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collaborate with Universities advancing payments innovation through data and research.

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Measuring Systemic Risk in Payment Systems: A Network-Based Approach

Research question

Does operational stress propagate and amplify across PSP networks?

Context + Research Focus

- **Interconnected Payment Infrastructures**
  Transactions flow continuously between banks and fintech firms through a dense network.
- **Stress Propagation Mechanisms**
  Operational disruptions spread across the network through established payment relationships.
- **Research Focus**
  Quantifying how operational stress transmits and how outages amplify these disruptions.

Methodology

- **1. Dynamic Network-Based Spatial Econometric Model**
  Captures stress persistence, neighbour spillovers, and shock interactions across PSPs.
- **2. Transmission–Fragility Score**
  Composite indicator combining transmission capacity and operational fragility to identify systemic importance.

Data Summary

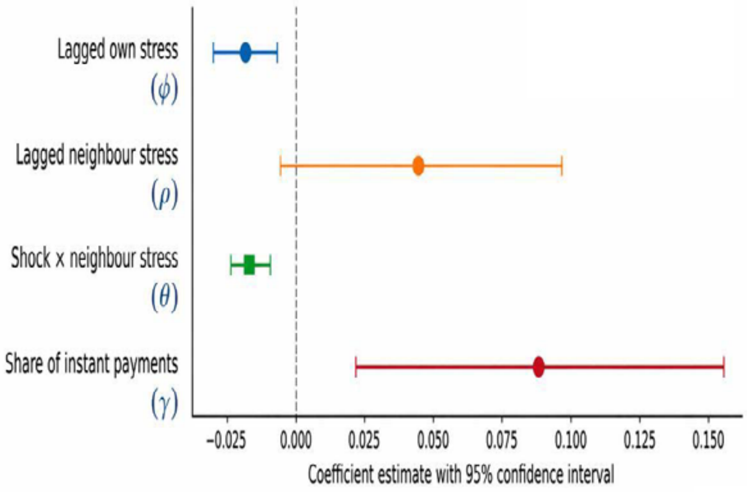
Unit and Frequency
PSP week panel observed across 53 weeks in 2024.

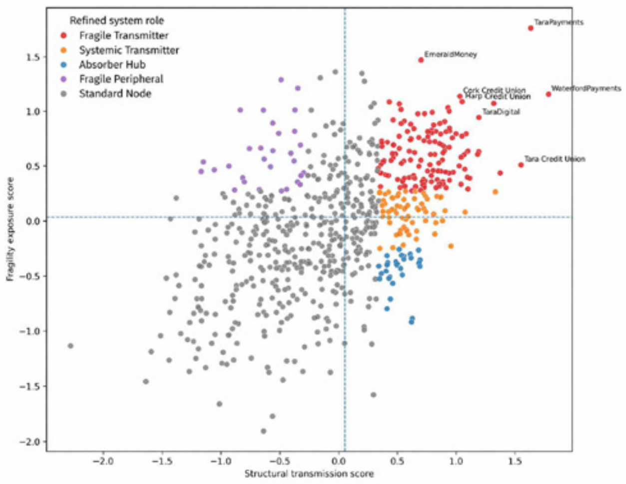
Observation Volume
36,994 observations covering approximately 698 unique providers.

Data Sources
5 million transaction records and 3.3 million latency observations.

Network and Shocks
200 system outage events transformed into shock intensity scores.

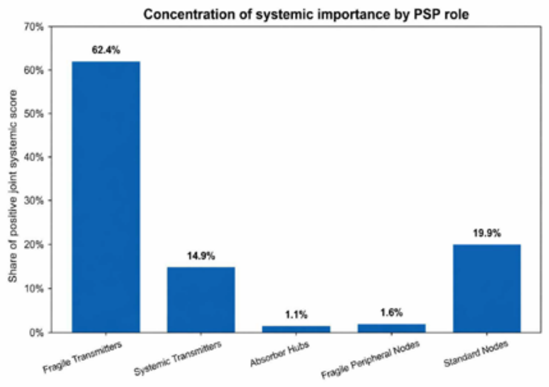
Results (Main Section)



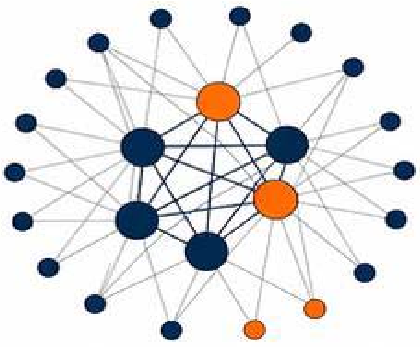


- **Mean Reverting Stress**
  Operational stress persists internally but tends to return to a baseline.
- **Weak Network Propagation**
  There is no evidence of significant average stress propagation across providers.
- **Resilience to Shocks**
  Infrastructure outages do not amplify the transmission of stress.
- **Drivers of Congestion**
  Higher operational intensity is directly associated with increased latency.

Concentration of Systemic Importance by PSP Role



Network Visual



Nodes = PSPs; Lines = Transaction Edges

Key Message

The Interaction Principle
Systemic risk is driven by the interaction of transmission capacity and operational fragility.

Takeaways

Targeted Oversight
Monitoring should focus on structurally critical fragile transmitters.

Structural Resilience
The payment network is robust as disruptions remain predominantly localized.

Early Warning Tools
Transaction level data can identify emerging risk concentrations befor

Domenico D'Ausilio

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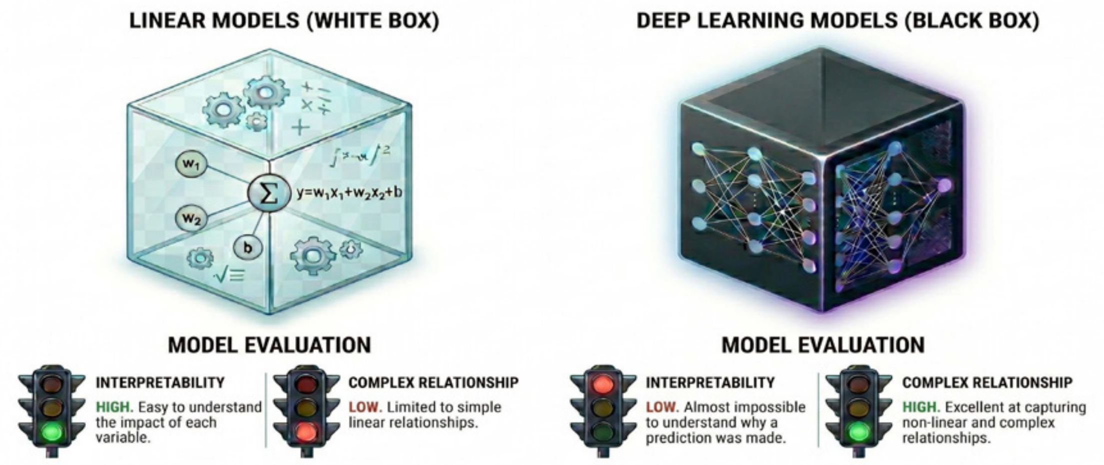
Interpretable AI for Anomaly Pattern Detection in Instant Payment

Can Explainable AI help us to understand unusual behaviors in istant payments while keeping decisions transparent and trustworthy?

FINANCIAL PROBELM

Financial institutions must model anomaly patterns under regulatory transparency.

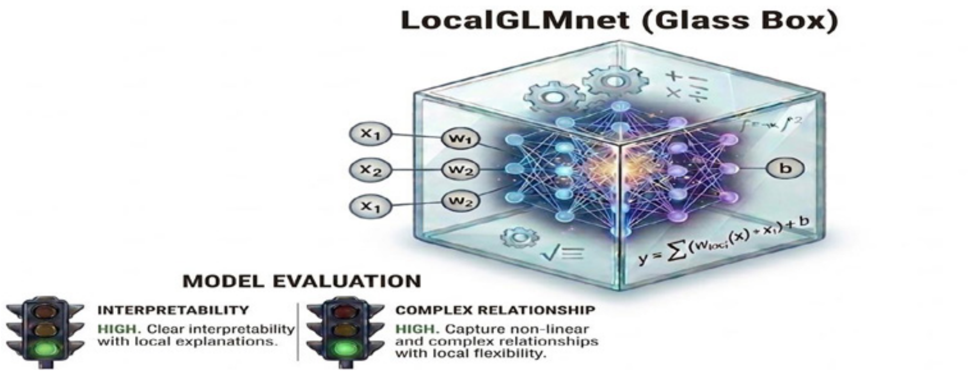
TRADITIONAL APPROACHES



OUR IDEA

We solve this trade-off using **GLASS-BOX AI** frameworks, simultaneously accounting for:

