

# A Smart Contract Framework as an Alternative Method for Letter of Credit Use in Construction Procurement

Furkan Uysal<sup>1</sup>, Salar Ahmadisheykhsarmast<sup>2</sup> and Rifat Sonmez<sup>2</sup>

<sup>1</sup>Ankara Social Sciences University, Ulus, Ankara, Turkey

<sup>2</sup>Middle East Technical University, 06100, Ankara, Turkey  
furkanuysal@gmail.com

## Abstract

Letter of credit (L/C) use in construction procurement is a common practice particularly for international trades. L/C is a commitment of banks which reduces buyers' and suppliers' risks related to transactions. In international trades both buyer and supplier need a third-party involvement in order to ensure smoothness of procurement procedures. However, third party involvement makes trading more cumbersome, add extra fees, credit limit of individual parties may affect the whole process adversely and it is lack of physical control over delivered items such as materials or equipment.

A more reliable, cheaper and faster framework is proposed in this paper as an alternative method to common use of L/C. This framework is based on smart contracts where contractual agreement is made in a decentralized blockchain with smart contracts. Different from routine L/C practice, physical control over delivered item is possible using IOT devices and it makes whole procurement procure more straightforward, cheaper and more reliable.

## Keywords

Smart Contracts, Letter of Credit, Construction Procurement

## 1. Introduction

Procurement is an essential part of construction projects and it is highly labor intensive. From identifying the item to be procured to the final approval, procurement requires several steps. It requires experienced and dedicated expert during estimating quantities, selecting the right equipment, planning delivery times, selecting the right supplier, performing quality assurance and accepting and approval of delivery. Both material and equipment cost could constitute the highest percent of total projects cost. According to Agapiou et al (1998) only material procurement costs can reach approximately %40-45 of total project cost. Most often stakeholders of procurement process do not know each other, maybe separated by distance and may not have a commercial relationship before. Particularly in international trades both seller and buyer have serious concerns regarding transactions and material and equipment acceptance procedures. On one hand, buyer needs to ensure delivery on time, right amount of quantity and with desired quality as described in request for proposal, on the other hand, seller needs to ensure the amount of money is transferred on time and with the negotiated amount. Since it is not easy to create full trust between two parties, both tend to trust a third-party involvement like banks or notaries.

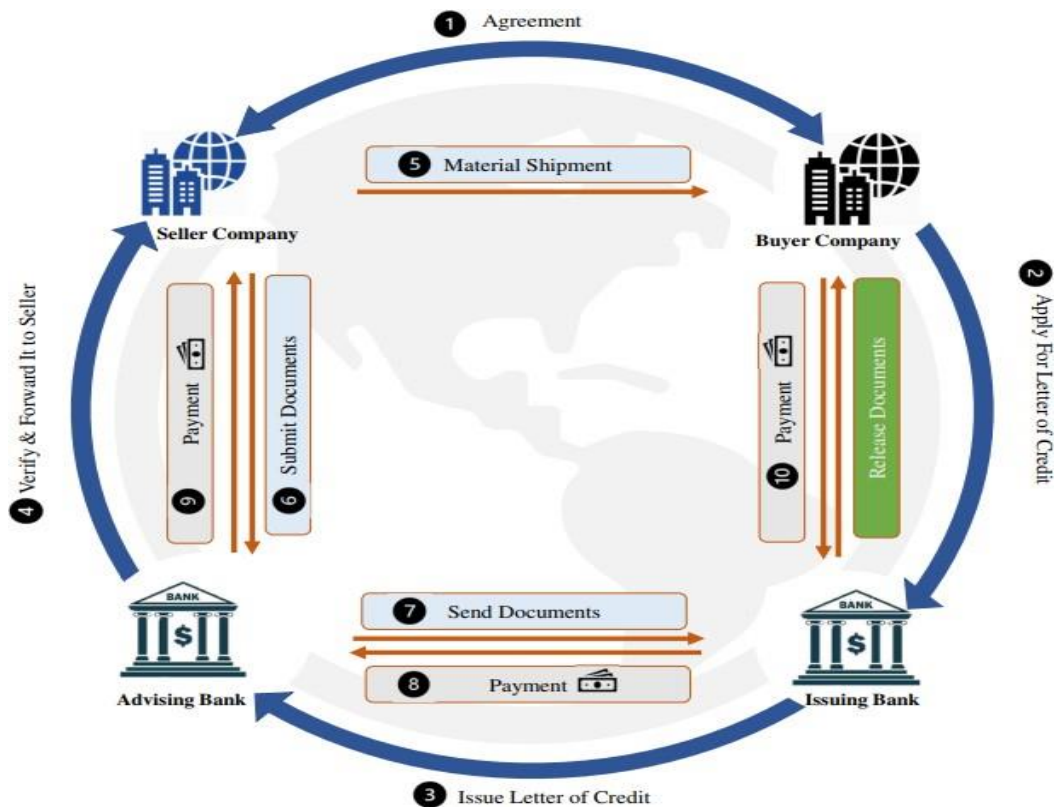
Banks issue special kind of loans to the applicants called Letter of Credit (L/C) to build trust between seller and buyer. It has been an effective way of securing buyers' and sellers' interests in construction business for decades particularly between international stakeholders. It is a commitment by a bank to ensure that a predetermined amount of money will be paid for the account of bank's customer. This payment is made after the documents are obtained and accepted in accordance to L/C requirements. Considered as a bank loan, L/C guarantees the seller's payment and ensures buying action is completed in accordance to L/C requirements. L/C is an effective way of minimizing payment risks in trades, however, it has three major limitations. First, due to the long and cumbersome process and high fees of banks (Li, 2021) it adds extra cost to procurement process. Second, since L/C is considered as a bank loan, buyer's credit limit is used to obtain it (Effiom & Edet, 2018). Third, L/C transaction authorizations is done based on documents only and there is no physical control over material delivery.

