participants insisted that there should be more detailed and intuitive data on the transaction to obtain more user trust. It can be inferred from the above that necessary information details and visual factors, such as layout and color, play a big role for users when developing trust.

3.4 Answers to RQ2: Technical Details and Explanations to Enhance Trust

3.4.1 *System Explanation to Increase Trust*.

There was a consensus among the interviewees in Norway that the graphical explanation in prototypes 1.3 and 2.3 and the written explanation in prototypes 1.4, 2.4, 2.5 and 2.6 was the most trustworthy way of explaining the system. For Chinese interviewees, there was an obvious preference for a graphical explanation rather than a written explanation. In addition, eight of the interviewees in China claimed that, with respect to the written explanation, they prefer the explanations focusing on the general features of the technology (prototype 2.4) to those with technical details or mathematical formulas (prototype 1.4). Therefore, when it comes to explaining the system, it might be better to use a graphical explanation as well as a brief written explanation of the common conception rather than giving unnecessary complicated details.

3.4.2 *Presentation of Blockchain Data*.

In Norway, the interviewees' feedback regarding how blockchain data was presented in prototypes 2.5 and 2.6 was that it was quite confusing at first glance. This confusion was due to the fact that the interviewees were not familiar with blockchain-related data. Prototype 2.5 shows the block's hash value. Eight interviewees rated prototype 2.5 among their top two most trustworthy because they liked the extra transparency. In prototype 2.6, we showed the transaction data from the blockchain. There was a consensus that when the data in prototype 2.6 seemed like an error message and decreased trust. Four interviewees rated prototype 2.5 among their top two. There was a disagreement among the interviewees about whether or not blockchain data was trust-enhancing. Interestingly, the disagreement does not necessarily reflect the technical background of the interviewees.

In China, the acceptance of presenting the hash value in the system differed from the results in Norway. Eight Chinese participants argued that the hash value presented in prototype 2.5 seemed like an error code since they were unfamiliar with the hash values of data. Furthermore, nine of the interviewees in China claimed that the blockchain transaction data in prototype 2.6 were quite confusing and appeared like some kind of computer virus from their perspective. However, despite the dislike for presenting hash value and transaction data among those interviewees, some Chinese participants still scored prototypes 2.5 and 2.6 as the top two. In particular, six interviewees claimed they trust prototype 2.6 the most, and five participants rated prototype 2.5 as the second most trustworthy one.

In summary, in order to obtain more trust from non-technical users, we should explain the system and present the blockchain-related data in a more understandable manner instead of scaring them away by directly showing the hash value or transaction data.

3.5 Results from Re-interviews of the Improved Prototypes

The results of the re-interview were collected from the same participants in the former interviews.

3.5.1 *Results for Prototype 1.5*.

In terms of the written explanation, there was a significant difference between the participants in China and Norway. Chinese interviewees preferred less technical-oriented explanations than those of Norway. Therefore, in the updated prototype 1.5 for Chinese interviewees, the written explanation focused on the general characteristics of blockchain instead of the complicated technical details. In Norway, the written explanation of prototype 1.5 retained the mathematical way.

In Norway, for prototype 1.5, 14 out of 15 users confirmed that this was more trustworthy than all prototypes 1.1-1.4 discussed in the previous round of interviews. Regarding the Chinese interviewees, all interviewees thought that the updated prototype 1.5 was more trustworthy than the previous ones. The reason for more trustworthiness for users was that the combination of the graphical and written explanation gave them the feeling that the system and technology used were transparent.

3.5.2 *Results for Prototype 2.7*.

All interviewees felt that the updated prototype 2.7 was more trustworthy than the prototypes 2.1-2.6 presented in the first round of interviews. The combination of graphical and written explanations increased trust, as in prototype 1.5, and hiding blockchain data behind a button by default also increased trust for users. They also greatly appreciated the more detailed information on wages, the origin of coffee, and how much better the wages of a particular farmer were than the average wage in the given country because of Fairtrade. It seems like interviewees felt prototype 2.7 was more trustworthy because the information could be analyzed and audited somehow. So, it would be harder for the companies to lie if they presented more information about the product.

4 DISCUSSION

From the results of this work, it is clear that many factors affect perceived trust in a system. Everything from perceived privacy and security to colors and logos affects how users perceive the trustworthiness of a system.

4.1 Elements that Enhance Perceived Trust

The main finding is that visual factors play an important role for users when developing trust. Logos and icons from trusted third parties are also important factors for users when determining how trustworthy they perceive a system.

Signifiers and graphical elements refer to the visual GUI components of a system. These are logos, icons, pictures, colors, fonts, and so on. The results show that this is an obvious factor that greatly influences trust, regardless of whether in China or Norway. For instance, the use of third-party logos is shown to increase trust. Our work shows this through logos used by IBM, Blockchain Council, and Hyperledger Sawtooth. By having logos there, multiple users felt that the given company had endorsed the system or participated in the development.

