A Quantitative Framework for Safe AMM-Based Settlement: Applying the Jackson Liquidity Framework

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Abstract

Instant settlement and tokenised financial infrastructure promise lower counterparty risk and faster transaction finality, but at the cost of significantly increased liquidity demand. As payment systems transition toward atomic settlement and AMM-based FX conversion, institutions must size and manage liquidity under new and nonlinear dynamics.

This whitepaper introduces a practical, regulator-compatible interpretation of the Jackson Liquidity Framework (JLF), designed to help FMIs, central banks and liquidity-managing institutions quantify required reserves, assess corridor stability and visualise liquidity behaviour under both normal and stressed operating conditions.

Using Monte Carlo simulations and case studies—covering baseline Poisson flows, intraday clustering (Hawkes), and liquidity fragmentation—the paper demonstrates how AMM-based settlement can operate safely and predictably when supported by JLF's four components: the Jackson Liquidity Requirement (JLR), the Jackson Stability Invariant (JSI), the Jackson Liquidity Surface (JLS), and the Jackson Corridor Coefficient (J-score).

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1 Executive Summary

The shift toward instant or atomic settlement is remaking the liquidity foundations of the global financial system. Tokenised assets, CBDC experiments and programmable settlement mechanisms promise efficiency gains, but they also expose institutions to intraday liquidity volatility not addressed by existing regulatory frameworks.

This whitepaper presents the Jackson Liquidity Framework (JLF), a unified methodology for quantifying, monitoring and managing liquidity in AMM-based FX corridors and next-generation settlement systems. The framework provides four components:

- **JLR** — a minimum liquidity requirement combining slippage limits, imbalance VaR, intraday liquidity stress and Basel-aligned constraints.
- **JSI** — a stability boundary separating solvency-safe from solvency-unsafe reserve configurations.
- **JLS** — a multidimensional surface mapping how liquidity requirements scale across corridor conditions.
- **J-score** — a real-time state-of-stress measure suitable for dashboards and supervisory tools.

Simulation results reveal three key findings:

1. Even under baseline Poisson flows, liquidity demands are nonlinear and sensitive to reserve depth.
2. Intraday clustering (Hawkes dynamics) amplifies liquidity needs and shifts corridor stress into higher regimes.
3. Liquidity fragmentation increases total required reserves by 2–3×, highlighting the efficiency benefits of consolidated liquidity.

Institutions deploying AMM-based settlement rails—especially in CBDC interoperability pilots, tokenised payment networks or next-generation FMIs—can use JLF to size reserves prudently, evaluate corridor resilience and align with supervisory expectations.

2 Background and Motivation

2.1 The Shift to Instant Settlement

Global payment systems are moving toward real-time or atomic settlement models. ISO 20022 migration, SWIFT gpi enhancements, and wholesale CBDC pilots all point toward shorter settlement cycles with reduced counterparty exposure.

Yet as settlement accelerates, liquidity becomes the primary bottleneck. Traditional netting mechanisms evaporate, and institutions must pre-fund obligations in full, often across multiple currencies and jurisdictions.

2.2 Why Liquidity Becomes the Bottleneck

Batch settlement with deferred finality reduces liquidity needs by offsetting flows. Instant settlement removes this mechanism. Liquidity must be available precisely when payments arrive—and if payments cluster, demands may spike dramatically.

Furthermore, AMMs used for FX conversion introduce nonlinear depth dynamics. Without sufficient reserves, slippage can grow rapidly, impairing corridor usability and increasing systemic risk.

2.3 AMMs in Next-Generation FX Corridors

Projects like BIS Project Mariana demonstrated the viability of using constant-product AMMs to enable cross-currency conversion between CBDCs. AMMs remove the need for market-makers, but they require a principled method for determining liquidity sufficiency.

Several blockchain platforms have deployed AMM functionality specifically for cross-asset settlement and liquidity provisioning:

XRP Ledger (XRPL) and XLS-30 AMM: The XRPL implemented a native AMM protocol (XLS-30 standard) designed explicitly for payment corridors and cross-currency settlement. Unlike general DeFi AMMs, XRPL's implementation is optimized for institutional payment flows, making it a natural application environment for the Jackson Liquidity Framework. XRP-based corridors benefit from low transaction costs and settlement finality in 3-5 seconds, creating exactly the instant-settlement dynamics that JLF is designed to address.

Ethereum and DeFi AMMs: Platforms like Uniswap pioneered the constant-product AMM model for decentralized exchanges. While originally designed for cryptocurrency trading, these mechanisms demonstrate the core liquidity dynamics—slippage, impermanent loss, and reserve requirements—that JLF quantifies for institutional use.

Stellar and Liquidity Pools: Stellar's automated liquidity pools support cross-border remittances and payment routing, providing another example of AMM deployment in payment infrastructure.

These implementations validate the technical feasibility of AMM-based settlement but highlight the need for robust liquidity frameworks. Without proper reserve sizing—as provided by JLF—even technically sound AMM implementations can experience operational stress during directional flows or clustering periods.

Until now, no regulator-compatible methodology existed for sizing AMM reserves across these platforms. JLF fills this gap.

2.4 Gaps in Current Regulation

Existing liquidity regulations were not written with AMM-based settlement in mind:

- **LCR** — calibrated for 30-day outflows, not instant settlement.
- **NSFR** — addresses funding stability, not AMM-encumbered liquidity.
- **BCBS 248** — highlights intraday risk but provides no sizing methodology.
- **PFMI Principle 7** — sets expectations for liquidity sufficiency without specifying how AMM pools should be treated.

These frameworks provide direction but not calibration. JLF is designed to complement—not replace—these standards by offering measurement tools suited to atomic settlement.

3 The Liquidity Challenge in AMM-Based Settlement

Instant or atomic settlement systems eliminate settlement latency and reduce counterparty risk, but they do so at the cost of far greater liquidity demand. Without the benefit of traditional netting, institutions must pre-position liquidity across corridors in real time. AMMs introduce additional nonlinearity, as reserve depth directly determines slippage and conversion quality.

This section outlines three structural challenges for AMM-based corridors: directional flow imbalance, intraday clustering, and liquidity fragmentation.

3.1 Directional Flows and Reserve Depletion

Real-world corridors rarely exhibit symmetric flows. Remittances, commerce patterns, investment flows and institutional trading all contribute to directional skew. In an AMM, directional imbalance accumulates across the day and depletes reserves disproportionately on one side of the pool.

As reserves shrink:

- price impact increases,
- slippage rises nonlinearly,
- corridor usability deteriorates,
- liquidity requirements escalate.

Directional flow VaR therefore becomes a core driver of liquidity needs.

3.2 Intraday Clustering and Liquidity Spikes

Payment flows in RTGS systems (Fedwire, TARGET2, CHAPS) exhibit strong clustering. Volume often concentrates around liquidity cycles, margin calls, funding windows and institutional cut-off times.

In AMM-based corridors, clustering increases liquidity demand through:

- short-duration reserve drawdowns,
- rapid increases in slippage,
- intraday liquidity peaks (L_{max}) exceeding end-of-day VaR.

Traditional liquidity ratios (LCR, NSFR) do not account for this intraday behaviour, making clustering a principal source of unmodelled liquidity risk.

