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Blockchain-based smart contracts technology
for enhancing banking services

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Abstract

A Blockchain-based smart contract is a stored code to represent a contract between different parties; it executes automatically when predetermined terms and conditions are met. The smart contract resides on a blockchain shared by participants and hence guarantees exact execution of transactions and keeps immutable transaction records. The smart contract has a lot of advantages such as decentralization and distributed ledger which facilitates a direct communication between different parties in a network, trustworthy and transparency. The direct communication feature leads to Peer-To-Peer based transaction that removes a high cost and overheads needed for handling transactions that require intermediate. Banks - as financial institutions- use such type of transactions in different areas of their business especially for the areas where require interaction between many parties such as trade finance transaction. So One of the potential incentives for banks in case of the development of distributed blockchain technologies for these types of transactions involves the reduction of overhead and costs associated with audit and regulation. In addition, more automation and efficiency in transaction processing, clearing and reconciliation can help to reduce counterparty credit risks. This paper discuss the concept of smart contract blockchain based technology and its potential to disrupt the world of banking through facilitating complicated banking transactions The implementation of smart contract application will use an Ethereum platform and Solidity language. The Ethereum is a block chain technology that provides an open global computing platform, called the Ethereum Virtual Machine (EVM), and the Solidity is a JavaScript-like language developed specifically for creating smart contracts, it considers as the most popular languages for coding smart contracts.

Keywords: Blockchain, Ethereum, EVM, Smart contracts, Solidity

Introduction

A step-forward bank should apply new technologies that meet and satisfy customers' needs and create a brand-new reality for digital banking that redefines the

way people perceive their finances [33]. It has witnessed the emergence of a number of disruptive technologies during the 21st century [34]. Through the internet technologies billions of people, as well as thousands of corporations could be connected and interacted on a daily basis. Banking sector is growing increasingly digital, it uses and applied different technologies to reach this like The Internet of Things (IoT) , Artificial Intelligence (AI) , chatbots, Natural language generation and Virtual reality. In spite of advent different type of technologies but smart contracts Blockchain-based holds promise for being the latest disruptive technology, and be involved in many applications in areas as varied as transaction processing government cash management, commercial bank ledger administration and clearing and settlement of financial assets [34] . Also this technology can support in the global remittance industry, by facilitating near-instantaneous global remittance with very low transaction fees. Another banking area can explore in the context of smart contact technologies is that of clearing and settlement as it have the potential to lead to near-instantaneous settlement and shortening the settlement cycle. The remainder of the paper is structured as follows: Section:3 details the problem statement and the reason of introducing the smart contract technology for banking sectors. Section:4 details the emerges of smart contract technology and its benefits. Section: 5 smart contract technology for banking sector. Section: 6 conclusions.

Problem statement

Banks play a major role in financial sector and in our daily life. Therefore, there is a need to develop sort set of technologies to facilitate bank services and products and to focus on taking a strategic approach to cost efficiency and effectiveness. There is an additional cost in addition tradition cost considered when bank do service pricing such as cost of technology, product development, processes, maintenance, infrastructure, and other associated costs of servicing. So banks need to simplify not only the products and services they offer but also the processes by which products and services are sold and supported. Simplifying these processes can deliver significant cost savings, and it is an important step because it can help to avoid the digitization of poorly designed and wasteful processes [21]. Automation of business processes is helping banks rapidly scale up, improve process quality and accuracy, reduce cycle times, and improve compliance.

The report made by Capgemini Consulting [31] mentioned many drawbacks in banking traditional process that haven't transformed to digital , for example for the syndicated loan process , the average settlement time in the US is 20+ days and 48 days in Europe. In addition to concentration of risks that about £277 billion per day Volume handled by UK's Real-Time Gross Settlement (RTGS) payment system that went offline for ten hours in 2014, delaying deals worth billions.

However, the smart contract has its main advantages of decentralization as distributed ledger and immutable during the course of execution of a transaction, which facilitates the secure direct communication between different entities in a network. So smart contracts can be deployed for multiple bank applications especially for the services

require inference between different parties like cross boarder trading process and Settlement process [19]. It can transform the business model of many bank segments, solving many of the problems banks and regulators are facing . The structure of banks are usually include different sectors, each sector responsible for one or more services and has technology tools to services. The smart contracts an advanced technology may be applicable to support banks to enhance their services in different sectors. This paper study proposing the smart contract technology as a solution can be implemented in different banking service .And proposed solution for applying smart contact on Trade finance banking application and measured the result .

