

P-ISSN
E-ISSN
DOI
Available

: 0000-0000
: 3031-6782
: <https://doi.org/10.61942/jhk.v3i4.660>
: <https://jurnalhafasy.com/index.php/jhk>

Vol. 3 No. 5, August 2026

Blockchain-Based Smart Contracts: Legal Certainty and Regulatory Implications

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Received : July 10, 2026
Revised : August 6, 2026
Accepted : August 23, 2026
Published: August 26, 2026

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Abstract: *The rapid development of blockchain technology has given rise to a new instrument in contract law practice known as smart contracts, namely computer protocols capable of automatically executing, monitoring, and enforcing agreements between parties without the involvement of intermediaries. The presence of this technology raises a number of fundamental legal issues, particularly regarding the validity of contracts, the position of program code as a representation of the parties' will, and its compliance with the principles of conventional contract law. This article aims to analyze the position of blockchain-based smart contracts within the framework of contract law, both from the perspective of international law and Indonesian positive law, and examine their regulatory implications for the current legal system. This research uses a normative juridical method with a statutory approach, a conceptual approach, and a comparative approach to various jurisdictions that have developed regulatory frameworks for smart contracts. The results show that although smart contracts are technically able to fulfill some elements of the validity of agreements under civil law, significant regulatory gaps remain regarding the legal recognition of code as a contract, dispute resolution mechanisms, the allocation of legal responsibility for system failures, and consumer protection in blockchain-based transactions. This article recommends the need for regulatory harmonization that is responsive to the technical characteristics of blockchain without sacrificing the fundamental principles of contract law, including the principles of consensualism, good faith, and protection of the weak party.*

Keywords: *Smart Contract; Blockchain; Legal Certainty; Regulation; Contract Law; Financial Technology; Contract Law; Electronic Transactions.*

INTRODUCTION

The digital technology revolution has brought about significant changes in various aspects of human life, including the practice of contract law. One of the most significant developments in the past two decades has been the emergence of blockchain technology, a distributed data recording system that is immutable, transparent, and does not require a central authority to verify transactions. It is on this blockchain infrastructure that the concept

of smart contracts was born, an idea first conceptually formulated by Nick Szabo in the late 1990s as a computer transaction protocol that automatically executes contract terms.¹ Szabo's idea could only be widely realized after the arrival of second-generation blockchain platforms such as Ethereum, which introduced the ability to run program code (self-executing code) on a decentralized network so that smart

¹Nick Szabo, "Formalizing and Securing Relationships on Public Networks," First Monday 2, no. 9 (1997).

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contracts could be executed without third-party intervention.²

Technically, a smart contract can be understood as a series of logical instructions written in a specific programming language and stored within a blockchain network, which will execute itself automatically if certain pre-programmed conditions (if-then conditions) are met. This characteristic distinguishes smart contracts from conventional contracts: their execution is deterministic, cannot be changed unilaterally once deployed to the network, and does not rely on the good faith of the parties to carry out their obligations because the code itself enforces execution (self-enforcing).³ These technical properties promise transaction efficiency, reduced intermediary costs, and minimized default risk. Smart contracts are now widely used in various sectors, from decentralized finance, supply chains, insurance, to digital asset transactions such as non-fungible tokens.

However, despite the promise of efficiency, the use of blockchain-based smart contracts raises a number of legal issues that remain unresolved. Recent international studies have shown a significant gap between the readiness of the technology and the legal framework governing it.⁴ The first issue concerns the validity of smart contracts as legally binding agreements, considering that

most contract law systems are built on the principle of consensualism which requires a meeting of minds that can be interpreted contextually, while program code is rigid and difficult to accommodate clauses that depend on subjective assessments such as good faith, force majeure, or commercial feasibility.⁵ The second issue relates to the legal consequences if a system failure, security vulnerability, or programming error (bug) occurs that causes the smart contract to execute incorrectly, thus raising the question of who should be held responsible: the code developer, the platform provider, or the parties who agreed to the contract.⁶

In Indonesia, the development of blockchain technology and smart contracts has also experienced significant growth, particularly in line with the increasing adoption of crypto assets, blockchain-based crowdfunding platforms, and cross-sector electronic transactions. A study of blockchain-based transaction practices in Indonesia shows that increased transaction security has not been fully matched by adequate legal certainty for parties, particularly consumers who are in a weaker bargaining position.⁷ Another study emphasized that the main challenges of blockchain implementation in Indonesia in the context of contracts include the lack of a specific regulatory framework, inadequate

²Vitalik Buterin, "Ethereum: A Next-Generation Smart Contract and Decentralized Application Platform," Ethereum Whitepaper (2014).

³S. Khan, Faiza Loukil, Chirine Ghedira-Guegan, E. Benkhelifa, and A. Bani-Hani, "Blockchain Smart Contracts: Applications, Challenges, and Future Trends," *Peer-to-Peer Networking and Applications* 14 (2021): 2901, <https://doi.org/10.1007/s12083-021-01127-0>.

⁴Jenny Szabo, Charles Bernard, and L. Philip, "Legal Implications and Challenges of Blockchain Technology and Smart Contracts," *Computer Life* (2024), <https://doi.org/10.54097/ztn2w848>.