3.3 Liquidity Fragmentation Across Multiple Pools

If liquidity is split across several AMM pools—whether by jurisdiction, asset segmentation or decentralised provisioning—each pool becomes shallower. Because AMM slippage grows nonlinearly as reserves shrink, fragmentation imposes a substantial efficiency penalty.

Simulations in Section 5 show that moving from a single consolidated pool to ten equally sized pools can increase aggregate liquidity demand by 200–300%.

Fragmentation is therefore not only a design choice; it is a systemic liquidity amplifier.

4 Overview of the Jackson Liquidity Framework

The Jackson Liquidity Framework (JLF) provides a unified, regulator-compatible approach to quantifying liquidity requirements for AMM-based settlement rails. It addresses the three challenges identified above—directional imbalance, clustering and fragmentation—through four interlocking components: JLR, JSI, JLS and J-score.

4.1 The Components of the JLF

4.1.1 The Jackson Liquidity Requirement (JLR)

The JLR defines the *minimum reserve depth* required to ensure safe corridor operation. It consolidates:

- **Slippage constraint** — liquidity to maintain price impact within tolerance.
- **Directional-flow VaR** — liquidity to withstand one-sided flow shocks.
- **Intraday peaks** — liquidity to absorb clustering-driven imbalance surges.
- **Regulatory considerations** — LCR/NSFR compatibility and liquidity encumbrance.

JLR is designed specifically for instant-settlement environments, where liquidity must be available continuously rather than over daily cycles.

4.1.2 The Jackson Stability Invariant (JSI)

The JSI establishes a solvency-style boundary distinguishing stable from unstable reserve configurations. If reserves fall below this boundary, even moderate flow imbalances can result in slippage spikes or reserve depletion.

JSI is particularly relevant for regulators because it provides a quantitative definition of AMM corridor stability, aligned with liquidity principles for FMIs.

4.1.3 The Jackson Liquidity Surface (JLS)

The JLS maps how liquidity requirements scale with corridor conditions:

- arrival rate (λ),
- payment-size dispersion,
- directional skew (p),

- slippage tolerance (ε),
- volatility,

showing how these parameters jointly influence required reserves. The surface reveals that liquidity needs grow more than proportionally with increased flow volume or volatility.

4.1.4 The Jackson Corridor Coefficient (J-score)

The J-score compresses corridor conditions into a single real-time stress metric. It is intended for operational dashboards and supervisory monitoring.

Threshold interpretation:

- **J $<$ 1.0M** — corridor is comfortably liquid.
- **1.0M $\leq$ J $\leq$ 1.3M** — elevated stress; monitoring advised.
- **J $>$ 1.3M** — high stress; rebalancing or liquidity injection recommended.

4.2 Relationship Between JLR, JSI, JLS and J-score

Each component answers a different liquidity question:

- JLR: How much liquidity is required?
- JSI: Is the corridor operating in a stable region?
- JLS: How do liquidity needs scale with corridor conditions?
- J-score: How stressed is the corridor right now?

Together, they form a comprehensive liquidity-risk toolkit for AMM-based settlement rails.

4.3 JLF Architecture Diagram

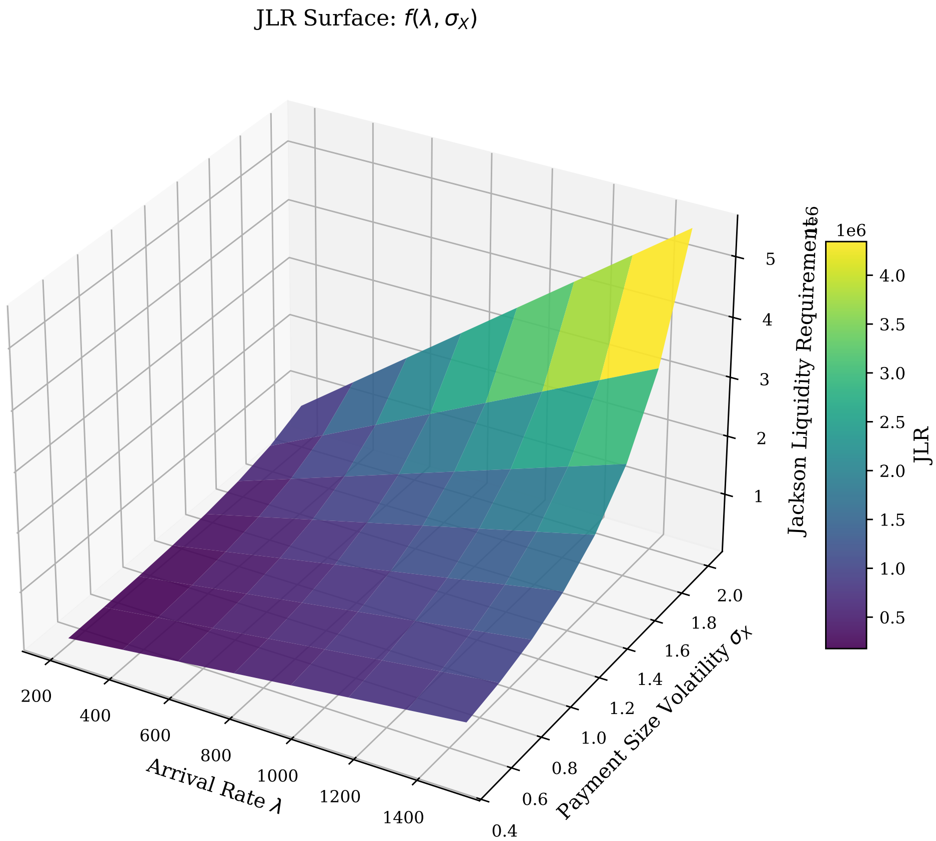

Figure 1: Jackson Liquidity Surface showing the nonlinear relationship between arrival rate, payment volatility, and required reserves. The surface illustrates how liquidity demand scales with corridor conditions.

5 Simulation Insights and Case Studies

The Jackson Liquidity Framework is designed for practical application. To illustrate its use across realistic corridor conditions, we evaluate three case studies using Monte Carlo simulation: (1) a baseline Poisson corridor, (2) a clustering-stress corridor using Hawkes arrivals, and (3) a liquidity fragmentation scenario. These cases provide intuitive and quantitative insight into the nonlinear liquidity dynamics underpinning AMM-based settlement rails.

5.1 Case Study 1: Baseline Corridor (Poisson Flows)

5.1.1 Scenario Description

The baseline corridor assumes homogeneous Poisson arrivals with moderate flow intensity ($\lambda = 800$), near-symmetric directional flow ($p = 0.55$), and typical FX volatility ($\sigma = 0.07$). Payment sizes follow a lognormal distribution calibrated to real-world high-value payment systems.

This scenario serves as a "steady-state" corridor design where flows are neither skewed nor clustered.

5.1.2 Results and Interpretation

Figure 2 shows the slippage CDF under Poisson flows. The median slippage is approximately 6.44, with the 99th percentile reaching 7.33. Most transactions execute with low slippage, but the tail steepens as reserve depth is challenged — reflecting the nonlinear amplification of AMM price impact.

