Contagion in Payment and Settlement Systems

Matti Hellqvist

Financial Markets and Statistics Dept. - Bank of Finland

Paper presented at the Expert Forum on Advanced Techniques on Stress Testing: Applications for Supervisors
Hosted by the International Monetary Fund
Washington, DC– May 2-3, 2006

Contagion in payment and settlement systems - stress testing liquidity with simulations

Matti Hellqvist
Financial Markets and Statistics dept.
Bank of Finland

3 May 2006

EUROJÄRJESTELMÄ
EUROSYSTEMET

Structure of this presentation

- Concepts and framework
  - What forms of contagion are discussed?
- Simulation model of payment and settlement systems
  - Bank of Finland payment and settlement system simulator
- Results from two analysis of Finnish infrastructure
  - Stress testing securities settlement systems
- Conclusions

Different forms of contagion

- Direct
  - Mediation of payments
  - Direct credit positions
- vs. Indirect
  - Reactions of external creditors
  - 2.nd round credit or liquidity problems of counterparties

- Disturbances in flows in **payment and settlement systems**
- Liquidity shortages, delays in payments

”Liquidity is available – until you need it”

Impact on the framework

EUROJÄRJESTELMÄ
EUROSYSTEMET

Strike

Liquidity shock

Earthquake

Terror Attack e.g. 9/11

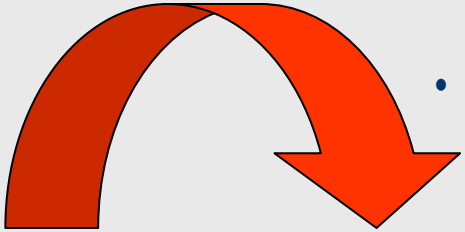
Power Outage

Default

Wide Scale Disruption

Financial Crisis

Operational incident e.g. BoNY 1985



Scenarios

- Participant(s)
  - Default / operational suspension
- **System**
  - **Suspend (duration?)**
- **Contingency procedures or algorithms**
  - **Revert to EoD settlement**
  - **From gridlock resolution to plain RTGS**

Direct impact

•**Cancelled or delayed payments,** changes in credit limits or in eligible collateral, Credit losses, …

Contagion

•Benchmarking liquidity positions with normal situation and known reserves

Original Slide by Morten Bech in the 3rd simulator workshop in Helsinki, 24-25 August 2005

EUROJÄRJESTELMÄ
EUROSYSTEMET

Structure of this presentation

- Concepts and framework
  - What forms of contagion are discussed?
- Simulation model of payment and settlement systems
  - Bank of Finland payment and settlement system simulator
- Results from two analysis of Finnish infrastructure
  - Stress testing securities settlement systems
- Conclusions

Bank of Finland Payment and settlement system simulator (BoF-PSS2)

- Versatile tool for reproducing real processing patterns in payment and settlement systems
  - Processing with RTGS or continuous/deferred netting
  - Gridlock resolution with multilateral, partial multilateral or bilateral netting, in batches or continuously
  - Balances, liquidity swaps, intraday credit, bilateral limits.
  - DVP (or PVP) processing for securities settlement (or FX)
  - Simulation of parallel interlinked systems e.g. TARGET or main RTGS + ancillary Securities settlement system

