The Timing of Liquidity-Saving Mechanisms in Securities Settlement Systems

(Work in progress)

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Research question

How should an FMI operator choose liquidity-saving-mechanism (LSM) schedules when both cash and securities can become binding?

Cash availability
Initial central-bank money available to cash payers.

Securities inventories
Issue-specific holdings available to deliverers.

Cycle schedule
Frequency and intraday timing.

Joint DvP feasibility
A transaction settles only if the cash-paying participant has sufficient money and the security-delivering participant has the required issue. The LSM selects a jointly feasible subset of pending instructions.

Outcomes
Liquidity usage
Settlement delay
End-of-day fails

Related literature and contribution

Our contribution: transaction-level evidence from an integrated DvP Model 1 infrastructure to study efficient intraday LSM cycle schedules when cash, securities, or both are binding.

1. RTGS, DvP and settlement safety

DvP Model 1 eliminates principal risk, but gross settlement may lead to gridlocks when either leg is unavailable.
CPSS (1992); CPMI–IOSCO (2012); Bech and Soramäki (2001, 2002).

2. LSMs

Queue-based offsetting can reduce liquidity requirements, increase settlement rates and mitigate gridlocks, with finality and legal certainty.
Bech and Soramäki (2001); Martin and McAndrews (2008); Galbiati and Soramäki (2011).

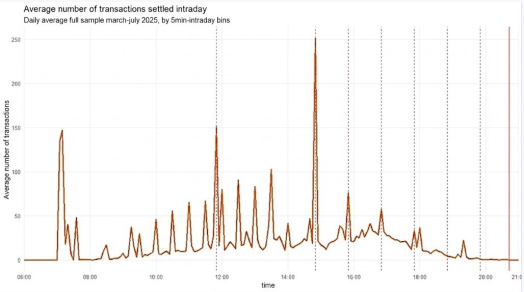
3. Behaviour

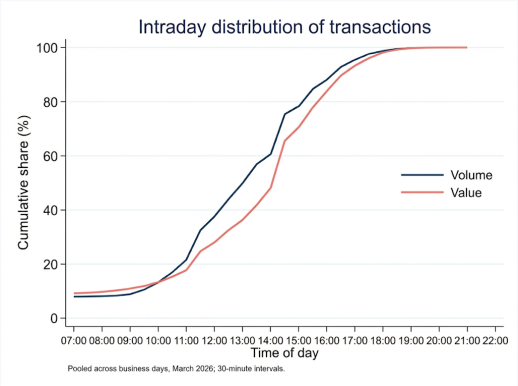
Frequent cycles shorten waiting times but may reduce the pool available for offsetting and vise versa. Expected LSM operation can also change participants' decisions.
Leinonen and Soramäki (1999, 2005); Bech and Garratt (2003); Martin and McAndrews (2008).

4. Evidence gap

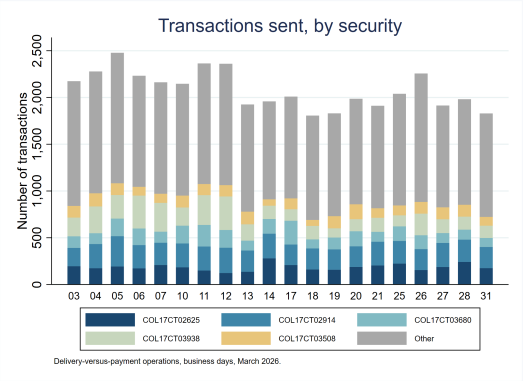
The scanty empirical evidence concerns cash-only RTGS systems and has not dealt with optimization in DvP systems, where settlement depends on central-bank money and securities supply.
CPMI–IOSCO (2012); Xing (2023); Duca-Radu and Testi (2021).

