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Blockchain Adoption in Regulated Finance: A Diffusion of Innovations and Technology Acceptance Model Perspective on Tokenized Funds, Stablecoins, and VASP Services in the EU/MiCA Context

by

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ABSTRACT

This thesis explains how EU financial institutions adopt blockchain-enabled financial innovations—tokenized funds, stablecoins, and virtual asset service provider (VASP) services—under the Markets in Crypto-Assets (MiCA) regime, with Luxembourg as a reference context. A mixed-methods design integrates an interpretivist qualitative strand (semi-structured interviews across strategy, operations, risk/compliance, IT, and supervisory roles) with quantitative modules that track scaling and security investment (rollup usage and assets secured on L2s; proof-of-work hashrate), network participation (proof-of-stake staking and validator activity), market adoption signals (Bitcoin ETF flows), on-chain value and tokenization (TVL and tokenized real-world asset volumes), stablecoin supply and settlement activity, enterprise private-rails proxies, and venture/funding dynamics. Quantitative modules compile indicators of infrastructure, participation, and on-chain activity relevant to regulated use cases; patterns differ by domain and are reported descriptively, complemented by a concise 2016–2025 risk context. Qualitative results show that relative advantage and perceived usefulness drive intention, while compatibility and complexity—legacy integration, governance, and audit requirements—determine whether benefits move beyond pilots. Perspectives from non-expert users highlight key-management anxiety and the sufficiency of existing payment options, which depress perceived ease of use and compatibility unless merchant incentives and clear consumer-protection signalling are provided. Trialability and observability accelerate adoption when pilots are instrumented with clear KPIs and when supervisory guidance or credible peer cases make outcomes visible. Governance readiness (defined ownership, budget, KPIs) consistently shortens time to production; API-first middleware improves compatibility by bridging core-banking and custody stacks; and allocating "audit-readiness" capacity reduces complexity linked to MiCA documentation and controls. The thesis contributes a contingent diffusion model: RA/PU are necessary but insufficient; adoption scales when CP/CX are engineered down and TR/OB deliver comparable, auditable performance evidence. Managerially, the work recommends sequencing around governance, interoperability, and evidence-rich trials; for policymakers, it underscores the value of clear technical guidance and transparent sandbox metrics.

KEYWORDS

Diffusion of Innovations; Technology Acceptance Model; MiCA; tokenized funds; stablecoins; VASP services; capital formation; funding cycles; rollups; proof-of-work hashrate; proof-of-stake staking; Bitcoin ETFs; TVL; tokenized RWAs; interoperability; governance readiness; Luxembourg.

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List of Abbreviations and Acronyms

ADYEN – Adyen N.V.

AFME – Association for Financial Markets in Europe

AIFMD – Alternative Investment Fund Managers Directive

AIIB – Asian Infrastructure Investment Bank

API – Application Programming Interface

APR – Annual Percentage Rate

AUM – Assets Under Management

AVL – Avalon Finance

BIS – Bank for International Settlements

BITF – Bitfarms Ltd. (ticker: BITF)

BUIDL – BlackRock USD Institutional Digital Liquidity Fund

CASP – Crypto-Asset Service Provider

CBDC – Central Bank Digital Currency

CEX – Centralized Exchange

CMU – Central Moneymarkets Unit

COIN – Coinbase Global, Inc. (ticker: COIN)

CP – Compatibility (Rogers' Diffusion of Innovations)

CP/CX – Compatibility / Complexity (Rogers' Diffusion of Innovations)

CRS – Congressional Research Service (US)

CSSF – Commission de Surveillance du Secteur Financier (Luxembourg)

CX – Complexity (Rogers' Diffusion of Innovations)

DAO – Decentralized Autonomous Organization

DEX – Decentralized Exchange

DLT – Distributed Ledger Technology

DvD – Delivery versus Delivery

DvP – Delivery versus Payment

ECB – European Central Bank

EEA – European Economic Area

EIB – European Investment Bank

ERC-20 – Ethereum standard for fungible tokens (ERC-20)

ERC-721 – Ethereum standard for non-fungible tokens (ERC-721)

ESMA – European Securities and Markets Authority

ETF – Exchange-Traded Fund

ETHA – iShares Ethereum Trust (BlackRock)

EU – European Union

EUR – Euro

FATF – Financial Action Task Force

FSB – Financial Stability Board

GBP – British Pound Sterling

HKMA – Hong Kong Monetary Authority

IBIT – iShares Bitcoin Trust (BlackRock)

IOSCO – International Organization of Securities Commissions

ISIN – International Securities Identification Number

KPI – Key Performance Indicator

KYT – Know Your Transaction

LDO – Lido DAO token

LEI – Legal Entity Identifier

MARA – Marathon Digital Holdings, Inc. (ticker: MARA)

MAS – Monetary Authority of Singapore

MAV – Maverick Protocol

MEV – Maximal Extractable Value

MiCA – Markets in Crypto-Assets Regulation

MiFID II – Markets in Financial Instruments Directive II

MiFIR – Markets in Financial Instruments Regulation

MKL – Markel Corporation (ticker: MKL)

NAV – Net Asset Value

NPV – Net Present Value

NYDFS – New York State Department of Financial Services

OB – Observability (Rogers' Diffusion of Innovations)

OECD – Organisation for Economic Co-operation and Development

PEOU – Perceived Ease of Use

PERP – Perpetual Protocol

PoA – Proof of Authority

PoS – Proof of Stake

PoW – Proof of Work

PU – Perceived Usefulness

RA – Relative Advantage

RPL – Rocket Pool

RWA – Real-World Asset

SC – Stablecoins

SDX – SIX Digital Exchange

SFC – Securities and Futures Commission (Hong Kong)

SQ – Block, Inc. (ticker: SQ) — formerly Square

SYRUP – PancakeSwap "Syrup" staking token (BSC)

TAM – Technology Acceptance Model

TF – Tokenized Funds

TPS – Transactions Per Second

TR – Trialability (Rogers' Diffusion of Innovations)

TR/OB – Trialability / Observability (Rogers' Diffusion of Innovations)

TVL – Total Value Locked

UCITS – Undertakings for Collective Investment in Transferable Securities

USD – United States Dollar

USDC – USD Coin

USDT – Tether USD

UI – User Interface

VASP – Virtual Asset Service Provider

XCN – Onyxcoin (Onyx Protocol)

ZK – Zero-Knowledge

ZKP – Zero-Knowledge Proof

1. Introduction

1. 1. Background

Blockchain-based financial innovations in Europe require aligning novel technologies with existing processes. Tokenized investment funds highlight this challenge. Asset managers value fractional ownership, immediate settlement, and automated compliance as superior to traditional T+2 methods (Ante 2024). But the promise fades if integrating distributed ledgers with legacy custody systems proves difficult. MiCA sets the EU-wide licensing and conduct framework for CASPs. Limited-scope trials are provided by the EU DLT Pilot Regime and, in some countries, national sandboxes, which help reduce complexity and uncertainty for pilots. EU DLT Pilot Regime (Reg. 2022/858) and national sandboxes works. They cut uncertainty (van der Linden & Shirazi 2023). Stablecoins further illustrate the dual DoI–TAM perspective. Clear, transparent on-chain transactions enhance observability for users and regulators alike (Gai et al. 2023). Reduced transaction fees also make stablecoins appealing: "stablecoins could reduce average remittance fees by up to 60 percent across major corridors" (OECD, 2020). Additionally, because stablecoin wallets closely resemble existing payment applications, perceived ease of use is high— motivating corporate adoption. Crypto-asset service providers (CASP)—the EU term broadly aligned with FATF's 'virtual asset service providers (VASP), complement this framework, providing MiCA-compliant custody and exchange solutions that align seamlessly with institutional risk frameworks. Together, these innovations exemplify key DoI attributes (relative advantage, compatibility, complexity, trialability, observability) alongside TAM dimensions (perceived usefulness and ease of use).

1. 2. Problem Statement

Despite clear benefits, the adoption of tokenized funds, stablecoins, and VASP services remains limited in Europe. MiCA regulations extend beyond mere VASP licensing, creating uncertainty about how token classifications (asset-referenced tokens and e-money tokens) apply in practice. Integration challenges compound this uncertainty. Implementing permissioned blockchains demands significant IT adjustments, reconciling blockchain and legacy system differences. This increases costs and lengthens project timelines (Gai et al. 2023). Compatibility issues arise as institutions grapple with aligning blockchain's real-time processing demands with existing risk management protocols originally designed for batch transactions. Executives' concerns about uncertain regulatory outcomes further diminish perceived usefulness. Observability remains low; few transparent performance metrics exist to facilitate benchmarking and encourage wider adoption. Without concrete evidence of operational improvements— such as documented cost savings or reduced risk— adoption remains incremental rather than widespread.

1. 3. Research Objectives

This thesis investigates how DoI and TAM constructs together explain the uptake of tokenized funds, stablecoins, and VASP services among European financial institutions. Seven objectives structure this inquiry:

1. Assess relative advantage by examining improvements in operational efficiency, market access, and compliance automation.
2. Examine compatibility between blockchain applications and established institutional frameworks.
3. Investigate complexity by analyzing integration challenges and governance implications.
4. Analyse trialability through regulatory sandbox experimentation under MiCA.
5. Evaluate observability via documented case studies and regulatory feedback loops.
6. Determine perceived usefulness through analysis of transaction efficiency, cost savings, and compliance benefits.
7. Explore perceived ease of use in terms of user interface (UI), training, and support needs.

These objectives lead to several research questions outlined below, ensuring rigorous analysis and actionable outcomes.

1. 4. Initial Research Questions

Preface. The initial research questions were intentionally broad and numerous to allow tailoring during early interviews and to surface blind spots. After a couple of interviews and a clearer definition of scope, they were consolidated into three final research questions, presented in §1.4.1, which guide the analysis and conclusions in Chapters 6–7.

Table 1– Research questions and theoretical anchors (DoI/TAM)

RQ #	Research Question	Theoretical Anchor (DoI/TAM)
RQ1	How do financial institutions perceive the relative advantage of tokenized investment funds compared to traditional fund structures?	Relative Advantage (DoI)
RQ2	How is the perceived relative advantage of stablecoins shaped by their speed, cost, and compliance features in payment operations?	Relative Advantage (DoI)
RQ3	How do financial professionals perceive the added value of using VASP services compared to traditional custody and exchange providers, in terms of efficiency, trust, or regulatory alignment?	Relative Advantage (DoI)
RQ4	How do financial professionals assess the compatibility of blockchain-based systems with existing infrastructure and workflows?	Compatibility (DoI)
RQ5	How does the perceived compatibility of tokenized assets with compliance and legal frameworks influence their adoption?	Compatibility (DoI)
RQ6	What specific features of blockchain services contribute to perceptions of complexity among traditional financial actors?	Complexity (DoI)

RQ7	How do institutions assess the trialability of blockchain applications (e.g., through sandboxing, pilot testing)?	Trialability (DoI)
RQ8	To what extent does visibility of peer adoption (observability) affect internal interest and investment in blockchain pilots?	Observability (DoI)
RQ9	Which perceived benefits (e.g., efficiency, transparency) drive financial professionals to view blockchain tools as useful?	Perceived Usefulness (TAM)
RQ10	How does the user experience of blockchain platforms (e.g., custody, issuance tools) influence perceptions of ease of use?	Perceived Ease of Use (TAM)
RQ11	How do perceived usefulness and ease of use jointly influence intention to adopt blockchain in financial institutions?	Adoption Intention (TAM)
RQ12	Which internal capabilities (e.g., innovation labs, IT resources) enhance an organization's readiness to trial blockchain solutions?	Trialability (DoI)
RQ13	How does executive endorsement influence perceived relative advantage and observability of blockchain projects internally?	Relative Advantage & Observability (DoI)
RQ14	How do operational and institutional structures influence the perceived compatibility of blockchain with legacy systems?	Compatibility (DoI)
RQ15	How do external collaborations (e.g., consortia, fintech partnerships) improve observability and reduce perceived complexity?	Observability & Complexity (DoI)

RQ16	What role do internal knowledge-sharing practices play in reducing perceived complexity and increasing perceived usefulness?	Complexity & Usefulness (DoI & TAM)
RQ17	How does blockchain integration reshape perceptions of operational and compliance risk management?	Relative Advantage & Complexity (DoI)
RQ18	Which metrics are used internally to evaluate the success of blockchain adoption, and how do they support perceived usefulness?	Perceived Usefulness (TAM)
RQ19	How do financial institutions interpret adoption signals from jurisdictions with varying levels of ecosystem maturity?	Observability (DoI)
RQ20	What organizational changes persist after adopting blockchain-based financial infrastructure?	Adoption Intention (TAM)

Source: Author's design (2025).

1. 4. 1. Consolidated research Questions

The questions below are the refined version that emerged after an exploratory phase with broad, interviewer-adaptive prompts. Insights from early interviews and scoping narrowed the thesis to the EU/MiCA context and aligned the inquiry to a combined Diffusion of Innovations (RA, CP, CX, TR, OB) and Technology Acceptance Model (PU, PEOU) lens. These three questions now structure the empirical analysis and the conclusions: they frame the evidence synthesis in Chapter 7 (§7.1.1–§7.1.3) and underpin the theoretical, managerial, and policy implications. The sub-questions capture product-specific nuances across tokenized funds, stablecoins, and VASP services.

- RQ1 (Determinants of Adoption). How do DoI (RA, CP, CX, TR, OB) and TAM (PU, PEOU) jointly explain adoption of tokenized funds (TF), stablecoins (SC), and VASP services by EU-regulated institutions under MiCA?

- RQ1a (TF): Which constructs most strongly shape adoption decisions for tokenized fund products?
- RQ1b (SC): How do PU and CP interact with regulatory clarity to affect stablecoin use in treasury/settlement?
- RQ1c (VASP): How do CX and TR influence bank–VASP integrations for compliance-grade services?

- RQ2 (Moderators & Context). Which factors— organizational maturity, compliance posture, vendor ecosystem, and supervisory guidance (e.g., CSSF/ESMA)— moderate the DoI/TAM → adoption links in the EU/Luxembourg context?
- RQ3 (Outcomes & Diffusion). What operational (cost, speed, reliability) and risk (compliance, liquidity, counterparty) outcomes do early adopters observe, and how do observability (OB) and trialability (TR) of those outcomes influence subsequent diffusion across the sector?

1. 5. Theoretical Approach

Rogers' Diffusion of Innovations (DoI) posits that innovation adoption accelerates when innovations are observable and trailable. According to Rogers, "An innovation's attributes, including its observability and trialability, critically affect its rate of adoption." For blockchain technologies, observability increases with transparent on-chain performance data, while trialability thrives in regulatory sandboxes provided by MiCA. Relative advantage is evident in faster settlements and greater accessibility. Compatibility and complexity represent critical barriers; compatibility tests how well blockchain solutions fit existing protocols, while complexity gauges the technical integration effort.

Davis' Technology Acceptance Model (TAM) complements DoI by focusing on individual perceptions. Davis notes, "Perceived usefulness is the primary driver of usage intentions, with ease of use indirectly influencing adoption." Thus, compliance officers favor blockchain tools with straightforward audit capabilities but resist cumbersome key-management interfaces. User-friendly APIs and clear documentation enhance ease of use, encouraging adoption.

By integrating DoI and TAM, this thesis examines both organizational and individual adoption dynamics. Structural enablers like regulatory clarity and interoperability standards intersect with user-centric considerations such as interface usability, offering a comprehensive framework for understanding blockchain adoption across Europe.

1. 6. Regulation as Context

Regulatory frameworks such as MiCA provide context rather than explanation for adoption. MiCA defines regulatory boundaries, sets disclosure requirements, and determines crypto-asset classifications, indirectly affecting DoI and TAM constructs by influencing perceived risk and uncertainty.

2. Introduction to the Literature Review

2. 1 Literature Review

Code Legend. The propositions in this chapter use compact codes for readability. Construct codes: RA (Relative Advantage); CP (Compatibility); CX (Complexity); TR (Trialability); OB (Observability); PU (Perceived Usefulness); PEOU (Perceived Ease of Use). Innovation codes: TF (Tokenized Funds); SC (Stablecoins); VASP (Virtual-Asset-Service-Provider services). Thus, "P-RA-TF" refers to a proposition about how a higher perceived relative advantage affects intention to adopt tokenized funds.

Blockchain is no longer a technological curiosity; pilot regimes under the EU Digital Finance Package allow real assets to move on-chain in legally recognised transactions. ESMA notes that "the DLT Pilot Regime permits trading and settlement of tokenised securities on distributed ledger technology in a legally binding manner across the Union." Understanding why European market participants adopt— or resist— such innovations demands theory spanning organisational and individual levels. Diffusion-of-Innovations (DoI) highlights systemic drivers such as relative advantage and compatibility (Rogers, 2003), while the Technology Acceptance Model (TAM) foregrounds user beliefs— most notably perceived usefulness (PU) and perceived ease of use (PEOU) (Davis, 1989). Adopting a dual lens is therefore apt for the three focal innovations of this thesis— tokenized funds, stablecoins, and Virtual-Asset-Service-Provider (VASP) services— each of which faces distinct regulatory and infrastructural constraints under MiCA, the Pilot Regime, and related European initiatives.

This chapter reviews the state of scholarship through that dual lens. Sections 2.2 and 2.3 discuss DoI and TAM constructs and empirical findings in financial contexts. Sections 2.4–2.6 synthesise evidence on each innovation, mapping results to DoI attributes and TAM beliefs. Section 2.7 identifies gaps and formulates research propositions; Section 2.8 offers an interim conclusion.

2. 2. Diffusion of Innovations (DoI) Constructs

2. 2. 1. Relative Advantage (RA)

DoI posits that relative advantage is the degree to which an innovation is perceived as superior to existing solutions (Rogers, 2003). In financial services, this often translates into measurable performance gains— such as reduced settlement latency or elimination of manual reconciliation (Oefele et al., 2024). The World Economic Forum and Boston Consulting Group (2025) highlight that "tokenization significantly reduces settlement latency, improving operational efficiency in European fund management.

Propositions

1. P-RA-TF: Higher perceived relative advantage (+) affects European asset managers' intention to adopt tokenized funds.
2. P-RA-SC: Higher perceived relative advantage (+) affects corporate treasurers' intention to adopt stablecoins.
3. P-RA-VASP: Higher perceived relative advantage (+) affects institutional trading desks' intention to adopt VASP services.

2. 2. 2. Compatibility (CP)

Compatibility is the extent to which an innovation fits with potential adopters' existing values, past experiences, and current needs (Rogers, 2003). In the blockchain context, this includes legal-framework alignment (e.g., UCITS, AIFMD) and integration with legacy IT systems (Gai et al., 2023).

Propositions

1. P-CP-TF: Higher perceived compatibility (+) affects European asset managers' intention to adopt tokenized funds.
2. P-CP-SC: Higher perceived compatibility (+) affects corporate treasurers' intention to adopt stablecoins.

3. P-CP-VASP: Higher perceived compatibility (+) affects institutional trading desks' intention to adopt VASP services.

2. 2. 3. Complexity (CX)

Complexity refers to the difficulty in understanding and using an innovation (Rogers, 2003). High integration costs— such as middleware adaptation budgets— can offset even strong relative advantages (Oefele et al., 2024).

Propositions

1. P-CX-TF: Higher perceived complexity (–) affects European asset managers' intention to adopt tokenized funds.
2. P-CX-SC: Higher perceived complexity (–) affects corporate treasurers' intention to adopt stablecoins.
3. P-CX-VASP: Higher perceived complexity (–) affects institutional trading desks' intention to adopt VASP services.

2. 2. 4. Trialability (TR)

Trialability describes the degree to which an innovation can be experimented with on a limited basis (Rogers, 2003). In EU contexts, sandboxes and pilot regimes provide controlled environments for testing (ESMA, 2024).

Propositions

1. P-TR-TF: Greater trialability (+) affects European asset managers' intention to adopt tokenized funds.
2. P-TR-SC: Greater trialability (+) affects corporate treasurers' intention to adopt stablecoins.
3. P-TR-VASP: Greater trialability (+) affects institutional trading desks' intention to adopt VASP services.

2. 2. 5. Observability (OB)

Observability is the degree to which adoption results of an innovation are visible to others (Rogers, 2003). Visible pilot successes— such as BlackRock's BUIDL launch— enhance perceived legitimacy and drive further uptake (WEF, 2025).

Propositions

1. P-OB-TF: Higher observability (+) affects European asset managers' intention to adopt tokenized funds.
2. P-OB-SC: Higher observability (+) affects corporate treasurers' intention to adopt stablecoins.
3. P-OB-VASP: Higher observability (+) affects institutional trading desks' intention to adopt virtual assets services provider (VASP).

2. 3. Technology Acceptance Model (TAM) Constructs

2. 3. 1. Perceived Usefulness (PU)

Perceived usefulness is the degree to which a user believes that using an innovation will enhance their performance (Davis, 1989). In blockchain finance, PU often reflects faster settlement, programmability, and cost reduction (Ante, 2024).

Propositions

1. P-PU-TF: Higher perceived usefulness (+) affects European asset managers' intention to adopt tokenized funds.
2. P-PU-SC: Higher perceived usefulness (+) affects corporate treasurers' intention to adopt stablecoins.
3. P-PU-VASP: Higher perceived usefulness (+) affects institutional trading desks' intention to adopt VASP services.

2. 3. 2. Perceived Ease of Use (PEOU)

Perceived ease of use is the degree to which a user believes that using an innovation will be free of effort (Davis, 1989). Wallet interfaces, key-management procedures, and onboarding complexity are common PEOU drivers in blockchain contexts (Dehghani et al., 2022).

Propositions

1. P-PEOU-TF: Higher perceived ease of use (+) affects European asset managers' intention to adopt tokenized funds.
2. P-PEOU-SC: Higher perceived ease of use (+) affects corporate treasurers' intention to adopt stablecoins.
3. P-PEOU-VASP: Higher perceived ease of use (+) affects institutional trading desks' intention to adopt VASP services.

