Exploring blockchain technology in international trade

Business process re-engineering for letter of credit

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Abstract

Purpose – The purpose of this paper is to explore the applicability of blockchain technology in international trade process from a perspective of letter of credit payment.

Design/methodology/approach – A blockchain-based re-engineering process is designed by employing the blockchain and its affiliated smart contract technology to harvest the benefits of distributed ledger and distributed business workflow automation.

Findings – Comparative analysis and feasibility study were conducted to identify and validate the prospects, in terms of facilitating process flow and enhancing overall trade performance, of the proposed blockchain-based international trade process model.

Practical implications – Traditional trade processes suffer from a great number of issues about intermediaries, information latency and trust, which, in turn, hinder overall process efficiency. The emerging blockchain technology may have potentials to mitigate those issues by revolutionizing business processes across enterprise borders in various industries.

Originality/value – This study contributes to the conceptual design of a blockchain- and smart-contract-based process along with a provision of practical case in business process re-engineering. Further endeavors devoted to blockchain research and application across different sectors are suggested to reach better performance of business process operations.

Keywords International trade, Blockchain, Letter of credit, Smart contract, Distributed ledger technology, Business process re-engineering

Paper type Research paper

1. Introduction

With the rapid development of the internet, many industries are forced to reform in terms of organizational behavior, business process, managerial strategy and technology adoption (Wong and Chin, 2007). The overall business process may have been improved to a more efficient level through suitable adoption of innovative technologies (Popovič *et al.*, 2019). However, one of the major issues in industries is how to combine existing business process with emerging technologies (Chang *et al.*, 2019). For example, past international trade is greatly hindered by opaque information and subjected to tedious confirmations on traceability of goods, cash and information flows. The advancement of the internet results in the emergence of e-commerce and the internet-based global trade while related manipulations on information are still confined to transmission delays which greatly reduce the performance of international trade processes.

Among those unresolved issues, trust between trading partners and process transparency have been highly stressed, thus greatly affecting the efficiency of payment and the overall trade processes. Letter of credit (L/C), traditionally considered as a rather secure and effective manner among a number of payment methods in international trade transactions, has been used to serve as the building block of trust (Clark, 2014). However, confirmations on L/C

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documents and logistics-related information during payment process have increased the inconvenience of business operations, consequently lowering the usage level of L/C.

Nowadays, international trade can take advantage of information and cyber technology to provide all participating companies and individuals with convenience and equal opportunity for transaction. Blockchain, serving as a distributed ledger (or database) for recording transaction-related information, is believed to have potentials for improving business process progressing by virtue of its immutable, time-stamped, secured and decentralized consensus features (Swan, 2015). Its "trustless" and yet secured network environment may be established via collaborative operations of participating parties, such as transaction verifications and validations (Zamani and Giaglis, 2018). Its affiliated technology, smart contract, is able to facilitate process automation on blockchain-based environment through preset agreement on contract terms (Szabo, 1996; Zamani and Giaglis, 2018). This paper explores the potential of blockchain and smart contract in improving traditional L/C payment with traceability. The pursuit of decreasing intermediation along with the mitigation of transaction time and cost may bring different thinking on coping with international trade processes. With a re-engineered and integrated method, this study contributes to the prototype development and performance improvement in renovating the transaction process of international trade.

Following this introduction, a literature review is provided to help comprehend drawbacks and pain points over existing L/C payment process along with the promising features that blockchain may present. Afterwards, a new L/C trading process based on blockchain and smart contract is proposed with use case and flow process details elaborated in design and specifications. The feasibility of the proposed model is analyzed along with a comparative discussion against incumbent processes. Finally, the suggestions of future study are made after concluding remarks are presented.

2. Literature review

2.1 Traditional L/C payment process

Generally, L/C in international trade serves as a documentary proof of trust among trading participants. Payment is often made when L/C clauses are met. Through the presentation of a number of logistics-related documents, the ownership of goods or payment could be transferred among trading counterparties. Compared to its credit proof, L/C suffers issues from higher cost, requirement of issuance and malicious alterations.

Multiple participants involved in international trade have caused difficulties in communication and coordination which result in high cost and bad user experience. Among them, the transmission of document and information between process participants has limited the adoption of L/C even though it provides a better foundation of trust. This could be explained by five root causes: increasing intra-trade between parent company and subsidiaries, shorter product lifecycle, rising bargaining power due to globalization, higher issuing margin (guarantee deposit), and issues resulting from document transmission (Kant, 2016). According to Clark (2014), issues including poor user experience, rising trade cost and restrictive regulations may hinder international trade, and they are described as follows.

2.1.1 Poor user experience. Poor user experiences in B2B trades exist among parties such as banks, importers/exporters and carriers. These experiences not only result from complicated coordination across multiple players (negotiating banks, advising banks, importers/exporters, carriers and insurance companies) in L/C payment, but also come from tedious paperwork, time consuming and opaque document flow, and high uncertainties during transactions. Although L/C is prepared for liability, there are still concerns from the course of shipment subjecting to damage or piracy (Guo and Liang, 2016).

2.1.2 Ever rising trade cost. For importers, the expense involving huge capital and good trading records to apply for L/C is high. For banks, they have to bear risk on cash advances for importers. In addition, prior audit before issuance and huge human resource costs even decrease banks' willingness to provide services (Brunner *et al.*, 2017).

2.1.3 Regulations and restrictions between countries. Regional risk concerns (war, poverty, disease, malicious inflation, etc.) and trading regulations (required by the know-your-customer and anti-money laundering policies) render international trade custody stricter and make it difficult for international trade (Buterin, 2014).

With the aforementioned issues in using L/C, the adoption of L/C in international trade is still commonly practiced. Table I summarizes issues (pros and cons) of using L/C in international trade, from the perspectives of major participants.

2.2 Blockchain

Blockchain is the underpinning technology of Bitcoin, serving as decentralized database which utilizes cryptography to generate a series of related data blocks (Nakamoto, 2008). Each block contains all transaction information during specific time span and is used to generate next block and to verify the authenticity of carried information. All transaction results are broadcasted to every node on the network through a variety of verifying mechanisms, such as Proof-of-Work (PoW) by HashCash, against security attacks (Back, 2002). A cryptography technology, Merkle tree, is used to verify transaction authenticity with the conception of zero-knowledge proof to provide better reliability (Merkle, 1987). However, disadvantages such as complicated ledgering procedures also result in storage issues and consumption of computational resources. Table II shows a general overview of blockchain technology.

