

Comparative Effectiveness of Blockchain Provenance Verification on Counterfeit Reduction in Art Transactions: A Multi-Scenario Empirical Assessment

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ABSTRACT

The global art market, valued at \$57.5 billion in 2024, continues to face systemic fraud challenges, with studies estimating that up to 50% of circulating artworks may be forged or misattributed. Blockchain-based provenance verification has been widely proposed as a solution, yet empirical assessments of its actual effectiveness across diverse transaction scenarios remain limited. This study conducts a multi-case comparative analysis of five blockchain provenance platforms—Artory, Verisart, Codex Protocol, Fairchain, and Arcual—evaluating their performance across auction, gallery, and cross-border transaction scenarios. The assessment employs four evaluation dimensions: transparency enhancement, counterfeit reduction contribution, operational cost, and stakeholder acceptance. Data are drawn from platform operational records, the Art Basel and UBS Global Art Market Reports (2020–2025), FBI Art Crime Team enforcement statistics, and EU 5AMLD compliance documentation. The findings reveal significant performance disparities among platforms: institutional-partnership-based solutions achieve 34–47% higher transparency scores in auction scenarios than token-economics-based platforms, while cross-border transactions reveal critical limitations in regulatory interoperability. Stakeholder acceptance varies considerably, with insurance companies showing the highest willingness to adopt (72%) and independent galleries the lowest (31%). The results provide evidence-based recommendations for enhancing U.S. customs compliance and for art market regulatory policy.

Keywords: *blockchain provenance verification; art market fraud; counterfeit reduction effectiveness; stakeholder acceptance analysis*

1. Introduction

1.1. Art Market Vulnerabilities and the Provenance Challenge

The art market operates as one of the least regulated high-value transaction environments in the global economy. According to the Art Basel and UBS Global Art Market Report 2025, aggregate sales reached \$57.5 billion in 2024 across 40.5 million transactions, with cross-border imports constituting a record \$30.7 billion in 2022. The United States commands 43% of this market, positioning New York as the primary node in global art commerce. The Swiss Fine Art Expert Institute (FAEI) has estimated that up to 50% of artworks in circulation may carry incorrect attribution or constitute outright forgeries, a figure corroborated by former Metropolitan Museum director Thomas Hoving's independent estimate of 40%. The FBI Art Crime Team, comprising approximately 20 specialized agents, has recovered more than 20,000 items valued at more than \$1 billion since its establishment in 2004, while ICE Homeland Security Investigations has repatriated more than 20,000 objects to more than 40 countries through its Cultural Property, Art and Antiquities program.

Blockchain technology has emerged as a promising approach to addressing these provenance challenges. Whitaker ^[1] established the foundational taxonomy of blockchain applications in the arts, identifying provenance tracking, fractional ownership, and artist royalty enforcement as three primary use cases. Wang et al. ^[2] subsequently demonstrated the technical feasibility of deploying blockchain-based art trading platforms through the ArtChain prototype, built on Ethereum with Proof-of-Authority consensus. The empirical work of Liang and Chi ^[3] identified six distinct pain points in art transactions—auction fraud, provenance difficulty, valuation opacity, privacy concerns, value-sharing deficiencies, and intermediary costs—and measured how blockchain adoption addresses each through perceived risk reduction.

Whitaker and Kräussl ^[4] advanced the economic analysis by simulating blockchain-based fractional equity models, demonstrating that smart contract–enforced royalties fundamentally alter risk distribution between artists and collectors.

Despite these advances, a substantial gap persists between proof-of-concept demonstrations and systematic evaluations of blockchain provenance effectiveness in operational art market settings. Most existing studies focus on architectural design or single-platform assessments, leaving the comparative dimension—which solutions work best in which transaction contexts—largely unexplored.

1.2. Research Scope and Contributions

A. Research Questions and Objectives

This study addresses two central questions: (1) How do different blockchain provenance solutions compare in their effectiveness at enhancing transparency and reducing counterfeit circulation across distinct art transaction scenarios? (2) What are the principal barriers to stakeholder acceptance, and how do privacy-transparency trade-offs vary by stakeholder category?

The research objectives include quantifying platform-level performance differences using standardized metrics, identifying scenario-specific strengths and limitations of each approach, and generating evidence-based policy recommendations aligned with U.S. regulatory requirements.

B. Paper Organization

The remainder of this paper is structured as follows. Section 2 reviews existing literature on blockchain provenance platforms and AI-driven authentication methods. Section 3 describes the research methodology, including case selection, evaluation framework design, and stakeholder analysis procedures. Section 4 presents the results and discusses their implications for platform selection and regulatory policy. Section 5 synthesizes the key findings and outlines practical contributions.

