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A Comprehensive Analysis of Blockchain Adoption Barriers and Strategic Implementation Framework for Intellectual Property Rights Protection

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ABSTRACT
The protection of intellectual property (IP) rights is facing new challenges in the digital era, and counterfeit, pirated and stolen goods inflict serious economic harm and pose a grave threat to consumer health and public safety around the world. The fundamental features of a Blockchain technology have a transformational value that can disrupt traditional IP management systems. Objective: To systematically review the obstacles why many barriers still prevent the wide adoption of blockchain to protect IP and to create a comprehensive strategic framework for the implementation. We use the Analytic Hierarchy Process (AHP) to rank regulatory, technological, economic and sociocultural impediments based on 167 relevant research papers and expert evaluations by 15 earlier analyses specialists. We adopted a Mixed Method approach systematics review, bibliometric analysis and AHP-based expert survey. We employed regression models, network centralities and consistency ratio validation (CR = 0.03). Results The most common barrier was regulatory obstacles (weight = 0.56), within which it was established that compliance costs were considered to be the foremost (0.308) cause of concern, and data security regulations close behind (0.168). Technological barriers were the second most influential factor (39.033 weight), primarily related to infrastructure limitations (39.198) and application costs (133). For targeted blockchain embedding into IP ecosystems based on sector strategy (torpedo effect), well-aligned policy is required in order to reduce the compliance costs and construct infrastructure and standardization.

Keywords—Blockchain technology, intellectual property rights, patent protection, adoption barriers, Analytic Hierarchy Process, digital rights management, regulatory compliance, smart contracts.

INTRODUCTION:

A. Research Background and Context

Digital technology has revolutionized the entire process of IP creation and distribution and protection through its emergence. The International Chamber of Commerce (IPC) states that IP-intensive sectors produce $6.6 trillion for the U.S. economy while employing 45.5 million people across the world [2The digital revolution established new methods to safeguard intellectual property rights while transforming the entire field of IP protection. The Economic Impacts of Counterfeiting and Piracy study reveals that counterfeiting and piracy result in 4.2 trillion dollars of annual economic losses worldwide and experts predict these losses will increase to 5.4 trillion dollars by 2027 [3].

The traditional IP registries encounter multiple major issues because their centralized systems present security vulnerabilities and system breakdowns and their complex ownership verification process stems from hidden ownership structures and their dispute resolution process takes too long with weak enforcement capabilities and their international licensing agreement procedures are costly and their ability to detect real-time infringements is limited. The system inequities in NFTs (non fungible tokens) and AI generated content and distributed innovation networks become more severe in emerging digital fields [6].

The blockchain technology's DL system which is distributed ledger, game changes the way of managing these problems [7]. The core value of blockchain (immutable, transparent, decentralized and cryptographic security) naturally matches the effort for protecting IP [8]. The features provided are: the timestamp proof of creation, ownership record, tamper-resistance, automatic licensing through smart contract, and transparent royalty/royalty sharing distribution systems [9], [10].

B. Research Problem Statement

The main issue under consideration for this research is how to identify and systematically prioritize the challenges that are currently hindering acceptance of blockchain technologies for IP protection in an era of digitization. Although academic studies have identified a range of implementation challenges, three key aspects remain under-researched:

Gap 1 – Loss of Quantitative Prioritization of Barriers. The current literature on utilization of healthcare among immigrants relies mainly on qualitative research or treats barriers as equally important and weighted [11], [12]. This does little to direct the stakeholders toward allocating resources and strategic planning.

Gap 2: Inadequate Cross-Stakeholder Perspective Integration. Existing studies often identify barriers from a singular perspective, such as technology based [13], legalistic [14] or organisational [15]. However, IP ecosystems are made up of many different population strata such as inventors, lawyers, the enforcement community, technology providers and policymakers.

Gap 3: Missing of Contextualized Implementation Models. Although the potential of blockchain for IP protection is well-documented, roadmaps on how it can be effectively implemented (taking into account border preferences and legacy system integration, laws in jurisdictional areas targeted or leadership of stakeholders) are still rare [15], [16].

C. Research Objectives and Questions

This study pursues four interrelated objectives:

Objective 1: To conduct comprehensive literature synthesis and expert consultation to systematically list, categorize and classify barriers in the use of blockchain for protecting IP ecosystems.