Research questions

This paper tries to answer the following questions:

- ➢ What are the potential impacts of Smart contact technology approaches on the efficiency, transparency, and trustworthiness of trade finance operations?
- ➢ How can the proposed solution of smart contracts in trade finance to ensure their correctness and identify potential vulnerabilities or errors?
- ➢ What are the key factors and considerations in designing robust and secure smart contracts for trade finance applications?

Research Objective

The research is aiming to achieve the followings:-

- ➢ Identify the potential impacts of smart contract proposed solution on the efficiency, transparency and trustworthiness of trade finance operations conducted through smart contracts on the Blockchain .
- ➢ Identify the specific challenges and vulnerabilities that arise in smart contracts used in trade finance transactions.
- ➢ Know the key factors and considerations in designing robust and secure smart contracts for trade finance applications, taking into account formal verification techniques.

Research limitation

- ➢ The research is limited to the application of smart contracts in trade finance banking applications. It may not encompass other domains or industries.
- ➢ The research assumes the availability of a Blockchain platform and infrastructure suitable for trade finance applications. The specific Blockchain technology used may have its own limitations or constraints.
- ➢ The practical implementation of the proposed framework may encounter challenges related to scalability, performance, and real-world adoption of Blockchain technology in trade finance.
- ➢ The research will not study the different type of Letter of Credits, it will focus on the normal type. Also, the research will not study the legal issues of smart contracts

Smart Contracts Technology Emerges

The smart contact can encode the rules of a contract in computer code, which is replicated and executed across the blockchain's nodes. Such a contract can be self-enforcing, monitoring external inputs from trusted sources. The smart contracts backed originally to the 1990s when Wei Dai, created an anonymous credit loans with redeemable bonds to be collected at maturity [8]. In 1994 Nick Zezabo discussed the potential form of smart contracts and proposed to use cryptographic mechanisms to enhance security [6]. In 2008 Satochi Nakamoto developed "Bitcoin" platform, which is a set of simple pre-defined commands and limited conditions. In 2015, the second generation of Blockchain developed in the form of 'Ethereum' platform, which developed to support and enable the smart contracts functionalities. After that, different Blockchain platforms developed and supported the smart contracts such as Hyperledger Fabric, Neo and Ripple. In spite of existence of many Blockchain platforms, still the most famous platform is the "Ethereum" [6]. The integration of Blockchain technology and smart contract gives lot of flexibility to develop and design as well as implement solutions for real world problems with cost and time saving. Such efficiency comes from eliminating an intermediate or a third party from the cycle of process as this technology uses peer to peer (P2P) technique. Accordingly smart contracts can be considered one of technologies that banks seek for applying to enhance the efficiency of their service and products.

Definitions

The smart contact had defined in many literatures as follows:-
Smart Contract as a computer program intended to digitally facilitate the negotiation or contractual terms directly between users when certain conditions are met [3].The smart contract as a programming code which stored on Blockchain and automatically execute when predetermined and programmed terms and conditions are met [5].In [6] the smart contract was defined as a computerized transaction protocol that verifies the terms of a contract with general objectives such as satisfying common contractual conditions (such as payment terms, confidentiality, and even enforcement), minimizing exceptions both malicious and accidental, and minimizing the need for trusted intermediaries. However, the [7] defined the smart contract as legal contract between two parties in the form of programming code which is unaltered and stored on distributed database that executes on the Blockchain without intermediary involved. The smart contract also had been defined in [9] as an event-driven program that runs on a replicated, distributed and shared ledger, which cause a difficulties for any party to modify the program.
Therefore, it can be said that the smart contract is an executable programming code that runs on top of Blockchain to check agreed terms between more than party and then execute automatically once a specified conditions met. The advantages of smart contracts is used as an agreement between different   parties

without involving any intermediary because the transaction is recorded in Blockchain as it is shared between the participants and can be viewed at any time. So smart contracts lead to low transaction fees compared to traditional systems that require a trusted third party to enforce and execute the terms of an agreement.

