Adv. J. Manag. Humanit. Soc. Sci. (**2026**), Volume 2, Issue 3, 281-287

Advanced Journal of Management, Humanity and Social Science

Journal homepage: https://www.ajmhss.com/

DOI: https://doi.org/10.5281/zenodo.21864217

Legal Analysis of Smart Contracts and Challenges of Their Enforcement in the Iranian Legal System

Nima Asadi Azizabadi

Master's Degree, Department of Law of Documents and Commercial Contracts, University of Judicial Sciences and Administrative Services

Article info

Received: 12.06.2026

Accepted: 06.08.2026

Available Online: 09.08.2026

Checked for Plagiarism: Yes

Keywords:

Smart Contract, Blockchain, Contract Law, Information Technology Law, Electronic Commerce Law

ABSTRACT

The expansion of blockchain technology and the evolution of digital platforms have led to the emergence of new concepts in contractual relations, of which "smart contracts" are among the most significant. These contracts are designed as blockchain-based computer programs that execute the terms of the parties' agreement in the form of digital codes and enable the automatic performance of obligations without the need for traditional intermediaries. Such features have increased the speed, transparency, and efficiency of transactions. However, the introduction of this technology into the field of contract law has raised fundamental questions regarding the legal nature, validity, and enforcement of such contracts in various legal systems, particularly those based on classical traditions. The aim of this research is to elucidate the legal nature of smart contracts and analyze the challenges of their enforcement in the Iranian legal system. The research method is descriptive-analytical, and data have been collected through library studies and the examination of domestic and international legal sources. Additionally, with a comparative approach, some legislative experiences of other countries in this field have been examined. The findings indicate that, despite technical differences, smart contracts can be analyzed within the framework of general contract rules. The principle of party autonomy and Article 10 of the Civil Code provide the capacity to accept this type of contract, and the Electronic Commerce Law, by recognizing data messages and electronic signatures, has established a basis for the validity of digital transactions. However, challenges such as ascertaining the true intent of the parties, determining liability for technical errors, and the conflict between the immutability feature of blockchain and institutions such as rescission and mutual rescission persist. Accordingly, the formulation of supplementary regulations, the development of legal infrastructure, and the enhancement of specialized knowledge appear essential for the safe and effective utilization of this technology.

Introduction

The expansion of modern digital technologies in recent decades has fundamentally transformed traditional legal and economic structures. One of the most important achievements of these transformations is the emergence of smart contracts; contracts designed on the blockchain technology platform that provide for the automatic execution of contractual obligations without the need for direct intervention by persons or intermediary institutions [1].

These types of contracts, utilizing programming codes and cryptographic mechanisms, enable the recording and execution of agreements in a transparent, immutable, and reliable manner, and for this reason, they have attracted the attention of many researchers in the fields of law and technology [2]. Despite the significant advantages of smart contracts, including increased transaction speed, reduced intermediation costs, and enhanced transparency in contractual relations, the

Corresponding Author:* ***Nima Asadi Azizabadi* *(nimaasadi14764@gmail.com)*

introduction of this phenomenon to traditional legal systems is accompanied by numerous challenges.

Many legal systems have not yet developed a clear framework for identifying and regulating this type of contract, which has led to ambiguities regarding their legal nature, validity, and enforcement [3]. In the Iranian legal system, the issue of smart contracts faces similar challenges. Although the general principles of contract law, particularly the principle of freedom of contract enshrined in Article 10 of the Civil Code, allow for the conclusion of various types of modern contracts, important questions arise regarding the adaptation of smart contracts to concepts such as intent and consent, the capacity of the parties, the method of proving the contract, and liability arising from defects in programming codes. Furthermore, although Iran's Electronic Commerce Law has recognized some legal foundations for electronic transactions and digital signatures, this law has not specifically addressed blockchain-based contracts and their self-executing mechanisms [4]. Accordingly, examining the legal dimensions of smart contracts and analyzing the challenges of their enforcement within the framework of the Iranian legal system is of particular importance. The present research has been conducted with the aim of elucidating the legal nature of smart contracts, examining their compatibility with the principles of contract law in Iran, and identifying the most important obstacles and challenges to the enforcement of this type of contract.

