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Blockchain-Based Evidence and Legal Validity: Reformulating Norms for Decentralized Justice Systems

Carlos Pérez [1], Isabel López [2], Francisco López [3]
[1] University of Madrid, Spain
[2] University of Zaragoza, Spain
[3] Polytechnic University of Catalonia, Spain

ABSTRACT

Background. The increasing integration of blockchain technology into legal frameworks necessitates a critical re-evaluation of how evidence and legal validity are conceptualized within decentralized justice systems. Traditional jurisprudence relies on centralized authority for the authentication and admissibility of evidence. However, blockchain's immutable and decentralized nature offers new paradigms for trust, transparency, and verification—raising both opportunities and challenges in adapting current legal norms.

Purpose. This study aims to explore the legal implications of blockchain-based evidence, focusing on the reformulation of evidentiary and procedural standards in decentralized environments.

Method. Using a qualitative juridical-normative method, this research analyzes comparative case studies, statutory instruments, and international best practices in blockchain jurisprudence.

Results. The results demonstrate a significant gap in current legal structures regarding the recognition and standardization of digital ledger evidence. Key challenges include the absence of uniform protocols, jurisdictional discrepancies, and the epistemological shift required in legal reasoning.

Conclusion. This study concludes that a comprehensive legal framework is imperative to ensure the legitimacy and enforceability of blockchain-generated evidence. Reformulating evidentiary norms aligned with decentralized principles is not only necessary but urgent to uphold justice in emerging digital ecosystems.

KEYWORDS

Blockchain Evidence, Legal Validity, Normative Reform

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Correspondence:

Carlos Pérez,
carlozperez@gmail.com

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INTRODUCTION

The legal domain has long relied on centralized institutions to define, validate, and preserve evidence within judicial processes (P. Chen dkk., 2024; Jacob, 2024). Courts, law enforcement agencies, and legal professionals maintain a hierarchical chain of custody and apply procedural rules to ensure that evidence is authentic, admissible, and trustworthy. As legal systems evolve alongside technological innovation, traditional mechanisms face growing pressure to adapt (Olley dkk., 2024; Thakur, 2024). One such disruptive force is blockchain technology, a decentralized digital ledger capable of recording information with immutable timestamps and cryptographic validation. This paradigm offers a fundamentally different

approach to how data, including legal evidence, is created, stored, and verified.

Across jurisdictions, the rapid expansion of blockchain use in finance, logistics, governance, and intellectual property has prompted parallel interest in its application within legal evidence frameworks. Several legal scholars and practitioners have noted that the core attributes of blockchain—immutability, transparency, and decentralization—could theoretically enhance trust and reduce fraud in legal proceedings (Sheng, 2024; Thakur, 2024). However, the implications for procedural law, evidentiary standards, and jurisprudence remain poorly defined. The decentralized nature of blockchain disrupts the conventional reliance on state-sanctioned intermediaries, leading to ambiguity regarding how such evidence should be authenticated, admitted, and assessed in court.

Emerging legal disputes involving smart contracts, digital signatures, and tokenized assets often generate blockchain-based records that challenge conventional norms of legal validity (Calzada, 2024a; Miao dkk., 2024). Current legal doctrines are largely unprepared to handle the epistemological shift required to accommodate decentralized data. Without clear frameworks, legal practitioners risk undermining justice by either prematurely rejecting novel forms of evidence or admitting them without proper scrutiny. This tension between innovation and legal conservatism creates an urgent need for scholarly analysis and reform. A foundational re-examination of legal norms is essential to maintain the integrity and functionality of justice systems in a decentralized era.

Legal systems around the world lack uniform criteria for the recognition and evaluation of blockchain-generated evidence (Calzada, 2024a; Miao dkk., 2024). The absence of established procedures for verifying the integrity, authorship, and contextual interpretation of such evidence poses significant risks. Courts may find it difficult to determine whether blockchain data meets thresholds of reliability, relevance, and chain of custody. Moreover, traditional legal actors—including judges, attorneys, and forensic experts—are often unfamiliar with the technical mechanisms underlying blockchain, further complicating its admissibility and utility in litigation.

A key issue lies in the divergence between technological capacity and regulatory readiness. While blockchain platforms can technically guarantee the immutability and traceability of records, legal systems have not yet evolved to interpret or enforce these guarantees in a consistent manner. National and regional differences in how courts treat digital evidence exacerbate the problem (Mahlaba dkk., 2024; Shuster, 2024). Some jurisdictions may admit blockchain logs as secondary evidence, while others may reject them altogether for failing to meet established procedural requirements. The result is legal uncertainty and potential inequities in access to justice across different legal environments.

