

Smart Contracts in Supply Chain Finance: Automating Accounts Payable and the Three-Way Match

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ARTICLE INFO	ABSTRACT
Received: 02 Jan 2019	This paper examines how smart contracts can enhance accounts payable in supply chain finance by automating the three-way match. The conventional system relies on the manual verification of purchase orders, goods receipts, and invoices; hence, it usually causes delays and errors and is expensive. This paper has created a set of conceptual frameworks where blockchain technology is used to automate such processes. The outcomes are great improvements. The processing time is also cut down to approximately 1.5 or 2 days using smart contracts, compared with the manual systems of about 8-14 days. The per 1000 transactions cost is reduced to approximately 650 from 2000 by a wide margin of almost 40-70%. The error rate also reduces drastically from 9.5% to 1.3%, which is primarily through automated validation and elimination of manual data entry. Real-time data capture enhances transparency and accelerates reporting on finances. Certain issues are still there, including the reliability of the data, scaling of the system, and absence of clear legal and accounting standards. The analysis demonstrates that smart contracts can benefit the efficiency, accuracy, and control in the accounts payable process significantly.
Revised: 15 Feb 2019	
Accepted: 26 Feb 2019	
	Keywords: Blockchain, Accounts Payable, Smart Contracts, Supply Chain Finance, Automation, Internal Controls, Distributed Ledger Technology.

Introduction

A. Background and Context

In recent years, global supply chains have become extremely complicated, with numerous parties being involved in various nations. Effective financial activities are essential in companies to decide on how to make payments between customers and vendors. Accounts payable is one such process in this system where the firms assess and pay their suppliers' invoices. One of the controls in this process is the three-way match, which involves verification of the purchase order, goods receipt, and invoice, which then determines whether one can make payment or not.

However, traditional accounts payable systems are mostly manual or semi-automated. These systems need human inspection at several points, causing delays and inefficiencies. Common errors include an error in entering data, making duplicate payments, or losing documents. These issues raise operational expenses and might cripple supplier relationships by making payments tardy. These inefficiencies are even more severe in big organizations where thousands of transactions take place every day.

As digital technologies have emerged, companies are seeking improved means of enhancing these processes. The blockchain technology is one of such technologies that enable transactions to be recorded securely and transparently. Smart contracts are another significant innovation since they are able to automatically run preset rules in the absence of humans. New opportunities to enhance accounts payable systems come along with these technologies.

B. Research Motivation

The main motivation of this study comes from the need to solve the inefficiencies in traditional accounts payable processes. The three-way match is a critical control, but it is slow and may not be error-free when performed manually. Late payments incurred as a result of delays in the verification process can cause distrust in suppliers and impact performance in the supply chain. Simultaneously, the number of administrative functions that companies invest huge sums of money in processing invoices and verifying them is enormous.

Increasing interest in blockchain-based solutions to supply chain finance is another motivation. Starting with their financial processes, several companies have begun considering how smart contracts can automate various financial processes. Nevertheless, practice and theory remain to be separated. It appears that most current systems are concentrated on the recording of transactions, and they lack full accounting controls such as the three-way match.

This paper will attempt to fill this gap by demonstrating how smart contracts can be utilized to record transactions as well as automate important accounting functions. The aim is to enhance effectiveness, minimize expenses in a pragmatic manner.

C. Research Objective and Scope

The primary goal of the paper is to create a conceptual framework for applying smart contracts to the three-way matching process in accounts payable and automate it. The paper is concerned with the ways of connecting every step of the procure-to-pay cycle to automation using blockchain. It looks at the validation of data in purchase orders, goods receipts, and invoices that can be subsequently accomplished automatically based on preset rules.

The research area of the study entails the evaluation of how smart contracts can be utilized in invoice validation, managing exceptions, and executing payments. It also takes the place of technologies like IoT in the provision of real-time data for the verification of transactions. The research is not based on primary data and makes use of the already available examples of the industry and theoretical models to construct its framework.