View from	Pros of using L/C	Cons of using L/C
Importers	1. Lower risk of non-compliance of exporters: importer may reject payment if cargoes are not delivered as requested 2. Improved finance flexibility and availability: importers with good credit enjoy preferential treatment (e.g. lower guarantee deposit) 3. Confirmed cargo delivery time: cargo delivery can be handled with timely logistic control	1. Expensive charge on L/C: compared to other payment means, the charge on issuance of L/C is higher 2. Higher barrier on issuance of L/C: it is hard for traders with poor credit to get L/C issued 3. Documentation-based (superficial) process: payment on presentation of requested documents without physical cargo inspections
Exporters	1. Advantageous financing terms from banks: help exporters increase capital agility 2. Ensuring the completion of trade deals: help exporters reduce risk of trade cancellation and confirm the fulfillment date of trade deals 3. Audited warranty for foreign exchange: help exporters ensure the capability to pay for charge with sufficient foreign exchange funds	1. Risk of malicious clauses: there may be unfair terms set by importers 2. Excuses for refusal: importers are not willing to pay even the cargo has shipped according to the contract 3. Interest expense: export bills are in the scope of cash advances. Exporters need to pay banks the cash advances and interests if refusal of payment happened 4. Fake L/C: L/C is subject to tampering or alterations
Banks	1. Profit from service charge 2. Elimination of the need for up-front cash payment 3. A more secure payment method	1. Potential cause of disruptions in transaction 2. Labor-intensive process of paper-based administration (e.g. reconciliation) 3. Risk on buyer's bank
Logistic carriers	Low risk for trade disputes	High cost for dealing with paperwork

Table I.
Pros and cons of using L/C from major trade participants' views

Advantage	Disadvantage
1. Distributed ledger: participating node has a common shared ledger of transactions 2. Transparency: transaction information and the latest transaction status are transparently available to all blockchain nodes (Gatteschi *et al.*, 2017) 3. Immutability: with Merkle tree data structure, any information verified by nodes and thus written into blockchain becomes immutable. Such recorded information can be verified to assure its integrity (confirmation of no malicious alterations) (Webster and Tavares, 1985)	1. Limited transaction speed: Bitcoin takes approximately 10 min to create one single block (Zheng *et al.*, 2017). High frequency transactions may not be available even for an improved platform like Ethereum (Eberhardt and Tai, 2017) 2. Waste of computational resources: blockchain mining scheme favors and rewards the final miner who gets the right to record transactions while many others only waste electric power in competing mining efforts 3. Security: blockchain security relies on the security of user's private key. Illicit theft and other causes (e.g. loss of key) may result in security concerns (e.g. loss of coins) (Hurlburt and Bojanova, 2014)

Table II.
General descriptions and features of blockchain

2.2.1 Types of blockchain. In terms of access control, blockchains can be divided into two categories: "permissioned" and "permissionless." Their difference is related to not only the ability nodes can read, write and submit transactions, but also the extent to which nodes may participate in the consensus process. Permissionless blockchains have no restriction on user registration and identity anonymity. In opposite, access control of a permissioned blockchain is governed by a single node (private chain) or a group of nodes (consortium chain). Users are allowed to join in permissioned chains under the premise of permission or invitation.

Various compositions and functions of participating nodes on maintaining blockchain network define different blockchain types including: public, private and consortium chains. A public chain (e.g. Bitcoin) is considered as a full disintermediated system via PoW consensus mechanism in the sense that participating nodes contribute their computational power to the system by getting reward in return (Teutsch *et al.*, 2016). Providing better privacy than the public chain, a private chain (e.g. Multichain and Hyperledger Fabric) can be controlled by a single node with an access control layer to create a highly encrypted and permissioned environment that is similar to a centralized system environment (Pilkington, 2016). Private chain, as a more restricted version of blockchain, may provide access and authority only to specific entity, normally the initiating company or organization. Consortium chain refers to the working consensus controlled by certain pre-selected nodes and these nodes comprise the preset consortium (Kang *et al.*, 2017). Consortium chain (e.g. R3) is partly decentralized as a hybrid version between public and private chains (Joshi *et al.*, 2018). Participating nodes may have authority to choose transaction details as open or private to the network. The access control is shifted to a preset group of nodes, similar to the operation of traditional board members. This type is suitable for institutional transaction and settlement. For example, consortium R3 is composed of 43 banks, and each bank runs an individual node, with exemptions of the trust issue among participants and the complicated PoW consensus mechanism (Brown, 2016). Table III shows the comparison of key features (which may affect the implementation of blockchain applications) among public, private and consortium blockchains.

2.2.2 Major issues and challenges facing blockchain applications. Blockchain technology may help improve business processes and synchronize business documents, but it suffers issues related to efficiency (transaction throughput and latency), scalability, security and privacy that still require technical solutions (Chang *et al.*, 2019). For financial services and transactions, Oh and Shong (2017) argued that while public chains are inappropriate for financial services because of efficiency, scalability, security and privacy issues, consortium and private chains may harvest more blockchain benefits such as cost reduction without losing the needed control of authority and security principles. For ameliorating issues relating to service efficiency, privacy and security, it is suggested to adopt permissioned private or consortium chains in various contexts (Brown, 2016; Joshi *et al.*, 2018; Zheng *et al.*, 2018). In addition to privacy and security, consortium chain can also mitigate the slow transaction speed and network scalability problems of public chain (Oh and Shong, 2017), so our research adopts the consortium chain for the design and implementation of blockchain applications.

2.3 Smart contract

Smart contract is a programmable protocol capable of automatically executing, verifying and updating process status via coding. The concept of smart contract was coined by Szabo (1996) and referred as a series of digital agreement of promise, including terms and agreements made by participants in the contract. Smart contract may be designed with preset coding conditions related to business process. Generally, business process procedures executed via smart contracts are set to be triggered by specific entity, event or time (Zamani and Giaglis, 2018; Chang *et al.*, 2019). Table IV shows the difference between traditional trade contract and Ethereum smart contract (GitHub Wiki, 2018).

A smart contract could be automatically executed by preset conditions triggered by specific entity, event, timing, etc., while traditional contract would not initiate subsequent activities until the receipt of paper contract by mail delivery. In this sense, shipment delays due to documentary delivery usually happen, whereas smart contract may update process status and boost the process within seconds or minutes without distance concerns (Eberhardt and Tai, 2017). Moreover, in terms of data security, traditional paper-type contract subjects to artificial tampering and manipulations which cause disputes or arguments. Based on immutable characteristic and distributed verification of blockchain platform, Ethereum smart contract is more likely to be tamper-proof against

Table III. Comparison among public, private and consortium blockchains

Key feature	Public blockchain	Private blockchain	Consortium blockchain
Efficiency	Low	High	Medium
Performance	Low	High	Medium
Privacy	Low	High	Medium
Operations cost	Low	High	Medium
Centralization	No	Yes	Partial
Consensus determinants	All miners (permissionless)	One node (organization)	Selected set of nodes
Read permission	All nodes (public)	Restricted/Controlled	Restricted/Controlled
Immutability	Hard to be tampered	Could be tampered	Could be tampered

Table IV. Comparison between Ethereum smart contract and traditional trade contract

	Ethereum smart contract	Traditional trade contract
Execution method (mode)	Automatic execution by preset conditional triggers specified by specific entity, event or time	Execution followed by manual examination and judgment of contract terms and agreements
Execution speed	Within few seconds or minutes	Depending on distance (usually for in a couple of days)
Data security	Tamper-proof (Antonopoulos, 2014)	Vulnerable to tampering, damage and easy to cause disputes (Roberto, 2018)

malicious intentions. When trade dispute occurs, arbitration by international chamber of commerce is requested. If the major disputes stem from tampered documents and inauthenticity, it would result in trade postpone and cost increase. In contrast, smart contracts record every single change chronically in the distributed ledger which may greatly decrease such disputes. Indeed, complicated L/C procedures in processing traditional L/C not only make it difficult to decrease trading cost but cause a number of trade disputes due to lack of trust. Compared with traditional contract, smart contract has potentials to reduce tedious procedures and inconvenience resulting from traditional L/C procedures.

