



Blockchain - Enabled Framework for Enhancing Transparency in Modern E- Commerce Transactions

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Abstract-Today's e-commerce systems are affected by the problems associated with information asymmetry, non-transparency of the supply chain, and control of transactions by intermediary parties, which impede trust in the process. In this paper, a blockchain-based framework for increasing the level of transparency in e-commerce transactions is suggested. It combines distributed ledger technologies with smart contract automation and IoT technologies for recording every transaction in an immutable way. The suggested methodology uses a Proof of Authority consensus algorithm tailored for e-commerce needs and a multi-level architecture consisting of product registration, transaction processing, and dispute solving stages. To test the performance of the suggested solution, simulation experiments focused on assessing the latency of the transaction process, dispute resolution, and counterfeiting prevention capabilities have been conducted. Comparison of the results with traditional e-commerce systems shows that using the suggested framework leads to reducing dispute rates and faster transaction verification, preserving the system's scalability at the same time.

Key Word: Blockchain, E-Commerce, Transparency, Smart Contracts, Distributed Ledger Technology, Supply Chain, Trust Management

I. Introduction

With the fast-paced growth in e-commerce, there have been changes to business transactions through which business enterprises and consumers conduct their transactions across borders conveniently and easily. E-commerce sales have risen steadily over the last ten years due to the increase in mobile connectivity, digital payments and also due to a shift in consumer behaviour favouring online shopping [5][8]. However, with this increase, structural weaknesses in e-commerce have become evident. The buyers make purchases from sellers who are unknown to them; they depend on trust factors provided by the intermediary platforms while they lack the capacity to confirm the genuineness of the products and the authenticity of the transactions [2][9].

Trust is the primary issue of online commerce [2][4]. In physical markets, where one can examine a good and form a personal relationship with a seller, e-commerce happens in time and space that preclude all of the traditional means of trust building. In order to overcome this problem, platforms have created various systems such as rating systems, buyer protection, and escrow services. However, these are also centralized and thus susceptible to manipulation and conflicts of interest [4][5]. In addition, when the same platform acts as a facilitator for trade, payments, and arbitration, there is a conflict of interest in trying to satisfy the needs of the platform itself above all else [5][9].

The blockchain architecture represents an effective architectural solution to the problem of centralization of trust [4][5]. Blockchain distributes transaction records between participants of a network and uses cryptography for verification purposes, thus creating a distributed and tamper-proof ledger that cannot be modified unilaterally by any party unless there is an agreement in the network about such change [5][8]. This approach solves the problem of manipulation associated with the centralized architecture of e-commerce systems [4][9]. The introduction of smart contracts allows executing commercial agreements automatically without involving intermediaries in the process and reducing costs of transactions along with eliminating potential discretionary interference [3][6][7]. Furthermore, integration of IoT sensors into blockchain network provides extra options for provenance verification of physical products [3][6].

Despite considerable scholarly attention to the application of blockchain technology to electronic commerce, many voids exist in the body of knowledge [5][9][10]. Many research papers that exist today focus only on the payment system of cryptocurrencies or hypothetical uses of blockchains in the supply chain without considering the entire transaction process [5][8]. Most studies do not present an approach that addresses product registration, transaction processing, and dispute



resolution in one single framework [6][7]. In addition, implementation issues such as choosing the right consensus algorithm, scalability, and regulatory requirements have not been considered [1][5][6].

The following paper seeks to fill the existing gaps through proposing a blockchain-based framework that is specifically designed to promote transparency in the current generation of e-commerce transactions. The framework consists of three distinct but interlinked layers, including a product registration and validation layer responsible for creating immutable provenance, a transaction execution layer for automatic payments and validation of the delivery process using smart contracts, and a dispute resolution layer for maintaining a transparent record of all dispute resolution processes. The method used in the framework is based on Proof of Authority consensus mechanism due to the fact that it offers the most appropriate level of security and energy efficiency [1].

