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BLogCHAIN: PROOF-OF-CONCEPT AND PILOT TESTING OF A BLOCKCHAIN APPLICATION PROTOTYPE FOR CONSTRUCTION LOGISTICS IN SWEDEN

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ABSTRACT

Blockchain technology has a potential for construction logistics, also within Sweden. In this paper, a proposal of a blockchain system and its practical implementation is presented (the BLogCHAIN prototype). BLogCHAIN was preliminarily tested during the early construction of a school in Sweden, in November-December 2020. Methodologically, we reviewed studies on blockchain for construction logistics, interviewed the BLogCHAIN testers (suppliers and contractor's operatives), and understood the test's practical outcomes through sociomateriality. Our results include the confirmation of envisioned benefits when implementing BLogCHAIN (e.g. reducing accounting rework), but also a simplification from its initial conceptualization, mainly due to rigidly established work practices.

INTRODUCTION

Blockchain can be considered an emergent general-purpose technology, making its potential implementation across applications and business fields quite versatile (Filippova, 2019). This versatility can also be reflected to its various definitions, which can be information-oriented, economy-oriented, and even approached through other lenses (e.g. sociomateriality) (Kifokeris & Koch, 2020). Nonetheless, blockchain is often described as a distributed digital ledger for peer-to-peer transactions (on various levels of decentralization), which are kept in a historical record updated through consensus (Singhal et al., 2018).

For the construction sector, ever since early related works (e.g. Cardeira, 2015) there has been a growing interest on the potential implementation of blockchain for several applications. Current studies describe, indicatively, the utilization of smart contracts (i.e. blockchain-powered computer protocols facilitating, verifying, or enforcing contractual clauses (Cuccuru, 2017)) for the automation and facilitation of progress and interim payments in procurement (Hamledari & Fischer, 2021), securing BIM information exchange through a permissioned blockchain platform (Suliyanti & Sari, 2021), and using blockchain to create a shared and secure data infrastructure for smart cities (Fu & Zhu, 2021). Considering construction supply chains and logistics, theoretical and exploratory studies have elaborated on the potential of blockchain for solving specific issues (e.g. the opportunistic behavior of supply chain actors in Qian & Papadonikolaki, 2020); a few efforts have even described related prototypes (e.g. in Shemov et al., 2020). However, studies documenting and analyzing actual use cases during the test implementation of such solutions, can scarcely be found. In this paper, we attempt to answer the research question of what such a targeted solution and its practical implementation could entail in, specifically, the Swedish context – where common logistics problems include flow disintegration, imprecise data retrieval, and accounting misalignments among the supply chain actors. Specifically, we present our proof-of-concept pilot BLogCHAIN (Building Logistics blockCHAIN), developed during the autumn of 2020 and tested during the early construction phase of a school building in Sweden (November-December 2020). BLogCHAIN was based on a previously conceptualized sociomaterial blockchain solution for integrated logistics flows. Our focus on the particular context of a single project in the Swedish construction sector aims to acknowledge the institutional specifities of different contexts.

This paper unfolds as in the following. After the Introduction comes the section of Theory, focusing on sociomateriality, the integration of the logistics flows, and the combination of these foci into a blockchain solution for the Swedish context. Then, the research method is briefly decribed. Following is a targeted literature review on blockchain-related research for construction logistics. Then, the empirical part containing the description of BLogCHAIN, as well as documenting and analyzing the conducted tests, is elaborated on. Finally, a discussion featuring some critical insights, and the conclusions of this research, are offered.

THEORY

Sociomateriality

The theory of sociomateriality emphasizes that the material and social aspects of (digital) technologies are inseparable and fused in practice (Orlikowski & Scott, 2008,2016). Actions of utilizing the digital technology are no longer considered to be exclusively human properties, but are performed through interactions between humans and non-humans (Moura & Bispo, 2020). This interactive co-shaping can in turn reflect the way in which the structure of an organization (or a constellation of actors) is realized (Moura & Bispo, 2020; Kohtamäki et al., 2020); the network of actors in a construction supply chain and logistics setup can be understood as such a constellation (Kifokeris & Koch, 2020). The inseparable entanglement of the material and social aspects of a digital technology (like blockchain), can provide the framework to describe the reconfigurations of work practices brought about by its introduction, as well as its further development (Orlikowki and Scott, 2016).