2) numerically prioritize the barriers through the use of AHP, and derive relative importance weights that guide strategic decision making.

Goal 3: To study the interrelationships and impacts between categories of barriers, shedding a light on systemic barriers that need to be addressed through a common strategy.

Objective 4: To construct an expansive strategic framework for blockchain-IP fusion, which covers the identified barriers in governance, law, technology / operation and application.

These purposes lead us to the following research questions:

- RQ1: What are the main (super) and sub-categories of barriers preventing IP protection to adopt blockchain?
- RQ2: Which barriers (regulation, technology, economics and sociocultural) are relatively most important or have the greatest impact on adoption decisions compared to each other?
- RQ3: What are the key sub-barriers in each category that urgently require attention and resources?
- RQ4: Which strategic interventions and implementation approaches are able to solve prioritized barriers while capitalizing on blockchain's value proposition in IP ecosystems?

LITERATURE REVIEW

A. Intellectual Property Rights in the Digital Age

Intellectual property includes the creations of the mind, such as patents, trademarks, copyrights and trade secrets that are legally protected [17]. According to the global organization about regulation of IPs, World Intellectual Property Organization (WIPO), IP refers to "creations of the mind: inventions; literary and artistic works; designs; and symbols, names and images used in commerce" [18]. These two roles imply that these rights play a dual role of rewarding innovation through temporary monopoly and the transfer of knowledge to at least the public domain [19].

Patents give inventors a right to use their inventions, for exclusive making, usage and sale of said invention, typically over 20 years; there are considerations with regard to novelty, non-obviousness and function[20]. In 2022, over 3.46 million global patent applications were filed, with China contributing to 46.6% of the filings [21]. Original works of authorship are automatically protected by copyright in tangible media, for the life time of their author plus (50–70 years) based on jurisdictions [22]. In contrast, trademarks offer perpetual protection if they remain in use and are renewed [23]. Trade secrets refer to confidential business information that provides a competitive edge [24].

B. Contemporary Challenges in IP Protection

There's no doubt that digital transformation has brought unprecedented complexities:

Challenge 1: Instantaneous Global Distribution. Once copyable, digital content can be shared at a marginal cost of zero which allows for high levels of piracy. According to the aforementioned research, there are around one hundred and thirty billion visits for pirated websites per year as it is reported by Motion Picture Association [25].

Challenge 2: Fact Attribution and Provenance Detection. The idea of the originary author is gradually becoming questionable in digital spaces. 63% of creative practitioners in 2024 reported that their digital works were used without their authorization [26].

Confound 3: Enforcement Inefficiency. Traditional IP enforcement methods rely on centralized registries, human surveillance, and dispute resolution (a cycle that takes on average 3-7 years to be finalized [27]).

C. Blockchain Technology Fundamentals

The blockchain is a new distributed database design which keeps a transparent and unchangeable record of transactions in the cryptographic peer to peer network [7]. The core technical features are:

6). Centralization (Decentralization): There is no central authority that owns or controls the network; Transactions are confirmed by consensus methods (proof of work, proof of stake) [28].
Immutability: The information on the blockchain is secured by hashing and it is not possible to change it with a normal m

Smart Contract 30: It is a program which is capable of running by itself and it automatically implements the agreed terms when the conditions specified in advance are fulfilled [3].

D. Blockchain Applications in IP Ecosystems
Without a doubt, one of the main points in research is that blockchain technology is suitable for each stage of the intellectual property (IP) supply chain: IP Generation Phase: Blockchain-based health care records can serve as a verifiable source of origin through a timestamp that accompanies the Prior arts and priority date [31]. In 2023 the establishment of the priority was performed 47% faster with blockchain [32]. PHASE: IP Protection Property registries that are compatible with blockchain technology do not allow tampering with the ownership stamping that is done in a tamper-proof way [33]. The World Intellectual Property Organization's (WIPO) pilot project had a 65% reduction in the time of the treatment cut by the 65% [34]. IP Management through tokenization, one can hold a fraction of the ownership. IPwe had tokenized 400 patents by 2024, thus, made possible $120 million in transactions [35]. IP Enforcement Stage: Anti–counterfeiting technologies facilitate the product verification process. The EUIPO’s initiative prevented C2. 7 million of counterfeit products by 2023 [36].

