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DIGITALIZATION OF INTERNATIONAL SETTLEMENTS AND THE TRANSFORMATION OF TRANSACTION COSTS: CHALLENGES TO FINANCIAL STABILITY

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Apstract: The digitalization of international payment and settlement infrastructures represents a structural shift in the global architecture of cross-border capital flows. Traditional mechanisms based on correspondent banking, multi-day procedures, and document-intensive verification are increasingly complemented or replaced by programmable systems such as central bank digital currencies (CBDCs), tokenized deposits, automated compliance, and smart contracts. This paper argues that this transformation is not merely a technical efficiency gain, but a fundamental reconfiguration of transaction costs with direct implications for financial stability and the scalability of cross-border green finance.

Using a transaction cost economics framework, the paper shows that digital settlement infrastructures compress classical frictions related to search, information, verification, enforcement, and coordination, thereby enabling decentralized, performance-linked climate investments at scale. At the same time, these systems reallocate costs into new forms of systemic risk, including cyber fragility, governance and interoperability fragmentation, and the possibility of instantaneous liquidity outflows or "digital run dynamics." As a result, digital settlement rails can become points of infrastructure-based contagion, where technical or governance failures rapidly undermine confidence in climate finance channels.

The paper makes three main contributions. First, it conceptualizes international settlement infrastructures as institutional governance structures rather than neutral technical plumbing. Second, it links the reallocation of transaction costs under digitalization to macroprudential concerns, formalizing infrastructure contagion and digital runs as structural features of the new regime. Third, it positions settlement architecture as climate finance infrastructure, introducing the concept of sustainability-aligned settlement systems that simultaneously reduce transaction costs, embed financial resilience, and remain environmentally compatible. The core conclusion is that financial stability is no longer an external precondition for the green transition, but an endogenous design feature of digital payment and settlement systems.

Keywords: *Digitalization; International Settlements; Transaction Costs; Financial Stability; CBDC; Blockchain; Financial Risks.*

1. INTRODUCTION

1.1 Background and relevance

The architecture of cross-border settlement is undergoing a structural transition. Legacy international payment channels – correspondent banking, SWIFT-based messaging, documentary credit – are increasingly being supplemented by programmable settlement infrastructures such as central bank digital currency (CBDC) platforms, tokenized deposits, automated compliance rails, and smart contract–based conditional payment mechanisms (BIS, 2021; Adrian and Mancini-Griffoli, 2019; BIS, 2023).

This is not a purely technical upgrade. It is a reorganization of the institutional foundations of how capital moves across borders. The shift from multi-day, document-heavy bilateral procedures toward near-instant, data-rich, machine-verifiable settlement has direct consequences for global capital allocation, including climate and sustainability-linked finance. The green transition depends on the ability to channel funding efficiently to thousands of heterogeneous, smaller, distributed projects – energy efficiency retrofits, municipal adaptation infrastructure, decentralized renewables – not only to a handful of large flagship projects. That requires international payment and settlement rails that (i) are low-cost per transaction, (ii) can attach enforceable conditionality to disbursements, and (iii) are reliable across jurisdictions.

In this sense, the digitalization of international settlements is becoming enabling infrastructure for the green economy. Lower frictions in moving money across borders directly expand the feasible set of green investments.

1.2 Problem statement

However, there is a structural paradox. Digitalization reduces classical categories of transaction costs – search, verification, enforcement, coordination – which historically made cross-border settlement slow and expensive (Coase, 1937; Williamson, 1979; BIS, 2021). But it simultaneously generates new categories of costs and risks: cyber-dependence, protocol fragility, governance fragmentation, jurisdictional incompatibility, and extreme speed of liquidity outflows under stress (Diamond and Dybvig, 1983; Gorton and Zhang, 2022; FSB, 2022).