Theory and Literature Review

The emergence of blockchain technology and the expansion of its application in various economic and legal fields have given rise to a new type of agreement known as "smart contracts." A smart contract, in its simplest definition, is a set of computer codes that translate the terms of an agreement into machine language and guarantee its automatic execution upon the fulfillment of predetermined conditions [1]. In this structure, the data and obligations of the parties are recorded on a distributed ledger, and cryptographic and consensus mechanisms ensure its security and immutability [5]. Thus, the smart contract lies at the intersection of contract law and information technology, and this connection raises serious theoretical and practical questions in the legal domain.

From a technical perspective, smart contracts are based on three main pillars: first, blockchain as the infrastructure for recording and storing data; second, asymmetric cryptographic algorithms that enable authentication and digital signatures; and third, specific programming languages such as Solidity used for coding contractual conditions [2]. The existence of consensus mechanisms such as Proof of Work (PoW) or Proof of Stake (PoS) ensures the validity of transactions without the need for a centralized authority [5]. These features distinguish smart contracts from conventional electronic contracts, which are merely the digital form of traditional contracts; because in smart contracts, execution is also automatic and code-based, not merely the conclusion and exchange of data messages. At the theoretical level, three major approaches regarding the legal nature of smart contracts have been proposed in the literature. One group of authors considers them to be nothing more than "classic contracts in a new format" and believes that general contract rules govern them, with only the means of execution having changed [2]. Another group considers the smart contract to be essentially "executable code" and distinguishes it from the legal concept of a contract [3]. The third approach, which has received attention in more recent works, attributes a dual nature to this phenomenon, meaning that one layer is the legal agreement between the parties, and the other layer is the computer code that automatically executes the agreement [5]. The dual approach appears more suitable for comparative analysis in various legal systems, including that of Iran.

In Iranian law, the analysis of smart contracts must inevitably begin with the framework of general contract rules, particularly Article 10 of the Civil Code, which recognizes the principle of freedom of contract and considers private agreements valid as long as they do not conflict with the law, public order, or good morals [6]. Accordingly, as long as a smart contract possesses the essential elements of a contract namely, intent and consent, capacity, a definite subject matter, and lawful consideration it can theoretically be placed within the framework of valid contracts [7]. On the other hand, the Electronic Commerce Law, by recognizing data messages, electronic signatures, and the validity of electronic documents, has provided a legal basis for accepting modern forms of contract conclusion and proof to some extent [4]. However, these laws have not specifically addressed blockchain and self-executing contracts, and this constitutes the basis for many legal ambiguities. It is noteworthy that numerous theoretical and practical challenges regarding smart contracts have arisen in the Iranian legal system. One of the most important of these challenges is the manner of ascertaining "intent and consent" in situations where the terms of the contract are written in code and algorithmic form, and ordinary users do not directly see the legal text [3]. Another issue is determining liability in the event of coding errors or cyberattacks; whether liability rests with the programmer, the user, the hosting platform, or all of them jointly, requires precise legal analysis [2]. Furthermore, the immutability feature of blockchain makes the modification, rescission, or termination of the contract difficult, and this situation is not fully compatible with the traditional rules regarding options and the possibility of contract rescission in Iranian law [6].

Regarding the foreign research background, numerous works have examined the legal aspects of smart contracts, including Szabo (1997), who, by proposing the initial idea, emphasized the "self-executing" function of these contracts and their role in reducing transaction costs [1]. Werbach and Cornell (2017), in an article on smart contracts and machines, demonstrate that smart contracts cannot completely replace contract law but must be understood alongside the existing legal system [8].

In examining the domestic background, in recent years, articles and dissertations have addressed various dimensions of smart contracts. Some research has analyzed the possibility of validating smart contracts based on Article 10 of the Civil Code and the principle of party autonomy, concluding that from a theoretical perspective, there is no explicit prohibition against accepting this type of contract, provided that their terms do not conflict with mandatory laws and religious standards [6,7]. Another group of studies has focused on digital signatures, data messages, and the admissibility of electronic documents within the framework of the Electronic Commerce Law and has attempted to demonstrate that the infrastructure of this law can be extended to blockchain-based contracts as well [4]. Additionally, works in the field of contemporary transaction jurisprudence, particularly concerning cryptocurrencies and blockchain-based financial instruments, have raised discussions about legitimacy, uncertainty (gharar), and usury (riba), which are indirectly related to smart contracts.