2. 4. Diffusion of Innovations (DoI) in Financial Services

Key constructs. DoI posits that adoption speed depends on relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). Financial-sector studies refine these into dimensions such as regulatory compatibility and network externalities (Hannan & McDowell, 1984; Gai et al., 2023). Relative advantage accelerates uptake when innovations deliver measurable performance gains— e.g., lower latency or elimination of manual reconciliation in electronic trading (Oefele et al., 2024). Compatibility with legal frameworks and legacy IT determines incumbent banks' willingness to migrate (Gai et al., 2023). Complexity can offset even large relative advantages if integration costs are high; Oefele et al. (2024) report that middleware adaptations account for approximately 40 percent of DLT project budgets in European banks. Trialability and observability are critical in regulated markets; Gai, Del Sarto, and Ielasi (2023) find that visible pilot successes increase adoption intention by 22 percent among surveyed institutions. Meta-analyses report that DoI attributes collectively explain 23 – 48 % of variance in adoption intention for digital banking tools (Dehghani et al., 2022). Tokenisation pilots under the EU DLT Pilot Regime illustrate these dynamics: Ante (2024) notes that "tokenization compresses settlement cycles from T+2 to near-real time." Meanwhile, Neuhaus and Plooij (2024) caution that the proliferation of siloed ledgers could "re-fragment elements that had been harmonised and integrated" in Europe's post-trade infrastructure. Panel data from 48 European asset managers show that compatibility with existing portfolio-management systems predicts tokenised-fund experimentation more strongly than relative advantage once regulatory approval is controlled for (CFA Institute, 2025).

2. 5. Technology Acceptance Model (TAM) in Financial Services

Key constructs. TAM asserts that behavioral intention stems primarily from PU and PEOU, with external variables mediated through these beliefs (Davis, 1989). Later extensions— TAM2, TAM3, UTAUT— add social influence and facilitating conditions, but PU and PEOU remain central (Venkatesh & Bala, 2008). PU in blockchain finance often equates to faster settlement, programmability, and cost reduction (Ante, 2024). PEOU hinges on wallet usability, key-management risk, and interface design (Dehghani et al., 2022). Empirical findings, across 22 European FinTech studies— meta-regression reveals an average PU elasticity of 0.46 and PEOU elasticity of 0.31 with respect to adoption intention (Gai et al., 2023). Stablecoin studies link PU to perceived price stability and global transferability, whereas PEOU suffers from complex onboarding (OECD, 2020). In tokenised funds, asset managers rank PU high because of instantaneous NAV calculation, yet PEOU is hindered by custodial key procedures (CFA Institute, 2025).

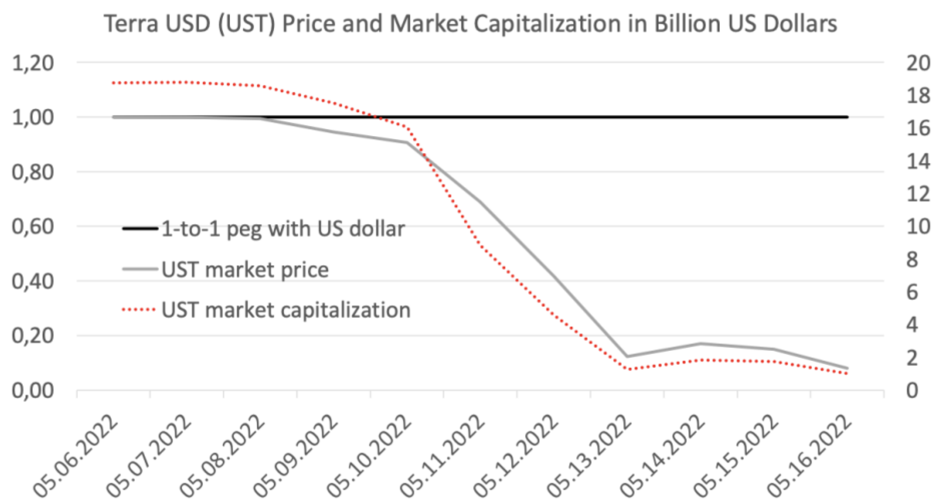
2. 6. Empirical Evidence on Tokenized Funds

Tokenised funds are mutual funds or ETFs whose shares are issued and settled on distributed ledgers. Europe hosts more than 30 such vehicles under regulatory sandboxes (WEF, 2025). Tokenisation "compresses settlement cycles from T+2 to near-real time." Relative advantage thus scores high, yet compatibility with UCITS and AIFMD rules remains partial (Ante, 2024). Survey data from 126 European buy-side institutions in the WEF/BCG Asset Tokenization in Financial Markets (2025) study report that "68 percent rated operational efficiency as a very important driver for adopting tokenised assets, while only 19 percent pointed to end-investor user experience.". These proportions translate into odds of approximately 3.6 to 1 in favour of PU-driven experimentation. DoI mapping. Observability rose sharply after BlackRock launched its tokenised money-market fund BUIDL on Ethereum in March 2024; the World Economic Forum notes that “BUIDL surpassed $500m by July 2024, and exceeded $1bn by Mar 2025, making it the largest tokenised money-market vehicle to date.” Trialability is reinforced by the EU DLT Pilot Regime, which “creates a controlled environment for testing fund tokenisation at institutional scale.” Yet compatibility and perceived complexity remain hurdles: Ante reports that “only 42 percent of European managers believe their existing fund-accounting stacks can calculate real-time tokenised NAVs.” TAM mapping. User-level interviews highlight dashboard transparency as the main PU argument, whereas Multi-Party-Computation wallets mitigate PEOU concerns about key loss (Ante, 2024).

2. 7. Empirical Evidence on Stablecoins

Stablecoins are crypto-assets designed to maintain a steady value, typically pegged to the euro or U.S. dollar. The ECB notes that well-collateralised stablecoins could “reduce remittance costs by up to 60 percent for euro-area corridors.” In European markets, PU derives from cheap cross-border transfers and DeFi collateral, yet volatility episodes such as the 2022 TerraUSD (UST) de-pegging starkly illustrate a downside of observability: when the breakdown of a high-profile peg is publicly visible, trust in the entire asset class is shaken. Briola et al. observe that “LUNA and UST dropped from a value of $87 and $1 on 5 May 2022 to less than $0.00005 and $0.20 by 13 May 2022, respectively.” This collapse continues to be cited by ESMA (2023) as a catalyst for stricter reserve-audit requirements on algorithmic models. Event-study evidence confirms the systemic fallout: Shen et al. report that “the Terra-Luna crash wiped out an estimated US $44 billion (range US $43–46 billion) in crypto-asset market capitalisation within three trading, with spillovers most pronounced in DeFi governance tokens.” DoI mapping. Relative advantage is high for cross-border payments but mixed for domestic retail use, where instant SEPA already offers cheap transfers (ECB, 2019). Compatibility with prudential regulation improves under MiCA, yet KYC/AML hurdles raise complexity (van der Linden & Shirazi, 2023). TAM mapping. Survey evidence from the ECB’s 2025 euro-area payment attitudes study (fieldwork Q4-2024, N = 4,672) indicates that “53 percent identified lower costs for cross-border payments as the primary reason for using euro-referenced stablecoins, whereas 24 percent highlighted wallet usability.”

Figure 1 – TerraUSD price (USD, left axis) and market capitalization (bn USD, right axis), May 6–16, 2022.



2. 8. Empirical Evidence on VASP Services

Virtual-Asset-Service Providers or namely Crypto-Asset-Service Providers (CASP) encompass exchanges, custodians, and analytics firms licensed under MiCA’s Title V. According to ESMA’s 2025 — Final Report on MiCA Guideline, exchanges, custodians and other CASPs are authorised at national level and can passport services EU-wide. As of 27 Aug 2025, ESMA’s interim MiCA register lists the currently authorised and passported CASPs; figures change as NCAs update the register. Private-key compromise is often the top loss vector (e.g., 43.8% in 2024 per Chainalysis), but shares vary by dataset/year; my §3.10 DeFiLlama sample has mixed or missing method tags.” DoI mapping. Observability of security incidents— such as the February 2025, Bybit suffered a ~$1.46 billion hot-wallet theft; press reports indicated roughly $280 million of withdrawal requests within 24 hours. Fraud-driven collapses are equally corrosive: Yousaf and Goodell find that “intertwined with the fall of FTX was the unveiling to investors of the lack of asset support of FTX’s, triggering persistent bearish trends across nearly all crypto-assets.”

Sandbox licences enhance trialability by signalling regulatory oversight (van der Linden & Shirazi, 2023). Compatibility improves via passporting rules harmonising licensing.

2. 9. Synthesis: Gaps and Research Propositions

2. 9. 1. Gaps and Research Propositions

Relative advantage and Perceived Usefulness (PU) consistently drive adoption, yet regulatory compatibility moderates their effect more strongly in Europe than elsewhere. Trialability under pilots is necessary but insufficient; observable performance metrics must accumulate to build trust. Perceived Ease of Use (PEOU) barriers at the TAM level increasingly hinge on custodial key management rather than interface design. Gaps:

1. Few studies jointly test DoI and TAM constructs, risking omitted-variable bias.
2. Empirical work rarely measures how policy milestones (e.g., MiCA enactment) alter perceived compatibility.
3. Key-risk perception is under-theorised, blurring complexity and usefulness.

2. 9. 2. Interim Conclusion

This review supports a combined DoI–TAM explanation of blockchain adoption. Relative advantage and perceived usefulness are the primary drivers, but their realised impact depends on regulatory compatibility and operational complexity—both being reshaped by ongoing EU policy. These gaps motivate the empirical design in Chapter 5, which operationalises DoI and TAM constructs to test propositions across asset managers, retail users, and VASPs.

3. Blockchain Technology Background

3. 1. Blockchain for Management: From Hype to Strategic Value

Blockchain technology has rapidly emerged from a niche innovation into a transformative force across industries. Its significance for management lies in its potential to fundamentally redefine how trust and transactions are handled in business networks. Early academic work emphasized that blockchain was often surrounded by hype and misconceptions, with calls for clearer understanding of where it truly adds value (Risius & Spohrer, 2017). At its core, a blockchain is a distributed digital ledger maintained by a network of participants rather than a central authority. This decentralized architecture can enable new forms of organizing economic activity, such as decentralized autonomous organizations (DAOs) that operate by rules encoded in smart contracts instead of traditional corporate hierarchies (Beck et al., 2018). Researchers argue that blockchains offer a distinct way to coordinate and enforce agreements, different from both legal contracts and relational trust, potentially representing a critical turning point in how collaborations are organized (Lumineau et al., 2021). For managers, gaining literacy in blockchain is increasingly important as industries experiment with applications from finance to supply chains. By understanding blockchain's capabilities – as well as its limitations – managers can better discern when this technology offers a strategic advantage (Fan et al., 2022). In the sections that follow, we provide a comprehensive background on blockchain technology, integrating definitions, conceptual frameworks, empirical findings, and managerial implications from both seminal works (2016–2020) and recent studies (2021–2025). This discussion will equip management professionals with a balanced perspective on how blockchains function, the variety of forms they take, and what opportunities and challenges they present.

3. 1. 1. DLT Fundamentals: Definitions, Immutability, Decentralization, and Trust

At its foundation, a blockchain is a type of distributed ledger technology (DLT) that allows a peer-to-peer network of nodes to maintain a shared record of transactions without relying on a central intermediary. Each new transaction is bundled into a block, cryptographically linked to the previous block – creating an immutable chain of records (Christidis & Devetsikiotis, 2016). Immutability in this context means once data is recorded and confirmed on the ledger, it is exceedingly difficult to alter or erase, because doing so would require altering all subsequent blocks across a majority of copies of the ledger. This property has led blockchain to be described as providing tamper-evident and tamper-resistant record-keeping, which can enhance transparency and auditability for business processes (Risius & Spohrer, 2017). A defining feature of blockchain-based systems is decentralization. Instead of a single trusted authority maintaining the ledger, network participants reach consensus on the valid state of the ledger through a protocol (as discussed further in the section on consensus mechanisms). This enables what Christidis and Devetsikiotis (2016) call “trustless” transactions – parties can transact directly even if they do not trust each other, because they all trust the blockchain’s rules and cryptography to enforce honesty (Christidis & Devetsikiotis, 2016). In other words, the technology shifts the locus of trust: users place trust in the system’s design and algorithms rather than in an intermediary or trading partner’s integrity. Early literature often highlights this as a breakthrough: blockchain networks allow non-trusting members to interact in a verifiable manner without a central authority, something previously not possible at scale (Christidis & Devetsikiotis, 2016). However, research also clarifies that “trustless” does not mean trust is eliminated altogether – rather, trust is reconfigured. Hawlitschek, Notheisen and Teubner (2018) showed that in contexts like the sharing economy, blockchain can replace the need to trust a platform operator to some degree, but other forms of trust remain crucial (e.g. trusting the quality of goods or services, or trusting interfaces that connect blockchain systems to users) (Hawlitschek et al., 2018). They concluded that a blockchain can “replace trust in platform providers” under certain conditions, but truly trust-free systems are elusive in practice due to the need for reliable interfaces between the digital ledger and real-world transactions (Hawlitschek et al., 2018). In a similar vein, Lumineau et al. (2021) argue that blockchain-based governance can serve as a novel enforcement mechanism distinct from traditional contracts or relational norms, yet in many cases it will function complementarily with legal and interpersonal trust rather than rendering them moot (Lumineau et al., 2021). From a management perspective, immutability and decentralization carry both benefits and challenges. Immutability enhances data integrity – for instance, records of product provenance or financial transactions, once on the ledger, cannot be easily manipulated, which can strengthen compliance and reduce fraud. Decentralization can increase system robustness (no single point of failure) and potentially lower dependency on costly intermediaries. At the same time, managers should recognize that blockchains do not automatically guarantee accuracy or trustworthiness of data entering the system. They also introduce new governance questions (who controls protocol updates? how to handle errors on an immutable ledger?) that organizations must address (Risius & Spohrer, 2017). In essence, blockchain shifts some trust from institutions to technology – managers must then ensure that the technology itself is sound and that appropriate governance structures exist around its use.

3. 1. 2. Managerial Takeaways – Fundamentals:

1. Blockchain ledgers provide tamper-resistant recordkeeping, which can improve transparency and reduce fraud in business transactions by eliminating unauthorized data changes.
2. Decentralization allows parties to transact without a central middleman, potentially lowering costs and enabling new business models – but managers must still trust the blockchain protocol and code.
3. "Trustless" systems are not entirely trust-free; instead, trust is shifted to the technology and its interfaces. Managers need to ensure data entering the blockchain is accurate and that there are processes to govern the blockchain's use.
4. Immutability is a double-edged sword: it enhances data integrity, but errors or inappropriate data on the ledger are hard to correct. Effective governance and planning (e.g. defining off-chain dispute resolution or data verification mechanisms) are required.

3. 2. Network Typologies & Governance: Permissioned vs. Permissionless vs. Consortium

Not all blockchains are created equal – there is a spectrum of network models ranging from completely open, public blockchains to closed, private ledgers. It is crucial for managers to distinguish among permissionless, permissioned, and consortium blockchain architectures, as they differ in participation, governance, and suitable use-cases.

3. 2. 1. Permissionless (Public) Blockchains

In permissionless networks (e.g., Bitcoin or Ethereum), anyone in the world can join the network, validate transactions, and read the ledger. These networks epitomize decentralization: decision rights (such as validating blocks or proposing protocol changes) are broadly distributed among anonymous or pseudonymous participants. Public blockchains rely on economic incentives and consensus algorithms (like Proof of Work or Proof of Stake) to maintain integrity in an open environment. Governance in these systems often emerges through open-source processes and community consensus.

3. 2. 2. Permissioned Blockchains

Permissioned networks restrict participation to known, vetted parties. They may be operated by a single organization (fully private) or a group of organizations (consortium). Participants have to be granted permission to read or write to the ledger, often via a membership agreement. These blockchains are attractive in enterprise settings where companies require more control, privacy, or compliance with regulations. Because participants are known, lighter-weight consensus algorithms (not as computationally intensive as Bitcoin's Proof of Work) can be used – for example, by rotating a leader or using voting-based protocols. The governance of permissioned chains tends to mirror traditional arrangements: a governing body or committee (perhaps representing each member organization in a consortium) sets rules for the network, manages software upgrades, and decides on onboarding of new members. This on-chain governance blends with off-chain legal agreements. Risius and Spohrer (2017) observed that early blockchain research focused heavily on technology, with relatively less attention to governance and organizational questions, underscoring that how these permissioned networks are managed is critical for their success. Indeed, inter-firm blockchain consortia require careful governance frameworks – decisions about data sharing, intellectual property, and dispute resolution must be agreed upon by the members in advance.

3. 2. 3. Consortium Blockchains

A consortium blockchain is a special case of a permissioned blockchain where multiple independent organizations jointly operate the network. No single party controls the ledger; instead, a group of predetermined nodes (belonging to the consortium members) validate transactions. This model can foster trust and collaboration among businesses by providing a neutral shared infrastructure. For example, a consortium of banks might run a shared ledger for interbank payments or trade finance, ensuring that each bank has an equal say in validation. Consortium governance must address how decisions are made collectively – often through a steering committee or voting system among members. Lumineau, Wang, and Schilke (2021) note that different types of blockchains (public vs. private) will involve different sets of actors and motivations, and thus different governance needs.

3. 2. 4. An illustrative real-world example: JPMorgan's Onyx platform.

Onyx is a permissioned, consortium-based blockchain developed by JPMorgan in collaboration with partner banks, designed to facilitate instantaneous interbank payments and tokenized cash transfers. Consensus on Onyx is achieved through a lightweight voting protocol among pre-approved validator nodes, eliminating the need for energy-intensive Proof of Work. Governance is handled by a steering committee composed of member banks, which collectively sets network rules, manages software upgrades, and decides on onboarding new members, blending on-chain governance with off-chain legal agreements (Adebayo, Mensah, & Adukpo, 2025). By design, Onyx enhances operational efficiency, transparency, and liquidity management in wholesale banking, processing over USD 1 billion in daily transactions across more than 15 participating institutions (Adebayo et al., 2025).
Koroye (2024) warns of potential rent-seeking risks in private permissioned consortia like Onyx. Rent-seeking occurs when consortium members leverage exclusive control over network access, fee structures, and governance to extract economic rents without creating additional value (Krueger, 1974). In Onyx, this may manifest through high membership or transaction fees charged to approve nodes, governance processes that entrench incumbent banks, and proprietary controls over protocol standards that compel third-party service providers to license interfaces under favorable terms for the consortium. Without transparent fee schedules, rotating leadership, and

open-source reference implementations, such practices can undermine the collaborative and efficiency gains promised by blockchain consortia. In a consortium, governance involves aligning incentives among competitors or partners – a socio-technical challenge beyond just software rules.

3. 2. 5. Managerial Takeaways – Network & Governance:

Public vs Private: Public (permissionless) blockchains like Bitcoin and Ethereum allow anyone to participate, which can spur innovation and broad ecosystems but come with slower governance and potential uncertainty. Private/consortium blockchains restrict access for more control and privacy – better for inter-company collaboration with agreed rules. Managers should align the choice of blockchain type with the trust environment and regulatory needs of their project. Governance is Key: Successful blockchain implementations require robust governance mechanisms. In a consortium, establish governance committees and legal agreements up front (who can add nodes, how are software updates decided, etc.). In public blockchain initiatives, understand that protocol changes are community-driven – plan for flexibility and influence through open-source communities or foundations. Decision Rights & Accountability: Blockchain networks reallocate decision-making power. Managers should be aware of who holds decision rights (miners/validators in public chains, versus consortium members in private chains) and how that affects risk. For example, in a supply chain consortium ledger, clarity on data ownership and liability is crucial. Trust Trade-offs: A permissioned blockchain can reduce the need to trust outside parties by sharing a single source of truth among partners, but members must still trust the consortium's governance. Ensuring transparency in governance processes will help maintain trust among participants that the system is fair and reliable.

3. 3. Consensus Mechanisms: PoW, PoS and the Performance–Security Trade-offs

A cornerstone of any blockchain network is its consensus mechanism – the method by which distributed participants agree on the correct state of the ledger. Consensus mechanisms directly impact both the security and performance of a blockchain, and are closely tied to the infamous "double-spend" problem (the risk that the same digital token could be spent twice). Two of the most prominent consensus algorithms are Proof of Work (PoW) and Proof of Stake (PoS), each with distinct implications for managers evaluating blockchain platforms.

3. 3. 1. Proof of Work (PoW)

PoW was first popularized by Bitcoin. In PoW, network nodes (miners) compete to solve a complex cryptographic puzzle; the winner earns the right to add the next block and receive a reward. PoW's security comes from economic deterrence – an attacker would need to control over 50% of the network's computational power (hashpower) to consistently outsolve honest miners and rewrite the ledger, which is extremely costly. This mechanism has proven robust for Bitcoin and similar cryptocurrencies, but it has drawbacks. PoW is computationally intensive and slow. Blocks require significant energy to mine, resulting in low throughput (Bitcoin handles only ~7 transactions per second) and high latency (confirmations may take 10 minutes or more). Gervais et al. (2016) quantitatively analyzed PoW security and performance, finding inherent trade-offs: for example, increasing block size or reducing block time can improve throughput, but it also raises the risk of network forks and double-spending attacks if propagation of new blocks cannot keep up (Gervais et al., 2016). They showed that simply reparameterizing Bitcoin (e.g., making blocks bigger) provides only limited scalability gains and can weaken security margins against double-spend adversaries (Gervais et al., 2016). Croman et al. (2016) echoed this, arguing that major performance improvements would require fundamentally new approaches (beyond just tweaking PoW parameters), because Bitcoin's design hits bottlenecks in how fast information can reliably spread through the network (Croman et al., 2016). In essence, PoW-based systems deliberately sacrifice speed for decentralization and security, leading to what some call the "scalability trilemma" – balancing decentralization, security, and scalability is challenging.

3. 3. 2. Effective Decentralization in PoW: Evidence from Pool Revenues and Miner Economics (2022–2025)

Using pool-share and revenue data from 15 August 2022 to 11 August 2025, I document a concentrated distribution of Bitcoin's proof-of-work (PoW) security budget. Importantly, "Unknown" in pool attribution does not denote a single coordinator; rather, it aggregates blocks that cannot be reliably mapped to a named pool and likely include a mix of independent miners, pool users who obfuscate their template signatures, and operators choosing privacy-preserving or nonstandard announcement paths. The largest identifiable pools (e.g., AntPool, F2Pool, ViaBTC) collectively account for most of the remaining revenue. This pattern suggests that effective decentralization hinges on the dispersion of independently governed hashrate— not node counts— and on the economics that sustain miners' participation.

