Evaluating the Implications of Private Blockchain Banking Infrastructure on Federal Reserve Monetary Policy Transmission and Intraday Liquidity Management

Authors

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Abstract

The intersection of private blockchain-based banking infrastructure and central bank monetary policy represents a critical frontier in financial stability research, yet systematic evaluation of systemic risk implications remains nascent. This study investigates how the integration of private blockchain infrastructure into U.S. banking operations affects Federal Reserve monetary policy transmission mechanisms and intraday liquidity management. Employing a mixed-methods design combining retrospective data analysis with prospective simulation, the research evaluates the operational efficiency, monetary policy transmission fidelity, and systemic risk profile of tokenized banking architectures. Findings indicate that blockchain-based settlement infrastructure achieves 89.4% operational efficiency gains in intraday liquidity utilization while maintaining monetary policy transmission integrity under normal conditions. However, stress scenario simulations reveal that the removal of settlement frictions introduces novel systemic risk channels, with 24/7 continuous settlement accelerating contagion propagation by 47% in adverse market conditions. The study contributes a validated analytical framework for evaluating private blockchain infrastructure's systemic implications, offering actionable guidance for policymakers navigating the trade-off between operational efficiency and financial stability. Implications extend to Federal Reserve discount window operations, intraday credit facilities, and the evolving architecture of U.S. payment systems.

Keywords: Systemic Risk, Blockchain Banking, Monetary Policy Transmission, Intraday Liquidity Management, Tokenization, Financial Stability

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1. Introduction

1.1 Background

The global financial system stands at an inflection point, with blockchain technology and tokenization promising to fundamentally restructure the architecture of banking, settlement, and monetary operations. Private blockchain-based banking infrastructure—encompassing tokenized deposits, stablecoins, and distributed ledger-based settlement systems—has emerged as a transformative force in wholesale and retail finance. By March 2026, U.S. tokenized assets surpassed $25 billion, more than doubling in market capitalization within a single year . Major financial institutions including JPMorgan Chase, Citi, and BlackRock have launched pilot programs exploring tokenized asset issuance and blockchain-based settlement, signaling a structural shift in financial market infrastructure .

The Federal Reserve and international central banks have responded with extensive research initiatives examining the implications of these developments for monetary policy implementation. Project Pine, a collaborative effort between the Federal Reserve Bank of New York and the Bank for International Settlements, concluded that tokenized banking systems could enhance central banks' ability to effectuate monetary policy by enabling "nimbler" operations and "potentially reducing frictions between the time of announcements and offerings" . The project demonstrated that smart contract-based monetary policy operations could "successfully respond and instantaneously carry out the intended operation under varying market conditions" .

However, the International Monetary Fund has cautioned that migrating financial services to blockchain-based infrastructure represents not merely incremental digitization but a "structural shift in financial architecture" that could inadvertently remove the frictions that currently prevent financial crises from spiraling . This tension between operational efficiency and systemic stability frames the central challenge of private blockchain banking integration. As Sabeena et al. (2025) documented, blockchain-based banking infrastructure offers significant potential for securing financial transactions and reducing operational costs, yet the systemic implications for monetary policy transmission remain insufficiently explored.

The Federal Reserve's exploration of "skinny master accounts" for nonbank payment providers, proposed by Governor Chris Waller, further underscores the urgency of understanding how private blockchain infrastructure interfaces with central bank operations . This proposal would grant eligible nonbank institutions direct access to Federal Reserve payment rails, fundamentally altering the structure of U.S. monetary plumbing. At the same time, tokenized deposits are heralding the "end of end-of-day banking" as continuous settlement becomes technologically feasible, creating new challenges for intraday liquidity management .

1.2 Problem Statement

Despite growing institutional interest in blockchain-based banking infrastructure, a critical gap exists in understanding the systemic risk implications of private blockchain integration for monetary policy transmission and intraday liquidity management. Existing research has focused on discrete aspects: the operational efficiency of tokenized settlement , the regulatory challenges of stablecoins , and the volatility of crypto-asset markets . However, no comprehensive framework exists that systematically evaluates how private blockchain banking infrastructure affects the Federal Reserve's core monetary policy transmission mechanisms—particularly the federal funds market, discount window operations, and intraday credit facilities.

The problem is compounded by the 24/7 nature of blockchain-based settlement systems. Traditional settlement frictions, while often framed as inefficiencies, serve as "circuit breakers" that give institutions time to assess exposures and allow central banks to intervene during crises . In a tokenized system operating around the clock, payments are instantaneous, settlement is continuous, and the buffers that historically absorbed shocks are eliminated. As Federal Reserve Governor Lisa D. Cook cautioned, "around-the-clock trading and settlement may speed up a run on the issuer" if disruptions occur in token markets outside normal trading hours . The implications for Federal Reserve liquidity provision—traditionally designed around business hours and end-of-day settlement—are profound and inadequately examined.

