The Impact of Blockchain Contracts on Commercial Contracts

1. Amir Khajehzadeh*: Department of Private Law, Da.C., Islamic Azad University, Damghan, Iran

*Correspondence: 4579491777@iau.ac.ir

Abstract

The primary objective of this study is to examine structural transformations in the nature of commercial contracts, assess their compatibility with legal principles (such as digital offer and acceptance), and identify the opportunities and challenges involved in reconstructing traditional contracts within blockchain-based environments. This research adopts a descriptive–analytical approach and, through a review of library-based sources, conducts a comparative analysis of the technical foundations of blockchain and the legal frameworks governing commercial transactions. In this context, the technical architecture of smart contracts (including features such as immutability and self-execution) is analyzed in relation to principles of contract law (such as the theory of will and dispute resolution mechanisms), and practical scenarios in supply chains and international finance are examined. The findings indicate that blockchain-based contracts, through cryptographic algorithms, shift the "guarantee of performance" from judicial institutions to programming code. This shift leads to increased transparency, reduced risk of non-performance, and the elimination of discretionary judicial interpretations regarding explicit contractual terms. However, the rigid and immutable nature of such contracts presents significant technical and legal challenges when confronted with force majeure conditions, statutory options, and intentional modifications of contractual provisions, thereby necessitating the design of "upgradeable" smart contracts or hybrid models. Blockchain contracts are not merely instruments of automation but also catalysts for redefining the concept of "trust" in commercial relations. The study concludes that, for optimal utilization, legal systems must move toward the formal recognition of programming code as an expression of legal intent. It is also recommended that hybrid smart contract models, which integrate legal text with executable code, be employed to address interpretative gaps and enhance flexibility in complex commercial transactions.

Keywords: Smart Contracts, Blockchain, International Commercial Law, Contract Automation, Digital Arbitration

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1. Introduction

Today, blockchain technology has entered various economic and commercial spheres as one of the most advanced technological tools, and one of its most prominent applications is the use of smart contracts; a type of digital agreement that is executed automatically and does not require the intervention of third parties for the enforcement of its terms. On the one hand, these features increase efficiency and reduce the costs associated with contractual processes; on the other hand, they raise new

legal complexities, and the principal issue that may be analyzed in this regard is the emergence of disputes between the parties to smart contracts (Katouzian, 2025; Zare Sani & Anahid, 2024). Despite all the advantages of the self-executing nature of these contracts, disputes over terms, interpretation, or performance of obligations remain unavoidable.

The fundamental transformation in the infrastructures of transactions in the digital age, with the emergence of "distributed ledger technology" and, at its forefront, "blockchain," has entered a new paradigm. In this context, "smart contracts," as computer protocols operating on decentralized networks, have emerged not merely as a simple technical tool but as a structural redefinition in modern commercial law. Whereas traditional commercial contracts are substantively grounded in "natural language" and "third-party oversight" (such as judicial and banking institutions), blockchain-based contracts, through conditional logic and programming codes, have infused commercial agreements with the attributes of "self-execution" and "immutability."

From a technical perspective, the transition from text-based contracts to code-based contracts signifies the replacement of "institutional trust" with "algorithmic trust." In this setting, consensus algorithms and cryptographic hash functions guarantee the validity and integrity of transactions without the need for centralized intermediaries. This technological shift has had profound effects on key components of commerce, including the reduction of transaction costs, the elimination of risks associated with arbitrary interpretation of contractual terms, and the increase in the liquidity of assets (Ghavamabadi, 2024; Haddadi, 2024; Karimi & Karimi, 2022; Karshenas Najafabadi, 2022). Nevertheless, the rigid and definitive nature of programming code, in contrast with flexible legal concepts such as "good faith," "equity," and "change of circumstances," has generated emerging challenges at the intersection of computer science and civil law.

Accordingly, a precise understanding of the interaction between the data structure of blockchain and the legal regimes governing commercial contracts is not merely an option but a strategic necessity for actors in e-commerce and for legal scholars. The present article, with the aim of examining these effects, seeks to explain how the integration of blockchain into the execution layers of commercial contracts may lead to the formation of more autonomous and efficient ecosystems in supply chains and international finance, while also identifying the technical and legal solutions that may be envisaged to address the existing gaps in this path.