The rest of the paper is organized as follows. In section 2, we review the current literature about the use of blockchain in the context of e-commerce and SCM. In section 3, we introduce our proposed framework architecture and discuss it in detail through the use of algorithms and pseudocode. In section 4, we perform experiments and analyze results with respect to quantitative performance measures.

II. Literature Survey

Blockchain technology has been increasingly used in the context of e-commerce, and studies about the topic cover various aspects such as trust mechanisms, supply chain integration, use of smart contracts, and implementation issues [5][8][10]. In this part of the paper, recent research is summarized to develop the theoretical basis of the proposed framework.

Consumer trust towards online marketplaces is the key driver of research on blockchain technologies [2][4]. The multi-method study carried out by Uchikoshi and Frank with 727 participants in the randomized experiment and 563 participants in the multi-wave survey demonstrated that the blockchain characteristics such as privacy ownership, privacy monetization, and metadata transparency have a strong positive effect on the level of consumer trust toward the e-commerce platform [2]. The results of this study show that trust mediates the effect of the transparency features provided with the help of blockchain technology and is positively associated with willingness to pay additional fees [2]. Related research conducted by Garaus and Treiblmaier shows that food traceability systems based on blockchain create stronger consumer trust compared to firm-owned traceability systems, which depends on retailer familiarity.

The other prominent research trend concerns blockchain-enabled supply chain transparency and counterfeit prevention [3][6]. Many studies focus on how blockchain technology allows building a tamper-proof record of the product provenance in order to fight with counterfeits [3][8]. The research of counterfeit prevention based on smart contracts reveals that by leveraging the machine learning model and blockchain-based smart contracts, it is possible to monitor the product authenticity in real time and decrease the number of counterfeit cases [3]. As for the technical implementation, this usually includes the registration of unique product IDs in the distributed ledger using smart contracts and then registration of further handling of the goods by other supply chain members [3][6]. After detecting the counterfeit product by cross-verifying during transactions, the producers will be able to track the responsible seller and fix the situation [3].

The use of smart contracts is the key innovation behind the automation of e-commerce processes without any intermediate supervision [3][6][7]. In studies concerning cross-border e-commerce trust management, systems have been suggested wherein the use of smart contracts, which are unchangeable, is used for automated payments and transactions if certain delivery time constraints and product standards are satisfied [6][7]. Internet of Things sensors are used for monitoring the transit products, with the score being updated in accordance with the participants' performances [6][7]. In one case study conducted in the field of independent e-commerce stations in Dongguan, the implementation of smart contracts allowed increasing the efficiency of cross-border transactions processing by 23%, lowering costs to 1.2% in comparison with the traditional approach, and reducing dispute rate to 9% from 18% [7].

The choice of consensus mechanism is an important architectural decision when designing e-commerce applications that leverage blockchain technology [1][5]. A comprehensive comparative study of blockchain consensus algorithms revealed that the best algorithm for e-commerce applications is Proof of Authority, providing good trade-offs between security and requirements regarding transaction throughput and latency [1]. Proof of Authority leverages a number of pre-selected validators whose identities can be verified externally, thus allowing higher block confirmation rates in comparison with proof-of-work algorithms while providing Byzantine fault tolerance [1]. Security effectiveness and performance times sufficient for

e-commerce transaction volumes have been confirmed by research on integration of Blockchain Consensus Algorithm with Distributed Ledger Technology [1][8]. However, scalability is becoming an issue with increasing transaction volumes [1][5].

Another relevant topic in recent scholarly literature on blockchain in e-commerce is implementation barriers [5][10]. Systematic reviews indicate that high implementation costs, technical complexity, and regulatory uncertainty are the main impediments to implementation [5][10]. In this regard, a systematic literature review about blockchain adoption factors in e-commerce indicates that although firms are aware of the value of blockchain in addressing security issues, the limitations of this technology hinder its acceptance and adoption [5][9]. The discrepancy between blockchain's transparency advantage and current regulations leads to uncertainty, especially in matters of data privacy compliance, cross-border data transfers, and liability allocation in decentralized networks [5][10]. A study on cross-border e-commerce highlights that the regulatory compliance framework should change along with technological implementation in order for blockchain systems to become commercially viable [6].

