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BLOCKCHAIN-BASED COMMON DATA ENVIRONMENTS TO ADDRESS DATA AND INFORMATION FRAGMENTATION IN THE DUTCH CONSTRUCTION INDUSTRY

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Abstract

In the Dutch construction industry, the demand for advanced information storage and sharing is growing due to the complexity of construction projects. Limitations of traditional methods include lack of transparency and inefficient communication. Blockchain offers a promising solution by enabling decentralized storage and immutable recording of data increasing transparency and efficiency in the construction supply chain. Combining a Common Data Environment with the InterPlanetary File System – decentralized file storage and exchange, and a powerful tool for secure, efficient and reliable data management in construction – can emerge to improve cooperation between parties increasing effectiveness of projects.

Introduction

The construction industry is not known for being highly innovative. In general, construction companies struggle to keep up with the speed of technological developments and innovations (van Sante, 2016). A major obstacle to innovation and change in construction is the high degree of project-driven working and fragmentation (Nawi et al., 2014; Li, 2023). The different construction phases of a structure (vertical fragmentation), the specialized stakeholders (horizontal fragmentation) and the different, often complex projects create many challenges within the industry (Fergusson, 1993; Adriaanse, 2014).

While the application of Building Information Modelling (BIM) has become increasingly accepted in construction, making optimal use of it appears difficult (Canon, 2019). According to Koutsogiannis and Berntsen (2019), 95% of the data generated is lost between the parties involved and the different construction process phases. Construction information is rarely reliable and available, which is largely due to the limited connection between parties as a result of fragmentation (Adriaanse, 2014; Volker, 2019).

In the Netherlands, strong fragmentation and specialization perpetuate, with project-based approaches being the norm (Adriaanse et al., 2020). These characteristics present significant challenges, especially considering the growing amount of information generated throughout the life cycle of projects (Koutsogiannis and Berntsen, 2019). In practice, there often appear to be problems related to the availability and reliability of construction information, which has significant implications for the efficiency and effectiveness of construction projects (Chong et al., 2014). The transfer and preservation of construction information is a crucial part of the construction process and will become even more important in the future. Making and keeping information available and reliable is something that is a hot topic in many sectors. A development which is often associated with transparent and reliable exchange of data is Blockchain Technology (Puthal *et al.*, 2018).

The overarching objective of this study is to assess the viability of integrating blockchain with Common Data Environments (CDEs) to enhance the accessibility and dependability of building information within the Dutch construction sector. This focus is crucial as building information plays a pivotal role in streamlining construction processes across the life cycle of buildings in the Netherlands, ultimately fostering opportunities for long-term material reuse initiatives (Jaskula, et al., 2023).

The research question for this study is: "*How can the integration of blockchain and CDEs be leveraged to enhance the availability and reliability of building information in the Netherlands?*"

This paper reports on preliminary research focused on the exploration of information management within the Dutch construction sector. By examining local practices and challenges, this study allows researchers to contextualize and compare the findings in the Dutch context with research from other countries regarding information management in construction. This adds insights to the body of knowledge and facilitates the Netherlands in learning from other contexts, thus contributing to a broader understanding of information management practices in the construction sector.

In next section, the literature review introduces blockchain technology, and identifies challenges to current information management and CDEs in construction. The methodology explains the approach for the study centred on interviews and a use case evaluation, the results of which are then presented. The final two chapters bring discussion and conclusions of the study.