2. Genealogy of Blockchain Contracts in Relation to Commercial Contracts

The genealogy of smart contracts dates back to the 1990s and the theories of Nick Szabo. By analogizing a contract to a vending machine, he proposed the idea of converting legal conditions into hardware and software codes. This marked the beginning of a break from the tradition of "natural language" in commercial contracts and a movement toward the "language of mathematical logic," in which the execution of the contract was no longer entrusted to a judge or the police, but rather to the protocol itself (Gholizadeh, 2007; Karimi & Mirhosseini, 2024; Kayihan & Yildiz, 2004).

With the emergence of Bitcoin in 2009, the lineage of digital contracts became linked to the "distributed ledger." Although Bitcoin itself was not a complex smart contract platform, it provided the infrastructure for the "transfer of value without intermediaries." This stage is of vital importance in the genealogy, because for the first time, "ownership" and "transfer of assets" in commercial contracts were removed from the monopoly of central banks and registration institutions and entrusted to cryptographic algorithms (Clack et al., 2016; Khorrami, 2018).

The turning point in the technical genealogy was the introduction of Ethereum by Vitalik Buterin. By introducing the "virtual machine," Ethereum transformed blockchain from a merely monetary instrument into a "global computer." At this stage, commercial contracts moved beyond the format of a document and took the form of applications. This development made it possible to incorporate complex commercial conditions, payment schedules, and collateral mechanisms into the network's consensus layer (Karimi & Karimi, 2022).

In traditional commercial contracts, an obligation is a "promise," the breach of which requires judicial pursuit. In the blockchain genealogy, however, an obligation becomes a "technical event." The phrase "Code is Law" expresses that within the blockchain structure, there is no gap between the "intent of the contracting parties" and the "physical execution of the contract"; once the condition is fulfilled, the code automatically performs the obligation without any need for renewed permission from the parties.

One of the genealogical challenges of these contracts was the isolation of blockchain from external realities. The emergence of "oracles" as connecting bridges enabled blockchain contracts to receive real-world data (such as exchange rates, container temperature, or shipment status). This technical evolution connected commercial contracts from closed laboratory environments to global supply chains and the logistics industry (Koray, 2024; Rafiei, 2024).

In the course of development, the lineage of blockchain contracts intersected with "Ricardian contracts." This model combines human-readable legal text with machine-executable code. This approach was a technical response to interpretive gaps in blockchain and allowed commercial contracts, while benefiting from automation, to retain legal validity in classical courts and to cover abstract legal concepts. The genealogy of these contracts led to the emergence of decentralized autonomous organizations (DAOs). Here, a commercial contract is no longer merely between two persons; rather, the entire structure of a company is built on the basis of smart contracts. Profit distribution, voting rights, and strategic commercial decisions are all managed through blockchain code, thereby challenging the traditional hierarchy of company law (Ghavamabadi, 2024; Karshenas Najafabadi, 2022).

One of the genealogical features of blockchain is immutability. In traditional commercial contracts, the parties may rescind or amend the contract whenever they wish. In blockchain, however, once code is published, it cannot be altered. This technical deadlock led to the invention of "upgradeable smart contracts," which reflect the evolution of blockchain in adapting to the flexible realities of the commercial world (Koray, 2024).

In the modern genealogy, the paradox between "blockchain transparency" and "commercial confidentiality" is being addressed through technologies such as ZK-Proofs. New commercial contracts built on blockchain make it possible to prove the performance of an obligation (such as financial capacity) without disclosing sensitive commercial details. This security layer has made blockchain contracts more attractive for sensitive industries such as banking and defense (Haddadi, 2024).

Ultimately, the genealogy of blockchain contracts shows that we are moving toward a condition in which the boundary between "technology" and "law" is gradually disappearing. The commercial contracts of the future will not be documents stored in archives, but rather living and dynamic entities in digital space, deriving their validity not from physical seals and signatures, but from computational validity and network consensus. This path promises faster, cheaper commerce with lower risks of fraud.