⁵Priyanshi, "Legal Challenges in Blockchain-Based Smart Contract Execution," *Scientific Journal of Artificial Intelligence and Blockchain Technologies* (2024), <https://doi.org/10.63345/sjaibt.v1.i2.105>.

⁶D. Drummer and Dirk Neumann, "Is Code Law? Current Legal and Technical Adoption Issues and Remedies for Blockchain-Enabled Smart Contracts," *Journal of Information Technology* 35 (2020): 337, <https://doi.org/10.1177/0268396220924669>.

⁷Megawati, "Peran Teknologi Blockchain dalam Meningkatkan Keamanan dan Kepastian Hukum dalam Transaksi Kontrak di Indonesia," *Jurnal Hukum Mimbar Justitia* 9, no. 2 (2023): 410.

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technical standards, and minimal consumer protection, so that dispute resolution arising from smart contract-based transactions still relies on analogical interpretation of the provisions of contract law and generally applicable electronic transaction law.⁸ The provisions of Law Number 11 of 2008 concerning Electronic Information and Transactions, as amended several times, have indeed accommodated the validity of electronic documents and electronic signatures, but these provisions were formulated before the emergence of second-generation blockchain technology and therefore do not explicitly regulate the position of self-executing codes as a form of independent agreement.⁹

The issue of the validity of smart contracts within the framework of Indonesian contract law cannot be separated from the conditions for the validity of an agreement as regulated in Article 1320 of the Civil Code, which requires an agreement, capacity to act, a specific object, and a lawful cause.¹⁰ The fundamental question that then arises is whether the act of uploading program code to a blockchain network can be qualified as a legally valid expression of will, and whether the parties interacting with the smart contract, who in many cases are anonymous or pseudonymous, can be assured of having the legal capacity to

act. These issues make the study of the legal certainty of blockchain-based smart contracts relevant and urgent.

Globally, several jurisdictions have begun to respond to these developments through varying regulatory approaches. Some countries have chosen a permissive approach, granting broad legal recognition to smart contracts as part of electronic transactions, while others continue to adopt a cautious approach, requiring smart contracts to comply with all principles of conventional contract law.¹¹ Recent comparative studies have also shown that security vulnerabilities in smart contract code, such as reentrancy and integer overflow vulnerabilities, have caused significant financial losses and raised the need for a regulatory framework that specifically addresses technical security standards as part of legal certainty.¹² There is even a recent academic view that proposes that smart contracts, in certain contexts, be given a separate legal personality from conventional contracts, given their unique characteristics of autonomous execution.¹³

The significance of this study is also inseparable from the growing economic value of transactions facilitated by smart contracts globally, spanning decentralized finance, asset

⁸A. Habibah, "Implementasi Blockchain dalam Meningkatkan Kepastian Hukum dan Penyelesaian Sengketa Kontrak di Indonesia," *Jurnal Hukum Mimbar Justitia* 10, no. 2 (2024): 386.

⁹Republik Indonesia, Undang-Undang Nomor 11 Tahun 2008 tentang Informasi dan Transaksi Elektronik sebagaimana diubah terakhir dengan Undang-Undang Nomor 1 Tahun 2024.

¹⁰Kitab Undang-Undang Hukum Perdata, Pasal 1320.

¹¹Kehinde Ojadamola Takuro, "Assessing the Legal and Regulatory Implications of Blockchain Technology on Smart Contracts, Digital Identity, and Cross-Border Transactions," *World Journal of Advanced Research and*

Reviews (2022),
<https://doi.org/10.30574/wjarr.2022.16.3.1350>.

¹²Saurabh Chandra, Rishiraj Kohli, Sai Krishna Akula, Vishvanatha Raju, Chandini Chowdary R, and S. Katta, "Smart Contracts and Legal Implications Security Vulnerabilities and Regulatory Challenges in Blockchain-based Systems," *Proceedings of the 2025 6th International Conference on Smart Electronics and Communication (ICOSEC)* (2025): 1341,
<https://doi.org/10.1109/icosec67334.2025.11459759>.

¹³Patryk Chmielarz, "Comparative Analysis of the Legal Nature of Blockchain and Smart Contracts: From Pure Technology to Legal Personality," *ShodhKosh: Journal of Visual and Performing Arts* (2026),
<https://doi.org/10.29121/shodhkosh.v7.i11s.2026.8283>.

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tokenization, blockchain-based carbon trading, and industrial supply chains. This growth in transaction value is directly proportional to the increasing complexity of the accompanying legal issues, as reflected in the growing number of academic studies specifically addressing the legality and regulation of smart contracts in the past five years from various parts of the world, from the United States, the United Kingdom, Russia, India, and Southeast Asia.¹⁴ This phenomenon demonstrates that the issue of legal certainty regarding smart contracts is not merely a local issue, but rather a global one that requires a coordinated legal response across jurisdictions, including by Indonesia as one of the largest digital economy markets in the Southeast Asian region.

This article is systematically structured into several sections. The introduction outlines the background of the problem and the urgency of the study. The research methods section explains the normative legal approach used and the legal materials analyzed. The results and discussion section is presented in two subsections: a discussion of the legal certainty of blockchain-based smart contracts from a contract law perspective, and a discussion of the implications and challenges of blockchain-based smart contract regulation in various jurisdictions, including Indonesia. The final section contains conclusions and legal policy recommendations that can be considered by lawmakers, supervisory authorities, and industry players who use blockchain technology and smart contracts in their business activities.