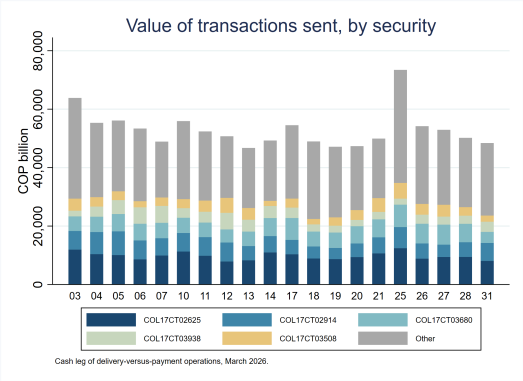
Intra-day flows in the Colombian interbank market





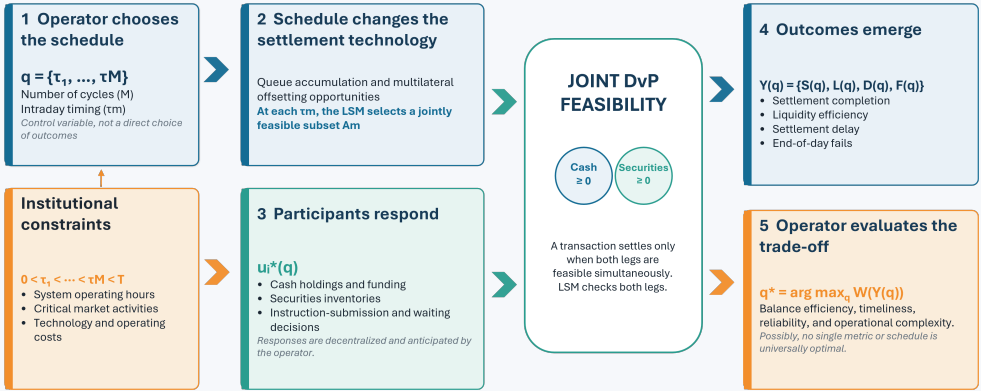
Main assets transacted in march 2025 (volume and value)





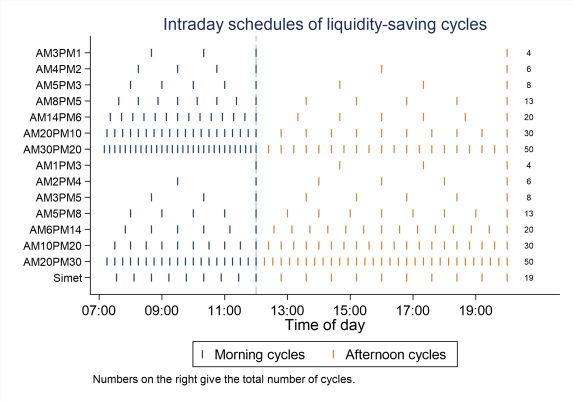
The operator's LSM scheduling problem

The operator controls cycle frequency and timing, but outcomes are jointly produced by DvP feasibility and participants' endogenous responses.



Intraday schedules of liquidity-saving cycles

We vary both the number of cycles and their intraday concentration.



Four counterfactual initial-balance architectures

The same transaction flow is replayed under alternative initial resource conditions and cycle schedules.

1. Cash-only

Cash balances are scaled; securities remain unconstrained.

Balance adjustments × cycle schedules

$21 \times 15 = 315$

simulations

2. Main security

The main-security inventory is scaled; cash is held at benchmark.

Balance adjustments × cycle schedules

$21 \times 15 = 315$

simulations

3. Two main securities

The inventories of the two main securities are scaled jointly; cash is held at benchmark.

Balance adjustments × cycle schedules

$21 \times 15 = 315$

simulations

4. MIX: cash × main security

Cash and the main-security inventory are varied jointly over a 5×5 balance grid.

Balance combinations × cycle schedules

$25 \times 15 = 375$

simulations

METHODOLOGICAL NOTE

Same transaction flow and participants, alternative initial resource conditions and cycle schedules. These scenarios are counterfactual replays of a common transaction flow, not independent observations from different days.