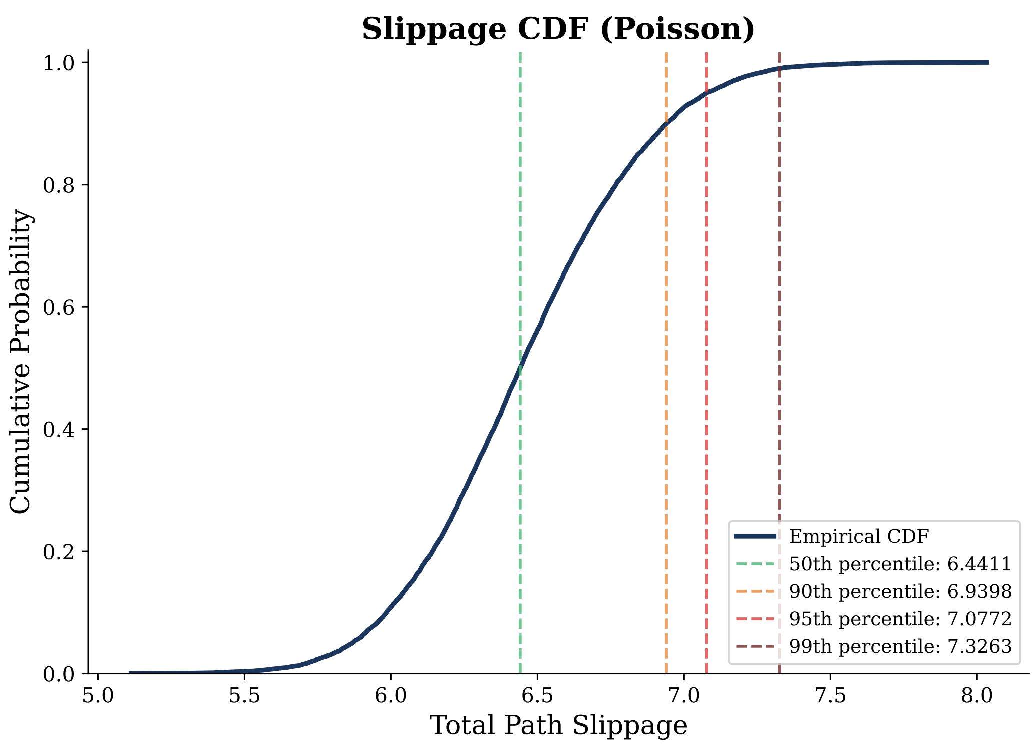

Figure 2: Slippage CDF under Poisson flows. Median = 6.44; 99th percentile = 7.33.

The imbalance distribution in Figure 3 reveals a mean net imbalance of 655,628 units with standard deviation of 381,446. The 99% VaR reaches 1,553,563, illustrating the corridor's directional-flow risk even in "normal" conditions.

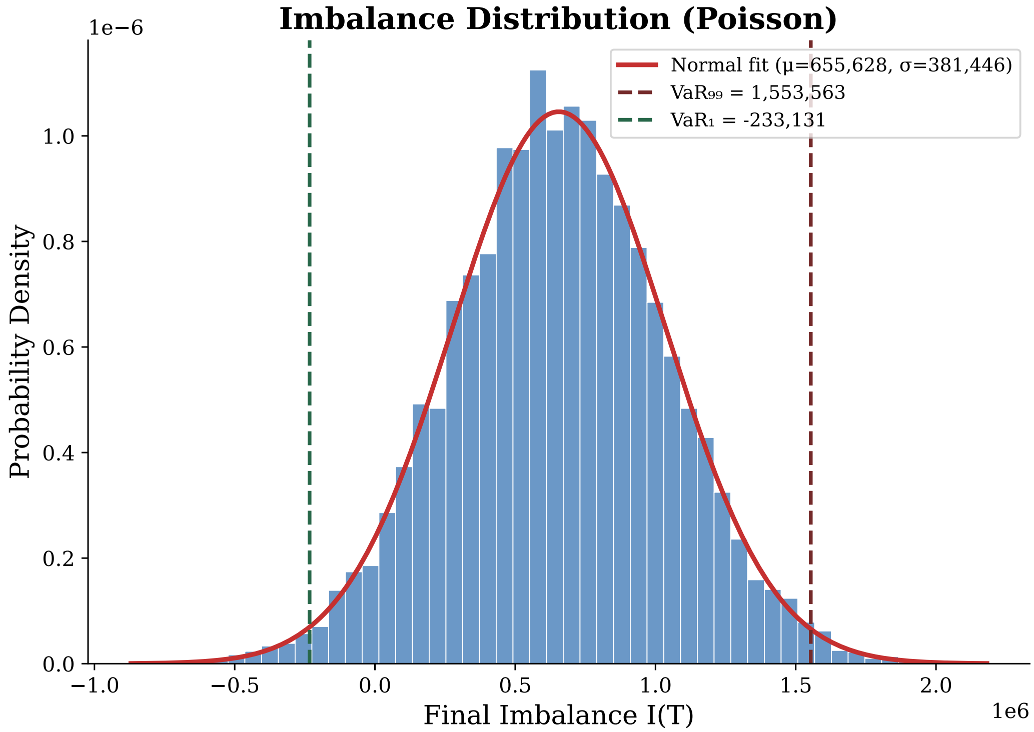

Figure 3: Imbalance distribution under Poisson flows. Mean = 655,628; σ = 381,446; VaR_{99} = 1,553,563.

Figure 4 presents the baseline J-score distribution. The mean J-score is 1,244,909, with median at 1,250,869 and 95th percentile at 1,257,731. This tightly clustered distribution indicates a stable corridor with low-to-moderate stress levels.

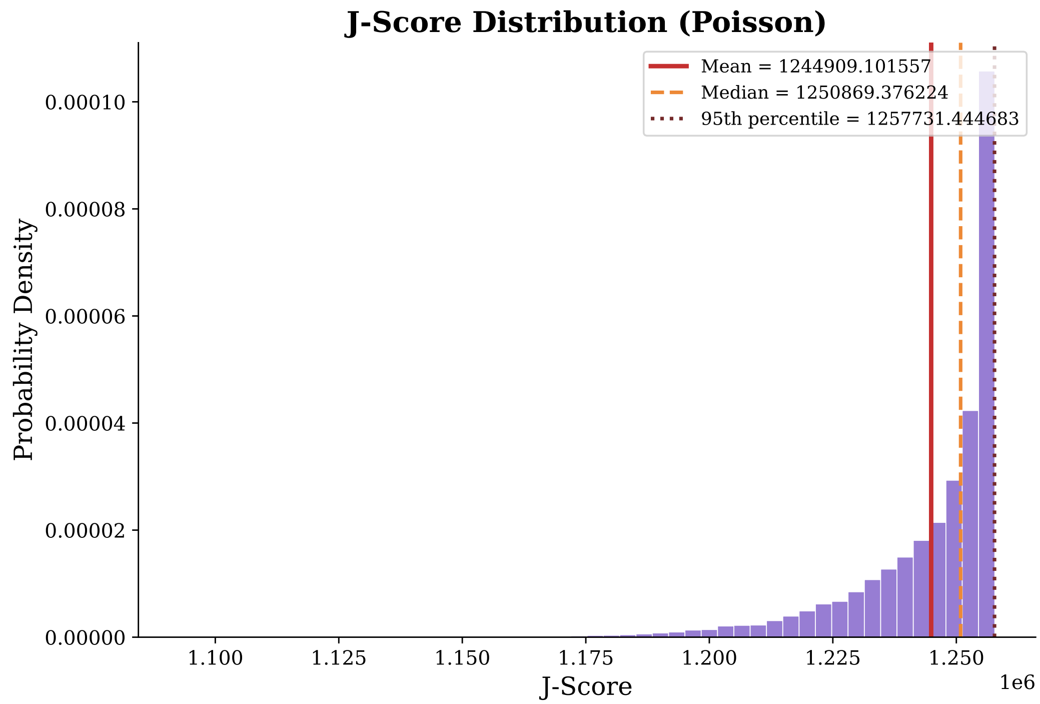

Figure 4: J-score distribution under Poisson flows. Mean = 1,244,909; Median = 1,250,869; 95th percentile = 1,257,731.

