

# **The RWA Tokenization Stack**

*Why Institutional Design Determines What Technology Cannot*

Chung Hei Sing

Working Paper

*November 2023*

# The RWA Tokenization Stack

*Why Institutional Design Determines What Technology Cannot*

## Abstract

Tokenization of real-world assets is frequently presented as a technological problem — where advances in blockchains, smart contracts, and digital infrastructure will eventually resolve. This paper argues that such framing misidentifies the binding constraint. Most tokenization initiatives stall not because technology fails, but because the institutional layers that determine investability — legal enforceability, governance authority, fiduciary accountability, and regulatory compatibility — are left under designed.

The paper reconceptualizes the RWA tokenization stack as a six-layer institutional system in which technology occupies only the lowest levels. Higher-order layers govern whether tokenized claims are enforceable, governable, and compatible with the fiduciary and regulatory frameworks within which institutional capital operates. Weakness at these layers cannot be compensated by sophistication at lower ones.

By mapping these layers and their interactions, the paper provides a framework for diagnosing why tokenization efforts stall and identifying the conditions required for tokenized RWAs can achieve durable institutional adoption. The central implication is direct: tokenization is not constrained by what can be built, but by what can be governed.

**Keywords:** real-world assets (RWA); asset tokenization; institutional market design; financial infrastructure; governance frameworks; legal enforceability; fiduciary accountability; regulatory compatibility; smart contracts; distributed ledger technology (DLT).

**How to cite this paper:** Sing, C. H. 2023. The RWA tokenization stack: Why institutional design determines what technology cannot. Working paper.

## 1. Introduction

Tokenization has emerged as a recurring theme in discussions of financial innovation, promising efficiency gains, broader access, and improved transparency across asset classes. Advances in distributed ledger technology (DLT) and smart contracts have made it technically feasible to represent claims on real-world assets in digital form. Yet despite sustained experimentation across finance, infrastructure, and capital markets, institutional adoption of tokenized real-world assets remains limited.

Prevailing explanations for this gap emphasize technical scalability, regulatory uncertainty, or insufficient market demand. While these factors are relevant, they obscure a more fundamental issue: tokenization is rarely constrained by technology alone. Institutions evaluate assets not merely by how ownership is recorded or transferred, but by how rights are enforced, decisions are governed, risks are allocated, and accountability is maintained over time. Technical feasibility is a necessary but insufficient condition for adoption (BIS, 2020).

Many tokenization initiatives implicitly assume that institutional barriers will dissolve once software infrastructure matures. This assumption reflects a misdiagnosis of the problem. For most real-world assets, the binding constraints are institutional rather than computational. Asset ownership and cash flows are defined through legal agreements, governance arrangements, fiduciary responsibilities, and regulatory recognition that predate and supersede any technical implementation. Tokenization does not replace these structures; it operates within them.

This paper advances a different framing. It argues that successful RWA tokenization requires treating the tokenization stack not as a single technological layer, but as a system of interdependent institutional layers in which technology is only one component. Failure to design and align the higher-order layers — legal enforceability, governance authority, fiduciary accountability, and regulatory compatibility — produces systems that may function operationally yet remain unusable for institutional capital.

## 2. From "technology stack" to "institutional stack"

In software engineering, a stack refers to a layered arrangement of technical components — hardware, operating systems, middleware, applications, and interfaces — each simplifying complexity from the layer below. Applied without careful scrutiny to real-world assets, this metaphor encourages a narrow focus on blockchains, protocols, and code execution, treating institutional features as external constraints to be addressed later.

For real-world assets, this framing is structurally incomplete. Unlike purely digital assets, real-world assets derive their economic meaning from off-chain institutions. Ownership, control rights, claims on cash-flows, and risk allocation are not created by code. They are defined through legal contracts, governance mechanisms, and regulatory recognition. Tokenization does not originate these relationships — it reflects them.