Table 2 - Pool-level Bitcoin miner revenue and implied hashrate

Pool	Share (%)	Total Revenue (USD)	Avg Daily Revenue (USD)	Avg Implied Hashrate (EH/s)
Unknown	52.75	$20,172,874,470	$18,456,427	287.37
AntPool	15.63	$5,977,147,991	$5,468,571	85.15
F2Pool	14.21	$5,433,770,901	$4,971,428	77.41
ViaBTC	12.61	$4,822,471,675	$4,412,142	68.70
SBI Crypto	2.13	$815,065,635	$745,714	11.61
Braiins Pool	1.24	$475,454,954	$435,000	6.77
BTC.com	0.71	$271,688,545	$248,571	3.87
Ultimus	0.53	$203,766,409	$186,429	2.90
Poolin	0.18	$67,922,136	$62,143	0.97

Source. Blockchain.com Explorer — Mining Information (Hashrate Distribution; Miners Revenue; Total Hash Rate from Aug 15, 2022–Aug 11, 2025). Valuing 2022–2025 revenues at today's BTC price (e.g., $112k) is look-ahead bias—it treats all past blocks as sold today and misstates USD revenues, profitability, and pool comparisons.

3. 3. 3. PoW Miner Economics: NPV Sensitivity and Power-Cost Dominance (2022–2025)

Using pool-share and revenue data from 15 August 2022 to 11 August 2025, I show that miner economics for a Poolin-sized counterfactual (fixed 0.18% network share; fleet ≈0.972 EH/s) hinge primarily on the *price of power* (USD/kWh). With explicit operating costs— energy, hosting surcharge, maintenance, overhead, and insurance— NPV turns positive only under cheap electricity and efficient hardware. For example, holding r = 12% p.a., fee = 2%, uptime = 95%, hosting = $0.005/kWh, maintenance = 3%/yr, overhead = $15k/MW/month, insurance = 1% of revenue, and salvage = 10% of capex: (i) at 17 J/TH and $0.05/kWh, FCF-based NPV is positive on the low-capex band ($19.5/TH) but turns negative on the high-capex band ($30/TH); (ii) a one-cent increase in power (to $0.06/kWh) materially compresses NPV; (iii) at $0.08/kWh most scenarios exhibit no discounted payback. These results support the conclusion that *$/kWh is the dominant driver* of value, with efficiency and capex/TH as important— yet second-order— modulators. As context, "Unknown" in pool attribution is an aggregation bucket, not a single coordinator; decentralization should be read through the dispersion of *independently governed* hashrate rather than node counts. I also draw on practitioner experience as a miner (2017–2020), which motivates using present-value (NPV) metrics alongside undiscounted ROI and discounted payback.

Table 3 – Sensitivity analysis: Power-Cost Dominance in Mining

Efficiency (J/TH)	Power ($/kWh)	Operating CF/day (USD)	FCF NPV (Low capex)	FCF NPV (High capex)	Disc. Payback (Low)	Disc. Payback (High)
17	0.05	$26,316	$6,783,233	$-2,695,873	815 days	1,358 days
17	0.06	$22,549	$3,291,889	$-6,187,217	974 days	1,654 days
17	0.08	$15,014	$-3,690,799	$-13,169,905	1,603 days	2,976 days
20	0.05	$21,201	$2,043,436	$-7,435,670	1,047 days	1,794 days
20	0.06	$16,769	$-2,064,028	$-11,543,133	1,392 days	2,501 days
25	0.05	$12,677	$-5,856,225	$-15,335,331	2,010 days	4,035 days
25	0.06	$7,137	$-10,990,554	$-20,469,660	5,609 days	No payback
25	0.08	$-3,944	$-21,259,213	$-30,738,319	No payback	No payback
30	0.05	$4,153	$-13,755,886	$-23,234,992	No payback	No payback
30	0.06	$-2,496	$-19,917,081	$-29,396,187	No payback	No payback
30	0.08	$-15,793	$-32,239,472	$-41,718,577	No payback	No payback

Methods note. Daily cash flows are discounted with daily compounding: PV = CF/(1+r)^(t/365) at r = 12% p.a. Assumptions: fee 2%, uptime 95%, hosting surcharge $0.005/kWh, maintenance. Valuing 2022–2025 revenues at today's BTC price (e.g., $112k) is look-ahead bias—it treats all past blocks as sold today and misstates USD revenues, profitability, and pool comparisons.

3. 3. 4. Proof of Stake (PoS) — Overview

PoS has emerged as a leading alternative to PoW, aiming to maintain security while drastically reducing resource consumption and potentially increasing throughput. In PoS systems, there are no miners expending electricity; instead, validators stake a certain amount of the blockchain's native token (locking it up as collateral) to earn the right to validate blocks and collect rewards. The consensus algorithm pseudo-randomly selects validators (weighted by their stake or other factors) to propose and vote on blocks. An attacker in PoS would need to obtain a majority of the staked tokens to control consensus— which is theoretically expensive— and if attempted, the stake can be slashed (destroyed) as a penalty for malicious behavior. Fahad Saleh (2021) provides a formal economic analysis of PoS and demonstrates that under certain conditions, PoS can achieve consensus securely without the "waste" of PoW. One key insight is that requiring validators to be stakeholders aligns incentives: those validating have skin in the game and thus a disincentive to undermine the system's value. Saleh (2021) finds that with a sufficiently modest and well-calibrated reward schedule, PoS can avoid persistent forks and ensure finality of transactions efficiently. Unlike PoW, where forks can occur naturally due to two miners finding a block at nearly the same time, PoS protocols often finalize blocks through voting, greatly reducing the chance of competing chains. PoS designs vary (e.g., Ethereum's Casper, Algorand's lottery, Cardano's Ouroboros), but generally they offer faster block times and higher throughput than PoW because they are not gated by physical computing limits. They also use orders of magnitude less energy, addressing environmental and cost concerns. However, PoS is not without trade-offs and risks. One concern is the potential for centralization of stake— those with large token holdings can exert significant influence and also earn more rewards, potentially growing their share over time (though some protocols try to mitigate this). There is also the "nothing-at-stake" critique: because creating conflicting blocks in PoS is cheap (unlike PoW, where it costs energy), validators might sign multiple chains. PoS protocols counter this with penalty mechanisms (slashing deposits of dishonest validators) and finality rules. Recent real-world data points to PoS's viability: major blockchains like Ethereum transitioned from PoW to PoS in 2022, significantly improving energy efficiency while maintaining security levels in line with theory (Saleh, 2021 provides the theoretical underpinning for why such a transition can work).

3. 3. 5. Proof of Stake (PoS) — Finance Perspective

Proof of Stake (PoS) replaces the electricity-and-ASIC security budget of PoW with a financial one: validators lock the native token as collateral and earn rewards (issuance, priority fees, and MEV) for proposing/attesting blocks. The key economic driver in PoS is the spread between the validator's net staking yield and their opportunity cost of capital r. When the net yield— after commissions, infrastructure OPEX, and expected slashing losses— exceeds r, adding stake has positive NPV; when it falls short, staking underperforms simply holding the token liquid. Security comes from the fact that attacks require acquiring (and risking) a large fraction of staked tokens, which can be slashed on equivocation or censorship. Compared with PoW, the dominant lever shifts from power price ($/kWh) to the financial return on stake (issuance + fees + MEV minus costs), while throughput and energy use improve substantially. Designs differ across protocols, but modern PoS systems combine pseudo-random validator selection with finality/voting rules and slashing to minimize long-range or nothing-at-stake failures. A practical decentralization caveat is stake concentration via pooled or custodial validators; policy levers include commission caps, client diversity, and penalty design to reduce correlated failures. Formal foundations show that, under appropriate reward schedules and penalties, PoS can achieve secure consensus without expending physical resources (Saleh, 2021; Kiayias et al., 2017; David et al., 2018).

Table 4 – Drivers of validator participation (proof-of-stake)

Driver	**Increases validator participation when…**	**Notes**
Net staking yield	Gross yield (issuance + fees + MEV) rises or commissions/OPEX fall	Dominant variable; compare directly to r (opportunity cost).
Opportunity cost r	r is low relative to net yield	If net yield < r → negative NPV vs. holding the token.
Slashing risk	Low probability × loss (good operational security)	Expected loss = p(slashing) × stake × penalty.
Client/diversity	Validator set uses diverse clients/infra	Reduces correlated failures and systemic slashing.
Liquidity & custody	More solo/pooled options with low commission	Concentration risk if few providers dominate.

Source: Author. Notes. PoS validator economics— dominant drivers and how they affect NPV. Formulas: Gross staking yield ≈ issuance% + priority fees + MEV. Net validator APR ≈ gross yield − commission − infra OPEX − expected slashing loss. Dominant spread S ≡ (net validator APR − r). S > 0 → positive NPV; S < 0 → negative NPV.

3. 3. 6. Performance and Security Trade-off

Beyond PoW and PoS, numerous consensus algorithms exist (Proof of Authority, Delegated PoS, Byzantine Fault Tolerance variants, etc.), each balancing throughput, security, and decentralization differently. The performance-security trade-off is a recurring theme. Generally, more decentralized and open systems (lots of nodes, global participation) tend to have lower raw performance due to coordination overhead and security constraints. For example, Bitcoin's conservatism in throughput is directly tied to maintaining a high security margin against double-spending. On the other hand, permissioned chains or newer consensus methods can push performance higher (thousands of transactions per second in some cases) by reducing the number of validators or using more centralized consensus at the cost of some decentralization. Croman et al. (2016) highlighted that achieving “next-generation, high-load blockchain protocols” likely requires rethinking layers of the stack – such as using layer-2 solutions or sharding – to break the linear transaction processing bottleneck of first-generation designs (Croman et al., 2016)

3. 3. 7. Managerial Takeaways – Consensus

For managers evaluating blockchain solutions, it’s important to assess the consensus mechanism under the hood. Proof of Work systems like Bitcoin are battle-tested for and truly trust-minimized, but they are slow, energy-intensive, and may not suit applications requiring high throughput or low latency (e.g., real-time trading platforms). Proof of Stake and related algorithms offer better scalability and energy efficiency, but managers should vet how the protocol handles validator incentives, potential concentration of power, and failure recovery. Additionally, double-spend risk underscores that in permissionless blockchains, transaction finality is probabilistic – one must wait for a number of blocks to be very confident a transaction won’t be reversed. Private or consortium blockchains often achieve instant or near-instant finality using fast consensus (since known nodes are less likely to be adversarial), which can be an advantage for certain enterprise applications. Proof of Work (PoW) provides strong security but with significant performance and cost drawbacks. It is best suited for untrusted public environments requiring censorship resistance (e.g., Bitcoin’s digital gold use case). Managers using PoW networks must account for slow transaction times and energy costs, and implement policies (like waiting for multiple confirmations) to mitigate double-spend risk for high-value transactions.
Proof of Stake (PoS) and newer consensus mechanisms drastically improve efficiency and throughput by leveraging economic incentives rather than computation. They are more eco-friendly and can handle higher volumes, which may be important for enterprise and consumer-facing applications. However, managers should scrutinize the governance of PoS networks (who are the major validators, is stake widely distributed?) to ensure the network remains decentralized and secure against collusion. There is no one-size-fits-all: consensus design involves trade-offs. For private or consortium chains, simpler consensus algorithms (like PBFT or Proof of Authority) can provide fast finality since participants are known – a boon for use cases needing speed and guaranteed finality (e.g., interbank settlements in seconds). The trade-off is reliance on trusted validators. Managers must align their choice of blockchain consensus with the trust model of their

use case (completely trustless vs. semi-trusted participants). Staying informed about scalability solutions is key. If a public blockchain's base layer is too slow for your needs, look into layer-2 solutions (payment channels, rollups) or hybrid architectures. As research suggests, major advances in blockchain scalability are underway (Croman et al., 2016), so a strategic approach might involve leveraging these innovations to get both security and performance (e.g., using Bitcoin or Ethereum for security and a layer-2 network for transaction throughput).

3. 4. Asset Tokenization: Rwa, Liquidity, and Fractional Ownership

Asset tokenization is the issuance of blockchain-based tokens that represent ownership or rights in real-world assets (e.g., securities, real estate, commodities, fine art). Tokenized assets blend features of traditional financial instruments with crypto-native properties such as programmability and peer-to-peer transfer/settlement. In practice, smart contracts can encode transfer rules, distributions, and compliance checks, bringing operational efficiency to illiquid markets (Ciriello, 2021).

3. 4. 1. Fractional ownership and liquidity: evidence from real estate

Empirical evidence shows tokenization can substantially fragment ownership and enable secondary trading. Studying 58 U.S. residential rental properties tokenized by a single platform, Swinkels (2023) finds an average of 254 token holders per property; investors with > $5,000 stakes tend to diversify across properties/cities; and ownership typically changes about once per year, with higher turnover for tokens listed on decentralized exchanges. Token prices broadly track local house price indices, suggesting exposure to fundamentals.

3. 4. 2. Governance and agency considerations

Tokenization redistributes— rather than eliminates— governance needs. When a sponsor/platform manages the underlying asset and retains a meaningful token stake, small investors may rationally free-ride, heightening classic principal–agent risks unless oversight is enforced (e.g., via disclosures, audits, or token-holder voting). Automated flows (e.g., rent/dividend distribution) help, but human accountability for asset management remains essential (Swinkels, 2023).

3. 4. 3. Regulatory treatment and compliance

Most leading jurisdictions continue to apply technology-neutral principles: when a tokenized instrument qualifies as a "security," it is regulated under existing securities laws (prospectus, market abuse, custody/record-keeping, trading and settlement). In the EU, the DLT Pilot Regime has applied since 23 March 2023, enabling DLT-based MTFs/SSs/TSSs under targeted exemptions. ESMA's 2025 review reports limited uptake so far and flags persisting frictions around settlement finality, custody/record-keeping, interoperability with legacy systems, and scope thresholds—issues that interact with MiFID II/CSDR. (ESMA, 2023; ESMA, 2025.

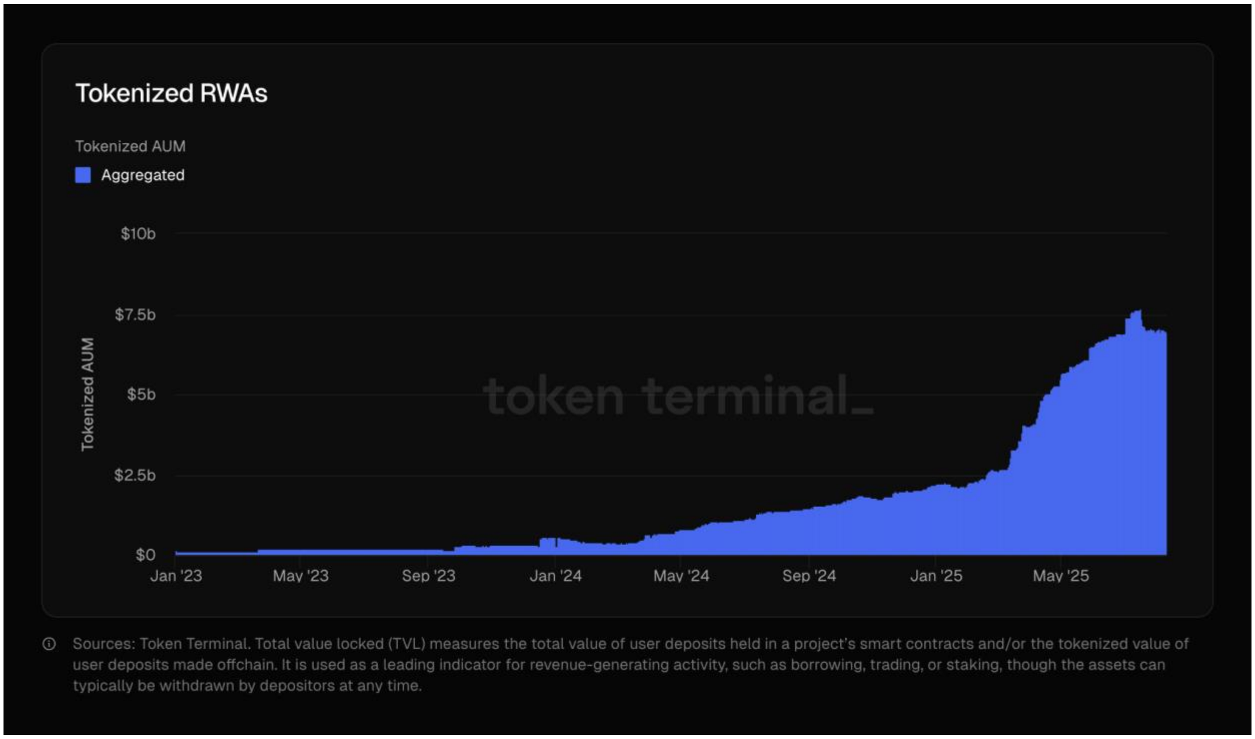
3. 4. 4. Market design, infrastructure, and price efficiency

Market microstructure strongly influences whether tokenization delivers liquidity and price discovery. Mechanisms that facilitate arbitrage and orderly secondary trading (e.g., reliable oracles, transparent valuation, market-maker participation) help keep token prices aligned with fundamentals— an insight consistent with stablecoin markets where improved arbitrage access reduced peg deviations (Lyons & Viswanath-Natraj, 2023). In real-asset tokens, DEX listing correlated with more frequent ownership changes, underscoring the role of venue design and trading access (Swinkels, 2023)

3. 4. 5. Market Snapshot — Tokenized RWAs

Using Token Terminal's "Stablecoins & tokenized RWAs" dashboard (retrieved August 17, 2025), the tokenized real-world-asset (RWA) AUM totals ≈$7.0 billion. Concentration remains high: BlackRock's BUIDL (≈$2.3B), Ondo (≈$1.3B), and Superstate (≈$0.88B) lead issuance. Ethereum dominates tokenized RWAs (≈$4.4B), with zkSync Era (≈$1.1B) and Solana (≈$0.32B) next; The takeaway is that tokenized RWAs are still small but scaling, with issuer and chain concentration that simplifies diligence (few large operators) yet increases dependency risk;

Figure 2 – Token Terminal. Dashboard - Stablecoins & tokenized RWAs . Retrieved August 17, 2025



3. 4. 6. Managerial Takeaways–Asset Tokenization

Tokenization can turn illiquid assets (real estate, collectibles, etc.) into tradable tokens, allowing fractional ownership and easier exit for investors. This can broaden the investor base and potentially raise asset values due to liquidity premiums. Managers of asset-heavy businesses should explore whether tokenization could improve capital flexibility (e.g., selling tokenized shares of inventory, property, or revenue streams to investors).

1. Efficiency and Automation: By representing assets on a blockchain, transactions (sales, transfers, dividend payouts) can be automated via smart contracts, reducing administrative overhead. However, managers must ensure the smart contracts are thoroughly tested and compliant with legal requirements (for example, automating a dividend payment to token holders must still adhere to securities law).
2. Governance and Investor Relations: When assets are tokenized, traditional governance mechanisms (like shareholder meetings or board oversight) may need rethinking. A large

number of small token holders will likely not engage in active governance. Thus, managers might need to provide transparency dashboards, regular updates, and possibly on-chain voting systems for major decisions to maintain investor confidence. Clear communication about who manages the asset and how token holder rights are protected is essential.

3. Regulatory Compliance: Managers should treat tokenized asset offerings with the same rigor as traditional securities offerings. This means working with legal counsel to ensure compliance in each jurisdiction, implementing whitelisting or investor accreditation checks if needed, and being prepared for evolving regulations. Embracing dialogue with regulators (perhaps through sandboxes or pilots) can mitigate legal risks.
4. Infrastructure and Market Support: Simply minting tokens doesn't guarantee a liquid market. Managers should consider partnering with reputable asset exchanges or platforms to list the tokens, and perhaps engage market makers or use automated market-making protocols to facilitate trading. Ensuring that reliable oracles and auditing mechanisms verify the link between the token and the underlying asset (e.g., confirming the property exists and is not double-pledged) will be vital for maintaining investor trust in tokenized assets.

3. 5. Token Types: Stablecoins, Utility Tokens, and Security Tokens

Blockchain tokens broadly fall into categories such as stablecoins, utility tokens, and security tokens. Each type has distinct characteristics, risks, and use cases, making them suitable for different managerial applications (OECD, 2020; Cong et al., 2021).

3. 5. 1. Stablecoins: Stability and Market Utility

Stablecoins maintain their value by pegging to a fiat currency or other stable assets, providing a bridge between traditional finance and blockchain ecosystems (Lyons & Viswanath-Natraj, 2023). For example, Tether (USDT) and USD Coin (USDC) use fiat collateral, whereas algorithmic stablecoins like DAI rely on crypto-collateralization and smart contracts for stability. Effective arbitrage mechanisms, collateral quality, and market incentives critically influence stablecoin stability (Lyons & Viswanath-Natraj, 2023). The sector has reached material scale. Using Token Terminal's dashboard in August 25, outstanding stablecoin supply is approximately \$263.5 billion, with issuance concentrated on Ethereum (≈\$149.9 billion) and Tron (≈\$82.7 billion). Issuer concentration is also pronounced: Tether's supply is about \$168.6 billion and Circle's about \$66.9 billion on a 30-day average basis, implying that the top two issuers account for roughly 88–90% of USD-denominated stablecoins in circulation.

3. 5. 2. Industry Examples – USDT and USDC

Peer-reviewed analyses illustrate contrasting issuer models and market dynamics. Tether (USDT), launched in 2014, has historically relied on commercial paper and repo market collateral; its delayed reserve attestations have generated skepticism (Lyons & Viswanath-Natraj, 2023; Cong et al., 2021). In contrast, Circle's USDC, introduced in 2018, committed to fully collateralized reserves held in cash and short-term U.S. Treasuries, subject to monthly attestations by independent auditors (Gai et al., 2023; BCG, 2025). Circle's USDC platform has continued to strengthen institutional confidence through robust audit practices and wider integration in regulated financial systems (Lyons & Viswanath-Natraj, 2023). (Ante, 2024; Dehghani et al., 2022).