- Complex relationships
- Interpretability



We focus our analysis flagged SEPA payments, solving two tasks simultaneously:

1) FRAUD LABEL
2) LOSS GIVEN DEFAULT (LGD)

THE GLASSBOX AI MODEL

Unlike traditional linear models, which estimate fixed coefficients:

$$\text{LGD} = \beta_0 + \beta_1 amount_i + \dots + \beta_p avg\_transi$$

However, our **LocalGLMnet** using varying regression parameter for each observation

$$\text{LGD}_i = \beta_{i0} + \beta_{i1} amount + \dots + \beta_{ip} avg\_trans_i$$

structure

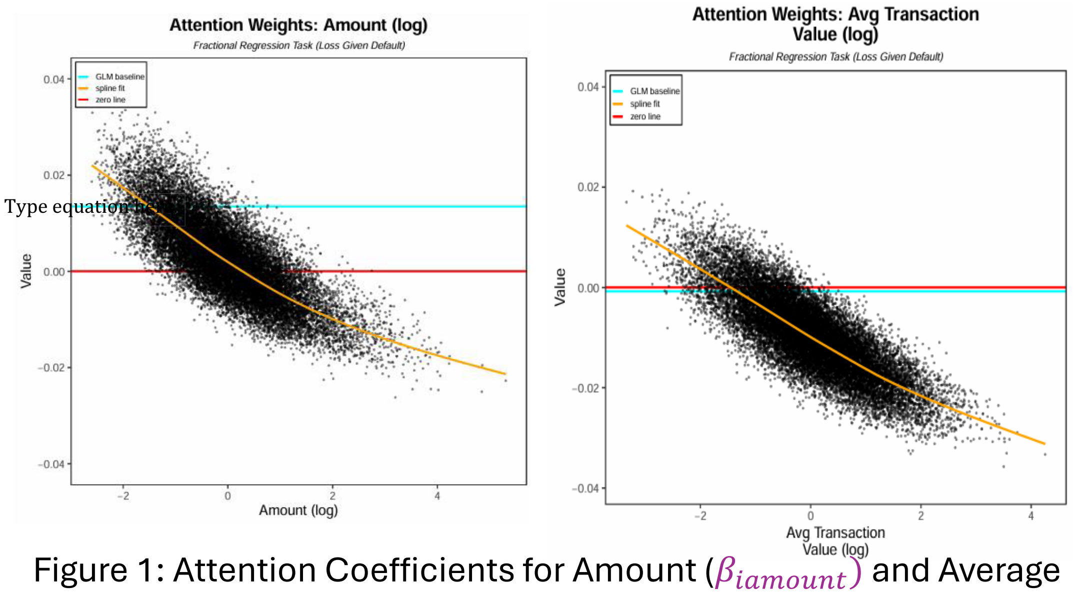


Figure 1: Attention Coefficients for Amount ($\beta_{iamount}$) and Average transaction value ($\beta_{iavg\_transaction\_value}$)

We can summarise the impact(attention) of k−th variable :

$$Attention_{\mathrm{k}} = \sum_{\mathrm{k}=1}^{\mathrm{p}} |\beta_{ik}|$$

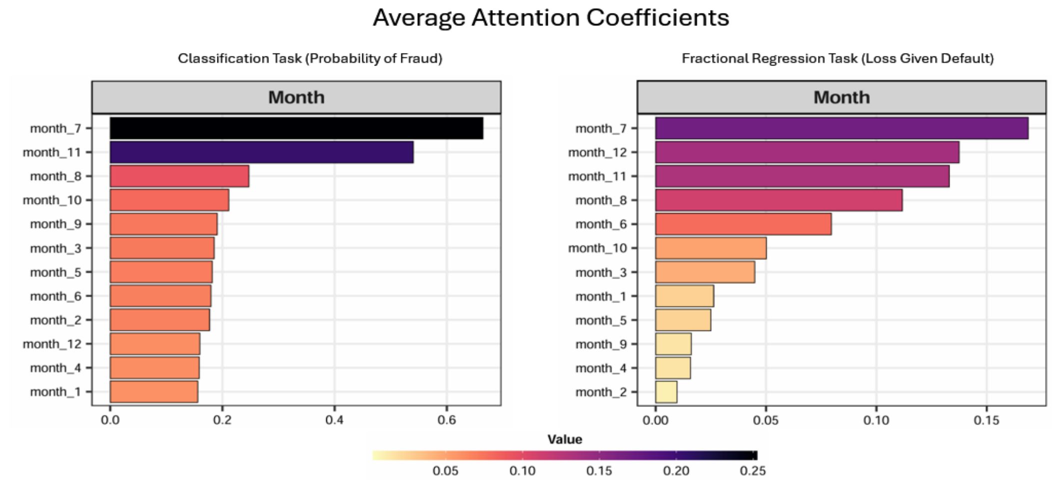


Figure 2: Attention Coefficients of Month (β_{iMonth}) for both tasks.

GlassBox

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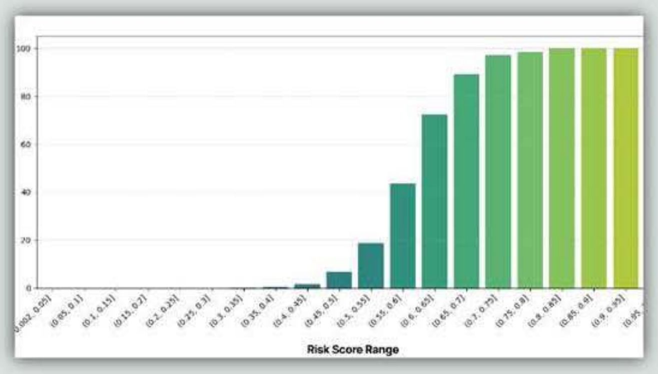
Silent Signals: Mapping Resilience in Retail Payment Networks

Can predictive topology and real-time stress signals forecast systemic payment crises?

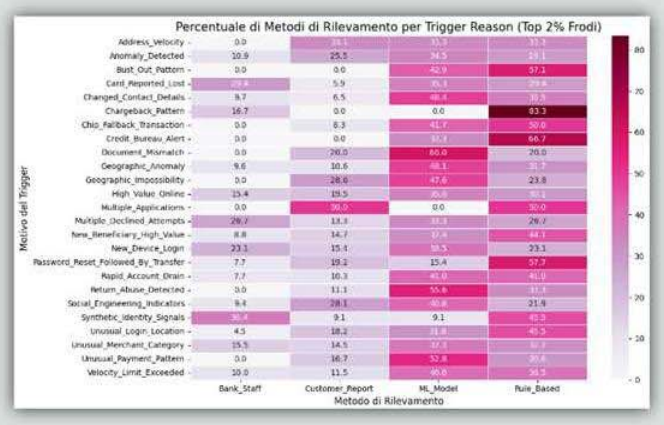
INTRODUCTION

SEPA networks face a "cry wolf" crisis where systemic noise masks real danger. We silence this digital saturation, allowing institutions to stop chasing glitches and start neutralizing genuine threats for a truly resilient financial future.



DISCUSSION

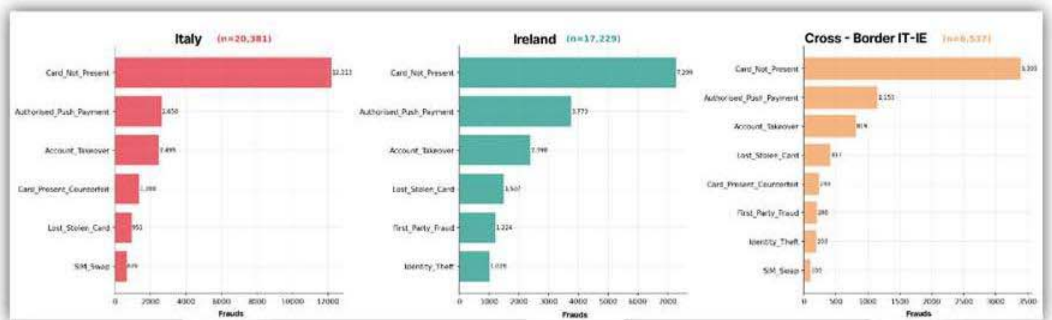
This is more than a filter; it is a visionary early warning system. By mapping the health of the financial ecosystem and spotting weak signals, we allow institutions to anticipate disruptions and intervene long before they impact the real world. We transition from reactive defense to proactive foresight, safeguarding the network through intelligent, invisible design.



METHODOLOGY

Our framework integrates three analytical pillars to transform raw data into actionable intelligence. First, we executed a rigorous data audit using Cramér's V to isolate and eliminate geographic biases that lead to false alarms. Second, we deployed advanced Machine Learning models, specifically Random Forest and Gradient Boosting, optimizing them via Simulated Annealing to maximize fraud detection while minimizing operational friction.