A technology-centric view of the tokenization stack therefore systematically underestimates the importance of non-technical layers. Many projects succeed at issuing tokens but fail to answer the institutional questions that determine investability: What exactly does the token represent? Who has authority to intervene when conditions change? How are disputes resolved? Who bears fiduciary responsibility if outcomes diverge from expectations? Without clear answers to these questions, tokenized assets remain incompatible with institutional portfolios regardless of technical sophistication.

The relevant analytical question is therefore not whether a token can be created, but whether the full stack supporting that token satisfies institutional requirements. This stack includes technical components, but it also encompasses governance authority, legal anchoring, fiduciary accountability, and regulatory integration — the layers that determine whether tokenized claims are enforceable, investable, and scalable within existing market systems (De Filippi & Wright, 2018).

Reframing tokenization as an institutional stack shifts attention from isolated technical innovation toward system-level design. It clarifies why progress at lower layers cannot compensate for weakness at higher layers, and why institutional adoption proceeds incrementally through structures that preserve accountability and control.

### **3. The RWA tokenization stack: Six layers**

This paper proposes a six-layer framework for analyzing real-world asset tokenization. The layers are ordered from lowest to highest — not by technical sophistication, but by institutional significance. Lower layers enable functionality; higher layers determine investability. While progress at lower layers is often visible and rapid, institutional adoption depends on the alignment and robustness of the upper layers.

Crucially, the layers are not independent. Weakness or ambiguity at higher layers cannot be compensated by improvements at lower ones. Tokenization efforts frequently fail not because technology malfunctions, but because institutional layers remain undefined, misaligned, or incompatible with existing fiduciary and regulatory systems.

**Figure 1. The RWA Tokenization Stack**

<b>Layer</b>	<b>Description</b>
Layer 6	Regulatory and market integration
Layer 5	Fiduciary and risk accountability
Layer 4	Governance and decision authority
Layer 3	Asset representation and legal anchoring
Layer 2	Smart contracts and execution logic
Layer 1	Distributed ledger infrastructure

**Layer 1: Distributed ledger infrastructure**

At the base of the stack lies distributed ledger infrastructure, including public and permissioned (i.e. restricted-access) blockchains. This layer provides cryptographic security, transaction ordering, data integrity, and resistance to unilateral manipulation. It establishes a shared record of transactions and ownership changes.

From an institutional perspective, this layer is largely commoditized. Competing ledger designs differ in transaction capacity, governance, and access structure, but the inability of blockchains to process transactions reliably is rarely the reason RWA initiatives stall. Ledger choice may influence operational characteristics, but it rarely determines whether an asset is investable. Distributed ledgers are necessary, but they do not resolve questions of ownership, authority, or responsibility.

**Layer 2: Smart contracts and execution logic**

Smart contracts sit above the ledger, encoding rules for issuance, transfer, settlement, and basic lifecycle events. They automate standardized processes and reduce reliance on manual reconciliation or trusted intermediaries for routine actions.

Execution logic is inherently constrained by what can be specified ex ante. Smart contracts excel in rule-based environments but perform poorly where discretion, judgment, and exception handling are required. Real-world assets routinely encounter events — regulatory changes, operational disruptions, force majeure, renegotiations — that cannot be fully anticipated or resolved through code alone (Williamson, 1985).

When tokenization initiatives substitute automation for institutional discretion, they introduce rigidity rather than resilience. Smart contracts function best as procedural tools within a broader governance framework, not as replacements for it.

### **Layer 3: Asset representation and legal anchoring**

This layer defines what a token legally represents. Is it a direct ownership interest, a contractual claim, a beneficial interest held through a trust, or a reference to an off-chain agreement? These distinctions are not merely definitional — they determine enforceability, priority in insolvency, and the rights of token holders under stress (Hart & Moore, 1990).

Legal anchoring establishes the connection between on-chain representation and off-chain reality. It governs how tokenized claims are recognized by courts, regulators, custodians, and counterparties. Without clear legal documentation and jurisdictional recognition, tokens remain informational artifacts rather than enforceable financial instruments.

