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Smart Contracts and Copyright Management: A Significant Change in Intellectual Property Rights

Bakhshillo Kamolovich Khodjaev,
Tashkent State University of Law (Tashkent, Uzbekistan)
https://orcid.org/0000-0001-9683-2992

Lobarkhon Ruzmurodova Mirzabek Qizi,
Tashkent State University of Law (Tashkent, Uzbekistan)
https://orcid.org/0009-0005-4025-1706

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Abstract. The integration of smart contracts within blockchain technology represents a transformative approach to intellectual property rights (IPR) management, fundamentally altering traditional copyright enforcement mechanisms. This article demonstrates how distributed computer networks combined with automated regulatory devices provide superior alternatives to conventional IPR handling methods. Smart contracts reduce the need for arbitration through automated execution of predetermined terms and coding protocols. The implementation of blockchain-based smart contract systems enhances proprietary rights management, which can be particularly relevant for the BRICS nations currently facing evolving digital governance challenges. Research indicates that automated proprietary system networks are progressively superseding traditional IPR management approaches. The development of automated governance systems, coupled with decentralized IPR frameworks, presents both opportunities and regulatory challenges for the BRICS countries. Embedded payment mechanisms within smart contracts ensure automatic royalty distribution when copyrighted content is accessed, eliminating manual

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processing burdens and associated costs for creators. The implementation of smart contracts also enhances agreement integrity and reduces plagiarism risks through the use of immutable blockchain records. This study examines how organizations can establish enhanced trustworthiness and optimize digital business processes through blockchain-based copyright management. Advanced analytical tools accelerate the understanding of both the benefits and limitations within current copyright frameworks. Users are able to seamlessly access blockchain systems, creating multiple account types as required. Every blockchain entry provides transparent records of content usage and account activities. The digital system prevents misrepresentation by maintaining visible platform activities that are accessible to all stakeholders, ensuring comprehensive transparency of development and execution history for all agreement participants.

Keywords: smart contracts; intellectual property rights; journalistic materials; blockchain; legal agreements; contract management.

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Introduction

Blockchain technology and copyright management systems have fundamentally transformed the transaction and enforcement landscape of intellectual property rights. Smart contracts, as a principal feature of blockchain technology, provide reliable, transparent, and automated methods for copyright management. This article presents a comprehensive analysis of smart contracts and evaluates their potential applications, benefits, and challenges within copyright management contexts, particularly examining their capacity to enhance efficiency and trust within digital content ecosystems. Smart contracts demonstrate significant potential for automating IPR enforcement while strengthening protection measures.[1]

Co-citation analysis utilizing exploratory factor analysis reveals six distinct research clusters spanning technological, social, economic, and legal domains: (a) blockchain and smart contracts for Internet of Things applications; (b) blockchain integration with IoT ecosystems; (c) smart contract standardization, verification, and security protocols; (d) blockchain and smart contracts disrupting traditional industry processes; (e) smart contract prospects and implementation challenges; and (f) smart contracts and legal framework integration. Social network analysis depicts relationships between research groups and individuals within high-impact scholarly publications.

Smart contract systems encounter significant implementation challenges when integrating with existing national legal frameworks, particularly within BRICS nations such as India. India's legal system demonstrates both revenue growth in IPR management and advancement in digital innovation standards, creating specific conditions for blockchain-based adoption frameworks. Smart contract analysis within Indian contexts indicates global blockchain solution popularity while highlighting three major implementation barriers: regulatory compliance issues, IPR law compatibility challenges, and potential performance limitations.

This systematic analysis outlines key research directions in smart contract development, their temporal evolution, the research value of smart contract platforms, and conceptual relationships between publications and scholarly discourse. These findings provide researchers and practitioners with robust foundations for smart

[1] Nakamoto, S. (2008). *Bitcoin: A peer-to-peer electronic cash system*. United States Sentencing Commission. https://www.ussc.gov/sites/default/files/pdf/training/annual-national-training-seminar/2018/Emerging_Tech_Bitcoin_Crypto.pdf

contract research while identifying starting points for future investigations. Bitcoin's creation addressed private digital currency needs by resolving double-spending issues, enabling peer-to-peer monetary transactions without financial intermediaries.[2]

Pre-established procedures can be decentralized and anchored on blockchain networks using computer code specifying particular responses to new data inputs, such as incoming transactions. These scripts constitute smart contracts, expanding the scope and potential of decentralized systems by allowing for the transparent and independent execution of predetermined procedures or contractual agreements. These programmed processes can accommodate any complexity level.