On the one hand, the literature indicates great opportunities; however, at the same time, certain gaps can be found. Behavioural literature proves the trust-enhancing nature of the blockchain; technical literature provides evidence about the possibility of implementing smart contracts [2][3][6]. Yet, few authors have tried to build an integrated model covering all the stages of transactions in e-commerce [5][6][10]. The proposed framework aims at closing this gap.

III. Proposed Methodology

1. Framework Architecture Overview

The proposed system that makes use of blockchain technology for transparent transactions in e-commerce is based on a three-layered model aimed at solving the different phases of commercial transactions. The first layer, referred to as the Product Registration Layer, provides the provenance records of the products being added to the e-commerce environment, which cannot be altered. The second layer, known as the Transaction Execution Layer, provides automated systems for payments, delivery validation, and smart contracts execution. The third one, Dispute Resolution Layer, records transparently the conflict resolution process.

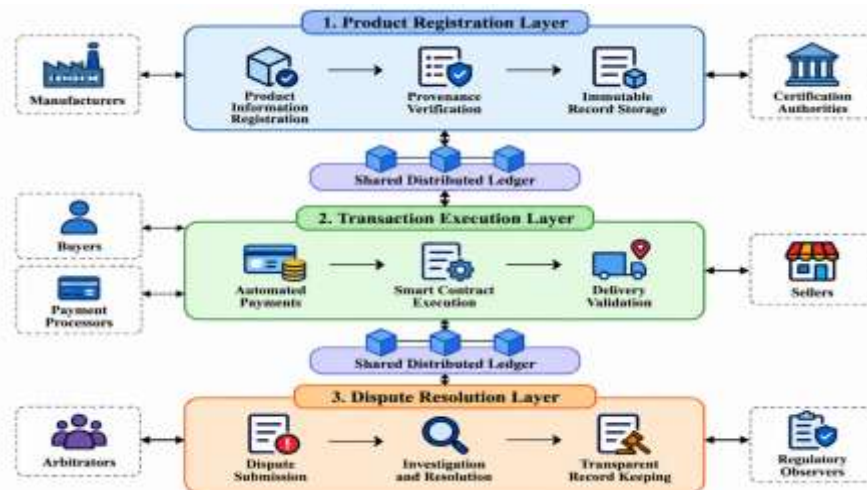


Figure 1: Three-Layer Framework Architecture

2. Consensus Mechanism Design

The blockchain system uses Proof of Authority consensus algorithm, chosen after an analysis of the comparison showing its fitness for use with e-commerce transactions. In this case, a predefined number of validator nodes run by operators of e-commerce platforms, logistics organizations, and third-party auditors take turns in proposing and validating blocks. Identities of validators are known to the public and receive reputation scores that influence their ability to propose new blocks. This approach ensures that blocks can be validated at times suitable for business transactions.



3. Product Registration and Verification Algorithm

Through the process of product registration, a distinct digital identity is created for each item being incorporated into the online business supply chain. The manufacturers will create a cryptographic product identification code, which will be recorded in the blockchain database alongside information about the product such as its attributes, certification details, and ownership status. Ownership transfer information will then be added to the blockchain as the item passes through other players in the supply chain until the consumer buys it.