Finally, we introduced a first-of-its-kind Resilience Scoring layer. This layer incorporates real-time outage logs from Payment Service Providers (PSPs) to map the underlying robustness of the network. By shifting the focus from individual anomalies to systemic stability, we developed a "digital filter" capable of distinguishing between harmless technical malfunctions and sophisticated fraudulent activity. This methodology ensures that oversight is not just reactive, but structurally informed by the unique temporal and geographical pulses of the SEPA corridor. The result is a high-precision triage system that decodes the silent signals of the financial ecosystem with surgical accuracy.



RESULTS AND CONCLUSIONS

Silent Signals represents the evolution of financial security, moving from reactive monitoring to a visionary Early Warning System. By mapping the hidden health of the entire ecosystem and spotting weak signals before they escalate, we empower institutions to anticipate disruptions long before they impact the real world.

Our findings demonstrate that "smart suppression" is a strategic necessity for modern central banking, turning overwhelming data into actionable wisdom. As we scale this innovation to international corridors, we build a future where every transaction is protected by the power of invisible, intelligent design. This project proves that through data-driven resilience, we can secure the integrity of the retail payment network while maximizing operational efficiency. We are not just filtering noise; we are safeguarding the pulse of the global economy.

ParthenoPay

Benedetto Siria
Carotenuto Christian
Di Bennardo Salvatore Claudio
Fehrat Aymen
Fiorillo Alessandra
Maddaluno Luca
Militano Rosario

Read the full report here:
https://linktr.ee/parthenopay

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Invisible Money Risk Index (IMRI)

Measuring Invisible Payments and Predicting Consumer Vulnerability

Do low-salience and fragmented payment pattern increase the probability of financial distress?

1 The Problem

Digital payments are becoming increasingly invisible: micro-payments, frictionless transactions and subscriptions require little attention but may hide growing financial risk.

Relevance for central banks and the financial sector:

- Consumer Protection
- Payment System Resilience
- Early detection of vulnerable users

2 Conceptual Framework

IMRI (0-100)
Captures exposure to invisible payments
- Micro-transactions
- Frictionless payments
- Low-salience spending

Higher IMRI = more exposure to invisible payments

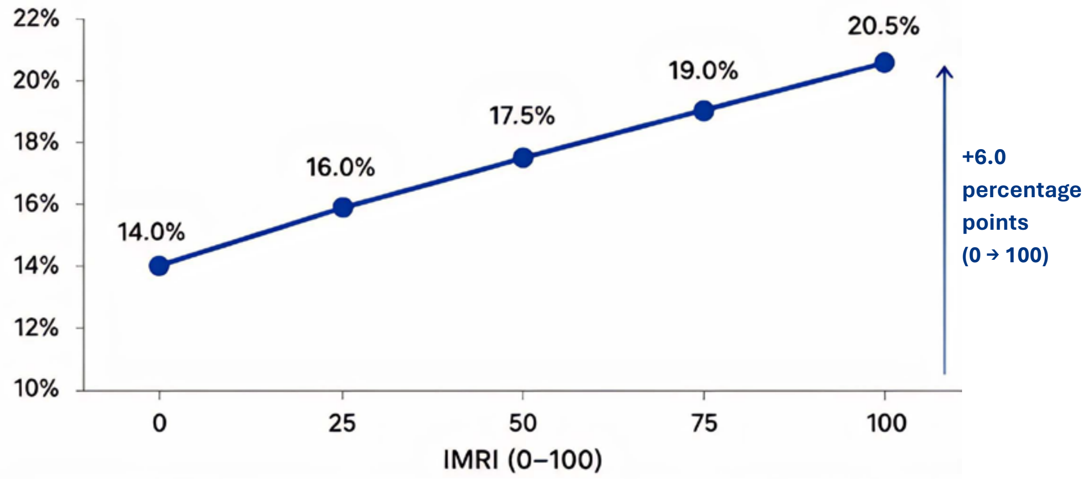
Predictability
Captures regular and expected payments
- Subscription-like patterns
- Recurring payments

Predictability reflects structure, not intensity of spending

3 Key Findings

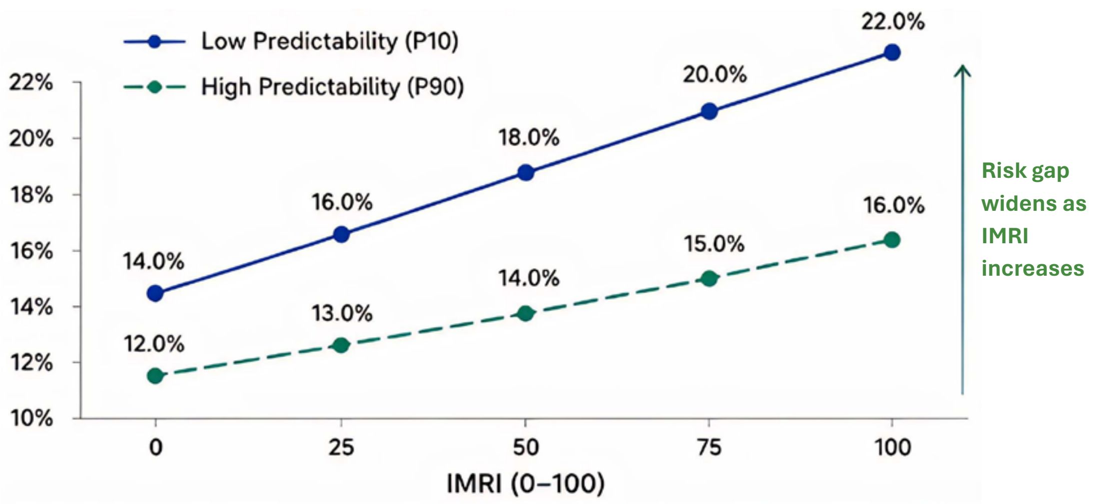
The figures show the Predicted probability of insufficient funds (%)

A. IMRI and Financial Vulnerability



Higher IMRI levels are associated with a significantly higher probability of insufficient funds.

B. The Role of Predictability (Interaction)



Predictable payments reduce financial risk

They mitigate the impact of IMRI

Risk increases mainly when payments are fragmented and non-predictable.

4 What We Learned

IMRI drives risk
More exposure to invisible payments leads to a higher probability of insufficient funds.

Predictability protects
Regular and expected payments reduce financial vulnerability.

Structure matters
Risk depends on how people spend, not just how much.

5 Policy Implications

Early warning tool	Better consumer protection	Stronger payment systems
IMRI helps identify vulnerable users before liquidity stress materializes.	Supports transparency, alerts, nudges and spending awareness.	Improves monitoring of micro-level financial stress and enhances system resilience.

Conclusion

IMRI transforms low-salience payment patterns into a measurable indicator of financial vulnerability, providing actionable insights for central banks and financial institutions.

The Invisibles

Salvatore La Barbera, Giuseppe Garofalo, Vincenzo Bassolino, Alfonso Coppola, Alessia Cuomo
Supervisor: Prof. Gabriele Sampagnaro

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“Hawkes Processes and Monte Carlo Methods for Bitcoin Dynamics Under Geopolitical Shocks”

1. Motivation

Why geopolitical risk matters?

- Primary source of global financial shocks;
- Traditional markets mask high-frequency reactions via circuit breakers.

Why Bitcoin is different?

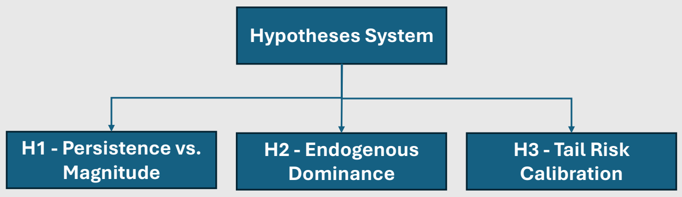
- 24/7 Continuous Trading;
- No Circuit Breakers;
- Deep Liquidity.

Research Motivation

Bitcoin’s 24/7 market makes it the ideal real-time laboratory: every impulse in λ(t) is a genuine response, and geopolitical arrive at known timestamps, enabling precise identification of microstructural dynamics.

2. Research Question & Objectives

- ***How does the magnitude of a geopolitical shock impact the persistence and absorption of trading activity in Bitcoin’s microstructure, as measured by the trade-arrival rate $\lambda(t)$?***



Hypotheses System

H1 - Persistence vs. Magnitude

H2 - Endogenous Dominance

H3 - Tail Risk Calibration

3. Data

- **Source**: Binance API BTC-USD minute bars.
- **Sample**: 2.2 million observations (Jan 2022 – Mar 2026).
- **Events**: 100 high-impact geopolitical shocks.
- **Magnitude**: Normalised pre-shock return $|\Delta P|_{norm}$.
- **Segmentation**: K-means ($k = 4$) into quartiles Q1–Q4.