Recent advancements in smart contracts can propose number of solutions for aforementioned drawbacks of traditional L/C. Since a third-party involvement is not required in smart contracts, contractual agreement can be automated and costs can be reduced. In addition to automation, adhered characteristics of smart contracts like transparency and immutability could increase its usage in international trading. Moreover, physical control and delivery verification could be possible with smart devices. Therefore, in this paper, a smart contract framework is proposed as an alternative method for L/C use in material and equipment procurement in construction. Framework is configured to make physical control over delivery and the verification of delivery can be done using blockchain network.

This paper is organized as follows: In section two, L/C and its applications in the construction industry are discussed. Smart contracts, their working mechanism and applications are given in section three. Fourth section includes proposed framework and it is explained together with its potential contributions to traditional L/C. Finally, concluding remarks are made for a more effective material procurement in construction with smart contracts.

## 2. Letter of Credit

In construction procurement, most often seller and buyer are geographically dispersed and have not been involved a commercial relationship before. Therefore, in order to build trust between seller and buyer traditional L/C usage is a very common practice. L/C serves as a document proof of transaction guarantee and minimizes payment risks of both parties. However, material and equipment delivery verification are based on documents only. Traditional L/C process includes several steps. As it can be summarized from Figure 1, this process depends heavily on documents and heavy communication between banks, seller and buyer.



**Fig. 1. Letter of Credit Flow in Material Procurement**

In order to start material and equipment procurement process, first, buyer and seller makes an agreement. This agreement includes type of procurement item, quality standards, delivery schedule, payment details and any other technical issue related to item itself. Buyer then applies to an issue bank in order to start L/C procedures. Seller also uses his representative bank as an advising bank throughout the whole process. Issuing bank applies to the advising

bank together with necessary documents for the delivery process and advising bank verifies the related documents and forwards it to the seller. Seller then applies to the advising bank in order to start payment process at the item delivery. Documents are sent to the Issuing bank and the bank makes the necessary document investigation and verifies the delivery. After the verification which is based on documents only, issuing bank sends payment to the advising bank. Finally, advising bank makes the required amount of payment to the seller.

