VILNIUS TECH
Vilnius Gediminas Technical University

24TH BANK OF FINLAND SEMINAR ON FINANCIAL MARKET INFRASTRUCTURES

The Safety Valve: A Comparative Stochastic Agent-Based Model of CBDC-Induced Bank Runs Cross-Country Evidence from Germany, Finland, and Lithuania Under Geopolitical Shock

Author: Martynas Rajunčius (Bank of Lithuania & Vilnius Tech University) | Assoc. Prof. Dr. Algita Miečinskienė

The Policy Dilemma: Disintermediation vs. Sovereign Utility

1. The Disintermediation Fear

• Retail CBDC enables frictionless conversion of private commercial bank deposits into risk-free central bank liabilities.
• Threatens structural liquidity, increasing wholesale funding costs and disintermediating commercial lending.

2. The Proposed Static Fix

• The Eurosystem consensus centers on an individual static holding limit of €3,000 per citizen.
• Assumes a one-size-fits-all cap preserves payments usability while preventing large-scale run migration during crises.

3. The Asymmetric Flaw

• Ignores deep structural asymmetries across member states: median deposits range from €2k (LT) to €12k (DE).
• Disregards digital payment velocities (Finland ~100%) and localized Geopolitical Risk (GPR) exposure at Eurozone borders.

The 'Safety Valve' Transmission Mechanism

Stage 1: Geopolitical Shock

Day 15 GPR index surges to 180 (95th percentile). Households initiate instant mobile runs to CBDC.

Stage 2: Digital Cap Saturation

The static €3,000 limit is reached rapidly by high-deposit households in core economies (DE, FI).

Stage 3: The Safety Valve Spillover

Panic is not extinguished; unappeased run demand pivots 100% into unconstrained physical cash.

Stage 4: Reserve Exhaustion

Physical cash drains central bank reserves 1:1, destroying commercial bank HQLA and crashing LCR < 100%.

Theoretical Foundations & Scientific Lineage

- **Diamond & Dybvig (1983) Framework:**

Canonical maturity mismatch; private commercial banks hold illiquid assets funded by short-term demand liabilities, generating multiple self-fulfilling run equilibria.

- **Global Games & Coordination (Goldstein & Pauzner, 2005):**

Resolves equilibrium indeterminacy by introducing noisy private and public signals. Real-time digital banking visibility acts as a synchronized coordination trigger.

- **Geopolitical Risk Shocks (Caldara & Iacoviello, 2022):**

Exogenous macro-shock calibration via the GPR Index. Quantifies non-linear sentiment deterioration during severe border conflicts and military escalations.

- **CBDC Remuneration & Disintermediation (Bindseil, 2020; Meller & Soons, 2023):**

Tiered interest rate frameworks vs. quantitative caps. We demonstrate that during acute panics, flight-to-safety behavior becomes entirely interest-rate insensitive.

Methodological Framework: Stochastic ABM Equations

1. Logistic Sigmoid Panic Function

$$P(i, t) = 1 / (1 + \exp[-k * (\Psi(i, t) - \theta(i))])$$

- k = 12.0 (Sigmoid steepness parameter)
- θ(i) ~ N(0.62, 0.08) (Household panic tolerance threshold)

2. Perceived Stress Index (Ψ)

$$\Psi(i, t) = \alpha * Fragility(i) + \beta * Herding(t) + \gamma * GPR(t)$$

- α = 0.25 (Micro HFCS financial fragility)
- β = 0.35 (Market-wide digital withdrawal velocity)
- γ = 0.40 (Normalized exogenous GPR shock)

3. Bank Liquidity Coverage Constraint (LCR)

$$LCR(j, t) = HQLA(j, t) / Net\_Outflows(j, t) >= 100\%$$

- HQLA = Central Bank Reserves + Haircut Sovereign Bonds
- Physical cash drain depletes Reserves euro-for-euro.
- Secondary liquidations incur an emergency fire-sale haircut (15%).
- Regulatory Failure: LCR drops below 100% threshold.

ABM Engine Scale: 10,000 synthetic households per country (30,000 total) simulated over 60 days.

Number of Runs: To ensure full stochastic convergence of the results, the model conducts 1,000 independent Monte Carlo replications for each country scenario.

Demand-Side Calibration: ECB HFCS Microdata

Calibration Metric	ECB HFCS Table	Germany (DE)	Finland (FI)	Lithuania (LT)
Median Sight Deposits (DA2101)	Table C2 (Conditional Medians)	**€12,000**	**€7,500**	**€2,000**
Deposit Share of Liquid Assets	Table D3 (Portfolio Shares)	**41.2%**	**37.6%**	**65.8%**
Top 10% Wealth Ceiling (p90)	Tables J2 & J3 (Net Wealth)	**€855,100**	**€626,600**	**€214,500**
Negative Net Wealth Incidence	Table F3 (Financial Fragility)	**5.6%**	**12.1%**	**0.4%**
Payment Digitalization Level	ECB SPACE Survey (2022/24)	**Moderate (Cash Base)**	**Very High (~100%)**	**High / Expanding**

Supply-Side Calibration: Top 5 Credit Institutions Panel

Germany (DE)

Baseline Sector LCR: ~149.0%
HQLA Reserve Share: 50.0%

Sampled Pillar 3 Panel:

1. Deutsche Bank AG (Global Systemic)
2. Commerzbank AG (Major Retail)
3. DZ BANK AG (Cooperative Central)
4. LBBW (Landesbank Baden-Württ.)
5. ING-DiBa AG (Digital Retail Leader)

Finland (FI)