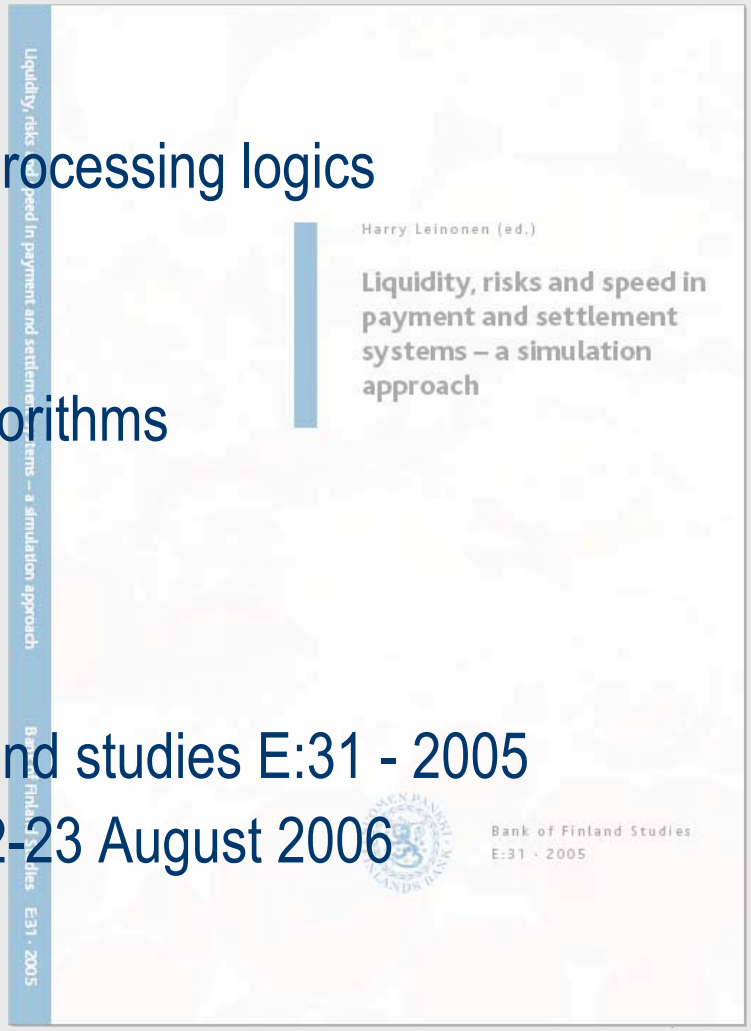
A laboratory of payment and settlement systems


Main menu
Bank of Finland Payment and Settlement Simulator
Main menu
Project example1
Initial specifications
User module definitions
Input generation subsystem
Define system data
Import input file
View data sets
Delete data sets
Export input file
Simulation execution subsystem
Simulation configuration
Simulation execution
View simulation logs
Output analysing subsystem
Basic statistics reports
Account comparison
System comparison
Delete output data
Export output file
Help
Exit program