In general, it can be said that despite these efforts, the review of the background indicates that most domestic studies have either focused on the technical and economic aspects of blockchain or have only partially and sporadically examined some legal dimensions of smart contracts, such as electronic signatures or civil liability. Few studies have comprehensively addressed the combination of three axes: "the legal nature of smart contracts," "challenges of their enforcement in adjudication and dispute resolution," and "solutions for amending and completing the existing legal framework in Iran." Therefore, the present research, drawing on the theoretical literature and relying on the foundations of Iranian civil law and electronic commerce law, provides a coherent analysis of the status of smart contracts in the Iranian legal system, identifies existing legal and interpretive gaps, and proposes solutions to address them.

Methodology

This research is classified as descriptive-analytical in nature. In the descriptive phase, fundamental concepts including blockchain technology, smart contracts, their technical elements, and legal requirements are explained based on authoritative domestic and international sources. In the analytical phase, Iranian legal rules and principles particularly the Civil Code and the Electronic Commerce Law of 2003 are compared with the inherent characteristics and enforcement mechanisms of smart contracts, and the degree of compatibility or conflict is examined through inferential analysis. In terms of purpose, the present study falls within the category of applied research, as it seeks not only to analyze the nature and legal challenges of smart contracts but also to provide practical solutions based on Iranian legal foundations for the legislator, the judiciary, and regulatory bodies in dealing with this phenomenon. Thus, the research findings, in addition to enriching the scientific literature, have the potential to be utilized in legal policy-making and technology regulation. The data collection method is library-based and documentary. Data have been extracted through the systematic study of books, scientific-research articles, dissertations, regulatory drafts, specialized legal reports, international documents, as well as domestic laws and regulations including the Civil Code, the Electronic Commerce Law (2003), the Computer Crimes Law, and related directives. In terms of comparative methodology, the research employs an analytical-comparative model to compare the existing rules in the Iranian legal system with the practices and regulations of some leading legal systems in the field of blockchain and smart contract regulation. The purpose of this comparison is to identify points of divergence, convergence, and possible gaps in Iran's legal framework and to extract patterns compatible with the domestic legal structure for use in policy-making and legislation. The data analysis method is based on legal analysis, inferential reasoning, and purposive interpretation. To this end, general legal principles such as party autonomy, attribution, rules of evidence, the effects of mistake, and liability arising from the act of a third party, alongside specific rules of electronic documents and digital signatures, are revisited and compared with the self-executing and immutable structure of smart contracts. Subsequently, an attempt is made to infer the compatibility or incompatibility of smart contracts with Iranian law by drawing upon jurisprudential foundations and authoritative domestic legal theories. Finally, the results of these analyses are presented as recommendations for legislative amendment, regulation, and the development of judicial practice.

Analysis of Findings

The research findings indicate that smart contracts, as one of the most important applications of blockchain technology, have significant potential to transform the manner of concluding and executing contracts. Features such as automatic execution of obligations, reduced need for intermediaries, increased transparency, and lower transaction costs are among the advantages that have made this type of contract attractive in many economic and

commercial fields. However, the examination of legal foundations shows that the introduction of this technology into traditional legal systems is accompanied by numerous conceptual and practical challenges, as the technical structure of smart contracts differs from many classical concepts of contract law. From a legal perspective, the first important finding of the research concerns the legal nature of smart contracts. The analysis of the legal literature indicates that smart contracts cannot be considered merely as independent contracts distinct from traditional contracts; rather, in most cases, they should be regarded as a technological tool for the execution of contractual agreements. In other words, in many cases, the "contract" is formed as a legal agreement between the parties, and its terms are then implemented in the form of computer codes to enable automatic execution. Therefore, from a legal perspective, one can speak of a dual structure that includes a "legal agreement" and an "executable code."