Many tokenization pilots stall at this layer. Tokens may trade or settle successfully on-chain, yet institutional investors remain unable to assess legal risk, creditor standing, or recovery rights. Technical success at Layers 1 and 2 masks institutional failure at Layer 3.

### **Layer 4: Governance and decision authority**

Governance determines who has authority to intervene when conditions deviate from expectations — including the power to pause transfers, modify parameters, unwind transactions, resolve disputes, or respond to external shocks.

In institutional markets, governance authority is deliberately discretionary and concentrated. Boards, trustees, general partners, and regulators retain discretionary control precisely because not all contingencies can be specified in advance (Sing, 2021). Tokenization efforts that attempt to eliminate or obscure these authority structures undermine institutional trust rather than building it.

Failures at this layer are particularly damaging. When authority is unclear, responsibility becomes diffuse, and institutions face uncertainty about who can act, when, and under what mandate. No amount of technical robustness at lower layers compensates for ambiguous governance at this level.

### **Layer 5: Fiduciary and risk accountability**

Institutions operate under fiduciary obligations that govern asset selection, custody, risk management, and oversight. This layer assigns responsibility for losses, ensures alignment of incentives, and enables auditability and escalation (Sing, 2023).

A tokenized structure without clearly defined fiduciary accountability may function operationally yet remain unsuitable for institutional portfolios. If losses occur, institutions must be able to identify who is accountable, what responsibilities they had, and how breaches are remedied. Structures that distribute exposure without assigning responsibility violate these requirements and are incompatible with the fiduciary frameworks within which institutional capital is managed.

Fiduciary accountability is not optional or negotiable. It is embedded in law, regulation, and professional standards. Tokenization designs that treat fiduciary considerations as secondary constraints rather than core design inputs will not scale.

### **Layer 6: Regulatory and market integration**

At the top of the stack lies integration with regulatory frameworks and existing market infrastructure. Institutions must incorporate tokenized assets into compliance systems, reporting regimes, capital and liquidity calculations, and operational workflows (IOSCO, 2020).

This layer determines whether tokenized assets can move beyond isolated pilots. Regulatory compatibility is a precondition for scale, not a downstream consideration. Tokenized assets that cannot be supervised, reported, or reconciled within existing systems remain marginal regardless of their technical merits.

Regulatory integration reflects institutional logic rather than regulatory caution. Supervisory frameworks evolve around identifiable entities, accountable managers, and enforceable rules. Tokenization succeeds where it preserves these anchors — not where it bypasses them.

### **Layer interdependence and the dominance of upper layers**

The six layers form an integrated system. Lower layers enable functionality, while upper layers determine legitimacy, trust, and scale. Misalignment across layers — such as advanced automation paired with weak legal anchoring or ambiguous governance — produces systems that are technically capable yet institutionally unusable.

Understanding tokenization through this layered framework clarifies why institutional adoption proceeds unevenly, and why progress at the technological frontier so often fails to translate into deployable financial infrastructure. Tokenization is not constrained by what can be built, but by what can be governed.

## **4. Why misalignment causes tokenization failures**

Most stalled RWA tokenization initiatives fail not because of technological malfunction, but because progress across the tokenization stack is uneven. Lower layers — distributed ledgers and smart contracts — advance rapidly, while higher-order institutional layers remain weak, ambiguous, or unresolved. This misalignment produces systems that operate technically but [do not operate in a way that fits what institutions need; therefore, cannot be adopted at scale by institutional investors.

A common failure pattern involves sophisticated on-chain execution paired with insufficient legal anchoring. Tokens may be issued, transferred, and settled seamlessly, yet the underlying claims remain unclear in insolvency, unenforceable across jurisdictions, or subordinate to off-chain agreements. Technical clarity masks legal uncertainty, preventing institutions from assessing downside risk with the confidence required for fiduciary decision-making.