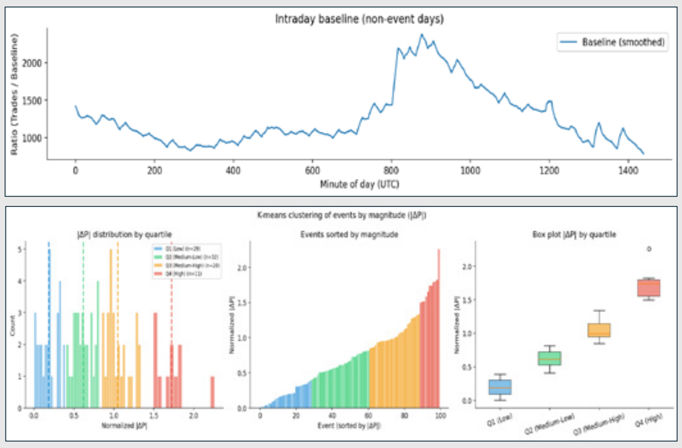


***Fig. 1**: Intraday baseline activity (up) and event distribution by quartile (down).*

4. Methodology

Model: Bi-exponential discrete-time Hawkes process with covariate augmented shock layer (9 parameters).

$$\lambda(t) = \mu + a_1 Z_1(t) + a_2 Z_2(t);$$
$$Z_i(t) = k_i Z_i(t-1) + N(t-1)$$

At shock t_0: $\lambda(t_0) = \mu + \gamma$, with

$$\gamma = \max(\gamma_0 + \gamma_{neg} 1_{neg} + \gamma_{pos} 1_{pos} + \gamma_p |\Delta P|_{norm}, 0)$$

Analytical Pipeline:

INPUT	2.2M bars | 100 events | K-means Q1–Q4
ESTIMATE	Poisson MLE (L-BFGS-B, 10 restarts) per event
DIAGNOSE	Branching ratio $\hat{\eta}$, half-life $\tau_{1/2}$, endo/exo split
SIMULATE	2,000 MC paths per quartile (bootstrap MLE pool)
OUTPUT	Peak ratio, VaR_{95}, $CVaR_{95}$, excess trades

5. Results: Endogenous vs. Exogenous

- Endogenous Dominance: The exogenous impulse accounts for less than 3% of steady-state intensity; over 97% of post-shock trading is generated by internal market dynamics (self-excitation).
- The geopolitical event acts as a fuse; the market’s own momentum sustains elevated activity.
- The slow kernel ($k_2 \approx 0.79$) accounts for 75%– 95% of $\hat{\eta}$.

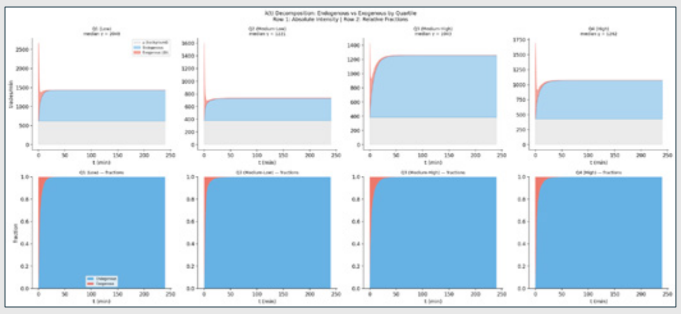


***Fig. 2:** Exogenous vs. endogenous intensity decomposition by quartile.*

	Q1	Q2	Q3	Q4
Endo. share	97.6%	97.3%	98.4%	97.9%
Tot $\hat{\eta}$	0.252	0.325	0.360	0.264
Slow share of $\hat{\eta}$	92%	75%	86%	95%

***Table 2:** Endogenous/exogenous decomposition by quartile.*

6. Results: Shock Absorption

- Ultra-fast recovery: Half-life $\tau_{1/2} \approx 1$ minute across all quartiles.
- 90% of the shock is absorbed within 3 - 8 minutes.
- This relaxation is significantly faster than in traditional equity markets, supporting semi-strong efficiency.

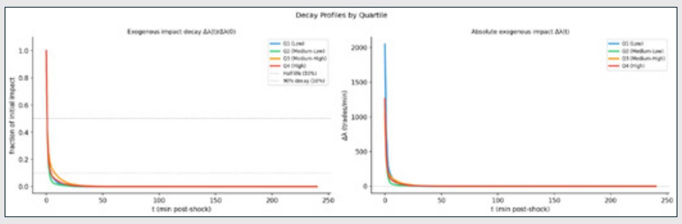


***Fig. 3:** Normalised exogenous shock absorption by quartile.*

	Q1	Q2	Q3	Q4
$\tau_{1/2}$ (min)	1	1	1	1
90% decay (min)	5	3	8	4
Median $\hat{\gamma}$	2,048	1,221	1,043	1,262
Cumul. exo trad.	4,746	2,363	3,396	3,148

***Table 3:** Shock absorption metrics by quartile.*

7. Results: Monte Carlo Scenarios

- Inverse magnitude pattern: lower-magnitude shocks (Q1) generate the highest median peak ratio (2.47 ×), while high-magnitude shocks (Q4) produce only 1.64 ×, driven by pre-shock price discovery in Q4 events.

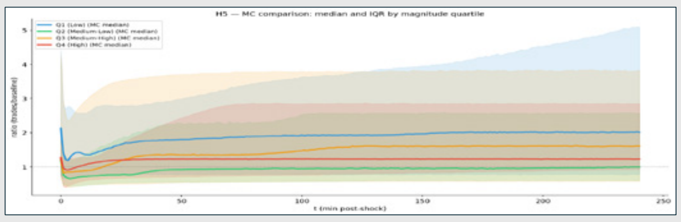


***Fig. 4:** MC median intensity paths by quartile (NMC = 2,000).*

	Q1	Q2	Q3	Q4
Peak ratio (med.)	2.47 ×	1.36 ×	2.05 ×	1.64 ×
Peak P95	8.83 ×	7.63 ×	11.0 ×	6.83 ×
Tpeak (min)	122	0	80	51
Excess trades (med.)	200	< 1	136	53

***Table 4:** MC peak metrics and timing by quartile.*

9. Discussion

- **Trigger, not driver**: Over 97% of post-shock activity is endogenously generated. The market “remembers” the event through a protracted clustering phase driven by the slow kernel.
- **Semi-strong efficiency**: Geopolitical news is priced almost instantaneously ($\tau_{1/2} \approx 1$ min), leaving little room for intensity-based arbitrage.
- **Inverse magnitude paradox**: High-magnitude events (Q4) are often anticipated, with price discovery before t_0 muting the impulse. Low-magnitude events (Q1) act as genuine surprises, hitting a quiet market and triggering a sharper response.

10. Conclusions

Main findings

- **Subcriticality (H2)**: $\hat{\eta} \in [0.25, 0.36]$ - Bitcoin microstructure absorbs shocks without cascade risk.
- **Rapid absorption (H1)**: $\tau_{1/2} \approx 1$ min - faster than traditional equity markets.
- **Inverse magnitude pattern (H1, H3)**: unexpected low magnitude shocks (Q1) produce higher peak ratios and tail risk than anticipated high-magnitude events (Q4).

Limitations & future extensions

- **Tick-level data**: removing the 1-minute discretisation would capture sub-minute micro-clustering.
- **Negative Binomial intensity**: addressing trade-count overdispersion.
- **Multivariate Hawkes**: cross-asset contagion (BTC, ETH, VIX) under geopolitical stress.
- **Time-varying baseline**: non-stationary $\mu(t)$ following the intraday activity profile.

11. Key References

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Measuring & Predicting Friction in Cross-Border SEPA Payments

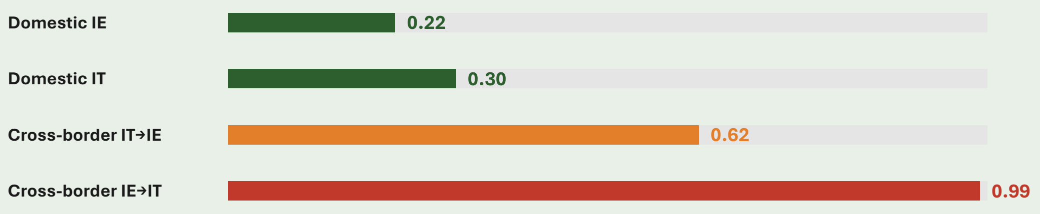
Research question

What structural factors drive friction in cross-border SEPA payments between Ireland and Italy, and which interventions could reduce failures and settlement delays for businesses?