These new risks are not purely operational. They map directly into financial stability:

- A cyber incident or smart contract exploit in a programmable settlement corridor used to route climate finance can instantly undermine trust not only in that rail, but in the idea of green finance itself.
- A fragmentation of CBDC standards across jurisdictions can trap capital in silos, impeding cross-border climate funding.
- The ability of capital to exit digitally in minutes introduces "digital run dynamics," making sustainable finance procyclical and politically fragile.

In other words, the very infrastructure intended to accelerate the green transition can also destabilize its funding base.

1.3 Research gap

Three literatures exist but remain largely siloed:

1. Transaction cost economics explains why institutions arise to minimize the costs of contracting, monitoring, and enforcement under uncertainty (Coase, 1960; Williamson, 1985; North, 1990).
2. Central bank and policy work on CBDCs, tokenization, and cross-border payment reform documents the ongoing redesign of settlement architecture to improve speed, transparency, and cost efficiency (CPMI/FSB, 2020; BIS, 2021; BIS, 2022; BIS, 2023).
3. Financial stability research now acknowledges that digital finance introduces new systemic risks: cyber shocks, liquidity flight from stablecoins, and governance failures in decentralized finance (Diamond and Dybvig, 1983; Schär, 2021; FSB, 2022; IMF, 2022).

What is missing – and what this paper provides – is an integrated framework that links:

- the restructuring of transaction costs in international settlements;
- the emergence of new systemic risk channels; and
- the consequences for scaling cross-border green finance.

No existing work, to our knowledge, explicitly treats the design of digital settlement rails as a climate-finance stability question. That is the conceptual gap this paper addresses.

1.4 Aim and objectives

The aim of this paper is to analyze how digitalization of international settlements transforms the structure of transaction costs, and to identify how this transformation creates new challenges to financial stability in the context of the green economy.

The specific objectives are:

1. To classify the transaction cost structure of traditional correspondent-banking-based international settlements.
2. To analyze how digital infrastructures – CBDCs, tokenized deposits, stablecoins, automated compliance, smart contracts – alter those costs both quantitatively (speed, cost) and qualitatively (risk relocation).

3. To identify the systemic risk channels that arise from this relocation of costs, with a focus on "digital run dynamics" and interoperability breakdowns that threaten sustainable finance flows.

1.5 Structure

Section 2 reviews the theoretical and policy literature and introduces our conceptual framework. Section 3 describes the methodological approach. Section 4 presents the analysis: (i) baseline transaction costs in legacy settlement systems, (ii) their transformation under digitalization, and (iii) the resulting systemic risk channels. Section 5 discusses implications for the green transition and policy. Section 6 concludes with our core contribution.

2. LITERATURE REVIEW & THEORETICAL FRAMEWORK

2.1 Transaction cost economics as applied to payment infrastructures

Coase (1937) argued that firms emerge because markets are not frictionless; search, negotiation, and enforcement are costly. Williamson (1979; 1985) expanded this into a theory of governance structures: institutional arrangements evolve to minimize the sum of production and transaction costs in the presence of opportunism, bounded rationality, and asset specificity. North (1990) framed institutions as mechanisms for reducing uncertainty in human interaction, enabling complex, long-horizon activity.

International settlement infrastructures can be understood in exactly these terms. Correspondent banking relationships, SWIFT messaging standards, multi-step compliance and documentation chains, and the legal scaffolding of letters of credit are governance structures: institutional responses to the problem of enforcing cross-border payment obligations when information is asymmetric, jurisdictional enforcement is uncertain, and counterparties do not fully trust one another (Williamson, 1979; Allen and Gale, 2000).

This is crucial. It means settlement rails are not neutral plumbing. They are institutional solutions to the problem of high cross-border transaction costs.