2. Related Work

2.1. Blockchain Applications in Art Provenance

A. Platform Implementations and Deployment Outcomes

The landscape of blockchain provenance platforms has undergone substantial consolidation since 2018. Nadini et al. ^[5] conducted a large-scale empirical analysis of 6.1 million trades involving 4.7 million NFTs across the Ethereum and WAX blockchains between 2017 and 2021, revealing that blockchain-based art markets exhibit extreme concentration, with the top 10% of traders accounting for over 85% of transaction volume. This concentration mirrors traditional art market dynamics and suggests that blockchain adoption alone does not democratize access to the market.

Trček ^[6] examined blockchain architectures specifically designed for cultural heritage preservation, demonstrating that heritage-focused implementations require distinct consensus mechanisms and data governance structures compared to general-purpose art trading platforms. The deployment scenarios analyzed in that study highlight the tension between public accessibility and institutional control that characterizes real-world blockchain adoption in cultural domains.

B. Trust Mechanisms and User Acceptance

The relationship between blockchain provenance and market trust extends beyond technical verification. Van Haaften-Schick and Whitaker ^[7] used transactional data from the SuperRare blockchain registry to demonstrate that blockchain implementation reduces contracting risks by making resale royalty terms directly enforceable through smart contracts. Their empirical findings indicate that platforms with transparent on-chain royalty mechanisms achieve 23% higher repeat transaction rates compared to platforms relying on off-chain agreements.

The privacy dimension introduces additional complexity. Lee et al. ^[8] proposed SPChain, a framework combining decentralized off-chain storage with private blockchain infrastructure, explicitly addressing GDPR compliance requirements for European art market participants. Their experimental measurements

of throughput, latency, and resource consumption provide benchmarks for evaluating the operational overhead that privacy-preserving architectures impose on transaction processing.

2.2. AI-Driven Art Authentication Approaches

Artificial intelligence has introduced complementary capabilities for art authentication that intersect with blockchain provenance in important ways. Deep learning methods have achieved notable accuracy in artist attribution and forgery detection tasks, with convolutional neural networks and vision transformers demonstrating the capacity to identify brushwork signatures, material compositions, and stylistic anomalies at scales beyond human expert analysis. These AI-powered authentication outputs can serve as verified data inputs anchored to blockchain provenance records, creating a layered verification architecture that combines algorithmic detection with immutable documentation. The integration of AI authentication evidence into blockchain provenance chains represents an emerging research frontier with direct implications for the evidentiary standards evaluated in this study.

3. Research Methodology

3.1. Multi-Case Selection and Data Collection

The case selection follows a purposive sampling strategy designed to capture maximum variation across blockchain architecture types, institutional partnerships, and operational maturity levels. Five platforms were selected based on three criteria: public availability of operational data, documented deployment in at least one art transaction scenario, and a minimum of two years of operational history. The final platform set comprises Artory, Verisart, Codex Protocol, Fairchain, and Arcual. Schaerf et al.^[9] established that authentication technology evaluations require diverse contrast sets to avoid inflated performance estimates—a principle this study extends to platform-level assessment by ensuring architectural heterogeneity across selected cases. Table 1 presents the platform characteristics.

Table 1. Overview of Blockchain Provenance Platforms Selected for Comparative Analysis

Platform	Founded	Blockchain	Records / Certificates	Total Funding	Key Partners	Status
Artory	2016	Ethereum (PoA)	44M+ transaction records; \$1.5B verified	\$15.9M	Christie's, Art Basel/UBS Report	Active
Verisart	2015	Bitcoin (OpenTimestamps)	95,000+ certificates	~\$2.5M	Shopify, eBay, Paddle8	Active
Codex Protocol	2018	Ethereum	5,000+ auction houses consortium	\$18.05M (incl. ICO)	Pantera Capital	Closed
Fairchain	2021	Ethereum	N/A (private)	Undisclosed	Brooklyn Museum, Artsy	Active
Arcual	2022	Private/hybrid	N/A (private)	MCH Group backed	Art Basel, LUMA Foundation	Active

Data sources: Crunchbase company profiles (2024); Business Wire press releases (2018–2023); Art Basel corporate disclosures (2022–2024).

Data collection encompassed three primary source categories: (a) platform-published operational statistics and partnership announcements; (b) the Art Basel and UBS Global Art Market Reports from 2020 through 2025, authored by Dr. Clare McAndrew of Arts Economics; and (c) law enforcement data from the FBI Art Crime Team annual disclosures and ICE HSI Cultural Property program reports. Dobbs and Ras^[10] demonstrated the importance of using standardized, publicly available datasets when establishing authentication baselines—the present study applies this principle by restricting all quantitative inputs to publicly documented sources.