Smart Contracts benefits

In general, the smart contracts inherent the benefit of Blockchain such as transparency. The Blockchain is a digital ledger, which store transaction publicly after verifying the transaction. Each verified transactions secured by cryptography hash function and linking the transactions with previous transaction's hash value as chain. Once transaction added to the Blockchain, no one can modify or alter it, the transaction can be viewed openly which bring transparency to the system.; the transaction is recorded and shared between the participants and can be viewed at any time, in addition to other features of Blockchain such as Security& Trustworthy & Fraud declination & Cost effectiveness and saving the time [1]. In addition, Smart contracts can facilitate any complex transaction, which requires more interactions and intermediate party to authenticate the transaction parties and trust the execution of the agreed relationship. Therefore, the main benefit of smart contract is securing the transaction as it stores all transaction details for verification and reduces the duplication

actions to confirm the validity of transaction. The smart contact executes automatically without interface of any third party and makes the transaction reliable [3].

Smart Contract technology for banking

Banking systems are large and complex, including a range of features such as back-end bookkeeping systems, which record customer account details, transaction processing systems, such as cash machine networks, all the way through to trading and sales, over the counter trades and interbank money transfer systems. To date, however there is unaware of any papers that go beyond this high level discussion and detail exactly how and what form smart contract technology may provide benefit in these aspects in banking settings [34].

The smart contracts an advanced technology can support banks to enhance their services. The structure of bank is divided into sectors; each sector is responsible for specific tasks and performs some activities to achieve these tasks. Table-1 summarizes the main sectors and suggests the smart contract application can use to support related activities.

Table-1: **Smart contract banking application [Author]**

#	Bank Sector	Main Task	Smart Contract Application
1	Center Operation Sector	Responsible for the central operation process like trade finance & opening account & external transfer and swift	- Trade finance process such as - Letter of Credit

2	Corporate Sector	Serve corporate customers	- Payment and settlement. - Syndicated loans.
3	Retails Sector	Serve individual customers	- Mortgage Lending - Personal and car loans. - Small and medium enterprises lending.
4	Finance Sector	Set the budget according to bank strategy, follow up the income and expense and prepare the budget and profit sheet.	- Liquidity management - Cash reserve management - Payment and Settlement
5	Treasury Sector	Handle the foreign exchange transaction and set the exchange rate as per market pricing	- Stock exchange market - Treasury accounts automation
6	Compliance Sector	Review the bank process against the central Bank regulation and banking standards regulations to confirm bank comply with these regulations.	- Know Your Customer (KYC) - Anti-Money Laundering (AML)
7	Admin Sector	Managing all administration process and purchase orders for supporting bank staff to do their jobs	- Asset and other devices like PCs tracking

Below sections provides a greater detail to these possible applications of smart contract technology. In particular they discuss things related primarily to a few important unexplored areas.

Smart contract and Payment settlement application

Payment across different countries in return of exchanging goods and service is depending mainly on trust as it is usually among unknown parties . the most famous method for payment is The Society for Worldwide Interbank Financial Telecommunications (SWIFT) which mitigates the trust problem but it has but it has coordination across multiple institutions and hefty fees [23]. However that Smart contract blockchain application using Ethereum platform allows the use of Turing-complete language and permits more complex contingent operations that is suitable for payment and settlement process as it has large volumes of financial

transactions . applications, such as Monax and Phi (String Lab), build on Ethereum to enrich and optimize their smart contract functionalities and processing power, similar to how Web sites build on the Internet protocol [23].
Group of banks participated in consortium for blockchain technology adoption to address the payment problem though what called Ripple, Ripple was founded in 2012 to provide global financial transactions and real-time cross-border payments and has since been increasingly adopted by major banks and payment networks. They reach about 80 banks from different countries.

Smart contract and Syndicated loans

Loan syndication is the process of involving a group of lenders in funding various portions of a loan for a single borrower. It most often occurs when a borrower requires an amount too large for a single lender to provide or when the loan is outside the scope of a lender's risk-exposure

levels. Thus, multiple lenders form a syndicate to provide the borrower with the requested capital. The cost of a syndicated loan consists of interest and several management fees, commitment fees, participation fees, structuring fees, front-end fees, agency fees and underwriting fees when a bank or a group of banks underwrites the loan. The participants in a Syndicated Loan are Arranging bank , Agent and trustee . The arranging bank is also known as the lead manager and is mandated by the borrower to organize the funding based on specific agreed terms of the loan. The bank must acquire other lending parties who are willing to participate in the lending syndicate and share the lending risks involved. The financial terms negotiated between the arranging bank and the borrower are contained in the sheet. The term sheet details the amount of the loan, repayment schedule, interest rate, duration of the loan and any other fees related to the loan. The arranging bank holds a large proportion of the loan and will be responsible for distributing cash flows among the other participating lenders. The Agent serves as a link between the borrower and the lenders and owes a contractual obligation to both the borrower and the lenders. The trustee is responsible for holding the security of the assets of the borrower on behalf of the lenders.