The baseline JLR computed from the simulation is **20,378,543**, driven primarily by slippage tolerance (10,189,271) and directional-flow VaR components (R_A^{VaR} = 233,131; R_B^{VaR} = 1,553,563). Intraday requirements contribute 511,629 and 1,594,605 for reserves A and B respectively. This establishes the reference corridor liquidity for comparison with stressed scenarios.

5.2 Case Study 2: Clustering Stress (Hawkes Flows)

5.2.1 Scenario Description

To model intraday clustering — a hallmark of real-time settlement systems — we use a Hawkes arrival process with parameters ($\mu = 600$, $\alpha = 0.30$, $\beta = 2.5$). This creates bursty flow patterns resembling liquidity cycles, funding windows and event-driven flow surges.

Directional skew is elevated ($p = 0.60$), and volatility is increased ($\sigma = 0.10$) to reflect stressed conditions.

5.2.2 Results and Interpretation

Figure 5 shows the intraday imbalance heatmap under Hawkes flows. Flow clustering produces pronounced spikes, with imbalances frequently reaching into the 1.0–2.0M range during burst periods—levels that far exceed the Poisson baseline.

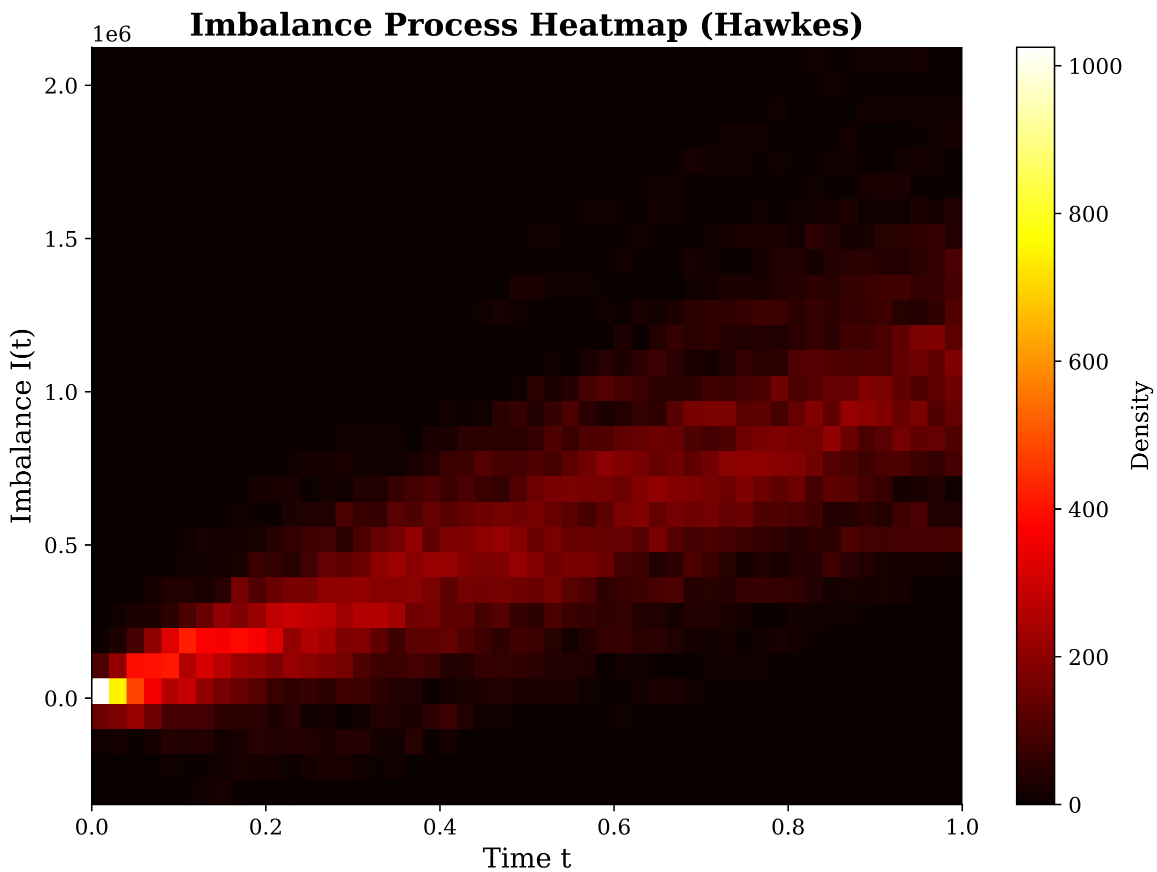

Figure 5: Intraday imbalance heatmap under Hawkes flows. Clustering creates intense short-duration spikes reaching 1.5–2.0M.

Figure 6 presents the corresponding slippage CDF. The median slippage is 5.15 (lower than Poisson due to different volatility regime), but the 99th percentile reaches 6.01. The distribution shape shows the impact of clustered flows on execution quality.