THE PROBLEM | FRICTION IS STRUCTURAL, NOT RANDOM

Friction Index by Corridor

5M transactions · Full-year 2024



Cross-border payments show >2× higher friction than domestic — and IE→IT is consistently the riskiest direction.

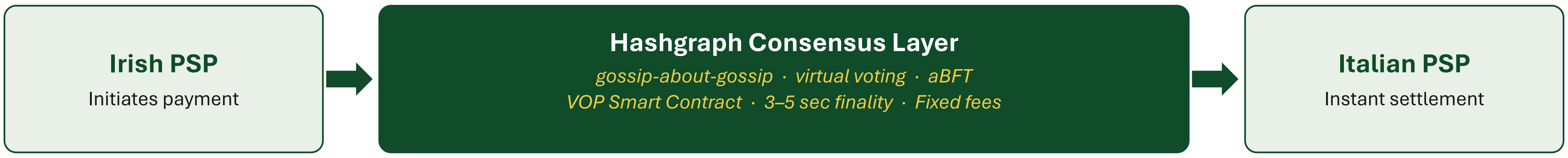
Settlement Speed — Structural Root Cause

Regression on cross-border flows · n = 749,706 · $R^2 = 0.60$

−24.0 hrs	**SEPA Instant** *Instant settles nearly a full day faster than standard*
+7.8 hrs	**Destination = Italy** *Italian receiving-side processing is the key asymmetry*
−4.0 hrs	**Origin = Italy** *Italian sending-side processes outgoing payments faster*

IE→IT is ~12 hours slower than IT→IE. Scheme + country infrastructure determine settlement speed — not channel, PSP, or transaction size.

THE SOLUTION | HASHGRAPH — A STRUCTURAL FIX



Irish PSP
Initiates payment

Hashgraph Consensus Layer
gossip-about-gossip · virtual voting · aBFT
VOP Smart Contract · 3–5 sec finality · Fixed fees

Italian PSP
Instant settlement

Not a Blockchain

- DAG consensus — no blocks, no forks, no leader
- aBFT finality: mathematically proven, not claimed
- 3–5 second settlement, deterministic

Not an Add-On

- VOP built into the protocol, not bolted on
- Rejections blocked before initiation — not after
- Directly targets the 60% preventable failures

Not Foreign-Owned

- Governed by Banca d'Italia + Central Bank of Ireland
- ECB as observer · sovereign EU infrastructure
- Aligned with the Digital Euro roadmap

Fills the gap between the Digital Euro (2029) and Pontes (wholesale) — retail cross-border settlement, today.

2×
higher friction on cross-border vs domestic flows

60%
of rejections preventable via real-time VOP validation

95%+
SCT Instant adoption — yet structural friction persists

WHY NOT THE ALTERNATIVES?

SWIFT GPI Overlay, not architecture — routing complexity and receiving-side lag remain unchanged
Ethereum 12–15 min finality, no legal accountability, public and ungoverned
Hyperledger Framework, not a network — no shared consensus across deployments

Team 12 — Sepa Team

Dea Gjermeni · Gleb Bogoiavlenskii · Luis Hysi · Yulia Petrova

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Smart Settlements

Programmable Retail Payments via Smart-Contract APIs

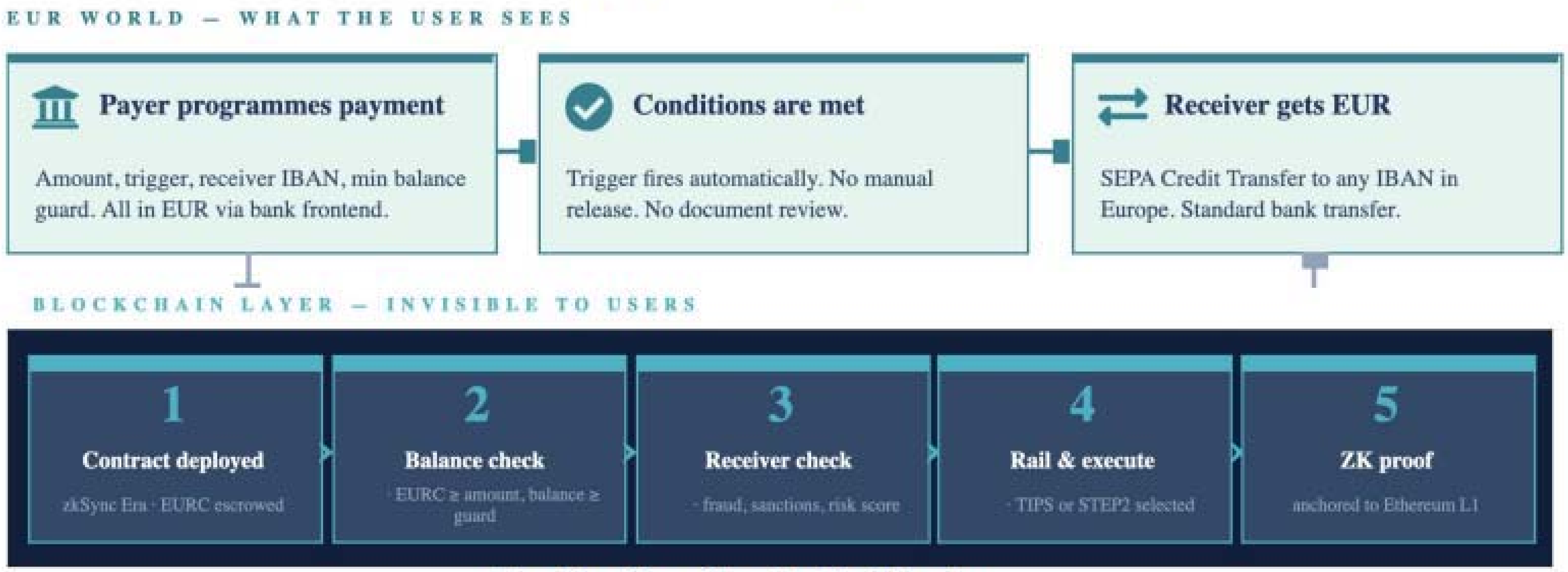
Current SEPA Limitations

- **No Programmability**
  Manual payment release after document review
- **No Mid-Flight Control**
  Once sent, payments cannot be conditionally held
- **70.6% False Positives**
  Current fraud systems block legitimate payments
- **Opacity**
  Settlement status siloed in bank systems

SmartSettlement Solution

- **Programmable Escrow**
  Auto-release EUR when conditions verified on-chain
- **Real-time Fraud Check**
  Oracle validates receiver before execution
- **93.5% Detection, 2% FP**
  Optimal threshold catches fraud, not customers
- **Full Audit Trail**
  Every state change on zkSync + database mirror

Full payment lifecycle, end to end



EUR WORLD — WHAT THE USER SEES

Payer programmes payment
Amount, trigger, receiver IBAN, min balance guard. All in EUR via bank frontend.

Conditions are met
Trigger fires automatically. No manual release. No document review.

Receiver gets EUR
SEPA Credit Transfer to any IBAN in Europe. Standard bank transfer.

BLOCKCHAIN LAYER — INVISIBLE TO USERS

1 **Contract deployed**
zkSync Era · EURC escrowed

2 **Balance check**
· EURC ≥ amount, balance ≥ guard

3 **Receiver check**
· fraud, sanctions, risk score

4 **Rail & execute**
· TIPS or STEP2 selected

5 **ZK proof**
anchored to Ethereum L1

Implications for Central Banks

🏦 **Digital Euro Ready**	Architecture compatible with future CBDC programmable payments
🔒 **Privacy-Preserving**	ZK proofs enable regulator viewing keys without mass surveillance
⚡ **TIPS Integration**	200ms latency preserved — adds intelligence without adding delay
🇪🇺 **Cross-Border SEPA**	Shift from "detect and recover" to "prevent and refund" paradigm

Sjoerd Boerema, Marco Longo,
Michele Leone Schettino d'Acquarone

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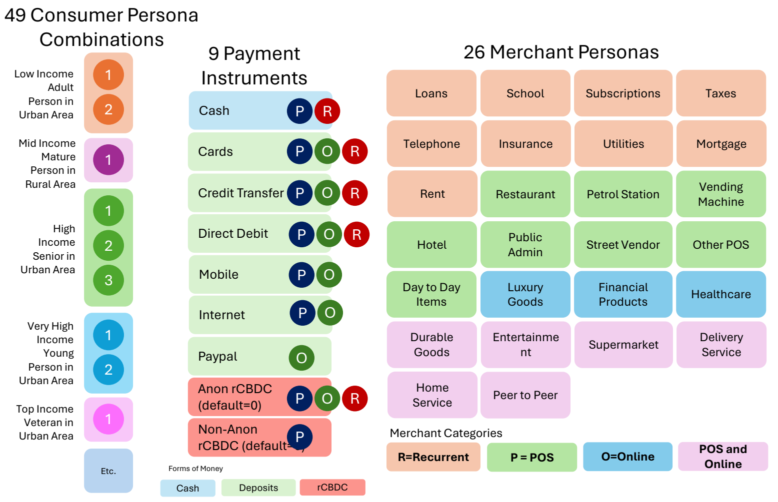
Would You Eventually Pay with an rCBDC?