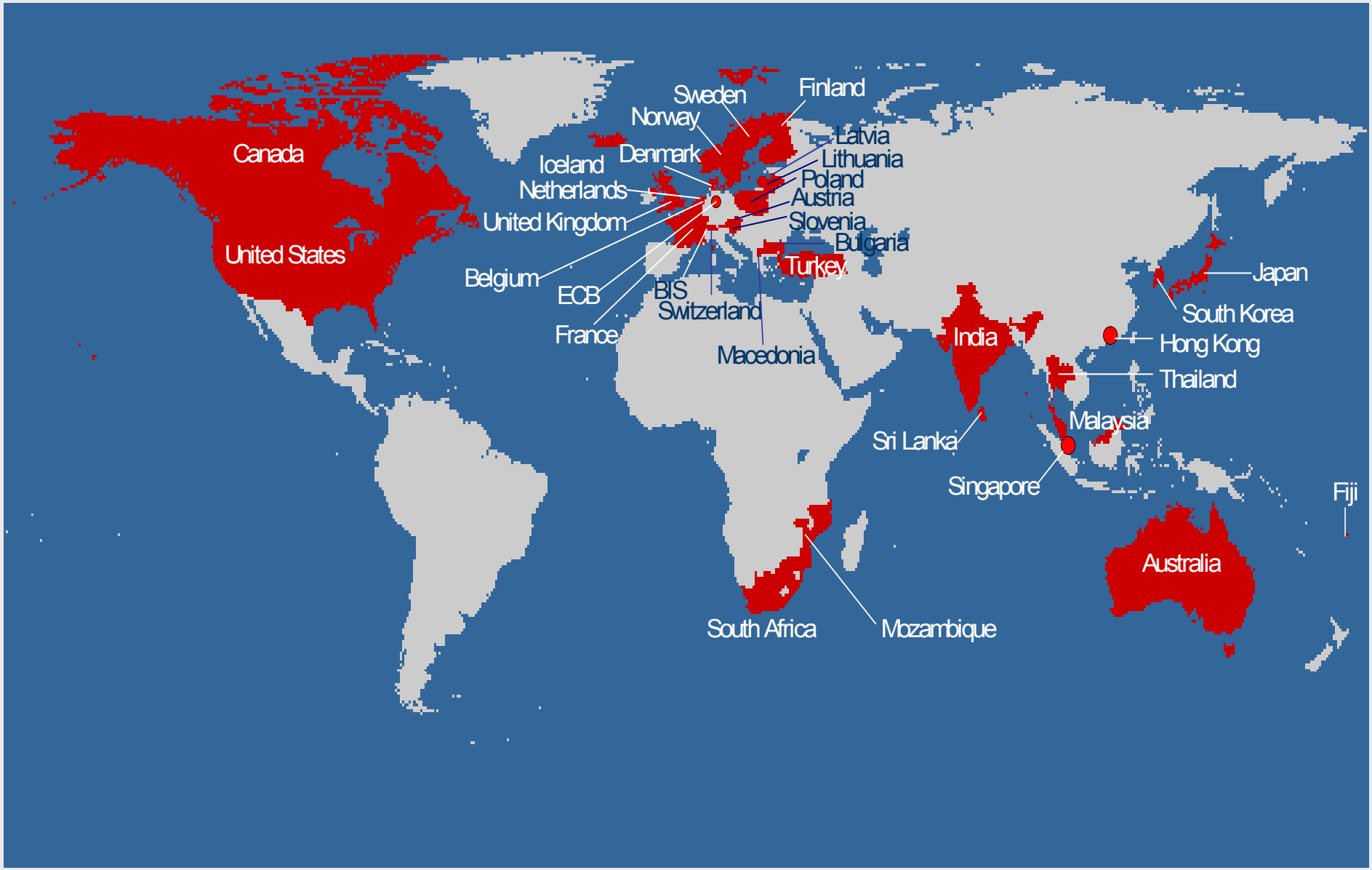
EUROJÄRJESTELMÄ
EUROSYSTEMET

BoF-PSS2 continued

- Useful tool for analysis of
  - Stress testing scenarios
  - Impact of structural changes or new processing logics
- It is not
  - only for ex post analysis of real data
  - bound to currently available set of algorithms
- Freely available for research purposes
  - see www.bof.fi/sc/bof-pss
- Examples of use
  - see e.g. Leinonen (ed.), Bank of Finland studies E:31 - 2005
  - 4th simulator workshop in Helsinki, 22-23 August 2006



BoF-PSS2 Simulator Diffusion (April 2006)