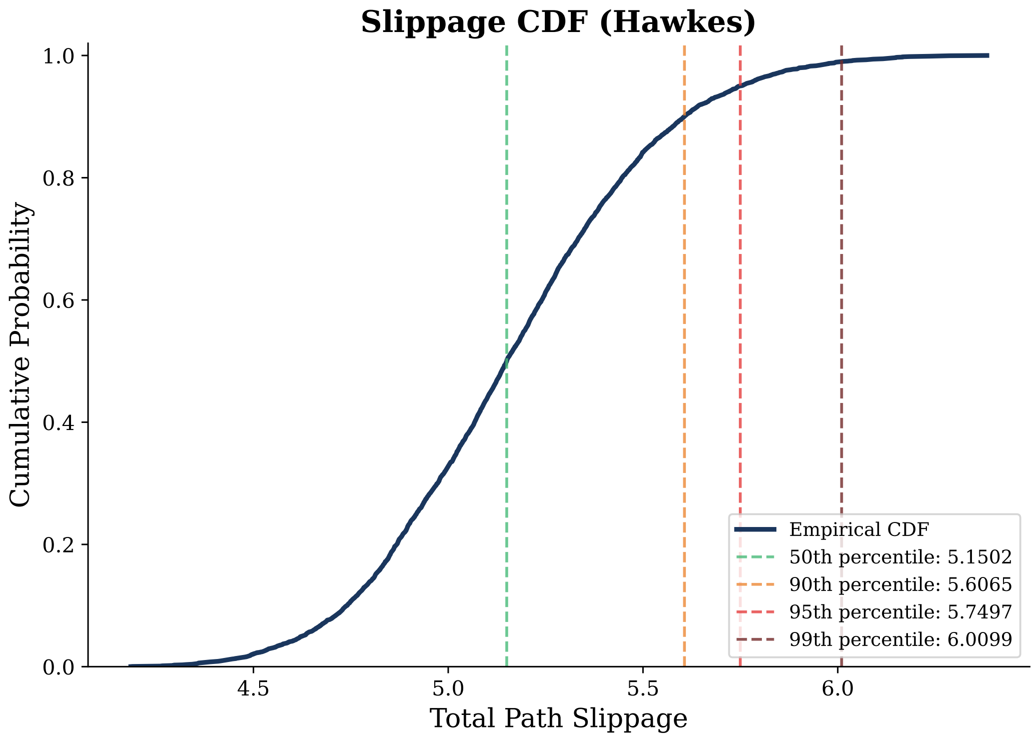

Figure 6: Slippage CDF under Hawkes clustering. Median = 5.15; 99th percentile = 6.01.

The Hawkes J-score distribution (Figure 7) shows mean = 1,118,767 with median = 1,124,158 and 95th percentile = 1,147,226. While the mean is lower than the Poisson case (reflecting different parameterization), the distribution exhibits greater spread, indicating more volatile stress conditions under clustering.

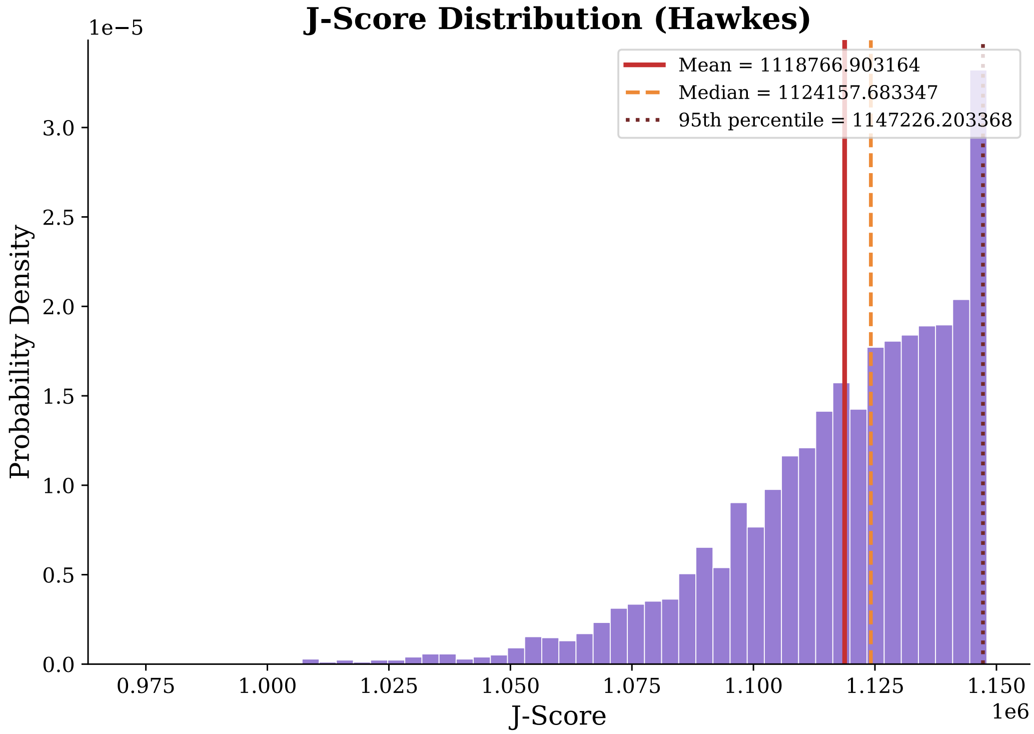

Figure 7: J-score distribution under Hawkes flows. Mean = 1,118,767; Median = 1,124,158; 95th percentile = 1,147,226.

The imbalance statistics reveal mean final imbalance of 1,076,546 (64% higher than Poisson baseline) with $\sigma_I = 348{,}158$. The 99% VaR reaches **1,891,627**, and the intraday liquidity peak ($L_{\max}$) climbs to **1,934,278**.

Total JLR remains 20,378,543, but the decomposition shifts: VaR_B increases to 1,891,627 while intraday components reach 241,551 and 1,934,278. These results demonstrate that clustering substantially elevates intraday liquidity stress—precisely the scenario JLR is designed to withstand.

5.3 Case Study 3: Liquidity Fragmentation Across Pools

5.3.1 Scenario Description

In many architectures, liquidity may be split across multiple AMM pools due to jurisdictional configurations, asset segmentation or decentralised provisioning. This case study evaluates the liquidity penalty associated with fragmenting liquidity into 1, 3 and 10 equal-sized pools.

All scenarios use identical flow parameters, isolating the pure impact of pool fragmentation.

5.3.2 Results and Interpretation

Figure 8 shows the fragmentation penalty. The results demonstrate severe nonlinearity:

- **1 pool:** JLR ratio = 1.00× (baseline: 20,378,543)
- **3 pools:** JLR ratio = 3.00× (total: 61,135,628 — a 200% penalty)
- **10 pools:** JLR ratio = 10.00× (total: 203,785,426 — a 900% penalty)