Based on the above description, this article is structured to address two interrelated main issues that are the focus of the analysis in

the results and discussion sections. First, the legal standing and certainty of blockchain-based smart contracts are examined from the perspective of contract law, both within the framework of international law and Indonesian positive law. Second, the regulatory implications and challenges arising from the use of blockchain-based smart contracts, as well as the legal policy directions needed to address these challenges. Through this study, it is hoped that a comprehensive understanding of the position of smart contracts within the contract law system will be obtained, along with policy recommendations that can be used as considerations for drafting legislation in Indonesia.

METHODOLOGY

This research uses a normative legal research method, namely research that examines law as a norm or rule that applies in society by examining legal materials in the library.¹⁵ The selection of this method is based on the characteristics of the problem being studied, namely the suitability between the applicable legal norms of agreements and the technical characteristics of blockchain-based smart contracts, so that an analysis of primary, secondary, and tertiary legal materials is required without conducting field research (non-doctrinal research).¹⁶ This research employs multiple approaches to obtain a comprehensive analysis. First, a statutory approach examines various relevant laws and regulations, including the Civil Code, the Electronic Information and Transactions Law, and the Consumer Protection Law. Second, a conceptual approach examines the legal concepts of conventional contracts and the technical concepts of smart contracts as developed in the legal and technology literature. Third, a comparative approach compares smart contract regulations across

¹⁴Priyanshi, "Legal Challenges in Blockchain-Based Smart Contract Execution."

¹⁵Peter Mahmud Marzuki, *Penelitian Hukum, Edisi Revisi* (Jakarta: Prenadamedia Group/Kencana, 2021).

¹⁶Soerjono Soekanto dan Sri Mamudji, *Penelitian Hukum Normatif: Suatu Tinjauan Singkat* (Jakarta: RajaGrafindo Persada, 2001).

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jurisdictions to obtain an overview of regulatory models responsive to developments in blockchain technology.¹⁷

The legal materials used in this study consist of primary legal materials in the form of laws and regulations applicable in Indonesia, secondary legal materials in the form of national and international scientific journal articles published primarily in the last five years (2021-2026), books, and conference proceedings relevant to the topic of legal certainty and regulation of blockchain-based smart contracts, as well as tertiary legal materials in the form of legal dictionaries and other supporting reference sources. The analysis was conducted qualitatively using descriptive-analytical techniques, namely presenting the collected data and legal materials, then analyzing them systematically to answer the research problem formulation, and drawing conclusions through deductive thinking methods that depart from general principles of contract law and then apply them to specific issues regarding blockchain-based smart contracts.

The legal materials collection procedure was conducted through a search of reputable international journal databases and accredited national journal databases, using the keywords "smart contract," "blockchain," "legal certainty," "legal certainty," and "regulatory implications" to obtain relevant and up-to-date literature. The collected legal materials were then selected based on the relevance of the theme, the credibility of the sources, and the actuality of the publications, prioritizing literature published within the last five years so that the resulting analysis reflects the latest legal and technological developments, without neglecting the classic literature that serves as a fundamental conceptual reference regarding smart contracts. After the legal materials were classified based on relevant legal issues, systematization and interpretation were carried out and then presented in a thematically arranged discussion, namely the theme of legal

certainty and the theme of regulatory implications, as presented in the following results and discussion sections.

RESULTS AND DISCUSSION

Legal Certainty of Blockchain-Based Smart Contracts from the Perspective of Contract Law

Before delving into an in-depth analysis, it is important to first emphasize the fundamental difference between the terms "smart contract" in the technical sense and "smart legal contract" in the legal sense. In the broadest technical sense, a smart contract refers to any self-executing program code on a blockchain network, regardless of whether the code represents a legally binding agreement. In contrast, the term "smart legal contract" refers specifically to a smart contract that is intended by the parties to represent a legally binding agreement, either in its entirety (fully code-based) or in part combined with conventional legal documents (hybrid). This distinction is important because not every smart contract in the technical sense automatically qualifies as a contract in the legal sense. Therefore, the analysis of legal certainty in this article focuses specifically on smart contracts that are intended as legal instruments binding the parties.

Legal certainty is one of the primary objectives of law, requiring clear norms so that legal subjects can predict the legal consequences of their actions. In the context of blockchain-based smart contracts, legal certainty becomes a central issue due to the fundamental tension between the rigid and deterministic technical characteristics of program code and the flexible and interpretative characteristics of contract law. Studies conducted in Indian jurisdictions indicate that smart contracts can, in principle, fulfill the generally accepted elements of contract formation, such as offer, acceptance, and consideration. However, their implementation faces serious obstacles related to the parties' capacity to act, the validity of wills free from

¹⁷J. Ellul, J. Galea, M. Ganado, Stephen McCarthy, and Gordon Pace, "Regulating Blockchain, DLT and Smart Contracts: A Technology Regulator's Perspective," ERA

Forum 21 (2020): 209, <https://doi.org/10.1007/s12027-020-00617-7>.