The blockchain technology, and particularly smart contracts, are well suited to reduce turnaround times for syndicated loan transactions by making interaction and communication between the various parties involved in the process more seamless [32].

Smart contracts could reduce the delay in processes such as documentation, buyer and seller confirmation and assignment agreement, and Know Your Customers (KYC) and Anti Money Laundering (AML), with the help of a permissioned ledger. The settlement period for Leveraged Loans could thus be reduced to the range of T+6 to T+10 days, making the Leveraged Loan market more liquid than it is current [31].

Smart contract and Trade finance process

International trade easily accounts for more than USD 18.89 trillion annually according to recent World Trade Organization (WTO) report [24] . Despite technological advances in many areas of financial services, trade finance remains a largely paper-based, manual process, involving multiple participants in various jurisdictions around the world, and prone to human error and delays along the supply chain.24 An importer may fail to strike a deal because the bank offering the letter of credit is not well known in the exporter's country. An exporter may fail to get advanced financing because the bank worries whether the goods can be successfully and timely delivered and whether payments from the importer can be secured. [23] . Between 80-90% of the world's international trade is reliant on trade financing. The process, whereby a bank in the importer/buyer's country issues a letter of credit to a bank in the country of the exporter/seller of the goods, enabling the exporter to release the goods, is fundamental to the world economy [20].

Every transaction of trade finance needs seller (exporter) and buyer (importer), ideally, an exporter would prefer the importer to pay upfront for an export shipment to avoid the risk that the importer takes the shipment but refuses to pay for the goods. However, if the importer pays the exporter upfront, the exporter may accept

the payment but refuse to ship the goods. Trade finance has methods like lending and factoring but the letter of Credit (LC) is the common solutions for this problem. The LC is a legal document representing a financial institution – most probably bank - promising to pay the money to seller when shipping the product. The parties involved in the LC are numerous and can include banks, trade finance companies, importer, exporter, insurers, export credit agency and service providers . Accordingly, it can be said that the LC is most important payment settlement method that provides effective risk mitigation for trading parties through bank facilitation in the trade finance process, the LC has frequently been described as the lifeblood of global trade, but their value can be seriously limited by the risks and inefficiencies in the current process [16].

LC process cycle

As the LC is evaluated on the basis of document and not actual good delivery or quality, the dispute between trading parties come from errors of terms and interpretation of the compliance requirements. . So it is obligated on bank to assure that the documents presented by the seller completely adhere to the LC terms and conditions. So the issuing bank must carefully evaluate whether the documents submitted by the seller comply with the LC because he must pay the seller as long as the LC terms and conditions have been met even if the sales contract terms have been breached.

The steps of LC when buyer wants to purchase good s from seller who in another country as follows:

- The buyer requests LC from buyer's bank confirming all required information.

- The buyer's bank sends LC to Seller's bank.
- The Seller's bank sends copy of the LC to Seller.
- The Seller Ships Goods to Port.
- The Seller obtains receipt documents from port .
- The Seller forwards it to Seller's bank.
- The Seller's bank reviews receipt documents, send them to buyer's bank.
- The Buyer's bank review and pays to seller's bank,
- The Seller's bank pays to seller.
- The buyer takes delivery of goods from Port

There are different challenges faces the LC process and affect its performance such as (1) contractual ambiguities which come due to discretionary determination for interpreting some unclear conditions ; (2) error in contract due to data mismatches or related discrepancies which come from wrong spelling companies names and addresses such discrepancies require the buyer's approval to be waived ; (3) high cost and delay , it issues through SWIFT as MT700 messages rather than as paper contracts, which costs average several hundred dollars and requires seven to 10 days 9 after documents are submitted for processing and payout, in addition to any change or waive due to data mismatch or discrepancies will add this to the cost and will delay the process [16].