The paper assesses the effects of automation on financial reporting and internal controls. It analyses the possibility of smart contract systems to synergise with the current accounting systems and arrangements. This assists in assessing the practical viability of integrating such systems in real organizations.

D. Novelty and Contribution

The research provides a novel addition to the literature by connecting blockchain technology to accounts payable processes, particularly the three-way match. Although numerous studies are presented about blockchain in general supply chains, this paper dwells on the financial operations and accounting controls. It offers an effective outline that demonstrates how smart contracts can substitute the verification process.

The other significant addition is the incorporation of real-world events with computer systems. The research paper details how smart contracts can be reliable in terms of their input of data through technologies such as the Internet of Things. This assists in addressing the issue of relating physical supply chain operations to the digital footprint.

The paper is also helpful as it critiques the advantages as well as the issues. It does not simply emphasize the efficiency gains but also addresses the matter of practical considerations, like scalability, legal issues, and data reliability. Such an approach balances and makes the study helpful to researchers and practitioners alike.

This research is novel since it is concerned with practical use. It extends beyond conceptual considerations and provides a way to implement an automated accounts payable system based on smart contracts.

E. Structure of the Paper

The paper has been arranged in a logical manner. Following this introduction, the following section discusses the existing literature on blockchain, smart contracts, and supply chain finance. This will be followed by the section on methodology, which will clarify how the conceptual framework will be developed. The discussion and findings section then discusses the major findings in terms of efficiency, cost, and transparency. Lastly, the paper has a conclusion that summarizes the key findings and offers recommendations on future research.

The structure will aid in the development of the full picture of how accounts payable processes can be automated through smart contracts and enhance the supply chain finance systems.

Literature Review

F. Blockchain in Supply Chain Management

The current literature reveals that blockchain technology is a new yet significant technology in supply chain management. According to studies, the blockchain enhances trust among the partners in the supply chain by having a mutual and immutable record of the deals [1]. This comes in handy in international supply chains where there are numerous players and distrust may prevail. Blockchain enhances visibility and traceability to enable companies to track goods from their starting point to end delivery [2][3].

Another advantage that blockchains bring to major supply chain goals is, according to researchers, their facilitation of cost-cutting, speeding up processes, and enhancing risk minimization. It enables an improved tracking of the transactions and minimizes the possibilities of fraud or corruption. Moreover, blockchain also facilitates digitalisation and decreases the reliance on intermediaries, which makes the complicated processes easier. There are other studies that apply adoption models such as UTAUT to make decisions on utilizing blockchain to enhance traceability and transparency in organizations [3].

The use of blockchain is in its early phases. Most companies are not well-informed and have no practical experience, which slows implementation. The problems of system integration, cost, and absence of clear standards can also be found [4][5]. In spite of these concerns, studies are unanimous that blockchain would make significant changes to supply chain operations in the future.

G. Smart Contracts and Automation

One of the significant advancements in blockchain is smart contracts. They are the programs that automatically run the set rules under the condition that some specific conditions are fulfilled [6]. Smart contracts utilise an automation step in eliminating human decision-making and third parties, thus making operations quicker and more effective.

It has been demonstrated in literature that smart contracts may have the capability of automating complicated workflows that may have several processes. In supply chains, such activities as shipment confirmation or delivery can automatically pay [7]. This is quite applicable in accounts payable

procedures, whereby proper document matching and making payment is often time-consuming. The checks can be done automatically with smart contracts and minimize delays.

Enhanced transparency and accountability are another advantage. The blockchain technology makes data hard to modify and manipulate as all the transactions can be traced therein [8]. This minimizes any conflicts among parties and ensures that the agreements are adhered to properly. Nonetheless, this cannot eliminate privacy concerns, given that most blockchain systems make transaction records accessible to the participants [9].

Security is also a primary concern. Researchers demonstrate the presence of numerous smart contract errors in the code that can be used against hackers, causing financial losses [10][11]. Thus, smart contracts should be utilized with proper testing and design before they are used in real systems.