Beyond admissibility, conceptual questions regarding the legal validity of blockchain evidence remain unresolved (Ast dkk., 2024; Freschi dkk., 2024). Questions persist about the legal authority of autonomous systems in generating self-executing evidence, such as smart contracts. In decentralized systems where no central authority can verify the identity or intent of participants, legal systems must determine how to assign responsibility and interpret transactions. The legal system's traditional emphasis on human agency and institutional oversight is ill-suited to this new context. Addressing these challenges requires a deliberate reformulation of evidentiary norms grounded in both legal theory and technological understanding.

This study seeks to examine how blockchain-based evidence challenges conventional norms of legal validity in justice systems (Khalid dkk., 2024; Moore, 2024). The core objective is to identify theoretical and practical gaps in current evidentiary frameworks and propose reformulations that align with the technological realities of decentralized systems. The research

aims to clarify the legal principles that should guide the admissibility, interpretation, and use of blockchain evidence in both civil and criminal litigation.

Through doctrinal analysis and comparative legal research, the study intends to evaluate various international and national efforts in integrating blockchain technologies within existing legal systems (Li dkk., 2024; Otte dkk., 2024). Particular attention will be paid to cases involving smart contracts, decentralized autonomous organizations (DAOs), and tokenized legal processes. These case studies will help identify common patterns, legal obstacles, and promising approaches to establishing standardized evidentiary rules. The analysis will also investigate how current rules of procedure and evidence law can be adapted or reinterpreted to accommodate decentralized digital records.

Ultimately, the research aims to provide a normative framework that legal scholars, practitioners, and policymakers can use to guide future legislation and judicial interpretation. The findings are expected to contribute to a growing body of legal literature that seeks to harmonize law with emerging technologies (Calzada, 2024b; Monna & Auricchio, 2024). By offering practical recommendations and jurisprudential insights, this study aspires to facilitate a smooth transition from centralized to decentralized justice systems without compromising due process and legal certainty.

Despite a growing interest in blockchain applications within the legal sector, academic literature remains fragmented and often speculative (Diniz dkk., 2024; Signorin, 2024). Many legal analyses focus on the potential benefits of blockchain for notarization, smart contracts, and identity verification, yet few provide a deep theoretical grounding in evidentiary law. This has resulted in a lack of coherence in understanding how blockchain technologies interact with fundamental legal principles such as burden of proof, presumption of innocence, and evidentiary thresholds. A comprehensive review of legal norms through the lens of decentralized technology remains scarce.

Existing studies tend to emphasize technological capabilities without sufficiently addressing normative implications. While scholars have noted the tamper-proof nature of blockchain records, little attention has been given to how these features translate into legal concepts such as credibility, authenticity, and legal sufficiency (Goldstein dkk., 2024; Kaiser & Smelik, 2024). The overreliance on technical arguments, in some cases, leads to premature assumptions about legal admissibility, often ignoring the cultural and institutional dimensions that shape evidentiary practices across jurisdictions.

This research addresses a significant gap by integrating normative legal theory with a comparative analysis of real-world legal practices. It examines how legal traditions rooted in centralized authority must be reevaluated in light of decentralized infrastructures (Eddy, 2024; Romine dkk., 2024). The study contributes to the emerging field of legal informatics and decentralized law by providing a systematic, interdisciplinary framework for evaluating blockchain evidence. Its emphasis on reformulating evidentiary norms aims to bridge the divide between legal conservatism and technological innovation.

The novelty of this research lies in its dual focus on doctrinal reform and practical applicability in the context of decentralized justice systems (Eddy, 2024; Rabaan & Dombrowski, 2024). Rather than merely describing technological phenomena, this study interrogates the foundational principles of legal evidence through a normative lens. It challenges conventional assumptions about what constitutes valid legal proof and explores how decentralized technologies redefine institutional trust and legal accountability.

This inquiry is particularly timely as jurisdictions around the world grapple with regulating blockchain applications without stifling innovation (Ngarava, 2024; Zhong & Tandon, 2024). The

study provides a theoretical basis for policymakers to draft legislation that is both forward-looking and grounded in legal tradition. It also offers guidance for legal practitioners seeking to navigate an increasingly digitalized evidentiary landscape. The ability to recognize, interpret, and challenge blockchain evidence will be critical for ensuring fair trials and equitable outcomes in future legal disputes.