4. Algorithm 1: Product Registration and Verification

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Input: Product batch B = {b1, b2, ..., bn}, Manufacturer credentials Mcred
Output: Product identifiers registered on blockchain, Verification status

1. FOR each product bi in batch B:
2.   Generate unique identifier IDi = H(bi.metadata || Mcred.publicKey || nonce)
3.   Create registration transaction Tx_reg = {
       product_id: IDi,
       manufacturer: Mcred.publicKey,
       metadata_hash: H(bi.metadata),
       timestamp: current_time
   }
4.   Sign Tx_reg with Mcred.privateKey
5.   Broadcast Tx_reg to blockchain network
6.   WAIT for consensus confirmation
7.   IF confirmation received:
8.     Store IDi in manufacturer's product registry
9.   ELSE:
10.    Flag registration failure, queue for retry
11. END FOR

Verification Procedure (at point of sale):
12. Consumer scans product identifier ID_scan
13. Query blockchain: retrieve Tx_reg associated with ID_scan
14. IF Tx_reg exists AND signature valid:
15.   Retrieve product metadata and ownership chain
16.   Verify ownership chain integrity (no gaps, valid transfers)
17.   IF chain valid AND product matches metadata:
18.     RETURN "Authentic"
19.   ELSE:
20.     RETURN "Chain violation detected"
21. ELSE:
22.   RETURN "Unregistered product"
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3.5 Transaction Execution via Smart Contracts

Transaction Execution Layer helps in automating the transactional process between the buyer and seller without any mediation from intermediaries. A smart contract defines conditions such as the payment amount, time of delivery, product specifications, and release of funds based on certain conditions. As soon as the delivery is confirmed by logistics firm or IoT sensors, the funds are released automatically via smart contracts.

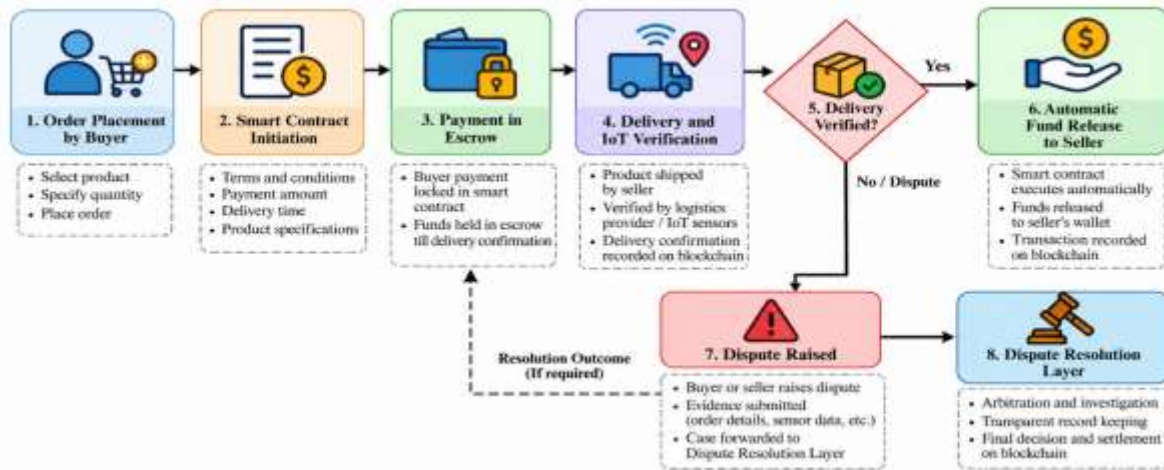


Figure 2: Smart Contract Transaction Flow

6. Dispute Resolution Mechanism

In case of any disagreement about transactions, there is a system that ensures transparency during decision-making. Claims are submitted to the blockchain system, which triggers the process of choosing arbitrators from an approved list. These arbitrators consider different evidence, such as transaction logs, delivery proof, and other information about the product on the blockchain. The decision will be immutable and serve as a precedence for future decisions. Decentralization of this decision-making process differs significantly from centralized decision-making through platforms.