A second failure mode arises when automation outpaces governance design. Smart contracts encode rule-based logic, but real-world assets routinely encounter unpredictable events — regulatory intervention, operational disruption, or contractual renegotiation. When authority to intervene is unclear or fragmented, institutions face intolerable uncertainty about who can act, under what mandate, and with what liability. Automation without governance increases rigidity rather than resilience — a structural parallel to the failure mode identified in capital allocation contexts where decision authority is fragmented across actors without clear accountability (Sing, 2022).

A third misalignment occurs when tokenization introduces tradability without corresponding fiduciary accountability. Tokenized claims may circulate widely while responsibility for oversight, loss management, and compliance remains unclear. Liquidity without accountability is not an advantage for institutional investors; it is a risk amplifier that creates exactly the asymmetry between exposure and control that fiduciary frameworks are designed to prevent—namely, situations where institutions bear risk without corresponding control or accountability.

These three failure modes explain why many tokenization efforts remain trapped at the pilot stage. Institutions do not reject tokenization because it is novel — they reject structures that redistribute risk without providing equivalent mechanisms for control and remediation. Until the upper layers of the stack are aligned with the lower ones, tokenization increases institutional uncertainty rather than reducing it.

## **5. Implications for institutional adoption**

Viewing tokenization through an institutional stack lens clarifies recurring patterns in adoption behavior. These patterns are often interpreted as transitional friction or temporary conservatism. They are neither — they reflect stable institutional logic shaped by fiduciary duty, governance requirements, and regulatory integration.

Financial vehicles with pre-existing legal and governance structures adopt tokenization earlier than bespoke assets. Funds, trusts, and pooled vehicles already embed authority, accountability, and regulatory recognition. Tokenization in these contexts modifies record-keeping and settlement mechanics without altering the underlying institutional architecture. Adoption can therefore proceed incrementally rather than disruptively — which is the only pace institutional capital reliably accommodates.

Permissioned or institution-led systems dominate early deployments because institutions prioritize environments where authority, access, and accountability are clearly defined. Open or fully decentralized systems may offer technical advantages but often lack the governance clarity required for fiduciary participation. In this context, retaining control is not a rejection of innovation — it is a precondition for accountability.

Traditional intermediaries persist rather than disappear. Custodians, administrators, trustees, and regulators remain essential because they occupy the upper layers of the stack — layers that

technology alone cannot replace. Tokenization reconfigures these roles but does not eliminate the functions they perform. Initiatives based on disintermediation routinely underestimate the importance of this structural reality.

Institutional adoption of tokenized real-world assets is therefore not a linear progression toward decentralization. It is a selective integration process in which innovation is absorbed where it reinforces existing accountability structures — and resisted where it does not.

## **6. Design principles for institutional tokenization**

The analysis points toward four design principles that distinguish tokenization efforts capable of institutional adoption from those that remain confined to pilots.

**Governance must precede automation.** Tokenization should encode clearly defined authority structures rather than attempt to eliminate them. Decision rights, escalation mechanisms, and intervention powers must be specified *ex ante* and remain clear to fiduciaries and regulators. Automation enhances efficiency only when it operates within an explicit governance framework — not as a substitute for one.

**Legal enforceability must anchor technical representation.** Tokens must correspond to claims that are enforceable under applicable legal regimes. This requires clear documentation of what a token represents, how rights are exercised, and how conflicts are resolved. Without firm legal anchoring, on-chain functionality does not translate into off-chain certainty, and institutional investors cannot assess the downside risk they are required to manage.

**Fiduciary accountability cannot be designed away.** Institutional adoption requires that responsibility for outcomes be clearly assigned. Tokenization structures that distribute exposure without assigning accountability undermine the fiduciary obligations of the institutions they seek to serve. Successful designs preserve clear lines of responsibility even as operational processes are automated or restructured.

