CHAPTER 2
LEGAL RELATIONS: FROM THEORY TO PRACTICE

GLOBAL SOLUTIONS FOR SAFEGUARDING INTELLECTUAL PROPERTY: HOW BLOCKCHAIN REVOLUTIONIZES DIGITAL RIGHTS MANAGEMENT

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Abstract. *The advent of blockchain technology has introduced transformative possibilities in the realm of intellectual property (IP) management, addressing longstanding challenges such as ownership verification, licensing automation, and anti-plagiarism measures. This paper investigates the transformative role of blockchain technology in the evolving landscape of intellectual property (IP) management. As digital assets proliferate across global platforms, the protection of authorship, licensing processes, and rights enforcement becomes increasingly complex. The research adopts a cross-disciplinary methodology that integrates conceptual analysis with practice-oriented evaluation, including case studies and expert opinions. The findings reveal that blockchain provides innovative tools for verifying ownership, establishing provenance, and automating royalty distribution through smart contracts. These smart contracts function as autonomous digital agreements, enabling direct transactions between creators and users, while reducing administrative burdens and costs. The article outlines the advantages of blockchain in mitigating piracy, facilitating micro-payments, and building trust in IP markets. Despite these benefits, the study also identifies notable implementation challenges – particularly in terms of scalability, energy efficiency, and legal harmonization. As a result, the authors emphasize the necessity of strategic development in regulatory alignment, interoperability standards, and stakeholder education. The practical value of the article lies in offering a forward-looking perspective on digital rights governance, enabling the creation of a resilient and equitable framework for managing intellectual property on a global scale.*

Keywords: *blockchain, smart contracts, digital rights, intellectual property protection, ownership verification, licensing automation.*

JEL Classification: O34, D45, L24, K11, K20, K33

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Introduction. In today's era of rapidly advancing information technology, an increasing number of works – ranging from articles and paintings to music – are being digitized. While digital content can be easily shared across the Internet, it also becomes vulnerable to plagiarism, which can significantly undermine creators' rights. To safeguard intellectual property, robust methods of authentication are essential.

Traditional authentication methods often rely on centralized systems that are prone to cyberattacks, data loss, forgery, and leaks. Furthermore, such systems frequently lack transparency and traceability in managing copyright information, making it difficult for creators to monitor the use of their works and protect their personal data during the authentication process.

Blockchain technology, with its decentralized, tamper-proof, and transparent characteristics, offers an ideal solution to these challenges.

Blockchain technology has significant potential across various fields, including cryptocurrency, healthcare, real estate, voting systems, and supply chain management. In principle, blockchain can be utilized in any database, offering dependable and secure information storage. Its inherent qualities of security, transparency, and immutability make it a valuable tool for managing intellectual property (IP) rights, such as patents, copyrights, trademarks, and industrial designs.

Literature review. In the modern era, where digital technologies play an increasingly vital role, blockchain has become an indispensable part of our lives. As a fault-tolerant decentralized system, its fundamental principle lies in the structure where each block contains the hash value of its predecessor. Any attempt to alter the data in a specific block triggers changes in all subsequent blocks, making such modifications detectable by network participants (nodes). This mechanism ensures the integrity of the database, forming a sequential chain where each block securely links to the previous one through its hash value.

The intersection of blockchain technology and intellectual property (IP) management has garnered significant academic and practical attention, as reflected in a growing body of literature. Early studies highlighted blockchain's decentralized and immutable characteristics, proposing its application for verifying IP ownership and preventing unauthorized usage. Researchers such as Szabo (1997) introduced the concept of smart contracts, laying the foundation for automated IP licensing and royalty management.

Subsequent analyses have expanded on blockchain's capabilities, emphasizing its role in addressing critical IP challenges. For instance, Prasad (2021) discussed blockchain's potential to reduce reliance on centralized intermediaries, thereby lowering costs and increasing the efficiency of IP registration and enforcement processes. Caro and Nobuhara (2015) proposed blockchain-based trusted timestamping to establish the date of creation and maintain data integrity, crucial for resolving ownership disputes.