7. Algorithm 2: Dispute Resolution and Automated Arbitration

Input: Dispute $D = \{\text{claimant, respondent, transaction_id, claim_type, evidence}\}$
Output: Resolution decision recorded on blockchain

1. Claimant submits dispute transaction $Tx_dispute$ with stake deposit
2. Validate $Tx_dispute$: verify $transaction_id$ exists, claimant has standing
3. IF validation fails: reject dispute, return stake
4. Randomly select panel $P = \{a_1, a_2, \dots, a_k\}$ from arbitrator pool
5. FOR each arbitrator a_i in P :
6. Notify a_i of dispute assignment
7. a_i retrieves evidence from blockchain records
8. a_i independently evaluates claim against smart contract terms
9. a_i submits signed vote v_i (claimant_favor | respondent_favor)
10. END FOR
11. Aggregate votes: $tally = \sum(v_i)$
12. IF $tally > \text{threshold}$:
13. Resolution = "Claimant favor"
14. Execute smart contract remediation (refund, replacement authorization)
15. ELSE IF $tally < (k - \text{threshold})$:
16. Resolution = "Respondent favor"
17. Release stake to respondent
18. ELSE:
19. Resolution = "Inconclusive"
20. Escalate to higher arbitration tier
21. Record Resolution on blockchain with arbitrator vote hashes
22. Distribute stakes according to outcome

8. Security and Transparency Properties

The system becomes transparent due to a variety of approaches. Every transaction history can be made transparent by network members, but confidential business information may be hashed instead of being in plain text. Immutability guarantees that the events of transactions are not going to be changed after being recorded. The execution of smart contracts is deterministic, which makes sure there will be no discretionary decision-making during payments and deliveries verification. The multi-party consensus approach ensures that nobody, including the e-commerce platform itself, will be able to make changes in the transaction history and results.

IV. Analysis And Results

1. Experimental Design

Performance of the framework under study was assessed via simulations in comparison with the performance of a classical centralized model of e-commerce. Simulations covered transaction traffic of up to 10,000 transactions per day with respect to the processes of products' registration, buying, delivery confirmation, and dispute resolution. Metrics for performance assessment were transaction processing delay, dispute resolution time, and throughput. For simulations, a Proof of Authority blockchain with five validator nodes was used (platform operator, logistic companies, and independent auditors).

2. Transaction Processing Latency

Latency refers to the delay in confirming a transaction, measured between the submission of the transaction and its ultimate confirmation. In the traditional architecture for online business transactions, the process of transaction confirmation is determined by the commit operation in the database as well as the processing queue of the system itself, taking milli seconds to confirm payment but minutes or hours to confirm delivery.

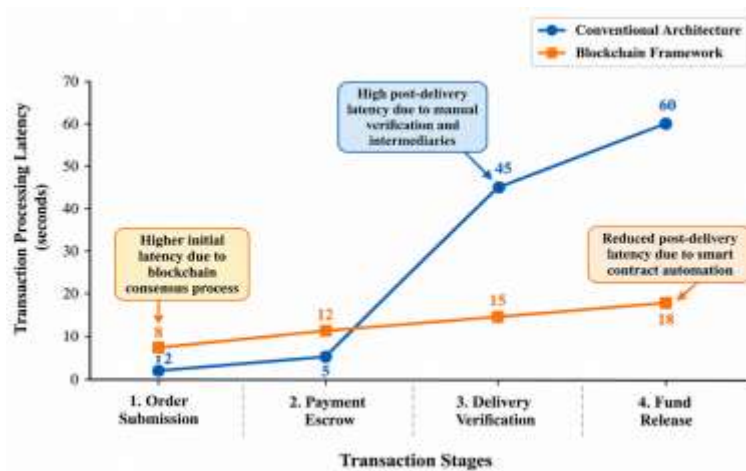


Figure 3: Transaction Latency Comparison

As seen from Figure 3, the blockchain platform has a higher order of submission latency because of the need for consensus confirmation, but on the other hand, there is a significant decrease in post-delivery latency due to the automatic release of funds.

3. Dispute Resolution Efficiency

Efficiency in dispute resolution was analyzed on the basis of resolution time and resolution consistency. The decentralized arbitration system gets rid of the sequential processing delays that are part of the centralized system.