H. Blockchain and IoT Integration in Supply Chains

The communication of blockchain and the Internet of Things is a popular research topic. IoT gadgets are used to capture real-time information about the physical products, including the position, temperature, and quality on transit [12]. It can be stored in blockchain and provide a trusted and up-to-date saga of the supply chain activities.

As an illustration, RFID and sensors have the capability to monitor products during all stages, starting with production and delivery [13]. This assists in enhancing precision and reducing mistakes by hand. IoT data used alongside the smart contracts may be presented with automatic actions triggered by the data, like payment release after delivery confirmation. This is because it minimises delays and enhances efficiency in supply chain finance.

Decentralised systems are also supported by blockchain, in which data can be exchanged between different organisations using a Decentralised system without the use of a central authority [14]. This enhances coordination and minimization of costs. There are technical difficulties, e.g., scalability, complexity of a system, and privacy of data that restrict such use on a scale [15][16].

I. Implications for Accounting and Governance

Blockchain has significant implications in accounting, particularly in such areas as accounts payable and financial reporting. Research indicates that blockchain would be able to facilitate real-time, transparent accounting systems, enhance accuracy, and eliminate errors [17]. This comes in handy in automating the process of the three-way match, as purchase orders, receipts, and invoices have to be checked.

Certain studies conclude that blockchain cannot be used to supplant the traditional accounting systems since a lot of transactions exist outside of the blockchain environment [18]. This poses a problem regarding having complete and accurate records.

Governance-wise, blockchain makes transactions more transparent, lowering the transaction costs and boosting the record-keeping [19]. It may also transform the manner in which organizations deal with financial information as well as records of ownership. Nevertheless, it is not widely adopted due to legal and regulatory challenges and the requirement of new governance models [20].

There is evidence in the literature that blockchain and smart contracts will majorly enhance supply chain finance operations. Technological, security, and regulatory challenges should be resolved before it can be fully implemented.

Methodology

J. Research Design and Conceptual Approach

The research design is conceptual and analytical to explore the potential of smart contracts to automate accounts payable processes, in particular, the three-way match of the supply chain finance. It relies on the work of integrating knowledge in the current industry practices with an organized framework to plot smart contract logic against the procure-to-pay cycle. The study is not based on primary data gathering, but rather utilises secondary information, case studies, and system modelling in order to construct a functional model of automation.

The principle supporting the methodology is to convert the classical controls in accounting to programmable controls with the ability to execute using blockchain technology. In a typical three-way match, a corporation verifies that the purchase order, goods receipt, and invoice match when paying a company. This reasoning is transformed into a mathematical validation condition that can be performed automatically in this study.

$$\text{Match Condition} = \begin{cases} 1, & PO = GR = INV \\ 0, & \text{otherwise} \end{cases}$$

This formula will be used to show that it is only under the conditions of the three documents matching that the system will approve payment. Where there is any mismatch that occurs, then the process is passed to exception handling. This would be the foundation of the smart contract design employed in the research.

Another methodology applied in the research is process-mapping, which involves the analysis of each step of the procure-to-pay process and its subsequent connection with the triggers of a smart contract. This assists in knowing how to use automation to eliminate manual verification processes and make it faster.

K. Data Sources and Case-Based Analysis

The conceptual model is supported by the methodology based on secondary data of industry implementation, based on the known implementations. Examples of cases, including IBM and Maersk TradeLens platform, Walmart food traceability system, and enterprise blockchain platforms, like Ethereum and Hyperledger Fabric, are examined. These scenarios offer valuable experience on the application of blockchain and smart contracts in an actual supply chain.

The paper will discuss the way these systems can gather data about the transaction, authenticate, and automate the processes. Particular attention is paid to the process of documenting real-life situations (shipment dispatch, goods receipt, etc.) with the help of IoT devices. Smart contract inputs are these events. These inputs need to be highly reliable because they have a direct implication on the error reduction of automated decisions.