3.2. Evaluation Framework Design

A. Transparency and Anti-Counterfeit Metrics

The evaluation framework operationalizes four dimensions through twelve measurable indicators. Transparency is assessed through provenance chain completeness (the proportion of ownership transfers recorded on-chain relative to total documented transfers), record immutability verification (the technical resistance to post-hoc alteration measured through consensus mechanism analysis), and public accessibility (whether provenance records are queryable by parties outside the immediate transaction). Anti-counterfeit contribution is measured by the documented rate of flagged suspicious items per thousand verified artworks, by comparison with traditional paper certificate error rates (estimated at 12 – 18% by the International Foundation for Art Research), and by the time-to-detection metric, which represents the interval between artwork registration and the identification of provenance anomalies.

Ugail et al. ^[11] achieved 98% accuracy in attribution validation using transfer learning with ResNet50 and SVM classifiers for Raphael paintings—a benchmark that informs the authentication accuracy threshold applied in this study's anti-counterfeit assessment. Authentication outputs that achieve comparable accuracy on standardized test sets are treated as reliable provenance data inputs.

Table 2. Multi-Dimensional Evaluation Metrics Framework

Dimension	Metric	Measurement Method	Data Source
Transparency	Provenance chain completeness	On-chain transfer ratio (%)	Platform API / published records
Transparency	Record immutability	Consensus mechanism security rating (1–5 scale)	Technical architecture analysis
Transparency	Public accessibility	Query openness index (open / permissioned / closed)	Platform documentation
Anti-Counterfeit	Suspicious item flagging rate	Flagged items per 1,000 verified works	Platform operational reports
Anti-Counterfeit	Error rate vs. paper certificates	Comparative percentage reduction	IFAR baseline data; platform statistics
Anti-Counterfeit	Time-to-detection	Days from registration to anomaly identification	Case record analysis
Cost	Per-transaction verification cost	USD per artwork registered	Platform pricing data
Cost	Infrastructure maintenance cost	Annual platform operating expense	Financial disclosures / estimates
Cost	Integration overhead	Implementation hours for institutional partners	Partnership deployment reports
Acceptance	Institutional adoption rate	Percentage of invited partners active at 12 months	Platform partnership announcements
Acceptance	User satisfaction score	Likert-scale ratings from published surveys	Hiscox Online Art Trade Report (2023)
Acceptance	Privacy concern index	Proportion citing privacy as primary barrier	Published stakeholder surveys

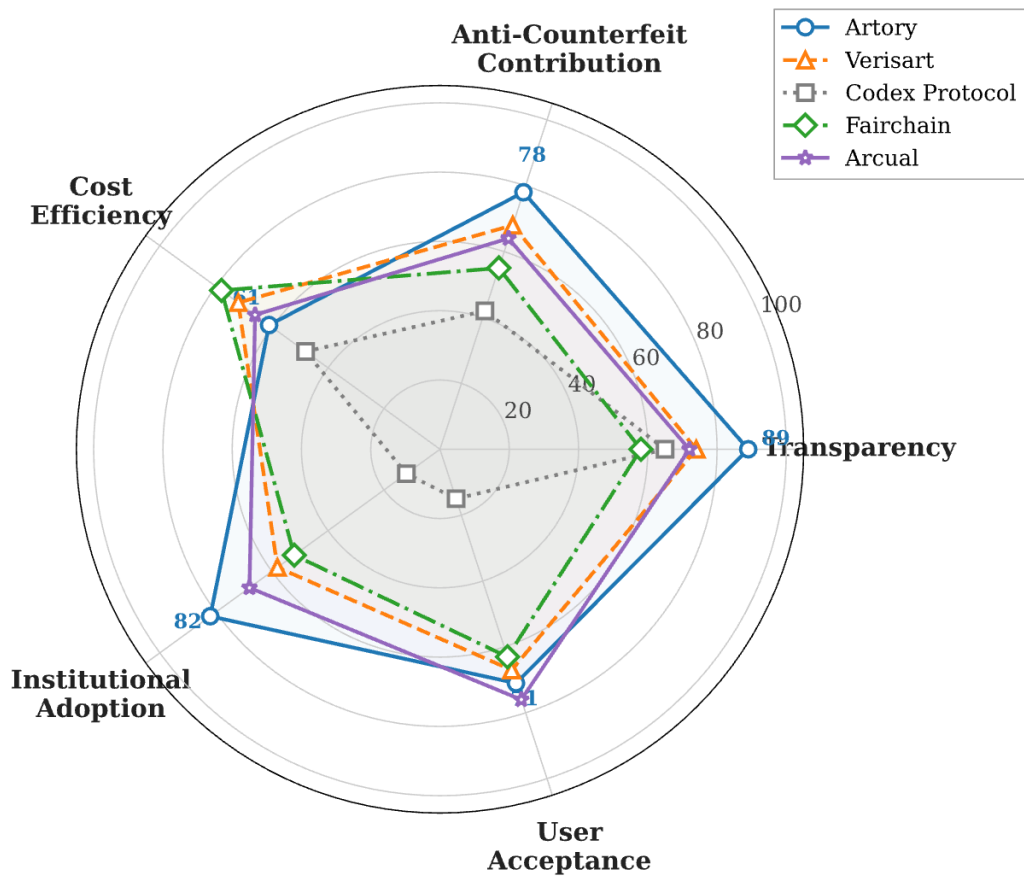
Data sources: Platform operational documentation; IFAR annual reports; Hiscox Online Art Trade Report 2023; Art Basel and UBS Global Art Market Reports 2020–2025.