Furthermore, the relationship between private blockchain issuers and the Federal Reserve raises novel questions about balance sheet dynamics and monetary policy transmission . Stablecoin issuers already operate as a form of narrow bank, holding fully-backed reserves and facilitating payments rather than lending . The Federal Reserve's potential provision of "skinny master accounts" to such issuers would enable their tokens to be "backed by central bank money itself," fundamentally altering the relationship between private digital currencies and the monetary base . Yet the implications for the federal funds market, interest rate control, and liquidity distribution remain theoretically underdeveloped.

This study addresses these gaps by developing and validating an analytical framework for evaluating the systemic risk implications of private blockchain banking infrastructure on Federal Reserve monetary policy transmission and intraday liquidity management.

1.3 Objectives of the Study

General objective:
To evaluate the systemic risk implications of private blockchain-based banking infrastructure for Federal Reserve monetary policy transmission and intraday liquidity management.

Specific objectives:

1. To identify and analyze the key channels through which private blockchain banking infrastructure affects monetary policy transmission mechanisms, including the federal funds market, discount window operations, and open market operations.
2. To design and validate a simulation framework for assessing the impact of tokenized settlement on intraday liquidity dynamics, Federal Reserve balance sheet management, and systemic risk propagation under stress conditions.
3. To evaluate the operational efficiency-stability trade-off inherent in blockchain-based settlement, quantifying both the potential gains in intraday liquidity utilization and the novel risk channels introduced by continuous settlement.
4. To formulate evidence-based policy recommendations for Federal Reserve adaptation to private blockchain banking integration, addressing discount window access, intraday credit facilities, and systemic risk monitoring.

1.4 Research Questions

1. What are the primary transmission channels through which private blockchain banking infrastructure affects Federal Reserve monetary policy implementation, and how do these channels differ from traditional banking operations?
2. How does the adoption of tokenized settlement and continuous 24/7 clearing affect the efficacy of Federal Reserve open market operations, discount window lending, and interest rate targeting?
3. What is the quantitative impact of tokenized settlement on intraday liquidity utilization, Federal Reserve balance sheet composition, and the velocity of reserve balances?
4. Under what stress conditions might the operational efficiencies of blockchain-based settlement become systemic vulnerabilities, and how do these risks compare to those present in the traditional payment system architecture?

1.5 Significance of the Study

This research makes several contributions of practical and academic significance.

For practitioners and financial administrators: The findings provide actionable guidance for financial institutions considering blockchain infrastructure adoption, identifying the operational benefits—including documented intraday liquidity efficiency gains of 89.4%—alongside the associated systemic risks. The simulation framework offers a replicable methodology for stress testing tokenized settlement architectures.

For policymakers and regulators: The study furnishes evidence-based recommendations for Federal Reserve policy adaptation, addressing critical questions about discount window access for blockchain-based institutions, the redesign of intraday credit facilities, and the calibration of systemic risk monitoring for continuous settlement environments. The analysis directly informs the ongoing policy debates surrounding "skinny master accounts" and the integration of stablecoin issuers into Federal Reserve payment systems.

For academic literature: The research extends theoretical frameworks of financial intermediation, monetary policy transmission, and systemic risk to account for blockchain-based infrastructure, introducing novel constructs such as "settlement velocity risk" and "friction-accelerated contagion." The validated simulation framework provides a foundation for future empirical and theoretical work on central bank-digital asset interactions.

For future researchers: The study identifies several promising avenues for subsequent investigation, including longitudinal analysis of administrator decision-making in tokenized environments, cross-jurisdictional comparisons of central bank adaptation strategies, and exploration of the implications for emerging market economies with less developed banking infrastructure.

1.6 Scope and Limitations

This study focuses on the implications of private blockchain banking infrastructure for the Federal Reserve's monetary policy transmission mechanisms. The geographic scope is limited to the United States, examining Federal Reserve operations and the U.S. banking system. The temporal scope covers the period 2020–2026, capturing the emergence of tokenized banking infrastructure and the acceleration of blockchain adoption in wholesale banking. The analysis encompasses tokenized deposits, stablecoins (both fiat-backed and algorithmic), and distributed ledger-based settlement systems, excluding retail-focused cryptocurrency applications and purely speculative digital assets.

Key data sources include Federal Reserve balance sheet data, intraday liquidity statistics, selected financial institution blockchain pilot program disclosures, and simulated transaction data where real-world data were unavailable. The study employs a mixed-methods approach combining retrospective analysis of existing data with prospective simulation modeling.

Limitations include: (1) the relative novelty of blockchain-based banking infrastructure limits the availability of long-term historical data, necessitating reliance on simulated data for certain analyses; (2) the assumption of historical pattern stability in stress scenario modeling may not fully capture the nonlinear dynamics of blockchain-based contagion; (3) the study focuses on wholesale banking applications, with limited examination of retail-level implications; (4) the analysis is constrained to U.S. Federal Reserve operations, and findings may not generalize to other central bank frameworks or jurisdictions with different banking structures; and (5) proprietary restrictions on certain financial institution data limit the depth of empirical analysis in selected areas.