To implement smart-contract-enabled blockchain applications and harvest aforementioned benefits of smart contract, businesses have to cope with five clusters of barriers including: adoption barriers, mindset barriers, risk barriers, nascent barriers and infrastructure barriers (Zamani and Giaglis, 2018). That is, there exist several smart contract-specific adoption, mindset, risk, nascent and infrastructure barriers which may negatively affect the implementation of desired blockchain applications. Actually, businesses have to identify and deal with influential factors suggested by Zamani and Giaglis (2018) for controlling and ameliorating those barriers to increase the odds of successfully implementing desired smart-contract-enabled blockchain applications.

3. Framework and overview of the proposed process

Blockchain-based international trade processes are proposed to establish an operational environment with distributed governance for value creation. The proposed framework is to facilitate business processes conducted by five major international trade participants: importers, exporters, negotiating banks, advising banks and shippers.

3.1 Overviews of existing international trade process

Generally, an international trade starts from the establishment of business order between traders and subsequently initiates related activities with banks and logistic service providers. A typical illustration of L/C process in international trade transactions is shown in Figure 1.

In international trade processes, the business interactions among five major trade players are elaborated in three process flows described as follows (see Figure 2).

3.1.1 Document flow. Documents, which carrying various information for claiming ownership of assets, formulate the execution of business processes. From quotation/order between traders, L/C among banks, to presentation documents (bill of lading (B/L), mate's receipt (M/R) and delivery order) between traders and shippers, verified/accredited documents provide trust and ownership proof across international trade operations.

3.1.2 Cash flow. Cash flow accompanies with transactional documents to offer value exchange among players. L/C in this study is functioned as a payment media once presented to stakeholders. Generally, buyer/importer makes payment to seller/exporter with the aid of cash transfer between advising banks and issuing banks.

3.1.3 Logistic flow. Logistic flow refers to the process from seller to buyer, including exporter packing by contract conditions, shipment from export country to import country after export customs clearance and final cargo claims by importer.

3.2 Blockchain- and smart-contract-based trading processes

This study utilizes advantageous features of blockchain and smart contract to build a distributed, shared ledger for recording transactional records. In this sense, aforementioned process flows regarding document, cash and logistics could be automatically executed upon the presentation of specific business events. In this section, the architectural design elements and the underlying rationale are introduced. Subsequently, the overall process is divided

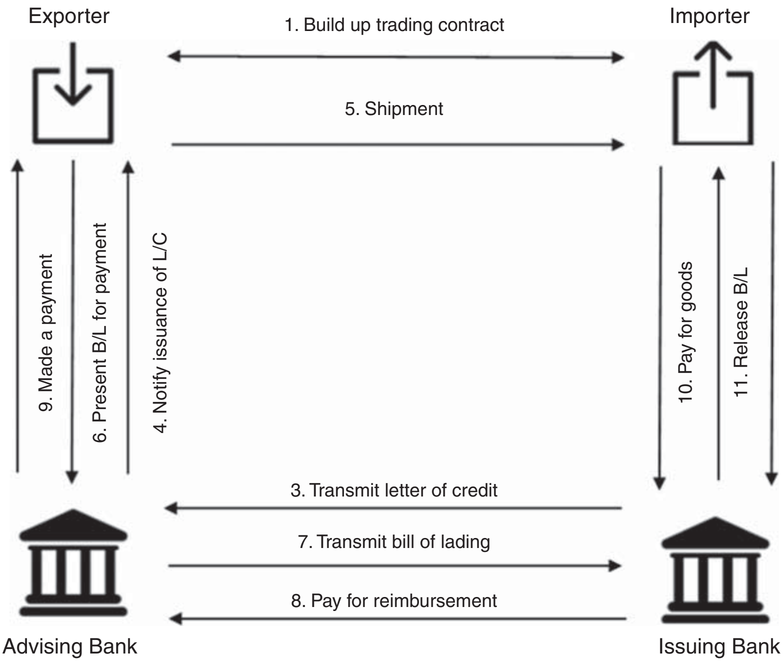


Figure 1.
L/C payment process in international trade

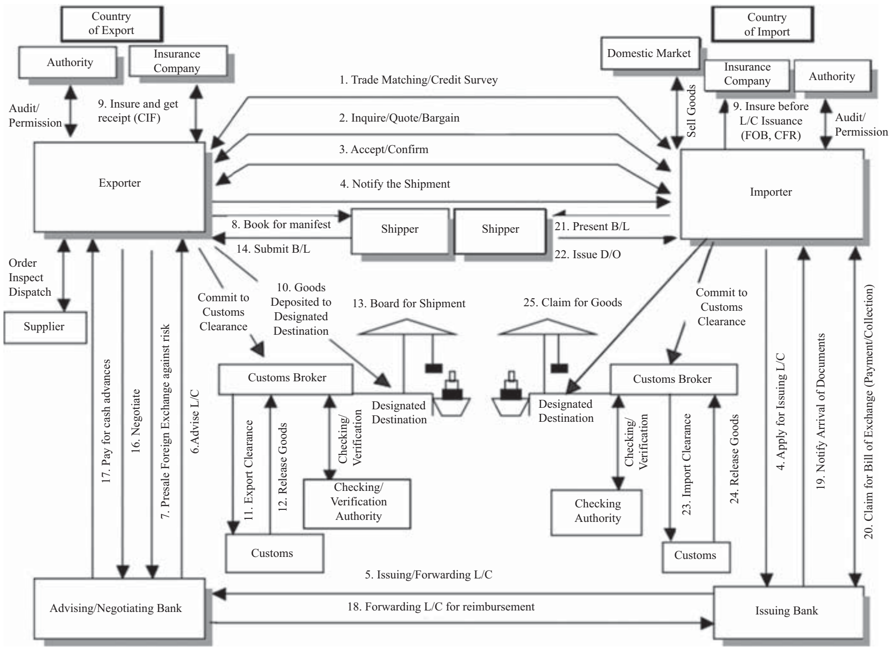


Figure 2.
Traditional international trade process

into three major steps: registration on consortium chain; order negotiation and smart contract establishment; and operational progress and trade fulfillment.

3.2.1 Architectural elements and design rationale. The proposed process, using consortium chain, focuses on the interactions among five major players in international trade. The auditing role of consortium chain is set from a bank perspective. The proposed process attempts to reform existing mechanism in terms of identity management, information update and automatic process execution upon programmed contract terms. A re-engineered international trade process dominated by specific process events would be able to integrate original functions and roles to provide better process efficiency. In current process, banks serve as one of the major service providers. Major services focus on financing for traders and credit assurance, etc. Additionally, with credit records and rights available for auditing, banks are functioning as auditor and initiator in consortium chain.

In the proposed system, we design three smart contracts which are responsible for trading, L/C and logistic processes. These contracts are introduced in terms of their functions, usages and design rationale described as follows.

3.2.1.1 Trading smart contract (TSC). TSC replaces the role of traditional paper-based contract for confirming sales, by specifying and recording every terms and conditions along with the time-specific events happening in trading processes. TSC helps exporters and importers timely track the progress of trades and serves as a formal record for arbitration if trade disputes occur. Moreover, it could transmit information for working with the logistics and letter of credit smart contracts (LSC and LCSC) to update process status for replacing the original B/Ls. Thus, exporters may claim the payment without presenting physical B/Ls while importers may claim goods from warehouses without traditional B/Ls.

Either exporter or importer can establish and issue TSC after needed negotiation and quotation are completed. TSC will be activated after the other trade counterparty authenticates it against its digital signature.