LC using Smart contract based

The Smart contract-blockchain based technology can help in LC process, however Blockchain platform is a distributed database that records all transactions that have ever occurred in the network, and this allows network parties to communicate with each other without the need of a third party as trusted party. This would automate compliance verification with contract terms

and ensure faster payment to sellers by preventing disputes from arising due to ambiguities in the payment contracts. Payments would also be expedited through early discovery of discrepancies and increased efficiency of the amendment process.

There are different experience for developing the LC smart contract based as follows:

In 2016, Barclays and Fintech start-up Wave claim to have become the first organizations to complete a global trade transaction using the new Wave blockchain platform [25]. IBM also has been spearheading the application of blockchain and smart contracts to trade finance [26]. In March 2017, IBM and Maersk, cooperating with Hyperledger Fabric, announced the completion of an end-to-end digitalized supply chain pilot using blockchain technology, which involves trading parties and various ports and custom authorities [27]. In early 2017, IBM has ventured further by rolling out the Yijian Blockchain Technology Application System for the Chinese pharmaceutical sector. It has also collaborated with a group companies to develop a blockchain-based crude oil trade finance platform [28] Some progress has been made in applying blockchain technology to the freight and logistics industry. In September 2017, Maersk partnered with EY, Microsoft,Willis TowersWatson, and several insurance companies to securely share shipping data on KSI, a blockchain developed by Guardtime [29]. In November 2017, it was reported that the association Blockchain in Transport Alliance , whose members include startup blockchain companies like ShipChain, had attracted global giants like SAP and UPS in the traditional sector [30].

A blockchain smart contract codifies the terms and conditions of trade. This is done by abstracting and expressing conditional clauses regarding the time, place , manner of shipment and delivery, the description and quantity of the goods shipped and the documentary evidence required for verification. Based on the documents submitted by the exporter, evaluating and verifying that the LC conditions meet specified shipment deadlines can be automated through program logic to indicate compliance or non-compliance for each case [16].

The steps of LC for the same buyer wants to purchase goods from seller who in another country will be as figure 1:
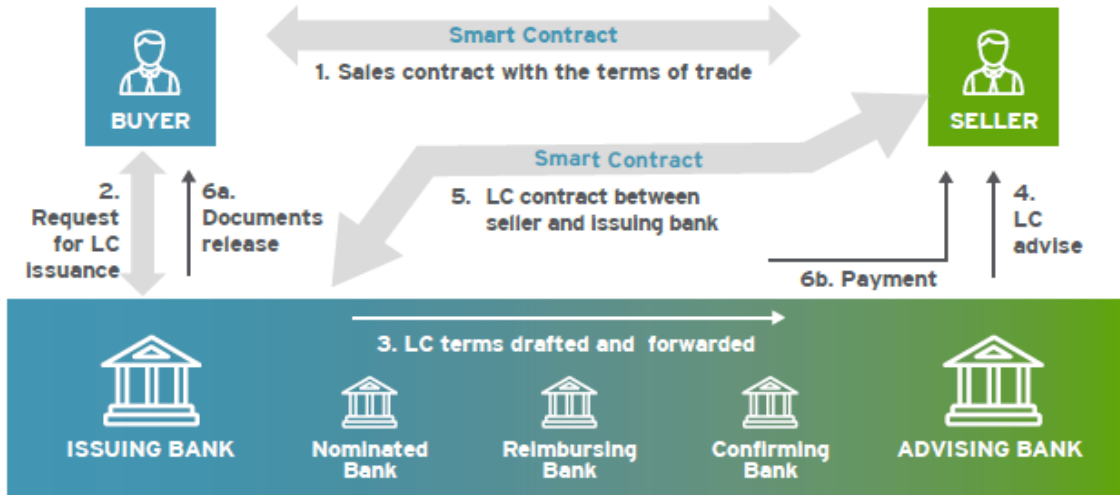
Figure-1 : LC proces through smart contract [16]

The LC will be issued on blockchain network consisting of buyer, seller, facilitating banks (including the issuing, advising, confirming, nominating, reimbursing and correspondent banks) and other trade finance entities acting as participating nodes. The LC terms and conditions can be drawn by the importer and stored immutably on the blockchain network as a draft. This draft is first made visible to the issuing bank, which, after reviewing and
underwriting the LC application, can digitally sign it to confirm its approval.
As per [4], to get really powerfully process, all the participants in the LC process must be on the blockchain network and use the smart contract solution, but even if only a few participants were using a smart contract solution this would generate significant advantages .