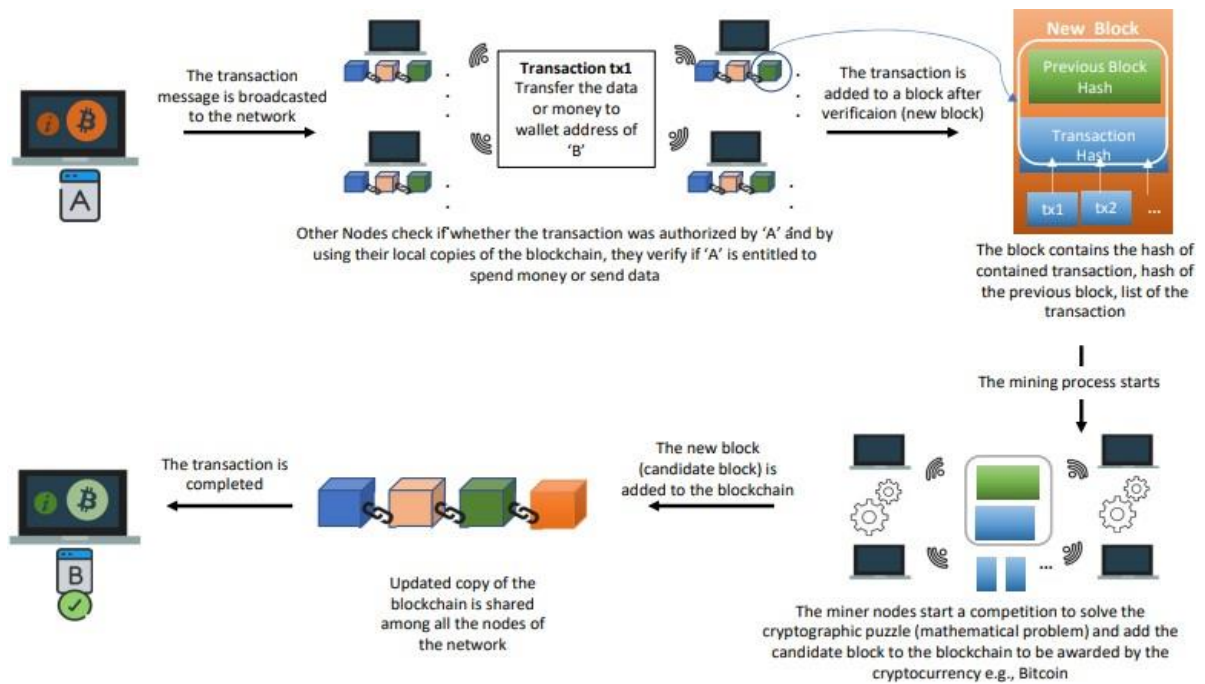
### **3. Smart Contracts and Blockchain**

The term smart contracts first used by Szabo (1996). Smart contracts are simply agreements made between parties of contract using a code executed in a decentralized blockchain. Blockchain serve as a decentralized community-based data management system where information flow is traceable (Anuradha, 2017). As new data entered to the blockchain, a new block is created to store the information. Each block contains three basic information: data itself, hash and hash of the previous block. Hash of each block uniquely identifies the block among others. After the creation of new blocks, they are chained to the previous blocks and information is stored in a chronological order together with cryptography. Different type of data can be stored in blocks such as transaction data. It is decentralized due the fact that no single person or single group is in charge of the system. One of the strongest features of blockchain is immutability, which defines that data is recorded in an irreversible way.

The transaction process in a blockchain can be summarized with Figure 2. As a first step user requests a transaction and transaction message is sent to the blockchain network. The transaction request is authenticated by the cryptographic keys, Public and private key and it is broadcasted throughout the whole blockchain network. Participants of the blockchain consensus check whether the transaction request is valid and if the user is entitled to spend money. The money is transferred to the wallet address of receiver and the transaction is added as a new block once the transaction is approved by the participants of the blockchain consensus. Newly created block is broadcasted to the other participants of blockchain consensus to validate the transaction. In a decentralized blockchain consensus is achieved by consensus protocols which mainly consist of Proof-of-Work or Proof-of Stake protocols (Nofer, Gomber, Hinz, & Schiereck, 2017). The smart contracts are based on blockchain 2.0 (Aggarwal & Kumar, 2021), can be automatically executed by consensus mechanism in the blockchain which enable to run a coded agreement between parties and can serve as a trusted party without physical involvement of a third party.

