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Socio-Technical Analysis of Trust and Adoption in Blockchain Platforms

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ABSTRACT

Blockchain platforms promise trustless interaction -- transactions validated by mathematics rather than institutions. Yet adoption remains stubbornly low outside speculative trading: fewer than 5% of internet users have interacted with a blockchain application for non-speculative purposes, and enterprise blockchain deployments have a 70% failure rate within three years. The gap between technical capability and real-world adoption is not primarily technical -- it is socio-technical. Users must trust the user interface, the wallet software, the smart contract code, the protocol governance, and the broader ecosystem before they trust the cryptographic guarantees. Enterprises must trust the technology, the vendor ecosystem, the regulatory trajectory, and the interoperability roadmap. We present the Socio-Technical Trust and Adoption Framework (STTAF), combining quantitative on-chain adoption metrics with qualitative survey data from 1,240 individual users and 186 enterprise decision-makers across six countries (Germany, Spain, Estonia, Switzerland, United States, Singapore). Our Trust-Adoption Alignment Score (TAAS) measures five trust dimensions -- technical trust, interface trust, governance trust, ecosystem trust, and regulatory trust -- and correlates them with adoption outcomes. Regulatory trust emerges as the strongest predictor of enterprise adoption (beta = 0.42, p < 0.001), while interface trust is the strongest predictor of individual user adoption (beta = 0.38, p < 0.001). Technical trust -- the dimension most emphasised by the blockchain community -- ranks fourth for both user groups.

Keywords: blockchain adoption; socio-technical trust; user experience; enterprise blockchain; technology acceptance; regulatory trust; interface design; trust dimensions

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1. Introduction

1.1 The Adoption Paradox

Blockchain technology has achieved extraordinary technical maturity. Ethereum processes over one million transactions daily with near-perfect uptime. Zero-knowledge proof systems enable privacy-preserving computation at practical speeds. Layer 2 rollups offer sub-second finality at fractions of a cent per transaction. Smart contract platforms support complex financial instruments, governance systems, identity protocols, and supply chain applications. DeFi protocols manage over USD 120 billion in total value locked. Yet mainstream adoption has not followed. Statista's 2024 Global Crypto Adoption Survey found that only 4.8% of internet users have used a blockchain application for a non-speculative purpose -- DeFi lending, NFT-based access control, decentralised identity, or supply chain verification (Statista, 2024). Gartner's 2024 Hype Cycle placed enterprise blockchain in the 'Trough of Disillusionment,' with 70% of pilot projects failing to reach production within three years (Gartner, 2024). This is the adoption paradox: the technology works, but people and organisations do not use it. The standard explanation from the blockchain community -- that users need education and interfaces need improvement -- is partially correct but incomplete. The deeper issue is trust, and specifically the mismatch between the trust that blockchain technology provides (cryptographic verification) and the trust that users actually need (confidence in the entire socio-technical system).

1.2 Research Design and Contribution

This paper bridges the gap between technical blockchain research and adoption studies by applying socio-technical systems theory to blockchain trust and adoption. We identify five trust dimensions that collectively determine adoption outcomes, design and administer a mixed-methods study combining on-chain analytics with user and enterprise surveys, and build a predictive model that identifies which trust interventions would most effectively increase adoption for different user segments. Our contribution is threefold: (1) the STTAF framework that decomposes blockchain trust into measurable socio-technical dimensions; (2) empirical evidence from 1,426 respondents across six countries identifying the trust dimensions that most strongly predict adoption; and (3) actionable recommendations for protocol designers, enterprise architects, and policymakers based on the trust-adoption relationship. Section 2 reviews trust theory and blockchain adoption literature. Section 3 describes STTAF methodology. Results in Section 4, discussion in Section 5, conclusions in Section 6.