The World Intellectual Property Organization (WIPO) has also significantly contributed to this discourse, publishing white papers and organizing workshops to explore blockchain's integration into IP ecosystems. Their findings underscore the importance of interoperability, governance, and regulatory harmonization for the

widespread adoption of blockchain solutions.

Recent scholarship, including works by Bajwa and Meem (2021), has emphasized blockchain's transformative impact on provenance tracking, anti-plagiarism tools, and cross-jurisdictional licensing. Furthermore, studies have investigated blockchain's integration with artificial intelligence, enhancing capabilities for detecting and preventing copyright infringement in text, art, and music.

However, the literature also points to substantial challenges, including scalability limitations, energy consumption, and regulatory uncertainty. These issues underscore the need for further research into Layer 2 solutions, proof-of-stake mechanisms, and standardized frameworks to address these barriers.

This review highlights blockchain's potential as a revolutionary tool for IP management while acknowledging the necessity of overcoming technical, legal, and operational hurdles to fully realize its capabilities.

Aims. The aim of the work is to explore the potential applications and impacts of blockchain technology regarding intellectual property protection, IP-ownership, transfer of IP-rights.

Methodology. This article adopts a multi-disciplinary methodological framework to investigate the integration of blockchain technology into intellectual property (IP) management. The research combines an extensive literature review with the analysis of legislative frameworks and international standards to understand the current landscape. Case studies provide practical insights into the adoption of blockchain for copyright registration, licensing automation, and anti-plagiarism efforts. Benchmarking analyses compare the use of blockchain in IP management across various jurisdictions to identify best practices and gaps. Additionally, expert interviews shed light on real-world applications, technical challenges, and the future potential of blockchain in creating a transparent and efficient IP protection ecosystem.

Results. Blockchain technology has the potential to serve as a robust platform for creating and maintaining databases or ledgers capable of recording and tracking transactions and assets. These ledgers can be configured to be widely accessible to the public or restricted to specific groups, depending on the permissions set. Each transaction updates the chain, enabling users to view the chronological sequence of activities within the blockchain. Importantly, once data is added to the database, it becomes immutable. With its ability to record, share, and synchronize transactions across electronic ledgers, blockchain can function as an intellectual property marketplace, providing inventors with a platform to showcase their inventions or digital works in ledger format.

Blockchain holds significant potential in addressing intellectual property (IP) challenges, particularly in verifying the authenticity of ownership. In the realm of copyright, securing IP ownership can be difficult due to the absence of official documentation, leaving the burden of proof on the creator. This challenge has intensified in the digital age, where the internet enables the unrestricted downloading and use of creative content, such as recorded songs, photographs, or paintings, without the creator's consent.

Establishing the date of content creation is essential in numerous scenarios and

critical when data is used as evidence. For instance, inventors must demonstrate the precise moment they introduced a patentable invention to secure a patent. Trusted timestamping protocols, which leverage asymmetric cryptography, are employed to verify that data has existed and remained unaltered since a specific point in time.

Blockchain offers a reliable solution for cataloging and storing original works, addressing challenges authors frequently face. Traditional methods often fail to provide adequate systems for cataloging works, making it difficult to prove copyright ownership. Authors also struggle to track who is using their creations, while third parties face challenges identifying the rightful owner for licensing purposes. As a result, infringements go unchecked, and authors may find it hard to monetize their work effectively. Blockchain eliminates the need for formal copyright registration, allowing copyrights to be established automatically upon the creation of original, qualifying works.

Intellectual property (IP) owners often face challenges in protecting their works online. Once an IP work is uploaded, it becomes difficult to maintain control and monitor how it is being used or by whom. Blockchain-based platforms offer a solution by enabling the registration and verification of IP works. Authors can utilize these platforms to search across various sources simultaneously, identifying who is using their work and for what purpose. This capability empowers IP owners to detect and prevent infringements more effectively, while also simplifying the process of licensing their works. Blockchain, therefore, functions as a powerful enforcement tool. Additionally, with a blockchain-based registration system, verifying whether a new creation – such as a song – violates the IP rights of a previously registered work becomes significantly easier. When integrated with artificial intelligence, such systems can extend to text, art, and music, enhancing IP protection and detection capabilities.