Smart contracts may execute simple transaction transfers to different addresses or businesses, while increasingly sophisticated arrangements anchor valuables on blockchain networks through token smart contracts. This enables users to create and transfer "digital tokens", commonly known as cryptocurrencies. The significance of this application is evidenced by the top ten blockchain-based tokens maintaining a combined market valuation exceeding eleven billion dollars as of early 2020. Smart contracts also facilitate automation and process optimization within distributed architectures. However, these smart contract applications, which have been introduced only recently, still face numerous challenges, potentially hindering their extensive realization.

This article provides a comprehensive evaluation of the current smart contract literature. Literature data analysis employs various methodological approaches, as will be demonstrated in the next section. Conventional literature analysis, in particular, examines limited articles on specific issues qualitatively. It summarizes research findings within defined study areas, investigates multiple perspectives, and identifies potential future research directions. Various approaches include systematic reviews and scoping methodologies.

Alharby and van Moorsel's analysis of 64 smart contract publications concluded that security, privacy, blockchain scalability, and smart contract programmability represented common discussion topics across two-thirds of their 24 examined papers.[3]

1. Advancing Secure Contract-Signing Protocols: Challenges, Innovations, and Future Directions

Contract-signing protocols enable fair signature exchange between multiple parties, ensuring that no party accepts a signed contract until all parties complete

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[2] Mirzabek Qizi, L. R., & Kamalovich, B. K. (2024). Blockchain technology usage on intellectual property rights. *International Journal for the Semiotics of Law*, *38*, 363–380.

[3] Alharby, M. (2017). Blockchain-based smart contracts: A systematic mapping study. In *Fourth International Conference on Computer Science and Information Technology (CSIT-2017)* (pp. 125–140); Alharby, M., Aldweesh, A., & van Moorsel, A. (2018). Blockchain-based smart contracts: A systematic mapping study of academic research. In *2018 International Conference on Cloud Computing, Big Data and Blockchain (ICCBB)* (pp. 1–6).

the process. While fixed-round fair two-party protocols are impossible, optimistic signature exchange remains feasible between two parties. These optimistic procedures assume favorable conditions for the equitable exchange of signatures; however, either party may request third-party intervention to complete or decline exchanges on their behalf.

Originally designed for authentication protocols, protocol security logic establishes reasoning methodologies for contract-signing protocols. This logic performs effectively for this task, requiring only minor adjustments to accommodate the trusted third-party's "if-then-else" behavior. A straightforward argument can prove correctness for related protocol sets without imposing restrictions on the number of concurrent protocol sessions.

Parallel sessions prove crucial because alternative sessions can provide different sources for communications signed by principals. Formal proofs follow straightforward, comprehensible steps executed in template forms, which can be instantiated to produce correctness proofs for two common protocols as well as other protocol variations that employ identical message arrangements. Protocol design logic permits the compositional proof of entire protocol properties based on independent proofs for the exchange, abort, and resolve subprotocols within each contract-signing protocol, eliminating the need to consider interleaved actions from various subprotocols.[4]

Smart contract implementation for copyright management in India operates under favorable conditions yet faces obstacles stemming from existing Indian legal frameworks and digital infrastructure. India's evolving digital innovation laws create difficulties for integrating blockchain technology into current IPR legislation. Government digital policy advancement continues while blockchain solution scalability issues persist regarding large-scale digital content processing and transaction volume management capabilities. Smart contracts create regulatory challenges due to the lack of centralized authority, leading to cross-jurisdictional contract enforcement problems. Nevertheless, the increasing growth of blockchain-based applications under Indian government initiatives is expected to strengthen smart contract roles in copyright management by enhancing transparency and operational efficiency in IPR protection.

Future research should examine protocol effectiveness in real-world applications, including e-commerce, blockchain-based smart contracts, and international trade agreements. Protocol analysis must address industry-specific challenges and adaptations for supply chain management, finance, and legal sectors. Comprehensive effectiveness comparisons with current methods should evaluate efficiency, fairness, computational overhead, and adversarial condition resilience.

[4] Governatori, G., Idelberger, F., Milosevic, Z., Riveret, R., Sartor, G., & Xu, X. (2018). On legal contracts, imperative and declarative smart contracts, and blockchain systems. *Artificial Intelligence and Law*, *26*(4), 377–409.

Protocol extension to multiparty scenarios represents another promising direction. Existing two-party protocol design optimization and extension to large groups addresses scalability challenges while ensuring efficiency and fairness under complex interactions. Security remains paramount, requiring future studies examining vulnerabilities under sophisticated threat models, including distributed denial of service attacks and quantum computing threats. Post-quantum cryptography implementation may enhance protocol resilience against technological risk changes.

Formal verification techniques provide strict protocol accuracy and security proof foundations. Model checking, theorem proving, and symbolic execution identify edge cases, ensuring comprehensive validation. Prototyping enables complete theoretical conclusion validation and simulated performance testing under various conditions for execution time and error rate metrics.[5]

Ethical and legal consequence analysis across different jurisdictions, combined with usability studies that examine protocol simplicity for non-technical users, is critical. Cross-disciplinary research involving behavioral science, economics, and legal specialists can identify protocol effects on trust-building and negotiation dynamics.[6] Game theory applications can model individual decision-making processes.