3. 5. 3. Circle Arc and Tether-Aligned Stablecoin Chains

While Tether historically issued USD₮ across third-party networks, mid-2025 saw announcements of USDT-centric Layer-1s backed by affiliates. Bitfinex-backed Stable is a payments-focused L1 that uses USDT as the gas token, positioning itself as a dedicated "stablechain" for retail and merchant payments; it disclosed a \$28 million seed round and published a public roadmap (The Block, 2025a; PR Newswire, 2025). In parallel, reports on Plasma describe a Bitfinex-affiliated network targeting zero-fee USDT transfers with analysts framing it as competitive to Tron's current USDT dominance (DLNews, 2025; Yahoo Finance, 2025). These moves narrow the strategic gap with Circle's Arc, an official, USDC-native Layer-1 announced by Circle with dollar-denominated fees and native CCTP connectivity (Circle, 2025). Importantly, governance and ownership may differ Stable/Plasma are presented as Bitfinex-backed or affiliate-led initiatives rather than direct Tether Holdings products, so managers should evaluate operator accountability alongside the usual stability fundamentals (redeemability, collateral)

3. 5. 4. PESTEL Analysis — Stablecoins (Tether, Circle)

- Political–regulatory. Policy has converged on prudential oversight of issuers, reserve quality, and par-redemption. In the European Union, the Markets in Crypto-Assets Regulation (MiCA) entered into force in 2023 and is now fully applicable: Titles III–IV (ARTs/EMTs) have applied since June 30, 2024, and the remaining provisions since December 30, 2024 (ESMA, 2025; Dechert, 2025).Globally, baseline standards are set by the Financial Stability Board's high-level recommendations on global stablecoin arrangements (July 2023) and IOSCO's 18 recommendations for crypto and digital-asset markets (November 2023) (FSB, 2023; IOSCO, 2023).In the United States, Congress enacted the Guiding and Establishing National Innovation for U.S. Stablecoins (GENIUS) Act on July 18, 2025, establishing a federal licensing regime for "permitted payment stablecoin issuers," mandating 1:1 high-quality liquid reserves and BSA/AML compliance, and amending the Bankruptcy Code to exclude reserves from the estate and grant holders priority/superpriority claims (CRS, 2025; Greenberg Traurig, 2025; Reuters, 2025). These federal rules complement state regimes such as NYDFS (2022), which requires full backing, routine attestations, and timely par redemptions for DFS-supervised USD-backed stablecoins (NYDFS, 2022).
- Economic. At current rates, fiat-backed issuers earn substantial interest on reserves, which finances operations and compliance. Sector-level on-chain data indicate strong concentration in supply and usage, with Ethereum and Tron hosting the majority of activity and Tether and Circle dominating the USD segment. Stability outcomes remain linked to collateral quality, redemption design, and arbitrage efficacy as emphasized in the academic literature.
- Social. Stablecoins are widely adopted by exchanges, merchant processors, and on-chain finance as working-capital and settlement instruments, but user trust is contingent on disclosure cadence and issuer governance.

- Technological. Chain concentration exposes users to base-layer risks, while robust oracles, audited reserve attestations, and automated transfer controls can mitigate operational risks.
- Environmental. On modern proof-of-stake networks, the marginal energy cost of stablecoin transfers is low; empirical work on Ethereum's transition suggests a power-consumption reduction on the order of 99.8% or more. Legal. Authorities increasingly align stablecoin oversight with payments and securities regimes; the BIS's 2025 assessment argues that while stablecoins can catalyze tokenization, they fall short of the monetary system's requirements absent robust regulation and settlement in central-bank money.

3. 5. 5. Utility Tokens: Access and Ecosystem Growth

Utility tokens grant holders access to products, services, or governance rights within a blockchain ecosystem. Their value depends strongly on user adoption and network effects (Cong et al., 2021). Unlike stablecoins, utility tokens lack stabilization mechanisms, making their prices highly volatile and speculative (Hawlitschek et al., 2018; Cong et al., 2021). Managers leveraging utility tokens must clearly articulate the token's practical utility (e.g., governance, discounts, ecosystem access) to foster sustainable adoption and mitigate speculative behavior (Cong et al., 2021). Regulatory considerations are critical, as many utility tokens historically issued during ICOs were retrospectively classified as securities (OECD, 2020).

3. 5. 6. Security Tokens: Tokenizing Regulated Financial Instruments

Security tokens are regulated digital representations of traditional instruments issued under existing securities frameworks (e.g., MiFID II in the EU). 2023–2025 pilots showed meaningful efficiency gains. The HKSAR multi-currency digital green bond used the HKMA's CMU with HSBC Orion and settled in T+1 (HKMA, 2024; HSBC, 2024). Euroclear's D-FMI hosted AIIB's USD digitally native note in 2024 (AIIB, 2024; Euroclear, 2024). Earlier, EIB priced a £50 million digital bond via HSBC Orion in 2023 (EIB, 2023). RWA.xyz indicates that tokenized real-world assets (ex-stablecoins) reached the tens of billions by mid-2025 (RWA.xyz, 2025). ESMA's 2025 review of the EU DLT Pilot noted limited uptake and highlighted legal/interoperability frictions (ESMA, 2025).

Table 5 – Selected Security Token Case Studies (2023–2025)

Issuer / Project	Instrument	Size & Currency	Platform / Rail	Jurisdiction / Legal	Settlement (target)	Source(s)
HKSAR Government (Green Bond)	Multi-currency digital bond	HK$6bn eq. (HKD, USD, EUR, CNH)	HSBC Orion via HKMA CMU	Hong Kong law; CMU registrar	T+1 (vs. T+5)	HKMA, 2024; HSBC, 2024
AIIB (Digitally Native Note)	USD digital note (5-yr)	USD 300m	Euroclear D-FMI	English law note; DLT infrastructure	Near-real-time DvP	AIIB, 2024; Euroclear, 2024
EIB (GBP Digital Bond)	Sterling digital bond	£50m	HSBC Orion (private) + public mirror	Luxembourg DLT issuance law	Same-day	EIB, 2023

Regulatory Mapping (EU & Selected Jurisdictions)

- EU MiFID II/MiFIR: Security tokens that qualify as financial instruments follow securities rules; non-financial-instrument utility tokens fall outside MiFID and may be under MiCA.
- EU DLT Pilot Regime (2023–2026): Sandbox for DLT infrastructures; ESMA (2025) notes three authorised venues and low uptake with legal/operational complexities.
- MiCA (EU): Covers crypto-assets not in MiFID (incl. utility tokens); issuer whitepapers and CASP obligations apply.
- Hong Kong (SFC): Tokenised securities are ‘securities’ under SFO; 2023 circulars set expectations on AML/KYC and custody.

- Switzerland (DLT Act): Recognises ledger-based securities and authorised DLT trading facilities (SDX); on-chain records may have legal finality.
- Singapore (MAS Project): Sandbox pilots for tokenised bonds/FX under securities laws.

3. 6. Smart Contracts & Oracles: Mechanics, Platforms, and Automated Compliance

Smart contracts are often described as the "business logic" layer of blockchain – self-executing programs that run on the blockchain and automatically enforce terms of an agreement when predetermined conditions are met. First implemented at scale on the Ethereum blockchain, smart contracts enable the automation of complex workflows without the need for intermediaries or manual oversight. For managers, smart contracts hold promise for streamlining processes, reducing contracting costs, and ensuring tamper-proof execution of rules. However, they also introduce new dependencies, notably on oracles for external data, and require rigorous coding and testing to avoid costly errors.

3. 6. 1. Mechanics of Smart Contracts

A smart contract is essentially code deployed to a blockchain (like Ethereum, Solana, etc.) that has its own address and state. When certain functions of the contract are invoked (via transactions), the code executes on every node of the network, ensuring that outcomes are agreed-upon and recorded on the ledger. Christidis & Devetsikiotis (2016) provided an early overview, explaining smart contracts as "scripts that reside on the blockchain that allow for the automation of multi-step processes" (Christidis & Devetsikiotis, 2016). For example, a smart contract for an insurance payout might automatically release funds to a farmer if a weather data feed indicates a drought in the farmer's region. Once deployed, smart contracts are typically immutable (or have tightly governed mutability), meaning the code will execute exactly as written each time – a feature that can eliminate ambiguity and the need to trust a counterparty's promise. This automation and finality can drastically reduce the cost of contracting, enforcement, and reconciliation. Lumineau et al. (2021) note that blockchains with smart contracts enable achieving cooperation and coordination in a distinct way, substituting for some traditional governance mechanisms

(Lumineau et al., 2021). For instance, instead of a escrow agent holding funds during a transaction, a smart contract can serve that role, releasing funds when both buyer and seller have fulfilled their parts, based on cryptographic proofs or oracle inputs.

3. 6. 2. Platforms Smart Contracts

Ethereum remains the most prominent smart contract platform, with its Turing-complete language Solidity enabling a wide range of decentralized applications (DApps). Other major platforms include Binance Smart Chain, Solana, Cardano, and Algorand, each with different language approaches and consensus, as well as permissioned platforms like Hyperledger Fabric which allow smart contracts (called "chaincode") in closed consortia settings. The choice of platform can have business implications: Ethereum has the largest ecosystem (tools, developer base, audit services) but has faced high transaction fees at times; newer platforms like Solana offer higher throughput and low fees but are more centralized and have encountered some instability (outages). Managers should weigh factors like maturity, security track record, and community support. Notably, Vogelsteller & Buterin's ERC-20 standard (2015) greatly facilitated smart contract deployment of tokens by defining a common interface, which led to explosive growth in token contracts and interoperability between DApps (Vogelsteller & Buterin, 2015). Similarly, standards for NFTs (ERC-721) and other contract types have paved the way for quick adoption in various domains (digital art, gaming, etc.). For enterprise consortia, frameworks like Hyperledger or Corda allow smart contracts in more controlled environments, which might appeal to companies needing privacy and fine-grained permissioning. Automated Compliance and Efficiency: One of the touted benefits of smart contracts is automated compliance – rules and regulations can be embedded in code, ensuring they are followed. For example, a bond token could have a smart contract that automatically pays coupons on schedule and prevents transfers unless the recipient's address is whitelisted (complying with securities law restrictions). This reduces the need for manual oversight or trust in an intermediary to manage these processes. Smart contracts can also reduce fraud and disputes; since all parties can examine the code upfront, there is less room for misinterpretation, and once executed, the outcome is verifiable on the blockchain. However, this assumes the code correctly encapsulates the intent – any bugs or unforeseen scenarios can lead to undesirable outcomes (as famously happened in the 2016 DAO hack on Ethereum, where a loophole in a smart contract was exploited to siphon funds). Therefore, companies employing smart contracts must invest in code auditing, testing, and perhaps formal verification for critical contracts.

3. 6. 3. Oracles

Blockchains and smart contracts are closed systems with respect to data – they excel at handling on-chain data (like token balances or cryptographic signatures), but they cannot inherently know about off-chain events (the weather, stock prices, delivery confirmations in the physical world). Oracles are the solution: they are agents or systems that fetch and verify external information and feed it into the blockchain environment. Ezzat et al. (2022) provide a state-of-the-art review of blockchain oracles, highlighting that oracles "act as agents that fetch external information into the blockchain ecosystem" and thus have revolutionized the blockchain's ability to interact with real-world data (Ezzat et al., 2022). Oracles can be software (pulling data from APIs), hardware (IoT sensors reporting data), or human (crowd-sourced inputs), and can be centralized or decentralized. A decentralized oracle network (like Chainlink) uses multiple sources and nodes to deliver data to a contract, to reduce reliance on any single source. The "Oracle Problem" refers to the trust and reliability issues introduced by relying on oracles. As Ezzat et al. (2022) summarize, a blockchain system is only as trustworthy as its data inputs – if an oracle is compromised or feeds false data, the smart contract will still execute based on that false data, potentially causing losses or incorrect outcomes (Ezzat et al., 2022). For example, if a sports betting contract relies on an oracle to report game results, a malicious or erroneous oracle could report the wrong winner and cause payouts to the wrong party. Unlike the blockchain's internal consensus (which is robust by design), the oracle lies outside that consensus. This is a critical managerial point: smart contracts do not eliminate the need for trust – they push it to oracles when external data is involved. Lumineau et al. (2021) emphasized paying attention to blockchain's "inherent challenges and limitations," and the oracle problem is a prime example (Lumineau et al., 2021). Managers must ensure that any oracle service used is trustworthy, has redundancy, and perhaps is insured or bonded against failure. In DeFi, major incidents have occurred due to oracle manipulation (attackers moving market prices on thin exchanges that an oracle reads, to trigger favorable actions in a contract).

3. 6. 4. Market Snapshot — Oracles

Oracle usage is highly concentrated: Chainlink is the default infrastructure layer, combining the broadest chain coverage with the highest value secured, which signals deep trust across major DeFi venues. Chronicle and "Internal" oracles secure large sums despite fewer chains— these are more concentrated deployments with high value per chain, reflecting tight integrations and stricter control. Mid-tier providers such as Switchboard, API3, DIA, Band, UMA, Stork, and Supra occupy specific niches or ecosystems. Overall, breadth (chains) and depth (value secured) tell a consistent story: a dominant incumbent, a fast-rising second tier, and a long tail optimized for particular chains, assets, or governance models.

Table 6 – Oracles Secured value

Oracle	**Chains**	**Secured value**
Chainlink	454	$57.011b
Chronicle	8	$8.035b
Internal	45	$6.89b
RedStone	84	$6.699b
Pyth	285	$5.848b
Edge	4	$2.764b
Switchboard	21	$2.103b
Supra	14	$740.44m
Stork	31	$732.02m
Api3	39	$444.96m
UMA	8	$253.59m
TWAP	89	$246.97m
eOracle	11	$237.41m
DIA	39	$229.08m
Band	21	$152.49m

DefiLlama. (n.d.). Oracles. Retrieved August 22, 2025

3. 6. 5. Use Cases and Platforms in Practice

Smart contracts are being applied in various sectors: finance (automated trading, loans via DeFi protocols, parametric insurance), supply chain (tracking provenance and automating payments upon delivery milestones), legal (smart contract-based escrows or even whole agreements in code with Ricardian contracts linking legal text to code), and more. For instance, a supply chain smart contract might automatically release payment to a supplier once an IoT sensor at a warehouse signals that goods have arrived and met quality checks – thereby enforcing the supply agreement terms instantly. Truby (2018) in the context of energy argued that smart contract technology, if paired with appropriate regulation, could help create more sustainable practices (e.g., automatically rewarding renewable energy generation in a carbon credit system) (Truby, 2018). Christidis & Devetsikiotis (2016) envisioned IoT devices using smart contracts to autonomously trade resources or services – for example, a smart electric car could negotiate and pay for charging with a charging station via a blockchain contract (Christidis & Devetsikiotis, 2016).

3. 6. 6. Managerial Takeaways – Smart Contracts & Oracles:

Managers considering smart contracts should match the platform to their requirements and risk profile, weighing public versus permissioned architectures, language/tooling, and cost. In many enterprise settings, a hybrid design is prudent: sensitive data or complex business logic remains off-chain in conventional systems, while the blockchain provides tamper-evident verification for critical steps. Because enforceability is still evolving, organizations often pair code with traditional legal text— e.g., Ricardian contracts or explicit references to a contract's code hash— so the intended meaning is clear even if the code behaves unexpectedly or is exploited. The most compelling early uses are rule-based, multi-party processes (settlement, royalties, supply-chain payments) where automation can lower costs, reduce intermediaries, and enable instant actions like micropayments or late-fee assessments. Engineering must follow mission-critical standards: skilled developers, independent audits, testnets, and— when value at risk is high— formal verification. Given the immutability of deployed code, upgrade patterns and circuit breakers may be advisable, provided governance defines who can pause or upgrade. Platform choice should reflect privacy and throughput needs (favoring permissioned systems for closed ecosystems) versus interoperability with broader networks (favoring mature public platforms with robust libraries and tooling). Finally, external data dependencies require resilient oracle designs (decentralized feeds or consortium attestations), explicit failure modes, and, where appropriate, human arbitration. Legal and compliance teams should ensure automated transfers meet KYC/AML expectations and that contract logic is transparent to auditors and regulators.

3. 7. Major Public Chains: Bitcoin, Ethereum, Solana – Technical and Business Comparison

While thousands of blockchain networks exist, a few public chains have established themselves as the most prominent "platforms" with widespread usage and distinct value propositions. Here we focus on Bitcoin, Ethereum, and Solana as exemplars of different generations of blockchain technology, and compare their technical characteristics and business relevance. Understanding these differences helps managers and decision-makers choose the right infrastructure for their needs or comprehend the trade-offs of building on or interacting with these networks.

3. 7. 1. Bitcoin (BTC)

Launched in 2009, Bitcoin is the original blockchain and remains the largest by market capitalization. Technically, Bitcoin is a relatively simple but robust system: it was designed primarily as a decentralized peer-to-peer digital currency. It uses Proof of Work consensus with thousands of miners globally, giving it unmatched security in terms of hashpower, but also resulting in limited throughput (about 7 transactions per second) and high energy usage. Bitcoin's scripting language is intentionally limited (not Turing-complete) for security, meaning it cannot natively support complex smart contracts like Ethereum can. From a business perspective, Bitcoin's strength lies in being a store of value and censorship-resistant payment network. Many institutional investors now view it as "digital gold" – a hedge asset, given its provable scarcity (capped supply of 21 million BTC) and decentralized nature. However, Bitcoin's direct use in everyday business transactions is limited by its throughput and volatility. Over the years, an ecosystem has formed to address some limitations: for example, the Lightning Network is a layer-2 protocol that allows fast, low-cost Bitcoin payments by opening off-chain payment channels

(Croman et al. (2016) alluded to payment channels as a scaling solution) (Croman et al., 2016). Lightning is seeing adoption for microtransactions and remittances. Still, Bitcoin is not programmable in the rich ways other platforms are – its use cases remain primarily transfers of value and as a base collateral (e.g., WBTC allows Bitcoin to be used in Ethereum's DeFi by wrapping it as a token on Ethereum). For managers, Bitcoin may enter strategy as a treasury asset (some companies hold BTC in reserves) or as a payment option, but less so as a platform to build applications on due to its limited feature set.

3. 7. 2. Ethereum (ETH)

Introduced in 2015 by Vitalik Buterin and others, Ethereum is a general-purpose blockchain that pioneered smart contracts on a large scale. It started with Proof of Work but in September 2022 transitioned to Proof of Stake (the Merge), massively reducing its energy consumption. Technically, Ethereum offers a flexible platform where developers can deploy smart contracts for anything from tokens (ERC-20 standards) to decentralized applications (dApps) for finance (DeFi), gaming (NFTs), supply chain, and more. Ethereum's throughput is higher than Bitcoin's (around 15–30 transactions per second on the main chain historically), but still limited, and fees have been high at times of congestion. To address scaling, Ethereum's roadmap includes Layer 2 solutions (like Optimistic and ZK-Rollups that can bundle transactions off-chain and submit compressed proofs to Ethereum) and eventually sharding. Sedlmeir et al. (2020) noted that non-PoW permissionless blockchains (Ethereum post-Merge, for instance) with many nodes can increase energy efficiency drastically while still being more scalable than PoW systems, though they still face higher energy per transaction than centralized systems (Sedlmeir et al., 2020).

From a business viewpoint, Ethereum has become the de facto platform for blockchain innovation. It hosts the majority of DeFi protocols (lending, exchanges, derivatives) and NFT marketplaces. Many enterprises experimenting with blockchain (for instance, in supply chain traceability or tokenization of assets) choose Ethereum or Ethereum-compatible chains for their pilot projects, because of the rich developer community and tooling. Ethereum's introduction of standards like ERC-20 (for fungible tokens) and ERC-721 (for unique tokens/NFTs) was a game-changer in enabling interoperability and rapid ecosystem growth (Vogelsteller & Buterin, 2015). However, Ethereum's openness and popularity also brought challenges: during the 2021 DeFi and NFT booms, transaction fees ("gas" fees) spiked to tens or hundreds of dollars per operation, which is impractical for many business uses. This has somewhat been mitigated by layer-2 networks and by the move to PoS (which sets the stage for future scaling upgrades). Another aspect is governance and stability: Ethereum has a quasi-formal governance (Ethereum Improvement Proposals process, core devs, community consensus), which so far has managed upgrades like the Merge successfully. But it has also had contentious moments (e.g., the 2016 DAO fork). Managers building on Ethereum should keep abreast of protocol changes and possibly participate in governance if they are heavily invested in the ecosystem.

3. 7. 3. Solana (SOL)

Solana, launched in 2020, represents a newer generation of high-performance Layer 1 blockchains. Technically, Solana uses a combination of Proof of Stake and a unique innovation called Proof of History (PoH) to sequence transactions, which allows for extremely high throughput (the network boasts theoretical capacity of 50,000+ transactions per second) and very low latency and fees. Solana achieves this by requiring validating nodes to be very high-performance machines and by optimizing for speed at the expense of some decentralization (fewer full nodes compared to Ethereum, for example). It does not shard; instead it tries to scale vertically on a single chain. From a business standpoint, Solana has positioned itself as a blockchain for mass adoption, supporting applications like high-frequency trading, social networks (e.g., some decentralized social media projects), and consumer apps where you might need many transactions per second (like games or Web3 social applications). Its low fees (fractions of a penny) make it feasible to do tiny transactions (like micro-tips or IoT-based payments) directly on-chain, which would be cost-prohibitive on Ethereum mainnet. However, Solana's approach has trade-offs: the network has experienced a few outages and stoppages, indicating perhaps a less battle-tested infrastructure. Also, the requirement for powerful hardware to run a validator means the set of validators is more limited (potential centralization concerns). In Sedlmeir et al.'s energy taxonomy, Solana as a non-PoW chain with a large number of nodes but high perf hardware might have higher energy per transaction than a small permissioned system, but still negligible compared to PoW networks (Sedlmeir et al., 2020). For managers, Solana might be attractive for consumer-facing DApps needing scale (some fintech apps and even an e-commerce stablecoin payment pilot have used Solana due to its speed). Its ecosystem, while growing (especially in DeFi and NFTs in 2021–2022), is smaller and less mature than Ethereum's. One risk is ecosystem lock-in: Solana is not EVM-compatible (the Ethereum Virtual Machine standard), so smart contracts have to be written in Rust or C++ for Solana specifically, and assets on Solana are not natively usable on Ethereum and vice versa without cross-chain bridges (which come with security risks, as highlighted by Zamyatin et al. (2021) that trustless cross-chain communication is fundamentally hard) (Zamyatin et al., 2021).