How schedules are evaluated and ranked

1. Three performance dimensions

Dimension	Measure and interpretation
Liquidity usage LU	Share of the available settlement resource consumed during the day. ↓ **lower is better**
Settlement delay D	Average time transactions remain pending before settlement. ↓ **lower is better**
Unsettled value F	Share of submitted value remaining unsettled at the end of the day. ↓ **lower is better**

How liquidity usage is measured

For cash, the resource is the monetary balance; for securities, it is the inventory of the selected issues. Opening balances, minimum intraday balances and submitted values are first aggregated across the relevant accounts.

$$LU = \frac{\sum_{i \in \mathcal{S}} (\textit{Opening balance}_i - \textit{Minimum balance}_i)}{\sum_{i \in \mathcal{S}} \textit{Submitted value}_i}.$$

The ratio is calculated after aggregation. It measures the drawdown of the initial resource relative to the submitted flow.

2. From outcomes to schedule rankings

Step 1: Put all dimensions on a common scale

Liquidity usage, delay and unsettled value are normalised between zero and one within each experiment. Zero denotes the best observed outcome and one the worst.

Step 2: Construct the composite index

For schedule c under balance scenario s:

$$I_{sc} = w_1\left(1 - LU_{sc}\right) - w_2 D_{sc} - w_3 F_{sc},$$

A higher index indicates a more attractive combination of resource savings, timeliness and settlement completion. The baseline uses equal weights; alternative operator preferences are reported as robustness checks.

Step 3: Rank within each balance scenario

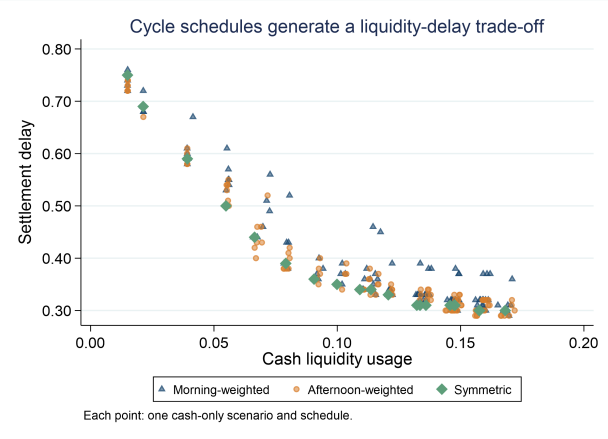
The 15 schedules are ordered from the highest to the lowest index:

$$\textit{Rank}_{sc} = \textit{rank}_{\downarrow}(I_{sc}), \qquad c = 1, \ldots, 15.$$

Across scenarios, robustness is summarised by: median index and median rank; frequency as the highest-ranked schedule; frequency in the Top 3; and participation in the Pareto frontier.

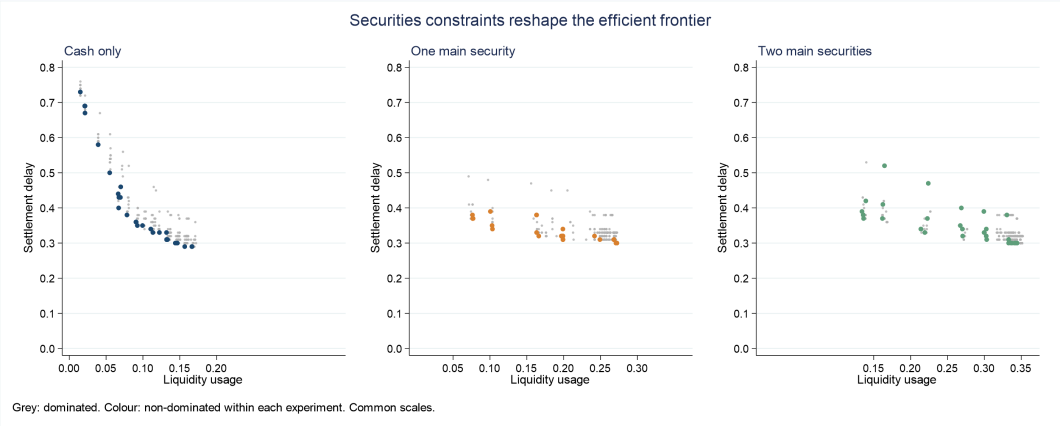
Cycle schedules generate a liquidity-delay trade-off (cash-only)

Liquidity conservation and settlement speed are competing operational objectives. Same happens with unsettled transactions and across architectures.