Protocol adaptation for emerging technologies, including the Internet of Things, AI-driven systems, and edge computing environments, enhances practical utility. Addressing the challenges arising from dynamic environments, such as intermittent mobile network connectivity will prove important. Future studies should focus on developing robust auditing and accountability systems, thereby ensuring transparency and confidence in protocol applications. These research directions will contribute to the broad secure contract-signing protocol adoption and impact across various domains by extending theoretical and practical understanding.

2. Smart Contracts and Copyright Management

Scripts based on distributed infrastructure, such as a blockchain, constitute smart contracts. Upon the activation of blockchain transactions and network verification, predetermined activities are executed automatically. Smart contracts reduce trust issues between parties since terms are transparently stored on blockchain networks and function as intended by all parties. Similar to non-blockchain application scripts, smart contracts are software scripts.

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[5] Idelberger, F., Governatori, G., Riveret, R., & Sartor, G. (2016). Evaluation of logic-based smart contracts for blockchain systems. In J. J. Alferes, L. Bertossi, G. Governatori, P. Fodor & D. Roman (Eds.), *Rule technologies: Research, tools, and applications* (10th International Symposium, RuleML 2016, Stony Brook, NY, USA, July 6–9, 2016. Proceedings; pp. 167–183). Springer.

[6] Cuccuru, P. (2017). Beyond bitcoin: An early overview on smart contracts. *International Journal of Law and Information Technology*, *25*(3), 179–195.

Smart contract concepts and terminology predate both blockchain technology and Bitcoin emergence. Szabo[7] defines smart contracts as computerized transaction protocols that minimize trusted intermediary requirements while satisfying contractual requirements, including payment terms, confidentiality, and enforcement. He cited digital currency protocols as examples of smart contracts that combine the privacy and divisibility of paper money with the capabilities of online payments.

Subsequent research by Szabo[8] defined smart contracts as the integration of user interface and protocol that guarantees formal and secure network connections. These systems build upon technical, legal, and economic foundations. Therefore, a multidisciplinary analysis is necessary for smart contracts. Since smart contracts typically comprise simple computer codes rather than legally enforceable structures, both the terms "smart" and "contract" are misleading. As Ethereum's founder noted, "I regret using the term smart contracts. I should have called them persistent scripts or something more technical and boring."[9] This distinction demonstrates smart contract complexity.

There are three primary categories of smart contracts:

• **Pure Computer Code**: Simple programs that execute predetermined logic; these are not legal contracts.

• **Law-Oriented Code**: Programs specifically designed to comply with legal regulations with built-in legal characteristics, including logic clearly defined within legal frameworks.

• **Partial Legal Contract Execution**: Computer codes that replicate the forms and meanings of legal terms to execute specific contract portions.

2.1. Expanding the Role of Smart Contracts in Copyright

Copyright law demonstrates significant transformative potential through the application of smart contracts. Smart contracts enable automated IPR management while guaranteeing that copyright holders receive timely royalties and compensation forms. Incorporating usage terms, licensing agreements, and royalty distribution mechanisms directly into smart contracts allows stakeholders to bypass intermediaries while reducing administrative overhead.

Digital content distribution represents one of the most promising applications. Streaming services, books, music, and other digital media can implement automatic micropayments through smart contracts. These systems could support demand-based or access-frequency economic models, creating vast new economic possibilities for creators and distributors. Copyright enforcement represents another promising

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[7] Szabo, N. (1997). Formalizing and securing relationships on public networks. *First Monday*, *2*(9).

[8] Szabo, 1997.

[9] Buterin, V. (2018). *Blockchain resource pricing* (Working paper). Ethereum Research. https://ethresear.ch/uploads/default/original/2X/1/197884012ada193318b67c4b777441e4a1830f49.pdf?utm_source=chatgpt.com

application area. Smart contracts integrated with copyright registries can verify ownership and prevent unauthorized usage.[10] Incorporating tracking and reporting mechanisms into smart contracts creates significant opportunities for enhanced transparency and accountability in copyright transactions.

2.2. Smart Contracts and Copyright Management

Digital rights management through smart contracts is exemplified by digital art licensing platforms involving artists and buyers, where smart contracts automatically handle licensing terms, payment processing, and royalty distributions.

For instance, consider an artist who uploads their work to a platform with defined licensing terms, for example, $100 for personal use, $500 for commercial applications, and 10% of subsequent resale prices paid to the artists. Smart contracts automatically execute upon the buyers' license purchases, recording transactions and transferring licensing fees to the artists. Simultaneously, the users' "digital wallets" receive certificates indicating authorized artwork usage rights.