How do retail CBDC design options affect consumer adoption, merchant acceptance, payment-instrument substitution, and the composition of money in Italian payment ecosystem?

1 Introduction

Retail Central Bank Digital Currency (rCBDC) introduces a new form of public money that could reshape payment behaviour and the structure of retail finance. As the Digital Euro is preparing for its pilot phase, it is crucial to assess how different design options may influence adoption before implementation.

This study uses an agent-based model (ABM) to examine whether rCBDC can achieve meaningful adoption while preserving financial stability, particularly in terms of its substitution effects on cash and bank deposits.



49 Consumer Persona Combinations

9 Payment Instruments

26 Merchant Personas

2 Data and Method

The agents are synthesized from 4,088 data points from the survey of Study on the Payment Attitudes of Consumers in the Euro Area (SPACE) 2024 by the European Central Bank (ECB) to represent Italian payment ecosystem. Agents are initialized with cash, deposit, and CBDC endowments, heterogeneous payment preferences, merchant acceptance constraints, then tested across alternative rCBDC design scenarios. This method is suitable because payment adoption emerges through repeated interactions, failed transactions, feasibility constraints, and learning effects in the 12 months of observation.

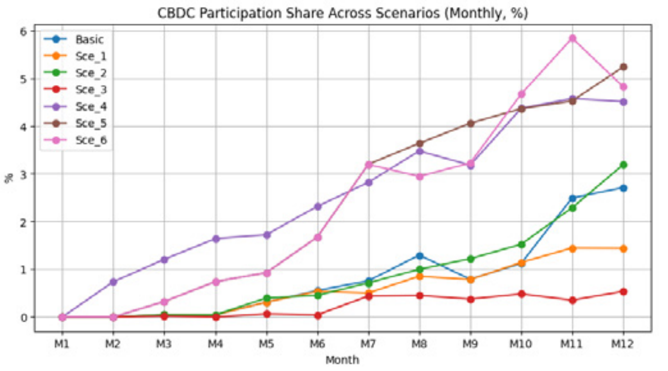
Design Options	Baseline (No rCBDC)	Basic	Sce. 1	Sce. 2	Sce. 3	Sce. 4	Sce. 5	Sce. 6
Balance Limit	NA	€3,000	€3,000	€3,000	€3,000	€3,000	€3,000	€1,000
Top-up Limit	NA	∞	€500	∞	∞	∞	∞	∞
Offline Threshold	NA	€200	€200	∞	€200	€200	€200	€200
Reverse Waterfall	NA	Yes	Yes	Yes	NA	Yes	Yes	Yes
Government Benefits via rCBDC	NA	NA	NA	NA	NA	Yes	NA	NA
Merchant Fee Waiver	NA	False	NA	NA	NA	NA	Yes	Yes

3 Model

The model simulates a retail payment ecosystem where consumers and merchants interact and choose between cash, deposit-based instruments, and two forms of CBDC (anonymous/offline and non-anonymous/online). Transactions occur across POS, online, recurrent, and P2P channels, with feasibility and merchant acceptance constraints. CBDC adoption emerges through unmet payment needs, social influence, and policy incentives, while preferences evolve via learning mechanisms. The model tests key design options such as balance limits, top-up constraints, offline transaction threshold, reverse waterfall function, government transfers, and merchant fee waivers, to evaluate their effects on adoption, payment behaviour, and money composition both on the consumers (demand) and the merchants (supply).

4 Key Findings

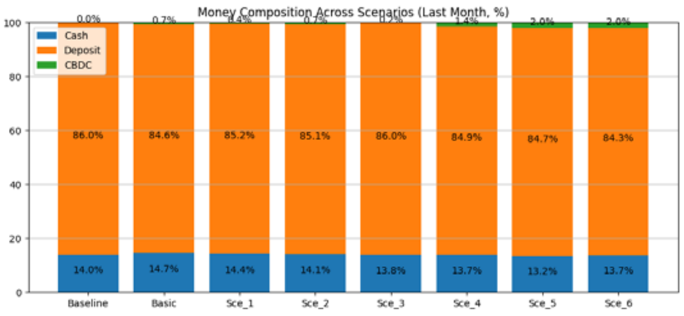
- CBDC participation remains low across all scenarios (peaking ~5–6%), indicating it complements rather than replaces existing payment instruments.
- Almost all CBDC usage comes from rCBDC non-anonymous, indicating that offline/anonymous payments' play a very limited role under current constraints.
- Government payments and merchant fee waivers are effective policy-driven tools to boost adoption.
- Reverse waterfall is an important feature, showing that liquidity access is a key barrier to CBDC usage.
- Top-up limits and balance limit are effective to restrain adoption.
- CBDC mainly replaces deposit-based instruments.
- No intermediation risk is shown where cash stays significant, and deposits remain ~85% of total money.
- The dense and centralized C2M network shows that CBDC adoption is mainly driven by consumer–merchant interactions, while the sparse C2C network limits the role of social learning.
- Traditional payment instruments still dominate both networks.



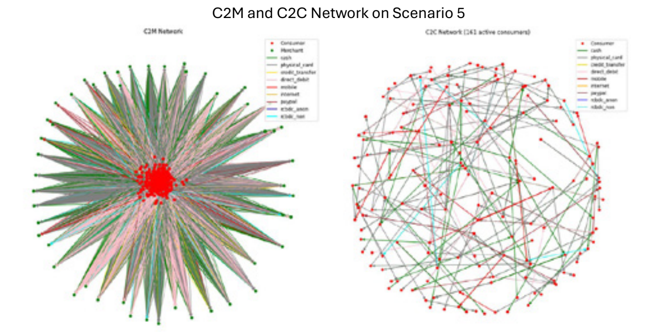
CBDC Participation Share Across Scenarios (Monthly, %)

===== PAYMENT INSTRUMENT PARTICIPATION SHARE (LAST MONTH) =====

	Baseline	Basic	Sce_1	Sce_2	Sce_3	Sce_4	Sce_5	Sce_6
cash	15.07%	18.09%	24.64%	17.58%	21.33%	24.44%	17.94%	23.70%
credit_transfer	1.62%	1.79%	1.83%	2.03%	1.32%	1.64%	1.47%	1.71%
direct_debit	43.36%	39.51%	37.38%	39.05%	38.23%	39.33%	37.33%	36.33%
internet	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
mobile	1.59%	2.04%	1.19%	1.98%	1.70%	1.58%	2.02%	0.91%
paypal	0.39%	0.49%	0.48%	0.30%	0.38%	0.58%	0.30%	0.31%
physical_card	37.97%	35.37%	33.03%	35.88%	36.50%	27.91%	35.70%	32.21%
rcbdc_anon	0.00%	0.13%	0.11%	0.16%	0.04%	0.09%	0.00%	0.18%
rcbdc_non	0.00%	2.58%	1.33%	3.03%	0.49%	4.42%	5.24%	4.65%



Money Composition Across Scenarios (Last Month, %)



C2M and C2C Network on Scenario 5

5 Conclusion

CBDC adoption remains limited and is mainly driven by C2M interactions, with traditional instruments like direct debit and cards continuing to dominate. Reverse waterfall, government benefits, and merchant waiver significantly increase adoption, while balance limits, top-up, and offline thresholds mainly restrict usage. Importantly, deposits remain stable, indicating minimal disintermediation risk and a feasible balance between adoption and financial stability.

References

[1] León et al. (2024), Simulating the Adoption of a Retail CBDC, Journal of Economics and Statistics.

[2] European Central Bank (2024), Digital euro pilot – FAQ.

[3] European Central Bank (2024), Study on the Payment Attitudes of Consumers in the Euro Area (SPACE 2024).