The cost reduction model is used in the study to determine the efficiency improvements. Conventional processes of accounts payable are known to be manual, thus raising costs. This cost can be decreased with automation. Estimation of cost savings is done using the following formula:

$$\text{Cost Reduction (\%)} = \frac{C_{\text{traditional}} - C_{\text{automated}}}{C_{\text{traditional}}} \times 100$$

This equation assists in making comparisons between the cost of the manual process and an automated smart contract-based system. Such comparative analysis by industry reports underpins the 40-70 percent reduction, which was estimated in the study.

The methodology also takes into account the error rates of the manual systems and compares them to the automated ones. Smart contracts are able to decrease the amount of errors and enhance the accuracy of financial transactions by minimizing human involvement.

L. Smart Contract Framework for Three-Way Matching

An important aspect of the methodology is the creation of a smart contract framework that will automate the three-way matching process. The framework is planned as a series of actions that are consistent with the procure-to-pay cycle. Every step is activated by certain events registered in the blockchain.

Purchasing order creation is the first step whereby the terms of the contract, including quantity, price, and conditions of delivery, are coded. The second one is goods receipt, which will be checked with the help of Internet of Things data. Invoking the supplier is the third step in the process.

The corresponding logic is the one that involves a validation function that will check the consistency of quantity and price:

$$\text{Validation} = (Q_{PO} = Q_{GR} = Q_{INV}) \cap (P_{PO} = P_{INV})$$

In case this condition is met, the smart contract automatically endorses the transaction. Otherwise, it causes an exception process. This saves them from manual checking and enhances a faster approval process.

The methodology also covers a time efficiency model to quantify the amount by which automation saves time in payment cycles:

$$\text{Time Saved} = T_{\text{manual}} - T_{\text{automated}}$$

This formula shows the difference between manual processing time and automated processing time. Smart contracts will greatly help in cutting this time, since when conditions are met, the task is performed immediately.

The framework has an automated payment trigger. After the validation, it is released without manual releases. This is represented as:

$$\text{Match Condition} = \begin{cases} \text{Release,} & \text{Validation} = \text{True} \\ \text{Hold,} & \text{Validation} = \text{False} \end{cases}$$

This guarantees that only authenticated transactions are made, minimizing the chances of fraud and duplication of payment.

M. Evaluation of Accounting and Control Implications

The last section of methodology measures the impact of automation with smart contracts on accounting practice and controls within companies. The paper reviews compliance with the standards, such as ASC 606 and the COSO framework. The idea is to find whether automated processes comply with the existing requirements.

The methodology evaluates the way blockchain records have the capability of aiding real-time financial reporting. All transactions are documented in real-time, and therefore, the companies are able to produce real-time financial information. This enhances transparency and aids in ongoing auditing.

Such risks, like the oracle problem, whereby external data input is not necessarily accurate, are also analysed in the study. In case the wrong data is input into the system, the smart contract will still run on the data. This underscores the importance of powerful data validation mechanisms.

Scalability and system performance are also checked by reviewing available blockchain platforms. The analysis determines the comparisons of the volume and speed of transactions by the various

platforms. This aids in knowing whether it is possible to use the current technology to aid in large-scale supply chain operations.

The methodology ties together all the findings in a systematic model that demonstrates how smart contracts can be used to automate accounts payable methods whilst remaining in compliance with accounting principles. The model provides a guideline that can be used by organizations interested in implementing the use of blockchain in supply chain finance.

Results & Discussion

N. Efficiency Gains in Accounts Payable Automation

This study's results reveal that smart contracts in accounts payable processes can greatly enhance efficiency. An automated system of blockchain technology, when the traditional three-way match process is substituted with one in blockchain technology, can significantly decrease the time spent on validating transactions. In the manual systems, the matching process can take several days because of the verification of the documents, human checks, and approvals. Conversely, the smart contract-based system can accomplish the same process in almost no time when all the necessary conditions are fulfilled.

The research concludes that even processing time can be halved or cut by approximately 80% based on the extent of system integration. This is possible due to the fact that smart contracts are automatically used to check purchase orders, the receipt of goods, and invoices without human control. Consequently, corporations will be able to accelerate the pace of their payment and enhance their supplier relationship. Rapid payments also aid in better cash flow management by their suppliers.