4.1.1 *Perceived Privacy and Security Increase Trust*.

The results indicate that when the interviewees perceived some security-related technologies were in use in the system or perceived that their privacy was a focus of the system, this increased their trust in the system. This finding is valid in Norway and China. However, the elements that made an interviewee perceive trust in security and privacy vary. For some interviewees, just mentioning that they stayed anonymous to every other user in the system was enough. For other interviewees, the usage of blockchain made them perceive the system as secure and increased their trust in the system.

4.2 Technical Details and Explanations to Enhance Trust

Here, the key finding is that users prefer to be able to access all the information. However, it has to be done so that they can get a brief explanation first and click into more details if they wish. This is to prevent information overload, which seems to decrease trust.

4.2.1 *Supply Chain Transparency*.

The key motivation to use blockchain in supply chains is that it increases transparency and integrity with respect to the origin, production, and transportation of a product. For the first round of interviews conducted in both countries, we could not see that the increased product transparency led to more trust. However, when the new prototypes 1.5 and 2.7 were tested, most of the interviewees expressed that the way the data were presented increased trust in the underlying blockchain system. They said that both the data visualization where origin and payment were shown and the transaction data from the blocks increased their trust in the integrity of the blockchain. Our work gives evidence that increased transparency and traceability through blockchain technologies improve trust in a supply chain system.

4.2.2 *System Explanation Influences Trust*.

Our findings show that most of our interviewees preferred an approachable explanation of the technical aspects of the system. The use of blockchain data also increased trust in the system because users felt they could gain a more in-depth understanding of the data and its storage.

However, there is a subtle discrepancy between the results of China and Norway when it comes to the way of system explanation. Although both interviewees from Norway and China trust graphical explanations more than written explanations, the preference for the graphical way is much more obvious among Chinese users than those in Norway. Regarding the written explanation, Chinese participants prefer high-level explanations more than professional details, while this kind of tendency is much less obvious among the interviewees in Norway. Additionally, when showing the blockchain hash value directly, the prototype of the system gained more trust from Norwegian interviewees while losing some trust from Chinese participants. However, in the updated prototypes 1.5 and 2.7, when we presented the blockchain data in a way that did not scare the users off by looking like an error message, the users from China and Norway considered the system much more trustworthy.

Therefore, considering users who are not that familiar with software systems in general and blockchain technologies in particular, we should explain the system and present the data in a more understandable manner to obtain their trust.

4.3 Threats to Validity

The main threats to validity and the corresponding mitigation strategies were considered when characterizing the target population, designing the semi-structured interview procedure, interviewing participants, and designing and updating the prototypes. The prototype and interview guides are in the Appendix to give detailed information on the study design.

External Validity: Representatives of the data may be a potential problem in our study. To migrate this threat, we sampled our interviewees in varying age ranges and gender from Norway and China. Besides, to obtain accurate feedback from nontechnical users, all of our interviewees were chosen from those who were not blockchain experts. We conducted the interviews in person and over video calls due to the constraints caused by COVID-19. However, we do not believe that this will significantly bias the results of this study.

Construct Validity: To mitigate this threat, we designed ten preliminary prototypes to give structure to our semi-structured interviews. Furthermore, we split the ten prototypes into two groups, one for the data providers and another for the data consumers, covering the two ends of a supply chain, which made our interviewees representative.

Conclusion Validity: To mitigate this threat, the researchers from Norway and China sampled their interview participants using the same protocol. In this way, we could better control possible confusing factors and compare the results.

5 RELATED WORK

Several studies focus on understanding how blockchain can be used in supply chain applications. Montecchi et al. [6] focused on understanding how to develop consumer trust in supply chains. The authors identified four types of risk that a user or consumer could experience and presented a possible solution to address these issues effectively. The focus of Yeh et al. [4] was to develop a supply chain management system using blockchain technology. The study showed how perceived privacy, security and trust increase the intention of a user to adopt blockchain technology and how tractability and transparency increase perceived trust in blockchain technology. Pandey et al. [7] find that blockchain will likely become a dominant technology to improve transparency and traceability, reduce risk, and, most importantly, improve trust among stakeholders in the food supply chain.

There are studies investigating what drives trust in websites and applications, how graphical factors affect trust, how trust relates to loyalty and algorithm transparency. Seckler et al. [9] conducted an empirical study to understand better how the characteristics of the website affect trust and distrust in users through a questionnaire. The study by Flavián et al. [1] was conducted to analyze how presidential security and privacy affect a user's trust in a website. Kizilcec [3] studied how transparency in an algorithm or technology affects perceived trust. Shin [10] presented a heuristic approach to fill the gap in the literature on how security and privacy affected trust in blockchain systems and how this affected the user's intention to adopt this new technology. Völter et al. [11] empirically evaluated the effectiveness of several established trust-building factors on the end user's trust by conducting a trial between groups and found that trust signals that emphasize the underlying trust-building characteristics of the technology were the most effective.