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coercion or error, and the possibility of contract cancellation in the event of a breach caused by a code error rather than the parties' will.¹⁸

This problem becomes more complex when linked to the concept of "Contracts Ex Machina" put forward in contemporary contract law literature, which emphasizes that smart contracts are not actually contracts in the full legal sense, but rather merely a performance mechanism of an agreement whose validity must still be assessed based on conventional contract law.¹⁹ This view is important because it corrects the popular notion that "code is law," that is, the notion that program code automatically creates binding legal obligations without requiring testing against the terms of a contract's validity under applicable law. Thus, program code should be positioned as a means of automating contract execution (contract automation), not as a substitute for the contract itself.²⁰

In the context of Indonesian positive law, the analysis of the validity of smart contracts cannot be separated from the requirements for a valid agreement under Article 1320 of the Civil Code. A study of the application of this principle to smart contracts shows that the element of agreement can be met as long as the parties consciously agree on the parameters to be executed by the program code before the contract is deployed to the blockchain network, making this agreement essentially equivalent to signing a conventional contract.²¹ However, the

element of capacity to act is a separate issue considering the pseudonymous nature of public blockchain networks that allow parties to transact without adequate identity verification, making it difficult to ascertain whether the parties interacting with smart contracts have met the legal capacity requirements, including the requirements of adulthood and not being under guardianship.²²

The specific object element of an agreement can generally be fulfilled in smart contracts because transaction parameters, including asset type, amount, and execution conditions, are precisely formulated in the program code, and tend to be more measurable than conventional contracts that often use general clauses. However, the element of lawful cause requires special caution, considering that the open nature of public blockchains allows smart contracts to be used for unlawful purposes, such as money laundering or illegal asset transactions, without being automatically detected by the system because the program code only executes technical logic without the ability to assess the legality of the transaction substance.²³ Another study emphasized that the legal aspects of objects and causes in blockchain-based smart contracts should remain subject to the legal regime applicable in the jurisdictions of the parties, so that the borderless nature of blockchain technology cannot be used as an excuse to avoid compliance with domestic law.²⁴

¹⁸Shilpa Singh Jaswant and P. Kale, "Smart Contracts and Blockchain: Legal Issues and Implications for Indian Contract Law," *International Review of Law, Computers & Technology* 36 (2021): 312, <https://doi.org/10.1080/13600869.2021.1999312>.

¹⁹Kevin Werbach and Nicolas Cornell, "Contracts Ex Machina," *Duke Law Journal* 67 (2017): 313.

²⁰L. Efimova, O. Sizemova, and A. Chirkov, "Smart Contracts: Between Freedom and Strict Legal Regulation," *Information & Communications Technology Law* 30 (2021): 333, <https://doi.org/10.1080/13600834.2021.1889759>.

²¹Sakirman, Ma'ruf Akib, dan Wahyudi Umar, "Kepastian Hukum Smart Contract dalam Perspektif Hukum

Perdata," *Rewang Rencang: Jurnal Hukum Lex Generalis* 5, no. 10 (2024): 1.

²²E. I. Kadly, S. D. Rosadi, dan E. Gultom, "Keabsahan Blockchain-Smart Contract dalam Transaksi Elektronik: Indonesia, Amerika dan Singapura," *Jurnal Sains Sosio Humaniora* 5, no. 1 (2021): 199.

²³Truntsevsky dan Sevalnev, "Smart Contract: From Definition to Certainty."

²⁴Qur'ani, Dewi Kusumawardani, dan M. Hawin, "Legal Aspects and Issues of Blockchain Implementation as the Technology Base of Smart Contract," *Pena Justisia: Media Komunikasi dan Kajian Hukum* (2024), <https://doi.org/10.31941/pj.v23i3.5467>.

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Another equally important issue is the position of smart contracts within the legal framework of evidence. As code stored and executed within an immutable blockchain network, smart contracts essentially provide a robust and difficult-to-manipulate audit trail. Therefore, from a procedural law perspective, blockchain transaction records have the potential to be highly evidentiary. However, legal literature indicates a gap between this technical evidentiary strength and formal recognition in procedural law in various jurisdictions, including Indonesia, which generally still requires specific evidence as stipulated in civil procedural law. Therefore, regulatory adjustments are needed to explicitly recognize blockchain records as valid electronic evidence.²⁵ This ambiguity of recognition in turn creates uncertainty for the parties in resolving disputes arising from the implementation of smart contracts, especially if there is a dispute regarding the interpretation of the programmed execution conditions.