Integration of supply chain and logistics flows

Integrating the material, information and economic flows within construction supply chains, has been identified as a key factor for logistics optimization and project success (Palaneeswaran et al., 2000; Love et al., 2004). The information flow has been identified as the bidirectional flow of requirements between supply chain actors (Titus & Bröchner, 2005), the material flow as the flow of physical goods (Titus and Bröchner, 2005), and the economic flow as the transactions pertaining to assets, cost entities, monetary exchanges, and the integrated data on prices, billing and invoices (Kifokeris & Koch, 2020).

Throughout the years, most studies on flow integration focused on the information and material flows (e.g. for choosing the best location for on-site temporary facilities (Golpîra, 2020)), and largely left the economic flow out. But blockchain technology can enable an event-driven integration of all three flows; those events can be conceived to include transactions between supply chain actors (such as the release of invoices and payments) via direct peer-to-peer information exchange after successful material deliveries, correct on-site placement, and resolution of work packages (Kifokeris & Koch, 2020).

A sociomaterial take on blockchain for construction logistics with integrated flows

Based on previous blockchain research, the theory of sociomateriality, the aforementioned vision of flow integration, and a field analysis on the Swedish construction sector (considering e.g. a type of business practice where public clients hire logistics consultants), Kifokeris and Koch (2020) conceived a blockchain solution for downstream construction logistics in the Swedish context.

In particular, this solution entailed the setup of a permissioned private digital ledger for partially decentralized peer-to-peer information and economic transactions within a project-specific networked constellation of supply chain actors (featuring the clients, contractors, logistics consultants, and suppliers). The databases of the digital ledger databases were conceived as permanent and append-only, with the data stored and accessed in a historical record updated through consensus, and shared across all network nodes reflecting the constellation actors. As a permissioned system, it featured a reduced but existing need for in-between transactional verification. Its logic was based on proof-of-authority algorithms, where the consensus stake (agreed upon between the networked actors) is identity (Verhoeven et al., 2018). This in turn was envisioned to create power shifts in the network, as in the sociomaterial autonomy-control paradox (Bader and Kaiser, 2017). A graphical depiction of this conceptualization is featured in Fig.1.

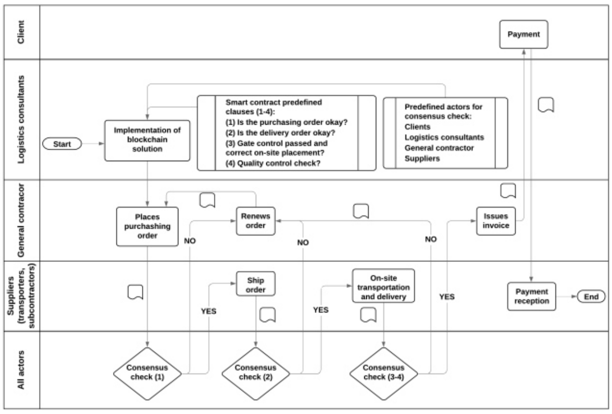

Figure 1: Concept of the solution (Kifokeris & Koch, 2020)

As shown in Fig. 1, the flow integration is accomplished as the transactions in the economic flow (e.g. issuing invoices) are connected to events in the information flow (e.g. placing purchasing orders) and/or the material flow (e.g. successful on-site material delivery).

RESEARCH METHOD

The research method of this study consists of: (a) a systematic literature review, (b) the collection of empirical data (before, during, and after the development and testing of BLogCHAIN), and (c) the integration of the literature review results and the empirical data.

For the systematic literature review, the concept-centric framework augmented by units of analysis (Webster and Watson, 2002) was used. The units of analysis emerged during the review, facilitating its revision in iterations. These iterations, partly attributed to the quickly expanding related research field, followed the abductive reasoning of qualitative research (Bell et al., 2019). Furthermore, the systematic literature review was strengthened with the use of the references-of-references and "snowballing" techniques (Greenhalgh and Peacock, 2005), while the conducted search comprehensive in order to avoid a narrow sample (MacLure, 2005).