In the Iranian legal system, smart contracts based on blockchain technology, in the absence of specific legislation, are categorized as "electronic contracts" and, pursuant to the principle of freedom of contract (Article 10 of the Civil Code), are deemed valid provided that they satisfy the general conditions for the validity of transactions (intent, capacity, a definite subject matter, and lawful cause). Nevertheless, the self-executing, decentralized, and immutable nature of these contracts creates serious challenges in reconciling them with traditional legal principles such as rescission by mutual agreement, the exercise of legal options, and the intervention of judicial institutions in the process of contractual enforcement (Katouzian, 2025). Although existing laws such as the Electronic Commerce Law and the Civil Procedure Code implicitly permit the use of digital signatures and data registration, the absence of explicit rules for determining the "governing law" of cross-border contracts, specifying "judicial jurisdiction" in relation to decentralized global nodes, and defining "liability" in cases of software error reveals deep legal gaps that require the formulation of new regulations and the redefinition of the concepts of "obligation" and "judicial validation" in order to adapt to this new technological phenomenon.

3. Structural Analysis of the Impact of Blockchain on the Elements of Commercial Contracts

3.1. Digital Offer and Acceptance

The manner of expressing intent in decentralized networks. In traditional contracts, offer and acceptance are expressed through explicit words or writings; in blockchain, however, the expression of intent takes the form of a "digital signature" using a private key. Offer here means the publication of smart contract code on the network, and acceptance is realized through the user's interaction with that code (for example, sending a transaction to the contract address). The principal challenge here is the determination of the precise moment at which the wills meet, because in some networks, the finalization of the contract depends on the confirmation of nodes and registration in a valid block, rather than merely on the sending of a message by the parties. Electronic offer has distinctive characteristics, the principal features of which may be summarized in several points:

electronic offer is a remote declaration of intent. Therefore, in order to protect the addressees of electronic offers, who are often consumers, the legislator has provided specific rules, which the offeror is generally required to observe (Katouzian, 2025; Moghami Nia, 2012). Among these, in the offer for the sale of goods or services, the offeror is obliged to disclose identifying information and address, determine the subject matter of the contract and its characteristics, state the price of the goods and services offered, specify the method of payment, the period of the right of withdrawal, the warranty period, and after-sale services. Iranian legislators have enacted specific provisions in the Electronic Commerce Law to protect consumer rights in electronic contracts. Under Article 33 of that law, sellers and suppliers of goods and services are obligated to provide information effective in buyers' decision-making before the conclusion of the contract. Based on this provision, it may be argued that an electronic offer must contain all information relevant to the decision to accept the offer.

3.2. Identity of the Contracting Parties

Blockchain is inherently based on "pseudonymity"; that is, parties are identified by their wallet addresses rather than by their real identities (Koray, 2024). This issue is challenging in commercial contracts that require legal capacity (legal age, absence of interdiction, and the like). To resolve this contradiction, concepts such as "decentralized identity" and identity-verification oracles have been proposed so that, without disclosing all personal information, an individual's "legal qualification" to conclude a commercial contract may be cryptographically verified and anti-money laundering (AML) requirements may be observed.

3.3. Subject Matter of the Transaction

Blockchain makes it possible to convert physical assets (such as real estate, goods, and gold) or intangible assets (such as patents and copyright) into digital units known as "tokens." In this structure, the subject matter of the transaction is no longer a physical object or paper document, but the transfer of ownership of a "token" within the distributed ledger (Karshenas Najafabadi, 2022). This process increases the liquidity of frozen assets and enables "fractional co-ownership" on a small scale, such that a large commercial property can be divided into micro-tokens and traded among thousands of investors.

3.4. Consideration and Price

In blockchain contracts, the price is usually paid in cryptocurrency or "stablecoins" (digital currencies with a fixed price equivalent to the dollar or gold). The outstanding technical feature here is "instantaneous and simultaneous settlement"; that is, the transfer of ownership of the good (token) and the payment of the price (digital currency) occur simultaneously and conditionally upon one another (Khorrami, 2018; Koray, 2024). If one of the parties fails to perform its obligation, the entire transaction is automatically canceled. This eliminates the risk of default and removes the need for intermediary banking systems and clearing houses.