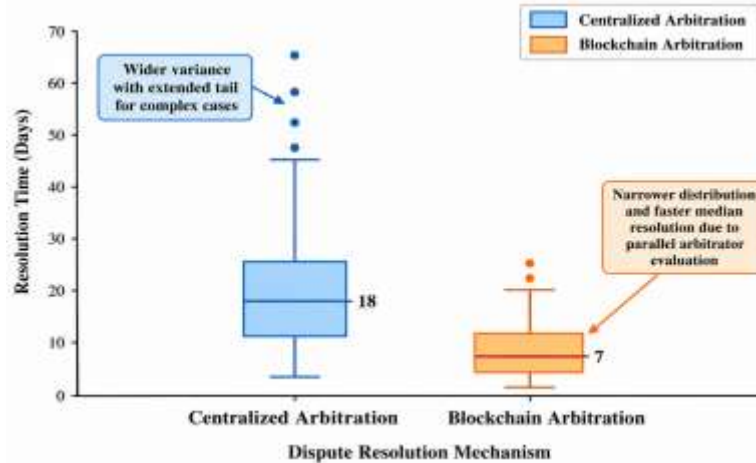


Figure 4: Dispute Resolution Time Distribution

According to quantitative analysis, the decentralized approach provides significantly lower median resolution times when compared to centralized platform arbitration, especially for simple cases like delivery verification and product authenticity issues where blockchain evidence can be used to provide conclusive answers.

4. Counterfeit Detection Capability

Product verification using blockchain helps identify counterfeits deterministically. In the simulation, products that were registered using the Product Registration Layer were checked during point-of-sale transactions, and the results were compared to the authentic label of the product.

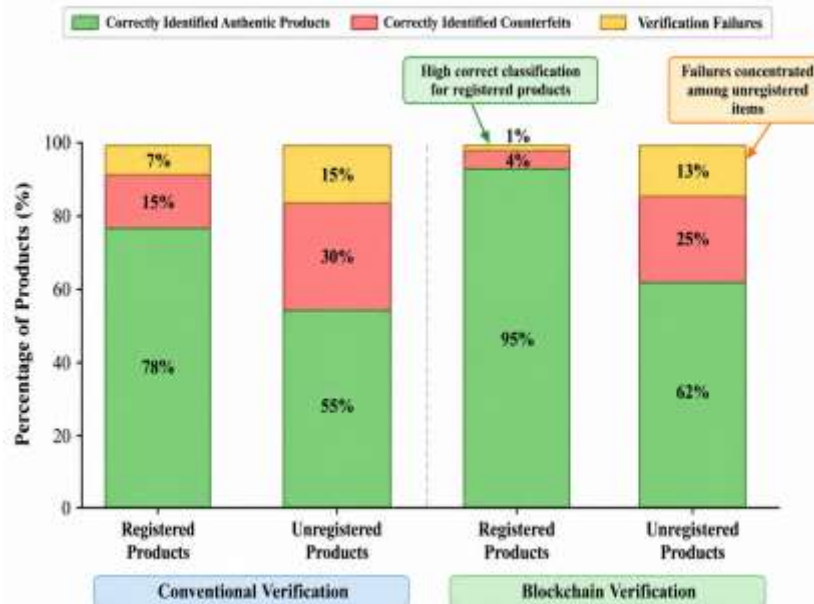


Figure 5: Counterfeit Detection Outcomes

The verification process has an evident ability to recognize genuine products with proper registration and also identifies unregistered products for further analysis. This ability helps solve the issue of counterfeits infiltrating into the centralized e-commerce system, which cannot regulate this threat.



5. Comparative Analysis

The following Table 1 shows a comparison of the proposed model with the traditional centralized e-commerce model on various performance criteria.