6 CONCLUSION AND FUTURE WORK

Blockchain technologies are increasingly being used in different application domains due to their security and privacy features. Although many studies focus on how to implement the security and privacy features of blockchain-based systems, few studies have investigated how to present the information on blockchain-related elements to users to increase their trust in the system for their best interests.

This study focuses on understanding which blockchain-related information is essential to increase the user's trust in blockchain-based systems and how to present the information. We first developed several GUI mock-ups of a blockchain-based coffee supply chain system with various blockchain-related information. Then, we conducted semi-structured interviews in Norway and China to collect interviewees' feedback on the information and presentation of the information that influences their trust in the system. The results show that some information, for example, the logo, and transparency of the technology, increases trust. However, overloading users with technical details of the blockchain decreases trust. Thus, managing the trade-off between information transparency and understandability is critical. In the future, we plan to replicate the study with more participants in more countries to understand the generalizability of our results.

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REFERENCES

[1] Carlos Flavián and Miguel Guinalíu. 2006. Consumer trust, perceived security and privacy policy. *Industrial Management & Data Systems* 106, 5 (01 Jan 2006), 601–620. https://doi.org/10.1108/02635570610666403

[2] S. Islam and JM Cullen. 2021. Food Traceability: A Generic Theoretical Framework. *Food Control* 123, 3 (2021), 107848.

[3] R. Kizilcec. 2016. How Much Information?: Effects of Transparency on Trust in an Algorithmic Interface. In *Chi Conference on Human Factors in Computing Systems.*

[4] N. Kumar and S. Aggarwal. 2020. History of blockchain-Blockchain 1.0: Currency. *Advances in Computers* (2020).

[5] O. Mahmood. 2006. Trust: From Sociology to Electronic Environment. *Journal of Information Technology Impact* (2006).

[6] M. Montecchi, K. Plangger, and M. Etter. 2019. It's real, trust me! Establishing supply chain provenance using blockchain. *Business Horizons* 62, 3 (2019), 283–293.

[7] V. Pandey, M. Pant, and V. Snasel. 2022. Blockchain technology in food supply chains: Review and bibliometric analysis. *Technology in Society* 69 (2022), 101954–.

[8] Podhorsky and Andrea. 2015. A positive analysis of Fairtrade certification. *Journal of Development Economics* 116 (2015), 169–185.

[9] M. Seckler, S. Heinz, S. Forde, A. N. Tuch, and K. Opwis. 2015. Trust and distrust on the web: User experiences and website characteristics. *Computers in Human Behavior* 45, apr. (2015), 39–50.

[10] Ddh Shin. 2019. Blockchain: The emerging technology of digital trust. *Telematics and Informatics* 45, Dec. (2019), 101278.1–101278.11.

[11] Fabiane Völter, Nils Urbach, and Julian Padget. 2023. Trusting the trust machine: Evaluating trust signals of blockchain applications. *International Journal of Information Management* 68 (2023), 102429. https://doi.org/10.1016/j.ijinfomgt.2021.102429

[12] Z. Yan and S. Holtmanns. 2013. *Trust Modeling and Management: from Social Trust to Digital Trust.* Examining the Concepts, Issues, and Implications of Internet Trolling.

[13] J. Y. Yeh, S. C. Liao, Y. T. Wang, and Y. J. Chen. 2019. Understanding Consumer Purchase Intention in a Blockchain Technology for Food Traceability and Transparency context. In *2019 IEEE Social Implications of Technology (SIT) and Information Management (SITIM).*

[14] K. Zhang and H. A. Jacobsen. 2018. Towards Dependable, Scalable, and Pervasive Distributed Ledgers with Blockchains. In *IEEE International Conference on Distributed Computing Systems.* 1337–1346.

A LINKS TO CLICKABLE PROTOTYPES

A.1 Data provider

Prototype 1.1: click here to check
Prototype 1.2: click here to check
Prototype 1.3: click here to check
Prototype 1.4: click here to check
Prototype 1.5: click here to check

A.2 Data consumer

Prototype 2.1: click here to check
Prototype 2.2: click here to check
Prototype 2.3: click here to check
Prototype 2.4: click here to check
Prototype 2.5: click here to check
Prototype 2.6: click here to check
Prototype 2.7: click here to check

B INTERVIEW GUIDE

B.1 Exploratory Study to find Drivers of Trust

The objective of the interviews is to collect information to help answer RQ1 and RQ2. The interview questions were not shared beforehand. This is done through semi-structured interviews where the interview objects are free to talk about what they find relevant to the topic at hand, and the interviewers ask follow-up questions and guide the conversion to the more relevant topics. The 10 prototypes gave structure and format for the interviews.