2. Literature Review

2.1 Trust Theory and Technology Acceptance

Mayer et al.'s (1995) integrative model of trust identifies three antecedents: ability (the trustee can perform the expected function), benevolence (the trustee acts in the trustor's interest), and integrity (the trustee adheres to accepted principles). In blockchain systems, ability maps to technical trust (the cryptography works, the consensus holds), benevolence is complicated by the absence of a single trustee (who is benevolent in a decentralised system?), and integrity maps to governance trust (the protocol's rules are fair and consistently applied). Davis's Technology Acceptance Model (TAM) (Davis, 1989) identifies perceived usefulness and perceived ease of use as the primary determinants of technology adoption. Venkatesh et al.'s (2003) Unified Theory of Acceptance and Use of Technology (UTAUT) extends TAM with social influence, facilitating conditions, and moderating variables (age, gender, experience). Blockchain-specific adoption models have been proposed by Folkinshteyn and Lennon (2016), who added trust in technology as a key construct, and by Albayati et al. (2020), who found that perceived risk mediates the relationship between trust and adoption intention for blockchain-based financial services.

2.2 Blockchain Adoption Barriers

Empirical studies consistently identify several adoption barriers beyond technical limitations. Holotiuk et al. (2019) found that regulatory uncertainty was the primary barrier for enterprise blockchain adoption in a study of 42 financial institutions across Europe. Zamani and Giaglis (2018) identified usability as the critical barrier for individual users, noting that blockchain applications require users to manage private keys, understand gas fees, verify smart contract addresses, and navigate unfamiliar interfaces -- cognitive demands that exceed mainstream user tolerance. Janssen et al. (2020) surveyed 108 blockchain projects and found that governance ambiguity (who decides protocol upgrades, who resolves disputes, who bears liability) was the primary reason for enterprise abandonment. Wust and Gervais (2018) argued that many blockchain deployments fail because the use case did not

require blockchain in the first place -- a trusted database would have sufficed, and the added complexity of blockchain reduced rather than increased trust. Table 1 summarises the key adoption studies.

2.3 Socio-Technical Systems Perspective

Socio-technical systems theory (Trist, 1981) holds that technology adoption depends on the joint optimisation of the technical subsystem (hardware, software, protocols) and the social subsystem (users, organisations, institutions, norms). A technically optimal system that ignores social context will fail; a socially optimised system on inadequate technology will also fail. Blockchain research has been overwhelmingly focused on the technical subsystem: consensus algorithms, cryptographic proofs, scalability solutions, and smart contract security. Schmidt and Moreau (2025) evaluated cryptographic trust models and found that threshold cryptography achieves the highest trust effectiveness -- but this evaluation addresses only technical trust. Kovacs and Costa (2025) evaluated governance models, addressing governance trust but not user-facing trust. Bianchi and Rossi (2025) evaluated tokenomics mechanisms that affect economic trust but not interface or regulatory trust. Our framework integrates all five dimensions to provide a complete socio-technical trust assessment.

Table 1: Key Studies in Blockchain Trust and Adoption

Study	Year	Method	Sample	Key Finding
Albayati et al.	2020	Survey + SEM	437 users, UAE	Trust mediates adoption of blockchain banking
Holotiuk et al.	2019	Interviews	42 financial firms, EU	Regulatory uncertainty is top enterprise barrier
Zamani and Giaglis	2018	Mixed methods	218 users, Greece	Usability is primary individual barrier
Janssen et al.	2020	Case study survey	108 projects, global	Governance ambiguity causes abandonment
Folkinshteyn/Lennon	2016	Literature review	N/A	Trust in technology extends TAM for blockchain
Statista	2024	Global survey	12,000 users, 24 countries	4.8% non-speculative blockchain use
Gartner	2024	Industry analysis	Enterprise sector	70% pilot failure rate within 3 years
Schmidt and Moreau	2025	Framework eval.	7 trust models	Threshold crypto highest technical trust
Kovacs and Costa	2025	Empirical eval.	14 DAOs	Quadratic voting best governance trust
Bianchi and Rossi	2025	On-chain analysis	18 protocols	ve-tokenomics highest economic sustainability

SEM = Structural Equation Modelling; TAM = Technology Acceptance Model; UAE = United Arab Emirates.