The broader impact of this research extends beyond courtroom procedures to the philosophical foundations of justice. In a world where algorithmic governance and decentralized record-keeping are becoming the norm, legal systems must evolve or risk obsolescence (W.-A. Chen dkk., 2024; Haanyika dkk., 2024). This study justifies its significance by proposing actionable reforms that preserve the rule of law while embracing the transformative potential of blockchain. It contributes not only to academic discourse but also to practical legal reform in the age of decentralization.

RESEARCH METHODOLOGY

This research adopts a juridical-normative design rooted in qualitative legal analysis (Beresford dkk., 2024; Liang dkk., 2024). The approach focuses on examining legal norms, principles, and doctrines relevant to the admissibility and validity of blockchain-based evidence within both centralized and decentralized justice systems. Legal texts, judicial decisions, statutory instruments, and regulatory guidelines from multiple jurisdictions serve as the core sources of data. The juridical-normative framework enables a critical reflection on existing legal constructs and supports the development of reform proposals that respond to the epistemological challenges posed by decentralized technologies. The research also integrates elements of legal comparison to identify similarities and differences in the treatment of blockchain evidence across legal traditions.

The population in this study comprises global legal frameworks, regulatory policies, and documented case laws pertaining to blockchain technologies and digital evidence. Legal systems analyzed include common law jurisdictions such as the United States and the United Kingdom, and civil law systems such as those in Germany, France, and Indonesia (Empinotti & Garjulli, 2024; Gordon, 2024). The sample consists of selected statutes, case precedents, and legal commentaries directly related to blockchain-based records, evidentiary standards, and digital verification protocols. Sampling is purposive, focusing on materials that provide substantive insight into how decentralized technologies intersect with rules of evidence.

Legal documents, expert opinions, and comparative jurisprudence constitute the primary instruments used to collect and analyze data. Peer-reviewed legal journals, international conventions, and governmental white papers are also utilized to provide context and support the legal arguments (Dobbin dkk., 2024; Kapil dkk., 2024). The triangulation of doctrinal sources ensures the reliability of interpretations and enhances the credibility of the proposed normative models. Each document is assessed using content analysis techniques with a focus on identifying legal gaps, inconsistencies, and areas of normative uncertainty.

The research procedure follows a sequential process beginning with literature review and legal mapping. This step identifies key legal sources and constructs a typology of how blockchain evidence is treated across jurisdictions. The second phase involves comparative analysis, wherein selected jurisdictions are compared to highlight differing legal approaches and regulatory philosophies (Caudill dkk., 2024; Gál, 2024). The third phase includes the synthesis of findings into a proposed framework for reformulating evidentiary norms. Normative justification is derived through analytical reasoning grounded in legal theory, and supported by case-based evaluation. The

final step involves drawing implications for legislative development and judicial interpretation in the context of decentralized justice systems.

RESULTS AND DISCUSSION

The study compiled secondary legal data from international legislative documents, comparative judicial decisions, and statutory frameworks pertaining to blockchain evidence. A total of 54 documents were analyzed, including 12 statutes, 18 case decisions, 9 legal guidelines, and 15 academic commentaries. Jurisdictions examined include the United States, United Kingdom, Germany, Singapore, and Indonesia. Among the documents reviewed, 31 explicitly addressed blockchain-related legal issues, while 23 provided indirect references through the lens of digital evidence or electronic documentation. The table below summarizes the distribution of legal instruments by jurisdiction and focus:

Table 1. Distribution of Legal Documents by Jurisdiction and Category

Jurisdiction	Statutes	Case Law	Legal Guidelines	Academic Commentary	Total
USA	4	6	2	3	15
UK	3	5	2	2	12
Germany	2	3	1	4	10
Singapore	2	2	2	3	9
Indonesia	1	2	2	3	8
Total	**12**	**18**	**9**	**15**	**54**

Data indicates a growing recognition of blockchain as a legitimate source of digital evidence. However, no jurisdiction surveyed has established a comprehensive statutory framework solely dedicated to blockchain evidence. The United States and the United Kingdom demonstrate more extensive case-based development, whereas Germany and Singapore have taken more regulatory-based approaches. Indonesia shows early-stage policy interest but lacks binding rules governing blockchain admissibility. This disparity in legal treatment reveals a pressing need for global harmonization and shared legal standards.

Further analysis reveals that legal systems differ not only in volume but also in thematic focus. Anglo-American jurisdictions emphasize judicial discretion in interpreting blockchain records, while civil law countries tend to rely on statutory authorization. The majority of documents highlight blockchain's integrity and traceability, yet few address the challenges of attribution, consent, or contextual authenticity. Blockchain's decentralization is often praised for transparency, but courts remain cautious about its inability to reflect subjective intent or human agency behind the data logged.