Table 1. Comparison of Legal and Technical Dimensions of Smart Contracts

Dimension Examined	Traditional Legal Agreement	Smart Contract Code
Nature	Voluntary agreement between parties based on contract law rules	Programmed instructions for automatic execution
Language	Natural (legal) language	Programming language (e.g., Solidity)
Method of Execution	Requires human supervision or intermediary institutions	Automatic execution on the blockchain platform
Flexibility	High (interpretable and amendable)	Low (rigid and based on code logic)
Role of Intermediaries	Prominent (courts, arbitration, intermediaries)	Minimal or eliminated
Transparency	Relative (depending on access to the contract)	High (recorded on a distributed ledger)
Amendability	Possible through renegotiation	Difficult; requires code modification or new contract
Risks	Different interpretations, legal disputes	Coding errors, security vulnerabilities
Enforcement Guarantee	Legal and judicial guarantees	Automatic execution without need for external guarantee

It is noteworthy that within the framework of Iranian law, the principle of party autonomy and Article 10 of the Civil Code provide significant capacity for accepting new forms of contracts. Based on this principle, private agreements are considered valid and enforceable as long as they do not conflict with mandatory laws, public order, or good morals. Therefore, if a smart contract possesses the essential elements of a contract including the parties' intent and consent, capacity, a definite subject matter, and lawful consideration it can be considered legally valid. Furthermore, the Electronic Commerce Law, by recognizing data messages and electronic signatures, has provided a preliminary framework for the validity of electronic transactions, which can to some extent encompass contracts based on modern technologies.

Despite these capacities, there are numerous legal challenges in the path of enforcing smart contracts in the Iranian legal system. One of the most important challenges is the issue of ascertaining the true intent and consent of the parties in situations where the contract terms are written in coding language and may not be fully comprehensible to the contracting parties. This issue can create problems in contract interpretation and the ascertainment of the parties' true intent. Another significant challenge concerns legal liability in the event of errors or defects in the coding of the smart contract. Since contract execution occurs automatically and without direct human intervention, determining the responsible party in the case of technical errors or cyberattacks can be complex. In such cases, the question arises as to whether liability rests with the programmer, the platform designer, the contract users, or a combination thereof. The absence of explicit regulations in this area can lead to ambiguity in judicial proceedings and dispute resolution.

Another important finding of the research is the issue of data immutability in blockchain. One of the fundamental features of blockchain is the immutable recording of information, which technically enhances security and trust; however, from a legal perspective, this feature can conflict with certain contract law institutions such as rescission, mutual rescission, or contract amendment. While traditional law allows for the amendment or dissolution of a contract under certain conditions, in smart contracts, the execution of the code may be designed in such a way that such changes are not easily possible. In summary, it can be said that although the Iranian legal system has capacities to accept smart contracts through general contract rules and electronic transaction regulations, the absence of specific and clear regulations in this area can cause ambiguity in the validity, interpretation, and enforcement of this type of contract. Therefore, it appears that for the effective utilization of the capacities of this

technology, it is necessary for the legislator and regulatory bodies to provide the conditions for the safe and secure use of smart contracts through the formulation of supplementary regulations, the establishment of clear legal frameworks, and the development of legal and technical infrastructure.

Table 2. Legal Challenges of Smart Contracts in the Iranian Legal System and Proposed Solutions

Challenge Axis	Description of the Issue	Existing Legal Basis in Iran	Gap/Challenge	Proposed Solution
Ascertaining Intent and Consent	Incomplete understanding of code terms by parties	Articles 190 and 10 of Civil Code	Ambiguity in ascertaining true intent	Requirement for written version/legal explanation alongside code
Nature of Contract	Duality between legal agreement and executable code	Principle of party autonomy	No explicit definition of smart contract	Legal recognition of "smart contract" as a tool for obligation enforcement
Liability for Code Errors	Occurrence of errors or defects in programming	Rules of civil liability	No designated responsible party	Definition of joint liability (programmer, platform, users)
Cyberattacks	Intrusion or exploitation of the contract	Computer Crimes Laws	Lack of specific coverage for blockchain contracts	Formulation of specific security regulations for smart contracts
Immutability	Conflict with rescission, mutual rescission, amendment	Institutions of rescission and mutual rescission in Civil Code	Inability to apply classical institutions	Design of "kill switch/amendment key" in the code
Contract Interpretation	Difficulty in interpreting code for judges	Principles of contract interpretation	Lack of technical expertise in judicial authorities	Establishment of technical-legal expert bodies
Electronic Signature	Validity of attribution of contract to parties	Electronic Commerce Law	Ambiguity in adaptation to blockchain	Development of blockchain-based digital signature standards
Dispute Resolution	Absence of specific mechanism for litigation	Civil Procedure Code	No provision for specialized arbitration	Development of specialized technology arbitration (Tech Arbitration)

Conclusion

Smart contracts, as one of the transformative consequences of blockchain technology, have the capacity to fundamentally change the traditional method of concluding and executing contracts. Features such as automatic execution of obligations, elimination of intermediaries, reduction of transaction costs, and increased transparency have made this type of contract an attractive tool in economic and commercial systems. However, the introduction of this technology into the domain of contract law, particularly in traditional legal systems such as that of Iran, raises fundamental questions and challenges that cannot be fully resolved without a review of legal rules and regulatory mechanisms.