Literature Review

Blockchain technology

Many current database systems operate within a centralized architecture, where users have permission to modify data stored on the central server. A central authority manages the entire database, including access

control and user authentication (Sarmah, 2018). Blockchain, often associated with cryptocurrencies such as Bitcoin, offers a decentralized approach. It is a type of Distributed Ledger Technology (DLT) that has the potential to spark a new industrial revolution (Perez, 2009). Unlike centralized systems, blockchain is managed and validated by a global network of peer-to-peer connected computers where no one individual or organisation has control over the data (Jena and Dash, 2021). This creates a digital database that is built, shared, validated and synchronized by participants eliminating the need for a central authority where everyone has access to the latest version of the ledger (Lashkari and Musilek, 2021). Transactions are sent to the network, validated by computer algorithms, and linked to previous transactions, creating an immutable chain. The distributed structure of blockchain and the confirmed guarantees of nodes make information almost impossible to manipulate, which increases trust between participants. This provides a solution to the limitations of traditional centralized systems (Bodkhe *et al.*, 2020).

Blockchains can be public or private. Public blockchains are open systems without authority; anyone can join and be granted full rights to participate (Guégan, 2017). The verifiability and transparency of information are central features as there are no access restrictions imposed. Public blockchains are not recommended for large or energy-sensitive domains. Private blockchains have limited access to the network and are shared privately between specific participants with communication protocols. Only pre-verified individuals meeting certain requirements are allowed to perform certain operations on the blockchain (Yang et al., 2020). Between public and private sits the consortium blockchain where only organizations or groups with the same goals can join (Jabbar et al., 2022). The degree of decentralization varies in DLT networks from full decentralization (e.g., Bitcoin) to lower decentralization with some form of hierarchy for direction and control (e.g., Hyperledger), depending on the specific application and parties involved (Hamilton, 2019).

Information management

Fragmentation in information management

Due to the dynamic and complex nature of construction, different professions and specializations have emerged, roughly divided into the well-known construction phases: initiators, designers, builders, maintenance parties (Nawi et al., 2014). In this subdivision, a clear structure is visible with strong separation between the different construction phases (Adriaanse, 2014). Within these phases, there is a high degree of specialization leading to many companies becoming involved in a construction project all having their own contributions and interests. In many cases, this leads to difficulties in communication and coordinating all the parties in the construction process (Chong et al., 2014; Di Giuda et al., 2020). Despite this high degree of specialization often presenting challenges, construction has proven to be a key piece in the overall development of society. Without the necessary infrastructure, many developments would have been much more difficult and society would be less developed (van Breugel, 2019). The construction industry exhibits considerable fragmentation as an inherent feature of its structure and mode of operation. It is often compared to an 'archipelago', consisting of several 'islands' that are highly distributed across three levels (Adriaanse, 2014) – vertical, horizontal and longitudinal. This complex structure leads to communication challenges between stakeholders, construction process phases and projects themselves (Dave and Koskela, 2009). This division results in significant challenges in communication and coordination among stakeholders (Fergusson, 1993).

CDEs for information management

The increasing complexity of construction projects, coupled with the need for real-time information sharing, underscores the necessity for digitalization in the construction industry (Agarwal et al., 2016). A CDE serves as a comprehensive data store for all project-related information, including geometric and semantic data, as well as documentation, throughout the construction project life cycle (British Standards Institution, 2013). By consolidating all information into one accessible location, the CDE acts as a central information management tool, facilitating efficient collaboration and communication among stakeholders (Preidel *et al.*, 2017). We consider whether the CDE can play a central role in integrating and managing information among stakeholders.

Efficient information management is paramount for project success due to the complexity and abundance of data generated during construction projects (Di Giuda et al., 2020). Defined by ISO 19650-1:2018, a CDE functions as an agreed-upon information resource for a project or asset, enabling the collection, management, and dissemination of information through a controlled process (ISO, 2018). It encompasses both a CDE solution, typically cloud- or server-based technology with database management features, and a structured CDE workflow that organizes information flow and management throughout the asset life cycle (BIM Dictionary, 2022).