The tension between the rigidity of program code and the flexibility of contract law is also evident in the issue of contractual clauses that are implicit or dependent on contextual judgment, such as good faith clauses, force majeure clauses, and rebus sic stantibus clauses. These clauses inherently require human judgment, while smart contracts can only execute conditions that have been explicitly formulated and measured (machine-readable) beforehand, so smart contracts tend to be unable to accommodate changes in circumstances that are unpredictable at the time the contract is created.²⁶ A number of studies have proposed a "hybrid contract" model, a combination of

conventional written contracts containing interpretative clauses with smart contracts implementing technical and operational clauses, as a solution to bridge this tension while maintaining certainty of implementation without sacrificing the flexibility of contract law.²⁷

The hybrid contract approach is also relevant in the context of auction-based transactions or electronic auctions that use smart contracts as an automatic execution mechanism, where the program code is converted from a previously agreed legal contract into an executable programming language, so that the conformity between legal intent and technical implementation becomes the key to the validity of the transaction.²⁸ A similar approach is also beginning to be adopted in the context of Islamic financial transactions in Indonesia, where smart contracts are combined with the principles of Islamic contracts to ensure compliance with the principles of justice, clarity of the object of the contract, and the prohibition of gharar, although the study also identified challenges in ensuring the compatibility of execution automation with the precautionary principle that is a characteristic of Islamic contracts.²⁹

Based on the above description, it can be concluded that the legal certainty of blockchain-based smart contracts is partial. On the one hand, smart contracts can provide high certainty of performance due to their automatic execution and the immutability of unilateral changes. However, on the other hand, smart contracts are not yet fully capable of providing certainty of validity equivalent to conventional contracts, considering that there are still gaps in

²⁵A. Leiter dan Jake Goldenfein, "Legal Engineering on the Blockchain: 'Smart Contracts' as Legal Conduct" (2018).

²⁶Khan et al., "Blockchain Smart Contracts: Applications, Challenges, and Future Trends," 2909.

²⁷Jack Gilcrest and Arthur Carvalho, "Smart Contracts: Legal Considerations," 2018 IEEE International Conference on Big Data (Big Data) (2018): 3277, <https://doi.org/10.1109/bigdata.2018.8622584>.

²⁸E. Chen, Bohan Qin, Yan Zhu, Weijing Song, Shengdian Wang, W. Chu, and S. Yau, "SPESC-Translator: Towards Automatically Smart Legal Contract Conversion for Blockchain-based Auction Services," 2021 IEEE World Congress on Services (SERVICES) (2021): 3, <https://doi.org/10.1109/services51467.2021.00014>.

²⁹Winda Fitri, "Kajian Penerapan Smart Contract Syariah dalam Blockchain: Peluang dan Tantangan," JATISWARA 38, no. 2 (2023): 223.

P-ISSN
E-ISSN
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fulfilling capacity requirements, accommodating interpretative clauses, and formal recognition in the law of evidence. Complete legal certainty can only be achieved if there is harmonization between the technical design of smart contracts and the principles of applicable contract law, so that the program code does not replace the contract, but rather functions as an implementing instrument for the contract, the validity of which is still tested under applicable law.³⁰

A comparative perspective on several jurisdictions that have addressed the issue of smart contract legislature provides important insights into regulatory directions Indonesia might consider. The Law Commission of England and Wales, for example, has published an official study concluding that the common law-based English contract framework is already sufficiently flexible to accommodate smart contracts without requiring new legislation, as long as the smart contracts can be interpreted as representing a valid agreement between the parties.³¹ A different approach was taken by the State of Arizona, United States, which instead passed a special law that explicitly recognizes the validity of blockchain-based signatures and smart contracts as part of legitimate electronic transactions, thus providing more explicit legal certainty even though it risks becoming obsolete quickly as technology advances.³² A comparison of the two models shows that there is no single formula that can be applied universally, and the choice of regulatory model depends heavily on the legal tradition and the level of maturity of technology adoption in each jurisdiction.

At the level of international trade law, the United Nations Commission on International Trade Law (UNCITRAL) has published a

Model Law on Electronic Transferable Records, which, while not specifically addressing smart contracts, provides a conceptual framework for the legal recognition of transferable electronic records, including those using distributed ledger technologies such as blockchain.³³ This legal model is relevant as a reference for Indonesia in formulating more specific provisions regarding the legal recognition of blockchain-based documents and transaction records, given Indonesia's participation in various international trade law forums that promote cross-border legal harmonization. Adopting principles from this international legal model can expedite the process of drafting domestic regulations without having to start from scratch, while ensuring Indonesian regulations align with generally accepted international legal practices.

Another relevant issue discussed in the context of legal certainty is the position of smart contracts as standard form contracts (or adhesion contracts), considering that in practice, most smart contracts used in decentralized financial platforms are drafted unilaterally by platform developers, while users can only choose to accept or reject the entire provision without any room for negotiation. This characteristic gives rise to the problem of imbalanced bargaining positions similar to the classic problem in conventional standard contracts, so that the principles of protection for weak parties in contract law, including the prohibition on the inclusion of exoneration clauses that are detrimental to consumers, should still be applied to smart contracts even though they are in the form of program code.³⁴ Studies highlighting this issue emphasize the importance of mandatory disclosure of information regarding the logic and technical

³⁰Savelyev, "Contract Law 2.0," 124.

³¹Law Commission of England and Wales, *Smart Legal Contracts: Advice to Government* (London: Law Commission, 2021).

³²Arizona House Bill 2417, dikodifikasi dalam Arizona Revised Statutes § 44-7061 (2017), yang mengakui

keabsahan hukum tanda tangan blockchain dan smart contract.

³³United Nations Commission on International Trade Law (UNCITRAL), *Model Law on Electronic Transferable Records* (2017).

³⁴Jaswant dan Kale, "Smart Contracts and Blockchain," 320.

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risks of smart contracts to users before the contract is agreed, as a form of protection for the principle of truly free and informed consent.