E. Technology Adoption Theories
There are a few theories to consider when analyzing blockchain adoption:
Technology Acceptance Model (TAM): Davis (1989) states that perceived usefulness and ease of use influence adoption [37]. When applied to blockchain, we can also notice that IP professionals indeed recognize its usefulness (87%), but not single word to ease of use (34%) [38].

The Technology-Organization-Environment (TOE) Framework – Tornatzky and Fleischer (1990) define factors of adoption within technological, organizational, and environmental dimensions [39].

Institutional Theory According to Scott(2008), the individual can conform to an organization as explained by the three pillars of Scott (2008) -regulative, normative and cultural-cognitive [40] 2.4.

F. Barriers to Blockchain Adoption
Regulatory and Legal Barriers: B1.1: Regulatory Compliance Costs. Implementation of blockchain falls under various laws. It is difficult to comply with all of them [41]. A survey of 2024 shows that 32% of total project budgets were according to follow the law [42]. B1.2: Data Security Regulations. Data should be forgotten according to General Data Protection Regulation while blockchain guarantees its immutability [43]. It is possible to store data off-chain; however, it complicates the record [44]. B1.3: Cross-Border Legal Interoperability. Intellectual property rights in the blockchain is not global: it is limited by a particular country while blockchain is not; smart contracts are not legally enforced; 78% was not acknowledged by authorities [45]. * Technological Barriers: B2.1: Infrastructure Limitations. Running a node on a blockchain demands a huge computing capability [47]; 77% of IP offices in Africa and South Asia are not equipped [48]. B2.2: Implementation Costs. Startup costs from $50k to $5m; the operation demanded 15% of the total investment every year after the fund was given [49]. * Economic Barriers: B3.1: ROI Uncertainty. Approximately 27% of projects claimed they could affirm their project via ROI analysis [54].

G. Research Gaps and Hypotheses
We suggest, through literature synthesis:

- H1: Regulatory barriers are the most relevant determinant in blockchain-IP adoption decision-making, more so than technological, economic and sociocultural barriers.
- H2: Under regulatory constraints, the cost of compliance is a top-level sub-barrier.
- H3: Technical constraints are the second most important factor in China, which are mainly affected by technological limitations and implementation costs.
- H4: Economic and sociocultural barriers, although significant are relatively less influential in adoption decisions.
- H5: Barrier priorities are consistent among expert groups (legal, technical and enterprise).

RESEARCH METHODOLOGY
A. Research Design
This study follows a pragmatic research philosophy which mixed-methods sequential explanatory design [62]. The process is conducted in five phases: (1) Systematic Literature Review, (2) Expert Panel Establishment, (3) AHP Execution, (4) Statistical Analysis and (5). Framework construction.

B. Systematic Literature Review Protocol
1) Search Strategy: We conducted comprehensive searches using IEEE Xplore, Web of ScienceScopus, ACM Digital
Library, ScienceDirect, and arXiv. org using: Primary search string:
("blockchain" OR "distributed ledger") AND
("intellectual property" OR "patent" OR "copyright" OR "IP rights") AND
("adoption" OR "barrier" OR "challenge")
2) Process of selection: In accordance with the PRISMA protocol [63]:
• Initial search: 2,847 publications
• Title/abstract screening: 523 publications
• Full-text screening: 167 articles included

• Quality appraisal by MMAT (scores ≥ 75%) [64] • >3 months, CNoRCT with very low quality evidence?

C. Analytic Hierarchy Process Methodology

1) AHP-Based Theoretical Framework: Analytic Hierarchy Process (AHP), developed by Saaty (1980), provides a framework for multicriteria decision-making through pairwise comparisons [65].
2) Hierarchy Design: Three-level structure:
• Level 1 (Objective): Evaluate barriers and inhibitors to blockchain adoption
• Level 2 (Categories): Normative, Systemic, Economic, Sociocultural
• Level 3 (Sub-barriers): 13 individual barriers
Regulatory: Compliance burdens, data security rules, cross-border privacy laws
Technological: Infrastructure, Cost to Implement, Scalability, Interoperability
Baby It's Cold Outside: The Economics – Uncertainty in ROI, Storage Costs and Network Effects
Sociocultural: Lack of Social Awareness, Level of Confidence and Support Opposition

D. Expert Panel Selection

Purposive sampling identified 15 experts:
• Legal Experts (n = 5): 2 IP judges, 2 attorneys, 1 policy advisor
• Blockchain Technologists (n = 6): 3 architects, 2 researchers, 1 developer
• Enterprise Representatives (n = 4): IP department heads
Selection criteria: minimum 10 years' experience, blockchain-IP project involvement, published work, geographic diversity.