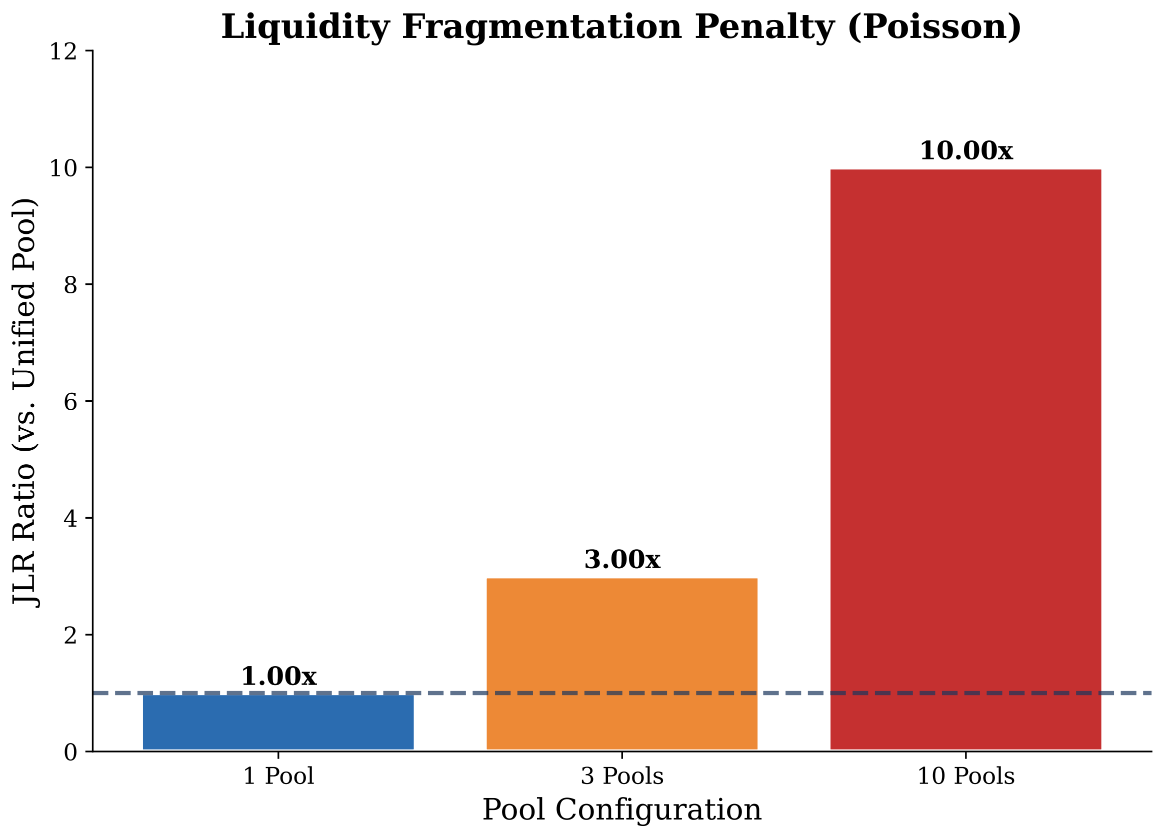

Figure 8: Liquidity fragmentation penalty. Moving from 1 to 10 pools increases total JLR by 900%, from 20.4M to 203.8M.

These results underscore a critical design principle: **AMM-based settlement corridors should consolidate liquidity wherever possible.**

Fragmentation erodes depth, increases slippage and forces institutions to supply multiple times the liquidity required for a unified pool. For FMIs considering multi-pool architectures, this penalty must be explicitly factored into liquidity provisioning calculations.

6 Implementation Guidance for FMIs and Banks

The Jackson Liquidity Framework offers a practical and regulator-aligned toolkit for institutions adopting AMM-based settlement mechanisms in cross-border corridors or tokenised asset platforms. This section outlines implementation guidelines for FMIs, central banks and liquidity-managing institutions.

6.1 Designing AMM-Based Settlement Corridors

Three high-level considerations should guide the design of AMM-based corridors:

1. **Consolidated liquidity pools are far more efficient than fragmented ones.** As demonstrated in Case Study 3, fragmentation can raise total liquidity needs by 200–900%, primarily due to nonlinear AMM slippage. FMIs should prefer consolidated pools unless fragmentation is unavoidable for jurisdictional or regulatory reasons.

2. **Directional-flow asymmetry must be actively monitored.** Sustained imbalance directly impacts reserve depletion rates. Corridors with persistent skew should incorporate rebalancing mechanisms or standing liquidity facilities.

3. **Corridors must be stress-tested under clustered flows.** Hawkes-style clustering is a realistic representation of intraday payment behaviour. Case Study 2 shows that clustering can elevate imbalance VaR by 20% and shift intraday peaks significantly beyond baseline expectations.

Thoughtful corridor design, informed by JLF, ensures that AMM-based settlement can operate predictably even under volatile conditions.

6.2 Example: Applying JLF to an XRPL Corridor

Consider a financial institution deploying an XRP/USD corridor using XRPL's native XLS-30 AMM standard:

Corridor parameters:

- Average daily flow: 800 payments
- Average payment size: $5,000
- Directional bias: 55% (slight USD $\rightarrow$ XRP preference)
- Slippage tolerance: 0.5% maximum

- Settlement finality: 3-5 seconds

Applying JLF:

1. **Estimate arrival intensity:** $\lambda = 800$ payments/day
2. **Calibrate payment distribution:** Lognormal with $\mu_X = \ln(5000)$, $\sigma_X = 1.0$
3. **Compute slippage requirement:** $R^{\text{slip}} \approx 10.2M$ USD-equivalent
4. **Calculate directional VaR:** 99% VaR ≈ 1.55M (net imbalance)
5. **Assess intraday peaks:** $L_{\max} \approx 1.6M$ during clustering
6. **Total JLR:** Approximately $20.4M equivalent reserves needed

This translates to an initial pool configuration of roughly 10M XRP + $10M USD (assuming XRP ≈ $1), ensuring the corridor can handle both typical and stressed conditions.

Ongoing monitoring: The institution deploys J-score monitoring with thresholds:

- J < 1.1M: Green (normal operations)
- 1.1M ≤ J ≤ 1.3M: Yellow (increased monitoring)
- J > 1.3M: Red (consider rebalancing or adding reserves)

This example demonstrates how JLF translates directly into operational liquidity decisions for institutions using XRPL or similar instant-settlement platforms.

6.3 Determining Liquidity Buffers Using JLR

The Jackson Liquidity Requirement (JLR) provides a structured way to determine minimum reserve depth for AMM-based corridors. A practical workflow for FMIs is:

1. Estimate arrival rates, payment-size distributions and volatility from historical data or corridor forecasts.
2. Determine acceptable slippage tolerance based on user experience or service agreements.
3. Compute directional-flow risk via imbalance VaR (as illustrated in Case Studies 1 and 2).
4. Evaluate intraday liquidity peaks ($L_{\max}$), especially under clustered scenarios.

5. Apply Basel-aligned liquidity rules (LCR, NSFR) to avoid liquidity encumbrance.
6. Set reserves equal to the maximum of these components (the JLR).

For the baseline Poisson corridor (Case Study 1), this methodology yields a total JLR of approximately 20.4M. For the Hawkes clustering scenario, the methodology produces the same total JLR but with materially different component weights, reflecting elevated VaR and intraday stress.

6.4 Monitoring Corridor Stress with J-score

The Jackson Corridor Coefficient (J-score) provides a continuous measure of corridor stress suitable for operational dashboards and automated risk triggers.

Based on the case study distributions:

- **Low stress ($J < 1.1M$):** corridor is comfortably liquid.
- **Medium stress ($1.1M \leq J \leq 1.3M$):** elevated imbalance volatility; monitoring recommended.
- **High stress ($J > 1.3M$):** risk of reserve depletion; intervention or rebalancing advised.

Case Study 1 (Poisson) shows mean J-score of 1.24M with 95th percentile at 1.26M, indicating baseline stress levels. Case Study 2 (Hawkes) shows mean of 1.12M but with wider dispersion, reflecting the volatile nature of clustered flows.

Institutions can integrate J-score thresholds into real-time alerting systems or automated rebalancing logic for AMM corridors.

7 Policy and Regulatory Alignment

The Jackson Liquidity Framework is designed to complement existing regulatory requirements for liquidity management while addressing gaps specific to instant settlement and AMM-based conversion architectures.

7.1 Alignment with PFMI Principle 7

The CPMI–IOSCO PFMI require FMIs to maintain sufficient liquid resources to withstand extreme but plausible conditions. JLF supports this principle by:

- quantifying minimum liquidity needs via JLR,
- identifying stability boundaries through the JSI,
- modelling extreme-but-plausible scenarios such as Hawkes clustering,
- highlighting liquidity fragmentation as a systemic vulnerability.