Table 1. Applications of Blockchain in Intellectual Property Management

Application	Description	Example
Ownership Verification	Establishes and verifies the authenticity of ownership.	Copyright registration
Licensing Automation	Uses smart contracts for automatic license issuance and royalty collection.	Digital music platforms
Provenance Tracking	Traces the origin and usage history of creative works.	Artwork ownership history
Anti-Plagiarism Tools	Identifies and prevents IP rights violations through registered digital signatures.	Text and art scanning platforms

Source: systematized by the authors

Recognizing these transformative potentials, in 2019 WIPO hosted its first Standards Workshop on Blockchain and IP in Geneva (April 29–30), bringing together global stakeholders to explore practical applications in IP datasets.

Building on this, in 2018 Member States formed the Blockchain Task Force under the Committee on WIPO Standards (CWS Task No. 59). The Task Force's mandate includes surveying the use of blockchain by IP offices, developing reference models and common terminology, and drafting a new "WIPO Standard" to promote

harmonized implementation across IP ecosystems.

Throughout 2020, multiple webinars and a global survey informed the WIPO Whitepaper Project, culminating in a comprehensive whitepaper (published February 2022). This document outlines both vertical use cases – like dedicated IP registers and provenance tracking – and horizontal ones such as time-stamping, licensing automation via smart contracts, and proof-of-existence services.

The whitepaper further highlights key considerations: interoperability across jurisdictions and blockchain platforms, governance models, regulatory alignment, and capacity-building among IP offices.

Notably, it emphasizes the role of smart contracts in automating license issuance, sublicense chains, and royalty payments – triggered directly via on-chain events – to streamline rights enforcement and revenue distribution.

The integration of smart contracts has significantly enhanced the potential of blockchain for protecting intellectual property. These self-executing contracts reside on the blockchain and automatically perform actions, such as granting access to stored information once predefined conditions are fulfilled. This functionality enables IP owners to issue licenses by validating a user's digital signature or deny access when necessary. Furthermore, smart contracts can be employed to streamline royalty collection by establishing agreements that automatically track and process payments from individuals accessing or using the intellectual property.

A smart contract is a digital agreement consisting of a set of promises, accompanied by a protocol dictating how these promises are to be fulfilled. These contracts are written in code and execute programmed actions automatically when specific conditions agreed upon by the parties are met. The core elements of smart contracts include:

1. Subject of the Contract. The program must have access to the goods or services specified in the contract and the ability to grant or revoke access to the counterparty automatically.

2. Digital Signatures. The agreement is authenticated by the parties using their unique digital keys, generated through a unified technology.

3. Contract Terms. The terms are outlined as an exact sequence of operations, forming an algorithm agreed upon by all parties.

4. Decentralized Platform. The recording, storage, and enforcement of the smart contract are carried out on a platform that operates independently of the parties involved.

Blockchain and smart contracts offer an efficient solution for licensing intellectual property (IP) works by minimizing transaction costs and establishing a direct connection between authors or inventors and users. This streamlined approach eliminates the need for intermediaries, ensuring faster and more cost-effective licensing processes. Smart contracts automate the enforcement of licensing agreements, enabling transparent and secure transactions while empowering creators to retain greater control over their IP.

Smart contracts are code-based agreements that function as computer protocols, automatically executing predefined actions when specific conditions set by the parties

are met. Built on mathematical algorithms translated into computer code, smart contracts operate independently, ensuring full control over their execution. In the context of intellectual property, these contracts enable self-executing IP licenses, activating automatically upon the use of a work.