**Regulatory integration is a precondition for scale, not a downstream optimization.** Tokenized assets must fit within supervisory, reporting, and compliance systems from the outset. Regulatory alignment determines whether tokenized instruments can move beyond isolated use cases into systemically relevant markets — and this alignment cannot be retrofitted after deployment without substantial friction.

These principles do not constrain innovation. They define the boundary between tokenization that enhances institutional markets and tokenization that shifts complexity without resolving the underlying governance and accountability problems that prevent adoption.

## 7. Conclusion

The limited institutional adoption of tokenized real-world assets is often attributed to technological immaturity or regulatory delay. This paper argues that such explanations misidentify the binding constraints. [current] Tokenization initiatives stall not because they cannot be built, but because they are not designed to operate within the institutional systems that govern ownership, risk, and accountability.

By reframing tokenization as an institutional stack rather than a technology stack, the paper clarifies why progress at lower layers fails to compensate for weakness at higher ones. Distributed ledgers and smart contracts enable functionality, while legal anchoring, governance authority, fiduciary accountability, and regulatory integration determine whether tokenized assets are investable at scale.

This perspective also explains observed patterns of adoption. Tokenized funds and pooled vehicles advance more rapidly than bespoke assets because they preserve institutional continuity. Permissioned environments dominate early deployments because they align authority with responsibility. Intermediaries persist not due to inertia, but because they occupy roles that technology alone cannot replicate.

The implication is not that tokenization will remain marginal, but that its trajectory will be shaped by institutional logic rather than technological possibility. Durable adoption will occur where tokenization reinforces existing governance structures — and stall where it attempts to bypass them. For institutions, regulators, and market designers, the central challenge is therefore not how quickly assets can be tokenized, but under what conditions tokenization can be governed.

## References

- BIS. (2017). Distributed ledger technology in payment, clearing and settlement. Bank for International Settlements. <https://www.bis.org/cpmi/publ/d157.htm>
- BIS. (2020). Central bank digital currencies: Foundational principles and core features. *Bank for International Settlements*. <https://www.bis.org/publ/othp33.htm>
- CPSS, IOSCO, & BIS. (2012). Principles for financial market infrastructures. *Committee on Payment and Settlement Systems; Technical Committee of the International Organization of Securities Commissions; Bank for International Settlements*. <https://www.bis.org/cpmi/publ/d101a.htm>
- De Filippi, P., & Wright, A. (2018). Blockchain and the law. *Harvard University Press*.
- FSB. (2019). *Crypto-assets: Work underway, regulatory approaches and potential gaps*. Financial Stability Board. <https://www.fsb.org/2019/05/crypto-assets-work-underway-regulatory-approaches-and-potential-gaps/>
- Hart, O., & Moore, J. (1990). Property rights and the nature of the firm. *Journal of Political Economy*, 98(6), 1119–1158. <https://doi.org/10.1086/261729>
- IOSCO. (2020). Issues, risks and regulatory considerations relating to crypto-asset trading platforms. *International Organization of Securities Commissions*. <https://www.iosco.org/library/pubdocs/pdf/IOSCOPD649.pdf>
- OECD. (2020). The tokenisation of assets and potential implications for financial markets. *OECD Blockchain Policy Series*. <https://www.oecd.org/finance/The-Tokenisation-of-Assets-and-Potential-Implications-for-Financial-Markets.pdf>
- Sing, C. H. (2021). Board governance as institutional design: What boards do well, where they fail, and how oversight actually works. Working paper.
- Sing, C. H. (2022). Capital allocation is a board responsibility: Why strategy fails without governance. Working paper.
- Sing, C. H. (2023). Fiduciary duty in complex organizations: A process-based framework for governance evaluation and oversight. Working paper.
- WEF. (2016). The future of financial infrastructure: An ambitious look at how blockchain can reshape financial services. *World Economic Forum*. <https://www.weforum.org/publications/the-future-of-financial-infrastructure-an-ambitious-look-at-how-blockchain-can-reshape-financial-services/>

Williamson, O. E. (1985). *The economic institutions of capitalism*. *Free Press*.