The proposed solution

The proposed solution replaces the current process of letter of credit (LC) with smart contract Blockchain based technology

process that provides more accuracy for all contract participants. The proposed system has three main actors: buyer, seller and shipping company in addition to settlement banks. The participants communicate through Blockchain smart contracts that will control the process of supply chain and also control money transfer process with participant banks. Smart contract is the only entity that have authority to transfer money after ensuring that all conditions of contract was achieved for all contract participants. As main solution process participant must be members of the block chain network through a registration module in our system to give every participant block chain address to let him communicate with smart contract. After that everyone use his own role, by the way there are three main roles in our system seller, buyer and shipping company so as normal process seller will add new item and set its name, count and price then the buyer can list available items and start to make contract to buy selected item and select shipping company. smart contract will verify that his balance can cover item price or not even that he bought items and this items still not delivered (freeze balance). After that the

seller and shipping company must approve a letter of credit (LC) contract to start the shipping process. If the shipping company delivered items to buyer LC status will be updated, then smart contract will request money transfer from buyer bank account to seller account.

Results and Findings

The practical implications of smart contracts in trade finance banking applications are significant. Here are some practical implications :

1. Increased Reliability: Through smart contract, the LC can be verified for correctness and adherence to specified requirements. This helps ensure that the contracts perform as intended, reducing the chances of errors, disputes, or unexpected behaviour that could disrupt trade finance operations.
2. Trust and Transparency: By providing proof that smart contracts meet specified specifications, participants can have more confidence in the reliability and fairness of the system, fostering trust among parties and easing smoother transactions.
3. Cost and Time Savings: by eliminating the intermediator in the process of LC.
4. Improved Risk Management: the smart contract solution contributed to better risk management in trade finance banking applications. By evaluating the behavior and incentives of participants, organizations can find potential risks, develop mitigation strategies, and perfect contract design to minimize the likelihood and impact of adverse events.

5. interoperable smart contracts in trade finance. By setting up common specifications, it promoted compatibility and seamless integration between different systems, easing collaboration and interoperability across the industry.

Conclusion

Banks as financial institution interest for recent innovations in the technologies approach to archive cost efficiency and effectiveness. A smart contract blockchain based technology one of most important technology for banks as it designed and has features are vital from a financial application perspective, including permissioning data integrity, data security and data authenticity as well as important regulatory requirements relating to account provisioning for financial asset reporting . The smart contact enables a network of users to engage in secure peer-to-peer financial transactions, eliminating the need for financial intermediaries and reducing the cost of overseas payments. Accordingly the banks can apply the smart contract in many areas and develop application for serve banking functions , including bank treasury ledgers, retail and investment bank ledgers, trading, settlement and clearing processes. Like all prior disruptive technologies there will be beneficial and detrimental aspects of smart contract blockchain-based technology that will need to be carefully considered prior to development and commercialization of the ideas presented in this paper.

References

[1] Maher Alharby, and Aad van Moorsel , "Blockchain-Based Smart contracts : A systematic mapping study", Taibah University, Medina, KSA, 2017

[2] K. Delmolino, M. Arnett, A. Kosba, A. Miller, and E. Shi, "Step by step towards creating a safe smart contract: Lessons and insights from a cryptocurrency lab," in International Conference on Financial Cryptography and Data Security, pp. 79-94, Springer, 2016

[3] K. Bhargavan, A. Delignat-Lavaud, C. Fournet, A. Gollamudi, G. Gonthier, N. Kobeissi, N.Kulatova, A. Rastogi, T. Sibut-Pinote, N. Swamy, et al., "Formal verification of smart contracts: Short paper," in Proceedings of the 2016 ACM Workshop on Programming Languages and Analysis for Security, pp. 91-96, ACM, 2016.

[4] G. Bigi, A. Bracciali, G. Meacci, and E. Tuosto, "Validation of decentralised smart contracts through game theory and formal methods," in Programming Languages with Applications to Biology and Security, pp. 142-161, Springer, 2015.