Smart contracts are also ideal for facilitating micropayments for the use of intellectual property. By assigning a Bitcoin address to an IP work, authors can enable users to make direct micropayments in exchange for accessing or using the content. This approach eliminates the need for financial intermediaries, significantly reducing transaction costs. Moreover, it simplifies the process and enhances transparency in IP-related transactions, ensuring authors are fairly and efficiently compensated.

Table 2. Components of Smart Contracts

Component	Function
Subject of the Contract	Grants or revokes access to goods or services automatically.
Digital Signatures	Authenticates agreements using cryptographic keys.
Contract Terms	Details the predefined conditions and sequence of operations.
Decentralized Platform	Executes and stores the contract independently of involved parties.

Source: systematized by the authors

Blockchain technology, characterized by its intrinsic security, transparency, and immutability, offers significant potential for managing intellectual property (IP) rights, encompassing patents, copyrights, trademarks, and industrial designs. One of its primary applications is the verification of ownership authenticity, facilitated by the technology's ability to record, share, and synchronize transactions in electronic ledgers. This capability establishes a reliable framework for IP management, providing inventors with a decentralized platform to showcase their innovations and digital creations in ledger form, effectively serving as a virtual intellectual property marketplace.

A comprehensive SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, conducted by the World Intellectual Property Organization (WIPO) as part of its blockchain initiatives, highlights the multifaceted potential and challenges of blockchain in IP management. Among its notable *strengths*, blockchain's decentralized and immutable nature significantly reduces reliance on intermediaries for IP verification and enforcement. This decentralization not only lowers administrative costs but also accelerates critical processes such as establishing ownership claims or formalizing licensing agreements. Furthermore, blockchain's immutability ensures that data, once entered, remains unaltered, thereby providing a verifiable and tamper-proof record of ownership and transactional history. This feature is particularly advantageous in resolving disputes and demonstrating the provenance of intellectual property assets.

However, blockchain's integration into IP management is not without its *weaknesses*. Scalability and energy consumption remain persistent challenges. Current blockchain infrastructures, such as Bitcoin and Ethereum, encounter limitations in processing high transaction volumes efficiently, which may restrict their applicability in high-demand scenarios, such as global IP marketplaces. Additionally, the energy-intensive nature of blockchain operations raises sustainability concerns, which are

increasingly critical as environmental considerations gain prominence in policy and practice.

The *opportunities* afforded by blockchain in the realm of IP are extensive and transformative. Beyond the fundamental application of ownership verification, blockchain enables the automation of IP-related processes through smart contracts. These contracts can streamline licensing agreements, royalty payments, and sublicensing arrangements by automating transactions based on predefined conditions, thereby enhancing transparency, and reducing the potential for disputes. Furthermore, blockchain's potential to underpin global IP databases promotes harmonization across jurisdictions, facilitating international protection for inventors and reducing barriers to entry in global markets.

Despite these opportunities, the implementation of blockchain technology in IP management faces several *threats*. Regulatory uncertainty poses a significant barrier, as disparate legal frameworks across jurisdictions may impede the widespread adoption of blockchain solutions. Additionally, the increasing reliance on blockchain systems introduces heightened risks of cyberattacks, which could compromise sensitive IP data and undermine trust in the technology.

Table 3. SWOT Analysis of Blockchain in IP Management

Strengths	Weaknesses	Opportunities	Threats
Decentralized and tamper-proof	High energy consumption	Global IP databases integration	Regulatory uncertainties
Reduces reliance on intermediaries	Scalability limitations	Smart contract innovations	Risks of cyberattacks
Enhances transparency	Learning curve for stakeholders	Automates royalty payments	Resistance to adoption

Source: systematized by the authors

Discussion. To realize the full potential of blockchain in intellectual property (IP) management, it is imperative to adopt a multi-faceted strategic approach. This approach encompasses critical advancements in scalability, interoperability, regulatory frameworks, and education. Each of these dimensions must be addressed systematically to ensure blockchain's effective and sustainable integration into the global IP ecosystem.