Jaskula et al. (2022) outlines three levels of CDE maturity based on document management, life cycle functionality, security, and BIM integration. At its core, the CDE enhances information management by providing stakeholders with a unified platform for accessing, sharing, and collaborating on project data. This centralized approach fosters transparency, reduces errors, and improves decision-making, ultimately contributing to the overall success of construction projects. Cloud storage services such as Dropbox are categorized as Level 1 CDE due to limited integration with BIM technology and do not offer advanced management capabilities nor a high level of security. More advanced CDE tools such as Viewpoint, Asite, Procore, Deltek, or ProjectWise are considered Level 2 CDE for BIM because they offer BIM visualization and communication based on BIM formats such as BIM Collaboration Format (BCF) and Industry Foundation Classes (IFC) in addition to document management. Additionally, integrating technology such as the InterPlanetary File System (IPFS) could enhance

the capabilities of CDE tools, potentially elevating them to Level 3 BIM integration. IPFS, with its decentralized and distributed file system, offers advantages such as increased data integrity, redundancy, and resilience against censorship. Platforms like Autodesk's BIM 360 or BIMcollab, integrated with IPFS, could offer Level 3 functionality for multidisciplinary real-time collaboration and document management, serving as a more comprehensive single source of truth throughout the life cycle of construction projects. However, this integration may still require further development and evaluation to ensure seamless compatibility and functionality within existing CDE frameworks (Jaskula et al., 2023).

IPFS as a solution to information management

While blockchain can store information, it is not a realistic solution for storing large amounts of building information (Kloosterman and Smits, 2023) for being prohibitively expensive and demands significant computational power. Therefore, current iterations of blockchain are not suitable for the collaboration and sharing of large amounts of data. This challenge can be addressed by integrating blockchain with IPFS (Steichen *et al.*, 2018), which allows participants to directly connect to each other without the need for a central server (Muralidharan and Heedong, 2019; Bennet, 2020). A major advantage is that IPFS allows flexible storage of large files. Each file uploaded to the IPFS network is encrypted into a cryptographic hash value referred to as a content identifier (CID). IPFS is considered a valuable addition because it can solve the problem of inefficient, bulky data storage in blockchain (Steichen *et al.*, 2018; Nyaletey *et al.*, 2019). In other words, users can choose to store design files or documents in IPFS and place only CIDs in blockchain transactions.

Implementation of the blockchain-IPFS CDE solution faces two challenges: (1) establishing the collaboration workflow of a CDE that integrates blockchain and IPFS, and (2) exchanging design information in such an environment. Regarding (1), limited studies have examined which CDE container(s) should use blockchain and the logic of collaborating in such a distributed environment (Ye and König, 2021). Regarding (2), in a blockchain network, users exchange information by proposing transactions and using smart contracts. But the data model of transactions and smart contracts that meets the requirements of CDE is not yet developed, which complicates communication between designers (Tao *et al.*, 2021). It is expected that these challenges will be addressed in due course within the research community; proposing solutions is outside the scope of this paper.

Methodology

To answer the research question, this study adopted an interpretivist philosophy and an inductive approach to data collection and analysis. The methodology can be seen graphically in Figure 1 below.

First, a literature review was conducted to understand the issues surrounding fragmentation in the Dutch construction industry, the nature of construction information and the opportunities offered by Blockchain.

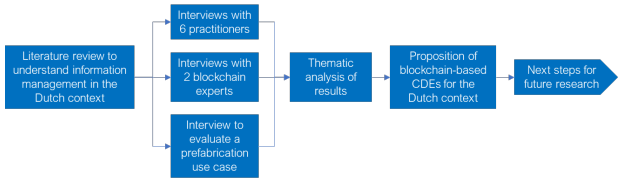

Figure 1: Methodology for the study

The findings of the literature review formed the basis of interviews with six industry practitioners (#1 to #6 in Table 1) and two blockchain experts (#7 and #8 in Table 1) contrasted with evaluation of a use case with a BIM Coordinator of a prefabrication project (#9 in Table 1) in the Netherlands. Finally, a validation interview took place with an academic with extensive knowledge of blockchain in construction (#10 in Table 1). The interviews with industry practitioners centred on investigating opportunities for enhancing communication and optimizing information utilization. Both positive and negative feedback were documented regarding various aspects including the availability and reliability of information, communication exchanges, and data storage. These insights are crucial for identifying areas for improvement and pinpointing specific pain points within current practices.