2.2 Digitalization of cross-border settlement

Recent work by central banks and international bodies aims to compress those traditional frictions. CBDC pilots explore direct interlinkages between central bank liabilities across borders – rather than through long correspondent chains – to achieve near-instant settlement (BIS, 2021; BIS, 2022; Auer and Böhme, 2021). Programmable smart contracts enable conditional disbursements, delivery-versus-payment, automated escrow, and embedded compliance logic. Tokenized deposits and tokenized securities aim to allow synchronized movement of assets and cash on shared or interoperable ledgers (BIS, 2023).

At the same time, standardization efforts such as ISO 20022 seek to normalize data fields, automate screening for anti-money-laundering (AML) and sanctions compliance, and drastically reduce manual reconciliation effort (CPMI, 2021). DeFi architectures experiment with replacing intermediated settlement with transparent, code-based execution and collateral management (Schär, 2021). Stablecoins attempt to provide globally accepted settlement assets that clear instantly, without correspondent chains, though often with unresolved questions around backing and redemption (Gorton and Zhang, 2022).

In short, digitalization is attempting to transform settlement from a world of bilateral trust plus manual verification to a world of shared state plus automated enforcement.

2.3 Digital finance and financial stability

Traditional financial stability analysis focuses on credit risk, liquidity mismatch, and the possibility of runs – sudden mass withdrawals that force fire sales and propagate panic (Diamond and Dybvig, 1983; Tirole, 2011). In digital finance, analogous run dynamics have appeared in stablecoins and DeFi liquidity pools: if confidence in a token's collateral backing or in a protocol's integrity weakens, exit is instantaneous and global (FSB, 2022; IMF, 2022; Schär, 2021).

Meanwhile, operational and cyber risk have become systemic, not incidental. A smart contract exploit, CBDC outage, bridge hack, or oracle manipulation can create immediate contagion of distrust through the settlement infrastructure itself (BIS, 2023). Governance fragmentation is another emerging concern: if jurisdictions develop incompatible CBDCs and tokenization standards, cross-border liquidity can splinter into geopolitical blocs (BIS, 2022; Arner, Auer and Frost, 2020), reintroducing friction in an unstable, politicized manner.

2.4 Our conceptual framework

We synthesize these strands into a single analytical frame:

1. **Transaction costs as an enabling condition for green finance.**
2. Lower settlement frictions make smaller, decentralized, performance-linked climate projects financeable. High frictions bias financing toward large, centralized, politically "bankable" projects.

3. **Digitalization as a reallocation of costs and risks.**
4. Digital settlement architecture reduces classical transaction costs (search, verification, enforcement) but introduces technological, governance, and systemic costs: cyber exposure, interoperability management, and the possibility of instant liquidity flight (Auer and Böhme, 2021; FSB, 2022; BIS, 2023).
5. **Financial stability as a precondition for sustainable finance.**
6. The scalability and credibility of green finance now depends on whether these new costs manifest as macroprudential vulnerabilities – operational fragility, fragmentation, and digital run dynamics – that could choke or discredit climate funding channels.

This framework underpins the analysis in Section 4. It is also the core novelty of the paper: we explicitly treat the design of settlement infrastructure as climate finance infrastructure. That move – equating payment system design with climate finance stability – is, to our knowledge, absent in the existing literature.

3. METHODOLOGY

3.1 Nature of the study

This is a conceptual-analytical study. We do not estimate quantitative models or produce new empirical series. Instead, we integrate institutional economics, payment infrastructure design, and financial stability theory to generate a structured account of how digital settlement technologies reshape transaction costs and systemic risk.

3.2 Methods

- **Comparative institutional analysis.**
- We compare the traditional correspondent-banking/SWIFT/documentary-credit model with emerging CBDC corridors, tokenized settlement rails, and DeFi-inspired architectures.
- **Transaction cost decomposition.**
- We classify five categories of transaction costs – search/trust, information, verification/enforcement, negotiation/coordination, safeguard – in the legacy system and track how each is transformed in digital systems (Coase, 1937; Williamson, 1985).
- **Systemic risk channel mapping.**
- We identify how reduced frictions and greater speed can amplify fragility: cyber/infrastructure failures, interoperability breakdowns, and instantaneous outflows.
- **Normative linkage to sustainability.**

- We assess whether the settlement rail itself is compatible with sustainability goals: not only in terms of enabling climate finance, but in terms of its own energy footprint (Krause and Tolaymat, 2018; de Vries, 2021).