3.2.1.2 L/C smart contract (LCSC). LCSC is designed to replace the functions of original paper-based L/C. The content of L/C is established in accordance with trading terms and agreements. LCSC is used to update related process status and share information with TSC and logistics smart contract (LSC). It also helps negotiating banks and issuing banks track every single transaction progress, replace the function of marine B/Ls and reduce the cost and risk resulting from transmission of L/Cs and B/Ls. When an importer applies for L/C issuance and goes through the necessary audit procedures, the issuing bank will issue LCSC and formally activate it after authenticating digital signatures from the importer and the advising bank.

3.2.1.3 Logistics smart contract (LSC). LSC is designed to replace the original functions provided by logistics-related documents (including B/Ls, M/Rs and packing lists). With the trading-related conditions specified in TSC, LSC can facilitate information sharing and status update, alongside the freight tracking from shipper's database via oracle. For shippers, a less complicated document processing and a more convenient and timely track of goods are therefore attained. Status updates will be triggered by events specified by traders, banks and smart contracts.

The reason to use three smart contracts is an analogy to practical process by reflecting the relationships/interactions among major actors in trade finance activities. Smart contracts are deployed on the blockchain system to facilitate event notifications and activate corresponding processes. In an L/C process, intermediary banks bridge importers and exporters by providing funding and managing L/C activities and capitals. This rationale comes from the functional similarities in existing trade finance ecosystem. According to the criteria proposed by Wüst and Gervais (2018), consortium chain is favored in trade finance context especially for security and privacy considerations. When sales contract established, banks need to review traders' credentials for issuing credits and facilitate capital flows. The complex trade procedures mainly involve importers/exporters, banks and shippers. Shippers need to validate/notify shipping status and manage key documents (e.g. B/Ls) for transferring ownerships/assets.

Trade disputes and frictions among parties are generated due to the complex nature of trade processes. The proposed three smart contracts are coded to avert manual errors and streamline process flows among sub-systems, which are function oriented to facilitate multiple interactions between counterparties. In so doing, smart contracts are affiliated to corresponding sub-systems for fulfilling needs from trade finance participants. The consortium design can mitigate privacy issues and achieve acceptable transaction throughput. The immutable nature with proper digital signature may reduce heavy paper-based administration in legacy system while providing sufficient transparency throughout the blockchain-based trade processes. Such blockchain platform may harvest benefits for all trade finance stakeholders and increase participation to leverage network effect.

The overall relationships and interaction scenarios among those three sub-systems facilitated by TSC, LCSC and LSC are illustrated in Figure 3. More detailed descriptions of the needed functions with corresponding scenarios and processes are covered in the next three subsections.

3.2.2 Registration on consortium chain. Traders must join the consortium chain (by applying for consortium memberships) prior to the overall trading processes. A permissioned consortium chain comprises banks, insurance companies, shippers and traders. Traders are requested to provide essential information (including business name, capital, financial reports, credit records, etc.) to the administrators (consortium banks), for validating and approving traders' membership applications. The reasoning of this audit mechanism comes from the consideration that certain credit reputation and capital loan are needed to avoid fake trades

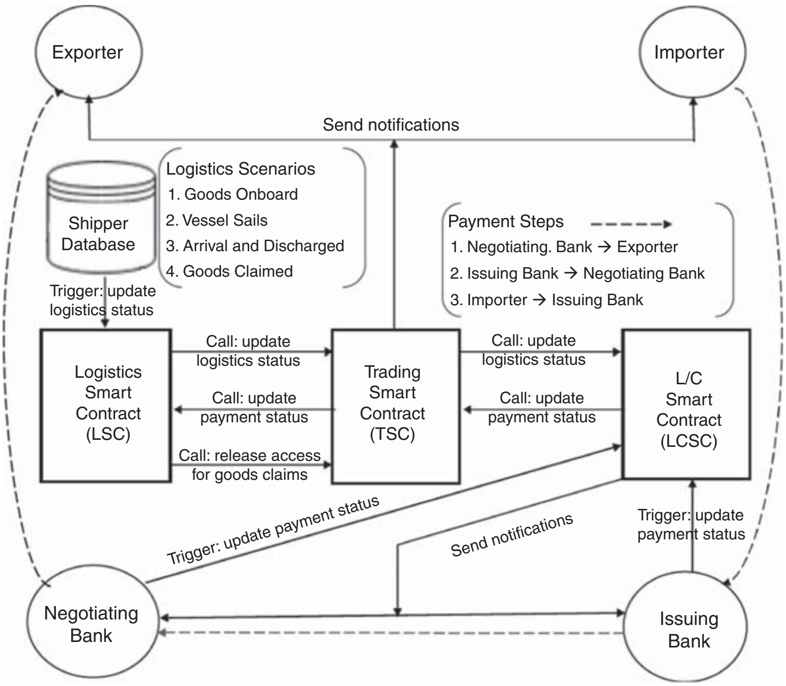


Figure 3.
Overall relationships and interaction scenarios among TSC, LCSC and LSC

manipulated by malicious players. After the registration, the information provided by a company can be referenced for credit evaluation and subsequently for mitigating the trading frictions and uncertainties involving the company.

3.2.3 Order negotiation and smart contract establishment. Traders may search for counterparties to make inquiry and request for quotations. When a deal is made, a TSC is established by either side of the trading counterparties. TSC is thus activated by the other counterparty after the digital signature on TSC is authenticated. TSC covers eight major trading conditions regarding transaction, quality, quantity, price, payment, shipment, package and insurance.

Importer applies for L/C from issuing bank to create a LCSC with respect to the corresponding TSC. This LCSC is activated after authentication of digital signatures from negotiating bank and importer. These two smart contracts are able to communicate with each other and access updated information. Exporter could start booking shipment with shippers and a LSC is issued by shippers and activated after exporter's authentication. The content of this LSC depends upon TSC which specifies manifest details, date of shipment, and ports of export and import, and in addition, the information in TSC is correspondingly updated.

3.2.4 Operational progress and trade fulfillment. Logistic traceability in international trade is highly related to the execution of trade processes. A blockchain- and smart-contract-based process could handle the coordination and information flows according to prescribed contract conditions. For example, different scenarios related to logistics state change are able to proceed with the aid of proposed framework. Figure 4 presents the four major logistic scenarios in international trade: goods onboard, vessel on sail, goods arrival/discharge and goods claimed. When each scenario takes place, shipper updates related information in its database. LSC is triggered to update corresponding information on TSC, and TSC, in turn, updates related information on LCSC. These automated series of

