

Crypto-Economic Incentives in the Construction Industry

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1 Problem

Construction is one of the largest industry sectors in the world both from an economic and society perspective. With current challenges of population growth, migrations into cities, and climate change, it is likely to grow in importance. Nevertheless, it faces problems related to productivity, sustainability, and transparency. Many of these problems can be related to fragmentation of a very complex industry with numerous actors involved. This structure was described with three dimensions of fragmentation: horizontal, vertical and longitudinal fragmentation as depicted in Figure 1 [1,2]. Vertical fragmentation occurs between project phases [3]. Each phase has a different set of stakeholders, decision-makers, and values. This creates displaced agency – also called ‘broken agency’ - where involved parties will engage in self-interested behavior and pass costs off to others in the supply chain in a subsequent phase [4]. Horizontal fragmentation occurs in the trade-by-trade competitive bidding environment of traditional project deliveries. Because it is difficult to cross-subsidize changes across trades, globally-optimal innovations cannot compete with traditional solutions that are more cost-effective from the perspective of a particular building element or phase [5]. Longitudinal fragmentation occurs when project teams disband at the end of projects and are selected on future projects by competitive bidding. They are thus unlikely to work with the same set of partner firms on future projects. Consequently, team members lose tacit knowledge about how to work together effectively [6] and organizations are unable to build long-term trusting relationships across firm boundaries.

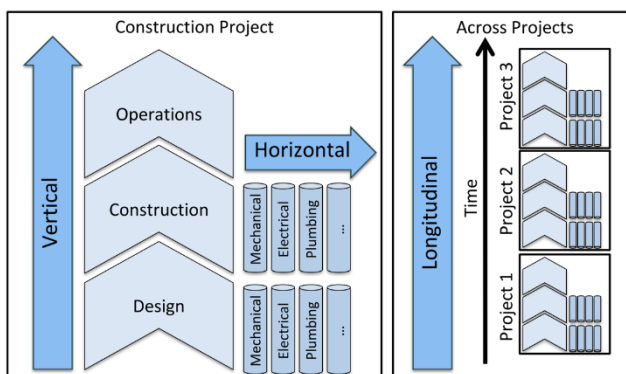


Figure 1. Three degrees of fragmentation in the construction industry (Source: [2], adapted from [1,3]).

Overcoming these different levels of fragmentation through more integration of the construction process seems to be one of the main hurdles in becoming a better and more efficient industry. For that,

of course various approaches are possible. Next to managerial concepts that try to achieve more integration through new multi-party construction arrangements, LEAN or agile methods, also technology is seen by many as very promising to achieve more integration. Especially Building Information Modelling (BIM) promises potential for more collaboration across stakeholders and is currently perceived as the baseline for information technology and industry 4.0 awareness in construction. Having said that, the integration of BIM as a systemic innovation poses again major challenges in the adoption due to the prevailing industry structure [7,8]. Next to the general difficulties with innovation diffusion, it was found that the adoption of BIM has lagged as project teams struggle with trust and liability concerns associated with sharing information on the project [9]. It seems that the industry structure and technology cannot be treated in isolation and digital technologies must be integrated with adaptations in management, contracts and collaboration forms [10]. In other words, technology implementation should be treated as means to an end to address the fundamental problems of the construction industry, and not the other way round [11]. Interestingly, one recent technology potentially enables better integration between these two worlds: distributed ledger technology (DLT), with blockchain as the best-known sub-type of DLT.

2 The Promise of Crypto-Economic Design

DLT offers an opportunity to increase trust and collaboration within the construction industry by integrating digital information with management and contracts. It can help making the construction process more efficient, transparent, and accountable between all involved participants [12]. Various use cases for blockchain in construction have already been proposed [13]. The main idea of blockchain is to track transactions over time and store them in a trustworthy, distributed manner. The users in the peer-to-peer network can trust the system to ensure valid transactions, instead of trusting intermediaries or other network users. One of the most promising features built on these distributed networks are *smart contracts*, which are code protocols running on top of the protocol layer. They allow for distributed workflow automation and the creation of so-called *tokens* as containers for different kinds of value, such as utilities, securities, currencies, or other [14]. With these tokens, incentive systems can be built to influence the human behavior when interacting with blockchain based digital processes.

“Blockchain gives us programmable money. When you can program money, you can program incentives, and when you can program incentives you can program people” - Mike Goldin

In fact, the use of smart contracts and tokens for crypto-economic incentives could be one of the major applications for the very fragmented construction industry. Such incentive systems can be targeted towards various goals in different contexts. In the example of Finance4.0, Dapp [14] describes a crypto-economic system based on the proposal of Kleineberg and Helbing [15] to incentivize sustainable behaviour through the use of cryptoeconomics by focusing on a multidimensional payment systems, instead of the one dimensional monetary system we have nowadays. Summarized, DLT offers opportunities to combine various dimensions of our socio-economic system nowadays, using financial or non-financial incentives to improve (business) processes by steering people's behaviour in a bottom-up, decentralized way. This particular application of DLT might help to create a new economic paradigm, potentially reducing fragmentation in construction by fostering more trust and collaboration across the life cycle. Having said that, designing incentive systems is not an easy task and could lead to many unforeseen and unwelcome secondary effects. There is emerging research fields of "crypto-economic system design" and "token engineering" [16] investigating possibilities to guide humans through smart contract based incentives.

3 Motivation in Construction

Despite of the increasing digitalization, technology was so far not been able to achieve the targeted productivity, transparency, and sustainability in construction that would be needed in the context of current challenges like climate change, resource shortages, or mass migrations into cities. One possible explanation is that part of the industry problems are linked to organizational and people related issues, rather than process and technology issues. New and innovative ways need to be explored to tackle the challenge of integrating technology and processes with the construction-industry, -organizations, and -workforce. DLT offers an opportunity to achieve this through new, decentralized incentive systems, building on the availability of data with increasing level of digitalization. An opportunity that should be also explored in the context of construction.

4 Research Objective

Therefore, the goal of this Ph.D. research is to investigate the potential of DLT and crypto-economic incentive design to overcome various problems related to the fragmented and complex context of construction. The hypothesis is that existing incentive structures in construction could be refined and adjusted through newly introduced incentives structures enabled by DLT. Acknowledging that there is a large number of potential application areas, the selected use cases for now are 1) incentives for data collection during design and construction, and 2) incentives to enhance collaboration in contractual arrangements. Both cases face issues regarding misaligned incentives, resulting in selfish behavior of individual participants instead of collaboration towards the overall project success.

5 Expected Outcome

The research is expected to give first insights to what extend the hypothesis on the potential alignment of fragmentation in construction, with the decentralized and bottom-up approach towards more collaboration through crypto-economic incentive design, holds true. Given the complexity in designing such

incentive systems and the size of the construction industry, more and interdisciplinary research e.g. with social science and system engineering will be needed in the future to fully understand the underlying dynamics. Nevertheless, the theoretical assessment of the use cases together with some initial prototypes should demonstrate to researchers and practitioners the potential future opportunities of crypto-economic incentives as an additional possibility towards better integration in the currently fragmented construction industry.

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