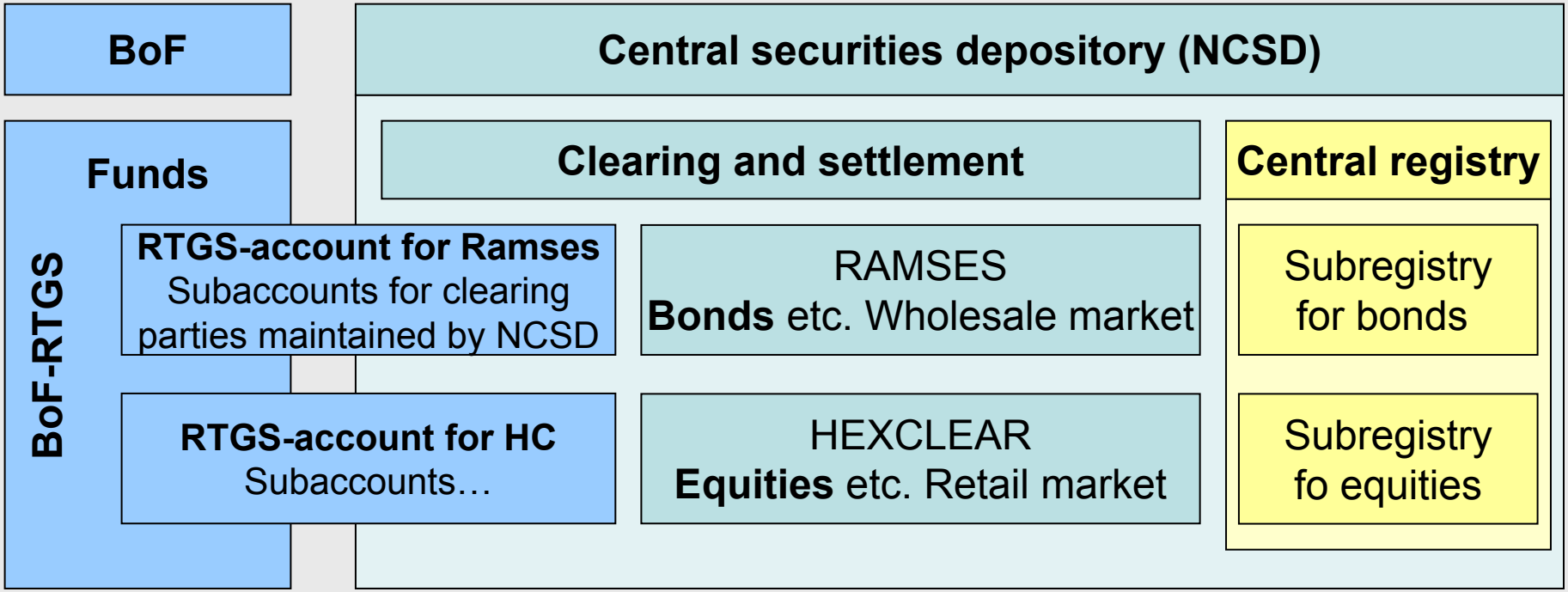


EUROJÄRJESTELMÄ
EUROSYSTEMET

Structure of this presentation

- Concepts and framework
  - What forms of contagion are discussed?
- Simulation model of payment and settlement systems
  - Bank of Finland payment and settlement system simulator
- Results from two analysis of Finnish infrastructure
  - Stress testing securities settlement systems
- Conclusions

The Finnish Securities settlement system infra



-Direct holding of securities by individual investors

-Gross settlement with batch type gridlock resolution (optimization)

-Model1 DVP (BIS 1992)

-"Modified integrated model", settlement in CB-money, no credit creation by NCSD, settlement process or clearing participants.