Empirically, we combined the sociomaterial methods of zooming in and out, meetings and interviews, observations, and participant mapping (Moura & Bispo, 2020). These techniques were implemented (in various combinations) during the following four sessions:

1. Before the development of BLogCHAIN. During this session we zoomed out with regard to the Swedish construction context, and tried to establish a bird's eye view over a wide geographical region in Sweden, in order to find a suitable construction site that could act as a testing ground. Simultaneously, we

conducted participant mappings to scrutinize our contacts in the industry and their possible relations to the respective construction sites. We then gradually zoomed in and established (in early September 2020) the collaboration with the specific school building construction site, and the actors (i.e. suppliers and the contractor's site managers) willing to test our app there. Afterwards, we conducted preliminary semi-structured interviews to gather data on the supply chain and logistics work practices of the specific actors at the specific construction site (e.g. the existence of other IT solutions, and different degrees of systemic integration between the contractor and each supplier). These, in turn, introduced constraints and alterations in the development of BLogCHAIN, eventually leading its design, functionality, and user interface to depart (in certain respects) from the initial conceptual vision in Fig. 1. More elaboration on that is offered in section "Empirical part".

2. During the development but before the field testing of BLogCHAIN. The development of the app took place roughly between September and early November 2020, and started before the last round of the preliminary interviews was finished. The developed proof-of-concept was based on the conceptualized solution by Kifokeris and Koch (2020), but modified according to the practitioners' input acquired in this and the previous stage.
3. During the field testing of BLogCHAIN. After finishing the development of the application, a series of meetings were conducted with the testers over the span of two weeks, in order to assist them in its installation and guide them through its functionality and interface. Afterwards, the tests took place through the rest of November and December, designating the end-of-year vacation as the stopping point of the field testing. The tests consisted of the collaborating suppliers and contractor's operatives carrying out supply chain transactions through BLogCHAIN. In order to not disturb the everyday work at the construction site, we agreed with the testers that the tests would run in parallel to the established way in which transactions were taking place – and not in replacement of those practices. During the tests, we conducted semi-structured and unstructured interviews with the testers, and engaged in observations as they used the application. More elaboration on the field testing is offered in section "Empirical part".
4. After the field testing of BLogCHAIN. We conducted semi-structured interviews with all the testers, in order to record their user experiences.

Due to the COVID-19 pandemic, all interations with the testers were remote. Also, only the information allowed by all involved actors is disclosed in this paper.

The literature review findings and the field data were combined to: (a) inform the actual development of the application – beyond the initial conceptualization of Kifokeris and Koch (2020), (b) understand the potential alterations in the work practices that can be realized through BLogCHAIN, (c) check which of the previously envisioned benefits and drawbacks of the blockchain solution did or did not materialize, and (d) document the delimitations and shortcomings of the pilot, while simultaneously gathering recommendations for its improvement and expansion. For this, the sociomaterial study framework by Moura and Bispo (2020), and the ten-step decision path to determine when to use blockchain technologies by Pedersen et al. (2019), were used.

LITERATURE REVIEW

For the purposes of this study, the literature review focuses on the potential of blockchain for construction supply chains and logistics – both in general, and the Swedish context in particular.

In the case of general studies, according to Cardeira (2015), streamlining the construction supply chain through digital distributed ledgers, can reduce insolvencies like withheld payments. Wang et al. (2017,2020) and Nanayakkara et al. (2019) noted a facilitation of the information flow in downstream supply chain when tapping into blockchain's transparency and traceability. Lanko et al. (2018) posed that integrating blockchain with RFID sensor tagging can improve on-site logistics. Penzes (2018) noted that transactions through blockchain can lead to dynamic payments for logistics actors, and improved communication with the contractor. Moreover, the tampering with past logistics data can be avoided through the consensus required for the block updates and the storing of the complete transactional history (Penzes, 2018) – something that can also reflect positively on issues of productivity and efficiency (Shemov et al., 2020). Accounting rework and data errors across multiple ledgers can be reduced, which in turn can bring time and cost savings (e.g. instant delivery notice) (Penzes, 2018). Ma (2020) identified three key legal issues when implementing blockchain in construction supply chains, namely the restricted use of smart contracts to solely prescribed outcomes, the shared data access and ownership, and multi-jurisdiction concerns related to governing laws. Rodrigo et al. (2020) described using blockchain to make data transactions transparent and immutable in estimating the embodied carbon emissions along construction supply chains. Tezel et al. (2020) conducted a SWOT analysis showing that developing operational processes aligning with the supply chain actors and their roles, is a crucial step for embedding blockchain in construction supply chains. Qian and Papadonikolaki (2020) showed that the opportunistic behavior of logistics actors can be amended by shifting to a system- and cognition-based trust through blockchain-based data tracking and contracting.