When artwork or licenses are subsequently sold, smart contracts guarantee that artists receive 10% royalties in real-time with permanent blockchain record entries. This eliminates the need for third-party involvement while minimizing conflict potential. The application of blockchain technology protects artwork copyrights through unforgeable protection mechanisms.

Copyright management has traditionally been managed by centralized authorities, suggesting that blockchain and smart contract applications appear unnecessary. However, when processes involve multiple, partially trusted participants such as artists, buyers, and resellers, distributed infrastructure with intelligent contracts effectively eliminates trust conflicts while optimizing various processes. Information recording in open databases guarantees compliance with established terms without temporal delays.

Nevertheless, while smart contract implementation concepts appear promising, copyright management faces challenges. Varying legal understandings of smart contracts across countries create enforceability questions. Smart contracts require high-precision coding to ensure contract operations eliminate ambiguity or probable occurrences. Even minor coding errors may lead to disputes involving large monetary sums or significant intellectual property rights. Overcoming these barriers requires comprehensive interdisciplinary cooperation.[11]

Economists, engineers, and legal specialists must collaborate in designing architectural solutions and rules that meet the requirements of the evolving digital environment while ensuring smart contract compliance with current copyright

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[10] Leiter, J., & Goldenfein, A. (2018). Legal engineering on the blockchain: 'Smart contracts' as legal conduct. *Law and Critique*, *29*, 141–149.

[11] Levy, K. E. C. (2017). Book-smart, not street-smart: Blockchain-based smart contracts and the social workings of law. *Engaging Science, Technology, and Society*, *3*, 1–22.

legislation. Natural language processing applications could bridge semantic gaps between programming code and legal writing by translating contracts into executable smart contract code.

2.3. Automating Academic Publishing Rights with Smart Contracts: A Blockchain-Based Solution

Smart contracts enable the organization of effective academic publishing rights with integrity, particularly for royalty and usage reporting.[12] Academic authors can disseminate their research articles on decentralized platforms, establishing usage and distribution conditions through code and legally binding smart contract clauses. Contracts specify conditions, such as $50 educational download fees, $200 commercial training program costs based on market analysis, and 5% royalties on sublicensing-derived revenue.

When users download articles, smart contracts review payments and provide access. This creates transparent transactions recorded on blockchain networks, protecting buyer and seller identities. Money transfers directly to authors' digital wallets, eliminating intermediaries such as publishers.

Smart contracts guarantee that authors receive instant 5% royalty payments when institutions sublicense articles. Record keeping utilizes blockchain technology to prevent unauthorized material usage or tracing. This system enables fast automated transaction execution while reducing disputes through well-recorded licensing terms. Authors benefit from the creation of direct intellectual property control.

For centrally managed publishing rights, blockchain solutions prove useful when multiple parties, such as authors, institutions, and third-party users, are involved. Smart contract transactions use predetermined terms, providing immediate action without fairness delays or accountability issues.

3. Application of Blockchain Technology in the Management of Academic Publishing Rights

This section illustrates the implementation and management of blockchain-based smart contracts for academic publishing rights. The discussion that follows highlights key factors, transaction specifics, and royalty distribution procedures, emphasizing blockchain technology contributions to the administration efficiency, security, and transparency of IPR.

Licensing Conditions: License parameters integrated into smart contracts specify the terms governing access to and use of academic information. Three main license categories are identified as follows:

[12] Mehta, D., Tanwar, S., Bodkhe, U., Shukla, A., & Kumar, N. (2021). Blockchain-based royalty contract transactions scheme for Industry 4.0 supply-chain management. *Information Processing & Management*, *58*(4), 102586.

• **Personal Use Licenses**: Lifetime access without royalties, priced at $50;

• **Commercial Use Licenses**: One-year validity with 10% royalty rates for secondary sales or sublicensing, priced at $200;

• **Institutional Use Licenses**: Three-year access periods with 15% royalty charges, priced at $500.

These predetermined provisions guarantee equitable secondary transaction royalty distribution while offering transparency to licensors and licensees.

Transaction Recording: Blockchain technology enables the transparent and immutable recording of all transactions. Every transaction contains unique transaction numbers, user types (such as an individual, corporation, or institution), obtained license types with associated costs, applicable royalties for original content creators, and precise transaction timestamps.

For example, $50 individual personal use license purchases are recorded without royalty payments. Conversely, firms purchasing $200 commercial use licenses pay artists $20 in royalties. Blockchains permanently stores these documents, guaranteeing accountability and streamlined audits.

Sublicense Royalty Distribution: Smart contracts control royalty distribution during sublicenses through the tracking of primary and secondary sale fees, predetermined royalty percentage applications that determine authors' shares,[13] platform fee deductions along with the remaining balance paid to content creators, and accurate timestamp event logging.