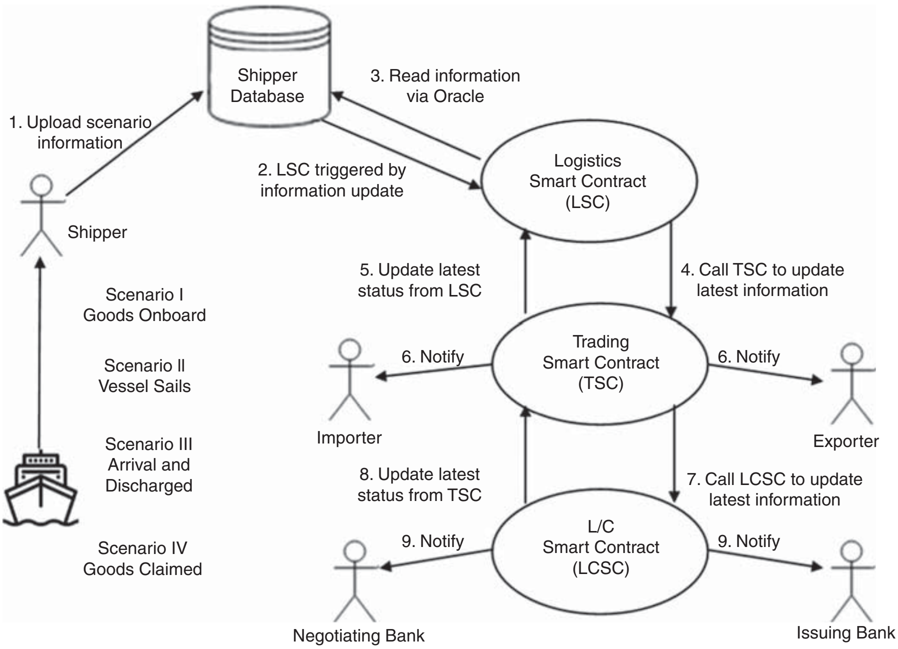
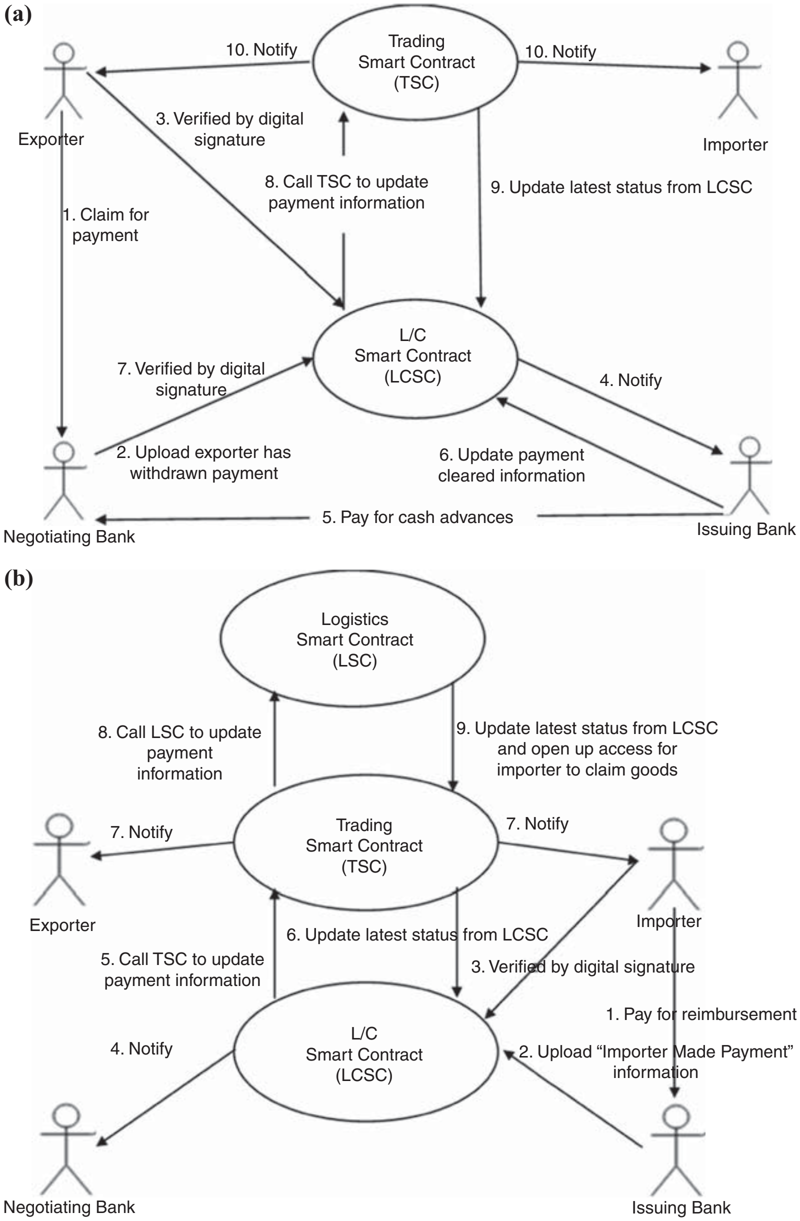


Figure 4.
Overview of proposed process: four typical scenarios correlated with logistic events

activities would change the status on specific smart contracts and initiate corresponding notifications to trade stakeholders.

As for the cash flow, payment is made between importer and exporter through similar manipulations between participating parties. Figure 5 shows the payment process from the



Notes: (a) Payment process from the perspective of exporter; (b) payment process from the perspective of importer

Figure 5.
Blockchain- and smart contract-based L/C payment process from the perspective of exporter and importer

perspectives of exporter and importer, respectively. The interactions among LSC, TSC and LCSC not only facilitate the business operations among trade players but achieve the desired benefit of using distributed ledger technology.

3.3 Smart contract deployment and trigger conditions

Smart contracts are programmed protocols deployed on blockchain platform (i.e. Ethereum in this study). They interact among one another according to the prescribed business processes and triggering events. Generally, an international trade starts from the establishment of business order between traders, and subsequently initiates related activities with banks and logistics service providers. Contracts are designed to interact with one another through functional calls depending on various operational demands in predefined trade process flows. When sales order together with contracts is established, trading information can be accessed from needed databases (managed by various trade participants) via oracles. Necessary process information controlling interactive operations among smart contracts is carried and transmitted by invoking functional codes. In addition, contracts deployed in blockchain environment are able to send notifications about the state/event changes to those previously registered participants in trade process, so that registered participants could track trade process flows in real time. Basically, four typical logistics-related scenarios (shown in Figure 4) are defined in a way to correspondingly update shipper database. A state change refers to an event in computational language which triggers LSC to proceed with subsequent procedures such as calling TSC and LCSC to notify other four players, updating trade states to represent the latest status on smart contracts, etc.

In the L/C payment process, exporter claims for payment, and importer corresponds through a series of contract interactions. The latest payment status is timely updated among traders and banks with authorized digital signatures. Moreover, real-time monitoring on traceability is achieved via automatic notification submitted/requested by smart contracts initiated by and associated with relevant trade participants. When all payment and settlement are accomplished, TSC invokes LSC to grant importer with the right to claim for goods. This smart-contract-enabled event-driven scheme is incorporated into practical trade flows by utilizing distributed ledger as an interaction and facilitating tool. In contrast to a centralized model, this proposed framework ameliorates information asymmetry and process hand-offs, facilitates process flows by blockchain technology, and realizes decentralized governance for achieving the goal of re-engineering and improving international trade process.

4. Implementation

This study utilizes object-oriented analysis (OOA) to extract system requirements from various users' perspectives, and subsequently adopts unified modeling language (UML) to specify use cases and system processes which define what the system is functionally required to do. The structure of proposed system is shown in Figure 6, and the use case diagrams (for specifying the system functions and the interactions among participants and sub-systems) are shown in Figure 7.

The proposed system is built upon participants' functional needs and correlated to analysis of use case diagrams. Use case diagrams assist in defining individual actor's role and its key activities. Use cases are generated in the basis of expected functions. Actors receive services from use cases and use cases represent consequential events generated by users' interactions. With well-defined actors and use cases, we can implement classes and generate codes. Our object-oriented development processes are detailed as follows.