Dimension	Centralized E-Commerce	Blockchain-Enabled Framework
Transaction Record Integrity	Platform-controlled, alterable	Immutable, consensus-verified
Dispute Resolution Authority	Platform-appointed arbitrators	Decentralized arbitrator pool
Product Provenance	Optional, platform-specific	Mandatory for registered products
Payment Escrow Control	Platform-held funds	Smart contract automated
Auditability	Limited, platform-dependent	Full transaction history available
Stakeholder Trust Basis	Institutional reputation	Cryptographic verification
Single Point of Failure	Yes (platform infrastructure)	No (distributed validation)
Dispute Rate (reported)	18% baseline	9% with smart contracts
Cost Structure	1.2% baseline	1.2% of traditional

Table 1: Comparative Analysis of Centralized E-Commerce vs. Blockchain-Enabled Framework

The comparative analysis utilizes empirical data generated through smart contract applications within the context of international e-commerce transactions. The reduction in the dispute rate and improvements in the cost structure offer validation of the design assumptions of the framework.

V. Discussion

From the results of the simulation, it can be concluded that blockchain technology-based transparency offers tangible gains in integrity of transactions and dispute resolution process efficiency. It can be noted that performance characteristics of the proposed framework allow one to see how the overhead related to consensus is mitigated by automation gains especially in post-delivery phases when centralized approaches demonstrate high latency. The dispute resolution procedure built on decentralized arbitration allows to solve the conflict of interest existing in the situation when the platform operates as both a marketplace and a dispute resolver.

There are a few limitations to mention. First of all, the simulation model ignores some real-world factors such as network splits, malicious validators and regulatory limitations on data storage. In case of Proof of Authority algorithm used in the framework, this assumption can be considered reasonable as long as this approach is suitable only for consortium e-commerce networks. However, this algorithm presupposes a level of coordination among the participants which could be difficult to achieve in competitive environment.

VI. Conclusion

This paper provides an approach to improving the transparency in today's e-commerce by means of a blockchain-based solution, which encompasses product registration, automation via smart contracts and dispute resolution on a decentralized basis. This paper identifies deficiencies of current e-commerce models from the perspective of transparency, as these models are characterized by centralization of transaction information, dispute resolution mechanisms and escrow accounts, with little to no accountability.

The theory contribution of this research is an example of application of the features of blockchain technology to solving specific issues in the context of trust and transparency problems in digital business. The identification of transparency needs and linking them to the corresponding solutions within the life cycle of transactions enables building a systematic approach to adopting blockchain technology, moving away from a general discussion of distributed ledger technologies to their implementation.

The implications for e-commerce players from this analysis is a clear path toward lower rates of disputes and transaction costs by way of automation along with greater consumer trust due to verifiable transparency. The comparative analysis demonstrates that blockchain implementation, done properly, does not necessarily have to involve a trade-off between transaction speed and integrity. Automation through smart contracts can achieve reduction of post-transactional lag time along with removing the intermediary's control over the release of funds.



Nonetheless, the route to adoption is far from being smooth. New regulatory policies have to be put into place to deal with issues related to liability assignment in the new system, data protection regulations compliance in different jurisdictions and the legal status of the agreements formed through the use of smart contracts. Technical problems such as interoperability of different blockchain networks, scalability of the system in peak transaction volumes and integration of the blockchain with existing enterprise infrastructure remain significant engineering concerns.

Some promising research directions to consider in the future include field deployment of e-commerce systems in operational contexts, hybrid architectures that marry blockchain's transparency with privacy features to protect business confidentiality, research on cross-chain interactions to allow multiple e-commerce ecosystems to participate in the process, and longitudinal research into consumer trust formation in e-commerce systems using blockchain technology.

The problems of transparency of modern e-commerce are structural because they derive from the concentration of information and adjudicative powers in a small number of central platforms. In contrast, blockchain technology provides different architectural designs to solve this problem. The framework proposed in this paper is an attempt to develop a systematic way of implementing this vision of architectural change into practice. Despite significant implementation difficulties, such solutions are justified by the potential of restoring the lost transaction transparency and consumer trust.

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