Table 1 presents the profiles of the participants, who were chosen based on their roles to ensure representation across different phases of construction projects. Conducted in Dutch, semi-structured interviews allowed for the organic evolution of topics and the emergence of new insights, with subsequent translation into English for analysis.

Table 1: Profile of Participants

ID	Function	Type of business	Subject
#1	Deputy director	Developer	
#2	Project leader	Architect	
#3	Managing director	BIM model elaboration	Data exchange and life cycle optimisation
#4	Project leader	Contractor	
#5	Project leader	Housing corporation	
#6	Transfer team leader	Housing corporation	
#7	Blockchain expert	Software developer	
#8	Blockchain expert	Knowledge organization	Blockchain
#9	BIM Coordinator	Prefabrication	Data generation and transfer
#10	Lecturer	University	Validation

Subsequent to the interviews, a use case was evaluated to examine the impact of using a single central source of truth on the availability and reliability of construction information with specific relevance to the Dutch context. The interviews with the blockchain experts also addressed these topics, but with a specific focus on the potential role of blockchain technology in transforming data exchange. The central question here was whether blockchain can add value to an alternative approach to data communication, addressing aspects such as information availability, reliability and storage in an innovative way. The use case was used to gain insights into whether working within a

single network – such as a blockchain – has benefits for information exchange and availability. In fact, different departments within the company use the same information sharing system.

Upon collection of the data, thematic analysis was applied following Williams and Moser's (2019) three-step coding process. First open codes were identified, then refined into selective codes and finally themes were identified across the data. Table 2 shows the resultant themes along with analysis of positive or negative comments being made across the three sets of interviews.

Table 2: Evaluation of comments from the interviews

Themes	Current		Blockchain		Use Case	
	-ve	+ve	-ve	+ve	-ve	+ve
Availability	58	56	5	18	2	23
Reliability-Trust	60	67	6	44	3	25
Exchange-Communication	83	95	2	12	4	11
Storage	29	19	9	16	0	9
Construction information	133	130	23	68	1	19
Collaboration	51	76	5	16	4	25
BIM	58	87	2	16	1	6

Results of the interviews

The interviews were designed to explore three main aspects: the current situation, the potential added value of blockchain and a use case. Three sets of interviews were conducted with respondents from the construction industry, blockchain experts and as part of a case study.

The results, analysed thematically and summarized in Table 2, show the current situation around these topics is fairly even, with roughly equal numbers of positive and negative comments. However, when asked whether blockchain can add value, more positive statements emerged. This suggests that blockchain could be beneficial for these aspects. Furthermore, it was found that working within one network and with one source of truth produced more positive as well as negative expressions on the various topics. This indicates the potential of a blockchain-based structure to improve collaboration and information sharing.

Current situation with information exchange

The results of examining the current situation with information exchange show there is a clear need for available and reliable construction information. One crucial aspect that emerged from the interviews is the location where information is stored. Several stakeholders emphasized that construction work information is often stored on their own servers or systems, resulting in scattered and fragmented data storage. The interviews also revealed that just a shared storage location is not enough. Participant #2 said, "*That is the place where everyone leaves their information. In several projects, we have found this often acts as a kind of dumping ground for information. While anyone can put information there, there is often a lack of adequate version control and determination of relevance. Managing older data or directing that information is often neglected*". This makes it difficult to quickly access the information needed and forces parties to exchange information through external channels as indicated by participant #6: "*I get a very large information portion from the contractor through a USB stick*" (#6).