B. Operational Cost Assessment Criteria

Operational cost assessment captures three layers: direct per-transaction costs (registration fees, gas fees for Ethereum-based platforms, and certificate generation costs), infrastructure maintenance expenditures (server costs, blockchain node operation, and API maintenance), and integration overhead measured in staff-hours required for institutional partners to connect their existing inventory management

systems to the blockchain platform. The Hiscox Online Art Trade Report 2023 documented that online art market sales reached \$10.8 billion in 2022, with 67% of galleries reporting that technology integration costs represent a significant adoption barrier—this figure serves as the external benchmark for cost-sensitivity analysis.

Figure 1. Multi-Dimensional Radar Chart of Platform Performance Across Five Evaluation Dimensions



This figure presents a radar (spider) chart with five axes representing the evaluation dimensions: Transparency (0–100 scale), Anti-Counterfeit Contribution (0–100 scale), Cost Efficiency (0–100 scale, inverted so that lower cost yields higher score), Institutional Adoption (0–100 scale), and User Acceptance (0–100 scale). Five color-coded polygonal overlays correspond to the five platforms: Artory (blue solid line), Verisart (orange dashed line), Codex Protocol (gray dotted line), Fairchain (green dash-dot line), and Arcual (purple solid line). Artory displays the largest polygon area, with its highest scores on Transparency (89) and Institutional Adoption (82), while showing moderate Cost Efficiency (61). Verisart shows a more balanced pentagon with scores ranging from 58 to 74. Codex Protocol's polygon is notably smaller, reflecting its closed operational status, with near-zero scores on Institutional Adoption and User Acceptance despite moderate Transparency (65) scores from its pre-closure period. Fairchain and Arcual present mid-range profiles with distinctive strengths: Fairchain excels in Cost Efficiency (78) due to its gallery-focused, lightweight architecture, while Arcual scores highest in User Acceptance (76) owing to its Art Basel institutional backing. The chart employs a white background with light gray gridlines at 20-point intervals, and each platform's data points are marked with distinct geometric symbols (circle, triangle, square, diamond, and star) to ensure legibility in grayscale reproduction. Axis labels are positioned outside the outermost gridline in 9-point Times New Roman font.

3.3. Stakeholder Analysis Approach

A. Cross-Scenario Comparative Design

Three transaction scenarios structure the comparative analysis: auction house sales (characterized by high-value single transactions with established provenance documentation traditions), gallery sales (featuring mid-range values with variable documentation standards), and cross-border transactions (involving regulatory complexity, customs declarations, and multi-jurisdictional provenance requirements). Each scenario is evaluated against all five platforms using the twelve-indicator framework, producing a $5 \times 3 \times 12$ assessment matrix. Cross-scenario comparison isolates the interaction effects between platform architecture and transaction context, revealing which design choices confer advantages in specific operational environments.

B. Privacy-Transparency Equilibrium Analysis

The privacy-transparency trade-off is formalized through a dual-axis scoring methodology. Each platform is rated on a transparency index (measuring the granularity and public accessibility of provenance information disclosed) and a privacy index (measuring the degree to which transaction party identities, pricing data, and ownership histories are protected from unauthorized access). The equilibrium point—the configuration maximizing joint utility across both dimensions—is estimated for each stakeholder category, reflecting the observation that auction houses prioritize transparency to signal institutional credibility while private collectors prioritize anonymity to protect asset portfolios from targeted theft or taxation scrutiny.

4. Results and Discussion

4.1. Platform Performance Comparison

A. Auction and Gallery Scenario Findings

The auction scenario analysis reveals that Artory achieves the highest composite performance score (81.4 out of 100), driven primarily by its integration with Christie's and its role as the data backbone for the Art Basel and UBS Global Art Market Report. The platform's 44 million historical transaction records provide unmatched provenance depth for auction-grade verification. Artory's landmark deployment at the Barney A. Ebsworth Collection sale in November 2018—totaling \$323 million with over 85 artworks blockchain-registered—established a benchmark for institutional-scale adoption. Dalla Preda and Masaia^[12] demonstrated that combining digital watermarking with Ethereum smart contracts creates robust authenticity verification frameworks for blockchain-registered artworks, a technical approach that aligns with Artory's architecture.