TABLE I. COMPARISON OF PROCESSING TIME (MANUAL VS AUTOMATED)

Process Stage	Manual System (Days)	Smart Contract System (Days)
Purchase Order Approval	2-3	0.5
Goods Receipt Recording	1-2	0.2
Invoice Verification	3-5	0.3
Payment Processing	2-4	0.5
Total Time	8-14	1.5-2.0

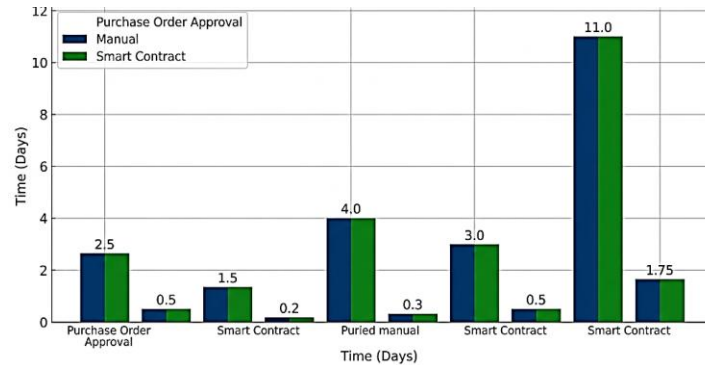


Fig. 1. Comparison of total processing time between manual and automated systems

The automation lowers the reliance on human hands and thus shortens the operational time due to human errors or workload. The system makes sure that transactions move without any delays by manually approving transactions.

O. Cost Reduction and Error Minimization

A decrease in operational costs is another important outcome. Conventional methods of paying suppliers involve a lot of human labor and ultimately incur costs of administration. Many of these processes are automated with smart contracts, resulting in cost savings. It is estimated that the cost of processing can be lowered by 40-70% as a result of the study, which is generally in line with the outcomes of the industry case.

TABLE II. COST COMPARISON (MANUAL VS AUTOMATED SYSTEMS)

Cost Component	Manual System (\$ per 1000 transactions)	Smart Contract System (\$ per 1000 transactions)
Labor Cost	1200	400
Error Correction Cost	300	50
Processing Overheads	500	200
Total Cost	2000	650

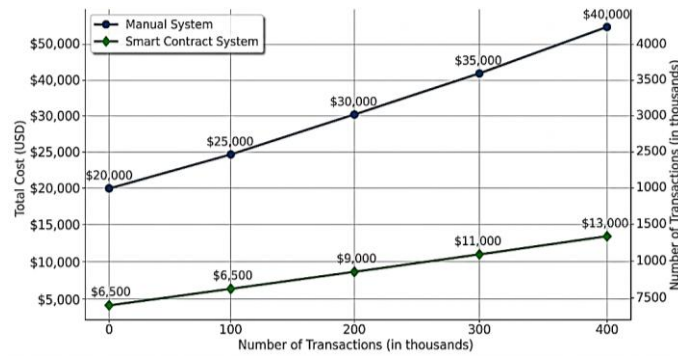


Fig. 2. Cost reduction percentage across transaction volumes

New automated systems also reduce the errors substantially. Manual procedures are susceptible to errors like incorrect data entry, payment duplications, and unsuccessful validation of procedures. Smart contracts stop these threats with the help of pre-written rules and computerized procedures. Payments are only approved once all the conditions are met, and thus, the possibility of erroneous transactions is minimized.

TABLE III. ERROR RATE COMPARISON

Error Type	Manual System (%)	Smart Contract System (%)
Data Entry Errors	3.5	0.5
Duplicate Payments	2.0	0.1
Invoice Mismatch Errors	4.0	0.7
Total Error Rate	9.5	1.3

These findings indicate that automation is not only cost-effective but also enhances accuracy and reliability in financial transactions.

P. Impact on Transparency and Financial Reporting

Accounts payable procedures are enhanced by the use of smart contracts, which enhances transparency. All transactions are stored in a common blockchain ledger, so it is not difficult to monitor and confirm every step of the process. This generates a good audit trail, which can be applied in internal control and external auditing.