### **4. Literature Review**

Applications of smart contract in construction industry is gaining considerable attention in recent years. Since Cardeira (2015) highlighted the potentials of smart contracting in construction, various frameworks and applications proposed from information management in construction (Zhang, 2021) to the quality control (Wu, 2021). However, contractual payment issues found to be the focus of many researches in construction due the the fact that main source of disputes are contracts. An expert panel of construction industry stakeholders listed as smart contracts and novel applications as the highest potential area in order to improve efficiency of payments (Nanayakkara, 2021). Traditional contracting and smart contracting differences are highlighted by Ahmadisheyksarmast and Sonmez (2018) and concluded that smart contracting has high potential to reduce disputes between stakeholders. It is also stated that letter of credit usage in construction is a common problem and smart contracts could be a solution to the problem. Chang et al. (2019) investigated the use of letter of credit in international trades and prospects to facilitate an information flow based on blockchain based smart contracts were discussed together with a conceptual design of an international trade system. Problems related to the proposed system discussed security as the main problem. Kumar and Nerurkar (2020) discussed potentials and problems related to blockchain together with cloud technologies and proposed a secured smart contract framework in a permissioned blockchain. However, to the best of our knowledge this study is the first study which directly focuses on letter of credit use in construction procurement only and proposes an applicable framework with IOT devices which makes it possible to automatically control material and equipment delivery on site.

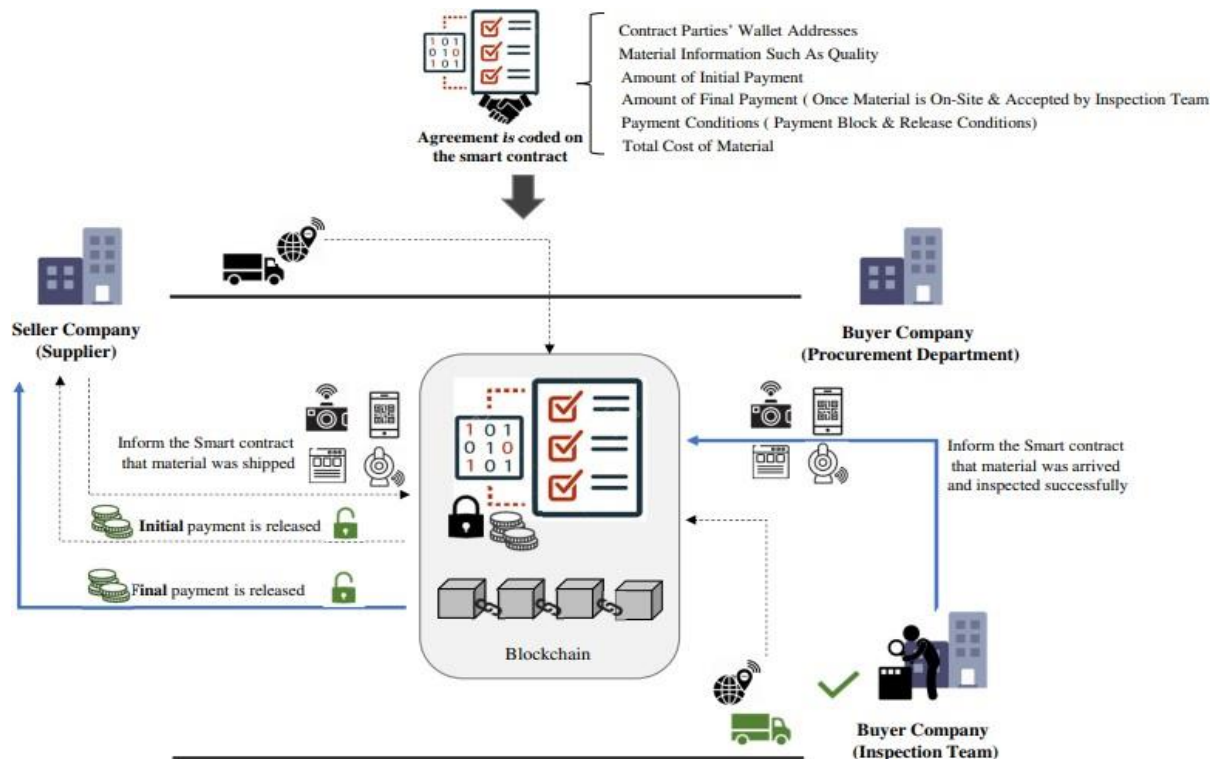


**Fig. 2. Transaction in a Blockchain Network**

## 5. Smart Contract Based L/C Framework

The proposed framework is defined to ensure the payments for material and equipment supply of construction procurement domain through smart contracts. As demonstrated in Figure 3, the buyer company and the supplier first make an agreement and then the agreed contractual terms are written as a code through smart contract which is run on the blockchain. As in most construction projects, payments of material are made in two stages, initial payment is made once the material order is submitted and final payment is made once the material is on site and inspected successfully. The suggested framework enables automated payment as well as it records and stores the process information on a secure, transparent, and trustworthy blockchain network.