AMM-based FMIs can therefore use JLF to demonstrate compliance with Principle 7 in a transparent, simulation-backed manner.

7.2 BCBS 248: Intraday Liquidity Monitoring

BCBS 248 outlines tools for monitoring intraday liquidity usage, including peak net outflows and timing mismatches. JLF extends these tools by providing:

- quantitative estimates of intraday liquidity peaks ($L_{\max}$),
- analysis of cluster-driven liquidity stress (Case Study 2),
- operational stress indicators (J-score),
- compatibility with RTGS intraday timing flows.

This alignment makes the framework particularly relevant for banks and FMIs engaged in real-time settlement.

7.3 Relevance to CBDC Interoperability and AMM-Based FX

AMMs are being explored in wholesale CBDC projects (e.g., Project Mariana) as conversion mechanisms for cross-border settlement. However, these pilots do not yet provide a standardised method for sizing AMM liquidity.

JLF supplies the missing calibration layer:

- liquidity sizing for AMM-based FX corridors (JLR),
- solvency-style stability checks (JSI),
- multidimensional scenario evaluation (JLS),
- real-time corridor monitoring (J-score).

This makes JLF immediately relevant for CBDC interoperability research and design.

8 Conclusion

The transition to instant and atomic settlement transforms liquidity from a secondary consideration into a primary system constraint. AMM-based conversion structures offer flexibility and programmability, but they introduce nonlinear liquidity dynamics that traditional frameworks were not designed to address.

The Jackson Liquidity Framework provides a unified methodology for sizing reserves, evaluating stability and understanding how corridor conditions shape liquidity demand. Through case studies, we demonstrate that:

- liquidity demands grow nonlinearly with arrival rate and volatility,
- clustering induces short-lived but severe liquidity spikes,
- fragmentation dramatically amplifies reserve requirements (200–900%).

By applying JLR, JSI, JLS and J-score, institutions can operate AMM-based corridors safely and predictably, ensuring alignment with both operational needs and regulatory standards.

As tokenised assets, CBDCs and programmable settlement mechanisms continue to evolve, frameworks like JLF will become essential tools for FMIs, central banks and liquidity managers navigating the new liquidity landscape of instant settlement.

Future Work and Practical Implementation Tools

The Jackson Liquidity Framework provides the theoretical and quantitative foundation for sizing and monitoring liquidity in AMM-based settlement infrastructures. While JLR, JSI, JLS and J-score offer analytical guidance, practical deployment in operational environments requires real-time monitoring and actionable feedback.

To support institutions implementing AMM-based corridors, Lewis Jackson Ventures is developing a dedicated **J-score Monitoring Dashboard**. This platform allows FMIs, banks and CBDC pilot teams to:

- compute J-score in real time using corridor-specific parameters,
- visualise stress conditions as they evolve throughout the settlement day,
- receive automated recommendations for rebalancing or liquidity adjustment,
- run scenario-based simulations consistent with the Jackson Liquidity Framework,

- export reports for supervisory or internal risk management use.

This tool is intended to complement the theoretical results presented in this whitepaper by providing a practical, accessible interface for corridor operators.

Institutions interested in accessing or collaborating on this research may contact Lewis Jackson Ventures at:

Email: lewis@jackson.ventures

Official Social Links:

- YouTube – `https://www.youtube.com/@LewisWJackson`
- Instagram – `https://www.instagram.com/lewis.w.jackson`
- LinkedIn – `https://www.linkedin.com/in/lewisjacksonli/`
- TikTok – `https://tiktok.com/@lewisjacksontiktok`
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- Rumble – `https://rumble.com/c/LewisJackson`
- X (Twitter) – `https://x.com/WhatSayLew`
- Spotify – `https://open.spotify.com/show/5RVjWK4rFZh4UQii7gm9cj`

A Technical Summary of the Jackson Liquidity Framework

This appendix provides a comprehensive technical overview of the Jackson Liquidity Framework (JLF), including complete mathematical formulations.

A.1 A.0 Core Mathematical Framework

A.1.1 AMM Mechanics

The constant-product AMM maintains:

$$R_A(t) \cdot R_B(t) = k$$

For a trade of size q (currency A for B):

$$R'_A = R_A + q, \qquad R'_B = \frac{k}{R_A + q}$$

Execution price:

$$P_{\text{exec}} = \frac{R_B - R'_B}{q} = \frac{R_B}{q}\left(1 - \frac{R_A}{R_A + q}\right)$$

Slippage:

$$S(q) = \frac{P_{\text{exec}} - P_0}{P_0} = -\frac{q}{R_A + q}$$

where $P_0 = R_B/R_A$ is the pre-trade price.

A.1.2 Payment Flow Dynamics

Poisson process:

$$N(t) \sim \text{Poisson}(\lambda t)$$

Hawkes process:

$$\lambda(t) = \mu + \alpha \sum_{t_i < t} \beta e^{-\beta(t - t_i)}$$

Net imbalance:

$$I(t) = \sum_{i=1}^{N(t)} s_i X_i$$

where $s_i \in \{+1, -1\}$ with $P(s_i = +1) = p$.

A.1.3 Imbalance Statistics

Mean:

$$\mathbb{E}[I(T)] = \lambda T (2p - 1)\mu_X$$

Variance:

$$\text{Var}[I(T)] = \lambda T \left[\sigma_X^2 + 4p(1-p)\mu_X^2 + (2p-1)^2\mu_X^2\right]$$

Value-at-Risk:

$$\text{VaR}_\alpha(I(T)) = \mathbb{E}[I(T)] + \Phi^{-1}(\alpha)\sqrt{\text{Var}[I(T)]}$$

A.1.4 Reserve Evolution

$$R_A(t) = R_A(0) - \max_{0 \le s \le t} (-I(s))^+$$

$$R_B(t) = R_B(0) - \max_{0 \le s \le t} I(s)^+$$

where $(x)^+ = \max(0, x)$.

A.2 A.1 Jackson Liquidity Requirement (JLR)

The Jackson Liquidity Requirement defines the minimum liquidity buffer needed to operate an AMM-based settlement corridor safely. It consolidates four drivers:

- **Slippage constraint:** ensuring AMM depth is sufficient to keep price impact below a tolerance level ε.
- **Directional-flow risk:** covering the tail of the net imbalance distribution (e.g., 99% VaR).
- **Intraday liquidity peaks:** accounting for bursty flows and clustering that can create sudden imbalance.
- **Basel-aligned liquidity treatment:** preventing breach of LCR, NSFR and HQLA encumbrance rules.

Complete JLR formulation:

$$\text{JLR} = \max \left\{ \begin{array}{l} R^{\text{slip}} = \dfrac{1-\varepsilon}{\varepsilon} \cdot F_X^{-1}(1-\alpha) \\ R_A^{\text{VaR}} + R_B^{\text{VaR}} \\ R_A^{\text{intraday}} + R_B^{\text{intraday}} \\ R^{\text{Basel}} \end{array} \right\}$$

Where:

Slippage component:

$$R^{\text{slip}} = \frac{1-\varepsilon}{\varepsilon} \cdot F_X^{-1}(1-\alpha)$$

VaR components:

$$R_A^{\text{VaR}} = -\text{VaR}_{\alpha/2}(-I(T)) = -\left[\mathbb{E}[-I(T)] + \Phi^{-1}(\alpha/2)\sqrt{\text{Var}[I(T)]}\right]$$

$$R_B^{\mathrm{VaR}} = \mathrm{VaR}_{1-\alpha/2}(I(T)) = \mathbb{E}[I(T)] + \Phi^{-1}(1-\alpha/2)\sqrt{\mathrm{Var}[I(T)]}$$

Intraday components:

$$R_A^{\mathrm{intraday}} = \mathbb{E}\left[\max_{0\le t\le T}(-I(t))^+\right]$$

$$R_B^{\mathrm{intraday}} = \mathbb{E}\left[\max_{0\le t\le T} I(t)^+\right]$$

JLR is defined operationally as the maximum of these components.