EUROJÄRJESTELMÄ
EUROSYSTEMET

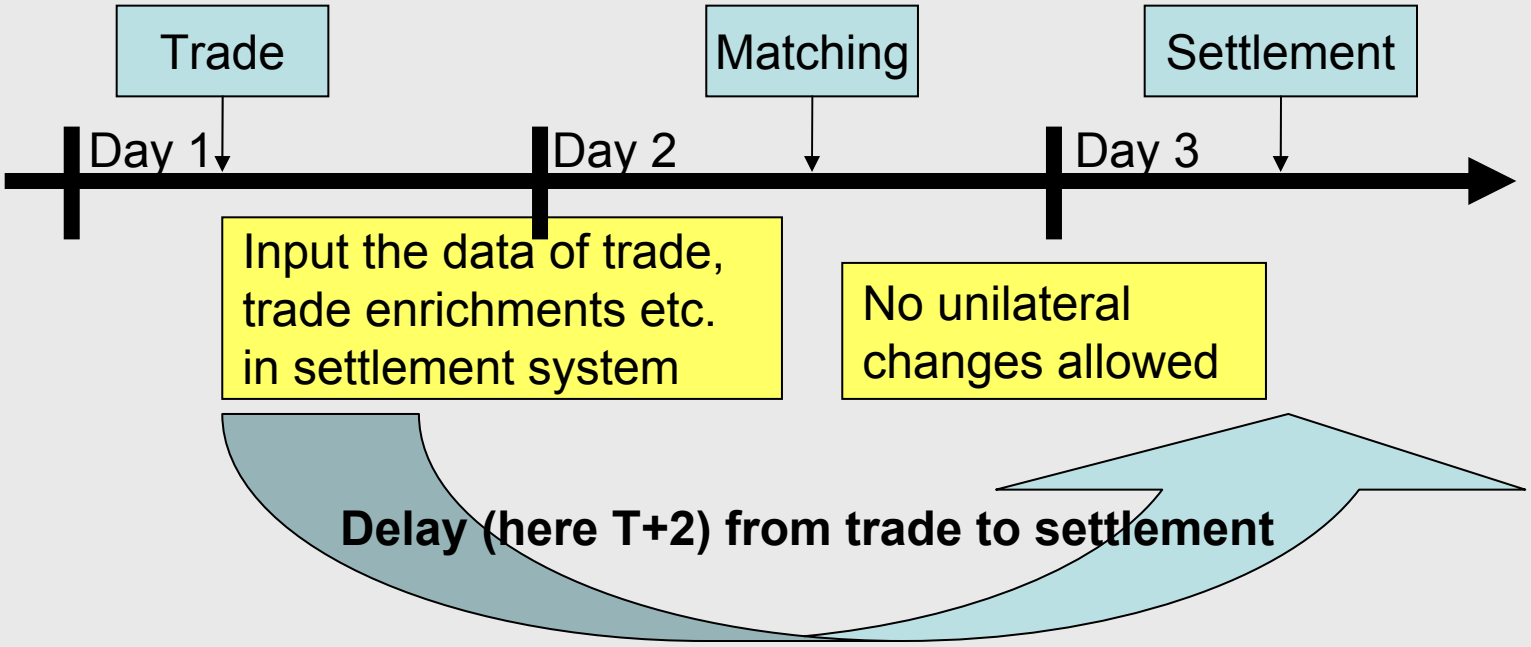
Stress testing projects

- The **bond** settlement system in 2004:
  - One month of comprehensive data from NCSD (20 settlement days)
  - 13 participants, c. 1500 trades with total value c.15 billion euros per month
  - Each clearing participant at a time failing to operate for one day => 260 scenarios => **distribution for impacts**
  - Point testing of default of a participant at assumed worst case moment
  - First (?) published stress test of SSS with real data (BoF studies E:31 - 2005)

- Currently working with the **equities** settlement system:
  - One month of data
  - 23 participants, c. 500 000 trades, 40 billion euros per month
  - Liquidity impact of switching from optimization to plain RTGS process
  - Technical default of the largest participants in the market
  - Single but important asset (ISIN) is not available