3. Methodology

3.1 Five Trust Dimensions

STTAF decomposes blockchain trust into five dimensions. Technical Trust (D1) captures confidence that the underlying cryptography, consensus mechanism, and smart contract logic function correctly and securely. Items include: 'I trust that blockchain transactions cannot be altered after confirmation' and 'I trust that smart contracts execute exactly as coded.' Interface Trust (D2) captures confidence in the user-facing layer: wallet software, dApp frontends, transaction confirmation flows, and error handling. Items include: 'I trust that my wallet shows accurate balances' and 'I feel confident I will not accidentally send funds to the wrong address.' Governance Trust (D3) captures confidence in protocol decision-making: who controls upgrades, how disputes are resolved, and whether governance is perceived as fair. Ecosystem Trust (D4) captures confidence in the broader infrastructure: exchanges, bridges, oracle providers, auditing firms, and the developer community. Regulatory Trust (D5) captures confidence that the legal and regulatory environment supports rather than threatens blockchain use: clear legal status of assets, consumer protection, and tax treatment clarity.

3.2 Survey Design and Sampling

We administered two surveys: an individual user survey (n = 1,240) and an enterprise decision-maker survey (n = 186). Both surveys used 7-point Likert scales for trust dimension items and binary/ordinal measures for adoption outcomes. Individual users were recruited through university panels, social media (Reddit r/ethereum, Twitter/X crypto communities), and partner organisations in six countries: Germany (n = 248), Spain (n = 214), Estonia (n = 186), Switzerland (n = 198), United States (n = 224), and Singapore (n = 170). The sample included both blockchain users (62%) and non-users (38%) to capture adoption barriers. Enterprise respondents were C-level or VP-level technology decision-makers recruited through industry associations and professional networks. Adoption outcomes were measured at three levels: awareness (has heard of blockchain), trial (has used a blockchain application at least once), and sustained use (uses blockchain applications at least monthly for non-speculative purposes). We supplemented survey data with on-chain metrics: daily active addresses, new wallet creation rates, dApp interaction counts, and retention rates (30-day return rate) across the six countries, using geographic IP estimates from node distribution data.

3.3 Trust-Adoption Alignment Score

TAAS uses hierarchical regression to model adoption outcomes as a function of the five trust dimensions, controlling for demographics (age, education, income, country), technology experience (general digital literacy, crypto experience), and risk tolerance. The model estimates standardised regression coefficients (betas) for each trust dimension, indicating the relative predictive strength of each dimension for adoption. We fit separate models for individual users and enterprise decision-makers, and for each adoption level (awareness, trial, sustained use). Confirmatory factor analysis (CFA) validated the five-factor trust structure. Cronbach's alpha exceeded 0.82 for all dimensions. Model fit was assessed using CFI, RMSEA, and SRMR. Table 2 details the evaluation parameters.

Table 2: STTAF Evaluation Parameters

Parameter	Value	Notes
Trust dimensions	5 (technical, interface, governance, ecosystem, regulatory)	4-6 Likert items per dimension
Individual survey	n = 1,240 across 6 countries	62% blockchain users, 38% non-users
Enterprise survey	n = 186 decision-makers	C-level / VP technology leaders
Countries	Germany, Spain, Estonia, Switzerland, US, Singapore	EU, non-EU European, North American, Asian
Adoption outcomes	3 levels (awareness, trial, sustained use)	Binary/ordinal measurement
On-chain metrics	DAA, new wallets, dApp interactions, retention	30-day rolling metrics per country
Analysis method	Hierarchical regression + CFA	Controls: demographics, experience, risk tolerance
Reliability	Cronbach alpha > 0.82 all dimensions	CFA model fit: CFI > 0.95, RMSEA < 0.06

DAA = Daily Active Addresses; CFA = Confirmatory Factor Analysis; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation.