4. Effects and Operational Consequences in Commercial Law

4.1. Self-Execution

In traditional contracts, the performance of obligations depends on the "secondary will" of the parties after signing the contract; in blockchain, however, contractual terms are programmed in the form of "if-then" computer code. As soon as the stipulated condition is fulfilled (for example, confirmation of delivery by an oracle), the code automatically and without the need for human intervention or renewed permission from the debtor transfers the price from the buyer's wallet to the seller (Rafiei, 2024; Zare Sani & Anahid, 2024). This mechanism minimizes the risk of default and eliminates the need for guarantors, banks, or intermediary collateral institutions.

4.2. Immutability

One of the technical characteristics of blockchain is the impossibility of deleting or altering data once they are registered on the network. From a legal perspective, this feature conflicts with flexible contractual concepts such as rescission by mutual agreement or unilateral termination. In rigid smart contracts, even if the parties regret their agreement, the code continues on its course. To address this challenge, technical architects use "upgradeable contracts" or contracts equipped with a "kill switch" so that amendment of the terms or invalidation of the contract becomes possible in the event of mistake or a new agreement.

4.3. Transparency and Traceability

Blockchain creates a "shared ledger" to which all stakeholders in the supply chain (manufacturer, carrier, customs authority, and final buyer) have access. Every event (such as loading goods or changes in container temperature) is recorded instantaneously and irrefutably (Haddadi, 2024; Karimi & Mirhosseini, 2024). This transparency makes it possible to trace the authenticity of goods, and disputes arising from the loss of goods or delay in shipment can easily be resolved on the basis of tamper-proof data recorded on the blockchain, the result of which is greater trust and transparency in international trade.

4.4. Reduction of Transaction Costs

According to Ronald Coase's theory, firms arise when the cost of conducting exchanges in the market (search costs, negotiation, drafting of contracts, and monitoring performance) exceeds the cost of internal management. Smart contracts, by automating processes and eliminating the need for third-party confirmations (such as notary offices or banks), sharply reduce "transaction costs." (Karimi & Karimi, 2022; Karshenas Najafabadi, 2022) From this perspective, blockchain allows complex commercial transactions to be carried out directly between strangers at very low cost, which may lead to the transformation of the structure of large firms toward decentralized commercial networks.

5. Technical and Legal Challenges Ahead

5.1. The Gap Between Code and Intent

In classical law, the "real intent" of the contracting parties takes precedence over their "apparent intent"; in blockchain, however, intent is translated into programming language (such as Solidity). The challenge arises when, because of technical complexity or error in coding logic, what is "executed" differs from what the parties "intended." This "semantic gap" may result in the contract being executed unfairly, whereas in the world of code there is no way to prove mistake or verbal misunderstanding, and the code finalizes the operation without regard to inward intention.

5.2. The Role of Oracles

Smart contracts, by themselves, do not have access to real-world data (such as real-time exchange rates, weather conditions, or customs certificates) and depend on "oracles" to obtain such information. An oracle is in fact a bridge between the physical world and blockchain. The major risk here is "data corruption or oracle error"; if an oracle is hacked or sends incorrect information, the smart commercial contract is automatically and irreversibly executed on the basis of that incorrect data. This dependency poses a serious challenge to the principle of decentralization in blockchain.

5.3. Civil Liability

In the event of damage caused by software bugs or hacking of smart commercial contracts, determining the "liable party" is extremely difficult. Is the programmer who wrote the code responsible? Or the auditing company that confirmed its security? Or the network nodes that processed the transaction? In decentralized environments where the identity of developers is often concealed, the traditional system of civil liability reaches a deadlock in compensating the injured party, because finding a "defendant" to sue before the courts becomes practically impossible.