[5] C. K. Frantz and M. Nowostawski, "From institutions to code: Towards automated generation of smart contracts," in 2016 IEEE 1st International Workshops on Foundations and Applications of Self Systems (FAS*W), pp. 210-215, IEEE, 2016.

[6] B. Marino and A. Juels, "Setting standards for altering and undoing smart contracts," in International Symposium on Rules and Rule Markup Languages for the Semantic Web, pp. 151-166, Springer, 2016.

[7] T. Chen, X. Li, X. Luo, and X. Zhang, "Under-optimized smart contracts devour your money," in 2017 IEEE 24th International Conference on Software Analysis, Evolution and Reengineering (SANER), pp. 442-446, IEEE, 2017.

[8] F. Idelberger, G. Governatori, R. Riveret, and G. Sartor, "Evaluation of logic-based smart contracts for blockchain systems," in International Symposium on Rules and Rule Markup Languages for the Semantic Web,167-183, Springer, 2016.

[9] Matteo Di Pirro : "How Solid is Solidity? An In-dept Study of Solidity's Type Safety", Corso di Laurea Magistrale in Informatica,c September 2018

[10] Vitalik Buterin and Virgil Griffith. "Casper the friendly finality gadget" , 2017.

[14] hildenbrandt-saxena-zhu-rodrigues-daian-guth-moore-zhang-park-rosu-2018-csf-public.pdf

[15]https://blockonomi.com/formal-verification-smart-contracts/ Accessed at Jan 2019

[16] Cognizant's Blockchain and Distributed Ledger Consulting : "Blockchain for Trade Finance: Payment Method Automation " , 2017.

[17]https://www.wowso.me/blog/technology-in-banking

[18] Afinextra white paper banking on blockchain: charting the progress of distributed ledger technology financial service . 2016

[19] Infosys limited, Bengalurue, India, "Bolckchain adoption in financial institution, " ,2017.

[20] PricewaterhouseCoopers, "Trade Finance understanding the financial crime risks", 2016

[21] World Trade Statistical Review, 2017 https://www.wto.org/english/res_e/statis_e/ wts2017_e/wts17_toc_e.htm.

[22]https://www.finance-monthly.com/2020/11/a-strategic-approach-to-cost-reduction-in-banking/

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[23] Cong, Lin Willian and Zhiguo , Blockchain Disruptions and Smart Contracts, Volume 32, Issue 5, May 2019, Pages 1 754–1797.

 [24] https://www.wto.org/english/res_e/statis_e/wts2020_e/wts2020chapter03_e.pdf

[25] Taylor," Ornua involved in groundbreaking blockchain transaction", 2016

[26] Haswell Maersk and IBM , " introduce Trade Lens blockchain shipping solution" , 2018

 [27] https://www.ibtimes.co.uk/maersk-ibm-aim-get-10-millionshipping-containers-onto-global-supply-blockchain-by-year-end-1609778.,2017

[28] http://www.coindesk.com/ibm-blockchain-platform-oil-trade-finance/, 2018.

[29] http://fortune.com/2017/09/05/maersk-blockchain-insurance/, 2017

[30] https://www.ccn.com/bita-looking-disrupt-freight-logistics-industry/, 2017

[31] B Cant, A Khadikar, A Ruiter, JB Bronebakk, J Coumaros, J Buvat, and A Gupta, ." Smart Contracts in Financial Services: Getting from Hype to Reality. Capgemini Consulting" , 2016.

[32]Terekhova, Credit Suisse-led blockchain solution makes progress" , 2017.

[33]https://www.softwaregroup.com/insights/blog/article/10-innovations-that-deliver-the-digital-banking-of-the-future-today .

 [34] Gareth W. Petersz, Efstathios Panayiy "Understanding Modern Banking Ledgers through Blockchain Technologies: Future of Transaction Processing and Smart Contracts on the Internet of Money", 2015

Annex-1 Keyword table

Item	Meaning
EVM	Ethereum Virtual Machine
LC	Letter of Credit
IOT	The Internet of Things
AI	Artificial Intelligence
RTGS	Real-Time Gross Settlement
P2P	Peer To Peer
KYC	Know Your Customer
AML	Anti-Money Laundering
SWIFT	Society for Worldwide Interbank Financial Telecommunications