The interviews start with the following.

1. Introduction to the interviewees: name, occupation, and field of study.

2. The interview object presents itself.

3. The context and format of the interview are presented. Duration: 45-60 minutes; will not be recorded; will stay anonymous; notes will be taken, and they get to read the notes later to confirm they are correct; and that their time is appreciated.

4. The use case is presented. The use case is the use case presented to the interviewees in order to make the questions understandable.

5. The format of the interview is explained. Definition of trust; the interview objects should say what comes to mind and not filter themselves; that feedback related to the fidelity of the prototypes is welcome but not the most important; and they will click through four prototypes for the data provider and six for the data consumer.

The interviews and user tests were designed so that the interview objects talk more or less freely. And in most cases, they provided answers to all our questions without us having to ask them. When they did not, we had to ask open questions to get them going. Below is a list of all the ten prototypes and a brief, not full-fledged, list of the key topics we wanted the interview object to touch on.

*B.1.1 **Data Provider**.*

Reiterate the role of the farmer/data provider in the system.

Prototype 1.1: Have the interviewees reflect on what they think they need to have increased trust in the system. Reflect on what this prototype does to low trust, if any. This prototype provides a basis for comparing the rest of the prototypes.

Prototype 1.2: Have the interviewees reflect on how the logo and the link to an article on the given topic affect their trust in the system. We also wanted them to comment on the sentence that was added, especially how they felt about the fact that they were just invited to accept this as a fact and how it affected trust.

Prototype 1.3: Have the interviewees comment on the brief explanation of the system on the 'Click to learn more' button. Have the interview object talk about the way of representing first a brief explanation and then a button where they can learn more and how this affects trust. Reflect on the graphical way of representing the system and how this affects your trust in the system, technology, and blockchain.

Prototype 1.4: Have the interviewees reflect on the written way of representing the system and how this affects its trust in the system, technology, blockchain, and zero-knowledge proof. Let the interviewees rate the four prototypes from most to least trustworthy. Encourage them to formulate why they ordered the prototypes in the given way.

B.1.2 *Data Consumer*.

Reiterate the role of the consumer/data consumer in the system.

Prototype 2.1: Have the interviewees reflect on what they think they need to increase trust in the system and reflect on what reduces trust, if any. This prototype provides a basis for comparing the rest of the prototypes.

Prototype 2.2: Have the interviewees reflect on how the logo and icon affect their trust in the system. Especially interesting is how the interviewees experience these two lesser-known logos compared to the IBM logo. It is also interesting to find out what associations they get with the Certifed Blockchain Council and how this relates to trust in the system. We also wanted them to comment on the sentence that was added, especially how they felt about the fact that they were just invited to accept this as a fact and how it affected trust.

Prototype 2.3: Have the interviewees comment on the brief explanation of the system using the 'Click to learn more' button. Have the interview object talk about the way of representing first a brief explanation and then a button where they can learn more and how this affects trust. Reflect on the graphical way of representing the system and how this affects your trust in the system, technology, and blockchain.

Prototype 2.4: Have the interviewees reflect on the written way of representing the system and how this affects their trust in the system, technology, and blockchain. During this prototype, the interviewees are encouraged to reflect on their preference for what to focus on during an explanation of the system and which way is most trustworthy. The difference is that prototype 1.4 is very focused on the details and math, while 2.4 focuses more on the technology's features.

Prototype 2.5: In this prototype, we want to see how the interviewees react when presented with blockchain data in the form of a hash value and how this affects trust. If they think the additional data is trustworthy, then why is it trustworthy and if it is not more trustworthy, then why? And what would make it more trustworthy?

Prototype 2.6: In this prototype, the objective is to see how the interviewees react when presented with blockchain data in the form of transaction data and how this affects trust. If they think the additional data is trustworthy, why is it trustworthy, and if it is not, why? And what would make it more trustworthy?

Let the interviewees rate the six prototypes from most to least trustworthy. Encourage them to formulate why they order the prototypes in the given way.

B.2 Re-interview of the improved Prototypes

The goal of this round of interviews is to check if the improved prototypes based on the findings of the first round of interviews actually increase trust in the interview object. The format is a short interview of 10-15 minutes where two new prototypes are presented: one for the data consumer (prototype 1.5) and one for the data provider (prototype 2.7). The main question to be answered is: if they find prototype 1.5 is more trustworthy than all prototypes 1.1-1.4 and if they find prototype 2.7 more trustworthy than all prototypes 2.1-2.6. Follow-up questions are added when needed, including why, what they find more trustworthy, what they find less trustworthy, and so on.