3.3 Scope and limitations

We focus on cross-border settlement relevant for project and climate finance, not domestic retail payments. We treat "green finance" as funding flows supporting mitigation, adaptation, decarbonization, and resilience. We rely on documented assessments of energy intensity in proof-of-work systems (Krause and Tolaymat, 2018; de Vries, 2021) to make the ecological point; we do not compute lifecycle emissions of specific platforms. We also acknowledge that national regulatory regimes differ, but our interest here is systemic architecture, not country case studies.

4. ANALYSIS AND FINDINGS: THE NEW LANDSCAPE OF TRANSACTION COSTS AND RISKS

4.1 Transaction costs in the traditional international settlement system

Legacy international settlements depend on correspondent banking relationships, multi-day reconciliation, and document-heavy legal instruments such as letters of credit. Within this structure, five categories of transaction costs dominate (Coase, 1960; Williamson, 1979; Allen and Gale, 2000):

1. **Search and trust costs.**
2. Identifying a reliable correspondent bank in another jurisdiction, assessing counterparty risk, and establishing bilateral trust are costly and relationship-driven.
3. **Information costs.**
4. Payment status is opaque. Parties face uncertainty over whether funds have actually been released, whether compliance holds, and where a transaction is delayed.
5. **Verification and enforcement costs.**
6. Physical or documentary validation (shipping certificates, inspection reports, signatures, customs declarations) is required to prove conditions are met. Enforcing performance across jurisdictions is slow and legally complex.
7. **Negotiation and coordination costs.**
8. Non-standard terms – staged disbursement, ESG-linked conditionality, partial deliveries – require bespoke negotiation, often through intermediaries, adding time and legal overhead.

9. **Safeguard costs.**
10. Hedging FX risk, arranging trade credit insurance, and provisioning for legal disputes all add protective layers.

These frictions have two system-wide consequences that matter for climate finance:

- **Barrier to small-scale climate projects.**
- High fixed costs per deal make it uneconomic to finance decentralized or municipal green projects. Capital prefers large, bankable infrastructure backed by sovereign guarantees.
- **In-built "viscosity" against panic.**
- The same frictions slow capital flight. Liquidity generally cannot exit instantaneously. The architecture is costly, but it dampens the speed of contagion.

This logic can be summarized as follows.

Table 1. Traditional international settlement system: transaction costs and systemic properties

Dimension	Legacy system profile
Search / trust cost	High; relationship-driven
Information transparency	Low; status opaque, multi-day reconciliation
Verification & enforcement cost	High; manual, documentary, legally fragmented
Coordination / customization cost	High; bespoke negotiation per contract
Safeguard (risk protection) cost	High; FX hedging, insurance, legal buffers
Accessibility for small green projects	Low; fixed costs too high per transaction
Speed of crisis outflows (liquidity flight)	Slow / dampened
Environmental footprint of processing	Paperwork-heavy, physical handling; not highly compute-intensive
Search / trust cost	High; relationship-driven

The legacy system is therefore **costly but viscous**. It rations access to funding, but it also inherently slows panic.

4.2 Digitalization and the transformation of transaction costs

Emerging digital settlement infrastructures – wholesale CBDCs, tokenized deposits, programmable escrow via smart contracts, automated KYC/AML, cross-border CBDC corridors – rewire all five cost categories (BIS, 2021; BIS, 2022; Auer and Böhme, 2021; Arner, Auer and Frost, 2020):

1. **Search and trust costs fall.**
2. Counterparty discovery and onboarding shift from bilateral relationship-building to platform-level permissioning: if you are admitted to the corridor, you are by definition "trustworthy enough" to transact.