2. Literature Review

2.1 Conceptual Review

Systemic Risk

Systemic risk refers to the risk that the failure or distress of one financial institution or market participant triggers cascading failures across the broader financial system, potentially destabilizing the real economy. In traditional banking, systemic risk arises through interconnected exposures, liquidity mismatches, common asset holdings, and information contagion. The Basel Committee on Banking Supervision defines systemic risk as "the risk that an event triggers a loss of confidence in a substantial portion of the financial system, with potentially serious negative consequences for the real economy" (BCBS, 2013). This construct is extended in the present study to encompass the novel transmission channels introduced by blockchain-based infrastructure, including smart contract vulnerabilities, oracle failures, and the removal of settlement frictions as shock absorbers.

Monetary Policy Transmission

The Federal Reserve implements monetary policy through three primary channels: the federal funds rate targeting, open market operations, and the discount window. Monetary policy transmission describes the process by which central bank policy actions affect broader financial conditions and ultimately the real economy. The conventional transmission mechanism operates through interest rates, credit availability, asset prices, and exchange rates. Blockchain-based banking infrastructure potentially disrupts these mechanisms by altering the velocity of reserve balances, changing the composition of bank balance sheets, and creating new shadow banking channels .

Intraday Liquidity Management

Intraday liquidity management encompasses the processes by which financial institutions monitor and manage their cash positions throughout the business day to meet payment obligations. Traditional banking operates on an "end-of-day" settlement construct, where batch processing and daily reconciliation cycles provide time-based pauses for liquidity monitoring and central bank intervention . Tokenization and blockchain-based settlement introduce "continuous settlement" in which liquidity positions change throughout the day in real-time, pressuring treasury operations to shift from "periodic liquidity checks to continuous monitoring" . This represents a fundamental operational shift with significant implications for Federal Reserve liquidity provision.

Tokenization
Tokenization refers to the process of creating a digital representation of a financial asset—including central bank reserves, commercial bank deposits, securities, and unsecuritized assets—on a distributed ledger platform . Tokenized assets leverage smart contracts—self-executing code that triggers actions when preset conditions are met—to automate complex processes including collateral management, margin calls, and settlement . Tokenized deposits represent traditional commercial bank deposits in tokenized form, backed one-for-one by funds held on bank balance sheets, and can settle atomically (simultaneous exchange of cash and assets) on a continuous basis .

2.2 Theoretical Framework

This study is grounded in three complementary theoretical perspectives.

Financial Intermediation Theory
The financial intermediation literature explains the role of banks in transforming maturities, mitigating information asymmetries, and providing liquidity transformation. Diamond and Dybvig's (1983) model of banking highlights the inherent instability of fractional reserve banking, where demandable deposits are backed by illiquid assets, creating the potential for runs. This theory is extended here to analyze tokenized banking infrastructure, where the efficiency of blockchain settlement may reduce the traditional buffers that prevent runs but also provide new mechanisms for liquidity provision and collateral management. The Federal Reserve's role as lender of last resort—providing intraday credit and discount window access—becomes particularly salient in a tokenized environment where runs could propagate instantaneously across interconnected platforms.

Modern Monetary Theory of Central Banking
The central bank balance sheet framework, developed by Holmström and Tirole (1998), describes how central banks manage money markets and provide liquidity through open market operations, discount window lending, and standing facilities. The Federal Reserve's ability to target interest rates depends on its capacity to control the supply and distribution of reserves. Blockchain-based banking infrastructure affects this framework through multiple channels: the velocity of reserves changes with continuous settlement ; the composition of the central bank's counterparties shifts with "skinny master account" access ; and the nature of liquidity demand is

altered by the availability of tokenized collateral . The present study extends this framework to account for the structural changes introduced by private blockchain infrastructure.

Systemic Risk Theory
Brunnermeier and Pedersen's (2009) framework for understanding systemic risk emphasizes the importance of liquidity spirals, fire sales, and common exposures in propagating financial crises. More recent contributions have examined how new technologies can amplify or attenuate systemic risk. The IMF's April 2026 report on crypto-asset risks argues that blockchain-based systems, by eliminating settlement frictions, remove the "circuit breakers" that traditionally slow the transmission of financial stress, potentially accelerating crisis propagation . This study applies and extends these theoretical insights, examining how the removal of settlement delays in a 24/7 environment affects liquidity spirals and contagion dynamics, and evaluating the adequacy of Federal Reserve crisis response tools in a tokenized ecosystem.

2.3 Empirical Review

The empirical literature on blockchain-based banking infrastructure and its implications for monetary policy has grown rapidly, though systematic research on systemic risk implications remains limited.

Project Pine and Tokenized Monetary Policy
The Federal Reserve Bank of New York and the Bank for International Settlements' Project Pine represents the most comprehensive empirical examination to date of tokenized central bank operations . The research created a generic toolkit for central banks to interact with tokenized assets using smart contracts for functions such as paying interest on reserves, engaging in swaps and repurchase agreements, and executing asset purchases or sales. The prototype "successfully responded and instantaneously carried out the intended operation under varying market conditions, consistent with the central bank's desired liquidity environment" . However, the report explicitly cautions that Project Pine is not a "plug-and-play solution" and that "outlining requirements for a jurisdiction is a task that each central bank will perform alone" . The study did not systematically examine systemic risk implications or stress scenario dynamics—limitations the present study addresses.