Essential features in securities settlement

- Delivery versus Payment (DVP)
- Settlement lag



Lucas critique does not bite (so badly) due to settlement lag

EUROJÄRJESTELMÄ
EUROSYSTEMET

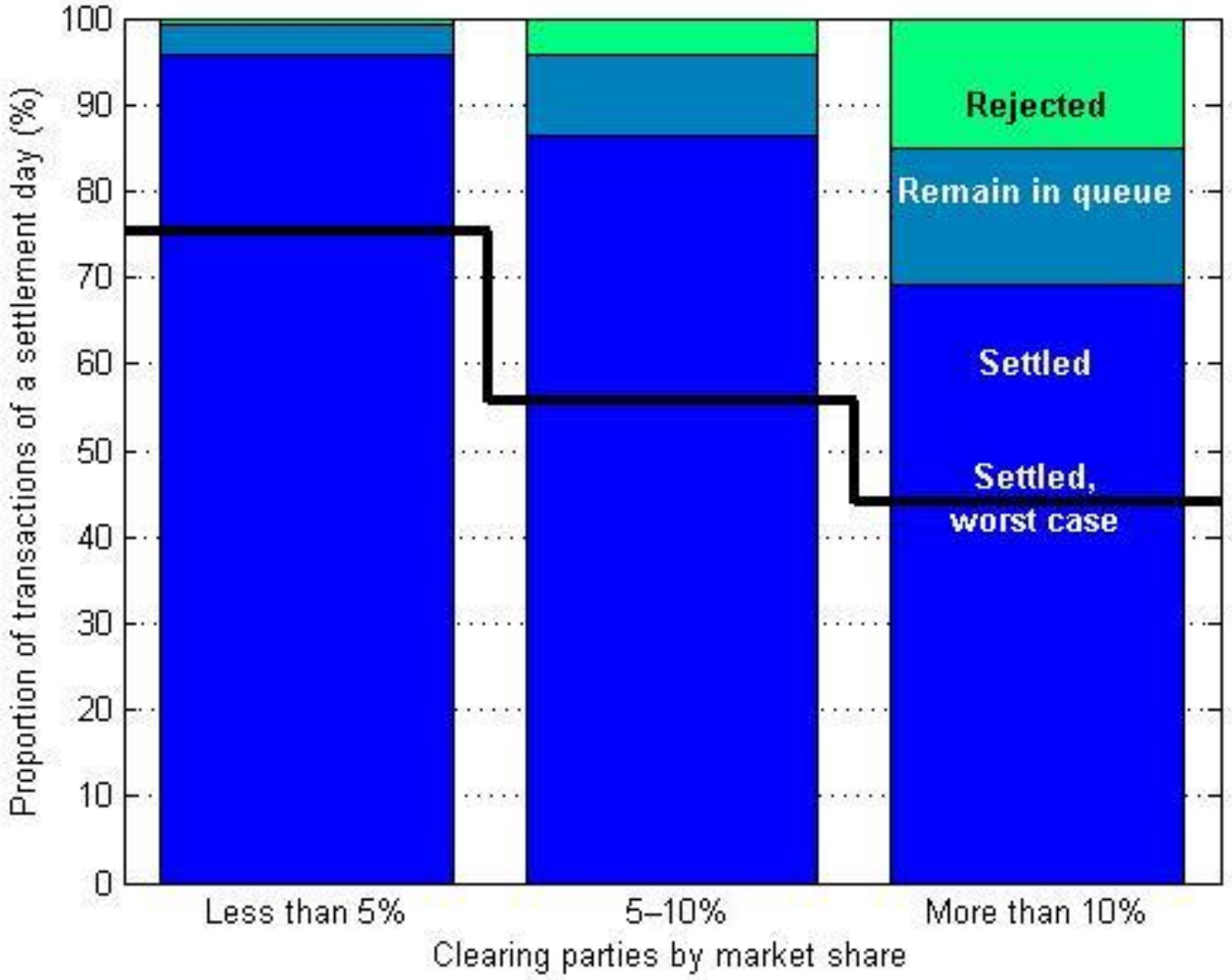
Stress tests

- In operational failure scenario
  - Transactions were removed from simulation input
    - System structure, rules, information flows and legislation was considered.
  - ”Chain reaction” in settlement
  - Distribution of funds and assets differs from normal situation
- Results by comparison with undisturbed benchmark case

No changes in behavior. Results measure the worst case i.e. ”what would be faced if participants fail to react”

EUROJÄRJESTELMÄ
EUROSYSTEMET

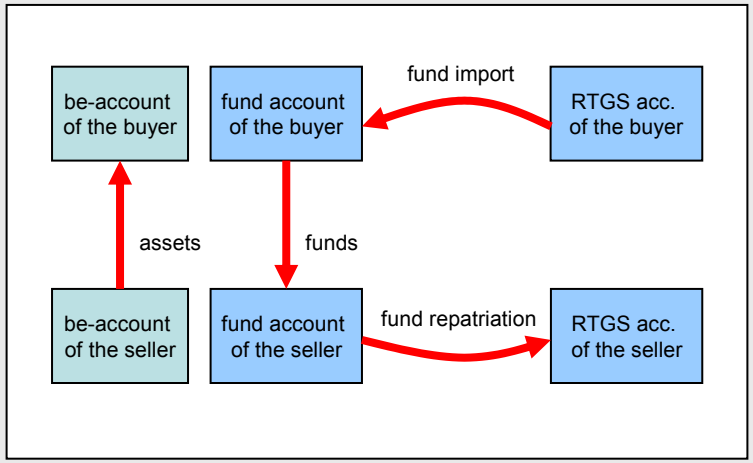
Average outcome of bond settlement on system level after operational failure of participants with different market share



EUROJÄRJESTELMÄ
EUROSYSTEMET

Impact of operational failures on system level explained

- Clearing participants are divided into three groups according to nominal value of their trades settled during the whole month. Each group includes at least three members.
- Settlement system for bonds is under study