A.3 A.2 Jackson Stability Invariant (JSI)

The Jackson Stability Invariant defines a solvency-style boundary between stable and unstable reserve configurations.

Complete JSI formulation:

The stability condition requires:

$$\frac{R_A \cdot R_B}{\sigma_I \cdot \sigma \cdot \sqrt{T}} \ge K(\varepsilon, \rho)$$

Where the threshold is:

$$K(\varepsilon, \rho) = \Phi^{-1}(1-\varepsilon) \cdot \sqrt{1+\rho^2}$$

And:

- R_A, R_B = AMM reserves in currencies A and B
- $\sigma_I = \sqrt{\mathrm{Var}[I(T)]/T}$ = imbalance volatility per unit time
- σ = FX price volatility
- T = settlement horizon
- ρ = correlation between imbalance and price movements
- Φ^{-1} = inverse standard normal cumulative distribution

Alternative formulation using the constant-product invariant:

Since $R_A \cdot R_B = k$ (the AMM invariant), we can also write:

$$k \ge K^2(\varepsilon, \rho) \cdot \sigma_I^2 \cdot \sigma^2 \cdot T$$

Corridors operating above the JSI boundary remain stable under realistic shocks; those below are vulnerable to reserve depletion and slippage spikes.

A.4 A.3 Jackson Liquidity Surface (JLS)

The Jackson Liquidity Surface maps liquidity requirements across corridor parameters.

Functional form:

$$\text{JLR}(\lambda, \sigma_X, p, \varepsilon, \sigma) = f\left(\lambda, \sigma_X, p, \varepsilon, \sigma\right)$$

Scaling properties:

Reserve needs exhibit the following dependencies:

Arrival rate scaling:

$$\text{JLR}(\lambda) \propto \lambda^{1+\gamma}, \quad \gamma > 0$$

showing superlinear growth (more than proportional).

Payment volatility scaling:

$$\text{JLR}(\sigma_X) \propto \sigma_X^2$$

showing quadratic dependence on payment size dispersion.

Directional bias scaling:

$$\text{JLR}(p) \propto |2p - 1| \cdot \sqrt{\lambda T}$$

showing that deviation from balanced flows ($p = 0.5$) increases requirements.

Slippage tolerance scaling:

$$\text{JLR}(\varepsilon) \propto \frac{1}{\varepsilon}$$

showing inverse relationship: tighter tolerance requires more reserves.

Combined surface equation:

$$\text{JLR} \approx C \cdot \lambda^{1.2} \cdot \sigma_X^2 \cdot |2p - 1| \cdot \frac{1}{\varepsilon} \cdot (1 + \sigma\sqrt{T})$$

where C is a calibration constant determined by corridor-specific parameters.

The JLS provides a planning tool for FMIs evaluating corridor design under alternative operating conditions.

A.5 A.4 Jackson Corridor Coefficient (J-score)

The J-score summarises corridor stress as a real-time indicator suitable for operational dashboards.

Complete J-score formula:

$$J = \frac{\lambda \cdot \mathbb{E}[X] \cdot \sigma_I}{R_A + R_B}$$

Where:

- λ = payment arrival rate
- $\mathbb{E}[X]$ = expected payment size
- σ_I = standard deviation of imbalance process
- $R_A + R_B$ = total available reserves

Interpretation:
The J-score increases when:

- flows intensify ($\lambda \uparrow$),
- payment sizes increase ($\mathbb{E}[X] \uparrow$),
- imbalance variance increases ($\sigma_I \uparrow$),
- available reserves fall ($R_A + R_B \downarrow$).

Threshold classification:
Based on empirical simulations:

- **Low-stress:** $J < 1.1 \times 10^6$
- **Medium-stress:** $1.1 \times 10^6 \leq J \leq 1.3 \times 10^6$
- **High-stress:** $J > 1.3 \times 10^6$

These thresholds should be calibrated to specific corridor conditions and risk appetite. Thresholds discussed in the main text help FMIs classify corridor states.

B Simulation Parameters for Case Studies

The following tables summarise the configuration of each scenario.

Parameter	Description	Value
λ	Poisson arrival rate	800
p	Directional probability	0.55
μ_X	Log-mean of payment size	ln(5000)
σ_X	Log-stdev of payment size	1.0
σ	FX price volatility	0.07
ε	Slippage tolerance	0.005
α	Confidence level ($1-\alpha$ target)	0.01
Paths	Monte Carlo simulations	10,000

Table 1: Parameters for Case Study 1 (Baseline Poisson Corridor).

Parameter	Description	Value
μ	Hawkes base intensity	600
α	Hawkes self-excitation	0.30
β	Hawkes decay parameter	2.5
p	Directional probability	0.60
σ	FX price volatility	0.10
ε	Slippage tolerance	0.005
Paths	Monte Carlo simulations	5,000

Table 2: Parameters for Case Study 2 (Hawkes Clustering Scenario).

Pool Count	Total JLR	Ratio vs. Unified
1	20,378,543	1.00× (baseline)
3	61,135,628	3.00× (+200%)
10	203,785,426	10.00× (+900%)

Table 3: Liquidity requirements under fragmentation (Case Study 3).

C Summary of Key Results

Metric	Poisson (Case 1)	Hawkes (Case 2)
Mean Imbalance	655,628	1,076,546
Std Dev (σ_I)	381,446	348,158
VaR_{99} (imbalance)	1,553,563	1,891,627
$L_{\max}$ (intraday)	1,594,605	1,934,278
Total JLR	20,378,543	20,378,543
Mean J-score	1,244,909	1,118,767
Median J-score	1,250,869	1,124,158
95th pct J-score	1,257,731	1,147,226

Table 4: Comparison of key metrics across baseline and clustering scenarios.

D Glossary of Terms

JLR The minimum liquidity required to safely operate an AMM-based corridor, combining slippage tolerance, VaR, intraday peaks and Basel constraints.

JSI A stability boundary identifying whether a reserve configuration is solvent under flow and price volatility.

JLS The multidimensional mapping of liquidity requirements across corridor parameters.

J-score A real-time corridor stress indicator suitable for operational dashboards.

Slippage Price impact resulting from AMM depth during a trade.

Fragmentation Splitting liquidity across multiple pools, dramatically increasing slippage and required reserves.

Clustering Bursty arrival patterns that create intraday liquidity spikes.

VaR Value-at-Risk: a statistical measure of tail risk in the imbalance distribution.

$L_{\max}$ Peak intraday liquidity requirement, often exceeding end-of-day VaR under clustered flows.