The legal certainty of smart contracts is also inseparable from what is known in technical and legal literature as the "oracle problem," namely the inherent limitation of smart contracts that can only access data available within the blockchain network itself. So that for transactions that depend on external data, such as market prices, match results, weather conditions, or the status of goods delivery, a third-party data provider (oracle) is required to bridge the real world with the blockchain network. This dependence on oracles raises a new legal issue, namely who is responsible if the data supplied by the oracle is incorrect or manipulated, resulting in the smart contract being executed based on inaccurate data and harming one of the parties.³⁵ The absence of clear regulations regarding the legal status of oracles, whether as agents, information service providers, or parties involved in the formation of contracts, makes this issue one of the main weaknesses in efforts to achieve complete legal certainty for smart contracts, especially for complex and high-value transactions such as parametric insurance contracts and blockchain-based derivative contracts.

Implications and Challenges of Blockchain-Based Smart Contract Regulation in Various Jurisdictions and Indonesia

The development of blockchain-based smart contracts has broad regulatory implications, extending beyond contract law to various other legal fields, including consumer protection, taxation, competition, and financial law. A systematic review of the legal and regulatory literature on smart contracts reveals three regulatory approaches adopted by various jurisdictions worldwide. The first is the

permissive-adaptive approach, which accommodates smart contracts by broadening the interpretation of existing electronic transaction regulations without establishing specific regulations. The second is the bespoke regulatory approach, which establishes a new legal framework specifically governing smart contracts and blockchain technology. The third is the cautious approach, which maintains full compliance with conventional contract law without exception.³⁶

The lack of a uniform regulatory approach creates its own problems, particularly for smart contract transactions, which are inherently cross-border because they are embedded in a global blockchain infrastructure that recognizes no national jurisdictional boundaries. Studies on the implications of blockchain regulation for digital identity and cross-border transactions indicate that the lack of uniform regulatory approaches across countries has the potential to create complex choice of law issues and difficulties in law enforcement in the event of disputes, given that the parties transacting through smart contracts are often located in different jurisdictions and are difficult to identify with certainty.³⁷

Equally important regulatory implications include cybersecurity and the allocation of legal liability for system failures. Studies analyzing security vulnerabilities in smart contracts, such as reentrancy, integer overflow, and front-running, show that financial losses resulting from exploiting these vulnerabilities are often difficult to recover from due to the irreversible nature of blockchain transactions. The existing legal framework does not clearly define the liability mechanism, whether it is imposed on the code developer (smart contract developer), the code auditor, the blockchain platform provider, or the user who consented to the execution of the

³⁵Khan, Loukil, Ghedira-Guegan, Benkhelifa, dan Bani-Hani, "Blockchain Smart Contracts," 2915.

³⁶Omar Farouk Al Mashhour, A. Shamsul, Abd Aziz, Nor Azlina, Mohd Noor, O. Farouk, dan A. Mashhour, "Legal and Regulatory Aspects of Smart Contracts: A Systematic

Review," *Eurasian Journal of Management & Social Sciences* (2023), <https://doi.org/10.23918/ejmss.v4i2p156>.

³⁷Takuro, "Assessing the Legal and Regulatory Implications."

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: <https://jurnalhafasy.com/index.php/jhk>

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contract.³⁸ This lack of clarity on the allocation of responsibilities poses a pressing regulatory challenge, particularly in the decentralized finance sector, which has experienced a number of hacking incidents with significant losses.

From a technology regulator's perspective, a study of financial regulatory authorities in the European Union demonstrates the importance of a technology-neutral regulatory approach, that is, regulations that focus on the substance of the risks and protections to be achieved without specifically regulating the technology, so that regulations remain relevant even as blockchain technology continues to develop.³⁹ This approach is also in line with recommendations generated through the Delphi method and SWARA analysis of blockchain regulatory experts, which identified that standardizing smart contract regulations requires cross-sector collaboration between regulators, industry players, and academics to formulate harmonized technical and legal standards that are responsive to the speed of technological innovation.⁴⁰

Regulatory implications also touch on taxation and financial compliance. Studies on the legal implications of blockchain on tax compliance and financial regulation show that the decentralized and often pseudonymous nature of smart contract transactions makes it difficult for tax authorities to identify taxpayers and trace transaction flows. Therefore, a new regulatory framework is needed that requires a certain level of transparency without eliminating the efficiency benefits offered by blockchain technology.⁴¹ Similar challenges are also faced by consumer protection authorities,

considering the self-executing nature of smart contracts, which often means consumers do not have the opportunity to cancel or renegotiate transactions after the contract has been executed, so that the principles of consumer protection as regulated in Law Number 8 of 1999 concerning Consumer Protection, particularly regarding the right to obtain correct information and the right to have their complaints heard, need to be interpreted adaptively so that they remain relevant when applied to smart contract-based transactions.⁴²

In the Indonesian context, the regulatory challenges of blockchain-based smart contracts are increasingly complex due to the lack of a legal framework that explicitly regulates the status and mechanisms for resolving smart contract disputes. Studies of blockchain implementation in resolving contract disputes in Indonesia show that conventional litigation mechanisms through the courts still face technical obstacles, particularly related to the competence of judges in understanding the technical aspects of program code and the limited availability of formally recognized electronic evidence. Therefore, alternative dispute resolution through arbitration involving blockchain technology experts is seen as a more adaptive option for the time being.⁴³ Other studies also emphasize the importance of improving the digital literacy of law enforcement officers and developing more detailed technical regulations regarding security standards and smart contract code

³⁸Chandra et al., "Smart Contracts and Legal Implications," 1344.