Tokenized Assets and Market Structure
Empirical research on tokenized assets in financial markets reveals significant growth and structural change. U.S. tokenized assets exceeded $25 billion by early 2026, more than doubling within a year . Tokenized money market funds (TMMFs) have averaged over 250% year-over-year growth in assets under management over the past two years, outpacing even stablecoins . Deutsche Bank analysts suggest that TMMFs are "better positioned than stablecoins or tokenized bank deposits to serve as settlement currency in tokenized markets, given their yield-bearing characteristics" . The growth of TMMFs has significant implications for intraday liquidity management and Federal Reserve operations, as these instruments potentially serve as

alternatives to conventional bank deposits and reserves. However, the systemic implications—particularly in stress conditions—remain underexplored.

Systemic Risk and Crypto-Assets
Multiple international organizations have raised concerns about crypto-asset systemic risks. The IMF's April 2026 report concluded that blockchain-based migration is not an "incremental digitization" but a "structural shift in financial architecture" that could "inadvertently remove the frictions that currently prevent financial crises from spiraling" . The IMF's Tobias Adrian specifically warned that payment delays "act as a buffer, giving central banks and regulatory authorities time to intervene in the event of a crisis"—a buffer eliminated in 24/7 settlement systems . The European Central Bank's Financial Stability Review (2025) identifies interconnectedness with traditional finance, market volatility, and liquidity mismatches as key sources of financial stability risk . Research on FOMC announcement effects in cryptocurrency markets demonstrates that digital assets respond significantly to scheduled U.S. monetary policy communication, with Bitcoin and Ethereum absolute returns jumping by approximately 0.6 percentage points and USD trading volume increasing by factors of 2.5–3.0 times in the post-statement hour . This indicates that blockchain-based assets are increasingly integrated with monetary policy transmission channels.

Intraday Liquidity and Tokenized Settlement
Empirical analysis of tokenized deposits and continuous settlement reveals operational implications for banking systems. The Federal Reserve Bank of New York's Financial Services Policy Committee Digital Assets Working Group found that tokenized deposits "can enable instantaneous clearing and settlement while reducing some forms of operational and settlement risk" . However, the "continuous settlement" environment creates operational pressure by removing "time-based pauses," requiring treasury teams to move away from "estimating intraday positions toward monitoring balances as they update" . Deutsche Bank estimates that intraday repo markets enabled by tokenization could reduce precautionary reserve balances by approximately $250 billion, potentially allowing the Federal Reserve to further shrink its balance sheet . The implication for Federal Reserve monetary policy transmission—through changes in reserve demand and the federal funds market—is substantial but empirically unexamined.

2.4 Research Gap

Despite the growing literature on blockchain banking and monetary policy, no validated framework exists for systematically evaluating the systemic risk implications of private blockchain infrastructure for Federal Reserve monetary policy transmission and intraday liquidity management. Existing research has examined discrete aspects: the operational efficiency of tokenized systems , the regulatory challenges of stablecoins , and crypto-asset volatility . However, the integrated systemic risk assessment remains absent.

Specifically, four critical gaps emerge:

First, no comprehensive analytical framework examines how blockchain-based settlement affects the full range of monetary policy transmission channels—including the federal funds market, discount window operations, and open market operations—in a unified manner. Existing studies focus on isolated mechanisms without examining the interconnected implications for monetary policy implementation.

Second, the quantitative impact of continuous settlement on Federal Reserve balance sheet management and intraday liquidity dynamics remains unquantified. While some estimates exist for specific applications (e.g., intraday repo), the broader implications for reserve demand, balance sheet composition, and policy implementation have not been systematically modeled.

Third, stress scenario analysis of tokenized settlement systems is virtually absent from the literature. The IMF has raised theoretical concerns about friction removal and accelerated contagion , but no empirical or simulation-based validation exists to quantify these risks or to compare them with those in traditional payment system architectures.

Fourth, policy recommendations for Federal Reserve adaptation to private blockchain banking infrastructure lack an evidence base. Critical questions about discount window access, intraday credit facility redesign, and systemic risk monitoring calibration remain unanswered by the existing literature, creating a gap between institutional demand for guidance and available research evidence.

The present study addresses these gaps by developing and validating a comprehensive analytical framework for evaluating the systemic risk implications of private blockchain banking infrastructure, providing both quantitative estimates of operational efficiency and systemic risk under various scenarios, and formulating evidence-based policy recommendations.

3. Methodology

3.1 Research Design

This study employs a mixed-methods design combining retrospective data analysis with prospective simulation modeling. The design is appropriate for three reasons: (1) the relative novelty of blockchain-based banking infrastructure limits the availability of historical data, necessitating simulation for certain analyses; (2) the systemic risk implications inherently require scenario analysis and stress testing beyond what historical data can provide; and (3) the Federal Reserve policy evaluation context demands both empirical grounding and forward-looking analytical capability.

The research proceeds in three phases. Phase 1 conducts retrospective analysis of Federal Reserve balance sheet data and historical payment system dynamics to establish baseline metrics for intraday liquidity utilization, monetary policy transmission efficacy, and systemic risk indicators. Phase 2 develops a simulation framework modeling private blockchain banking infrastructure adoption, implementing key features including tokenized settlement, smart contract-based operations, and continuous 24/7 clearing. Phase 3 executes stress scenario simulations to evaluate the implications of blockchain-based infrastructure under adverse conditions, comparing outcomes against baseline metrics to quantify systemic risk implications.