4.1 Use case diagrams

The use case diagram of the implemented blockchain-based system is shown in Figure 7, which describes the functional requirements and usage scenarios of the trade service. In the proposed trade system, four (Member Information, LCSC, LSC and TSC) sub-systems and five major players (importers, exporters, shippers, negotiating and advising banks) are involved. The five major players in international trade processes play different roles with their corresponding functions. For example, negotiating and advising banks need to login, audit and evaluate if traders are qualified to join the consortium trading system. In addition, negotiating bank needs to access TSC to establish, modify and verify importer-related information. For importers and exporters, functions such as login and inquiry upon credit evaluation of other traders are necessary for establishing TSC. In addition, exporters need to establish and modify LSC while importers need to build up LCSC to update and manage the latest status of trade process. At last, shippers need to access TSC to build up logistics-related information in LSC, and also account for maintaining LSC with needed update functions.

The interactions among four sub-systems, such as data transmission/reception and real-time update are prescribed and orchestrated according to needed business logic and process flows in practicing trade transactions. Based on the conception of use case diagram (Cox and Phalp, 2007), the abovementioned interactions from perspectives of various users are illustrated in the left portion of Figure 7, while the interactions of the needed three smart

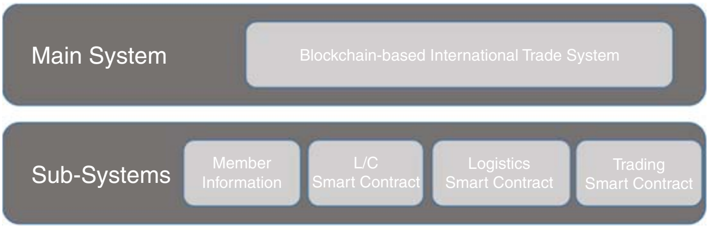


Figure 6.
Structure of the proposed blockchain-based international trade system

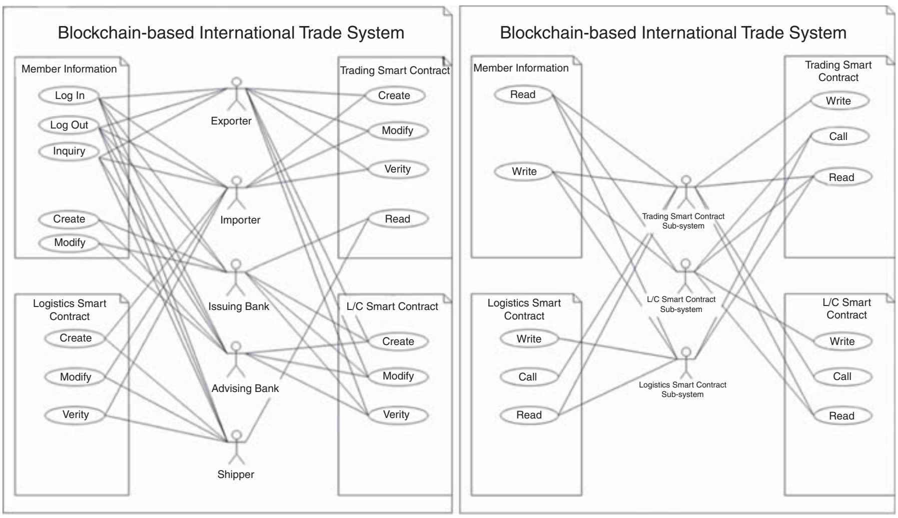


Figure 7.
Use case diagrams of the proposed system for participants and sub-systems

contracts (LCSC, LSC and TSC) are illustrated in the right portion of Figure 7. All these three smart contracts have access to membership database and are able to read and write (upload) transactional records. As shown in Figure 7, TSC needs to read and call LSC and LCSC, LCSC needs to read and call TSC, and LSC needs to interact with TSC and LCSC.

4.2 System processes and activity diagrams

After deriving the use case diagrams, we continued to design the system processes by modeling the use cases of our blockchain-based system one at a time to investigate its usage scenario, identify those trade events and interactions in each use case, and then use such events and interactions to develop the classes and define the relationships between classes in a scenario-oriented modeling approach suggested by Larman (2002). The system process for new traders (importers/exporters) to register for new accounts, and for traders with existing accounts to login the system for system services can be illustrated in an activity diagram (see Figure 8). With existing accounts, traders can log in with their passwords to access system services. New traders need to apply for memberships with needed credential information, and then banks review the submitted credentials to make decisions on issuing memberships. Approved traders will be notified with membership confirmation whereas traders with poor credit or lacking of necessary information would be requested for more supplementary information.

TSC could be established by either importers or exporters with both specified trading conditions and required digital signatures that have to be verified by counterparties of the trade. The process will terminate if it fails to pass banks' review and verification (see Figure 9).

Using the widely accepted object modeling process described in Larman (2002), we have derived class diagrams which were subsequently used to identify and develop classes. Finally, we used the normal object-oriented development methods to implement classes and generate codes for our proposed blockchain-based international trade system.

5. Discussion

5.1 Comparative analysis and research implications

We made a comparison between the traditional trade process and the blockchain-based trade process proposed in this study, and the comparison results are summarized in Table V.