An adverse consequence of this information sharing is the challenge of identifying the most recent version of documents (e.g., drawings). "*The more information you have to share, the more mistakes are made*" (#2). This creates the risk of working with outdated or incorrect information, which can damage the reliability of construction work information. "*You will always have the customer or contractor working with a different system*" (#9). To address these issues, some stakeholders are already experimenting with software solutions that bring together construction work information in one central location. These CDEs are welcomed by respondents who recognize the benefits of centralized access to and exchange of information: "*You really need to have a place where the information is centralized, because it disappears everywhere. Everyone has different information and then what's the right version? You just lose that overview*" (#3). They believe such CDEs will improve the availability and reliability of construction information in the future: "*Of course, it would be much nicer if something from the contractor went directly into our system*" (#6).

These statements represent that the exchange and storage of construction information in construction could be significantly improved. Often, information is distributed to stakeholders in different ways, leading to ambiguity about the correct version. This leads to mutual consultation among stakeholders without everyone being aware, often resulting in parallel efforts and different versions of the 'truth'. According to respondents, the demand for a central source of information can yield significant gains in information management. Participant #6 indicated that a lot information is lost during construction and after handover. As a result, valuable data are missing during operation. Participants also indicated that there is no seamless connection between business information, with participant #6 indicating that it would be more efficient if the contractor could add information directly to the server. When asked whether applying blockchain in the Dutch construction industry can help improve information management and collaboration, there were mixed responses. Mainly, the lack of knowledge about blockchain and overall market adoption are mentioned as obstacles. Proper education about the possibilities can promote broader implementation. Participant #9 indicated that they are open to new technologies if they are beneficial for overall construction and information management in the different phases.

Added value through blockchain technology

The interviews with blockchain experts aimed to explore how blockchain can contribute to achieving more reliable and accessible information. A key focus was to identify the most appropriate form of blockchain for collaboration between different stakeholders. This involved asking about different types of blockchains (e.g., public, private,

consortium), and examining the features most conducive to effective collaboration. In addition, the research assessed the impact of using blockchain in businesses by examining the potential benefits of blockchain adoption and identifying the challenges and adjustments needed when transitioning to a blockchain-based business model. Finally, they explored why blockchain, despite several years of existence, has not yet been fully utilized. Through these interviews, it was hoped the potential obstacles that may hinder implementation of blockchain in the Dutch construction industry could be better understood.

The results indicate that while storing large volumes of information on a blockchain is possible, it is also be prohibitively expensive and demands significant computational power. Therefore, it may be more practical to consider recording only the transactions associated with that information on the blockchain. *"The bitcoin-blockchain is extremely slow and poor to use for storing information. But it is very good at transferring values because it is so secure"* (#8). This approach can enhance the reliability of information without incurring excessive costs or energy consumption. Additionally, it is worth noting that the information is hashed, and the resulting hash code is processed through the blockchain, ensuring data integrity and security. Blockchain expert #8 expressed that "*you have to see the blockchain as the party that fixes the information that parties exchange with each other. A kind of notary*". This makes the implementation of a CDE a considerable necessity, as it promotes the availability of information for all parties involved. It ensures transparency and accessibility of information, which enhances collaboration and information sharing. The findings also highlight that blockchain is an additional layer within the ICT infrastructure because "*you actually have to really separate it from the database, it's just a different kind of technology*" (#8). It provides a secure and decentralized infrastructure for storing and verifying data, which promotes trust and transparency.

For collaborations involving stakeholders with hierarchical structures, private (consortium) blockchains are recommended by participant #8. This allows participants to work together within a shared network where specific roles and authority can be assigned as well as structured collaboration and decision-making giving parties "*the ability to share data among themselves. Moreover, it is configurable, so you can configure which parties specifically share data with each other. You have full control over this configuration*" (#7).

Based on these interviews, it can be said that the demand for structured and reliable information management is strong in the industry. The large-scale implementation of CDEs is lagging partly because of the lack of structure and control. This is where blockchain technology can add value. By capturing construction information using blockchain, it is possible to keep track of changes and other important issues. The ultimate goal with this is to roll out the large-scale application of central data management in construction.