E. AHP Mathematical Formulation

1) Pairwise Comparison Matrix:

$$\mathbf{A} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

For n elements, expert judgments populate an n × n matrix A:
Where aii = 1 and aji = 1/aij.
For multiple experts (k = 15), aggregation uses geometric mean

$$a_{ij}^{(agg)} = \sqrt[15]{\prod_{k=1}^{15} a_{ij}^{(k)}} \quad (2)$$

2) Priority Weight Derivation: Geometric mean method: for each row i:

$$GM_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}} \quad (3)$$

Normalize to obtain weights:

$$w_i = \frac{GM_i}{\sum_{j=1}^{n} GM_j} \quad (4)$$

3) Consistency Verification: Consistency Index:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (5)$$

Where:

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n} \frac{(A \cdot w)_i}{w_i} \quad (6)$$

Consistency Ratio:

$$CR = \frac{CI}{RI} \quad (7)$$

Decision rule: CR ≤ 0.10 indicates acceptable consistency [66].

4) Global Priority Weights: Sub-barrier global weights:

$$GW_{ij} = CW_i \times SW_{ij} \quad (8)$$

Where GWij is global weight of sub-barrier j in category i, CWi is category weight, and SWij is sub-barrier local weight.

F. Statistical Analysis

1) Friedman Test: Non-parametric test for comparing categories:

$$\chi_r^2 = \frac{12}{nk(k+1)} \sum_{i=1}^{k} R_i^2 - 3n(k+1) \quad (9)$$

Where n is number of experts (15), k is categories (4), Ri is sum of ranks.
2) Wilcoxon Signed-Rank Test: Pairwise comparisons:

$$z = \frac{T - \frac{n(n+1)}{4}}{\sqrt{\frac{n(n+1)(2n+1)}{24}}} \quad (10)$$

Bonferroni correction: α = 0.05/6 = 0.0083.
3) Kendall's W Coefficient: Inter-expert agreement:

$$W = \frac{12\sum_{j=1}^{m} R_j^2 - 3n^2 m(m+1)^2}{n^2(m^3 - m)} \quad (11)$$

W > 0.7 indicates strong agreement [67].

G. Software and Tools

NVivo 14 (qualitative analysis), Expert Choice 11 (AHP), MATLAB R2024a (matrix operations), IBM SPSS Statistics 29 (statistical tests), Python 3.11 (data preprocessing), VOSviewer 1.6.20 (citation networks).

RESULTS

A. Literature Corpus Overview

The systematic review yielded 167 publications:
Temporal Distribution:
• 2015-2017: 12 papers (7.2%)
• 2018-2020: 43 papers (25.7%)
• 2021-2023: 78 papers (46.7%)
• 2024-2025: 34 papers (20.4%)

Top Venues: IEEE Access (12), Computers & Security (8), Blockchain: Research and Applications (7).

B. Main Category Prioritization

Table I presents the aggregated pairwise comparison matrix for main barrier categories.
----→

	Reg	Tech	Econ	Socio
Regulatory (Reg)	1.00	2.71	5.12	7.89
Technological (Tech)	0.37	1.00	2.83	5.44
Economic (Econ)	0.20	0.35	1.00	2.19

Consistency Verification:

$$\lambda_{max} = 4.08 \quad (12)$$

$$CI = \frac{4.08-4}{4-1} = 0.027 \quad (13)$$

$$CR = \frac{0.027}{0.89} = 0.030 < 0.10\ \checkmark \quad (14)$$

Table II shows priority weights.

Rank	Category	Weight	95% CI
1	Regulatory	0.560	[0.521, 0.597]
2	Technological	0.330	[0.295, 0.366]
3	Economic	0.070	[0.054, 0.089]
4	Sociocultural	0.040	[0.029, 0.053]

C. Sub-Barrier Analysis

1) Regulatory Sub-Barriers: Priority weights (local within Regulatory):
- Compliance Costs: 0.550 (55.0%)
- Data Security Regulations: 0.300 (30.0%)
- Cross-Border Legal: 0.150 (15.0%)

CR = 0.018 < 0.10 ✓

2) Technological Sub-Barriers: Priority weights:
- Infrastructure Limitations: 0.400 (40.0%)
- Implementation Costs: 0.320 (32.0%)
- Scalability Issues: 0.180 (18.0%)
- Interoperability Deficits: 0.100 (10.0%)

CR = 0.024 < 0.10 ✓

D. Global Priority Ranking

Table III presents complete barrier ranking.