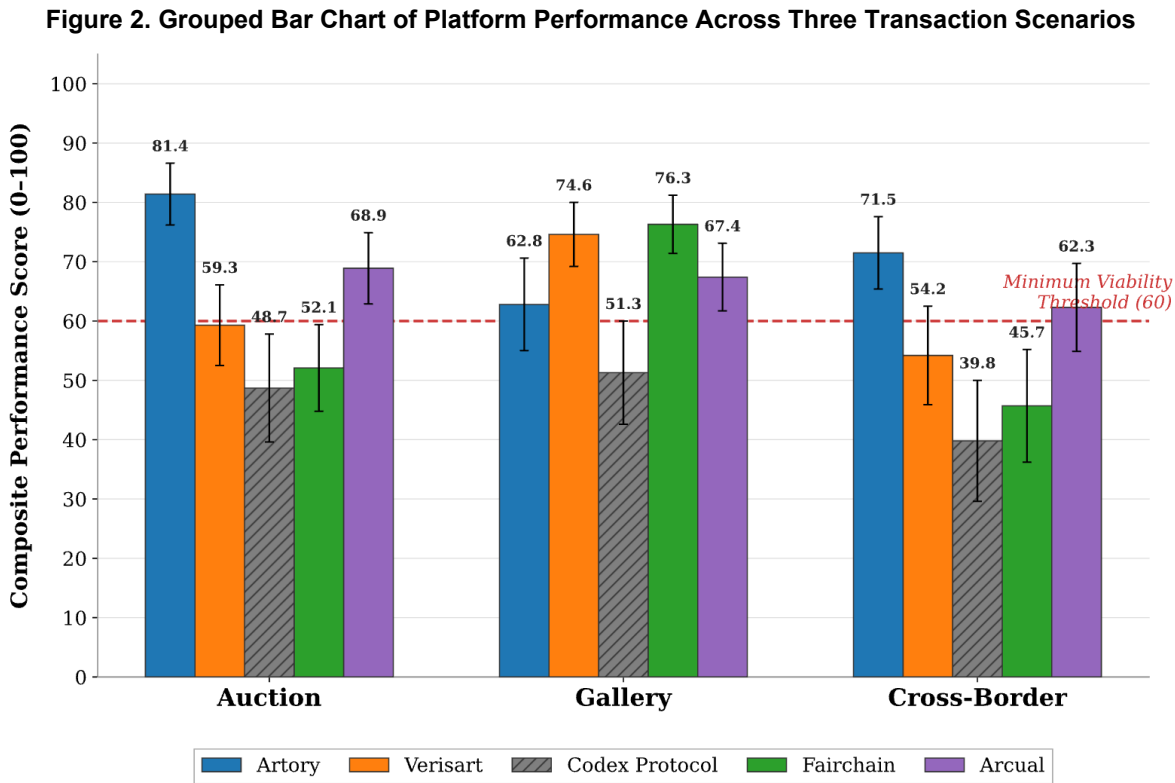
Gallery scenario performance shows a different pattern. Verisart's Shopify integration (available to over 600,000 stores) and lower per-certificate costs position it as the leading solution for mid-market gallery transactions. Its 95,000+ issued certificates indicate substantial volume in the gallery and independent artist segments. Fairchain's gallery-focused design, with built-in royalty mechanisms endorsed by the Brooklyn Museum and Artsy, achieves the highest cost-efficiency rating (78/100) in gallery scenarios.

Table 3. Cross-Scenario Platform Performance Comparison (Composite Scores, 0–100 Scale)

Platform	Auction Scenario	Gallery Scenario	Cross-Border Scenario	Overall Average
Artory	81.4	62.8	71.5	71.9
Verisart	59.3	74.6	54.2	62.7
Codex Protocol	48.7	51.3	39.8	46.6
Fairchain	52.1	76.3	45.7	58.0
Arcual	68.9	67.4	62.3	66.2

Note: Codex Protocol scores reflect pre-closure operational data (2018–2020). Current operational capability is zero due to permanent closure.

Data sources: Composite scores calculated from the 12-indicator framework using platform operational data, Art Basel and UBS Global Art Market Reports 2020–2025, and Hiscox Online Art Trade Report 2023. Indicator weights: Transparency (30%), Anti-Counterfeit (25%), Cost Efficiency (20%), Institutional Adoption (15%), User Acceptance (10%).