Baseline Sector LCR: ~143.0%
HQLA Reserve Share: 30.0%

Sampled Pillar 3 Panel:

1. Nordea Bank Abp (Pan-Nordic Flagship)
2. OP Financial Group (Cooperative)
3. Danske Bank A/S (Finland Branch)
4. Aktia Bank Abp (Regional Retail)
5. Savings Banks Group (Säästöpankki)

Lithuania (LT)

Baseline Sector LCR: ~214.0%
HQLA Reserve Share: 25.0%

Sampled Pillar 3 Panel:

1. Swedbank, AB (Retail Leader)
2. AB SEB bankas (Universal Banking)
3. AB Šiaulių bankas (Domestic Commercial)
4. Luminor Bank AS (Baltic Cross-Border)
5. Urbo bankas (Domestic Banking)

Simulation Stress Test Timeline: The Day 15 Shock

- **Phase 1: Steady-State Baseline (Days 0–14)**

Macro-environment is calm; GPR Index = 45. Household run probability is at basal equilibrium (<0.05% daily). Confirms baseline transactional frictions do not generate false runs.

- **Phase 2: Shock Epicenter (Day 15)**

Sudden exogenous geopolitical escalation (e.g., border crisis / critical infrastructure threat). GPR surges discontinuously from 45 to 180 (95th-percentile shock).

- **Phase 3: Contagion & Safety Valve Activation (Days 16–25)**

Herding contagion accelerates. High-wealth agents saturate the €3,000 cap within 48–72 hours, triggering immediate 100% spillover into physical cash.

- **Phase 4: Mean-Reversion & Solvency Audit (Days 26–60)**

GPR reverts exponentially toward baseline (50). The simulation tracks cumulative HQLA depletion, secondary fire-sales, and LCR statutory compliance.

Findings: Systemic Failure Under Static €3,000 Cap

Jurisdiction	Baseline LCR	Trough LCR (Static Cap)	Regulatory Failure Day	Observed Run Dynamic
Germany (DE)	**149.0%**	**89.60%**	Day 22 (7d post-shock)	Severe Cash Run; 100% Reserve Exhaustion
Finland (FI)	**143.0%**	**95.80%**	Day 28 (13d post-shock)	Rapid Digital Saturation -> Cash Switch
Lithuania (LT)	**214.0%**	**138.50%**	No Breach (>60 Days)	Resilient; Cap Covers 65%+ of Wealth Base

Core Takeaway: The Core-Periphery Vulnerability Inversion

Under the static €3,000 cap, Germany (the core economy) fails first because large deposit balances overflow into physical cash, whereas Lithuania (the periphery) remains solvent because its median deposits are already fully protected beneath the cap.

Cross-Border Divergence

Country / Parameter	Methodological Rationale
Germany (DE)	Core Eurozone economy; large median deposits (€12k); severe cash spillover.
Finland (FI)	Digitized Nordic economy; rapid digital payment velocity and electronic run switch.
Lithuania (LT)	Peripheral Baltic economy; compressed deposits (€2k); excess initial liquidity buffer.
Regulatory Minimum	Statutory 100% Minimum Liquidity Coverage Ratio (LCR) threshold.
Shock Epicenter	Days 15–25 acute Geopolitical Risk (GPR) shock window (GPR surging to 180).

Policy Solution: The 4-Level Dynamic Circuit Breaker

Level 1: Green (Normal Ops)

CBDC Limit: €5,000

Trigger:
GPR < 70 AND Velocity < 2%

Maximizes retail usability and digital euro adoption during calm periods.

Level 2: Yellow (Elevated Alert)

CBDC Limit: €3,000

Trigger:
70 <= GPR < 110 OR Velocity < 6%

Standard precautionary holding limit to prevent early reserve drift.

Level 3: Orange (Severe Stress)

CBDC Limit: €1,500

Trigger:
110 <= GPR < 150 OR Velocity < 12%

Throttles run velocity, preventing synchronized digital panic coordination.

Level 4: Red (Crisis Mode)

CBDC Limit: €500

Trigger:
GPR >= 150 OR Velocity >= 12%

Strict transactional rationing; halts both digital and cash run cascades.

Quantitative Impact: Dynamic Circuit Breaker Restores Solvency

Performance Indicator	Static €3,000 Cap Policy	Dynamic Circuit Breaker Regime	Macroprudential Policy Gain
Germany Trough LCR	**89.60% (Regulatory Breach)**	**118.40% (Fully Compliant)**	**+28.80 percentage points**
Finland Trough LCR	**95.80% (Regulatory Breach)**	**114.20% (Fully Compliant)**	**+18.40 percentage points**
Lithuania Trough LCR	**138.50% (Resilient)**	**172.10% (Substantial Buffer)**	**+33.60 percentage points**
Total Banking System Breaches	**2 of 3 Countries Fail**	**0 Breaches (100% Systemic Survival)**	**Complete Macroprudential Protection**

Conclusions & Recommendations for the Eurosystem

- **1. Reject Static Uniformity:**

A fixed €3,000 cap is fundamentally flawed across asymmetric wealth and payment systems.

- **2. Beware the Safety Valve:**

Capping digital outflows without managing panic directly accelerates physical cash runs, draining central bank reserves.

- **3. Adopt Dynamic Circuit Breakers:**

Embed state-contingent holding limits (€5k down to €500) triggered by real-time velocity and GPR indicators.

- **4. Legislative Recommendation:**

Integrate automated macroprudential circuit breakers into the digital euro regulatory framework.

Thank you! Floor open to Discussant Karol Karpiński (World Bank) & Audience Q&A.