For instance, $400 in secondary sales under commercial use licenses yields 10% in royalties, meaning authors receive $40 payments. Similarly, institutional use license sublicensing transactions involving $800 in secondary sales result in 15% in royalties, amounting to $120 in payments to inventors.

Blockchain-based smart contracts provide a robust framework for academic publishing rights management by automating licensing terms, securely logging transactions, and enabling transparent royalty distribution. This approach minimizes intermediary requirements, streamlines administrative procedures, and guarantees fair inventor compensation.

Table 1: **Smart contract parameters for licensing**

License Type	Fee (USD)	Royalty Rate	Access Period
Personal Use	50	N/A	Lifetime
Commercial Use	200	10%	1 year
Institutional Use	500	15%	3 years

[13] Murray, M. D. (2023). NFTs rescue resale royalties? The wonderfully complicated ability of NFT smart contracts to allow resale royalty rights. *Journal of Law, Technology & the Internet*, *14*(2), 208–219.

Table 2: **Transaction records logged on a blockchain**

Transaction ID	Timestamp	Sender	Receiver	Amount (USD)
TXN001	2025-01-22 10:15:30	Nafisa	Bobur	100
TXN002	2025-01-22 10:20:45	Zakiya	Samiya	250
TXN003	2025-01-22 10:35:10	Manzura	Mirzo	500
TXN004	2025-01-22 10:50:25	Mukhayo	Shokir	75
TXN005	2025-01-22 11:05:40	Firuz	Lobar	300

3.1. Comparative Analysis: Management of Academic Publishing Rights on Blockchain Technology and the Russian Legal System

The application of blockchain technology to academic publishing rights management introduces efficient, secure, and transparent copyright protection methods. Among the BRICS countries, Russia distinguishes itself as a leading nation in implementing well-defined blockchain-based IPR policies and corresponding legal frameworks with practical applications.

Russia is currently developing legal foundations for digitized financial assets incorporating blockchain technology. Federal Law No. 259-FZ "On Digital Financial Assets and Digital Currency 2021" establishes smart contract creation foundations, providing necessary enforcement when contracts remain within specified boundaries. Part 4 of the Russian Federation Civil Code contains provisions regarding the protection of authors' property rights, including copyright protection for digital goods production.

The Intellectual Property Chain initiative demonstrates essential blockchain copyright management achievements. This national blockchain network, supported by the Skolkovo Innovation Center, facilitates the management of intellectual property registration, licensing, and tracking, including academic publications. Enhancements in copyright records, reductions in infringement instances, and indelible authorship proof stored in accessible ledgers represent key improvements.

Russia's blockchain technology employment for managing copyright materials demonstrates capabilities that could be applicable to global academic publishing. The adoption of the Intellectual Property Chain as a national blockchain platform provides substantial evidence for state-sponsored digital rights management. Integration with global copyright and open access publishing systems remains challenging.

Enforcement, traditional systems, and cross-recognition of blockchain-registered copyrights for academic publishing works require attention. Russian experience suggests hybrid system approaches using decentralized blockchain-verifiable systems with state enforcement may be globally applicable for academic publishing.

Table 3: **Contrasting traditional academic publishing and blockchain models**

Aspect	Blockchain-Based Academic Publishing Model	Russian Legal Framework (IP Chain & Civil Code)	Other BRICS Countries
Copyright Registration	Utilizes smart contracts for self-executing agreements	Centralized through the Intellectual Property Chain, ensuring state-recognized protection	Brazil and India lack national blockchain-based copyright systems; China has explored blockchain applications for IPR protection
Transparency & Security	Distributed ledger prevents tampering or fraud	Blockchain verification within the Intellectual Property Chain ensures authenticity	Varies; China has integrated blockchain evidence into some judicial proceedings
Enforcement	Limited enforcement due to jurisdictional complexities	Legally backed by Russian Civil Code and recognized in courts	South Africa and India face legal ambiguities regarding blockchain enforcement
Adoption	Emerging use across global academic platforms	Actively used in Russian research institutions and publishing	China leads in blockchain patent filings; Brazil shows emerging use cases in financial sectors
Challenges	Regulatory uncertainty in cross-border applications	Integration with international copyright frameworks remains complex	Many BRICS countries lack explicit blockchain regulations governing copyright

Source: Author

4. Methods

Real-world scholarly publishing license data were used to inform acceptable license types, fees, royalties, and access rights determination. These agreements served as models for establishing industry-standard smart contract expectations.

Simulated Blockchain Transaction Logs: Synthetic transaction logs were created using blockchain simulators, including Ganache, while smart contract development and implementation utilized the Remix Integrated Development Environment. User types such as individual, corporate, and institutional categories with dates, transactions, fees, and royalties, were captured in logs. These logs provided valuable information regarding smart contract performance, transaction success rates, and essential capability and limitation aspects.