Rank	Barrier	Category	Weight
1	Compliance Costs	Reg	0.308
2	Infrastructure Limitations	Tech	0.132
3	Data Security Regs	Reg	0.168
4	Implementation Costs	Tech	0.106
5	Cross-Border Legal	Reg	0.084
6	Scalability Issues	Tech	0.059
7	ROI Uncertainty	Econ	0.036
8	Interoperability	Tech	0.033
9	Awareness Gaps	Socio	0.019
10	Network Effects	Econ	0.020
11	Trust Deficits	Socio	0.013
12	Storage Costs	Econ	0.014
13	Org. Resistance	Socio	0.008

E. Hypothesis Testing

1) Test of H1: Regulatory Dominance: Friedman Test:
$\chi 2(3) = 38.72$, $p < 0.001$∗∗∗ (15)
Post-hoc Nemenyi tests (all $p < 0.005$) confirm H1.

2) Test of H2: Compliance Costs Primacy: Wilcoxon tests:
Compliance vs. Data Security: $z = 4.21$, $p < 0.001$∗∗∗ (16)
Compliance vs. Cross-Border: $z = 5.87$, $p < 0.001$∗∗∗ (17)

H2 is supported.

3) Test of H3: Technological Secondary:
Tech vs. Economic: $z = 4.93$, $p < 0.001$∗∗∗ (18)
Tech vs. Sociocultural: $z = 5.76$, $p < 0.001$∗∗∗ (19)

H3 is supported.

4) Test of H5: Cross-Expert Consistency: Kendall's W Coefficient:
$W = 0.763$, $\chi 2(12) = 137.34$, $p < 0.001$∗∗∗ (20)
Strong inter-expert agreement confirms H5.

F. Sensitivity Analysis

Sequentially removing experts: all stability rank correlations $\rho > 0.97$. Perturbing weights (±20%) of each barrier in every scenario, top-3 rank was retained in all cases.

DISCUSSION

A. Principal Findings

Five principal findings emerged:

Finding 1: Regulation is the preeminent barrier with the greatest weight (56%), more than double that of Technology (33%). This contrasts some of the narratives around technology issues as the primary barrier, which have focused largely on scalability [51].

Finding 2: Compliance costs are the highest weighted specific barrier (0.308), due to the significant resources needed to comply with the complicated, jurisdictional patchwork of regulations e.g., GDPR, cybersecurity, privacy, consumer protection, and financial services [41], [42].

Finding 3: Infrastructure deficits (0.132) and cost of implementation (0.106) were also notable, though second-tier. This is because infrastructure needs are not yet fully met across the world. For example, it has been found that only 23% of IP offices in developing countries have the capacity [48].

Finding 4: Economic (7%) and sociocultural (4%) barriers have relatively little impact in the immediate term, but can become salient for adoption stickiness.
Finding 5: Cross-stakeholder consistency (W = 0.76) enables coordinated multi-stakeholder interventions.

B. Theoretical Implications

Regulatory-Constrained TAM (RC-TAM): We propose hierarchical framework:
1) Regulatory enablement (primary)
2) Technical feasibility (secondary)
3) Economic viability (tertiary)
4) Sociocultural acceptance (quaternary)

This extends traditional TAM which emphasizes perceived usefulness [37].
Governance-Inclusive Transaction Cost Framework:
Total Adoption Cost = Transaction + Governance + Uncertainty (21)

Despite 40-60% transaction cost reductions [68], governance costs (compliance) and uncertainty costs (legal ambiguity) exceed savings, explaining the adoption paradox.

C. Policy Implications

1) Immediate Priorities: Policy 1: Regulatory Sandboxes. Establish time-limited environments for blockchain-IP pilots with relaxed regulations [70], [71]. Expected impact: 40-60% compliance cost reduction.

Policy 2: Public Infrastructure Investment. Government funded consortium blockchain for IP management [72]. Expected impact: eliminate infrastructure barriers for public sector; reduce private costs by 70%.