3. 7. 4. Comparison Summary

Bitcoin, Ethereum, and Solana illustrate the evolution: Bitcoin prioritizes maximum decentralization and security at the cost of functionality and speed – it's a highly specialized network (digital money/store of value). Ethereum strikes a middle ground – general-purpose and fairly decentralized, but currently scaling through additional layers. Solana prioritizes speed and low cost, with a more moderate stance on decentralization. As Cong et al. (2021) pointed out, different categories of tokens (and by extension blockchains) serve different purposes – e.g., Bitcoin as a payment token vs. platforms like Ethereum/Avalanche for smart contracts (Cong et al., 2021). Each chain has developed a business ecosystem around it: Bitcoin's ecosystem is more about exchanges, custodians, and financial products (e.g., futures, ETFs) around BTC; Ethereum's ecosystem includes a vast array of applications enabling a decentralized financial system and beyond; Solana's ecosystem is emerging with fast-paced financial apps and NFT markets (often targeting retail consumers). The choice for a project might also consider community and longevity – Bitcoin and Ethereum have the longest track records and most decentralized communities, which can be important for trust. Solana, being newer and more "Silicon Valley" VC-backed in its early growth, carries more technology risk but also potential agility in updates.

Table 7 – Blockchains Layer 1

Project	**Active address (monthly)**	**FDV market cap**	**Coin volume (30d)**	**Fees (30d)**	**Daily active users**
Bitcoin (BTC)	10.8 M (-0.4%)	$2.3 T (-4.7%)	$1.3 T (+22.3%)	$15.2 M (+1.4%)	489.4 K (+3.8%)
Ethereum (ETH)	9.6 M (+23.0%)	$522.7 B (+15.6%)	$1.1 T (+41.5%)	$40.2 M (-15.2%)	550.7 K (+9.0%)
BNB Chain (BNB)	46.4 M (-0.1%)	$121.2 B (+10.6%)	$56.1 B (+70.1%)	$10.7 M (+3.4%)	4.9 M (+12.9%)
Solana (SOL)	56.2 M (-20.2%)	$113.8 B (-8.5%)	$266.9 B (+9.2%)	$41.5 M (+11.9%)	3.5 M (-5.2%)
Tron (TRX)	14.4 M (+1.8%)	$33.5 B (+12.1%)	$51.7 B (+15.3%)	$420.2 M (+16.6%)	2.6 M (+5.5%)
TON (TON)	1.4 M (-13.5%)	$16.8 B (-1.9%)	$8.8 B (+41.9%)	$570.5 K (-12.8%)	105.1 K (+16.0%)
Avalanche (AVAX)	663.6 K (-55.9%)	$10.7 B (-9.1%)	$21.8 B (+43.1%)	$633.4 K (+28.7%)	45.0 K (-49.0%)
Aptos (APT)	10.0 M (+6.1%)	$5.3 B (-16.4%)	$13.0 B (+57.1%)	$406.2 K (+383.1%)	682.5 K (-2.9%)
NEAR Protocol (NEAR)	51.1 M (+11.6%)	$3.2 B (-15.6%)	$7.6 B (+7.9%)	$319.3 K (+23.9%)	3.0 M (-1.8%)
Polygon (POL)	7.2 M (-12.1%)	$2.6 B (-4.1%)	$4.2 B (+45.6%)	$262.4 K (+19.1%)	596.6 K (+0.9%)

Source: Token Terminal. (n.d.). Blockchains (L1). Retrieved August 21

3. 7. 5. Managerial Takeaways – Public Chains:

Platform selection should follow the application's requirements. Bitcoin offers unmatched settlement security for value transfer and treasury use but limited programmability. Ethereum provides a mature smart-contract environment and broad interoperability, with scaling addressed via layer-2 solutions. For very high-throughput consumer use, newer networks such as Solana (and options like Polygon or Avalanche) may fit, but managers must weigh maturity and decentralization trade-offs. Ecosystem readiness is equally important: Ethereum currently has the deepest tooling, audited libraries, and integrations across wallets, exchanges, and custodians; Bitcoin's simpler scripting limits on-chain logic but benefits from established custody practices; Solana's Rust-based stack is improving, though specialized talent and enterprise integrations may be scarcer. Organizations should verify performance claims and resilience, review outage history and governance concentration, and align any decentralization compromises with the product's trust and censorship-resistance needs. Many firms adopt a multi-chain strategy— e.g., holding BTC as a reserve, using Ethereum for DeFi or token issuance, and employing a faster chain or layer-2 for user-facing scale— while explicitly managing interoperability and bridge risks (Zamyatin et al., 2021). Finally, because public chains evolve via community governance, managers should monitor roadmaps and proposed upgrades, participate in relevant forums or industry groups, and treat external protocol change management as part of IT governance.

3. 8. The Role of Decentralization

Decentralized finance (DeFi) and decentralized exchanges (DEXs) increasingly replace institutional intermediation with 'trust in code'— audited smart contracts, transparent state machines, and community governance. This is not trust-free: users depend on protocol code, oracle feeds, and upgrade keys (often controlled via multisig or DAOs). The literature frames this as a reconfiguration of trust, rather than its elimination (Hawlitschek, Notheisen, & Teubner, 2018; BIS, 2021). Supervisory work further warns that governance chokepoints and infrastructure concentration can recreate centralization (BIS, 2021). Empirically, DEX activity has grown to macro-relevant scale

3. 8. 1. Decentralized Exchanges (DEXs)

Decentralized exchanges are smart-contract–based trading venues where users keep self-custody and trade by interacting with on-chain mechanisms rather than a centralized order book. Two implementation patterns dominate: hybrid designs that perform matching off-chain (or on specialized rollups) but settle on-chain, and automated market maker (AMM) designs that set prices via constant-function market makers (e.g., constant-product curves). AMMs provide continuous liquidity and transparent price formation but expose liquidity providers to slippage and impermanent loss; their oracle-like properties and economic guarantees are formalized in peer-reviewed work (Angeris & Chitra, 2020). Empirical and conceptual surveys place DEXs within the broader DeFi stack— highlighting openness, composability, and new risk channels through smart-contract failures and cross-protocol linkages (Schär, 2021). Because DEX trading is embedded in public blockchains, transaction ordering and miner/validator extractable value can distort execution, liquidations, and oracle updates, with documented security and market-microstructure implications (Daian et al., 2020; Qin, Zhou, & Gervais, 2023). Fiat on/off-ramps remain mostly off-chain, so DEXs excel in crypto-to-crypto markets while relying on robust oracle design and governance to manage residual trust and latency constraints (Schär, 2021; Qin et al., 2023).

3. 8. 2. Market Snapshot — DEX

Market activity on decentralized exchanges is clearly concentrated: Uniswap and PancakeSwap carry much of the 30-day trading flow, with Raydium and Aerodrome forming a second tier. The mix of users differs across venues: Uniswap serves a broad base of everyday traders, while Curve's smaller daily user count points to heavier, more professional or aggregator driven flow.

Table 8 – DEX Volume & Market Cap

Project	Trading volume (30d)	FDV market cap	Token volume (30d)	Fees (30d)	DAU (latest)
Uniswap (UNI)	$107.5 B	$10.6 B	$18.0 B	$95.7 M	750.5 K
pump.fun (PUMP)	$3.1 B	$3.1 B	$11.8 B	$30.3 M	152.2 K
Curve (CRV)	$8.8 B	$2.0 B	$9.8 B	$4.7 M	2.6 K
PancakeSwap (CAKE)	$143.0 B	$973.5 M	$3.9 B	$121.0 M	437.8 K
Raydium (RAY)	$41.5 B	$1.9 B	$3.6 B	$66.5 M	1.1 M
Aerodrome (AERO)	$21.6 B	$2.4 B	$2.7 B	$15.6 M	60.4 K
SushiSwap (SUSHI)	$290.8 M	$225.6 M	$1.4 B	$580.2 K	21.2 K
SUN (SUN)	$468.6 M	$1.1 B	—	—	—
Orca (ORCA)	$18.7 B	$172.2 M	$1.1 B	$11.5 M	56.3 K
Maverick Protocol (MAV)	$44.3 M	$117.5 M	$836.1 M	$5.8 K	27.4 K
IDEX (IDEX)	$0.0	$25.7 M	$715.9 M	$0.0	—
Thena (THE)	$156.1 M	$107.7 M	$669.4 M	$182.9 K	4.0 K
Cetus (CETUS)	$97.5 M	$664.4 M	—	—	—
0x (ZRX)	$0.0	$249.6 M	$580.3 M	$0.0	0.0
Loopring (LRC)	$122.6 M	$504.8 M	—	—	—
Velodrome (VELO)	$1.1 B	$113.3 M	$367.3 M	$684.9 K	7.3 K
WOO (WOO)	$166.5 M	$340.1 M	—	—	—
Balancer (BAL)	$1.0 B	$96.1 M	$328.9 M	$604.6 K	27.0 K
Shadow (SHADOW)	$768.1 M	$53.4 M	$314.3 M	$1.7 M	3.1 K
Biswap (BSW)	$43.7 M	$15.0 M	—	—	—

Source: Token Terminal. (n.d.). DEX dashboards. Retrieved August 21, 2025.

3. 8. 3. Yield: Lending, Liquidity Provision, and Composability

DeFi 'yield' arises from three primary sources: (i) borrower interest on money markets (e.g., Aave, Compound), (ii) trading fees distributed to liquidity providers (LPs) on automated market makers (AMMs), and (iii) periodic token incentives. Key risks include smart-contract failure, liquidation cascades, oracle manipulation, and governance capture. Peer-reviewed surveys document these building blocks and associated attack surfaces (Schär, 2021; Qin, Zhou, & Gervais, 2023).

3. 8. 4. Market Snapshot — Yield Protocols

Lending activity is clearly anchored by Aave, which remains the default venue for most borrowers and lenders (~$27B 30-day volume and rising fees). Morpho is gaining ground by emphasizing capital efficiency: fees are up while daily users eased, suggesting larger, more sophisticated positions rather than casual traffic. Spark shows a sharp jump in token turnover (≈+390%), which reads as incentive- or listing-driven rather than broad organic demand. Fluid and Euler post solid fee growth with mixed user trends— selective adoption where the product fits. Smaller names (e.g., Dolomite) exhibit triple-digit growth off low bases, typical of campaign cycles. Overall, the market looks mature at the core (Aave) with challengers competing via better yields, collateral flexibility, and incentives; trends are best read directionally, since FDV and "daily users" have measurement caveats.

Table 9 – Yield activity

Project	**Trading volume (30d)**	**FDV market cap (latest)**	**Token volume (30d)**	**Fees (30d)**	**DAU (latest)**
Aave (AAVE)	$26.9 B	$4.8 B	$15.2 B	$91.8 M	9.0 K
Morpho (MORPHO)	$3.2 B	$2.2 B	$748.0 M	$15.8 M	2.4 K
Spark (SPK)	$2.1 B	$758.4 M	$10.5 B	68.0	—
Fluid (FLUID)	$1.4 B	$691.0 M	$93.0 M	$8.5 M	6.4 K
Onyx Protocol (XCN)	$619.6 M	$826.5 M	—	—	—
Kamino (KMNO)	$1.7 B	$577.9 M	$563.1 M	—	—
Maple Finance (SYRUP)	$1.3 B	$501.9 M	$3.3 B	$7.4 M	—
Compound (COMP)	$1.2 B	$464.5 M	$1.6 B	$5.2 M	226.0
JustLend DAO (JST)	$334.8 M	$1.2 B	—	—	—
Euler (EUL)	$1.4 B	$277.0 M	$86.1 M	$5.6 M	1.5 K
Dolomite (DOLO)	$116.7 M	$227.8 M	$830.4 M	$817.3 K	412.0
Venus (XVS)	$805.6 M	$183.9 M	$301.3 M	$2.7 M	613.0
Moonwell (WELL)	$232.0 M	$142.8 M	$134.7 M	$1.1 M	1.5 K
Avalon Finance (AVL)	$140.8 M	$323.8 M	—	—	—
Goldfinch (GFI)	$98.4 M	$70.6 M	$23.1 M	$162.7	3.0

Source: Token Terminal. (n.d.). Lending / Money Markets dashboards. Retrieved August 21, 2025.

3. 8. 5. Derivatives (Perpetuals)

Perpetual futures (often called perpetual swaps) are margined derivatives with no expiry date. Instead of converging at a maturity, the contract price is kept close to an external index (a basket of spot prices) through a periodic “funding rate” exchange between longs and shorts: when the perp trades above the index, longs typically pay shorts; when it trades below, shorts pay longs. This mechanism allows continuous trading and price anchoring without settlement, and it is now widely documented in the academic literature on blockchain-based markets (Schär, 2021). In decentralized finance, two implementation patterns dominate. A first family uses hybrid designs in which order matching and risk checks run off-chain (or on a specialized rollup/sidechain) while positions and settlements are committed on-chain. This reduces latency and tightens spreads but introduces reliance on the matching engine's operators or validators. A second family prices perpetuals with automated market makers (AMMs)— "virtual AMMs" or curve-based designs— so that inventory and prices are determined by a rule (the curve) rather than an order book. The economic properties of these AMMs— price formation, slippage, and their oracle-like behavior— have been formalized in peer-reviewed venues, providing theoretical footing for on-chain derivatives pricing (Angeris & Chitra, 2020; Schär, 2021). Across both designs, core risk mechanics are similar. Traders post initial and maintenance margin; if equity falls below maintenance (based on a mark price tied to the external index), positions are liquidated. Protocols commonly maintain insurance funds and, under stress, may apply auto-deleveraging. Because these markets operate on public blockchains, oracle robustness is critical: medianized feeds, time-weighted averages, and circuit breakers are deployed to resist manipulation and price spikes. At the same time, transaction ordering and miner/validator extractable value (MEV) can affect fills, liquidations, and oracle updates, a phenomenon analyzed in peer-reviewed security research (Daian et al., 2020). Recent systematizations of DeFi map how these elements— margining, liquidations, oracles, and composability with other protocols— can transmit shocks and amplify cycles if not carefully engineered (Schär, 2021).

3. 8. 6. Market Snapshot — Derivatives Protocols

Perps activity is concentrated around dYdX and GMX, which together carry the bulk of flow (~\$8.6B and ~\$8.4B over 30 days) on relatively small user bases (≈2.6K and 1.6K DAU). That mix— large notional with few users— suggests professional/aggregator-driven trading more than retail churn. The mid-tier is mixed: SynFutures holds meaningful flow with DAU edging up, ApolloX is growing from a smaller base, while Merkle and HMX cooled. Outliers reflect campaign effects: BMX shows triple-digit jumps off a tiny base, and Synthetix pairs lower notional with a sharp fee rise (likely parameter or routing changes rather than broad demand). Overall, the snapshot points to a two-hub market (dYdX/GMX), selective traction among challengers, and metrics that can swing with incentives— so trends (direction) matter more than absolute FDV or DAU levels.

Table 10 – Perps Volume

Project	Notional volume (30d)	FDV (latest)	Token volume (30d)	Fees (30d)	DAU (latest)
dYdX (DYDX)	$8.6 B	$627.9 M	$498.4 M	$1.9 M	2.6 K
GMX (GMX)	$8.4 B	$157.6 M	$1.1 B	$10.0 M	1.6 K
SynFutures (F)	$2.4 B	$72.9 M	$276.0 M	$506.2 K	2.7 K
ApolloX (APX)	$1.5 B	$288.0 M	$32.9 M	$369.1 K	174
Merkle Trade (MKL)	$618.6 M	$6.3 M	$160.2 K	$241.8 K	102
HMX (HMX)	$201.5 M	—	$1.1 M	$70.0 K	22
MUX (MCB)	$75.2 M	$10.3 M	$138.7 K	$52.3 K	18
Synthetix (SNX)	$71.0 M	$228.6 M	$538.7 M	$315.1 K	8
Kwenta (KWENTA)	$65.9 M	$8.8 M	$129.3 K	$20.6 K	3
BMX (BMX)	$28.0 M	$19.3 M	$2.0 M	$58.9 K	97
Hegic (HEGIC)	$3.6 M	$72.2 M	$5.0 M	$163.0 K	6
IPOR Protocol (IPOR)	$2.3 M	$0.0	$213.1	0.0	—
Perpetual Protocol (PERP)	$1.5 M	$41.9 M	$283.3 M	$1.6 K	10
Polynomial Protocol	$489.7 K	$293.3	0.0	0.0	—
Holdstation (HOLD)	$244.7 K	$38.9 M	$34.3 M	$211.1	2
Volmex	$3.7 K	$11.1	0.0	—	—

Source: Token Terminal. (n.d.). Derivatives / Perps dashboards. Retrieved August 21, 2025.

3. 8. 7. Liquid Staking (LSTs) and Re-/Restaking

Liquid staking tokens (LSTs) convert a locked proof-of-stake position into a transferable claim that accrues staking rewards while remaining usable as collateral across DeFi. In practice, designs differ: some tokens "rebase" by increasing the holder's balance as rewards accrue, while others are reward-bearing claims whose unit price drifts upward with pooled rewards. A recent peer-reviewed study in the Journal of Futures Markets shows that LSTs exhibit a persistent "liquid-staking basis," i.e., a price spread versus the native asset, and that this basis widens when LST yields lag direct staking, when market volatility rises, and when secondary-market liquidity is thin; it narrows when attention and sentiment improve. The same paper documents that LSTs contribute materially to price discovery in the underlying, underscoring that they are not merely wrappers but economically significant derivatives in their own right (Scharnowski & Jahanshahloo, 2025)

3. 8. 8. Market Snapshot — Liquid Staking

Liquid staking remains highly concentrated: Lido anchors the category (~$38B 30-day notional; fees up ~35%) despite a small dip in daily users, reflecting entrenched institutional/whale demand. Rocket Pool is steady, growing slower but organically, while cbETH and Liquid Collective point to a rising institutional lane. On Solana, Jito and Marinade still move large sums but saw softer FDV and DAU, suggesting consolidation after earlier growth spurts. Newer or niche players show mixed signals: Swell posts strong token turnover (+~78%) with weaker FDV, Stader’s token volume surged (+~292%) from a smaller base, and StakeWise holds a modest, consistent footprint. Overall, the snapshot suggests a mature core (Lido) plus a competitive second tier differentiated by validator strategy, incentives, and chain exposure; trends should be read directionally, since FDV and “daily users” have measurement caveats.

Table 10 – Perps Volume

Project	**Notional volume (30d)**	**FDV (latest)**	**Token volume (30d)**	**Fees (30d)**	**DAU (latest)**
Lido Finance (LDO)	$38.3 B	$1.3 B	$5.8 B	$84.1 M	461.0
Rocket Pool (RPL)	$2.8 B	$160.2 M	$410.8 M	—	8.0
Jito (JTO)	$2.8 B	$1.7 B	$1.3 B	$39.1 M	646.3 K
Marinade (MNDE)	$2.0 B	$115.2 M	$66.3 M	$12.5 M	112.0
cbETH	$1.9 B	—	—	—	—
Liquid Collective	$1.6 B	—	—	—	3.0
StakeWise (SWISE)	$1.4 B	$24.2 M	$1.1 M	$1.8 M	74.0
Swell (SWELL)	$1.3 B	$103.7 M	$572.4 M	0.0	—
Stader (SD)	$671.3 M	$83.8 M	$490.8 M	$80.8 K	13.0
Symbiotic	$405.0 M	—	—	—	245.0
Frax Ether	$398.4 M	—	$900.1 K	0.0	—
BENQI Liquid Staking	$369.2 M	—	$2.1 M	—	50.0
StakeStone	$99.7 M	—	—	—	11.0
Ankr (ANKR)	$41.3 M	$157.4 M	$521.4 M	—	1.0
StaFi (FIS)	$9.0 M	$19.0 M	$374.0 M	0.0	—
Allstake	—	—	—	—	—

Source: Token Terminal. (n.d.). Liquid Staking dashboards. Retrieved August 21, 2025.

3. 9. Exchange (CEX)

In regulatory terms, an exchange is a market intermediary that matches and executes orders and gives access to price discovery and liquidity. Under the FATF framework, an exchange that swaps virtual assets for fiat or other virtual assets— or transfers/safekeeps customers' assets— qualifies as a Virtual Asset Service Provider (VASP) and must be licensed/registered and comply with AML/CFT controls (e.g., customer due diligence and the "travel rule"). In the EU, exchanges fall under Crypto-Asset Service Provider (CASP) when they operate a trading platform or execute/exchange crypto-asset orders; CASPs require prior authorisation and are subject to governance, own-funds and client-asset safeguarding duties, and— where assets are admitted to trading— MiCA's market-abuse regime. Compared with the FATF's VASP category (AML-focused), the EU CASP perimeter adds prudential and conduct-of-business obligations; peer-reviewed analyses highlight, for example, MiCA's custody

3. 9. 1. Market Snapshot — Exchange

Across July 21–Aug 20, Binance dominates on assets and spot activity, with modest average leverage (~0.24×) and net inflows over the window— signaling continued user trust. OKX and Bybit form the second tier: "clean assets" are essentially on par with total assets, while Bybit looks more derivatives-heavy (large open interest) and shows a small outflow in the custom range. Bitfinex runs relatively low leverage (~0.10×) with steady, smaller inflows; Deribit is clearly options/perps-centric (high OI, outflows). Gate and Bitget show higher average leverage (≈3–4×), which can amplify risk even when assets rise. HTX and KuCoin exhibit net outflows, while MEXC shows sizable inflows. Robinhood holds large assets but posted notable outflows and limited trading metrics. Overall: a concentrated market led by Binance, a solid OKX/Bybit tier with different risk footprints, and a long tail where leverage and flows swing more with market cycles.