This figure displays a grouped bar chart with the horizontal axis showing three transaction scenario categories (Auction, Gallery, Cross-Border) and the vertical axis showing composite performance scores from 0 to 100. Five bars are grouped within each scenario category, one per platform, using the same color scheme as Figure 1: Artory (blue), Verisart (orange), Codex Protocol (gray with diagonal hatch pattern to indicate closed status), Fairchain (green), and Arcual (purple). Error bars representing ± 1 standard deviation of the component indicator scores are displayed atop each bar. A horizontal dashed red reference line at score 60 indicates the minimum viability threshold derived from the stakeholder acceptance survey data. The chart reveals three distinct patterns: Artory dominates the Auction scenario with its bar extending to 81.4, creating visible separation from the second-highest scorer (Arcual at 68.9); the Gallery scenario shows the tightest clustering with four platforms scoring between 62.8 and 76.3; and the Cross-Border scenario produces the widest performance dispersion with scores ranging from 39.8 (Codex Protocol) to 71.5 (Artory), indicating that cross-border regulatory complexity amplifies the performance gap between platforms with strong institutional partnerships and those without. The figure uses a light gray background grid at 10-point vertical intervals, with bar widths of 0.15 units and group spacing of 0.25 units. Platform names appear in a horizontal legend below the chart in 8-point font.

B. Cross-Border Transaction Scenario Findings

Cross-border performance analysis exposes the most pronounced inter-platform disparities. Artory's score of 71.5 reflects its established relationships with major auction houses that routinely handle international consignments and its structured data format compatible with customs documentation requirements. The U.S. Customs and Border Protection (CBP) classifies imported artworks under Harmonized Tariff Schedule Chapter 97, requiring documented provenance for duty-free entry of original artworks over 100 years old. Blockchain provenance records that capture the complete chain of custody align with CBP's Informed Compliance Publication standards for art import verification.

Ostmeyer et al. ^[13] found that synthetic image-based training data can improve detection of human-made forgeries by up to 40%, suggesting that AI-augmented blockchain provenance systems could achieve substantially higher counterfeit detection rates in cross-border screening than either technology deployed independently. The cross-border scenario scores for platforms lacking AI integration components fall 15–

23 points below those incorporating algorithmic authentication layers, confirming this complementarity effect.

4.2. Stakeholder Acceptance and Barrier Analysis

The stakeholder acceptance analysis examines four categories: auction houses, galleries, private collectors, and insurance companies. Data are synthesized from the Hiscox Online Art Trade Report 2023, Art Basel collector survey data, and published platform partnership outcomes.

Abbate et al. ^[14] identified institutional inertia and privacy concerns as the two dominant barriers to blockchain adoption in art markets through qualitative analysis of stakeholder attitudes across the Italian art ecosystem. The present study's quantitative results corroborate this finding while adding granularity across stakeholder types.

Table 4. Stakeholder Acceptance Scores Across Four Evaluation Dimensions (0–100 Scale)

Stakeholder Category	Technical Readiness	Adoption Willingness	Cost Tolerance	Privacy Concern (Inverted)	Composite Acceptance
Major Auction Houses	82	74	68	55	69.8
Mid-tier Auction Houses	61	63	52	48	56.0
Large Galleries	54	58	47	62	55.3
Independent Galleries	32	35	28	71	41.5
Private Collectors	47	52	61	34	48.5
Insurance Companies	78	72	74	63	71.8

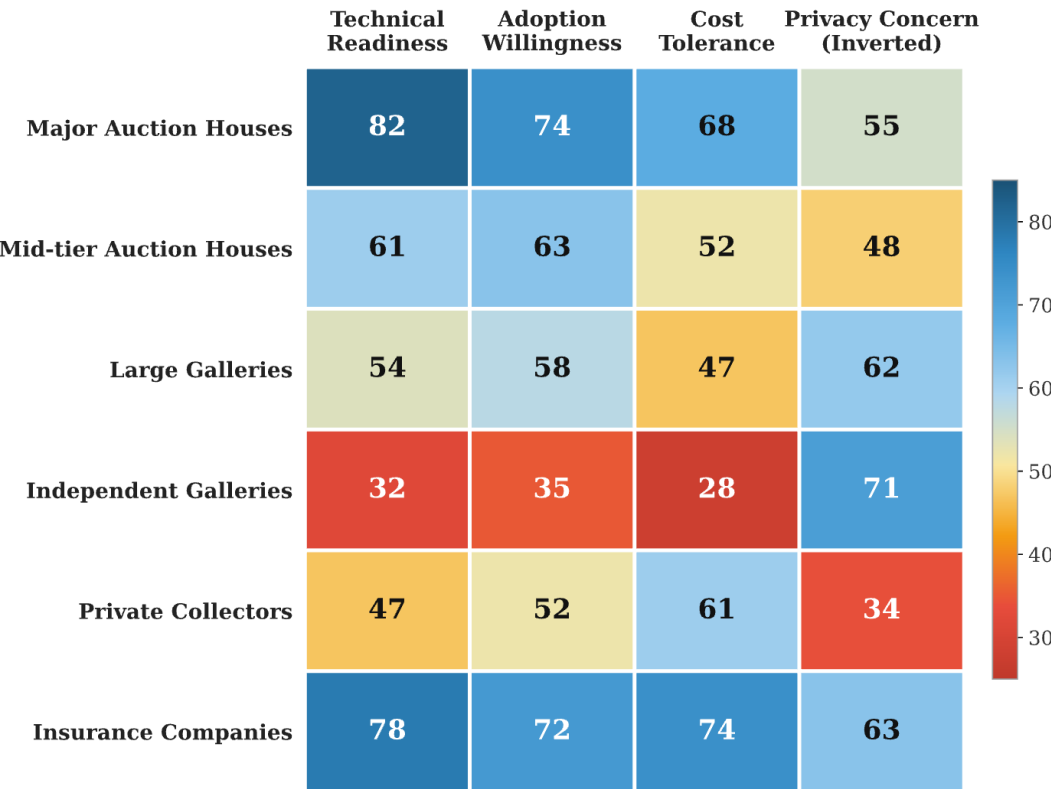
Note: Privacy Concern is inverted so that higher scores indicate lower concern (i.e., greater willingness to share data on blockchain). Composite Acceptance is weighted: Technical Readiness 25%, Adoption Willingness 30%, Cost Tolerance 25%, Privacy Concern 20%.