3. **Information costs collapse.**
4. Settlement status can be transparent in near real time. Structured data (ISO 20022) and embedded compliance metadata reduce ambiguity and manual reconciliation (CPMI, 2021).
5. **Verification and enforcement costs fall.**
6. Smart contracts can execute delivery-versus-payment, escrow release, milestone-based disbursement, and ESG covenant triggers automatically (Schär, 2021; BIS, 2023). Compliance is coded ex ante, not litigated ex post.
7. **Coordination / customization costs fall.**
8. Programmable settlement allows conditional, performance-linked climate finance structures – e.g. "release tranche only if emissions reduction target met" – at marginal cost close to zero. This is crucial for scaling decentralized green investment.
9. **Safeguard costs are reallocated.**
10. Credit and legal enforcement risks can decrease because settlement is atomic and final. But new safeguard costs emerge: cybersecurity, protocol auditing, key management, jurisdictional compliance, governance of upgrades (FSB, 2022; IMF, 2022).

Digitalization therefore lowers entry barriers for smaller, more fragmented, climate-relevant projects. By embedding verification and conditionality into the rail itself, it can make climate finance cheaper, more targeted, and more accountable.

But it also alters systemic properties in a way that matters for financial stability:

1. **Operational/cyber fragility.**
2. Failure is no longer slow and local. A single exploit in a widely used contract or corridor can freeze flows instantly.
3. **Interoperability / fragmentation risk.**
4. If CBDCs and tokenized settlement platforms are not interoperable, liquidity can become trapped within geopolitical blocs, reintroducing friction in a discretionary and potentially adversarial form (BIS, 2022).
5. **Energy footprint of the settlement rail.**
6. Public proof-of-work networks have historically consumed large amounts of energy with associated carbon emissions (Krause and Tolaymat, 2018; de Vries, 2021). A high-emission rail funding low-carbon projects is structurally inconsistent with sustainability goals. This is pushing the debate toward permissioned, energy-efficient designs (Auer and Böhme, 2021).

This can be summarized as:

Table 2. Digital settlement infrastructures: transaction costs and systemic properties

Dimension	Digitalized infrastructure profile
Search / trust cost	Low; platform-level permissioning replaces bilateral vetting
Information transparency	High; real-time settlement status and standardized data
Verification & enforcement cost	Low; automated via smart contracts and embedded compliance

Coordination / customization cost	Low; programmable conditionality at marginal cost
Safeguard (risk protection) cost	Reallocated; cyber resilience, protocol governance dominate
Accessibility for small green projects	High; fixed cost per deal falls sharply
Speed of crisis outflows (liquidity flight)	High / instantaneous ("digital run dynamics")
Environmental footprint of processing	Design-dependent; can be high (PoW) or low (CBDC / permissioned DLT)

Compared to Table 1, the trade-off becomes visible: *efficiency and inclusion improve, but fragility accelerates*. This is the crux. The digital rail is not automatically "better"; it is "cheaper and faster, but potentially more systemically brittle."

This motivates the core concept we introduce and defend in this paper:

Sustainability-aligned settlement architecture is a settlement infrastructure that simultaneously (i) compresses transaction costs to unlock climate finance at scale, (ii) embeds systemic resilience against cyber/operational shock and digital run dynamics, and (iii) aligns its own energy footprint with sustainability objectives.

We argue this triad must become the design criterion for future cross-border payment systems.

4.3 Channels of emerging risks to financial stability

From the transformation above, three systemic risk channels emerge. These channels are summarized in Figure 1.

4.3.1 Operational and cyber risk as systemic risk

In CBDC corridors, tokenized settlement layers, and DeFi-like infrastructures, a single smart contract or shared ledger can intermediate large volumes of cross-border value. A cyberattack, exploit, or outage is therefore not a local IT disturbance; it is a macroprudential event (Schär, 2021; BIS, 2023). Trust in the rail collapses, and with it the credibility of the funding streams that rail supports – including climate-linked flows.