For the Swedish context, subsequent studies by Kifokeris and Koch (2019a,b,c; 2020) have gradually investigated the integration of the material, economic and information flows in the construction supply chain, through a blockchain solution forming part of the value proposition in logistic consultants' business models. In particular, Kifokeris and Koch (2019a) investigated the suitability of Swedish construction supply chains and logistics for the accommodation of a blockchain solution integrating the logistics flows, involving independent logistics consultants (usually hired by public clients in building projects) that can incorporate such a solution in their digital business model; the study then proceeded with a preliminary mapping of such consultancies operating in Sweden. In Kifokeris and Koch (2019b), the scientific perspective of sociomateriality was initially introduced in relation to a potential blockchain solution for integrated logistics flows, and the power shifts that such a solution would bring in constellations of supply chain actors in the Swedish context, was discussed; these constellations included the typical case of large contractors internalizing logistics services, the atypical case of using independent logistics consultants, and the emergent case of third-party actors offering dedicated digital building logistics services. In Kifokeris and Koch (2019c), sociomateriality was used to map potential benefits and threats pertaining to construction-related blockchain visions and prototypes (documented mainly in industry reports) and discuss how those can be extrapolated to a solution for integrated supply chain and logistics flows in Sweden. Finally, Kifokeris and Koch (2020) offered the sociomaterial conceptualization of such a solution (see Fig. 1), mapped the ways in which such a solution transforms a generic logistics setup, planted the solution in a conceptual digital business model canvas for independent logistics consultants, and customized the canvas on the business of a specific consultant company (with the input of the company's representatives).

The general studies show that core blockchain properties, such as peer-to-peer transactions and record immutability, can generate most of its envisioned benefits when used for construction logistics – like the avoidance of tampering with past logistics data, cost savings through the reduction of accounting rework, and the streamlining of payments to suppliers. When it comes to specific blockchain aspects, the digital ledgers and smart contracts are the ones principally considered to have the biggest potential for construction logistics. It can be observed that the general studies conduct their investigation mostly on a conceptual level and follow a blended economic flow- and information flow-oriented approach. Nonetheless, Tezel et al. (2020) and Qian and Papadonikolaki (2020) do investigate social issues across the construction supply chain, such as the facilitation of trust. However, none of the general studies elaborates explicitly on flow integration, nor adopts sociomateriality.

The studies pertaining to the Swedish context do bring the attention to the issue of flow integration, and they introduce sociomateriality for a deeper consideration of the transformation of work practices that could be realized through the implementation of a related blockchain solution. However, while their context-specific approach can be considered as a methodological strength due to the consideration of institutional particularities, it also makes their conceptualizations (and especially the one in Kifokeris and Koch (2020)) vulnerable to any departure from that particular context. As shown in the next section, this vulnerability actually materialized during the empirical part of the present study, since the absence and/or inactivity of certain supply chain actors initially considered in the conceptualized solution (the logistics consultants and clients, particularly), forced the development and testing of a proof-of-concept that was reduced in comparison to the setup in Fig. 1.

As an endnote, potential barriers and security issues when implementing blockchain for construction logistics, are only limitedly considered in some studies (e.g. in Kifokeris and Koch 2019c, 2020; Ma, 2020; Shemov et al., 2020; and Tezel et al., 2020). Regarding potential barriers in adopting blockchain for construction supply chains and logistics, the common denominator of the aforementioned studies reveals that adoption success is affected by whether strategic objectives of logistics management can be achieved; at the same time, adoption can be impeded by the currently limited engagement with the technology within the construction sector. Considering security, the studies jointly highlight that there is currently a presumptive mistrust in the viability of blockchain as a technology investment, while there is uneasiness regarding a potential abuse of blockchain properties; e.g. illegal activities cloaked by the anonymity of the nodes, and tensions between the transaction parties due to the inflexibility of the smart contract clauses.