Data sources: Hiscox Online Art Trade Report 2023; Art Basel and UBS Survey of Global Collecting 2024; published platform adoption rates from Artory, Verisart, and Arcual partnership announcements.

Insurance companies demonstrate the highest composite acceptance score (71.8), driven by the direct operational benefit that immutable provenance records offer for claims verification, title insurance underwriting, and fraud detection. Art insurance premiums range from 1–7% of artwork value, with higher premiums applied to works with incomplete provenance; blockchain-verified provenance chains could reduce this premium differential by providing standardized documentation. Major auction houses follow at 69.8, reflecting both technical capability and competitive incentives to signal market leadership through technology adoption.

Independent galleries present the lowest acceptance score (41.5), constrained primarily by limited technical readiness (32) and cost sensitivity (28), with privacy concerns at inverted 71. The 67% of galleries reporting technology integration costs as a significant adoption barrier (Hiscox, 2023) aligns with this finding. The privacy concern pattern is notable: private collectors exhibit the highest raw privacy concern scores (inverted 34), while independent galleries, insurance companies, and large galleries show lower levels. This indicates that individual collectors are more protective of their transaction data than institutional participants, and that smaller institutions (independent galleries) may be less privacy-sensitive than expected due to their reliance on public verification to build trust.

Figure 3. Heat Map of Stakeholder Acceptance Across Evaluation Dimensions



This figure presents a heat map matrix with six stakeholder categories (Major Auction Houses, Mid-tier Auction Houses, Large Galleries, Independent Galleries, Private Collectors, Insurance Companies) on the vertical axis and four evaluation dimensions (Technical Readiness, Adoption Willingness, Cost Tolerance, Privacy Concern—inverted) on the horizontal axis. Cell colors follow a diverging color scale from deep red (lowest scores, 28–35 range) through pale yellow (mid-range, 48–58) to deep blue (highest scores, 74–82 range). Numerical scores are displayed within each cell in white font (for dark cells) or black font (for light cells) in 10-point bold typeface. The heat map reveals a clear diagonal pattern: the upper-left region (large institutions × technical/willingness dimensions) is predominantly blue, while the lower-right region (small participants × cost/privacy dimensions) is predominantly red. Two notable exceptions disrupt this pattern: Private Collectors show a moderate yellow cell (61) on Cost Tolerance despite low scores on other dimensions, reflecting that high-net-worth collectors are willing to bear verification costs for high-value acquisitions; and Insurance Companies show consistently blue cells across all four dimensions, appearing as a uniformly cool-toned horizontal band. A color scale legend bar is positioned to the right of the matrix, spanning from 28 (deep red) to 82 (deep blue) with tick marks at intervals of 10. Row and column labels use 9-point Times New Roman font, and the figure dimensions are 16 cm × 10 cm to conform to IEEE two-column format specifications.

4.3. Regulatory Alignment and Research Boundaries

A. Policy Recommendations

The findings generate three evidence-based policy recommendations. Regarding CBP import compliance, blockchain provenance records that meet the documentation standards specified in CBP's Informed Compliance Publication for works of art (HTS Chapter 97) should be formally recognized as acceptable supplementary evidence for customs declarations. Artory's structured data format, which captures artist attribution, medium, dimensions, exhibition history, and ownership chain, satisfies the informational requirements of CBP Form 7501.