Securities constraints reshape the efficient frontier

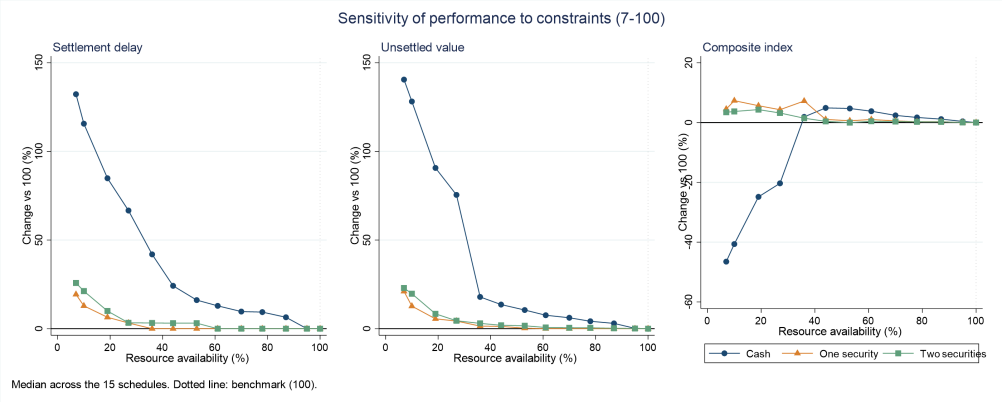
The key test is whether securities scarcity changes the identity of efficient schedules.



Grey: dominated. Colour: non-dominated within each experiment. Common scales.

Sensitivity of performance to cash and securities constraints (composite index)

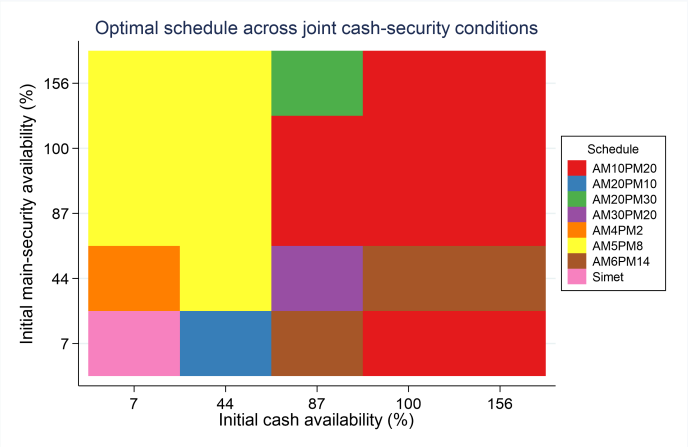
This comparison identifies whether DvP performance is more sensitive to cash scarcity, securities scarcity, or breadth across issues.



Median across the 15 schedules. Dotted line: benchmark (100).

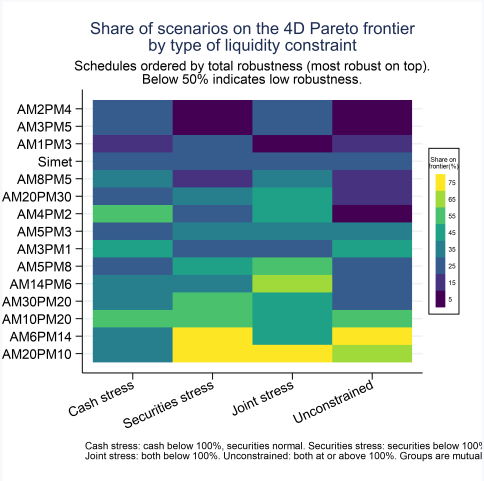
Optimal schedule across joint cash-security conditions (composite index, MIX)

The MIX experiment translates the joint-resource problem into a state-contingent schedule choice.