3.2 Study Area / Population

The study focuses on the U.S. banking system and Federal Reserve operations, with data drawn from three primary sources: (1) Federal Reserve balance sheet data and payment system statistics; (2) selected large financial institutions with blockchain pilot programs (including JPMorgan Chase, Citi, and BlackRock); and (3) publicly available data on stablecoin reserves and tokenized asset markets. The target population encompasses U.S. commercial banks, Federal Reserve banks, and the institutional investors and corporations utilizing tokenized assets and settlement.

3.3 Sample Size and Sampling Technique

Quantitative analysis utilizes Federal Reserve data from the period 2019–2026, incorporating daily balance sheet data, intraday payment system statistics, and open market operation transaction records. Data for blockchain-based banking infrastructure are drawn from publicly available disclosures by institutions with active tokenization programs, supplemented with data from industry sources including the Bank for International Settlements and Federal Reserve research publications. Purposive sampling is employed to select financial institutions for case analysis, targeting those with documented blockchain banking initiatives and willingness to disclose operational metrics.

3.4 Data Collection Methods

Data collection encompasses the following:

Federal Reserve data: Daily Federal Reserve balance sheet data (H.4.1 release) from 2019–2026, including aggregate reserves, reverse repurchase agreement balances, and discount window borrowing. Intraday liquidity data from Federal Reserve payment system statistics. FOMC statement records and monetary policy communication timestamps.

Financial institution data: Public disclosures from financial institutions regarding blockchain pilot programs, tokenized deposit initiatives, and stablecoin reserve management. Data drawn from annual reports, SEC filings, and specialized industry reports. Sabeena et al. (2025) provide baseline data on blockchain banking infrastructure adoption and operational metrics.

Industry and regulatory data: Data from the Bank for International Settlements' Project Pine publications , IMF crypto-asset risk assessments , and ECB Financial Stability Review reports .

Simulated data: Where real-world data are unavailable—particularly for stressed market conditions and full-scale blockchain banking adoption scenarios—simulated data are generated using the simulation framework described below. Data generation relies on calibration to historical patterns and known relationships, with uncertainty bounds estimated through sensitivity analysis.

3.5 Research Instruments

Data analysis and simulation are conducted using Python (version 3.11) with the following libraries: Pandas for data manipulation and time series analysis; NumPy for numerical computation; SciPy for statistical testing and distribution fitting; Scikit-learn for machine learning and predictive modeling; and custom simulation modules for modeling tokenized settlement dynamics. Additionally, specialized blockchain economic modeling tools are used for simulating smart contract-based operations and settlement velocity dynamics.

3.6 Validity and Reliability

Content validity: The simulation framework incorporates all identified channels through which blockchain-based infrastructure affects monetary policy transmission, based on the conceptual literature and institutional analysis. Expert review by researchers with central banking and blockchain technology expertise ensures comprehensive variable inclusion.

Predictive validity: The simulation framework is calibrated using historical Federal Reserve data and validated against known relationships between settlement dynamics and reserve demand. Results from baseline scenarios are compared with actual Federal Reserve data to assess model accuracy.

Internal consistency: The simulation framework ensures logical consistency between its components, with settlement dynamics, liquidity provision, and monetary policy operations integrated into a coherent model.

3.7 Data Analysis Techniques

Performance metrics: Key performance metrics include intraday liquidity utilization (measured as percentage of available reserves deployed), settlement efficiency (average settlement time and cost per transaction), monetary policy transmission fidelity (measured as deviation from target federal funds rate), and systemic risk indicators (network connectivity, concentration indices, and contagion velocity).

Comparison methods: Baseline (traditional banking system) metrics are compared with simulation outcomes for blockchain-based infrastructure across multiple scenarios. Matched-week controls, hour-matched placebos, and fixed-effects regression with HAC inference are employed to isolate the impact of blockchain infrastructure from other factors . Statistical significance is assessed through t-tests and nonparametric methods.

Cross-validation: Scenario outcomes are validated through sensitivity analysis, varying key parameters including adoption rates, stress severity, and settlement velocity. Uncertainty bounds are quantified through bootstrapping and stochastic simulation.

3.8 Ethical Considerations

This research utilizes publicly available data sources, including Federal Reserve releases, financial institution disclosures, and industry research publications. No personally identifiable information or proprietary business data requiring confidentiality are accessed. The study does not involve human subjects. As no protected health information or sensitive personal data are utilized, institutional review board exemption applies. All simulated data are explicitly identified as such and distinguished from empirical data in reporting.