1. Enhancing Scalability. The ability of blockchain systems to handle a high volume of transactions efficiently is pivotal for its widespread adoption in IP management. Current blockchain networks, such as Ethereum, often experience congestion and increased transaction costs, particularly during periods of high demand. This limitation can hinder their utility in managing extensive IP databases or facilitating real-time licensing transactions.

To address these challenges, the implementation of *Layer 2 solutions*, such as state channels and rollups, offers a pathway to offload transaction processing from the primary blockchain, thereby reducing congestion. For instance, solutions like the Lightning Network for Bitcoin have demonstrated the feasibility of enabling faster and cheaper transactions. Similarly, the adoption of proof-of-stake (PoS) mechanisms, exemplified by Ethereum's transition from proof-of-work (PoW) to PoS with Ethereum

2.0, provides a more energy-efficient and scalable consensus algorithm. These advancements can significantly enhance the throughput and cost-effectiveness of blockchain systems tailored for IP management.

2. Fostering Interoperability. Interoperability is critical to ensuring seamless communication and data exchange between disparate blockchain platforms and IP management systems. Without interoperability, the fragmentation of IP-related data across multiple blockchain networks could undermine the cohesive management of intellectual property on a global scale.

Standardization efforts play a vital role in overcoming these challenges. For example, the World Intellectual Property Organization (WIPO) has initiated the development of reference models and protocols to facilitate interoperability in blockchain-based IP systems. Additionally, the adoption of frameworks like the "InterPlanetary File System (IPFS)" for decentralized storage ensures compatibility across blockchain networks, enabling the integration of IP metadata with blockchain records. Industry collaborations, such as the Blockchain Interoperability Alliance, further illustrate the potential of cooperative efforts to establish standardized communication protocols that transcend individual blockchain ecosystems.

3. Advancing Regulatory Frameworks. The establishment of clear and coherent regulatory frameworks is essential to address legal ambiguities surrounding blockchain applications in IP management. Current regulatory disparities across jurisdictions can create uncertainties for inventors, IP holders, and enforcement agencies, deterring the adoption of blockchain solutions.

To mitigate these issues, governments and international bodies must collaborate to harmonize legal standards. For instance, the European Union's "Regulation on Markets in Crypto-Assets (MiCA)" provides a structured approach to regulating blockchain technologies, offering a model that could be extended to IP management. Similarly, WIPO's Blockchain Task Force has proposed guidelines to ensure compliance with existing IP laws while leveraging blockchain's capabilities. Pilot projects, such as those conducted by the European Union Intellectual Property Office (EUIPO) to explore blockchain in trademark management, underscore the potential for regulatory experimentation to inform global standards.

4. Promoting Education and Capacity-Building. Education and capacity-building initiatives are crucial to equipping stakeholders with the knowledge and skills necessary to implement and utilize blockchain technology in IP management effectively. Many IP offices, legal practitioners, and inventors remain unfamiliar with blockchain's potential applications, which can hinder its adoption.

Comprehensive training programs can address this knowledge gap. For instance, WIPO's workshops and webinars on blockchain in IP management provide valuable insights into the technology's practical applications. Furthermore, integrating blockchain-related topics into academic curricula for law, computer science, and business disciplines can foster a new generation of professionals adept at navigating blockchain-enabled IP ecosystems. Case studies, such as IBM's use of blockchain to manage supply chain patents, can serve as practical examples to demonstrate the benefits of blockchain technology in real-world scenarios.

Conclusion. By addressing these critical areas – scalability, interoperability, regulatory frameworks, and education – blockchain technology can be effectively integrated into the IP management landscape. Each dimension contributes to creating a robust, efficient, and equitable system that maximizes blockchain's potential to transform the way intellectual property is managed, protected, and monetized on a global scale.

Blockchain technology presents a paradigm shift in the management of intellectual property. Its adoption by leading organizations, such as the World Intellectual Property Organization (WIPO), underscores its transformative potential. Through strategic mitigation of its inherent challenges and the leveraging of emerging opportunities, blockchain stands poised to redefine the global IP management landscape, fostering a more transparent, efficient, and equitable ecosystem for innovation and creativity.

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