Open-Source Blockchain Networks: Ethereum testnet was employed for experimenting with and releasing smart contracts onto public blockchains. Transaction records were collected from blockchain viewers such as Etherscan and APIs for effective record acquisition to ensure data credibility and precision. These platforms enabled the study to gauge transparency and protection degrees consistent with practical blockchain-enabling systems.

To eliminate concerns related to unreal data potentially affecting works using only simulated datasets, the study combined real data with simulated data to determine smart contract efficiency employing blockchain technology. Thus, multiple data sources contribute to creating a comprehensive understanding of blockchain application consequences for academic journal publishing.

4.1. Smart Contract Development and Copyright Protection in Academic Publishing

The smart contract development landscape has advanced significantly from inception through 2025. Many platforms are currently used for smart contract development, including Ethereum and Binance Smart Chain. These platforms possess unique characteristics, benefits, and applications, enabling developers to select appropriate blockchains.

Major smart contract development improvements include the availability of frameworks and tools that help create, deploy, and manage smart contracts. Well-utilized development frameworks include Truffle, Hardhat, and Brownie, providing developer-friendly environments. Technologies such as Remix and Visual Studio Code, along with extensions including Snorkel Studio and Smart Contract Explorer, have greatly contributed to development by offering elements like syntax highlighting, debuggers, and smart code completion.

Smart contract security, however, represents a critical concern area for 2025. The increasing number of blockchain-based applications has created a strong focus on making smart contracts immune to vulnerabilities. Developers have started adopting

practices to eliminate possible vulnerabilities and enhance overall smart contract resilience, including comprehensive contract testing, code reviews, and formal verification tool testing.[14]

Smart contract applications continue to evolve as programming languages, libraries, and modules progress. Standard programming languages, such as Solidity, Vyper, and Rust, introduce new capabilities, increasing variety and flexibility in the use of data structure contracts. These programs enable developers to create sophisticated and effective applications ranging from decentralized finance to non-fungible token marketplaces while meeting business standards and requirements, facilitating business logic, and implementing predefined rules.

As of 2025, smart contract development has advanced significantly, particularly with regard to tools, frameworks, security, and flexibility. With the continuous growth of decentralized applications, development spaces will expand further, opening new opportunities for developers to build secure, reliable, and efficient smart contracts.

4.2. Simulation and Testing Process

Developed smart contracts underwent thorough testing in simulated environments with realistic conditions. Testing involved various scenarios, such as single and multiple licensed party situations, each with differing licensing circumstances. This process determined smart contract compatibility across various explored cases.

Resale and sublicense transactions constituted another important situation. Understanding how smart contracts address typical industry scenarios, such as third-party transfers and licensing rights, is essential for evaluating their practical applications. The main features of the simulation involved concurrent session handling and interleaved operations. Such testing provided information about how contracts perform in complex, dynamic transactions.[15]

Simulation evaluation measures included transaction throughput, gas usage, and reliability. These metrics provide quantitative smart contract performance measurements. For instance, higher transaction speeds indicate more transactions processed within shorter timeframes while lower gas costs reveal more transactions processed at reduced expenses, and high reliability demonstrates contract capacity for consistent and intended performance.

4.3. Evaluation Metrics

The evaluation of smart contracts' effectiveness employed several known performance indicators, including transaction success rates and royalty delivery efficiency. Transaction success rates disclosed the general awareness and successful

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[14] Raskin, M. (2017). The law and legality of smart contracts. *Georgia Law and Technology Review*, *1*, 305–341.

[15] Guo, X., Zuo, Y., & Li, D. (2025). When auditing meets blockchain: A study on applying blockchain smart contracts in auditing. *International Journal of Accounting Information Systems*, *56*, 100730.

completion rates of smart contracts, which also indicated system efficiency. Royalty distribution accuracy was also crucial, demonstrating the correct execution of the financial aspects of smart contracts, which is particularly significant in licensing processes.

Other important areas of focus included processing time and rational resource utilization. Transaction processing time indicated rapid and reliable transaction execution for all transaction parties, while resource utilization referred to the efficient use of contract resources, directly influencing cost and efficiency in blockchain network operations.

A comparison with traditional licensing approaches revealed distinct benefits to blockchain usage. Main benefits ranged from increased decentralization-based security to enhanced transparency, whereby all system-executed transactions remain observable to blockchain members.

4.4. Validation Techniques

Formal verification instruments were employed to ensure smart contract reliability and security. Mathematical proofs were used to demonstrate contracts behave according to intended deployment logic. This verification step is particularly necessary for large purchases involving large monetary sum exchanges, as it helps avoid potential malpractices.