Use Case: Prefabricated wall panels

To test an 'ideal situation' and focus on information exchange between cooperating departments within a single organization, a use case was evaluated. A factory specializing in the production of precast elements was chosen. As a modern method of construction, prefabrication has a more integrated supply chain than that of traditional construction sites (Ocheoha and Moselhi, 2018) and is, therefore, potentially more susceptible to adoption of blockchain in the near-term (Olawumi *et al.*, 2022).

The aim of the use case evaluation was to gain insight into how information is exchanged when internal stakeholders work together within the same network. This study focused specifically on the methods and processes used to share and communicate information among the departments involved and whether there is a 'Single Source of Truth' for all stakeholders to reliably access. The evaluation produced several results that highlight the benefits of working with a single source of truth. It was found to improve the reliability of information because all necessary data are stored in one central location, eliminating incorrect or contradictory information. This contributes to a higher degree of reliability and accuracy in the production process such that "*IFC is the digital source model of the prototype we make and with that we control the production*" (#9). In addition, working with a single source of truth adds value to the optimization and automation process. It streamlines information exchange and creates an efficient workflow. "*We have software that does our planning and also ultimately controls production. And through that system we have files for the lasers, for the plotter; files are generated*" (#9). By working with a centralized resource, processes can be automated and more emphasis can be placed on optimization and improvement of production. An additional advantage is that all employees and departments have access to the same data "*so we are working with the same source information*" (#9). Having the source information stored in one place with easy accessibility promotes communication and collaboration within the organization. Everyone can have access to the most recent and relevant data at any time ensuring better coordination and handling of tasks and processes. Information is no longer distributed through emails between internal stakeholders, but everyone knows where to find the information. This prevents duplication of information and ensures that the 'production model' is and remains the only source of truth. The downside of intensive use of the source model is that any changes made during the process must be updated in the model to avoid production errors, as many processes are based on the source information and automation. "*We aim to integrate as much information as possible into the production model that drives our production process. We want this to be the source of information*" (#9).

During the interview, it was noticed that company employees showed remarkably more mutual engagement than is common in the construction industry. This result can be attributed to the fact that they work together within

one network or all work for the same company, which fosters a sense of belonging. As a result, all employees have a common interest in the final product, which differs from the usual fragmented nature of the construction industry in which individuals perform their own tasks.

Evaluation of this use case has shown that working with a single source of truth offers significant benefits, including improved reliability of information, availability of information, optimization of processes and a sense of belonging among employees and departments as they advance toward a common goal.

Discussion

This paper aimed to evaluate the use of blockchain in combination with CDEs to improve the accessibility and reliability of construction information in the Netherlands. The Dutch construction industry is known for its fragmentation and specialization, which poses challenges for efficient information exchange. Integrating blockchain with CDEs could help solve problems of information management essential for optimizing construction processes. The research question being answered was, "*How can the integration of blockchain and CDEs be used to improve the availability and reliability of construction information in the Netherlands?*"

The literature review highlighted the benefits of blockchain and CDEs, particularly in terms of reliability, accessibility and efficiency of information management. Blockchain is recognized for its ability to secure information and provide transparency without the need for trusted intermediaries (Lashkari and Musilek, 2021). The concept of CDEs is considered an effective way to centralize construction information and facilitate collaboration among stakeholders (Preidel *et al.*, 2017). The interviews showed current practices in construction often result in fragmented and piecemeal storage of information, leading to problems such as finding the most recent versions of documents and miscommunication between different parties. This highlights the need for centralized solutions such as CDEs to address these challenges.