Based on the studies conducted, from the perspective of Iran's legal theoretical foundations, there is the necessary capacity to recognize smart contracts. The principle of party autonomy and Article 10 of the Civil Code allow for the acceptance of new forms of contracts, and the Electronic Commerce Law, by recognizing data messages and electronic signatures, has established a minimal framework for technology-based transactions. Therefore, smart contracts can be analyzed in terms of their legal nature as valid and enforceable contracts, provided that the essential elements of a contract are observed and their terms do not conflict with mandatory laws and public order. Despite these capacities, the research findings indicate that smart contracts face significant challenges in practice. These include ascertaining the intent and consent of parties in contracts drafted in code language, determining liability in the event of software errors or cyberattacks, and the relative incompatibility of the immutability feature of blockchain with institutions such as rescission, mutual rescission, or contract amendment. These challenges demonstrate that relying solely on general contract rules cannot address all issues arising from smart contracts, and the existence of complementary legislative and technical frameworks is essential. It is noteworthy that the comparative study also showed that many leading legal systems, despite their principled

acceptance of smart contracts, have taken steps to formulate guidelines, supplementary regulations, and legal and technical standards to resolve ambiguities. Some countries have attempted to create a clearer boundary between the legal agreement and the executable code by presenting dual contract models combining smart codes and legal contracts. These experiences can provide suitable models for the Iranian legislator to ensure that, on one hand, technological innovations are not restricted, and on the other hand, the legal security of transactions is maintained. Overall, the research conclusion indicates that although the Iranian legal system currently has the capacity to accept smart contracts, for the optimal utilization of this technology and the prevention of legal disputes, it is necessary for the legislator to formulate special regulations regarding blockchain-based digital signatures, legal liabilities arising from code errors, the ability to amend or suspend the execution of smart contracts, and dispute resolution rules. Furthermore, the development of technical knowledge alongside specialized training for judges, lawyers, and economic actors will play an important role in ensuring the correct and secure use of smart contracts. Such an approach will both pave the way for digital transformation in the country and enhance the legal security of actors in commercial and technological fields.

Table 3. Legal Status of Smart Contracts in Iran and Recommendations

Analysis Axis	Current Status in Iranian Law	Main Challenges	Legislative and Executive Recommendations
Basis of Validity	Acceptance based on party autonomy and Article 10 of Civil Code	Absence of explicit definition of smart contract	Legal recognition of smart contracts as an execution format for contracts
Essential Elements of Contract	Compatible with intent and consent, capacity, definite subject matter, lawful consideration	Difficulty in ascertaining true intent in code environment	Requirement for interpretability and existence of supplementary legal text
Electronic Transactions Framework	Recognition of data messages and electronic signatures in Electronic Commerce Law	Incomplete compatibility with blockchain technology	Development of specific regulations for blockchain-based digital signatures
Contract Execution	Possibility of automatic execution through code	Risk of software errors and cyberattacks	Formulation of specific civil liability rules for smart contracts
Legal Liability	Based on general civil liability rules	Ambiguity in determining responsible party (programmer, platform, user)	Definition of a multi-layered and transparent liability system
Contract Flexibility	Possibility of rescission, mutual rescission, amendment in traditional law	Incompatibility with blockchain immutability	Provision of technical mechanisms such as contract suspension or amendment in the code
Dispute Resolution	General adjudication system and arbitration	Lack of technical expertise in handling claims	Establishment of specialized bodies and technology-oriented arbitration
Comparative Approach	Experience of leading countries in regulation	Legislative gap with global standards	Benchmarking dual contract models (legal–code)
Institutional Infrastructure	Absence of a specific institutional framework	Institutional and educational unpreparedness	Specialized training in technology law for judges and lawyers

Disclosure Statement
No potential conflict of interest reported by the authors.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' Contributions
All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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