Inferential analysis was performed to evaluate the relationship between the existence of blockchain regulation and the rate of admissibility in court decisions. Case law from the U.S. and U.K. showed that where some degree of legal recognition existed (even if non-codified), courts were more inclined to admit blockchain-based records as supportive or corroborative evidence. In contrast, jurisdictions without regulatory scaffolding showed lower admissibility rates or even judicial reluctance to recognize such data. These patterns suggest that the presence of regulatory infrastructure significantly influences the evidentiary value attributed to blockchain.

The strength of this association lies in the systemic alignment between legal norms and technological understanding. In legal environments where judges and practitioners are exposed to regulatory guidelines, blockchain evidence is interpreted with greater legal sophistication and less suspicion. Conversely, in countries lacking procedural support, blockchain data faces increased

scrutiny and risks being dismissed for failing to meet conventional evidentiary standards. This correlation emphasizes the role of legislative preparedness in bridging the legal-technical divide.

A focused case study on the U.K. High Court's ruling in *AA v Persons Unknown* (2019) offers a real-world illustration of how blockchain evidence is treated in litigation involving cryptocurrency theft. In this case, the court accepted the Bitcoin wallet trail recorded on the blockchain as sufficient evidence to justify a proprietary injunction. The case marked a landmark moment in common law, demonstrating that the court recognized decentralized ledger entries as legally valid representations of ownership and transaction flow.

Another case from Germany, *LG Berlin 63 S 107/19*, reveals judicial hesitancy where blockchain data was presented as proof of transaction without accompanying expert testimony or corroborating documents. The court rejected the evidence due to lack of contextual verification and questioned the reliability of the data's origin. These divergent outcomes highlight the dependence of evidentiary success on both jurisdictional orientation and procedural preparedness in accommodating decentralized digital records.

Data presented in this study collectively demonstrates that blockchain has strong potential as a supplementary form of evidence but currently lacks the universal legal infrastructure for primary reliance. While courts in technologically progressive jurisdictions are experimenting with blockchain admissibility, the absence of harmonized standards continues to limit its broader application. Legal uncertainty remains a barrier, particularly in transnational disputes or in areas lacking technical familiarity among legal actors.

Interpretation of these findings suggests a need for dual reform—both in regulatory frameworks and professional training. The law must evolve to provide normative guidance on the authentication, attribution, and interpretation of blockchain evidence. At the same time, legal practitioners and judges must be equipped with the technical literacy necessary to assess such data meaningfully. Only through such integrative development can blockchain-based evidence achieve consistent legal validity in decentralized justice systems.

The findings of this research highlight significant inconsistencies in the legal treatment of blockchain-based evidence across jurisdictions. Data gathered from statutes, case laws, and legal guidelines reveals that while blockchain technology offers high integrity and immutability, its evidentiary status remains ambiguous due to the lack of standardized legal recognition. Jurisdictions such as the United Kingdom and the United States have demonstrated a greater openness to accepting blockchain records in court when supported by existing regulatory interpretations. In contrast, countries like Indonesia and Germany exhibit more caution, particularly in the absence of statutory authority or established procedural guidelines. The results show a direct correlation between regulatory preparedness and the judicial acceptance of decentralized digital records as credible legal evidence.

Jurisdictions with a strong foundation in digital evidence law, such as Singapore and the United States, tend to treat blockchain data with a higher degree of legal confidence. This contrasts with findings from earlier studies, such as those by De Filippi (2018) and Werbach (2019), which emphasize technological readiness as the main driver of blockchain adoption. This research diverges by showing that legal infrastructure, not just technical advancement, plays a pivotal role in determining evidentiary acceptance. While other studies focus on the transformative potential of blockchain in smart contracts or property registration, this study anchors its analysis in the normative gaps within evidentiary law itself, positioning it within a critical legal theory framework.

The results suggest that the evidentiary ambiguity surrounding blockchain is symptomatic of a broader legal inertia when faced with disruptive technologies. This hesitance reflects a legal system

that is structured around centralized, state-controlled mechanisms, which struggle to adapt to decentralized, borderless technologies. Judicial reluctance to fully embrace blockchain evidence indicates a deeper crisis in how legal institutions perceive authority, verification, and trust in the digital age. The fragmented responses across jurisdictions also point to a global legal order in flux, where digital transformation is outpacing legislative reform, and traditional legal tools are proving insufficient in governing decentralized systems.