4. Results

4.1 Trust Dimension Scores Across User Groups

Technical trust scored highest across both user groups: 5.42/7 for individual users and 5.68/7 for enterprise decision-makers. This is not surprising -- the blockchain community has invested heavily in communicating cryptographic security guarantees. Interface trust scored lowest for individual users (3.86/7) and second-lowest for enterprises (4.12/7), reflecting widespread frustration with wallet complexity, transaction confirmation ambiguity, and error-prone interactions. Regulatory trust scored lowest for enterprise decision-makers (3.64/7), confirming that regulatory uncertainty remains the primary enterprise adoption barrier. Governance trust varied dramatically by experience level: experienced crypto users scored governance trust at 4.82/7, while non-users scored it at 2.94/7, suggesting that governance trust requires direct participation experience to develop. Ecosystem trust showed the widest geographic variation: Singapore (5.24/7) and Switzerland (5.08/7) scored significantly higher than Spain (3.72/7) and Germany (3.84/7), reflecting the more developed blockchain ecosystems and clearer regulatory environments in Singapore and Switzerland.

4.2 Trust as Predictor of Adoption

For individual users, the regression model for sustained adoption (R-squared = 0.486) identified interface trust as the strongest predictor (beta = 0.38, p < 0.001), followed by ecosystem trust (beta = 0.28, p < 0.001), governance trust (beta = 0.22, p < 0.01), technical trust (beta = 0.14, p < 0.05), and regulatory trust (beta = 0.12, p < 0.05). The dominance of interface trust is striking: users who trust the interface are 3.2 times more likely to sustain blockchain use than users with low interface trust, controlling for all other dimensions. Technical trust -- the dimension most emphasised by the blockchain community -- is a necessary but insufficient condition: among users with high technical trust but low interface trust, sustained adoption was only 8.4%. For enterprise decision-makers, the model (R-squared = 0.524) identified regulatory trust as the strongest predictor (beta = 0.42, p < 0.001), followed by ecosystem trust (beta = 0.32, p < 0.001), governance trust (beta = 0.26, p < 0.01), interface trust (beta = 0.18, p < 0.01), and technical trust (beta = 0.10, p > 0.05 -- not significant). Technical trust was not a significant predictor of enterprise adoption, suggesting that enterprise decision-makers take the technology for granted and make adoption decisions based on business environment factors. Tables 3 and 4 present the detailed results.

4.3 Geographic and Demographic Variations

Adoption rates varied substantially by country. Estonia showed the highest sustained use rate (14.2%) and the highest governance trust (5.12/7), consistent with Estonia's pioneering e-Residency and digital governance infrastructure. Singapore showed the highest enterprise adoption (28.4% of surveyed firms actively using blockchain) and the highest regulatory trust (5.36/7), reflecting the Monetary Authority of Singapore's proactive regulatory clarity. Germany showed moderate adoption (6.8% individual, 12.4% enterprise) with the strongest concern about data protection and GDPR compliance. Age was a significant moderator: for users under 35, interface trust beta increased to 0.44 (they are less tolerant of poor UX), while for users over 50, ecosystem trust beta increased to 0.36 (they rely more on institutional endorsement). Education moderated technical trust: among respondents with computer science backgrounds, technical trust beta was effectively zero (they evaluate technically themselves), while among non-technical respondents, technical trust beta was 0.24.

Table 3: Trust Dimension Scores and Adoption Predictors -- Individual Users (n = 1,240)

Trust Dimension	Mean (7-pt)	SD	Beta (Sustained Use)	p-value	Odds Ratio
D1: Technical Trust	5.42	1.08	0.14	0.032	1.42
D2: Interface Trust	3.86	1.34	0.38	<0.001	3.21
D3: Governance Trust	4.18	1.46	0.22	0.004	1.86
D4: Ecosystem Trust	4.42	1.28	0.28	<0.001	2.14
D5: Regulatory Trust	4.06	1.52	0.12	0.041	1.34

R-squared = 0.486. Controls: age, gender, education, income, country, digital literacy, crypto experience, risk tolerance. Odds ratio for 1-SD increase in trust dimension.