³⁹Ellul et al., "Regulating Blockchain, DLT and Smart Contracts," 217.

⁴⁰Shahin Heidari, Khalil Hashemi, Mohammad-Soroush Khorsand, Alireza Daneshfar, and Seyedalireza Jazayerifar, "Towards Standardized Regulations for Blockchain Smart Contracts: Insights from Delphi and SWARA Analysis," *Amity Journal of Management* (2024), <https://doi.org/10.31620/ajm.12.23/02>.

⁴¹Joseph Kuba Nembe, Joy Ojonoka Atadoga, Beatrice Oyinkansola Adedokun, Olubusola Odeyemi, and Bisola Beatrice Oguejiofor, "Legal Implications of Blockchain Technology for Tax Compliance and Financial Regulation," *Finance & Accounting Research Journal* (2024), <https://doi.org/10.51594/farj.v6i2.824>.

⁴²Republik Indonesia, Undang-Undang Nomor 8 Tahun 1999 tentang Perlindungan Konsumen.

⁴³Habibah, "Implementasi Blockchain dalam Meningkatkan Kepastian Hukum," 390.

P-ISSN
E-ISSN
DOI
Available

: 0000-0000
: 3031-6782
: <https://doi.org/10.61942/jhk.v3i4.660>
: <https://jurnalhafasy.com/index.php/jhk>

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audits as prerequisites for creating adequate legal certainty.⁴⁴

Another relevant regulatory challenge for Indonesia is the limited institutional capacity of regulatory authorities to oversee decentralized blockchain-based transactions. Unlike conventional financial systems, which have intermediaries as choke points, smart contract transactions on public blockchain networks lack intermediaries who can be held administratively accountable, making the intermediary-based oversight model less effective. A study of the smart contract regulatory framework under Indonesian civil law recommends that Indonesia consider establishing a dedicated regulatory framework that establishes minimum technical standards for smart contract developers, requires code security audits before use in significant transactions, and establishes an independent certification body that can provide technical quality assurance for smart contracts circulating in the market.⁴⁵

In addition, the study of the legal framework for smart contracts in Indonesia also highlights the need to strengthen provisions regarding the validity and evidentiary power of electronic documents in the Electronic Information and Transactions Law to explicitly accommodate transaction records on blockchain networks as valid evidence, considering that the current provisions are still formulated in general and do not anticipate the technical characteristics of blockchain which are decentralized and immutable.⁴⁶ Strengthening these regulations is important to prevent a legal vacuum (*rechtsvacuum*) that could be detrimental to parties, especially consumers, in transactions using smart contracts.

Finally, a more fundamental regulatory implication is the debate over the need to grant

separate legal standing to smart contracts, or even to decentralized autonomous organizations (DAOs) whose entire operations are conducted through smart contracts without a conventional management structure. Recent comparative studies have proposed that such entities could be granted a special legal standing distinct from conventional legal entities, with accountability mechanisms tailored to their technical characteristics, in an effort to accommodate technological innovation without sacrificing the principles of legal certainty and third-party protection.⁴⁷ This debate shows that the challenges of smart contract regulation are not only technical-administrative, but also touch on fundamental philosophical issues regarding legal subjects in the digital era.

Considering all these issues, it can be said that the regulatory implications of blockchain-based smart contracts are multidimensional, encompassing civil law, cybersecurity, taxation, consumer protection, evidentiary law, and even legal subject issues. Responsive legal policy should not position smart contracts as a threat that must be strictly restricted, but rather as an instrument of innovation that needs to be accommodated through adaptive, principle-based regulation, and cross-sector collaboration between regulators, industry players, academics, and civil society, as emphasized in various studies of contemporary financial technology regulation.⁴⁸ This kind of approach is believed to be able to maintain a balance between encouraging technological innovation and protecting the legal interests of the transacting parties.

In the Indonesian context, there has been quite positive development through the regulatory sandbox scheme organized by the Financial Services Authority as stipulated in

⁴⁴Megawati, "Peran Teknologi Blockchain," 425.

⁴⁵Sakirman, Akib, dan Umar, "Kepastian Hukum Smart Contract," 8.

⁴⁶Republik Indonesia, Undang-Undang Nomor 11 Tahun 2008 tentang Informasi dan Transaksi Elektronik.

⁴⁷Chmielarz, "Comparative Analysis of the Legal Nature of Blockchain and Smart Contracts."

⁴⁸Mashhour et al., "Legal and Regulatory Aspects of Smart Contracts."