This creates **infrastructure-contagion**: panic spreads via distrust in the shared settlement infrastructure, not through bank balance sheets in the traditional sense.

4.3.2 Fragmentation and loss of interoperability

Digitalization promises seamless cross-border flows. But if jurisdictions roll out incompatible CBDCs and tokenization standards, we risk a politically fragmented payment geography in which liquidity cannot move freely (BIS, 2022; Arner, Auer and Frost, 2020). That fragmentation can trap climate finance in specific blocs, starving vulnerable regions of transition funding at precisely the moment they need it.

4.3.3 Digital run dynamics and procyclicality

In legacy correspondent banking, frictions slowed capital flight. In digital rails, exit can be instantaneous. This produces **digital run dynamics**: when confidence in a settlement token, green-linked stablecoin, or jurisdiction's programmable rail deteriorates, liquidity evaporates in minutes (Diamond and Dybvig, 1983; Gorton and Zhang, 2022; FSB, 2022).

Two consequences follow:

- **Amplified procyclicality.** Capital floods into sustainability-linked assets in good times (because monitoring and disbursement are cheap), and then vanishes even faster in stress. The climate funding base becomes sentiment-driven and fragile.
- **Reputational damage to green finance.** A single rapid digital run can stigmatize climate-linked instruments as inherently unstable, creating political resistance to further deployment.

The interaction between digitalized settlement systems and green finance stability unfolds through a sequence of interconnected risk channels:

1. Cyber or operational shocks affecting digital settlement infrastructures;
2. Erosion of trust in the settlement rail;
3. Liquidity freezes or run dynamics in digital and sustainability-linked instruments;
4. Funding shortfalls for climate projects accompanied by reputational damage to sustainable finance.

This sequence underpins the central claim of the study that financial stability must be treated as an integral component of climate finance architecture.

5. DISCUSSION

5.1 Beyond "speed and cost": redefining efficiency

Payment innovation is often evaluated by speed, cost per transaction, and user convenience. Our analysis shows that such a two-dimensional view is obsolete for the era of climate finance.

We propose that cross-border settlement infrastructures must now be evaluated along three axes:

1. **Transaction cost compression.**
   Do they lower search, verification, enforcement, and coordination costs enough to make decentralized climate investment scalable?
2. **Systemic resilience.**
   Do they internalize macroprudential safeguards against infrastructure-contagion, interoperability breakdown, and digital run dynamics (Diamond and Dybvig, 1983; FSB, 2022; Tirole, 2011)?

3. **Environmental compatibility.**
   Do they avoid settlement architectures whose own energy footprint directly contradicts sustainability objectives (Krause and Tolaymat, 2018; de Vries, 2021)?

This triplet is what we call **sustainability-aligned settlement architecture**. This is the normative design criterion we are putting on the table.

5.2 Implications for green finance

Climate transition financing is extremely sensitive to reliability, continuity, and credibility. The promise of digital settlement is that it can democratize access to capital, enforce performance-linked disbursement, and reduce overhead. But if the rails are fragile – exposed to cyber shocks, fractured by geopolitics, or prone to instant panic – then "green finance" becomes brittle, procyclical, and politically vulnerable.

The result is strategic: sustainable finance cannot be treated as "just ESG money going to solar panels." It is inseparable from the architecture of cross-border settlement. In the digital era, climate finance is only as sustainable as the rails that carry it.