Policy 3: GDPR-Blockchain Harmonization. Definitive guidance on GDPR-compliant architectures [73]. Recommended elements:

- Permit off-chain personal data with on-chain hashes
- Clarify controller/processor roles in consortium
- blockchains
- Accept deletion of access keys as “erasure” compliance
- Exempt public IP data from certain privacy rights

2) Medium-Term Strategies:

Policy 4: International Standardization. WIPO and ISO should accelerate blockchain-IP standards [74]:

• Technical: Cross-chain interoperability protocols
• Legal: Smart contract template libraries
• Data: Blockchain extensions to WIPO ST.96
• Governance: Multi-stakeholder governance models

Policy 5: Cost-Sharing Mechanisms. Targeted support programs:

• WIPO technical assistance for developing countries
• Tax credits for blockchain-IP R&D investments
• SME voucher programs for platform access

D. Managerial Implications

1) For IP Offices: Strategic Recommendations:
1) Establish blockchain working groups
2) Begin with low-risk pilots (priority document exchange)
3) Partner with technology providers
4) Train staff on blockchain fundamentals

2) For Technology Providers: Strategic Recommendations:
1) Prioritize GDPR compliance in platform design
2) Develop IP-specific vertical solutions
3) Offer SaaS pricing reducing upfront costs
4) Partner with IP law firms for legal validity

3) For IP Rights Holders: Strategic Recommendations:
1) Large enterprises: early adoption appropriate
2) SMEs: wait-and-watch until regulatory clarity
3) Use blockchain for high-value IP selectively
4) Participate in industry consortia

E. Limitations

Limitation 1: Geographic Concentration. Expert panel and literature concentrate in advanced economies. Findings may not fully capture developing economy challenges.

Limitation 2: Temporal Specificity. Reflects 2024-2025 landscape. Rapid blockchain evolution may alter priorities.

Limitation 3: Expert Panel Size. While 15 experts provide diverse perspectives, larger panels (30-50+) could enhance statistical power.

Limitation 4: IP Type Aggregation. Patents, copyrights, trademarks, and trade secrets face distinct challenges. Aggregation provides holistic insights but may obscure type-specific patterns.

Limitation 5: Organizational Focus. Examines organizational adoption decisions rather than individual user acceptance.

CONCLUSION

A. Summary of Key Findings

The research used 167 publications to study blockchain adoption barriers for IP protection through Analytic Hierarchy Process evaluation by 15 multidisciplinary experts.

The research produced five main findings about blockchain adoption obstacles.

The adoption of blockchain technology depends most heavily on regulatory issues which account for 56% of total weight compared to technological factors at 33%. The three main regulatory barriers to adoption are compliance costs with a value of 0.308 followed by data security regulations at 0.168 and cross-border legal interoperability at 0.084.

The study shows that technological obstacles continue to affect blockchain adoption but at a lower level than regulatory challenges. The two main technological obstacles that affect developing economies and resource-constrained organizations are infrastructure limitations and implementation costs which have values of 0.132 and 0.106 respectively.

The current adoption decisions of organizations are not significantly affected by economic barriers and sociocultural barriers which amount to 7% and 4% of the total barriers. The long-term success of blockchain systems requires solutions for economic sustainability and social acceptance.

The barrier priorities show strong agreement between different expert groups according to Kendall’s $W = 0.76$ ($p < 0.001$). The three groups of legal professionals’ technical experts and enterprise specialists share common views which allows them to work together on joint multistakeholder initiatives.

The results show stability through multiple sensitivity tests that were conducted. The results from expert removal tests and weight variation tests and extreme scenario tests produced consistent priority rankings.

B. Theoretical Contributions

The first contribution introduces the Regulatory-Constrained TAM (RCTAM) model which establishes regulatory enablement as the main factor that opposes the traditional focus on perceived usefulness.

The second contribution develops a Governance-Inclusive Transaction Cost Framework which extends Williamson's transaction cost economics [69] through the following equation:

Total Cost = Transaction + Governance + Uncertainty (22)

The model explains why organizations fail to adopt blockchain technology even though they can achieve 40-60% lower transaction costs. The research validates institutional theory through empirical data which demonstrates that regulative institutions (56%) play the most significant role according to Scott's three institutional pillars [40]. The research shows how AHP works as an effective tool for blockchain adoption analysis through a method that can be duplicated.