In proposed framework, the agreement terms of payment are defined as code in the smart contract. The smart contract enables the payment to be blocked in the contract and trigger automatically once the specified conditions met (Ahmadisheykhsarmast & Sonmez, 2020). Hence, payment is embedded in the smart contract. Transparency of smart contract allows participants of contracts to assure that payable amount is blocked in the system in such a way that no parties could access the money till the contract conditions are satisfied. Participants' wallet addresses besides initial and final payment amount are also defined in contract drafting stage. Finally, the smart contract is deployed on a blockchain supporting blockchain Ethereum.



**Fig. 3. Proposed Smart Contract Based L/C System Framework**

At the first stage of proposed framework, the supplier organization informs the buyer company as the material or equipment is ordered away through the smart contract. The interaction of the parties with the smart contract could be provided by a user interface or IoT devices such as smart sensors or QR codes. Once the smart contract notifies the shipment, the initial payment is deducted from the blocked amount and transferred to supplier's wallet address. The real time shipment status could be provided by the GPS data stored in the blockchain. At the time of delivery of items on construction site, the quality standards, which were drafted in contract in smart contract stage, are verified by the buyer company. To finalize the final payment for the delivered items, The procedure requires buyer's confirmation. So, the smart contract deduces the final amount from the blocked amount and triggers into the suppliers' wallet address once the buyer notifies the smart contract about item verification.

## 6. Discussion

Applying the smart contract technology in procurement phase promises a significant potential to accelerate the process and reduce the cost substantially. Also, the payments are assured since the smart contract locks up the agreed amount and releases automatically based on the preset conditions. Different from third party involvement and required fees, smart contract framework do not include any extra cost since all the preset clauses are executed by the smart contract automatically. Hence, involvement of the intermediaries to contract execution and payment transaction are minimized. Furthermore, all the information during the process regarding the transactions, operations, real time status of material, and data provided by IoT devices are stored in the blockchain and distributed throughout the contract participants in the secure blockchain network. Due to the fact that blockchain environment is immutable, no data is lost or modified. Hence, the disputes, payment withheld, and ambiguities among the parties could be significantly reduced.

There are various blockchain platforms which support the smart contracts development. Ethereum is one of the common blockchain network with the largest market cap that enables smart contract application. Ethereum is a digital asset and its tradable. One possible critic for the proposed approach may come from the volatility of cryptocurrencies like Ethereum. Due to the increased demand from investors across the world, prices of cryptocurrencies could change from day to day. Ethereum prices for example, grew over %10.000 between the years 2016 to 2021. Considering the fact that construction procurement could take months, both supplier and buyer may hesitate to apply the framework because of the fluctuations. Nevertheless, there are stable cryptocurrencies to hedge the price fluctuations stable coins like Dai or USDC which could be selected as currency of the platform. Both USDC and Dai is aimed to fix 1 unit of cryptocurrency to be equal to 1 U.S. dollar which makes it very suitable to use. Both currencies also work with smart contracts. Therefore, volatility problem could be eliminated in order to create a more efficient framework based on smart contracts for construction procurement. Another possible critic may come from the fact that construction sector cannot adopt new technologies easily. Since smart contracts are very new and not commonly used, both supplier and buyer may hesitate to use this technology. However, there are various applications of smart contracts and use of blockchain network is pervading. If the proposed framework can be proved as an efficient mechanism and advantages can be understood, people would choose to work with this system.

## 7. Conclusion

Smart contracts promise significant improvement to the traditional L/C applications in construction procurement. Lack of trust between buyers and supplies during international trades can be surpassed using smart contracts, which will ensure a smoother procurement process without any extra fee due to the third-party involvement. Moreover, physical control over delivered items is possible with IOT devices, which significantly reduces the risk of buyer and makes procurement more reliable. In this paper, a framework is discussed in order to show that smart contracts can be used with IOT devices in order to improve the procurement process. At first glance, volatility seems are very important concern for the use of smart contracts. However, as stable blockchain networks arise, this problem automatically diverges. The diffusion of new technology is the biggest challenge against the use of smart contracts in construction. As applications related to smart contracts populate, advantages will appear and construction practitioners would learn from it, which ultimately would make it possible to use this new technology in international trades more often.

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