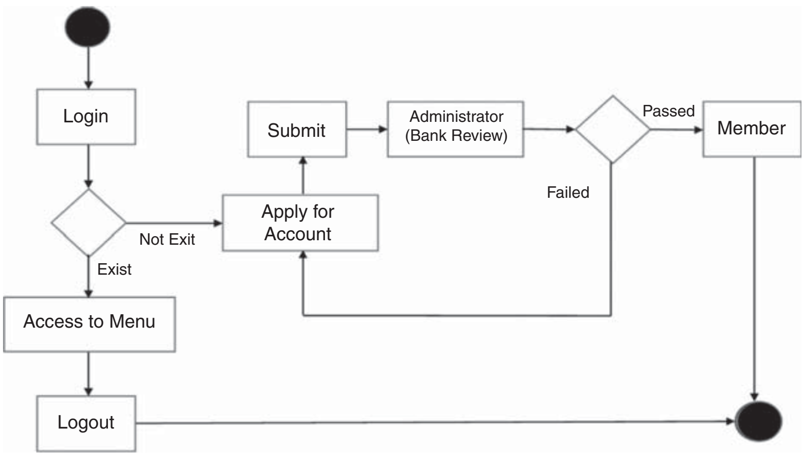


Figure 8.
Activity diagram for membership application

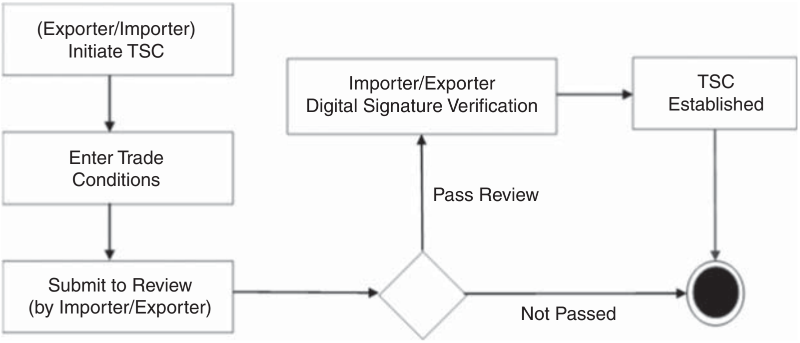


Figure 9. Activity diagram for establishing the trading smart contract

Table V. Comparison between traditional trade process and proposed trade process

Issues	Traditional trade process	Proposed trade process
Trading contract	Malicious alterations and tampers on contract terms can cause trade disputes even after contract endorsement	Contract terms are recorded on blocks and any alteration is kept on chain. This design mitigates the tampering issue
Bill(s) of lading	1. Shippers need to present bill of lading (B/L) in exchange of payment claims after cargo dispatched by exporters 2. Advising bank needs to forward B/L to negotiating bank for reimbursement. Cost rises in this scenario and depends on the distance (normally takes for days) between countries of traders 3. Importers still wait for document at times even after cargo arrival and cost rises in turn	1. No need for shippers to print out or exporters to present B/L(s) for cargo claims. Consortium identifications are the only needed proof for payment 2. Without B/L delivery, records regarding withdraws from exporters and cash advances by notifying banks are timely recorded on blockchain within minutes 3. In this sense, importers with consortium identifications could therefore claim for cargo without presentation of B/L(s)
Information transmission	Information updates rely on manual workforce, such as e-mail, messages, telegraph, etc. It takes lots of expense for coping with information transmission and confirmation	Event-driven mechanism is adopted to make trade activities automatically executed. For example, logistic traceability could be timely tracked with contract notifications. Cost for coping with information transmission and confirmation could be reduced
Credit	Credit evaluation among traders is usually committed to local trustful and trustworthy companies	A member database can be searched for an examination of credit ratings which results in a better user experience

This study contributes to the innovation of traditional international trade process. According to Rogers (1995), innovation refers to an idea which is accepted or adopted by individuals or organizations. The acceptance of an innovation could be influenced by five critical factors: relative advantage, compatibility, complexity, trialability and observability. Relative advantage refers to the goodies or pros the innovation could generate and offer. Compatibility means the coincidence between value and user's needs of new thing and past experience. Complexity is the extent innovation be easily used or understood while trialability represents the degree under a premise that innovation could be experimented. Finally, observability is considered as the extent to which the contribution of an innovation could be potentially observed or acknowledged by users. We analyze the value of the proposed blockchain-based system against these critical factors about innovation acceptance, and the analysis results are described as follows.

5.1.1 Relative advantage. Guo and Liang (2016) argued that banks are influenced by blockchain in four constructs. First, user experience, compared to incumbent procedures, could be better presented in a blockchain-based trade system, especially in the provision of a customized service. Second, in terms of efficiency, smart contract could be preset with an event-driven manner. Trade frictions could therefore be reduced among multiple participants and the speed of document transmission can be drastically improved from days to minutes (Eberhardt and Tai, 2017). Third, the security is realized through the inherent immutable characteristic of blockchain-based distributed ledger, which provides a more secure and controlled way to share knowledge and services (Zamani and Giaglis, 2018). Finally and most importantly, our proposed system can reduce the cost and risk resulting from transmission of L/C and B/L (see Table IV). In this sense, the proposed system possesses advantages against incumbent ones in terms of cost, security, customer and user experience, and efficiency.

5.1.2 Compatibility. Weber *et al.* (2016) suggested that in process re-engineering with regulations issues across different countries, the compatibility could be attained by suitable design models such as peer-to-peer or interactive modeling (Decker and Weske, 2011). The proposed system is not only designed with the aid of UML and activity diagram but built on the basis of existing L/C payment process. From process design to parameter settings, it is obvious that an enhanced efficiency is achieved by executing process flow with blockchain technology. Based on past experience and the valuable process in using original L/Cs, our re-engineering approach preserves good parts with amendments to user' pain points about L/Cs. Our blockchain-based L/C process is therefore quite compatible with the original ones.

5.1.3 Complexity. Blockchain comprises a variety of technology, including cryptography, consensus algorithm and several programmable application languages (Antonopoulos, 2014). It raises the threshold/barrier of user adoption due to the unacquaintance of underlying technological operations, whereas it is viewed as a disruptive technology for next generation followed the internet (Swan, 2015). A report from Gartner Research also predicts that blockchain will have spreading applications within 5–10 years (Panetta, 2017), implying that the complexity of using blockchain will be expectedly reduced.

5.1.4 Trialability. Many blockchain and smart contract applications have been designed and deployed in international trade. For example, IBM and Maersk cooperate on container tracking and successfully lower down the cost for document transmission to 15 percent of total cost (Groenfeldt, 2017). In September 2017, Hyundai Merchant Marine also used blockchain technology to track refrigerated containers from Busan to Chengdu in China (Yoon, 2017). Judging from the success of such trial testing and implementation of blockchain technology in global shipper and international trade industries, the trialability of proposed system is deemed as acceptable.

5.1.5 Observability. Friedlmaier *et al.* (2018) asserted that the observability of blockchain system is currently and comparatively low. The main reason is because major research participants are experts in related areas, and other researchers are yet to join blockchain research in broader application domains. With more applications emerge in our daily life, related reports and publications would be released for us to reference or follow. For example, IBM published a book for blockchain novices, hoping that the general public will start to get in touch with this emerging technology (Laurence, 2017). Due to its advantages including lower costs, higher transparency and better user experience (see Table VI), blockchain systems and applications are going to have higher and higher observability in the near future.

Based on the afore-described analysis results, blockchain-based platform provides several benefits to participants by enhancing transparency, traceability and process automation, thereby creating relative advantage. System design based on OOA and UML modeling preserves usage patterns and averts information asymmetry, thereby ameliorating compatibility for traditional L/C users. Moreover, blockchain applications can run in a plug-and-play package/module (e.g. the modular-based IBM Hyperledger environment) for increasing ease-of-use and mitigating adoption complexity. Blockchain innovations may be better dispensed with proven successful trials. With more trial success, potential users are prone to afford the uncertainties/risks caused by blockchain innovations. Indeed, blockchain technology and applications possess high potential to reform/renovate business processes across industries (Panetta, 2017).

5.2 Additional discussions on theory, practice and implementation

5.2.1 Additional theory-based discussions. To explore the potentials of blockchain in an inter-organizational context, Treiblmaier (2018) developed a theory-based research framework by adapting various theories to investigate the impact of blockchain on business operations. Among those theories, principal agent theory (PAT) and transaction cost analysis (TCA) are considered of great interest by our research, particularly suitable for discussing relevant issues and elaborating implications to guide the research and practice of blockchain applications.

PAT concerns about the interaction and relationship between the principal and the agent in the industry, and deals with how the principal selects a right agent by considering the important issue of trust. PAT focuses on contract design/execution/supervision, how to control the agent by contract and discussion of contract efficiency. In this regard, the proposed blockchain-based system may ameliorate the information asymmetry problem between the principal and the agent, and help the principal in design/execution/supervision of trade contract with better control on the agent (Treiblmaier, 2018). That is, the trade contract would be more efficiently and more effectively monitored and executed, and consequently the proposed system can help enhance trade contract efficiency and harmonize conflicting goals of various trade participants.

TCA can deal with sourcing issues and investigate how blockchain optimizes transaction costs and reduces transaction risks, by focusing on governance efficiency from the selection of governance structures and the change of organizational boundaries (Treiblmaier, 2018). In this regard, the proposed blockchain-based L/C system can not only replace the function of paper-based documents and reduce the cost resulting from transmission and verification of documents (e.g. L/C and B/L), but also decrease contractual costs for trade finance because transaction histories are immutably recorded on blockchain and shared among all participating nodes with no extra monetary and time expenses incurred for checking/ensuring contract validity in the future. Through improved data sharing, transaction transparency and shipment traceability, the blockchain-based system can also reduce opportunism (opportunistic behavior) from both trading parties since verifiable smart contracts are immutably recorded on the blockchain.