5.3 Policy orientations

Several policy directions follow:

1. **Regulatory sandboxing and staged deployment.**
   CBDCs, tokenized settlement corridors, and sustainability-linked programmable finance must be piloted under controlled conditions to test cyber resilience, governance, and liquidity backstops before scaling (BIS, 2022; IMF, 2022). This is macroprudential discipline, not just consumer protection.
2. **Interoperability standards as climate policy.**
   Common data, identity, and settlement standards (CPMI/FSB, 2020; CPMI, 2021) should be treated as prerequisites for climate finance to flow internationally. Interoperability is no longer a "technical nice-to-have"; it is a condition for decarbonization capital to reach emerging and frontier markets.
3. **Energy efficiency as a supervisory criterion.**
   The energy profile of settlement infrastructure should be supervised as part of its prudential assessment (Auer and Böhme, 2021; de Vries, 2021). High-emission consensus mechanisms are structurally misaligned with climate objectives. Permissioned, lower-energy CBDC-style architectures are more consistent with sustainable finance pipelines.
4. **Liquidity backstops for digital runs.**
   Just as deposit insurance and lender-of-last-resort facilities evolved to address classic bank runs (Diamond and Dybvig, 1983), credible liquidity backstops and resolution regimes may be required for systemically important digital settlement rails and stable-value instruments used in climate finance (Gorton and Zhang, 2022; FSB, 2022). Without them, digital run dynamics will remain an existential vulnerability.

6. CONCLUSION

6.1 Summary of findings

This paper has shown that digitalization of international settlement infrastructures is transforming the structure of transaction costs. Classical frictions – search, verification, enforcement, coordination – are being compressed through programmable settlement, shared ledgers, and automated compliance. This reduction in frictions is precisely what can make decentralized, performance-linked green finance scalable.

But the same transformation creates new systemic vulnerabilities. Settlement rails become single points of failure. Interoperability becomes geopolitical. Liquidity can flee instantaneously, generating digital runs that not only withdraw funding from climate projects but also politically stigmatize green finance as unstable and speculative. Furthermore, some high-energy consensus mechanisms threaten to undermine sustainability goals through their own carbon footprint.

The implication is direct: financial stability is no longer an external condition for the green transition. It is an intrinsic design parameter of the payment and settlement infrastructures through which climate finance moves.

6.2 Academic contribution

The core novelty of this paper is threefold.

First, we reinterpret international settlement infrastructures explicitly through the lens of transaction cost economics (Coase, 1937; Williamson, 1979; North, 1990), treating them as governance structures rather than neutral plumbing.

Second, we link that reinterpretation to the macroprudential debate on financial stability (Diamond and Dybvig, 1983; FSB, 2022), showing that digitalization does not simply reduce costs – it reallocates costs into systemic risk channels such as cyber fragility, interoperability breakdown, and digital run dynamics. We formalize "infrastructure-contagion" and "digital run dynamics" as structural features of the new regime.

Third, and most critically, we position settlement architecture as climate finance infrastructure. We introduce the concept of **sustainability-aligned settlement architecture**, defined as a cross-border settlement system that (i) compresses transaction costs to unlock green finance at scale, (ii) embeds systemic resilience, and (iii) is environmentally compatible. To our knowledge, no prior work has made this triad an explicit design criterion for international settlements in the context of the green transition.

This is not just an incremental theoretical refinement. It reframes the governance of digital settlement systems as climate policy by other means.

6.3 Policy implications

For central banks, supervisors, and international financial institutions, this means:

- Interoperability, cyber-resilience, and liquidity backstops in digital settlement rails are now part of climate finance strategy.
- Energy efficiency of settlement technology is not branding, but prudential alignment.
- Fragmentation of CBDCs and tokenized platforms is a direct threat to the ability to fund climate transition in emerging markets.

6.4 Limitations and future research

This study is conceptual. Future work should:

- Quantify the energy and carbon profiles of alternative settlement architectures (proof-of-work, proof-of-stake, permissioned DLT, CBDC platforms).
- Model digital run dynamics in sustainability-linked instruments, extending Diamond–Dybvig logic to programmable liquidity pools.
- Design and stress-test "green settlement corridors": interoperable, low-carbon, backstopped cross-border rails dedicated to climate finance.

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