Table 11 – CEX Transparency

Exchange	Assets	Inflows (1m)	Spot vol (24h)	Open interest (24h)	Avg leverage	Custom-range inflow
Binance	$183.385b	$1.489b	$18.967b	$38.966b	0.24x	$1.99b
OKX	$28.126b	$3.663b	$10.929b	—	0.39x	$362.17m
Bybit	$23.924b	$270.68m	$3.037b	$25.448b	1.06x	-$330.04m
Robinhood	$21.69b	-$844.61m	—	—	—	-$835.73m
Bitfinex	$27.391b	$38.34m	$249.97m	$2.115b	0.10x	$5.63m
Gemini	$9.856b	$211.25m	—	—	—	—
HTX	$7.189b	-$778.05m	$3.198b	$9.008b	1.27x	-$662.2m
Gate	$8.566b	-$101.13m	$3.053b	$19.534b	3.03x	—
Bitget	$5.713b	-$122.28m	$3.288b	$25.038b	4.40x	-$157.08m
BitMEX	$5.589b	-$52.0m	$75,942	$1.93b	0.35x	-$72.67m
Deribit	$5.05b	-$45.96m	$3.667b	—	0.73x	-$274.63m
KuCoin	$5.076b	-$144.14m	$1.682b	$4.163b	0.99x	-$147.57m
MEXC	$4.058b	$2.575b	$2.953b	$8.899b	2.32x	$2.59b
Crypto.com	$3.838b	-$140.32m	$3.602b	$2.223b	0.62x	-$142.65m
Bitstamp	$3.158b	$427.04m	—	—	—	—

DefiLlama. (n.d.). CEX transparency. Retrieved August 22, 2025

3. 9. 2. Exchange Evolution & Trust: From Early Faucets to FTX – Building Institutional Confidence

In the early days of cryptocurrency (circa 2009–2013), obtaining Bitcoin or other crypto often involved informal methods such as "faucets" (websites that gave small amounts of Bitcoin for free) or peer-to-peer forums. As the industry grew, centralized exchanges became the primary on-ramp for users – these are companies like Mt. Gox (the dominant Bitcoin exchange in 2013), Coinbase, Binance, and the now-infamous FTX, where users could exchange fiat currency for crypto and vice versa, and trade various crypto assets. The journey from those rudimentary faucets to sophisticated (and sometimes opaque) global exchanges has been marked by cycles of exuberant growth and dramatic failures. Trust has been a central issue throughout this evolution, and it remains a critical factor for mainstream and institutional adoption of crypto.

3. 9. 3. Early Era – Wild West Exchanges

Early exchanges were often unregulated and run by tech enthusiasts rather than experienced financial institutions. The collapse of Mt. Gox in 2014, where approximately 850,000 BTC were lost due to hacks and mismanagement, was a wake-up call that highlighted the custodial risk users take by storing funds on an exchange. Exchanges essentially ask users to trust them like banks, but without the oversight or insurance that banks have. Over the years, this led to the mantra "not your keys, not your coins" among crypto users, encouraging individuals to hold their own crypto privately. However, for average users and certainly for institutions, managing private keys and securing crypto is non-trivial. Thus, exchanges (and custodians) evolved to improve security (multi-signature wallets, insurance funds, etc.) and regulatory compliance. The mid-2010s saw increasing professionalization: US-based exchanges like Coinbase sought licenses and implemented controls, while international ones like Binance scaled rapidly by offering many tokens and later adding compliance as regulators caught up.

3. 9. 4. Trajectory of Trust and Failures

Despite improvements, exchange failures continued. Sapkota (2024) provides a comprehensive analysis of cryptocurrency exchange failures, examining data from 845 exchanges worldwide since 2014 and finding that nearly half had collapsed by mid-2020s (Sapkota, 2024). This is an astonishing failure rate and underscores the operational and fraud risks in this industry. Some key insights Sapkota reports: paradoxically, exchanges headquartered in developed, highly regulated countries (like the US, Singapore) were not immune to failure and in fact showed fragility, perhaps due to the pressures of compliance costs and being prime targets for sophisticated fraud (Sapkota, 2024). The study indicates that centralized exchanges allowing U.S. customers had a higher probability of default than those that restricted U.S. clients (Sapkota, 2024). This could reflect the higher regulatory scrutiny and potential enforcement actions they face (or that bad actors target them precisely because U.S. customers are lucrative, while regulations add burdens). A striking finding is that centralized exchanges have a significantly higher risk of failure than decentralized exchanges (DEXs) – Sapkota notes that DEXs had about a 31.2% lower probability of failure relative to centralized platforms (Sapkota, 2024). This highlights an important shift: because DEXs allow users to trade directly from their wallets (self-custody), there is no central honeypot to hack or misappropriate, and no single point of corporate failure (though DEXs can have other risks like smart contract bugs). Sapkota (2024) also identifies warning signs for exchanges that are more likely to fail: high withdrawal fees (on average, defunct exchanges charged 1.5× higher withdrawal fees than surviving ones, which might signal attempts to deter withdrawals during cash crunches) and limited coin listings and poor user ratings (exchanges that did not offer a diverse range of assets or that had low reputation scores were more failure-prone) (Sapkota, 2024). Interestingly, exchanges that offered referral reward programs (incentivizing users to bring friends) tended to be less likely to default, potentially because a growing user base via referrals indicates good traction or because such programs align with transparent marketing rather than hidden fees (Sapkota, 2024).

3. 9. 5. FTX and Recent Turmoil

The collapse of FTX in November 2022 stands as one of the largest and most shocking failures, given that FTX was, by then, a top-three exchange valued at $32 billion, with a high-profile CEO and sponsorships (it had naming rights to an NBA arena, etc.). FTX's implosion due to alleged fraud (misuse of customer funds for risky bets by an affiliated trading firm) severely shook trust, even among seasoned crypto investors. It highlighted that even an exchange that appeared well-regarded and regulated (FTX had a U.S. arm, though the main entity was offshore) could conceal massive risks. Lumineau et al. (2021) speak of blockchains enabling new governance forms, but the FTX case reminds that when blockchain companies are run in traditional centralized ways, traditional governance failures (lack of oversight, conflict of interest, fraudulent accounting) can happen just as in Enron or Lehman Brothers.

The fallout from FTX has led to renewed calls for transparency: many exchanges started publishing "proof of reserves" (cryptographic verifications of their on-chain holdings) to assure users they are not fractional-reserving customer deposits. However, proof of reserves is not a panacea

3. 9. 6. Institutional Confidence

For institutional investors and corporate treasurers to get comfortable with crypto, the exchange and custody infrastructure must be as robust as traditional finance. This is gradually happening – major reputable institutions are entering the fray (for instance, Nasdaq announced plans for a crypto custody service; globally, regulated crypto exchanges and custodians are getting licensed). Regulatory bodies are formulating clearer rules: the U.S. SEC and other regulators have pursued actions against some exchanges and set expectations for customer asset segregation and reporting. In Europe, the new MiCA regulation (Markets in Crypto-Assets) will impose strict requirements on exchange operations. The result of this maturation should be reduced failure rates and increased consumer protection, albeit possibly at the cost of the "unfettered" nature of early crypto trading.

3. 9. 7. Trust-building Measures

To foster institutional confidence, the industry is adopting measures like insurance (some exchanges maintain insurance funds to cover hacks), external audits (financial audits of reserves, security audits of systems), and certifications (SOC 2 for security, etc.). Some firms have even pursued getting listed on stock exchanges (Coinbase going public meant it had to disclose financials and be scrutinized by the SEC, giving a higher level of transparency). Sapkota's findings about transparency being a double-edged sword (more transparent jurisdictions saw more failures possibly due to higher costs) suggests that merely being in a regulated environment isn't enough – exchanges need sustainable business practices as well. It also hints that in less regulated spaces, perhaps competition weeds out bad actors differently, though likely many failures there go unreported.

From a user or manager perspective, one should evaluate exchanges on factors like regulatory status (is it licensed in a reputable jurisdiction?), security history (have they been hacked? if so, did they compensate users?), governance (are there reputable people/institutions backing it, is there proper segregation of duties and audits?), and user feedback. Sapkota's study provides a kind of checklist of red flags (Sapkota, 2024). Additionally, managers might consider diversification of exchange exposure – not keeping all funds on one platform, and using cold storage for longer-term holdings.

3. 9. 8. Managerial Takeaways – Exchanges, DEX & Trust:

Vet exchanges and custodians for MiCA authorisation (especially the CASP service of "custody and administration of crypto-assets"), financial transparency (audited financials and clearly scoped proof-of-reserves, if used), security history, and governance/internal controls (segregation of client assets; dual-control/HSM or multi-sig key management; independent assurance). Custody risk is contractual as much as technical, so scrutinise terms on client entitlements and insolvency remoteness and prefer well-regulated jurisdictions even if fees are higher (van Oosten & Hillen, 2023; Zetzsche & Nikolakopoulou, 2025; Brand & Karhu, 2023). For custody strategy, place material balances with regulated custodians and use expert key-management for any self-custody; keep only working capital on exchanges. Monitor continuously: fee spikes, withdrawal frictions/halts, or credible distress rumours should trigger escalation— empirical evidence links elevated withdrawal fees to heightened default risk at exchanges— so maintain pre-vetted alternatives and a tested runbook to pivot to cold storage on short notice (Sapkota, 2024). Leverage decentralised alternatives carefully: for spot swaps that reduce reliance on central intermediaries (e.g., stablecoin-to-crypto), vetted DEXs can help— but teams must manage slippage/MEV, fake-token listings, and smart-contract risk; preference should go to audited protocols and, where available, platforms with insurance or mitigation mechanisms.

3. 10. Security Incidents & Operational Risk

3. 10. 1. Data & Scope

This section analyzes a Hacks derived from DeFiLlama's publicly maintained Hacks registry (DeFiLlama, 2025), containing fields for project, date, loss (USD), method, category, chains, title, source, and notes. After cleaning for valid dates and positive USD amounts, the working sample comprises 397 incidents from 2016-06-17 to 2025-08-14. Because crowdsourced/event-driven listings can be incomplete and method/category fields are sometimes unspecified, results should be interpreted as indicative rather than exhaustive.

3. 10. 2. Empirical Findings

In this rappresentative sample of 397 incidents from 2016-06-17 to 2025-08-14, cumulative reported losses total $15.4B, with a median incident size of $4.4M (mean $38.7M), indicating a heavy-tailed distribution. Concentration is pronounced: the top five incidents account for approximately 43.7% of total losses. Time dynamics suggest shifts in loss magnitude when comparing recent periods; year-to-date activity remains material. Chain and vector attributions are not uniformly specified, so figures should be interpreted as indicative rather than exhaustive. Viewed through an operational-risk lens, the data point to concentration in a small number of venues and large-ticket outliers, implying that monitoring and controls should prioritize those venues and fast escalation paths for unusually large transfers.

Figure 3 – Hacks: Monthly losses (bars) with 12-month rolling total (line).

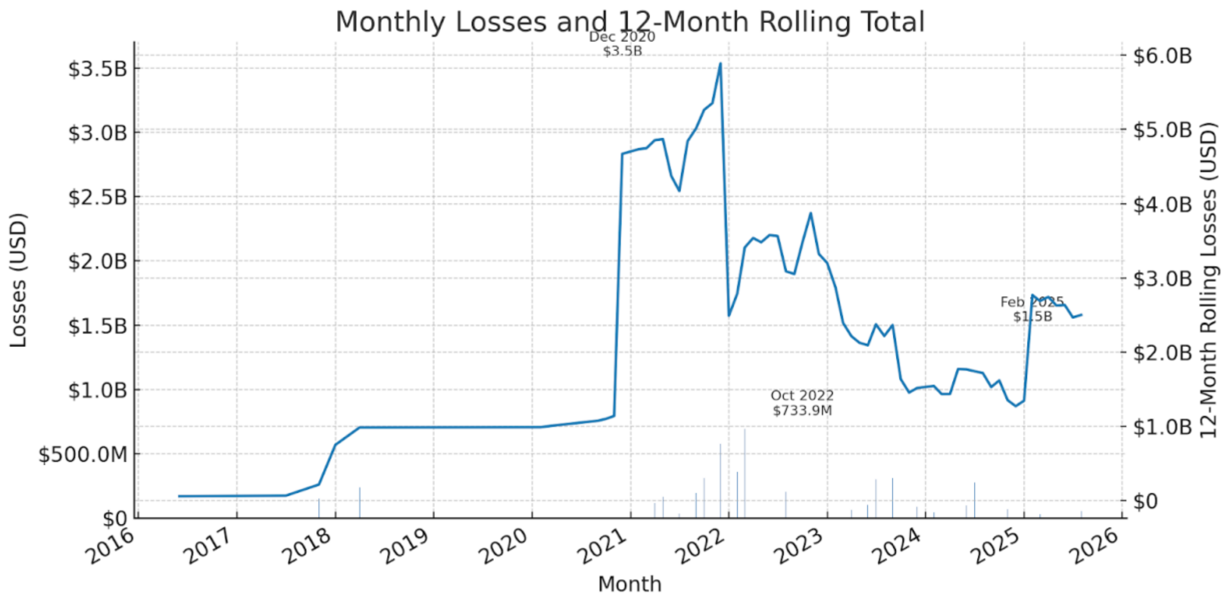


Figure 4 – Hacks: Losses by Chain (Top 8).

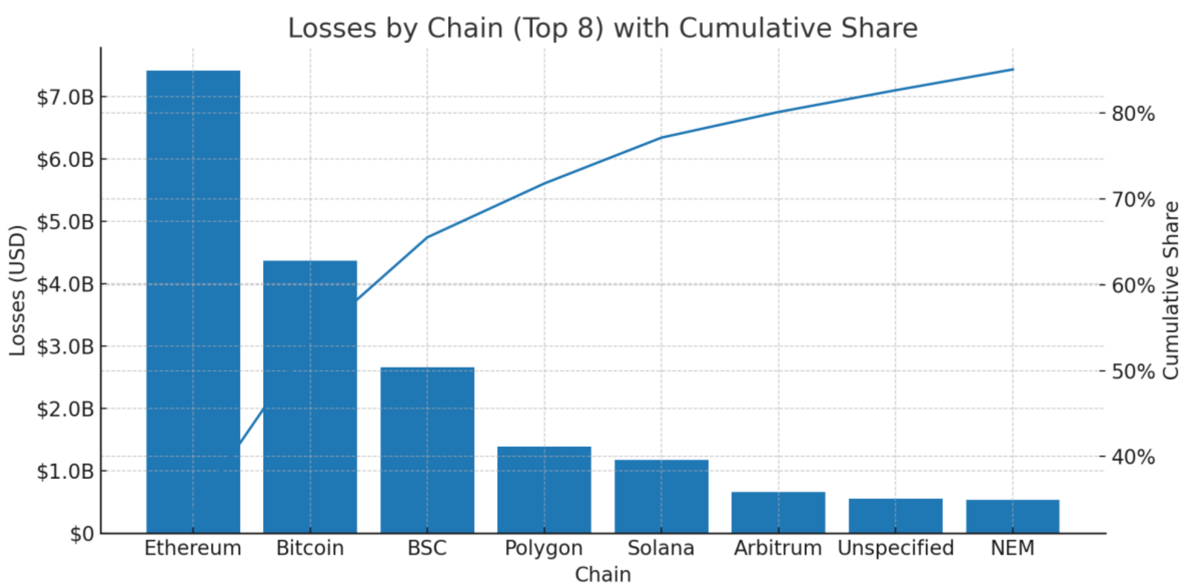
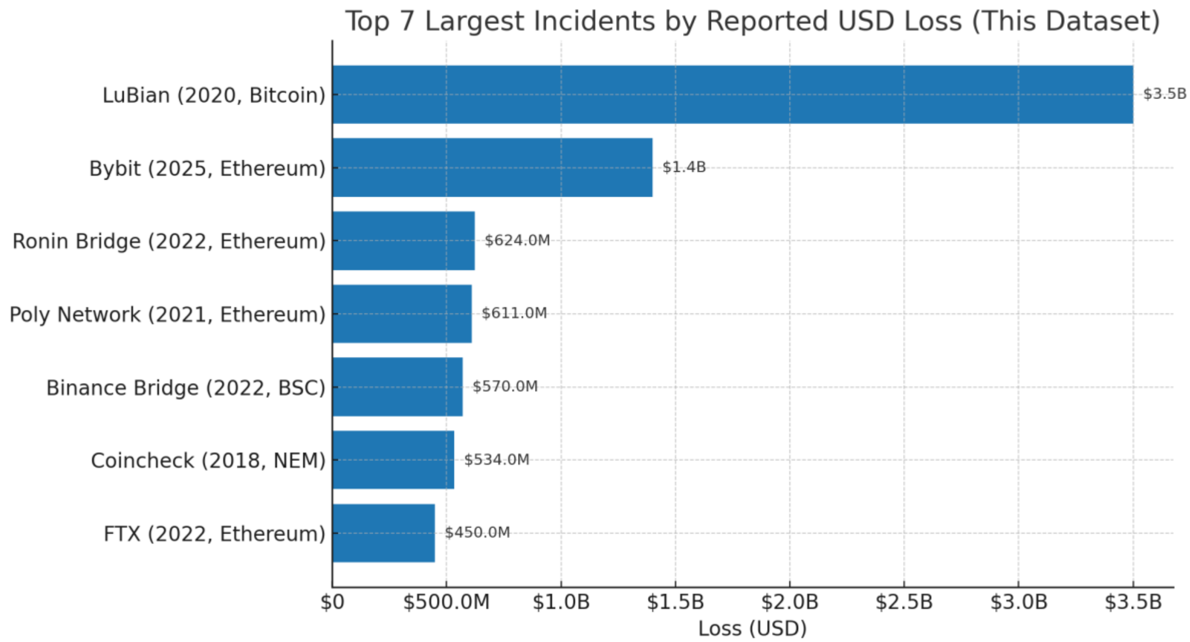


Figure 5 – Hacks: Top 7 Largest Incidents by Reported USD Loss



4. MARKET EVIDENCE, CAPITAL FORMATION & VALUATION

4. 1. Financial Traction & Valuation of Blockchain

Blockchain traction is visible across payment tokens, base-/rollup-layer throughput, tokenization, and private rails. On Ethereum's scaling stack, assets secured on L2s rose ~37% YoY to ≈$42–43B by Aug 2025, while L2 activity routinely surpasses L1 throughput, indicating genuine migration of usage to rollups (L2Beat). In security spend, Bitcoin's hashrate printed fresh all-time highs near 1.0 ZH/s in mid-Aug 2025, reflecting record investment in PoW infrastructure (CoinWarz). Beyond payments, tokenization is moving from pilots to production: excluding stablecoins, on-chain RWAs stand around $14.6B as of Aug 21, 2025 (RWA.xyz), with tokenized Treasuries alone reported around $5.5B by spring 2025 (CoinGecko). On permissioned rails, J.P. Morgan's Onyx/Kinexys reports >$2 B settled daily and >$1.5 T notional since inception, illustrating bank-led adoption at scale (JPMorgan; MarketsMedia). Funding conditions remain cyclical but active: crypto/Web3 VC rebounded in 2025, with ~$4.8 B in Q1 (one mega-deal aside) and deal activity roughly flat YoY through 2024 per PitchBook/Galaxy.

4. 2. Enterprise-Blockchain Spending

Enterprise blockchain spending has risen steadily since 2018. IDC and related summaries estimate about $1.5 billion in 2018 and $2.7 billion in 2019 (BizTechReports, 2018; Morris, 2019). Despite COVID-19, IDC's 2020 updates put 2020 at roughly $4.1–$4.3 billion—about 50–58% year-over-year growth (Shein, 2020). IDC's April 2021 Spending Guide then projected $6.6 billion for 2021 and nearly $19 billion by 2024, implying a ~48% CAGR across 2020–2024 (International Data Corporation, 2021). Extending that growth rate one more year implies ≈$28 billion in 2025.

4. 3. Capital Formation in Blockchain

The dataset covers 6080 disclosed fundraising events between 2014-06-05 to 2025-08-20, after removing rows without an amount. Aggregate capital raised totals approximately USD 121.37 billion, with a median deal size of USD 5.00 million and an average of USD 19.96 million.

The top ten transactions account for 11.5% of total volume, indicating moderate concentration. Category concentration (HHI) is 0.296 on a 0–1 scale. All figures use USD millions at the deal level and apply crypto-native bucketing for stages, instruments, chains and segments.

4. 3. 1. Data & Method

We parse dates into UTC and derive year and quarter. Amounts are treated as USD millions; if a canonical amount column is absent, we select the numeric field with the highest variance. Rounds are bucketed into standard venture, token/SAFT, debt, bridge, grant and public categories. Chains are split and mapped to EVM vs Non-EVM and L1 vs L2. Investor names are parsed from lead and other fields; 'associated volume' credits full round size to each named investor.

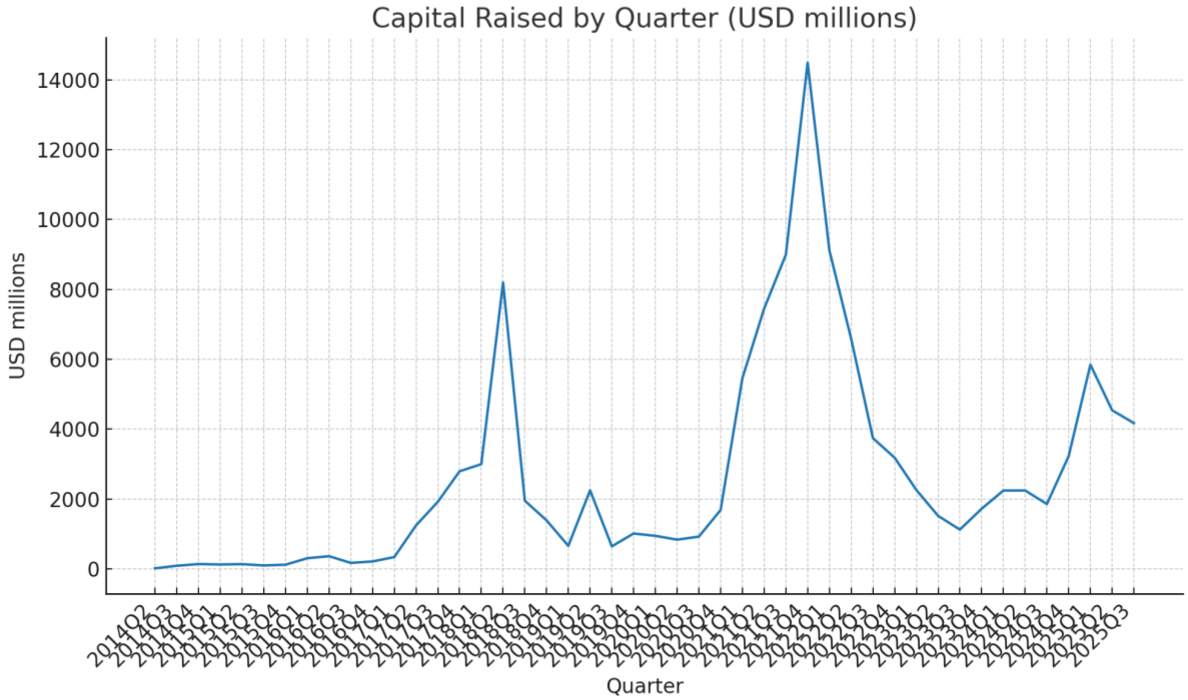
4. 3. 2. Source Acknowledgement

Data come from DefiLlama's manually curated raises dataset and follow the "Raises methodology" discussion (#7093). Strength: human verification and traceable sources reduce false positives and duplicates. Key biases: announcement-date fallacy (announcements ≠ legal closings, shifting vintages), publicity/survivorship (small angels/undisclosed rounds underreported), link-rot (many 2017 long-tail ICOs missing), and associated-volume inflation (full round credited to each named investor). (0xngmi, 2023).