EMPIRICAL PART

Preparing the development of BLogCHAIN

The site elected to host the field tests of BLogCHAIN accomodated the construction of a public school building in Sweden. At the time of the establishment (early autumn of 2020) of the collaboration, the early construction phase had started (e.g. laying of the foundations and the reinforced concrete structural system of the superstructure). The project's main contractor is one of the four biggest construction companies in Sweden, while the main active suppliers at that point in time were the company supplying the concrete and aggregates in bulk quantities), a company supplying the steel for the reinforcements, and a company supplying a variety of less heavy materials (e.g. wood) in smaller quantities. Our correspondence was mainly established with one out of four site managers at the contractor's side, and one operative in each of the aforementioned suppliers.

Soon after the contacts were in place, a series of semi-structured interviews with the colleagues mentioned above was conducted, in order to understand the specificities pertaining to the supply chain and logistics setup at the construction site. Through these interviews, it was confirmed that in most cases, the accounting systems of the suppliers and the contractor were disintegrated and passed through different control nodes. Additionally, no independent logistics consultants were involved in the setup; the constellation in place was rather the typical one of the main contractor internalizing the logistics services, as descibed in Kifokeris and Koch (2019b). Moreover, the municipality did not exercise an active client role in overviewing the logistics processes (especially since no logistics consultants were hired in the first place), and instead preferred to let the contractor take care of those. When it comes to the role of transporters, no precise information was elicited in this preliminary stage; it was not ascertained whether they were parts of the supplying companies, or independent actors. Furthermore, a description of the established on-site work practices led to a reduction of the scope of the application's implementation, and pointed to a set of partially different (and more demarcated) smart contract clauses and logistics flows than the ones described in the conceptual solution in Kifokeris and Koch (2020).

These findings showed that the development of the blockchain application would have to depart from the conceptualization in Fig. 1 and lead to a proof-of-concept that would be in places simplified and/or altered. In particular, the only actors left to enact transactions through the application and participate in its consensus checks, would be the contractor, the suppliers, and (conditionally) the transporters. Additionally, the section of the stream of the material, economic and information flows on which the BLogCHAIN was to be implemented and attempt the flow integration, would start when the supplier issued the confirmation of the order already placed by the contractor, and would finish with the contractor accepting (or not) the supplier's invoice (issued after the material delivery had taken place). As such, the steps before (e.g. the contractor issuing the order) and after (e.g. the payment of the supplier) this segment, as described in Kifokeris and Koch (2020), were left out. Finally, the subsequent smart contract clauses and checks depicted in Fig. 1 were replaced with the following partially different statements: (1) Is the purchasing order confirmation accepted? (mandatory) (2) Is the delivery receipt accepted? (man.) (3) Did the transporters of the delivery notify the construction before their arrival (if such an action had been agreed upon beforehand)? (optional check) (4) Was the material delivered at the right place? (opt.) (5) Was the labeling and the quantities of the delivery correct? (opt.) (6) Is the packaging (when applicable) of the delivery undamaged? (opt.) (7) Is the invoice accepted? (man.).

The difference between the mandatory clauses and the optional checks, reflects their ability to block (or not) the process in case of non-satisfaction. Non-satisfaction of the mandatory clauses prevents the transaction from being completed, while in the optional clauses it shows stumbles in the process, but does not prevent initiation of the next step. The clauses were respectively deemed mandatory or optional according to the interviewees' collective input. Moreover, the sociomaterial constellation of actors led to a setup where, within the proof-of-authority algorithm, the consensus checks were to be replaced by checks performed by the contractor, and the transporters assumed a passive observant role.

Developing BLogCHAIN

The new concept of the blockchain solution that was used for the developed of BLogCHAIN is summarily depicted in Fig. 2.