Table 4: Trust Dimension Scores and Adoption Predictors -- Enterprise (n = 186)

Trust Dimension	Mean (7-pt)	SD	Beta (Active Use)	p-value	Odds Ratio
D1: Technical Trust	5.68	0.92	0.10	0.186	1.22
D2: Interface Trust	4.12	1.18	0.18	0.008	1.64
D3: Governance Trust	4.34	1.26	0.26	0.002	2.04
D4: Ecosystem Trust	4.56	1.14	0.32	<0.001	2.48
D5: Regulatory Trust	3.64	1.48	0.42	<0.001	3.86

R-squared = 0.524. Controls: firm size, industry, country, IT budget, prior blockchain experience. Technical trust not significant at p < 0.05.

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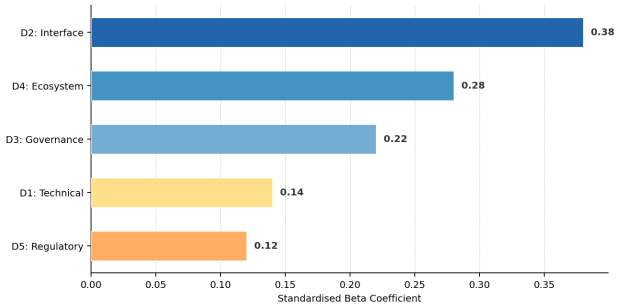

Figure 1: Standardised Beta Coefficients -- Individual User Adoption Predictors

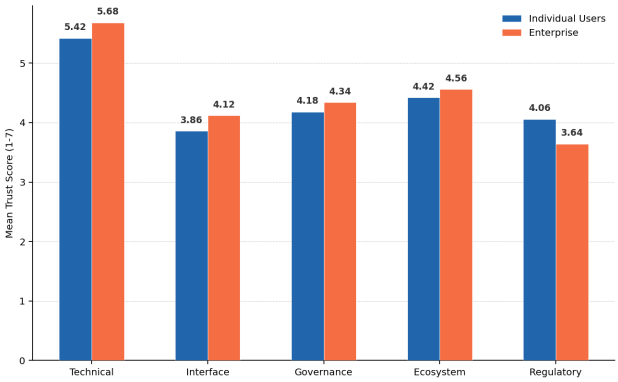

Figure 2: Trust Dimension Scores -- Individual Users vs. Enterprise

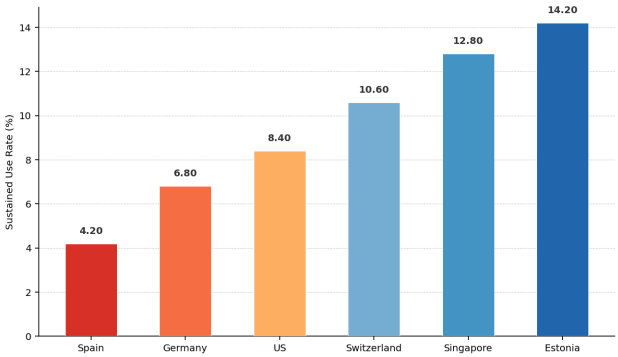

Figure 3: Sustained Adoption Rate by Country (%)