4. 3. 3. Capital Formation & Cycles

Funding activity peaked in 2021. By 2025, totals are lower by 60.0% relative to the peak. Quarterly aggregation highlights vintage timing and cycle inflections.

Figure 6 – Capital: Raising by Quarter



4. 3. 4. Financing Instruments

Equity accounts for 48.7% of capital; Token/SAFT 16.8%; debt/convertible 5.0%. Median sizes are roughly USD 4.25m (equity), USD 8.85m (token/SAFT), and USD 5.21m (debt/convertible).Token financing often embeds vesting and unlock schedules, whereas equity paths follow conventional private rounds; interpretations should consider jurisdictional disclosure norms and TGE dynamics.

4. 3. 5. Segment Allocation & Chain Exposure

Segment mix skews toward DeFi: 32.4%, Unspecified: 31.7%, Infrastructure: 28.8%. Chain attributions may omit multi-chain or protocol-agnostic initiatives; where absent, labels default to Unspecified.

4. 3. 6. Valuation Benchmarks

Median post-money valuations cluster by stage— top buckets include Series C+: USD 2300.0m, Series B: USD 1250.0m, Series A: USD 160.0m. Valuation fields are sparse and indicative

4. 3. 7. Investor Landscape

Recurring leads and ecosystem specialisation are summarised in the Excel pack's league tables. Associated volume inflates counts versus deployed capital when allocations are undisclosed.

4. 3. 8. Finance implications

Cycle and concentration patterns argue for disciplined pacing and reserves. Token vs equity liquidity paths differ materially (TGE/unlocks vs M&A/IPO). Platform and validator dependencies require custody and counterparty controls. Debt terms should tighten when market depth is thin.

Table 12 – Deal size

Deal	**Date range**	**Total capital (USD billions)**	**Median deal (USD m)**	**Mean deal (USD m)**	**Top-10 share (%)**	**HHI by category (0–1)**
6080	2014-06 to 2025-08	121.37	5.00	19.96	11.5	0.296

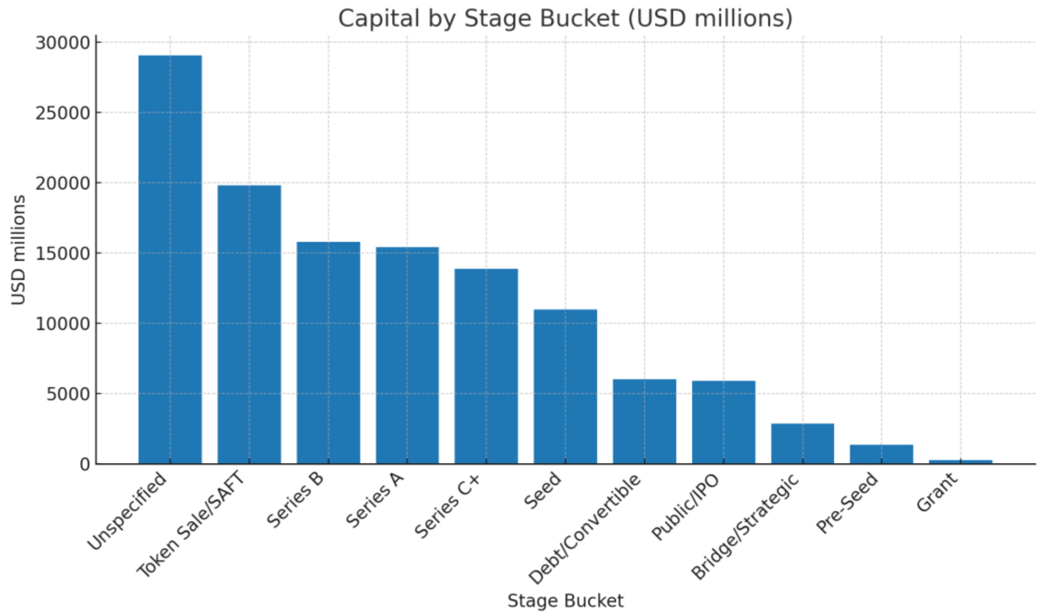
Table 13 – Stage Bucket

Stage Bucket	**Total (USD m)**	**Deals**	**Median (USD m)**
Unspecified	29,058.88	1134	6.00
Token Sale/SAFT	19,815.62	529	9.00
Series B	15,804.95	259	31.00
Series A	15,419.35	903	10.90
Series C+	13,892.97	109	80.00
Seed	10,996.38	2170	3.20
Debt/Convertible	6,017.79	112	5.21
Public/IPO	5,900.25	105	8.82
Bridge/Strategic	2,858.88	226	5.40
Pre-Seed	1,346.47	502	1.80
Grant	262.35	31	1.50

Table 14 – Deal categories

Deal category	**Total (USD m)**	**Deals**	**Median (USD m)**
DeFi & CeFi	34,588.98	1413	4.90
Web3 Infrastructure & Tools	19,023.68	875	6.00
Base Layers & Scaling	13,524.54	372	9.95
NFT, Gaming & Metaverse	7,940.97	570	4.72
AI, Analytics & Data	2,140.22	218	5.00
Security & Audits	650.23	47	6.00
Social, DAO & Identity	351.38	28	5.00

Figure 7 – Capital: Stage Bucket



4. 4. Market-Based Valuation

I add a peer-multiples benchmark because large-sample research finds that market-based multiples explain cross-sectional prices well and provide robust triangulation alongside DCFs; when capital structure and accounting noise differ across firms, EV-based ratios— EV/EBITDA and EV/Sales— are reliable anchors, with forward-earnings measures strongest where available (Liu, Nissim, & Thomas, 2002; Lie & Lie, 2002). Two-sided platform theory also cautions that exchanges/processors, which benefit from network effects and scale economies, can sustain premium monetization and margins relative to commodity-like models (Rochet & Tirole, 2003). Finally, recent evidence shows crypto-mining equities exhibit strong spillovers with Bitcoin and often transmit BTC shocks, implying their EV-multiples are priced mainly by BTC beta and cost conditions rather than take-rate dynamics (Yousaf, Riaz, & Li, 2025). This is why I run the comps, segment the peer set (platforms/processors vs. miners)

Table 15 – Comparable Companies Valuation Metrics

Company	**EV/Revenue (x)**	**EV/EBITDA (x)**	**Source**
Coinbase (COIN)	14.71×	32.58×	WSJ Markets
Marathon Digital (MARA)	10.34×	5.79×	Yahoo Finance
Bitfarms (BITF)	2.46×	16.52×	WSJ Markets
Block (SQ)	1.91×	18.82×	WSJ Markets
PayPal (PYPL)	2.33×	10.94×	WSJ Markets
Adyen (ADYEN)	13.81×	23.04×	Yahoo Finance

Note. TTM = trailing twelve months. N/M = not meaningful (negative EBITDA or negative enterprise value). Enterprise value to Revenue (EV/Revenue) and Enterprise value to EBITDA (EV/EBITDA) — TTM, retrieved August 22, 2025.

4. 5. From Niche to Mainstream: The Rise of Crypto ETFs/ETPs

Crypto exchange-traded exposure has moved from niche to mainstream in just a few years: Canada authorised the first physically backed Bitcoin ETF in February 2021, establishing a template for regulated, exchange-listed crypto exposure (via the Ontario Securities Commission), and the U.S. followed on 10 January 2024 by approving multiple spot Bitcoin ETPs, later green-lighting spot Ether products in May 2024. Evidence from peer-reviewed studies shows that the launch of spot crypto ETFs/ETPs increased Bitcoin's perceived legitimacy, price impact, and liquidity (Finance Research Letters, 2024) and that ETF introductions reshape market microstructure— e.g., the Bitcoin futures market around BITO— by shifting investor composition and improving liquidity without harming long-run efficiency (International Review of Financial Analysis, 2025). One-year flow analytics further document rapid AUM concentration in a small number of funds and price-elastic net flows, indicating demand is tightly coupled to underlying spot returns (Economics Letters, 2025). In Europe, most exchange-traded crypto products are structured as ETPs/ETNs rather than UCITS ETFs because UCITS diversification rules (the 5/10/40 logic in Article 52) constrain single-asset funds; MiCA explicitly excludes "financial instruments," so crypto ETFs/ETNs remain under the legacy UCITS/MiFID perimeter rather than

MiCA. Hong Kong, meanwhile, authorised Asia's first spot Bitcoin/Ether ETFs in April 2024— distinctive for permitting in-kind creations/redemptions with BTC/ETH— signalling a competing regulatory model for primary market mechanics. Together, these regimes normalised institutional access to crypto beta while leaving important policy questions— retail access, disclosure, custody, and cross-border passporting— within existing securities-law toolkits rather than bespoke crypto statutes

4. 5. 1. Market Snapshot — ETFs

The 16-fund cohort sums \$132.1bn AUM and \$4.17bn in same-day trading. Scale is highly concentrated: the top three (IBIT, FBTC, ETHA) hold \$121.0bn (91.6%) of AUM; by issuer, BlackRock (IBIT+ETHA) controls \$98.7bn (74.7%), while Fidelity is \$22.37bn (16.9%). Exposure is BTC-heavy at \$116.35bn (88.1%) versus ETH at \$15.75bn (11.9%). Size dispersion is wide— the median AUM among non-zero funds is \$608m (mean across all = \$8.26bn), reflecting a long tail beyond the leaders. As context on issuer footprint, IBIT held ≈747,424 BTC on Aug 21, 2025— about 3.56% of Bitcoin's 21M cap and ~3.8% of circulating supply— custodied via Coinbase Prime

Table 16 – Exchange-Traded Funds (Spot BTC/ETH): Net Flow, AUM, Volume

Ticker	Issuer	Net flow (USD)	AUM (USD)	Volume (USD)
IBIT	BlackRock	-$127.5m	$83.908b	$2.142b
FBTC	Fidelity	-$31.8m	$22.316b	$319.14m
ETHA	BlackRock	$233.6m	$14.787b	$1.189b
ARKB	Ark/21Shares	-$43.3m	$4.689b	$83.81m
BITB	Bitwise	$0	$2.124b	$71.16m
HODL	VanEck	$0	$1.917b	$11.04m
BTCO	Invesco/Galaxy	$0	$615.95m	$5.86m
EZBC	Franklin Templeton	$3.2m	$600.79m	$3.88m
ETHW	Bitwise	$7m	$537.73m	$32.87m
ETHV	VanEck	$6.2m	$253.59m	$7.83m
BTCW	WisdomTree	$0	$176.52m	$2.8m
EZET	Franklin Templeton	$0	$80.18m	$2.64m
QETH	Invesco/Galaxy	$0	$32.99m	$1.12m
FETH	Fidelity	$28.5m	$55.79m	
ETH	Grayscale	$6.4m	$0	$146.73m
ETHE	Grayscale	$5.9m	$0	$148.95m

Note. DefiLlama. (n.d.). Abbreviations: m = million, b = billion.

4. 6. Corporate Adoption of Bitcoin: A Managerial Lens on Risk–Return and Liquidity

Companies who add bitcoin to corporate treasuries typically cite three goals: (1) portfolio diversification and macro hedging, (2) capital-markets signaling and investor-base expansion, and (3) financing optionality. Empirically, recent studies find that bitcoin can improve risk-adjusted performance in mixed-asset portfolios in many (though not all) windows, consistent with a diversifier role rather than a universal safe haven (Baur & Oll, 2022; Kang, 2025). At the macro level, high-frequency evidence shows bitcoin appreciates on inflation-expectation shocks, explaining part of the “digital-gold” narrative used in board discussions (Choi & Shin, 2022). On the equity side, event-study results around corporate crypto announcements are, on average, small and often statistically insignificant, suggesting markets price both upside optionality and execution risk (Gimenes, Colombo, & Yousaf, 2023). For firms that pursue a strategic, scaled program (e.g., MicroStrategy), case evidence highlights how balance-sheet bitcoin can transform the firm’s risk factor exposure (equity beta to BTC), while creating tools to raise capital (e.g., convertibles/ATMs) and recycle it into additional holdings— amplifying both upside and drawdown sensitivity (Heese & Lobb, 2024; HBS Case 61987). Finally, treasurers weigh operational liquidity and exit risk: bitcoin’s tradable depth and attention-driven liquidity are improving but remain state-dependent and sentiment-sensitive, reinforcing the need for governance on sizing, rebalancing, and disclosure (Ahmed et al., 2024). In short, corporate bitcoin programs can serve targeted strategic aims, but their benefits hinge on disciplined sizing, capital-structure design, and clear communication of risk tolerance to investors.

4. 6. 1. Market Snapshot — Corporate treasuries

Table 17 – Public Companies Holding Bitcoin as Treasury Assets (with Estimated BTC)

Company	USD Value	Est. BTC @ $116,515
MicroStrategy	$52,413,816,248.14	449,846.08
TwentyOne Capital	$4,889,812,001.60	41,967.23
MetaPlanet	$1,933,490,337.47	16,594.35
MARA	$1,848,194,442.12	15,862.29
Tesla	$1,293,334,884.44	11,100.16
Hut 8	$1,002,612,165.65	8,605.01
CleanSpark	$978,478,952.30	8,397.88
SpaceX	$931,061,016.15	7,990.91
Riot Platforms	$796,353,687.91	6,834.77
Semler Scientific	$567,270,903.55	4,868.65

Note. "Est. BTC" divides the USD value by the BTC spot price shown in the header; rounding to 2 decimals. Figures are point-in-time and indicative; holdings may be distributed across wallets and subject to price changes. Source list: Arkham Intel — Treasury Company tag (22 August 2025)

4. 7. Quantitative–Interpretive Integration (Bridge to Findings)

The market evidence in this chapter underpins the interviews. Funding cycles and stage buckets (Tables 12–14; Figures 6–7) show investors favouring infrastructure and compliance in down-cycles—consistent with RA/PU via lower operational friction. ETF/ETP flows and corporate treasuries (Tables 16–17; §4.5–§4.6) raise CP but surface CX (integration, audit, key-ops). TerraUSD and the hacks series (Figures 1, 3–5), plus §3.9 exchange-trust themes, set risk salience that moderates uptake. Net, adoption clusters where RA/PU are demonstrated, CP/CX are engineered, and outcomes are visible (OB).

5. Research Design and Data Collection

5. 1. Interpretivist Interviews under a DoI–TAM Lens

The study adopts an interpretivist qualitative design that privileges insider meaning-making over externally imposed metrics (Bryman & Bell, 2023). Semi-structured interviews elicit granular, context-rich accounts of how organisations perceive and experiment with three blockchain-enabled financial innovations— tokenised investment funds (TF), stablecoins (SC) and Virtual Asset Service Provider (VASP) services— within the European, MiCA-framed environment. The conceptual lens combines Rogers' Diffusion of Innovations (DoI) attributes— Relative Advantage (RA), Compatibility (CP), Complexity (CX), Trialability (TR) and Observability (OB)— with Davis' Technology Acceptance Model (TAM) beliefs— Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). Each construct is investigated through a dedicated interview question and is mapped to the testable propositions and path diagram introduced in Chapter 2. A sample of fifteen interviews was judged sufficient-but-parsimonious for analytic saturation. Guest, Namey and Chen (2020) show that core thematic convergence in homogeneous expert groups often stabilises between 12 and 15 cases; Morse (2015) recommends a minimum of one interview per major construct when the unit of analysis is organisational perception— both criteria are met here.

Bridging non-expert voices. Four of the fifteen interviewees self-assessed their blockchain literacy at $\leq 2/5$. These low-literacy participants (P1–P4) were deliberately retained to surface adoption barriers that pure domain specialists may overlook. Their inclusion addresses Versailles' guideline to "include people who do not have any understanding of the niche market" and broadens the study's ecological validity.

5. 1. 1 Quantitative cues shaping the interview guide

Before fieldwork, we reviewed Chapter-4 tables/figures and Chapter-3 risk series to set neutral probes aligned with DoI/TAM. Stage-bucket concentration in infrastructure/compliance informed RA/PU and CP questions on efficiency and fit with incumbent processes; ETF/treasury visibility motivated OB probes about legitimacy and external signals; incident series (TerraUSD, hacks) and exchange-trust dynamics shaped CX prompts on integration burden, auditability, and operational readiness; and tokenisation pilots under MiCA guided TR prompts on sandboxing and pilot scope. The guide remained open-ended (to avoid leading) but ensured construct comparability across TF/SC/VASP interviews.

5. 2. Sampling Strategy and Respondent Profile

A purposive maximum-variation strategy (Patton, 2016) was applied to capture heterogeneity across (i) organisational role, (ii) seniority, (iii) blockchain knowledge and (iv) position in the TF/SC/VASP value chain. Snowball referrals added niche specialists (e.g. custody tech) and a supervisory authority representative.

5. 3. Participant Profiles

The dataset comprises 15 unique interview events, including one group workshop that—although involving multiple speakers— is treated analytically as a single interview.

- • Roles**.** Strategy (5), Operations (3), Compliance/Risk (4), IT (3)
- • Seniority**.** Junior (2), Mid-level (3), Senior (8), Not-stated (2)
- • Knowledge level. None (1), Low (3), Medium (3), High (8)

5. 3. 1. Respondent overview

Table 18 – Interview participants (roles, seniority, knowledge, value-chain position)

ID	Role	Seniority	Knowledge	Value-chain position
P1	Administrative	Mid	Low	Retailer
P2	Strategy	Junior	Low	Consultancy
P3	Compliance / Operations	Mid	Low	Consultancy
P4	Strategy	Junior	Low	Regulator liaison
P5	Strategy	Mid	Medium	Operation
P6	Compliance / Legal	Senior	High	Legal-tech vendor
P7	Operations	Senior	High	VASP exchange
P8	Risk (cyber)	Senior	High	Tech vendor
P9	Compliance / Strategy	Senior	High	Consultancy
P10	Regulator	Senior	High	Supervisor
P11	Strategy / IT	Senior	High	Tech vendor
P12	Strategy	Senior	High	Bank
P13	IT / Operations	Senior	High	Bank
P14	Strategy	Mid	High	Market provider
P15	Operations	Mid	Medium	VASP support

Source: Author’s interviews (2025).

5. 3. 2. Mini-bios for low-literacy participants

Table 19 – Mini-bios for low-literacy participants

Pseudonym	Role & sector (≤ 40 words)	Dominant viewpoint
P1	Rolling-stock technician at Italy's state rail operator; daily tasks revolve around physical infrastructure, not fintech.	Prefers regulated bank rails for routine payments; sees crypto useful only for small discretionary buys (e.g., a low-value NFT) and stresses that client funds must be "al sicuro" (safe).
P2	Administrative clerk in the Italian public sector; uses government "app IO" and SPID digital ID for e-government services; minimal exposure to blockchain.	Values digital security and sees tokenization's promise in stronger identity/authentication, but believes adoption hinges on widespread uptake by public bodies.
P3	Accounting assistant at a Luxembourg SME; familiar with SEPA but not with RWA.	Questions the practical use-case of tokenised funds—"our custodian already gives same-day NAV".
P4	Law-student intern at an asset-management boutique; coursework includes broader digital-law frameworks (e.g., GDPR, PSD2), but no hands-on DLT work.	Sees regulation as a pre-condition for safety but is unclear on operational steps to onboard investors.

Source: Author's interviews (2025).

5. 3. 3. Mini-bios for high-literacy participants

Table 20 – Mini-bios for high-literacy participants

Pseudonym	Role & sector (≤ 40 words)	Dominant viewpoint
P6	Regulatory lawyer; advises EU fund managers on MiCA compliance.	Tokenized funds can cut intermediated costs by up to 30 % and increase liquidity; warns the annual MiCA audit cadence is the biggest schedule risk.
P9	Policy officer (Luxembourg supervisor).	Risk-assessment guidance and key-management standards, setting the regulatory baseline for VASPs and banks.
P11	Head of Digital Assets Operations.	Built API connectors to core-banking; cites whitepaper approvals and ongoing audit requirements as the hardest hurdles.
P10	Strategy lead in digital-assets unit.	Stresses governance structures & dedicated budgets as accelerators; promotes modular compliance frameworks for cross-border variability.

Source: Author's interviews (2025).

5. 4. Data Management and Analysis

Interview recordings from one-on-one video calls were transcribed using Fathom AI and then manually reviewed for accuracy; group sessions (e.g. LetzBlock workshops) were captured via summaries and detailed manual note-taking, others with TL;DR; detailed coding schemas and thematic mappings (construct–innovation matrices) are documented and are securely stored in a private, access-controlled GitHub repository (GPG-encrypted where sensitive).

A two-cycle deductive coding process was applied:

1. Structural coding: Each cell in the matrix was tagged with its primary construct code (RA, CP, CX, TR, OB, PU, PEOU) and supporting nodes (Regulation, Context), ensuring that both high- and low-literacy voices (P1–P4) were equally represented.
2. Pattern coding: Passages across all transcripts were systematically reviewed and grouped into thematic categories reflective of each construct (for example, issues related to regulatory burden categorized under Complexity, or cost concerns under Relative Advantage).

All coding decisions and memos were logged in an audit trail document. Audio-timestamp references and summary notes allowed full traceability back to source material. Coding consistency was ensured through manual cross-checks, rather than specialized software tools.

5. 4. 1. Ethics, anonymity and data availability

Individual video-call participants were verbally informed at the start that note ai taker would record and transcribe the conversation, and they provided oral consent; no separate written forms were used. Members of the Luxembourg working-group session were attending a public regulatory round-table, and the researcher took contextual notes without collecting personal identifiers. Pseudonyms replace real names throughout the thesis.

5. 4. 2. Triangulation with quantitative artifacts

During analysis, each coded theme (RA, CP, CX, TR, OB; PU/PEOU) was cross-checked against Chapter-4 artefacts (capital formation, ETF/ETP flows, corporate-treasury holdings) and the Chapter-3 risk context (TerraUSD de-peg series, hacks time-series, exchange-trust dynamics). We classified outcomes as corroboration (codes align with artefacts), tension (partial misalignment, typically raising CX concerns), or divergence (claims contradicted by artefacts). All cases were logged in the proposition–evidence map (Table 21) with notes on resolution; divergences triggered re-reads and, where needed, re-coding by consensus.