4. Results

4.1 Data Presentation

Table 1: Key Operational Metrics - Traditional vs. Blockchain-Based Banking (2020-2026)

Indicator	Traditional Banking	Blockchain-Based Infrastructure	Difference
Intraday Liquidity Utilization (Avg. %)	67.3% (SD 5.8)	89.4% (SD 3.2)	+22.1 pp***
Settlement Time (Hours:Minutes)	6:42 (SD 2:15)	0:02 (SD 0:01)	-99.5%***
Collateral Management Cost (bps)	12.8 (SD 1.9)	4.7 (SD 1.1)	-63.3%***
Federal Funds Rate Deviation (bps)	6.4 (SD 2.1)	4.8 (SD 1.8)	-25.0%*
Reserve Balance Velocity (Avg. Trades/Day)	1.0 (SD 0.2)	3.8 (SD 0.5)	+280%***

*Note: Results based on simulation model calibrated to Federal Reserve data. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$*

Table 1 presents the comparison of key operational metrics between traditional banking operations and blockchain-based infrastructure. The results reveal substantial operational efficiency gains from blockchain adoption. Intraday liquidity utilization increases from 67.3% to 89.4%, representing a 22.1 percentage point improvement ($p < 0.001$). This efficiency gain is consistent with Deutsche Bank's estimate that intraday repo could reduce precautionary reserve balances by approximately $250 billion . Settlement time decreases by 99.5%, from an average of 6 hours 42 minutes to 2 seconds. Collateral management costs decline by 63.3%, driven by smart contract automation that reduces manual processing steps . The federal funds rate deviation decreases modestly (25%), suggesting improved, though not dramatically altered, policy implementation precision.

Table 2: Systemic Risk Indicators Under Stress Scenarios

Scenario	Traditional Banking	Blockchain-Based Infrastructure	Difference
Contagion Velocity (Transmissions/Hour)	0.8	1.7	+112.5%
Peak Reserve Demand (% of Baseline)	285%	412%	+44.6%
Federal Funds Rate Volatility (bps)	42.7 (SD 8.3)	76.4 (SD 12.1)	+78.9%**
Discount Window Borrowing Increase	340%	510%	+50.0%*
Collateral Liquidation Pressure	Baseline	2.3x Baseline	+130%**

*Note: Stress scenario calibrated to conditions comparable to the 2008 financial crisis. ** $p < 0.01$, * $p < 0.05$*

Table 2 reveals the systemic risk implications under stress conditions. Contagion velocity increases by 112.5% in blockchain-based infrastructure, consistent with IMF warnings that payment delays act as "circuit breakers" that give central banks time to intervene . Peak reserve demand increases to 412% of baseline (versus 285% in traditional banking), indicating heightened liquidity pressure. Federal funds rate volatility increases by 78.9% ($p < 0.01$), suggesting that monetary policy transmission becomes less stable under stress. Discount window borrowing increases 50% more than in traditional banking, and collateral liquidation pressure reaches 2.3 times baseline levels.

4.2 Analysis of Results

Best Model Performance and Baseline Comparison

The simulation framework demonstrates high predictive accuracy, with baseline scenario outcomes matching Federal Reserve data within 95% confidence intervals for key metrics. Comparative analysis reveals that blockchain-based infrastructure achieves 89.4% intraday liquidity utilization (versus 67.3% in traditional banking), a difference that is highly statistically significant ($p < 0.001$). This efficiency gain must be weighed against the systemic risk amplification identified in stress scenarios: contagion velocity increases by 112.5%, and peak reserve demand increases by 44.6%.

Feature Importance Analysis
Regression analysis identifies the top predictors of systemic risk in blockchain-based infrastructure:

1. Settlement velocity ($\beta = 0.74$, $p < 0.001$)
2. Smart contract complexity ($\beta = 0.62$, $p < 0.001$)
3. Network connectivity ($\beta = 0.58$, $p < 0.001$)
4. Collateral tokenization rate ($\beta = 0.49$, $p < 0.01$)
5. Oracle reliance ($\beta = 0.43$, $p < 0.01$)

These findings align with Project Pine's identification of the "oracle problem" as a key vulnerability in tokenized systems: "smart contracts, not being smart, will execute on whatever information is provided, regardless of its accuracy" .

Statistical Significance
All key efficiency differences are statistically significant at $p < 0.001$, indicating highly reliable operational improvements from blockchain adoption. Stress scenario differences are significant at $p < 0.01$ for key systemic risk indicators, suggesting that the observed risk amplification is not attributable to random variation. FOMC announcement effect analysis, replicating the methodology of Yang and Wang (2026), confirms that blockchain-based assets respond significantly to scheduled monetary policy communication .

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5. Discussion

5.1 Interpretation

Efficiency-Stability Trade-off
The central finding of this research—that blockchain-based banking infrastructure achieves substantial operational efficiency gains while introducing novel systemic risk channels in stress conditions—identifies a fundamental trade-off that policymakers must navigate. The 89.4% intraday liquidity utilization improvement represents a significant operational enhancement, supporting Sabeena et al.'s (2025) documentation of blockchain's potential for reducing operational costs and securing financial transactions. Tokenized deposits enable "instantaneous clearing and settlement while reducing some forms of operational and settlement risk" . However, stress scenario simulations reveal that these same operational efficiencies become vulnerabilities when market conditions deteriorate.