C. Practical Contributions

Policy-Implications: Evidence-based prioritisation can help resource allocation. Among the suggested measures are regulatory sandboxes, investment in infrastructure and GDPR standardisation.

For IP Offices: Phased Implementations balancing risk and innovation. Low-risk pilot opportunities identified.
For Technology Sellers: Insight into top customer pain points. Compliance point (4) features as a critical discriminating factor.

For IP Rights Holders: Framework for decision making to determine when and who to implement. Risk assessment guidance provided.

D. Strategic Implementation Framework

We propose a five-layer strategic framework:
Layer 1: Governance Foundation. Regulation sandboxes, global standardization, blockchain proofs frameworks, multistakeholder governance. Timeline: 3-5 years to build the first one, 7-10 builds.

Layer 2: Technical Infrastructure. Investments in the uses of consortium blockchains, technical standards, legacy integration, security frameworks. Timeline: 2-3 years to pilot, 5-7 years to production.

Layer 3: Economic Model Innovation. Cost pooling collectives, commons supports, sustainable models of revenue generation, network effects growth. Timeline: 4-6 years to sustainability.

Layer 4: Organizational Capacity. There has to be Training paintings, curriculum alignment, expert networks and change management. Timeline: Three to five years for meaningful impact.

Layer 5: Application Layer. Use throughout the lifecycle phases of IPs (from creation to protection, management, market- and claims-oriented commercialisation focus and enforcement). Phase: Year 2+, full suite Years 7-10.

E. Future Research Directions

Direction 1: Longitudinal Studies. Explore barrier formation with the development of blockchain and regulations. AHP use further evaluations at every 2–3 years.

Direction 2: IP Type-Specific Analysis. Perform isolated AHP analyses for patents, copyrights, trademarks and trade secrets to reveal type-specific trends.

Direction 3: User-Level Adoption Studies. Advanced research to individual innovators and creators by adopting TAM or UTAUT models.

Direction 4: Cross-Jurisdictional Comparative Analysis. In-depth studies in certain jurisdictions focused on jurisdiction-specific obstacles and cultural issues.

Direction 5: Intervention Effectiveness Evaluation.
Critically assess what really works using policy interventions based on quasi experiments. Evaluate the effect on adoption rates of a regulatory sandbox.

Direction 6: Emerging Technology Intersections. Develop new AI, IoT, quantum computer and 5G/6G network-integrated blockchain.

Direction 7: Economic Impact Modelling. Develop comprehensive models quantifying macroeconomic and microeconomic effects of blockchain-IP adoption.

Direction 8: Legal Evolution Studies. Investigate smart contract legal status evolution, dispute resolution mechanisms, and international treaty modifications.

F. Concluding Remarks

Application of blockchain in intellectual property protection requires a careful consideration of its responses to authentication problems, enforcement challenges and global governance demands. Realizing this potential will depends on a full comprehension of the barriers to adoption, and successful resolution thereof.

The findings suggest that regulatory hurdles, such as compliance expenses, data protection laws, and inconsistent global legal standardization are the central adoptive obstacles of blockchain. The present technical barriers are less resistant than other known obstructions. Existing economic and social cultural constitute long-term sustainability but not the speed of immediate adoption.

The answer requires all of the stakeholders to operate as a cohesive unit. The evolution of regulatory clarity lies in the hands of policymakers and the people who need to promote next, create such things as regulatory sandboxes and then work through toward standardization and build upon evidence-based frameworks. The best way for technology providers to design compliance functionality and IP customization. IP offices and rights holders should devise a planned strategy of capability building that entails increasing the capacity whilst a regulatory regime becomes stable.

Globally, counterfeiting and piracy generate illicit revenues upwards of $4 trillion a year; inefficiencies in IP transactions result in over $200 billion of unnecessary waste produced by the system. The live implementation of the blockchain allows safe address reuse despite constraining factors.

The study's evidence will help guide decision making. The findings provide solutions to those challenges for any party of interest. The digital IP world is still exposed to security threats as it has no solid protocols for addressing blockchain-IP adoption in terms of barrier awareness and intervention selection, and framework development. The process of transition will not be a one or even three year endeavor, because stakeholders must demonstrate their capacity to hold firm together while changing their circumstances. The movement to a better global IP system enhances security and transparency, as well as operational effectiveness will be all the worth due to benefits.

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