5.2.2 Practical evidence in industry. While blockchain applications are in their infancy stage, promising initiatives and pilot projects have been announced by pioneer enterprises. Typical trade finance examples using blockchain-based L/C system include Barclay, Maersk and HSBC (Wang *et al*., 2019). Related projects using blockchain-based B/Ls could achieve timely logistic tracking and mitigate labor-intensive paper-based processes. These industrial cases have common blockchain-enabled features for improving data sharing, transaction transparency and

Table VI. Comparisons between existing and blockchain-based international trade processes

	Traditional process	Blockchain-based process
Transaction cost	High	Low
Cost in document transmission	High	Low
Transaction transparency	Low	High
User experience	Poor	Better

shipment traceability, significantly shortening traditional processing time from weeks to hours/days. Other promising blockchain projects initiated in Daimler, Foxconn, Skuchain and OriginalTrail have also achieved diverse objectives of trade finance (Wang *et al.*, 2019).

5.2.3 Challenges and difficulties facing the implementation of blockchain applications. To mitigate technological challenges (including efficiency, scalability, security and privacy) facing the implementation of blockchain applications, Chang *et al.* (2019) suggest to explore various technological configurations of blockchain that include: blockchain platforms (including Bitcoin, Ethereum, Hyperledger, etc.), consensus protocols (including PoW, Proof-of-Stake, Byzantine Fault Tolerance, etc.), on-chain/off-chain computation and data storage, block sizes, degrees of decentralizations, etc. Research into such configuration alternatives may shed light on ameliorating the issues and challenges facing the implementation of blockchain applications.

The implementation of blockchain applications also suffers non-technological difficulties and challenges. Intermediaries of trade finance activities may be reluctant to join blockchain ventures for the fear of damaging to their revenue models (Michelman, 2017). As suggested by Clohessy and Acton (2019), technology–organization–environment (TOE) adoption factors (such as perceived benefits, organizational readiness, regulatory environment, etc.) may significantly affect the implementation of blockchain applications. Indeed, research into relevant TOE factors may provide valuable hints and guidelines to help organizations implement their desired blockchain applications.

5.3 Forecast of blockchain development

It is known that blockchain has disruptive potentials for business process innovation. Business may leverage the potentials of blockchain to achieve better operational performance in a blockchain-enabled multiple-player context. Joint applications across various sectors would also facilitate the effectiveness of a distributed blockchain network. The potential trend of blockchain development, as reported by Gartner (Panetta, 2017), is shown in Figure 10.

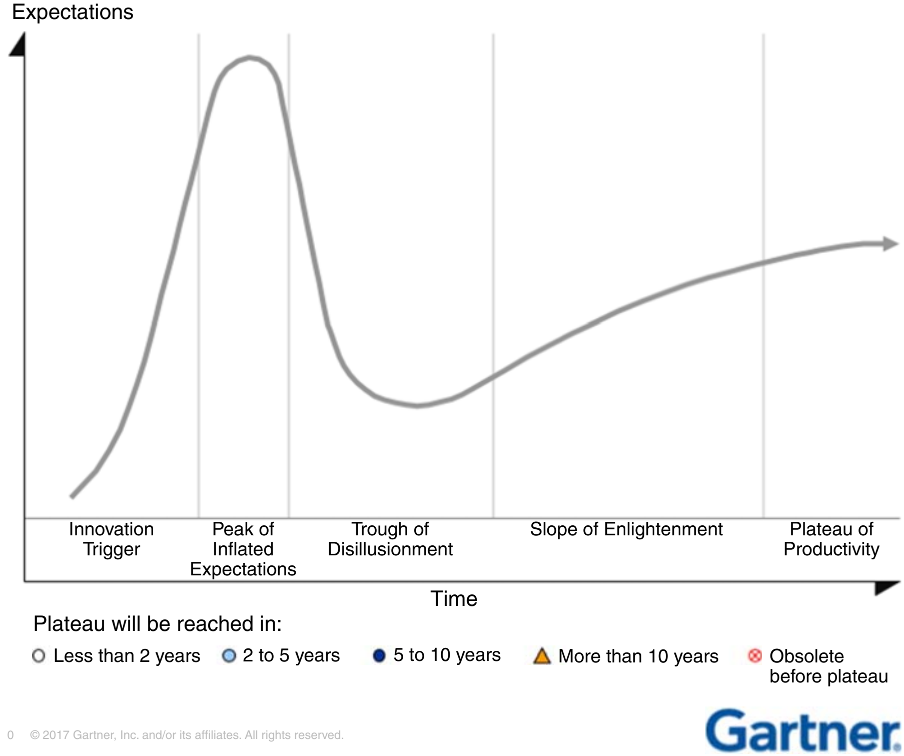
However, there still exist challenges remained to be resolved, and only by giving solutions to these challenges could blockchain be fully applied in various sectors and demanding areas. A number of technological issues such as block size, throughput and computational consumption may govern the trend of blockchain development. Even so, blockchain characteristics along with smart contract could still invigorate business innovation a promising energy from a perspective of distributed governance and process automation.

6. Conclusions and future work

This study focuses on the pain points and dilemma of traditional international trade related to L/Cs. A new blockchain-based L/C trade process is proposed via the utilization of emerging blockchain technology and smart contract. Former complicated procedures are improved and a better user experience is provided. By using use case diagram and activity diagram, a feasibility analysis is conducted for explaining the architecture of the proposed process. We made a comparative analysis between as-is and to-be models in the discussion and attempted to point out directions for future research.

6.1 Contributions

This research uses blockchain technology and smart contract to establish a consortium distributed ledger which aims to resolve opaque and trust issues in information transmission in international trade. In addition, a common ledger with immutable and tamper-proof characteristics makes this proposed model greatly reduce a number of trade disputes which might happen in traditional L/Cs presented in paper-based copies. Smart contracts based on the event-driven mechanism mitigate endeavors spent on manual manipulation and



"With bitcoin and Ethereum constantly in the news, blockchain might seem like it's just around the corner. However, most initiatives are still in alpha or beta stage. Enterprises are still deciding how to navigate this technology, but the lack of proven use cases and the volatility of bitcoin have created concerns about the viability of the technology. Long-term, Gartner believes this technology will lead to a reformation of whole industries."

Source: Panetta (2017)

Figure 10. Gartner Hype Cycle HD

confirmation. Managerially, the proposed model alleviates the pain points and hand-offs which may be confronted by traditional trade operations. The proposed system provides a distributed working environment for multiple trade participants. Such system maintained by consortium network could facilitate process flow and enhance overall trade performance. Also, a more secure payment method renders international trade to a more efficient level. For practitioners, this prototype grants global trades a testbed for further applications, such as insurance issues among trade participants. This conceptual framework also contributes to the application of blockchain technology in academic research.

6.2 Limitations and future research

Even though blockchain presents its potentials in business process disintermediation, a number of technical limitations are still left to be resolved for further adoption, such as block size, security and privacy concerns, transaction speed/frequency and computational resources. In addition, this study limits to the discussion of an enhanced L/C payment process while other channels, such as collection, cash on delivery, open account, etc., may still deserved for further investigations. It is suggested that future works may focus on model validation and quantitative study on adoption of blockchain technology with applications. Moreover, a better transaction process or a process combining blockchain with other emerging technologies, such as Internet of Things and artificial intelligence, is expected to make international trade process more efficient and to broaden the research scope of blockchain applications related to international trade. Finally, research into how various TOE factors affect the implementation of blockchain applications is also valuable and subject to our further investigation.

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