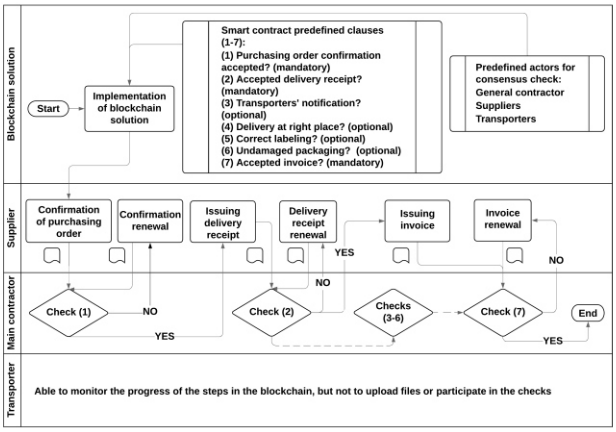

Figure 2: Updated concept of the blockchain solution

Based on this concept, the development started while the previous preparatory stage had not yet finished. The development featured one iteration, in which new insights from the interviews were gradually acquired.

In terms of technical documentation, BLogCHAIN was developed as an online application. Its user interface is suitable for both desktop PCs and smartphones, and is in Swedish. The infrastructure of BLogCHAIN utilizes the open source Hyperledger framework, and can be accessed through MetaMask, a crypto-wallet and gateway to blockchain applications. MetaMask functions as an extension for Google Chrome, a Google Play app, and an App Store app (for desktop computers, smartphones, and iPhones, respectively). BLogCHAIN can be found in https://constructionchain.blockalize.com/, but without an active MetaMark account, it cannot be accessed.

The (PDF) files to be uploaded on the online repository connected to BLogCHAIN (e.g. invoices), and they are encrypted in Microsoft Azure (MAz). Using of MAz was a utilitarian choice, as it was aligned with the available development resources in the project. Future development may explore another, fully decentralised platform; however, this will have to be contextualized in the respective business case. The trust and transparency of a permissioned system may entail only a certain level of transparency, rather than true decentralisation using the InterPlanetary File System (IPFS).

Testing BLogCHAIN

Right after developing BLogCHAIN, a series of remote meetings were held with the testers, in order to help them with installing and using the application. In some cases, short subsequent meeting were held for clarifications.

The tests themselves consisted of transactions between the contractor and two out of the three contacted suppliers (the one delivering concrete and aggregates, and the one delivering the assortment of less heavy materials). These transactions were infrequent and spread during the testing period of November-December 2020. As a result, only a handful of transactions were recorded on BLogCHAIN by the end of the testing period, most of which initiated by the concrete and aggregates suppliers. This infrequency and sparseness had to do with the construction phase itself, which mostly entailed a few bulk deliveries of heavy materials, as well as the COVID-19 pandemic crisis, which detained (to a certain degree) the supply chain and logistics processes.

Interestingly, while the third supplier (delivering the reinforcement steel) had been present in the preparatory stage and had also installed BLogCHAIN after its development, they ended up not using the application at all. Shortly after the installation, this supplier informed us that their company already deployed an automated digital system for handling the flows between them and the contractor (e.g. the issuing of the invoices). That system was deemed by the supplier to be optimized for the company's business model, and therefore the supplier lost interest in testing BLogCHAIN.

It should be noted that during the tests, one of the authors maintained dummy accounts within BLogCHAIN for technical and functional reasons. Moreover, several informal communications were held with the testers, in order to monitor their testing attempts on a hands-on basis, and offer continuous technical support.

After-test insights

After the completion of the tests, semi-structured interviews were held with the testers to record their experiences. By comparing their established supply chain and logistics practices to the test transactions conducted through BLogCHAIN in parallel, the interviewees confirmed a number of envisioned benefits in the implementation of the application: tampering with past data was avoided; the single platform of BLogCHAIN meant that there was no work needed to consolidate different ledgers; and the integration of the logistics flows led to a streamlining of the process, along with fostering a somewhat higher degree of trust among the testers. However, the barrier of the practitioners' almost absent previous engagement with blockchain, which made our pitch for the technology's potential more difficult to get through, was also confirmed.