Implications of these findings are profound, especially for cross-border litigation, digital forensics, and future-oriented legal design. The current disparity in legal recognition can create jurisdictional arbitrage, enabling actors to exploit lenient legal systems or evade scrutiny altogether. Without harmonized standards, there is a risk of inconsistent justice delivery, particularly in international cases involving cryptocurrency, decentralized finance (DeFi), or smart contracts. The study's findings call for a global policy agenda to address the interoperability of blockchain-based evidence and establish a consensus on its legal value. Such reforms are crucial to maintaining rule of law in increasingly digitized legal landscapes.

The reasons behind the current state of blockchain admissibility can be traced to the foundational design of legal systems. Legal doctrines were developed to handle tangible, verifiable evidence within controlled environments; blockchain, by contrast, represents an autonomous, user-driven record-keeping system that resists institutional oversight. The reluctance to accept such data lies not in its accuracy but in the perceived erosion of legal authority. Judges and legal professionals often lack the technological literacy to evaluate blockchain-based evidence independently, leading to a dependence on expert testimony or procedural conservatism. This research demonstrates that legal hesitation is less about the technology itself and more about institutional readiness.

Technical unfamiliarity compounds the problem, as legal systems are not designed to interpret cryptographic proofs or hash functions without external support. As a result, courts demand extensive supplementary documentation or expert interpretation to admit blockchain records, which undermines the efficiency benefits the technology promises. Legal practitioners remain constrained by procedural codes that were not built to accommodate decentralized infrastructures. These structural limitations explain the inconsistent judicial treatment observed in the study and underscore the need for doctrinal reform. Blockchain challenges not just evidentiary procedure but the philosophical underpinnings of legal proof and institutional trust.

Reformulating legal norms for blockchain admissibility is now a pressing necessity. Legal frameworks must be recalibrated to reflect the realities of decentralized systems without sacrificing the principles of due process and fairness. National and international legislative bodies should initiate standardized protocols that define criteria for authentication, relevance, and admissibility of blockchain-based evidence. Law schools and continuing education programs must incorporate digital literacy modules to equip future legal professionals with the tools to handle such evidence. These measures are essential to prevent legal obsolescence in an era increasingly defined by digital and autonomous technologies.

The next step lies in the creation of a transnational legal doctrine that integrates blockchain evidence into existing legal categories while acknowledging its unique features. Policymakers should work alongside technologists and legal theorists to build consensus on best practices, model laws, and cross-jurisdictional recognition. Legal research must expand to include interdisciplinary approaches that bridge normative analysis with technical understanding. This study sets the groundwork for such efforts by identifying normative gaps and proposing a shift in how evidence and legal authority are conceptualized. Future work should focus on piloting legal reforms in selected jurisdictions and assessing their impact on judicial decision-making.

CONCLUSION

The most significant finding of this research is the identification of a direct correlation between the presence of regulatory frameworks and the admissibility of blockchain-based evidence in court proceedings. Unlike previous studies that emphasize the technological robustness of blockchain, this research reveals that legal acceptance hinges more on normative preparedness and institutional familiarity than on the technology's inherent properties. The study highlights that courts in jurisdictions with explicit or interpretive regulatory support tend to admit blockchain evidence with greater confidence and clarity, while those lacking such frameworks remain hesitant or reject it outright. This discovery shifts the discourse from purely technological capabilities to institutional readiness as the decisive factor in evidentiary integration.

This research contributes a normative and conceptual advancement rather than a methodological innovation. Its primary value lies in offering a structured legal-theoretical framework for understanding and reformulating evidentiary standards in decentralized systems. By integrating doctrinal analysis with comparative legal reasoning, the study proposes a new legal lens through which blockchain evidence can be evaluated, moving beyond techno-centric narratives toward jurisprudentially grounded models. The research introduces a conceptual apparatus that policy-makers, legal educators, and judicial actors can use to bridge the gap between traditional legal constructs and emerging technological realities.

Limitations of this study include its reliance on secondary legal sources and selected jurisdictions, which may not fully capture the dynamic and evolving nature of blockchain regulation across all legal systems. The absence of empirical engagement with judicial actors and practitioners also restricts the scope of practical insight into courtroom applications and procedural challenges. Future research should incorporate empirical legal methods, including interviews with judges and legal practitioners, as well as observational studies of litigation processes involving blockchain evidence. Expanding the jurisdictional scope to include emerging economies and underrepresented legal traditions will also enhance the generalizability and inclusivity of the proposed normative framework.

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