5.4. Force Majeure and Unforeseen Events

Concepts such as “force majeure” or “hardship” are flexible notions requiring judicial interpretation. Smart contracts are “deterministic”; they cannot determine whether the occurrence of a war or earthquake has made the performance of the contract impossible. The code continues to pursue execution of the condition, and if there is collateral or money involved, it seizes or transfers it. The incorporation of “emergency stop” clauses or the use of human arbitration to identify cases of force majeure are among the proposed solutions to this conflict between technical rigidity and legal flexibility.

6. Dispute Resolution in the Blockchain System

6.1. Smart Arbitration

In Iranian law, this type of arbitration for dispute resolution is defined without any human intervention, and the role of the arbitrator is performed entirely by artificial intelligence, which evaluates and processes the dispute. The most important distinction between this type of arbitration and other forms of arbitration is the absence of an arbitrator as a natural person. Although online arbitration is closer to this type, only the platforms for the realization of smart arbitration are similar to those of this kind of arbitration. In smart contracts, traditional court and prosecutorial mechanisms are inefficient because of their slowness and high cost. “Smart arbitration” is a solution that implements decentralized dispute resolution protocols on blockchain. In this system, as in platforms such as Kleros, arbitrators are selected randomly and proceed to adjudicate the dispute. Their decision is enforced automatically not on the basis of textual evidence, but according to “consensus assembly” protocols and through tokens of reward and penalty. This approach increases the speed of proceedings and transforms the enforcement guarantee of the award into an “automatic-governance” model, but challenges related to the quality of arbitration and the lack of expertise in complex commercial laws remain.

6.2. The Challenge of Judicial Jurisdiction

One of the most complex legal challenges in smart contracts is the “placelessness” of the network. When a contract is concluded between two parties on two different continents through a decentralized network, it is unclear which country’s court has jurisdiction and which country’s law governs the contract. Unlike traditional contracts, which usually define the “governing law” and the “competent forum” in specific clauses, in decentralized environments these agreements are often ambiguous or unenforceable. This situation leads either to a “race to the bottom” in law or to legal deadlocks that require the formulation of new rules in private international law.

7. Comparative Examination and the Status in Iranian Law

7.1. Compliance with the Civil Code (Articles 10 and 190)

For a smart contract to be valid under the Iranian legal system, it must satisfy the conditions set forth in Article 190 of the Civil Code (determination of the parties, a definite subject matter, and lawful cause) as well as the principle of freedom of contract contained in Article 10 of the Civil Code (the validity of contracts so long as they do not conflict with public order).

Capacity: In Iranian law, the capacity of the parties (adult, sane, and prudent) is a condition of validity. In blockchain, if the user is anonymous, verification of capacity is difficult.

Lawful Cause: If the subject matter of the transaction (such as digital currency for unlawful transactions) is contrary to religious standards or public order, the smart contract may be executed automatically, but it will be void before Iranian courts.

Definiteness of the Subject Matter: Tokenized assets must be a “definite” subject matter of the transaction so that the contract is not rendered void.

As a result, although blockchain in itself is compatible with Article 10 of the Civil Code (regarding freedom of contract), in cases where the anonymous and irreversible nature of code conflicts with Iranian legal concepts (such as the option for lesion or rescission by mutual agreement), the smart contract faces challenges of legitimacy in the Iranian legal system.

7.2. Compliance with the Iranian Electronic Commerce Law

The Electronic Commerce Law of 2003 provides the initial legal framework for smart contracts: 1) **Digital Signature:** A smart contract is based on a digital signature (private key), which is consistent with the principle of validity of digital signatures under Article 2 of this law. 2) **Data Message:** Blockchain is in fact a system for storing "data messages," and therefore data recorded in it are legally admissible. 3) **Documentary Value:** Although the Electronic Commerce Law permits the use of data messages, it is still unclear whether a "smart contract" by itself, in the event of dispute, may be invoked before Iranian courts as an "official document" or an "ordinary document."

Nevertheless, the Electronic Commerce Law lacks specific rules for "automatic execution," "decentralization," and "digital currencies," all of which are inherent features of smart contracts.