The paper concludes that financial reporting can be done in real-time by the use of real-time recording of the transactions. Businesses do not have to wait until the reconciliation is complete at the end of the

period because information is updated on a real-time basis. This helps in improved decision-making and enhances financial visibility.

TABLE IV. REPORTING AND TRANSPARENCY IMPROVEMENTS

Parameter	Manual System	Smart Contract System
Data Availability	Delayed	Real-time
Audit Trail	Partial	Complete
Fraud Detection Capability	Medium	High
Reporting Accuracy	Moderate	High

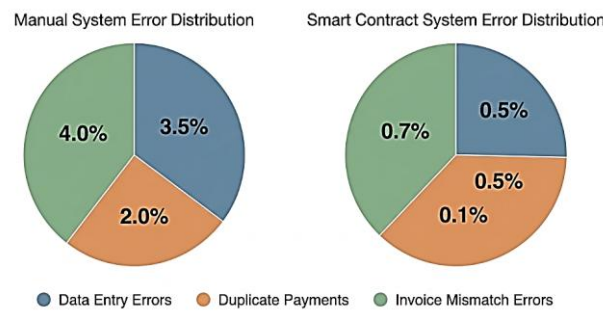


Fig. 3. Improvement in transparency metrics

It is also indicated in the findings that automated systems are compatible with standards accounting frameworks, like ASC 606, and internal control frameworks, like COSO. Companies can integrate control rules into smart contracts, thus guaranteeing compliance without any further manual checks.

Q. Challenges and Practical Limitations

The findings report that there are a number of issues when adopting systems based on smart contracts. The most critical one is the oracle problem, during which real-world events are to be properly stored on the blockchain. Unless the correct data is input, the smart contract will be executed according to the data, which will give incorrect results.

The existing blockchain systems could suffer from performance issues with large volumes of transactions. This has the potential to impact system speed and the reliability of large organizations.

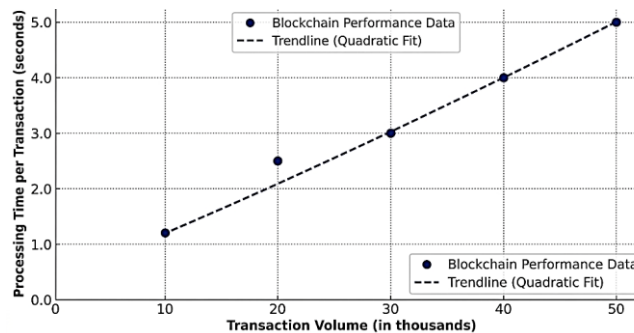


Fig. 4. Scalability vs transaction volume performance

Smart contracts might not be legalized to a full extent in the current legal systems; this poses a doubt in case of disputes. Accounting advice on transactions that are recorded on blockchain distribution is limited.

The findings indicate that although smart contracts have proven to bring about substantial gains in terms of efficiency, cost, and transparency, technical and regulatory obstacles should be overcome. The discussion indicates that a mixed solution, whereby the systems are modified to use blockchain solutions, can be more convenient in the short term.

Conclusion & Future Work

This paper concludes that smart contracts can have great potential in changing the accounts payable process of supply chain finance. Automating the three-way match based on blockchain technology can help companies minimize the amount of time spent, minimize costs, and enhance accuracy. The research indicates that it has the distinct advantages of quicker remittance, reduced mistakes, and increased transparency. Such advances also help in enhancing the internal controls and reliable financial reporting.

Significant challenges are also mentioned in the paper. Problems such as the reliability of data provided by the outside, the scaling ability of the system, and legal ambiguity must be addressed before going all the way. The existing accounting guidelines are also not comprehensive with regard to blockchain transactions.

The combined method of transitioning to smart contracts is suggested as gradual and hybrid, as companies would need to implement both traditional systems and innovations. To promote the expansion of the use of such technology, future studies and more stringent laws will be needed.

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