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Innovation Data Challenge 2026

The Architecture of Speed:

Operational Resilience, Early Warning Signals, and Predictive Modeling in European Payment Networks

As payment ecosystems accelerate towards real-time processing, a critical question emerges: **does instant payment adoption compromise operational resilience and increase systemic risk?**

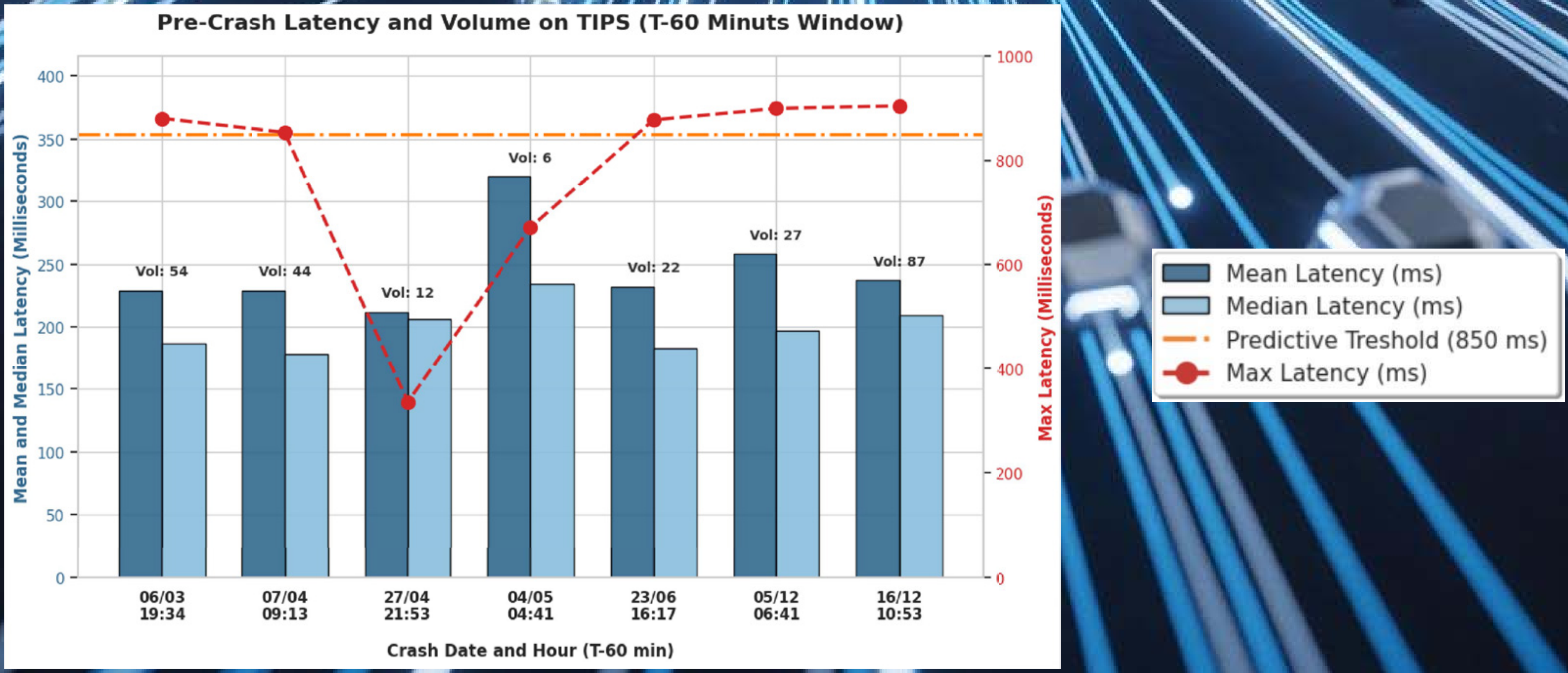
Key Findings & Results

Infrastructure Strain → Vast majority of failed volumes originated from Tier-4 "small players," rather than major bank outages.

Predictive Indicators

- 850ms latency threshold reliably signals network degradation when volume is *large enough*.
- Anomalous shifts in channel distribution (Mobile vs Web) serve as secondary indicators.

Practical Application → Conceptually designed an API tool to dynamically redirect transaction flows from TIPS to RT1 upon anomaly detection.



Pre-Crash Latency and Volume on TIPS (T-60 Minuts Window)

Team: The Ledger

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Innovation Data Challenge 2026

Real-Time Payment Adoption

Patterns and Frictions in Retail Payments Innovation

Axel Massimiliano Benedetti Bolf - Politecnico di Milano

THE PROBLEM

13%

RTP Adoption Rate

Only 13% of 5M transactions used instant rails in 2024

87%

Traditional Methods

Cost more, take longer. still dominate 87% of volume

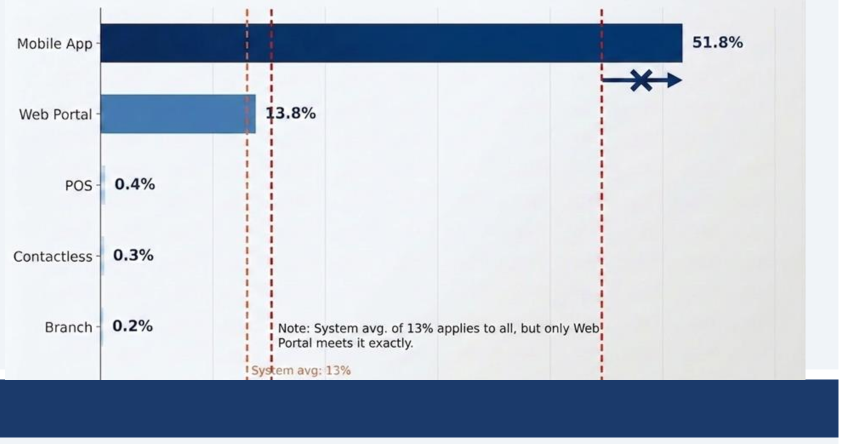
5M

Transactions Analyzed

Synthetic data, Italy & Ireland 2024

FINDING 1 — The Channel Is What Matters

- **Channel** is the strongest predictor of RTP adoption, stronger than age, amount, or segment combined
- **Mobile App → 51.8%** — nearly 4x the system average
- **Web Portal → 13.8%** — essentially the baseline
- **POS / Contactless / Branch → ~0%** — not wired to instant rails
- The barrier is **infrastructure, not behavior**



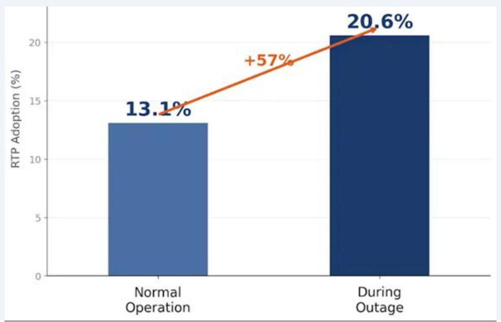
Note: System avg. of 13% applies to all, but only Web Portal meets it exactly.

FINDING 2 — Instant Payments Perform Better Across Every Metric

Metric	Traditional	Real-Time (RTP)
Mean processing time	**2,740 s**	**0.28 s**
Cost per transaction	**€0.0099**	**€0.0024**
Settlement rate	**95.6%**	**97.8%**
P90 processing time	**8,715 s**	**0.48 s**

FINDING 3 — RTP Functions as Contingency Infrastructure

- During outages, RTP adoption jumps from **13.1% to 20.6%**, a +57% relative increase
- Users actively switch to instant rails when traditional systems fail
- RTP is **what people fall back on** when the main system goes down
- Positions RTP as critical **payment resilience infrastructure**



TECHNICAL DELIVERABLES: From Insight to Incentive

Flask REST API

/api/overview → overall RTP adoption rate
/api/channel → adoption by channel
/api/performance → operational comparison
/api/outages → outage effect

All endpoints return HTTP 200 JSON

Solidity Smart Contract: Sepolia Testnet

- Rewards 10pts for RTP, 1pt for traditional
- Rate limiter (10s cooldown)
- No intermediary — enforced by code
- Tracks adoption as transactions arrive

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CONCLUSION

Making RTP available is not enough. Making it accessible is.

The EU Instant Payments Regulation (2024) removes price barriers, but physical channels must still be wired to instant rails. Expanding RTP access to POS and branch channels is the single highest-leverage policy intervention this data supports.