The results show combining blockchain and CDEs offers a potential solution to the limitations of traditional centralized systems in the construction industry by making manipulation of information virtually impossible increasing trust between participants. This is valuable due to the complex and specialized nature of the construction industry, where different professional groups are involved in different phases of the construction process (Nawi et al., 2014). A centralized information management system can help consolidate information and facilitate collaboration and communication between stakeholders. However, it was found that storing information on a blockchain is not effective due to its latency and poor storage abilities. The combination of blockchain and a CDE was considered a potential solution to this with IPFS suggested to complement blockchain to help solve problems with inefficient data storage (Steichen *et al.*, 2018; Nyaletey *et al.*, 2019). This was supported by the findings from the interviews, though practical considerations are still to be addressed, such as the perceived high cost and energy requirements of storing large amounts of information on the blockchain requiring a targeted approach. A solution being, for example, capturing only transactions involving information on the blockchain with the actual information stored on IPFS.

The promising applications of blockchain in construction, particularly in improving efficiency, transparency and time savings, are a key finding of this research. Optimizing CDEs by further exploring and developing these areas for the Netherlands, innovative solutions can be developed that lead to more efficient, transparent and sustainable construction processes and projects. Moreover, it is important to research similar situations in other countries. This helps not only to understand the applicability and effectiveness of blockchain in different contexts, but also to identify global best practices. By making international comparisons and drawing lessons from different experiences, we can gain a deeper understanding of the potential impact of blockchain on the construction industry worldwide. This can ultimately contribute to a more informed and inclusive approach to the implementation of blockchain technology in the construction industry.

Conclusion

The Dutch construction industry, characterized by fragmentation, experiences challenges in communication and coordination of construction work information, with loss of valuable data. This research answered the question, "*How can the integration of blockchain and CDEs be leveraged to enhance the availability and reliability of building information in the Netherlands?*" Qualitative methods were used to examine construction information in the chain, as well as opportunities and limitations of blockchain.

The research findings emphasized the importance and issues surrounding availability and reliability of information in the construction supply chain, often associated with negative experiences. The lack of connection between companies, operating mainly on their own ‘islands’, leads to manual dissemination of information across stakeholders. This results in conflicting versions, miscommunication and lack of a clear source of truth.

Research on blockchain integrated with a CDE has provided insights on its potential and limitations. Although further research is required to explicitly answer the research question, it is suggested that integration of a CDE with blockchain could be a valuable approach. Blockchain is not suggested for storing large amounts of information, rather integration with IPFS for a CDE that acts as a central repository for all construction information, could see increased security and prevent manipulation of data. This enables reliable and immutable storage of information, which is crucial for the efficient and effective execution of construction projects.

The evaluated use case showed that using a shared

network environment and working with a central source of truth brings several benefits in terms of optimization, efficiency and trust. This is because information is stored, managed and shared more efficiently within the network. The availability and reliability of construction information increases greatly when using a single source of truth. Because stakeholders know where information is stored, individual sharing is no longer necessary, which benefits information reliability and reduces the risk of miscommunication and duplicate versions.

One notable result is that stakeholders have more mutual trust and cooperate better when operating within the same network environment. This improvement comes from relying on each other's information within the same system, allowing individual goals to converge into a common interest. This highlights the importance of a shared platform and the potential of blockchain to enhance communication, trust and collaboration in the supply chain. In short, the study concludes that construction stakeholders benefit from available and reliable construction information, with blockchain serving as a valuable tool to achieve these goals.

As preliminary research, this study was limited regarding the number of stakeholders engaged and the use case evaluated. While the study gained insights from relevant perspectives, it is acknowledged that more engagement is needed. A wider range of stakeholders could provide a broader spectrum of insights and allow for a more comprehensive representation of diverse viewpoints in the Dutch construction industry. Extending the study to engage with a wider range of stakeholders across the project life cycle to gain a deeper understanding of the complex dynamics and challenges within the Dutch construction industry. The use case chosen considered information management at an intraorganizational level that arguably faces less challenges than at an interorganizational level, the latter will be included in the extended study. In addition, blockchain's technological elaboration and application alongside a central database will be explored.

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