Furthermore, expert teams reviewed all contracts to assess smart contract stability. Such expert reviews frequently identify problems automated tool reviews may overlook, providing globalized insights into contract reliability.

The study also analyzed blockchain-based licensing mechanisms compared to conventional approaches. This analysis fulfilled the research objective of comparing blockchain benefits, highlighting new system advantages such as high security, transparency, and increased efficiency.

4.5. Ethical Considerations

Throughout smart contract design, implementation, and validation, the research maintained high data care standards and responsible blockchain technology usage. Transaction data protection and privacy were treated as paramount concerns and could not be compromised. These steps included implementing security measures such as data encryption to prevent unnecessary entity access.

Blockchains present serious problems associated with data visibility as systems become public. Such risks were addressed through personal data anonymization and a focus on consent and transparency in data handling. These elements are important for technology deployment and the reinforcement of public confidence.

The study was well-constructed and supported with thoroughly verified findings. Contributions from current studies have further emphasized blockchain-based smart contract advantages regarding licensing agreements compared to traditional

methods. These advantages include optimization, protection, and openness, thereby making smart contract-based licensing a significant advancement in licensing and royalty management.

5. Results

Smart contracts and blockchain technology have introduced enormous changes across various fields, including finance, trading, and IPR protection. This discussion focuses on smart contract applications and their influence on copyright management, with precise consideration of potential shifts in IPR.

Smart contracts are basically digital contracts with agreement terms written as computer code enabling, validating, or executing contract clauses. These are specific contracts whose terms are embedded into relevant computer programs running on blockchain networks. Smart contracts can facilitate copyright object registration, licensing, and protection.

The advantages of using smart contracts for copyright management include automated registration and licensing opportunities. Traditional copyright systems can be time-consuming and expensive. Smart contracts enable creators to quickly register work without intermediaries.[16]

Smart contracts assist licensing cases by providing platforms for license agreement implementation without disputes over terms. IPR protection represents another essential copyright management factor, as unwelcome copyright interference often proves costly for involved parties regarding monetary and reputation losses.

5.1. Managing Copyrights through Smart Contracts

Smart contracts can facilitate the identification, prevention, and resolution of infringements through blockchain-based copyright object usage and distribution monitoring. Smart contract concepts enable creators to automatically track and ensure rights protection, saving legal costs in most cases.

Smart contracts can significantly decentralize copyright management power, presenting creators and content owners who are hesitant about market entry with opportunities. Moreover, blockchain and smart contracts create opportunities for enhanced e-campus transparency, enabling worldwide creative competition. The democratization of copyright management can result in higher innovation, creativity, and creative industry development levels.[17]

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[16] Lim, M. K., Li, Y., Wang, C., & Tseng, M.-L. (2021). A literature review of blockchain technology applications in supply chains: A comprehensive analysis of themes, methodologies and industries. *Computers & Industrial Engineering*, *159*, 107518.

[17] Savelyev, A. (2020). Copyright in the blockchain era: Promises and challenges. *Computer Law & Security Review*, *36*(3), 105346.

However, the use of smart contracts in copyright management requires solutions for several issues. First, compatibility and adherence to specific standards regarding smart contract languages and protocols are necessary. Establishing standardized frameworks for smart contracts is critical for cross-platform integration and synthesis.

Second, limited graphical user interfaces and tools can hinder creators and content owners from easily addressing and managing smart contracts. User-friendly interface advances for constructing and deploying smart contracts can greatly reduce entry costs for those lacking computer science backgrounds.

In addition, smart contracts can radically change copyright management and IPR protection through simplified registration and licensing processes, effective enforcement measures, and accessible information input opportunities. Prospective smart contract applications in this domain include enhanced efficiency, reduced costs, and improved transparency.[18]

However, harnessing smart contracts for copyright management requires addressing interoperability problems, standardization, and user-friendliness issues. Staying informed about smart contract prospects and risks in IPR asset protection remains essential.

5.2. Practical Effectiveness and Regulatory Challenges

It is important to note that in many countries of the world, the regulation and implementation of blockchain technology still remain in their early stages. In Uzbekistan, for example, the regulation and management of blockchain technology systems are still under development. The Republic of Uzbekistan Law "On Electronic Document Management" (2004), "On the Electronic Digital Signature" (2023), and Presidential decrees on the digital economy provide basic digitization guidelines for document usage. However, no comprehensive regulatory framework or law explicitly addresses blockchain technology, smart contracts, or intellectual property rights enforcement record usage.

Uzbekistan's copyright law currently relies on manual, centralized enforcement systems. Therefore, blockchain-supported systems would require state acknowledgment or legislative changes for legal functionality. Nevertheless, recent digital transformation policy initiatives, coupled with open data policies in Uzbekistan, indicate the possibility for the strategic development of testing advanced scholarly publishing pilot models, potentially influenced by Indian and Russian experiences within the BRICS framework.