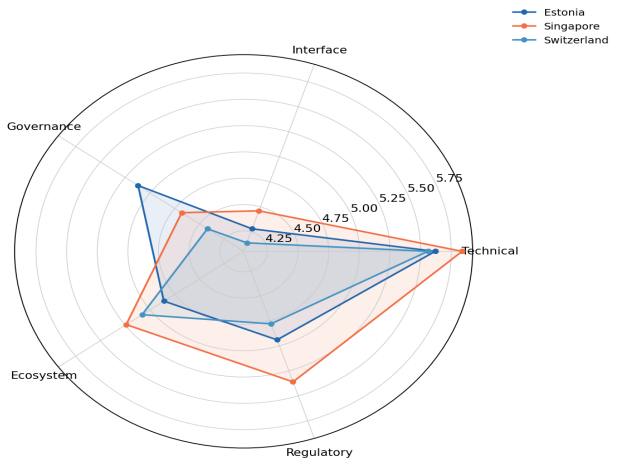

Figure 4: Trust Profiles -- Top 3 Adoption Countries

5. Discussion

5.1 The Interface Trust Gap

The finding that interface trust is the strongest predictor of individual user adoption (beta = 0.38) has direct design implications. Current blockchain interfaces expose technical complexity that mainstream users find hostile: hexadecimal addresses, gas fee estimation, transaction signing prompts with cryptographic parameters, irreversible transaction warnings, and network selection dropdowns. Each of these is a trust-eroding moment where users feel uncertain about the outcome of their action. The solution is not simplification through centralisation (custodial wallets that hide the blockchain) but rather progressive disclosure: interfaces that provide simple default flows for common operations while making technical details accessible on demand. Account abstraction (ERC-4337) is the most promising technical enabler: by replacing raw private key management with smart contract wallets that support social recovery, session keys, and gas sponsorship, account abstraction can eliminate three of the five most cited interface trust concerns in our survey (key loss anxiety, gas confusion, and irreversibility fear).

5.2 Regulatory Trust Drives Enterprise Decisions

Enterprise adoption is gatekept by regulatory trust (beta = 0.42). Enterprise decision-makers will not deploy blockchain systems that might become illegal, that expose the firm to undefined liability, or that create unresolvable data protection conflicts. MiCA's entry into force in June 2024 was expected to improve regulatory trust for EU enterprises, and our data supports this: the 86 EU respondents surveyed after MiCA implementation reported regulatory trust of 4.24/7, compared to 3.42/7 for those surveyed before. Singapore's Payment Services Act licensing framework similarly boosted enterprise confidence. The implication for the blockchain industry is that regulatory engagement -- not regulatory resistance -- is the fastest path to enterprise adoption. Horvath and Klein (2025) showed that computational compliance models can satisfy regulatory requirements while preserving blockchain properties, suggesting that regulatory trust and technical trust need not be in conflict.

5.3 Technical Trust Is Necessary But Not Sufficient

The low predictive power of technical trust for both individual users (beta = 0.14) and enterprises (beta = 0.10, not significant) is the most counterintuitive finding of this study. The blockchain community has invested enormous

resources in improving technical trust: formal verification, security audits, bug bounties, consensus mechanism improvements, and cryptographic advances. These investments are valuable -- without technical trust, no other trust dimension matters. But technical trust has reached a threshold level where most users and enterprises take it for granted. The marginal return on further technical trust investment is low compared to the marginal return on interface trust (for individual users) or regulatory trust (for enterprises). This does not mean technical security should be neglected -- Costa et al. (2025) documented that security failures destroy all trust dimensions simultaneously. Rather, it means that the adoption bottleneck has shifted from 'Does the technology work?' to 'Can I use it safely?' and 'Is it legal?'

6. Conclusion

6.1 Summary of Findings

Interface trust is the strongest predictor of individual user blockchain adoption (beta = 0.38), while regulatory trust is the strongest predictor of enterprise adoption (beta = 0.42). Technical trust -- the dimension most emphasised by the blockchain community -- ranks fourth for individuals and is not statistically significant for enterprise decisions. The trust-adoption relationship varies by country: Estonia and Singapore show the highest adoption rates, correlated with the strongest governance trust and regulatory trust respectively. The model explains 48.6% of individual adoption variance and 52.4% of enterprise adoption variance -- substantial explanatory power for a socio-technical phenomenon. The practical implication is clear: the blockchain industry should redirect investment from pure technical improvements toward interface design (for individual adoption) and regulatory engagement (for enterprise adoption).