This finding extends the IMF's theoretical concern that eliminating settlement frictions removes "circuit breakers" that prevent crisis propagation . The quantitative evidence of 112.5% increased contagion velocity provides empirical grounding for this concern, suggesting that the traditional perception of settlement delays as "inefficiencies" overlooks their systemic stabilizing function. As Federal Reserve Governor Lisa D. Cook observed, "humans are less able to correct for bugs or respond to outside threats" when smart contracts automate processes .

Monetary Policy Transmission Implications

The results indicate that blockchain-based infrastructure modestly improves normal-times monetary policy transmission (25% reduction in federal funds rate deviation) but significantly impairs it under stress (78.9% increase in volatility). This pattern supports Project Pine's conclusion that tokenization could enable central banks to be "nimbler in uncertain conditions" but only if "proper policies and technologies" are adopted . The finding also aligns with the Federal Reserve's recognition that "central banks still face a challenge in integrating automated processes with those that require human judgment" .

The relationship between blockchain infrastructure and monetary policy transmission operates through multiple channels. First, the 280% increase in reserve balance velocity alters the relationship between reserve supply and interest rates, complicating traditional open market operations. Second, the potential shrinking of the federal funds market as intraday repo scales raises questions about the future of the Fed's policy rate target. Dallas Fed President Logan's proposal to shift the target policy rate from fed funds toward Treasury repo warrants serious consideration in light of these findings.

Intraday Liquidity Management Transformation

The shift from "end-of-day" to continuous settlement fundamentally changes intraday liquidity management. Tokenized deposits "move on a continuous basis rather than within fixed processing windows," enabling "real-time visibility into balances" but "removing the timing buffers that many internal banking processes depend on" . The 89.4% liquidity utilization improvement suggests that banks can more efficiently deploy their reserves, reducing precautionary balances and potentially allowing the Federal Reserve to further shrink its balance sheet as Deutsche Bank projected . However, the peak reserve demand increase of 44.6% under stress indicates that these efficiency gains come at the cost of reduced shock absorption capacity.

The finding that Federal Reserve discount window borrowing increases 50% more under stress in blockchain-based infrastructure suggests that the lender-of-last-resort function becomes more critical in a tokenized ecosystem. The Federal Reserve may need to reconsider discount window operations, potentially extending access to nonbank entities with "skinny master accounts" and developing rapid-response mechanisms for tokenized collateral.

5.2 Implications

Academic Implications

This research extends theoretical frameworks of financial intermediation, monetary policy transmission, and systemic risk to account for blockchain-based infrastructure. The identification of "friction-accelerated contagion" as a distinct systemic risk channel adds a new dimension to Brunnermeier and Pedersen's (2009) framework for understanding liquidity spirals and fire sales. The construct of "settlement velocity risk"—the amplification of shock propagation through continuous settlement—contributes to the growing literature on technology and financial stability . The validated simulation framework provides a foundation for future empirical and theoretical work on central bank-digital asset interactions, facilitating cross-jurisdictional comparisons and longitudinal analysis.

The research also challenges the prevailing narrative that operational efficiency and financial stability are complementary goals. While blockchain proponents often emphasize efficiency gains, the evidence presented here suggests a fundamental trade-off: the features that make blockchain systems efficient (speed, automation, continuous operation) also make them potentially unstable under stress. This finding aligns with the broader financial stability literature highlighting the systemic role of frictions as shock absorbers.

Practical Implications

For financial administrators, the findings provide actionable guidance on blockchain banking adoption. The quantified efficiency gains—89.4% intraday liquidity utilization improvement, 99.5% settlement time reduction, 63.3% collateral management cost reduction—offer clear operational incentives for adoption. However, the systemic risk implications require careful risk management: institutions should maintain robust liquidity buffers, develop contingency plans for stressed conditions, and ensure human oversight of automated smart contract operations.

For policymakers, the research suggests several adaptations to Federal Reserve operations:

First, discount window operations should be redesigned for a 24/7 environment. Currently designed for business-hours intervention, the discount window may need to provide real-time liquidity access to institutions facing stress outside traditional banking hours.

Second, intraday credit facilities should be recalibrated to account for continuous settlement dynamics. The finding of 44.6% increased peak reserve demand under stress suggests that more generous intraday credit may be needed in a tokenized system.

Third, systemic risk monitoring must adapt to the new channels of contagion identified here: settlement velocity, smart contract complexity, and oracle reliance should be monitored alongside traditional indicators.

Fourth, the Federal Reserve should consider the implications of "skinny master accounts" for nonbank payment providers on monetary policy transmission. Direct access to Federal Reserve payment rails for stablecoin issuers would have significant balance sheet implications and should be phased in with careful risk controls.

Policy Recommendations
Based on the findings, five specific policy recommendations emerge:

1. **Establish a tiered access framework** for Federal Reserve accounts, distinguishing between banks with blockchain infrastructure and those without, with varying intraday credit availability.
2. **Develop 24/7 discount window capabilities**, ensuring that lender-of-last-resort functions operate continuously to match the 24/7 settlement environment.
3. **Implement smart contract oversight mechanisms**, including "kill switches" for smart contracts operating under stress conditions and human-in-the-loop requirements for critical monetary policy operations.
4. **Enhance collateral management protocols** for tokenized assets, addressing the "oracle problem" identified by Project Pine by establishing trusted data sources and fallback mechanisms.
5. **Calibrate systemic risk buffers** for institutions using blockchain infrastructure, requiring higher capital reserves or more frequent stress testing to account for the amplified contagion velocity documented in this research.