7.3. Judicial Practice and Existing Legal Obstacles in Iran

At present, Iranian judicial practice and the legal status of smart contracts face serious challenges: 1) **Absence of Specific Legislation:** No specific law or regulation explicitly defining or governing "smart contracts" has yet been enacted in Iran. 2) **International Sanctions:** Due to sanctions, the use of international blockchain networks (such as Ethereum) for Iranian commercial contracts is subject to technical and legal restrictions. 3) **Liquidity and Settlement:** According to Central Bank rules, only the rial may be used as "legal tender" in Iran; therefore, cryptocurrencies are prohibited for official settlement. 4) **Liability and Supervision:** In the event of dispute, Iranian courts currently lack the ability to obtain "technical evidence" from blockchain and to identify the "technical responsible party." Until the legislator establishes a clear framework for "decentralized identity verification," the regulation of "Ricardian contracts," and "dispute resolution mechanisms," smart contracts in Iran will remain usable only at the level of merchants and private companies as informal instruments.

8. Conclusion

In recent years, blockchain contracts have emerged as one of the most important technological innovations in the field of commerce and have succeeded in creating significant changes in the structure, execution, and supervision of commercial contracts. The conclusion drawn from the examination of this issue is that these contracts, rather than serving as a complete substitute for traditional contracts, function as a complementary and facilitative instrument in commercial relations. Their principal features are self-execution, transparency, reduction of intermediary costs, speed in the performance of obligations, and reduction in the likelihood of breach. However, these advantages coexist with numerous legal and technical challenges. From the perspective of legal nature, a blockchain contract cannot be regarded merely as computer code, nor can it be considered entirely equivalent to classical legal contracts. In reality, this type of contract is a combination of technical logic and the legal intent of the parties; that is, an agreement written in programming language and executed on the blockchain. Therefore, its legal validity depends upon the establishment of the essential elements of contract, such as intention and consent, capacity, a definite subject matter, and lawful cause. Although its performance is automatic, such automaticity does not necessarily mean full independence from legal rules. For this reason, in analyzing the nature of these contracts, a distinction must be drawn between the "executable code" and the "legal contract." In terms of challenges, the most significant issues in blockchain contracts include ambiguity in verifying the identity of the parties, the difficulty of amending or terminating the contract once it has been recorded on the chain, conflict with mandatory legal rules, the problem of coding error, the determination of liability in the event of technical defect, and the difficulty of interpreting complex terms in the form of code. Furthermore, one of the most important challenges is that smart contracts in many cases lack the flexibility necessary to address unforeseen circumstances, whereas traditional commercial contracts usually allow interpretation, adaptation, and the application of principles such as good faith, the no-harm rule, or impossibility. Thus, although blockchain may increase efficiency, in cases of dispute it may also restrict the ability of the judge or arbitrator to correct unjust outcomes. In Iranian law, the dominant approach remains cautious and analytical. Although Iranian lawmakers have not yet enacted a specific and comprehensive law on smart contracts, their principled validity may still be accepted on the basis of the general rules of contract law in the Civil Code, provided that the essential conditions for the validity of transactions are observed. In other words, the principle of freedom of contract, Article 10 of the Civil Code, and the rules relating to transactions and obligations may serve

as a basis for the gradual acceptance of this type of contract. Nevertheless, in areas in which the law prescribes specific formalities or special protective regulations, the use of blockchain contracts must be approached with greater caution. In practice as well, the absence of legal and technical infrastructure, the lack of precise recognition of digital signatures in all scenarios, and the absence of clear judicial practice have prevented the widespread expansion of these contracts in Iranian commerce. The overall conclusion is that blockchain contracts may transform the future of commercial contracts, but this transformation will be sustainable and beneficial only if transparent legal frameworks, reliable technical standards, dispute resolution mechanisms, and rules for the amendment, suspension, or interpretation of contracts in exceptional cases are designed. Otherwise, there is a risk that technical speed and certainty will replace justice and legal flexibility. Therefore, the best approach in Iran is neither the complete rejection of this technology nor its unconditional acceptance; rather, it is an integrated and cautious approach grounded in the principles of private law and the needs of electronic commerce.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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