The interviewees also provided proposals for improving BLogCHAIN, which were implemented before an iteration of the tests conducted in late January – early February 2021 (the presentation of which is beyond the scope of this paper); for this topic, even the supplier not participating in the tests offered some feedback, despite not having a user experience with BLogCHAIN. Central among those proposals were the conditional re-involvement of the roles of the client and the logistics consultants, deploying a notification function for the transporters as they approach the construction site, and making provisions to accommodate the different roles of managing the sales and issuing the invoices that can exist within the same supplier company. Other proposals, like the system checking, on behalf of the suppliers, the clients' creditworthiness, or the conduct of monetary transaction (possibly with the use of cryptocurrencies) were deemed interesting but out of the scope of this pilot; so they were categorized as recommendations for future work.

DISCUSSION

The discussion elaborates on the results of the literature review, our insights on choosing sociomateriality, and critical comments on the field testing of BLogCHAIN.

Regarding the literature review, the relevant insights show that construction logistics can gain value by exploiting core properties of blockchain. Therefore, there is room for construction logistics to benefit from even baseline blockchain architectures, e.g. basic digital ledgers and/or simple smart contracts. However, this has to be coupled with more engagement with the technology within the construction context, and not only in regard to its functional aspects – but also its effect on work practices and sociotmaterial implecations.

Our choice for a sociomaterial understanding did not only inform our background studies and choice of conceptual basis for the development of BLogCHAIN, but was also realized during our field tests. The prospective testers' experiences at the preparatory stage informed the development of BLogCHAIN itself, the evolution of the pilot's utility followed the the way it was used during the tests, and the recommendations we got afterwards – emanating from the social relations between the actors and the practcal work conducted in the supply chain and logistics constellation – were realizations of a sociomaterial co-shaping of the implementation of the digital technology with the related practices.

The created value for the users involved was limited in the test, but nonetheless demonstrated the utility of blockchain in supporting transparent coordination. Deficiences in coordination are known to create quality defects, and transparency can help in ameliorating those. For example, more precise information on truck deliveries can reduce waiting times and on-site work interruptions.

The prototype also highlighted the possibility of a more active and digitally supported role of the clients, despite not having a client node in the distributed digital ledger of the first iteration. Enabling the online surveillance of construction progress (especially the economic flows and accumulated costs) can be considered to provide the client with valuable knowledge, which could otherwise be considered to be accessed mostly by the contractor or indirectly through logistics consultants.

The function of BLogCHAIN can also point to its integration with collaborative project delivery approaches, like integrated project delivery (IPD). Since

IPD entails collaborative efficiency and involvement of all project team members throughout the project lifecycle, BLogCHAIN could be a connecting facilitator of such an involvement when it comes to logistics – especially considering a potentially increased importance and activity of the roles of the clients and the consultants.

Regarding the compulsory versus voluntary checks, some users (e.g. site managers) requested making blockchain transactions obligatory, while others (e.g. suppliers) preferred a more flexible solution maintaining some voluntary transactions. This is a dilemma for future development; however, it can already be considered that to avoid unneccessary bottlenecks in the process it is maybe adviceable to keep most steps voluntary. Nonetheless, it is possible that in the future, blockchain can support standardized processes involving obligatory steps. On another note, this dilemma can also be reframed as an incentive problem, i.e. keep the checks voluntary, but reward participation and sharing with incentives.

System disintegration seems to be a major deficit in the operation of the present prototype. Integration with other systems is crucial for the creation of value for the participating actors. However, the present project did not have enough resources to develop the necessary application programming interfaces (API) with other systems in the domain. Moreover, it is also a question of whether existing systems are designed in a way that makes (dis)integration easier or, actually, more difficult.

CONCLUSIONS

This paper sets out to discuss and analyze what a targeted blockchain solution for construction logistics with integrated flows, along with its practical implementation, could entail in a specified context. Our theoretical framework drew on sociomateriality. In our research method we conducted a literature review on blockchain solutions for construction logistics, presented our proof-of-concept pilot BLogCHAIN (Building Logistics blockCHAIN), and described the preliminary tests from utilizing BLogCHAIN in a construction site in Sweden.

The results of the test were limited; they did show that this solution could be an important contributor to improved transparency along the economic, material and information flows in the construction supply chain. Recommendations of future work can include more test iterations on a pilot updated via the testers' feedback after the first iterations, and the analysis of more related qualitative empirical data through a sociomaterial lens.

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