Tools: Python · pandas · Flask · Solidity · NayaOne Sandbox · Dataset: Banca d'Italia & Central Bank of Ireland

Innovation Data Challenge 2026

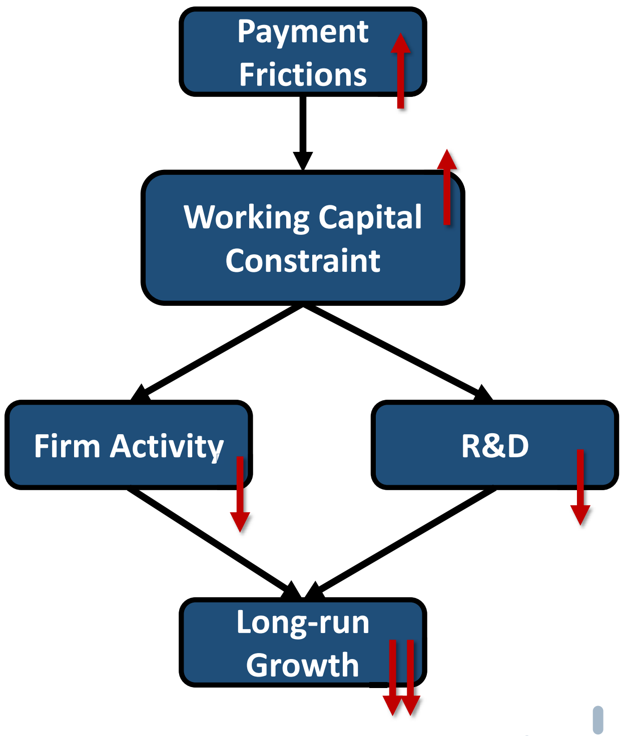
The Welfare Costs of Payment Glitches

How do payment failures affect production and long-run growth?

- *We embed payment execution risk in an endogenous growth model with production networks and working capital constraints.*
- *Payment failures disrupt production, reduce profits, and depress R&D investment.*
- *Using novel EU payment data, we show these shocks are frequent and persistent.*

Motivation

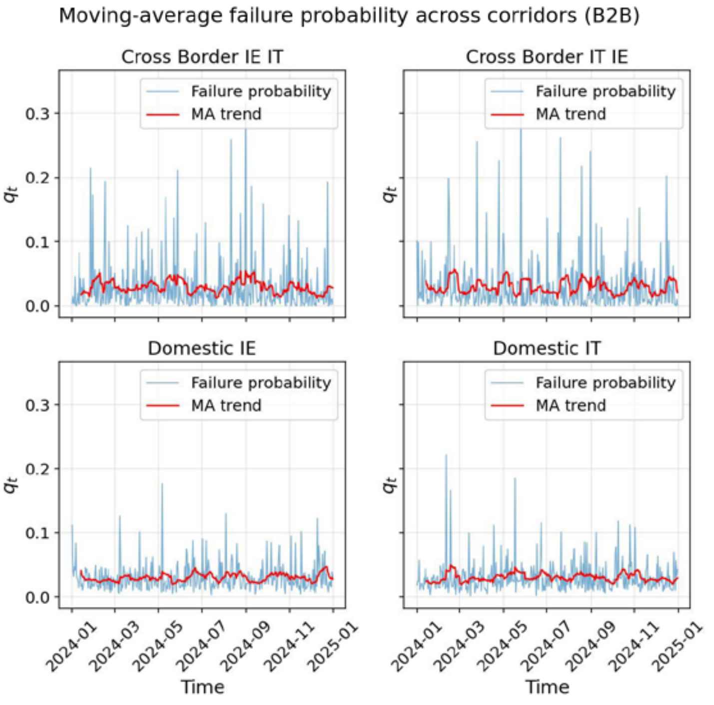
- *Payments are assumed* ***frictionless*** *in many macro model*
- *Yet, failure rates are* ***not trivial*** *(~3%) and time varying*

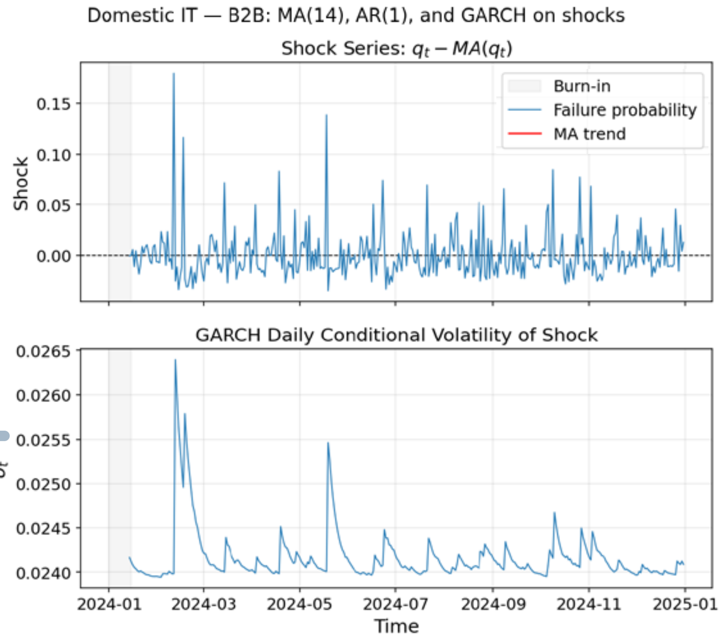


Key Insights

- *Payment failures amplify* ***working capital frictions*** *and depress growth*
- *Cross-border payment risk generates* ***global spillovers***
- *Ongoing work: linking payment risk to financial variables*

Empirical Evidence





- *Failures are* ***frequent and persistent***
- ***Large shocks*** *(2–4pp)*
- *Stronger for* ***cross-boarder payments***

Model

Romer-type endogenous growth model with payment execution risk

Three levels of production: *Final producers, intermediate manufacturers, innovators*

Payment failures disrupt production…

$$m_{i,t} \in \{0,1\}, \Pr(m_{i,t} = 1) = \lambda_t^p$$
$$x_{i,t}^{eff} = m_{i,t} x_{i,t}$$
$$\Gamma_t = \left[\int (m_{i,t} x_{i,t})^\nu di\right]^{1/\nu}$$

…potentially through production network

$$z_{i,t} = \left(\int a_{ij}(m_{ij,t}, x_{ij,t})^\rho\right)^{1/\rho}$$
$$y_{i,t} = A_{i,t}\, z_{i,t}$$

Policy Implication

- Payment systems crucial
- We measure growth and welfare costs
- Relevant for:
  - Payment infrastructure design
  - Digital currencies (Digital Euro)

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Innovation Data Challenge 2026

Liquidity Dynamics

Do Real-Time Payments Improve Firms' Cash Conversion Cycle in SME firms?

OBJECTIVE

Can transaction data be used to identify **financially fragile firms** before it becomes visible in financial statements?

DATA USED

SME TRANSACTIONS

Daily balances from real-time payments

FINANCIAL STATEMENTS

2024 & 2025

Risk metrics: liquidity & coverage ratios

DEFINING FINANCIAL DISTRESS

Distress = 1 if at least one condition holds:

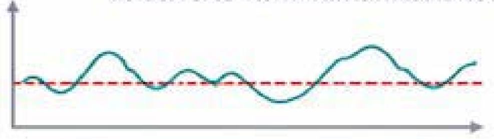
- Interest Coverage < 1.5
- Current Ratio < 1
- Operating Cash Flow < 0

A multi-dimensional definition to reduce noise and improve robustness.

TRANSACTION-BASED INDICATORS

1. LIQUIDITY BUFFER

Measures how much financial reserve a firm maintains relative to its minimum balance.



Higher = more resilience

2. STRESS FREQUENCY

Percentage of transactions with balance ≤ 0.

Higher = more frequent stress

3. STRESS SEVERITY RATIO

Captures how deep the financial stress is when it occurs.

$$\frac{|\text{average negative balance}|}{|\text{average balance}|}$$

Higher = more severe stress

MODEL

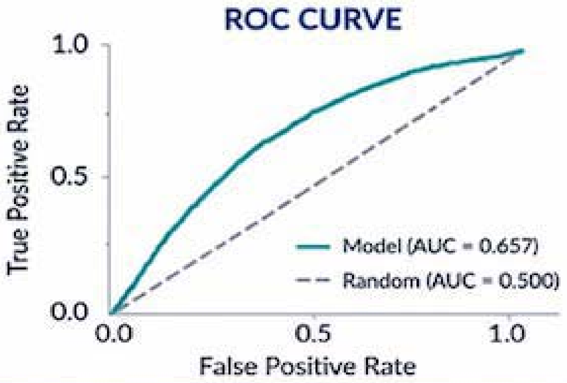
- ✓ Logistic Regression
- ✓ Standardized variables
- ✓ Output: **Probability of distress**

Chosen because the target variable is **binary (distress vs non-distress).**

RESULTS

AUC 0.657

Model significant (p ≈ 0.003)



INTERPRETATION

The model has **predictive power** beyond random chance.

It correctly ranks a distressed firm above a healthy one in **~66%** of cases.

Most informative indicators: **Liquidity Buffer** and **Stress Severity.**

BUSINESS IMPLICATIONS

EARLY WARNING SIGNALS
Identify financial fragility before it appears in financial statements.

CONTINUOUS MONITORING
Real-time insights into firm liquidity and financial health.

SCALABLE SOLUTION
With more data, the model's performance and reliability improve.

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