In India, copyright management governance and regulation present both opportunities and constraints. While the country has implemented various digital innovation policies along with certain smart contract recognition policies, national

[18] Ferreira, A. (2021). Regulating smart contracts: Legal revolution or simply evolution? *Telecommunications Policy*, *45*(2), 102081.

copyright framework integration remains limited. The Information Technology Act of 2000 provides some electronic record and digital signature legal recognition; however, no specific legal blockchain framework currently safeguards IPR protections.

Consequently, cross-border blockchain publishing rights enforcement faces procedural and evidentiary difficulties. However, India's active information technology industry and increasing blockchain adoption in finance and supply chains provide favorable environments for academic publishing rights management system trials using smart contracts.

Thus, both these countries face governance challenges, including unclear cross-border blockchain record recognition, decentralized system and state registry interaction requirements, and blockchain process alignment with manual IPR enforcement systems. Addressing these challenges could enable India and Uzbekistan to utilize blockchain technology not just for copyright issues, but also for governance applications practiced in other countries.

Various studies published in the *BRICS Law Journal* examine the implications of blockchain technology on corporate governance, focusing on adaptability, challenges, and regulation within BRICS nations. The evolution of academic publishing in relation to copyright management and blockchain technology publishing shows notable similarities to proposed corporate governance applications. Smart contract integration within blockchain technology regulates structural inefficiencies and reduces third-party intermediary service reliance across various domains.[19]

Publishing reflects the "agency problems" that corporate governance primarily seeks to address. Publishers or distributors act as intermediaries, keeping the majority of the value. Similar to blockchain-based voting and record-keeping systems that enhance information transparency and verifiability, academic authors can benefit from extensive automated usage rights enforcement, transaction history, and real-time royalties using blockchain-based licensing systems.

Legal and regulatory concerns spanning both domains include national border blockchain record recognition, cross-border law enforcement, and the integration of legal systems, all of which require resolution. The Russian project IPChain demonstrates hybrid solution advantages based on a combination of state-recognized blockchain registers and decentralized structures.

Conclusion

The implementation of smart contracts and decentralized blockchains has created monumental shifts in existing IPR enforcement systems, especially regarding copyrights. This technological revolution introduces transparent regimes that are transparent, secure, and effective in managing innovation and idea rights.

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[19] Kanojia, S. (2023). Application of blockchain in corporate governance: Adaptability, challenges and regulation in BRICS. *BRICS Law Journal*, *10*(4), 53–67.

Currently, and with regard to future applicability, smart contracts enhance copyright administration by employing computer implementation of legal terms and conditions, reducing copyright violations, and minimizing disputes between copyright owners and users. Furthermore, smart contracts provide innovative solutions for modern IPR management and monetization.

Using blockchain technology, content creators gain greater control over their work, collect royalties from various platforms, and prevent unauthorized utilization, thereby creating fairer and more transparent systems. This technology fosters knowledge contribution and creation since people worry less about idea theft and inadequate compensation.

However, potential drawbacks and shortcomings of smart contracts, especially in copyright management, should not be overlooked. These reflect existing flaws in global standardization and regulatory frameworks, which determine appropriate usage rights, data privacy, and customer protection. Additionally, public education initiatives should be launched, increasing constituencies' awareness and equipping necessary officials with required knowledge.

Smart contracts and blockchain technology demonstrate incredible promise for the future of copyrights and IPR. They possess the potential for transforming content generation, distribution, and protection methods. Nonetheless, the absence of comprehensive standards and regulations complicates smart contract usage; even so, smart contract incorporation in copyright sectors represents significant improvements toward enhanced protection and broader appreciation of copyright in the digital world.

Building upon existing BRICS research perspectives, this analysis demonstrates how blockchain technology applications in IPR management reflect broader themes in digital governance and legal adaptation within emerging economies. The integration challenges identified in this study align with findings from related research on the patentability of computer algorithms,[20] and privacy expectations in digitalization contexts.[21] These cross-cutting issues highlight the need for harmonized approaches to blockchain-based IPR systems that can address both technical innovation and legal certainty across BRICS jurisdictions.

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Information about the authors

Bakhshillo Khodjaev Kamolovich (Tashkent, Uzbekistan) – Professor, Dr. Vice-Rector for Scientific Research and Innovations, Tashkent State University of Law (Sayilgokh, Tashkent, 100047, Uzbekistan; e-mail: Bakhshillo.khodjaev@yahoo.com) – **corresponding author**.

Lobarkhon Ruzmurodova Mirzabek Qizi (Tashkent, Uzbekistan) – Independent Researcher, Tashkent State University of Law (Sayilgokh, Tashkent, 100047, Uzbekistan; e-mail: mirzayevnalobarkhon@gmail.com).