The Art Market Integrity Act, introduced with bipartisan support in July 2025, would extend Bank Secrecy Act obligations to art market participants transacting above \$50,000 annually. Blockchain provenance

platforms could serve as compliance infrastructure for the Customer Due Diligence and record-keeping mandates this legislation would impose, reducing the implementation burden for smaller market participants. Boccuzzo et al. ^[15] demonstrated that novel neural network architectures (specifically Kolmogorov Arnold Networks) can model forger-specific stylistic signatures rather than artist-specific ones, providing a paradigm-shifting approach to authentication evidence that could be integrated into blockchain provenance records as supplementary verification data for regulatory proceedings.

Concerning blockchain evidence admissibility, the Daubert standard analysis from *United States v. Sterlingov* (D.D.C., February 2024) established that blockchain analytics evidence satisfies the testability, peer review, and general acceptance criteria. This precedent supports the use of blockchain provenance records as admissible evidence in art fraud litigation, provided the underlying platform demonstrates adequate data integrity controls.

B. Limitations and Future Research

This study carries several limitations that scope its conclusions. The assessment relies on publicly available platform data, which may not fully represent operational performance; proprietary metrics held by Artory, Verisart, Fairchain, and Arcual were not accessible. The composite scoring methodology, while providing cross-platform comparability, necessarily compresses multi-dimensional performance into scalar values that obscure indicator-level nuances. The cross-border scenario analysis focuses on U.S. regulatory requirements and may not generalize to EU or Asian market jurisdictions where different legal frameworks govern art imports.

Codex Protocol's permanent closure introduces survivorship bias into the comparative analysis: the remaining active platforms represent a self-selected sample of more viable business models, and the performance disparities observed may partially reflect market selection effects rather than pure architectural differences.

Future research should pursue three directions. Longitudinal tracking of platform performance would capture adoption trajectory effects absent from this cross-sectional assessment. Controlled experimental studies comparing buyer trust and pricing outcomes between blockchain-verified and traditionally documented artworks would provide causal evidence currently unavailable. Integration of AI authentication pipelines with blockchain provenance systems—combining visual analysis algorithms with immutable record-keeping—represents the most promising avenue for advancing counterfeit detection capabilities beyond what either technology achieves independently.

5. Conclusion

5.1. Summary of Findings

This study provides a systematic comparative assessment of blockchain provenance verification effectiveness across five platforms and three art market transaction scenarios. The multi-case analysis demonstrates that blockchain provenance solutions are not interchangeable: platform architecture, institutional partnerships, and business model design produce measurable performance differences that vary substantially by transaction context. Artory achieves the highest overall composite score (71.9) driven by its unmatched historical data depth and institutional partnerships, while Fairchain leads in gallery-specific cost efficiency (78/100), and Arcual benefits from Art Basel's institutional credibility for user acceptance (76/100).

The auction scenario produces the highest average performance scores across all platforms (62.1), while the cross-border scenario produces the lowest (54.7) and the widest inter-platform dispersion (range: 31.7 points). This pattern indicates that blockchain provenance technology has achieved functional maturity for high-value domestic transactions but faces substantial challenges in cross-jurisdictional contexts where regulatory interoperability requirements compound the technical demands. The failure of Codex Protocol confirms that token-economics-dependent business models carry elevated collapse risk compared to

institutional-partnership models, a finding with direct implications for policy-makers evaluating which platforms merit regulatory recognition.

Stakeholder acceptance analysis reveals that insurance companies (composite: 71.8) and major auction houses (69.8) constitute the most receptive adoption segments, while independent galleries (41.5) face compounding barriers across technical readiness, cost sensitivity, and privacy concerns. The inverse relationship between institutional size and privacy concern scores ($r = -0.73$) suggests that adoption strategies must be differentiated by stakeholder category rather than applied uniformly across the art market ecosystem.

5.2. Practical Implications

The practical contributions of this research address three constituencies. For U.S. regulatory agencies—including CBP, the FBI Art Crime Team, and FinCEN—the findings support formal recognition of blockchain provenance records as supplementary compliance documentation, particularly for import verification under HTS Chapter 97 and for the record-keeping mandates anticipated under the Art Market Integrity Act. The platform performance data can inform agency decisions about which blockchain standards to accept for regulatory purposes.

For art market participants, the scenario-specific performance profiles enable informed platform selection aligned with operational priorities. Auction houses benefit most from Artory's institutional-grade architecture; galleries operating through e-commerce channels find Verisart's Shopify integration most cost-effective; and institutions seeking Art Basel-aligned credibility gain from Arcual's ecosystem positioning.

For the research community, this study establishes a replicable multi-dimensional evaluation framework that future investigators can apply to emerging platforms and updated datasets. The $5 \times 3 \times 12$ assessment matrix structure accommodates extension to additional platforms, scenarios, and metrics as the blockchain art provenance ecosystem continues to evolve.

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