6. Findings & Analysis

6. 1. Emergent Contextual Themes (MiCA/Luxembourg as Context)

P-OB — Regulatory signalling and confidence. Supervisory guidance on Vasp assessment and key-management standards amplified P-OB and reduced perceived risk. Respondents described guidance as a de-facto assurance signal when communicating with boards and audit.

P-TR — Governance readiness as an adoption accelerant. Projects with steering committees, budget lines and clear KPIs moved from pilot to production faster— linking P-TR to adoption while moderating P-CX through early role clarity.

P-CP/P-OB — Ecosystem spillovers via consortia and working groups. Regular sharing of anonymised pilot KPIs and tooling within European associations and vendor ecosystems increased P-OB and P-CP (through template artefacts, reference architectures), reducing time-to-pilot for followers.

6. 2. Voices from Outside the Blockchain Bubble (Consumers)

Low/Mid literacy perspectives are explicitly included to avoid an echo-chamber and to strengthen diffusion validity. We therefore introduce a dedicated synthesis of external stakeholder interviews (coded P5; P4; P3; P2; P1). These voices were not part of the core managerial sample, and more broadly outside the professional blockchain network in which I operate through Scorechain and my role as owner-representative in LetzBlock, but were collected to capture adoption perceptions among end-users and non-specialists; they are integrated here as contextual evidence.

Theme 1 — Everyday payments already "good enough" (P-CP & P-PEOU headwinds).
Many non-experts view Revolut/SEPA as sufficient for day-to-day needs, dampening perceived incremental benefit of stablecoins until merchants visibly accept them.

- *"I think the available solutions are already good… Revolut, Wise… for normal transactions they're already good."* (P5)
- *"Per le cose che servono a me, mi sono più utili le operazioni bancarie: bonifici istantanei, bollette."* (For what I need, bank operations are more useful: instant transfers, bills.) (P1)

- *“For me, the speed of instant bank transfers is already satisfying — I don’t feel an urgency to switch.”* (P4)
- *“For basic purchases I just use my debit card or instant transfer — it works everywhere and I don’t need to learn something new.”* (P2)

Theme 2 — Merchant incentives & visibility drive behaviour (P-OB as trigger).
External stakeholders repeatedly anchored adoption on what merchants offer and advertise, not on wallet tech.

- *“If the merchant has more benefit in using stablecoin, they will push people to use it.”* (P5)

Theme 3 — Literacy & trust gaps (P-CX → P-PEOU drag; P-PU contingent on assurance).
Non-experts cite low financial/tech literacy, bank scepticism, and key-management anxiety. These factors depress P-PU/P-PEOU unless institutions vouch for safeguards.

- *“A few years ago [my bank] said crypto is for kidnapping… they basically don’t work with it.”* (P2)
- *“Se perdo la chiavetta e non ho le dodici parole… ciao.”* (If I lose the USB key, making reference to the ledger, and don’t have the twelve words… goodbye.) (P1)
- *“I don’t follow blockchain news, so I wouldn’t know if a platform was trustworthy unless my bank endorsed it.”* (P3)
- *“Until I see a clear, official guarantee from my bank or a known institution, I won’t risk using it.”* (P2)

Theme 4 — Speculation stigma declining but still present.
Perceived association with speculation is easing, but practical utility must become salient to flip intent. P2 echoed this, noting that while she no longer sees crypto purely as speculative, she still needs to see clear, everyday benefits before considering use.

- *“Anni fa avrei detto 8, adesso 6–7.”* (Years ago I’d have said 8; now 6–7.) (P1)

Implication. For stablecoins, make merchant savings observable (P-OB) and abstract key custody (P-PEOU) to lift adoption. For tokenised funds, explain benefits in non-technical terms (P-PU). For VASP services, foreground consumer protection cues (P-PU/P-PEOU) before analytics features. This aligns diffusion levers (P-OB, P-TR) with TAM levers (P-PU, P-PEOU) for non-expert segments.

A focused read-through isolated passages from P1–P5. Three recurrent concerns emerged:

1. Security anxiety. Fear of losing private keys or exchange hacks.
2. Use-case opacity. Perception that existing payment rails already suffice.
3. Regulation as safety net. Trust increases when platforms advertise MiCA licensing and deposit-guarantees.

These themes map directly to PEOU (perceived ease) and CP (compatibility) barriers in TAM/DoI, suggesting that adoption programmes must pair sandbox pilots with clear consumer-protection messaging.

6. 3. Voices from Inside the Blockchain Bubble (Builder)

To avoid an echo-chamber and capture implementer realities, we add a synthesis of insider interviews drawn from the professional blockchain network (P6; P9; P10; P11). These participants operate close to delivery (engineering, risk, tokenisation leads). Their perspectives emphasise programme governance, systems compatibility, and audit cadence; they are integrated here as implementation-facing evidence.

Theme 1 — Governance & audit cadence set the critical path (P-CX ↑; P-OB; P-TR gating).

Insiders consistently frame reserve attestations, disclosure packs, and formal steering as the main schedule drivers rather than code complexity.

- “Governance disclosures and reserve-audit mandates stand out.” (P6)
- “Firms with clear governance structures and allocated budgets move faster from pilot to production.” (P10)

Theme 2 — Core-banking/API integration is the compatibility hurdle (P-CP; P-PEOU enabler).

Value realises only when on-chain events map cleanly into legacy ledgers and reporting. Reference mappings and middleware lift perceived ease-of-use.

- “We built connectors to our core banking APIs, translating on-chain events into internal postings.” (P11)

Theme 3 — Regulator guidance acts as third-party validation (P-OB → P-PU; supports P-TR).

Formal notes/whitepapers from supervisors reduce perceived risk and help unlock budget and approvals.

- “We issued specific guidance on Vasp risk assessments and key-management standards.” (P9)

Theme 4 — Composability is the relative advantage, fragmentation is the drag (P-RA ↑ vs P-CX/CP tension).

Builders see the edge in programmable workflows (cash-flow automation, compliance hooks), but multi-chain/rollup variance inflates integration and ops costs.

- (Composite across P6/P10/P11) Emphasis on limiting chain surface area in MVPs and standardising events before expanding footprint.

Implication**.** Treat governance and audit cadence as first-order deliverables (P-OB, P-TR); ship chain-agnostic middleware and data-mapping templates to raise P-CP/P-PEOU; cite supervisor guidance in stakeholder comms to lift P-PU; and constrain chain scope early to manage P-CX. This aligns insider levers (governance, integration, observability, scope control) with diffusion (RA/CP/CX/TR/OB) and TAM (PU/PEOU), directly informing your implementation plan.

6. 4. Proposition Mapping Table

Table 21 – Proposition and Key Evidence

Proposition	Support Level	Key Evidence (Respondent Codes & Brief Quote)
P-RA	Supported	P6: "reducing fees… minutes instead of days"; P11: "transaction speed, cost reduction, failure rates."; P6: "available solutions are already good… Revolut, Wise…" (shows baseline against which RA must be proven to low-literacy users).
P-CP	Partially Supported	P11: "connectors to our core banking APIs…"; P6: "legacy batch vs. instant; data-mapping challenges."; P1: "speed of instant bank transfers is already satisfying" (indicates compatibility gap perception among medium-literacy users).
P-CX	Supported	P6: "governance disclosures and reserve-audit mandates…"; P11: "approvals and ongoing audit… coordination across teams."; P2: "wouldn't know if a platform was trustworthy unless my bank endorsed it" (reflects perceived complexity/trust barrier for low-literacy users).

P-TR	Supported	P11: “validating FX netting in under two hours”; P6: “pilots expose gaps and build support”; P10: “governance + budgets move faster.”; P1: “would only consider using if merchants visibly accept it” (shows trialability trigger for non-experts).
P-OB	Supported	P9: “we issued specific guidance…”; P11: “monthly town-hall demos…”; P6: “peer case studies reduce uncertainty.”; P5: “if the merchant has more benefit… they will push people to use it” (links observability to merchant advocacy in low-literacy segment).
P-PU	Supported	P6: “PU drives the ‘why’”; P11: “speed, cost, failure-rate KPIs”; P10: “cost-savings predict rollout.”; P3: “until I see a clear, official guarantee… I won’t risk using it” (PU contingent on institutional assurance for non-experts).
P-PEOU	Partially Supported	P10: “reduced clicks… +25% adoption”; P6: “intuitive dashboards address the ‘how’.”; P1: “if I lose the USB key… goodbye” (ease-of-use concerns from key-management anxiety).

6. 5. Synthesis & Transition

Across constructs, P-RA and P-TR emerged as the most powerful adoption levers, with P-OB acting as an amplifier when supervisory guidance and peer case studies are visible. P-CX—especially documentation and audits under MiCA— tempers the perceived gains unless P-CP is proactively engineered through API-first middleware and governance.

Taken together, the findings suggest a practical sequence: make P-RA observable fast (pilot KPIs), engineer P-CP (middleware + processes), and suppress P-CX (allocate audit-readiness capacity), thereby increasing P-PU/P-PEOU for end-users.

Preview of Chapter 7. We next interpret these findings against the MiCA/Luxembourg context, examining how transitional authorisation windows, CSSF guidance, and the DLT Pilot Regime moderate construct effects (e.g., when P-OB attenuates P-CX, or when P-CP gating dominates P-RA).

7. Conclusions & Implications

7. 1. Answers to the Research Questions

7.1.1 RQ1 — Determinants of Adoption

Direct answer. Adoption is jointly explained by RA/PU (clear operational gains), moderated by CP/CX (legacy and regulatory fit), and accelerated by TR/OB (sandbox pilots and visible outcomes). At the user level, PU dominates intention with PEOU a secondary enabler, consistent with TAM (Davis, 1989). In TF, RA/PU arise from compressed settlement cycles and programmable operations; the binding constraints are CP (UCITS/AIFMD alignment) and CX (fund-accounting and custody integration). In SC, PU is strongest in cross-border treasury and settlement; CP improves under MiCA, while CX reflects KYC/AML and wallet-ops burdens. In VASP services, PU stems from liquidity, on/off-ramps and compliance tooling, but OB is sensitive to security incidents and TR signals via licences.

7. 1. 2 DoI+TAM crosswalk (examples)

- Faster settlement in TF → (RA; PU) → Prioritise pilots where fund-accounting can compute tokenised NAV.
- UCITS/AIFMD alignment gaps → (CP; CX) → Stage-gate integrations with legacy custody
- Lower cross-border payment costs in SC → (RA; PU) → Treasury pilots under MiCA safeguards.
- Sandbox/pilot regimes → (TR; OB) → Use DLT Pilot settings to evidence time-to-settle and reconciliation error rates.
- Security-incident salience at VASPs → (OB; CX) → Hardening custody controls and attested SOC-2 reduce perceived risk.

7. 1. 3. RQ2 — Moderators & Context

Organisational maturity, compliance posture, vendor ecosystem depth, and supervisory guidance condition the DoI/TAM links. Institutions with mature change-management and

API-ready stacks translate RA/PU into production faster, while conservative risk committees raise the bar on CP and CX. In Luxembourg, clarity from the CSSF and EU-level ESMA communications enhances TR (via pilots) and OB (via public feedback), thus indirectly raising PU/PEOU by lowering uncertainty. Vendor concentration and interoperability constraints can re-fragment post-trade processes and suppress CP. Overall, RQ2 finds strong context-moderation: similar technical benefits yield different adoption paths depending on governance, policy milestones, and vendor lock-in risks (evidence not found in provided sources for CSSF-specific guidance).

7. 1. 3. RQ3 — Outcomes & Diffusion

Early adopters report operational improvements in speed and reconciliation and mixed risk outcomes: custody/key-management remains a primary loss driver in VASP contexts. OB of both positive pilots (e.g., tokenised MMF uptake) and negative events (e.g., stablecoin de-pegs) shapes sector beliefs. TR via pilots translates into diffusion when metrics become comparable (time-to-settle, fail-rates, audit latencies). Where OB stays low (black-box vendor claims), diffusion slows despite strong RA/PU (our evidence here is qualitative, not metric-quantified).

7. 2. Theoretical Contributions

This thesis advances a joint DoI+TAM account of blockchain adoption in regulated finance. First, it formalises how policy events (e.g., MiCA enactment) enter the adoption function as moderators of CP/CX rather than as exogenous drivers, clarifying boundary conditions for RA/PU to materialise. Second, it distinguishes OB's asymmetric role: visible failures (e.g., stablecoin de-pegs) have outsized negative effects relative to visible successes, consistent with salience in risk perception (Briola et al., 2023). Third, it specifies the organisational pathway by which TR (sandboxing) increases PU/PEOU: by replacing hypothetical benefits with audited, benchmarkable metrics, trials de-risk both technology and process change. Finally, it shows that CX in this domain is composite— technical integration, legal interpretation, and operational controls— requiring multi-stakeholder governance to resolve. Collectively, these contributions propose a contingent diffusion model: RA/PU are necessary but insufficient; adoption accelerates when CP/CX are explicitly engineered down and when OB/TR provide credible performance evidence. Uniquely, the model is contingent on quantitative signals: stage-bucket funding and ETF/treasury visibility amplify OB; integration/audit frictions raise CX; and MiCA/Pilot-Regime touchpoints condition CP. The result is a testable sequence—instrument RA/PU with KPIs, design CP, suppress CX, and expose TR/OB—that was triangulated against Tables 12–17 and Figures 1, 3–7.

7. 3. Managerial implications

For EU-regulated firms, VASPs/custodians, and token issuers/fund managers, execution quality on CP/CX and evidence-building on TR/OB are decisive. Managers should treat tokenisation and stablecoin adoption as process-redesign programs, not IT pilots. Priority actions map to RA/CP/CX/TR/OB/PU/PEOU as follows.

1. Define two RA/PU metrics per pilot ex-ante (e.g., time-to-settle; reconciliation error-rate) and commit to public OB via dashboards (RA; PU; OB).
2. Run sandboxed TR with supervisory engagement; publish testing protocols and exception logs (TR; OB).
3. Execute CP due-diligence: legal mappings (MiCA categories, UCITS/AIFMD, custody) and interface contracts with legacy systems (CP; CX).
4. Reduce CX through standardised APIs, phased data cut-overs, and SOC-2/SLA attestations (CX; PEOU).
5. Lift PEOU: training for key-management, human-in-the-loop recovery, and UI that surfaces compliance artefacts (PEOU; PU).
6. Concentration risk controls: dual-vendor strategies and exit plans for critical services (CP; CX).
7. Incident-response drills with VASPs; require evidence of key-compromise prevention and proof-of-reserves where applicable (CX; OB).
8. Treasury-governance for SC pilots: issuer due diligence, redemption playbooks, and chain-exposure limits (PU; CP; CX).

These recommendations reflect the risk salience documented in Chapter 3's incident series and exchange-trust discussions and are intended to convert OB's negativity bias into comparable, machine-readable evidence.

7. 4. Policy & Supervisory Implications

EU and national supervisors can accelerate safe diffusion by improving OB and lowering CX. First, expand pilot/sandbox reporting to include harmonised operational metrics (e.g., settlement latency distributions, reconciliation fail-rates) so market participants can benchmark RA/PU. Second, provide interpretative guidance on custody/record-keeping for tokenised securities and on bank-VASP integrations to improve CP. Third, require public, machine-readable incident reporting for VASP security events to address OB's negativity bias with facts. Fourth, coordinate on interoperability standards to avoid re-fragmentation in post-trade. Finally, maintain technology-neutrality while clarifying the perimeter for SC (ART/EMT) so issuers' disclosures and attestation cadence meaningfully support PU/PEOU.

7. 5. Limitations & Validity

The study is constrained by data availability and scope. First, evidence is constrained by the curated corpus (EU-centric), where publication lags, paywalls, and the absence of supervisory microdata may exclude recent or non-European findings. Second, construct mapping from qualitative accounts risks measurement error (e.g., distinguishing CX from CP in legal-integration narratives). Third, external validity is limited to EU/MiCA contexts and to TF/SC/VASP products; generalisation beyond these settings should be cautious. Finally, selection effects may favour visible pilots and large issuers, overstating RA/PU relative to smaller deployments. Future versions should incorporate additional primary data (e.g., supervisory metrics, audited pilot KPIs) and multi-country panels to validate the proposed mechanisms. Finally, the quantitative modules are descriptive rather than causal; they benchmark adoption signals but do not identify treatment effects—future work should pair them with designs in §7.6 (e.g., DiD/event studies) to test mechanisms.

7. 6. Future Research

1. Field experiment: randomised onboarding frictions (e.g., KYC flow steps) to estimate PEOU → PU → intention elasticities for VASP users.
2. Difference-in-differences: MiCA policy shocks as instruments for CP/CX in TF adoption across EU fund jurisdictions.
3. Event studies: OB effects of stablecoin incidents on bank treasury pilot activity; measure persistence and heterogeneity by governance.
4. Panel study: interoperability standard releases and post-trade fragmentation metrics; test CP moderation on RA/PU realisation.
5. Case-control audits: custody/key-management controls at VASPs vs. incident outcomes to quantify CX risk-reduction levers.
6. Multi-method synthesis: combine supervisory dashboards with interview-based process tracing to validate the contingent diffusion model.

7. 7. Closing Paragraph

Chapters 1–2 motivated a dual-lens approach; Chapters 5–6 mapped evidence across TF, SC, and VASP services. Chapter 7 integrates those strands into a pragmatic conclusion: in EU-regulated finance, adoption follows demonstrable RA/PU but stalls without engineered CP/CX and credible OB/TR. For managers, this means instrumenting pilots for measurable gains and designing integrations that satisfy both supervisors and operations. For policymakers, it means mandating transparent, comparable metrics and clarifying boundary conditions. The central contribution is a contingent diffusion model that unites organisational and user-level drivers for blockchain in finance. With disciplined evidence and careful governance, tokenisation, stablecoins, and VASP services can migrate from pilots to production with integrity and scale.

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Appendix A — Supplementary Materials and Reproducibility

Purpose. This appendix gathers materials that would make the main text cumbersome: extended figures/tables, instruments, coding artefacts, and data-access instructions.

A.1 Data Availability and Reproducibility

Public repository: spadox4-4/Blockchain-Adoption-MICA — https://github.com/spadox4-4/Blockchain-Adoption-MICA

Contents: results/ (PDF bundles Figures.pdf and Tables.pdf), data/ (public datasets or pointers), scripts/ (chart regeneration code), and docs (README.md).

A.2 Figures (PDF bundle)

Full-resolution versions of all figures referenced in Chapters 2–5 are provided in Figures.pdf**.**

A.3 Tables (PDF bundle)

All tabular material is compiled in Tables.pdf**.**

A.4 Instruments and Protocols

Semi-structured interview guide; consent statement (anonymised template).

A.5 Codebook and Coding Frame

Construct mapping (DoI RA/CP/CX/TR/OB; TAM PU/PEOU), code definitions, inclusion/exclusion rules, example quotations.

A.6 Participant Profiles (Anonymised)

Role, seniority, domain knowledge, and value-chain position for each interviewee (IDs consistent with the main text).

A.7 Access to Encrypted Materials (Interviews)

Encrypted transcripts file: Interviews-Transcripts.docx.gpg (stored in the repository above).

Requesting access: email spadarosalvator@gmail.com from an institutional address with your research purpose.

Decryption (summary):

macOS/Linux: gpg -d Interviews-Transcripts.docx.gpg > Interviews-Transcripts.docx

Windows: use Gpg4win (Kleopatra) → "Decrypt/Verify" → enter passphrase.

A.8 Ethical Considerations

Anonymised identities; encrypted storage/transfer (AES-256 via GPG); access granted on a need-to-know basis.

A.9 Notes

Minor differences between in-text snapshots and repository charts may reflect upstream data revisions; commit history documents exact versions used.

A.10 Data processing rules (capital & investment dataset)

Stage bucketing (regex/keywords).
pre-seed|angel → Pre-Seed; seed → Seed; series a|series b|series c|series d|series e|series f|series g|series h|series i|series j → Series A/B/C+; ico|ido|ieo|saft|token sale → Token Sale/SAFT; debt|loan|note|bond|credit|convertible|venture debt → Debt/Convertible; bridge|extension|strategic → Bridge/Strategic; grant → Grant; ipo|spac|direct listing → Public/IPO.
This mapping is the canonical taxonomy used throughout.

Date basis & partial periods.
Event date = announcement date (acknowledging announcement≠closing). For quarterly charts, flag partial quarters in captions (e.g., "Q3-2025 (partial, to Aug-20)").

Row filtering.
Drop rows without amounts; exclude rows without dates from time-series charts. (Totals/medians use only rows with valid amounts.)

Amount field selection.
If multiple numeric fields exist, select the canonical "amount" column; if ambiguous, choose the field with highest variance across rows and record that choice in the script log.

Units & rounding.
Work in USD millions at deal level. Charts: totals rounded to 1 decimal; counts: 0 decimals. Tables: medians/means shown to 2 decimals.

Chain & segment labels.
Chains mapped to EVM vs Non-EVM and L1 vs L2. If chain/segment is missing or multi-chain is unclear, label Unspecified and note this in relevant captions.

Investor parsing & "associated volume."
Parse lead vs other investor fields. For "associated volume," credit the full round size to each named investor and note the inflation vs. actual deployed capital wherever such tallies appear.

Deduping.
Merge duplicate rounds on (company, date ±3 days, stage, amount). If conflicts remain, keep the most recent source and record discrepancies.

Valuation fields.
Often sparse/indicative; do not impute. Report by-stage medians when available; otherwise exclude valuations from totals and time-series charts.

Outliers & missing values.
No winsorization; outliers are kept but flagged. "Undisclosed" rounds are excluded from totals but counted in round counts.

Token events.
Token sales/SAFTs are separate from equity. Secondary-market volumes/events are excluded.

Top-10 share & HHI (for concentration measures).
Top-10 share = sum of the 10 largest deal amounts ÷ total capital.
HHI by category = $\Sigma(s_i^2)$ over category shares of total capital (0–1 scale).

Charts & outputs.
Time-series built on announcement date; bars/lines labeled with values. Script outputs write to results/Figures.pdf and results/Tables.pdf.

Known biases (interpret with care).
Announcement-date fallacy (vintage shifts), publicity/survivorship bias (smaller/undisclosed deals under-reported), link-rot (older ICOs missing), and associated-volume inflation for investor views.

STATEMENT OF INTEGRITY

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