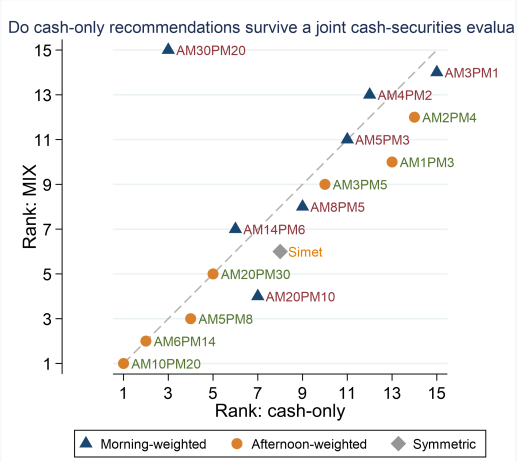
Pareto robustness under cash, securities and joint stress

Pareto shares identify efficient schedules without fixing the operator's weights.



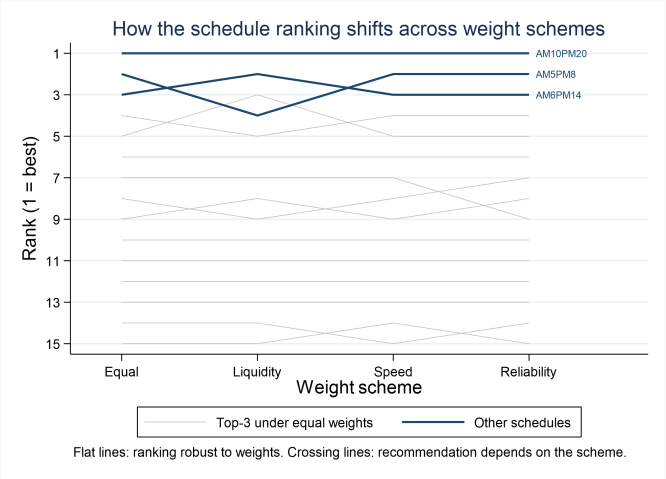
Does the cash-only ranking survive joint constraints? (composite index, MIX)

This comparison tests whether a conventional cash-only recommendation remains valid once securities constraints are introduced.



How robust are rankings to operator's weights?[very preliminary]

Surprisingly the dominant LSM scheduling is robust to different operator's weights but with low tolerance to failures it may be AM6PM14.



Work in Progress

Recalibrate securities-stress scenarios. Develop securities-stress experiments that are more comparable to cash-stress scenarios. Cash is the common settlement asset for all transactions, whereas stressing one or two securities constrains only a subset of activity (approximately one-fifth of intraday volume).

Incorporate institutional objectives and constraints. Explore operator preferences that may affect schedule rankings, including minimum settlement-fail requirements, risk aversion, and preferences for earlier settlement completion.

Expand the sample of simulation days. Extend the analysis to a larger number of business days (≥ 20) to assess the statistical robustness and stability of schedule rankings.

Develop richer diagnostics. Create indicators that identify whether settlement failures originate from cash shortages, securities shortages, or both.

Introduce market-operating-hour restrictions. Restrict feasible cycle schedules to the intraday operating events of the money market and government securities market.

Additional extensions. Suggestions/ideas on robustness checks and alternative operator objectives or other, are very welcome.

Three findings and one operational implication

1. Scarcity generates nonlinear trade-offs

Cycle schedules move the system along a liquidity–delay–completion frontier. Performance deteriorates disproportionately under severe resource scarcity, implying that schedule design should be evaluated as a joint timing-and-frequency decision rather than as a simple choice of cycle count.

2. Cash and securities affect different dimensions of efficiency

Cash scarcity generates the largest aggregate deterioration in settlement performance, while securities scarcity can reshape the efficient frontier and alter the identity of non-dominated schedules. The resource that drives system stress is not necessarily the resource that determines the optimal schedule.

3. The preferred LSM schedule is state contingent

The MIX experiments show that no single intraday schedule dominates across all combinations of cash and securities availability. Optimal timing depends on the joint resource configuration, and rankings obtained under cash-only conditions do not always carry over to a DvP environment.

4. Robust operational choices require multiple lenses

A defensible operating rule should not be selected solely on the basis of a single performance metric or a single stress scenario. Composite rankings, Pareto efficiency, robustness across states, and operator objectives provide complementary information for identifying resilient schedules.

The preferred LSM schedule is state-dependent: it reflects not only how much liquidity is available, but also whether the binding resource is cash, securities, or both.