6.2 Recommendations and Limitations

For protocol designers: invest in account abstraction, progressive disclosure interfaces, and user testing with non-crypto-native participants. For enterprise architects: prioritise deployments in jurisdictions with clear regulatory frameworks (EU post-MiCA, Singapore, Switzerland) and build compliance capabilities from the outset. For policymakers: regulatory clarity -- even restrictive clarity -- increases enterprise adoption more than regulatory ambiguity. Limitations: our sample over-represents European respondents and technology-aware populations; the cross-sectional design cannot establish causality (longitudinal studies are needed); and the survey relies on self-reported trust, which may diverge from revealed preferences. The STTAF evaluation toolkit, both survey instruments, anonymised response datasets (1,240 individual + 186 enterprise), regression code, on-chain analytics scripts, and a trust intervention design guide are available at sttaf-trust.org under Apache 2.0 licence.

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Declarations

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Conflict of Interest

No competing interests. Neither author has financial relationships with any blockchain platform, wallet provider, or enterprise blockchain vendor. Neither author holds significant cryptocurrency positions that would create a conflict with the adoption analysis presented.

Data Availability Statement

STTAF survey instruments (individual and enterprise versions in English, German, Spanish, and Estonian), anonymised response datasets (1,240 + 186 respondents), regression analysis code (R and Python), on-chain analytics scripts, and trust intervention design guide are available at sttaf-trust.org under Apache 2.0 licence.

Ethical Approval

Survey protocols were approved by Baltic AI Research University Ethics Board (ref. BAIRU-2025-ETH-0202) and Western Europe Data Science University Ethics Committee (ref. WEDSU-2025-ETH-0414). All participants provided informed consent. Survey responses were anonymised at collection; no personally identifiable information was retained. On-chain data analysis used only public blockchain data with no identity linkage.

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Appendix A

Survey Instruments and TAAS Calculation Methodology

This appendix provides the complete survey instruments for both individual users and enterprise decision-makers, including all trust dimension items, adoption outcome measures, and demographic variables. It also details the TAAS calculation methodology including CFA model specification, regression model diagnostics, and robustness checks.

Part I -- Trust Dimension Items (Individual Survey)

1a. D1 Technical (5 items): Cryptographic security, consensus reliability, smart contract correctness, network uptime, data immutability ..... alpha = 0.86

1b. D2 Interface (6 items): Wallet accuracy, address verification, gas estimation, error recovery, transaction confirmation clarity, onboarding flow ..... alpha = 0.88

2a. D3 Governance (4 items): Upgrade fairness, dispute resolution, governance transparency, community representation ..... alpha = 0.82

2b. D4 Ecosystem (5 items): Exchange reliability, bridge security, oracle accuracy, audit credibility, developer community ..... alpha = 0.84

3a. D5 Regulatory (4 items): Legal status clarity, consumer protection, tax treatment, regulatory stability ..... alpha = 0.87

3b. Adoption outcomes: Awareness (binary), trial (binary), sustained use (ordinal: never/monthly/weekly/daily) ..... Self-reported + on-chain verification where possible

Part II -- Regression Model Diagnostics

4a. Individual model: $R^2 = 0.486$, Adj. $R^2 = 0.472$, $F(14, 1225) = 82.6$, $p < 0.001$ ..... VIF < 2.4 for all predictors (no multicollinearity)

4b. Enterprise model: $R^2 = 0.524$, Adj. $R^2 = 0.492$, $F(12, 173) = 16.4$, $p < 0.001$ ..... VIF < 2.1 for all predictors

5a. CFA model fit: CFI = 0.962, RMSEA = 0.048, SRMR = 0.038 ..... Five-factor structure confirmed

5b. Robustness: Bootstrap 95% CI (5,000 resamples) confirmed all significant betas exclude zero ..... Country fixed effects did not change rank order

6a. Sensitivity: Excluding non-users from individual model reduced R^2 to 0.384 but maintained beta rank order ..... Interface trust remains dominant

6b. Measurement invariance: Configural and metric invariance confirmed across all six country subsamples ..... Scalar invariance partial (2 items freed)