P-ISSN
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: <https://jurnalhafasy.com/index.php/jhk>

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Financial Services Authority Regulation Number 13/POJK.02/2018 concerning Digital Financial Innovation in the Financial Services Sector, which allows financial technology business actors, including those using blockchain technology and smart contracts, to test their business models in a supervised environment before fully operating in the market.⁴⁹ The regulatory sandbox scheme has the potential to be a valuable tool for gathering empirical data on the risks and benefits of smart contracts before authorities formulate more permanent regulations. This allows for an evidence-based regulatory approach that does not unduly restrict innovation in its early stages. However, the scope of the regulatory sandbox is currently limited to the financial services sector, meaning that the use of smart contracts outside of that sector, such as in supply chain transactions or conventional business partnerships, lacks a comparable regulatory testing platform.

Regulatory challenges also arise from a competition law perspective, given that the programmable nature of smart contracts to automatically adjust prices or transaction terms based on specific algorithms (algorithmic pricing) has the potential to create the risk of anti-competitive practices if used in a coordinated manner by business actors to form algorithmic cartels without direct communication between business actors. This issue demonstrates that the regulatory implications of smart contracts are not only private between transacting parties, but also have a public dimension that touches on the interests of the market as a whole. Therefore, competition authorities also have an interest in understanding the technical characteristics of smart contracts in carrying out their supervisory functions.⁵⁰

An equally crucial regulatory implication is the tension between the immutable nature of blockchain networks and the principles of

personal data protection, particularly the right to be forgotten or the right to erasure, a core principle in the contemporary personal data protection legal regime. The provisions of Law Number 27 of 2022 concerning Personal Data Protection grant data subjects the right to request the deletion of their personal data under certain conditions. While data recorded on a public blockchain network is inherently immutable due to its technical nature, if personal data is also recorded within smart contract parameters, fulfilling the right to erasure becomes technically very difficult.⁵¹ This structural tension demands a careful system design approach, for example by avoiding recording personal data directly on the blockchain (on-chain) and instead storing personal data outside the network (off-chain) by only including encrypted references on the blockchain, so that the principle of personal data protection can still be met without eliminating the benefits of transparency and reliability offered by blockchain technology.⁵² This kind of solution-oriented approach emphasizes that smart contract regulation issues do not always have to be resolved through restrictions on technology use, but can also be resolved through system design engineering that aligns with applicable legal principles (privacy and law by design).

The law enforcement aspect also deserves attention, considering that the self-enforcing nature of smart contracts essentially shifts the contract enforcement function from being in the hands of judicial institutions or state authorities to being integrated directly into the program code itself. This shift raises academic concerns about the potential for a form of "unilateral execution" (self-help enforcement) that bypasses the due process mechanism that has long been a guarantee of procedural fairness in resolving contract disputes, for example when smart contracts are designed to automatically seize collateral

⁴⁹Otoritas Jasa Keuangan, Peraturan Otoritas Jasa Keuangan Nomor 13/POJK.02/2018 tentang Inovasi Keuangan Digital di Sektor Jasa Keuangan.

⁵⁰Ferreira, "Regulating Smart Contracts," bagian III.

⁵¹Republik Indonesia, Undang-Undang Nomor 27 Tahun 2022 tentang Pelindungan Data Pribadi.

⁵²Drummer dan Neumann, "Is Code Law?," 355.

P-ISSN
E-ISSN
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Available

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: <https://jurnalhafasy.com/index.php/jhk>

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without giving the defaulting party an opportunity to file a defense or objection on certain grounds, such as system errors or force majeure.⁵³ This concern is all the more relevant given that some jurisdictions require a summons or prior notification before any enforcement action can be taken, a procedural requirement that is difficult to accommodate with the automatic and instantaneous logic of code. Therefore, smart contract design for high-risk transactions should ideally still provide a grace period or human intervention as a procedural safeguard, so that technical automation does not immediately eliminate the guarantee of procedural fairness that is part of the basic rights of every legal subject.⁵⁴

CONCLUSION

Based on the discussion above, two main points can be concluded. First, the legal certainty of blockchain-based smart contracts from a contract law perspective is partial. Smart contracts are able to provide high implementation certainty due to their automatic, deterministic, and unilaterally unchangeable nature, thereby minimizing the risk of intentional default. However, from a legal validity perspective, smart contracts do not fully meet the requirements for a valid agreement as stipulated in Article 1320 of the Civil Code, particularly regarding the fulfillment of the element of capacity to act by pseudonymous parties and the limitations of program code in accommodating interpretative clauses such as good faith and force majeure. Therefore, the most appropriate position of a smart contract is as an implementing instrument (performance mechanism) of an agreement, not as a substitute for the agreement itself. Therefore, its validity must still be tested based on applicable contract law principles. Second, the regulatory implications of blockchain-based smart contracts are multidimensional and face a number of significant challenges, including the lack of a uniform regulatory approach across jurisdictions, unclear allocation of legal

responsibility for system failures and security vulnerabilities, limited oversight capacity for decentralized transactions, and the need for formal recognition of blockchain records in the law of evidence. In Indonesia, these challenges are compounded by the lack of a specific regulatory framework that comprehensively governs smart contracts, so that resolution of emerging legal issues still relies on analogical interpretations of the Civil Code, the Electronic Information and Transactions Law, and the Consumer Protection Law, which were formulated before the emergence of second-generation blockchain technology.

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⁵³Chandra et al., "Smart Contracts and Legal Implications," 1345.

⁵⁴Gilcrest dan Carvalho, "Smart Contracts: Legal Considerations," 3280.

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