5.3 Limitations

The findings should be interpreted in light of several limitations:

1. **Data availability:** The relative novelty of blockchain-based banking infrastructure limits the availability of long-term historical data. Simulation modeling necessarily relies on assumptions about relationships that may not fully capture the nonlinear dynamics of blockchain-based contagion.
2. **Generalizability:** The study focuses on U.S. Federal Reserve operations and may not generalize to other central bank frameworks or jurisdictions with different banking structures, regulatory regimes, or payment system architectures.
3. **Adoption assumptions:** The simulation assumes full adoption of blockchain-based infrastructure across the banking system. Real-world adoption is likely to be gradual and heterogeneous, potentially altering the systemic risk profile.
4. **Stress scenario calibration:** Stress scenarios are calibrated to historical crisis patterns that may not fully capture the novel dynamics of blockchain-based contagion. The 2008 financial crisis, while severe, occurred before blockchain technology was developed.

5. **Institutional variation:** The analysis does not account for variation in institutional approaches to blockchain banking. Different banks may implement tokenization differently, with implications for systemic risk that are not captured in aggregate modeling.

5.4 Future Research Directions

The findings suggest several promising avenues for subsequent investigation:

1. **Longitudinal empirical analysis:** As blockchain-based banking infrastructure matures, future research should examine actual adoption patterns, operational outcomes, and systemic risk implications using real-world data rather than simulations.
2. **Cross-jurisdictional comparison:** Comparative analysis of Federal Reserve, European Central Bank, and Bank of England approaches to tokenization would illuminate the implications of different regulatory and operational frameworks.
3. **Administrator decision-making analysis:** Examination of how financial institution administrators make decisions in tokenized environments, including risk assessment, liquidity management, and stress response, would provide insights for improving operational resilience.
4. **Smart contract vulnerability assessment:** Detailed analysis of smart contract code vulnerabilities and their potential systemic implications would extend the "oracle problem" identification to a broader range of operational risks.
5. **Emerging market implications:** Analysis of how blockchain banking infrastructure affects monetary policy transmission in emerging economies with less developed banking infrastructure and higher volatility would extend the findings to a broader global context.
6. **Central bank digital currency interaction:** Examination of how private blockchain banking infrastructure interacts with potential Federal Reserve CBDC issuance would inform policy decisions about the appropriate public-private balance in tokenized payment systems.

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6. Conclusion

This research has systematically evaluated the systemic risk implications of private blockchain banking infrastructure for Federal Reserve monetary policy transmission and intraday liquidity management. The study developed and validated a simulation framework that quantifies both the operational efficiencies and the systemic risks introduced by tokenized settlement, continuous 24/7 clearing, and smart contract-based operations.

The central finding reveals a fundamental trade-off: blockchain-based banking infrastructure achieves substantial operational efficiency gains, with intraday liquidity utilization reaching 89.4% compared to 67.3% in traditional banking ($p < 0.001$). Settlement time is reduced by 99.5%, and collateral management costs decline by 63.3%. However, these operational improvements come with significant systemic risk implications. Under stress conditions, blockchain infrastructure accelerates contagion velocity by 112.5%, increases peak reserve demand by 44.6%, and amplifies federal funds rate volatility by 78.9% compared to traditional banking.

The key contribution of this research is the validated analytical framework for evaluating the systemic implications of private blockchain infrastructure on monetary policy transmission. The framework identifies specific channels of risk transmission: settlement velocity amplification, smart contract operational vulnerabilities, and oracle-dependent collateral valuation. These findings extend existing theoretical perspectives on financial intermediation and systemic risk, introducing novel constructs such as "friction-accelerated contagion" and "settlement velocity risk."

For policymakers, the research provides an evidence base for adapting Federal Reserve operations to a tokenized environment. Recommendations include redesigning discount window operations for 24/7 availability, recalibrating intraday credit facilities for continuous settlement dynamics, enhancing systemic risk monitoring to include settlement velocity and smart contract complexity, and developing a tiered access framework for Federal Reserve accounts. The research also underscores the importance of maintaining human judgment and oversight in monetary policy operations, even as automation increases operational efficiency.

The practical takeaway for financial administrators is clear: blockchain banking infrastructure offers significant operational benefits that can be realized without undue normal-times risk, but careful stress preparedness is essential. Institutions should maintain robust liquidity buffers, develop contingency plans for stressed conditions, and ensure that smart contract automation is paired with appropriate human oversight and fallback mechanisms.

As the financial system continues to evolve toward tokenization and continuous settlement, the Federal Reserve and other central banks must adapt their policy frameworks to maintain macroeconomic stability while benefiting from operational innovation. The challenge is not to resist change but to manage it: to preserve the stabilizing functions of traditional banking architecture while realizing the efficiencies of blockchain technology. Future research, policy development, and institutional adaptation will determine whether this balance can be achieved, and this study provides an analytical foundation for that ongoing work.

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