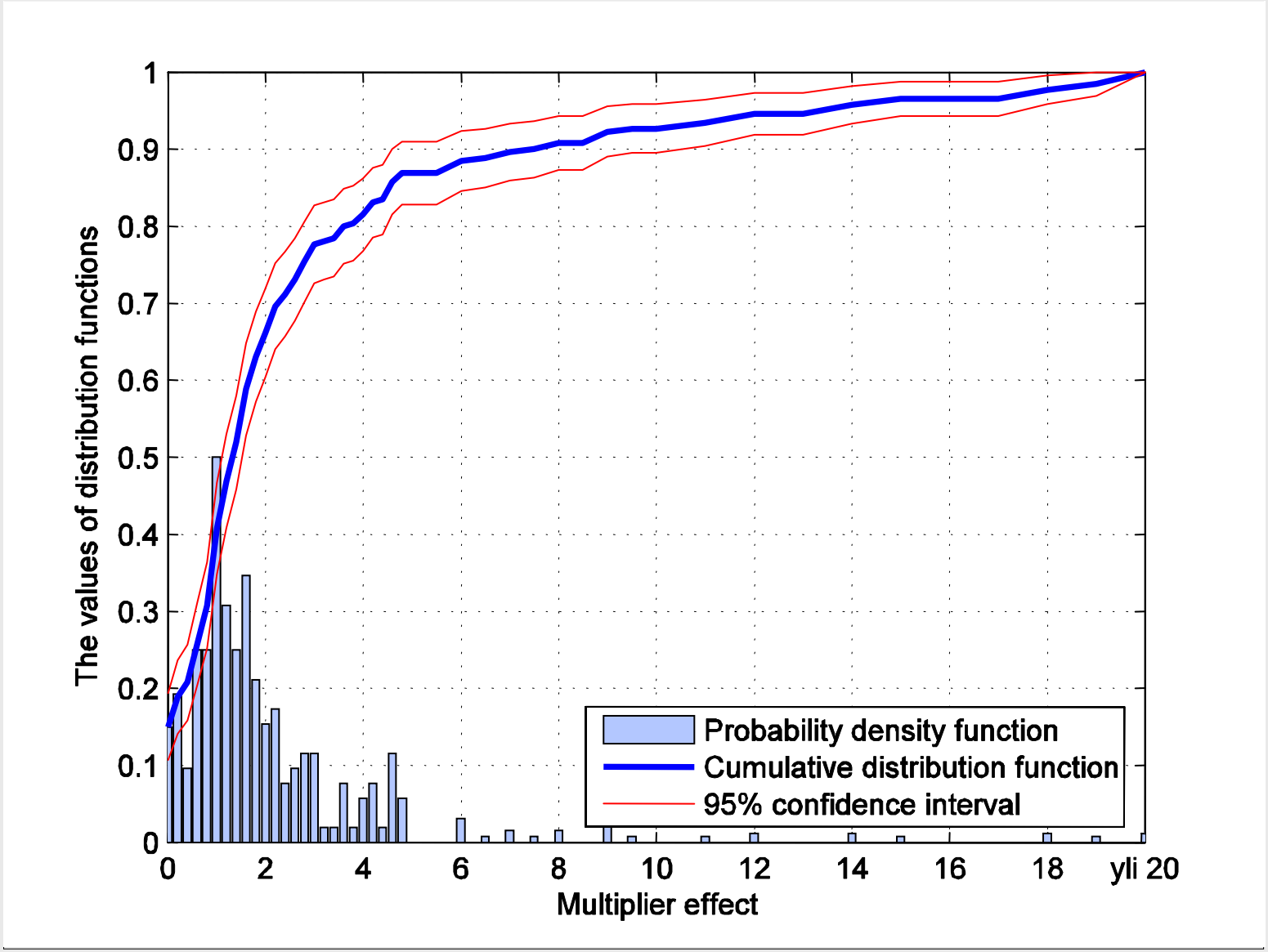


- The values include all simulated transactions:
  - Fund transfers between BoF-RTGS and Ramses
  - Asset and fund transfers in Ramses
  - ⇒ One trade can show up even four times

- Classification:
  - **Rejected**: Transactions excluded from the simulation due to failure
  - **Queued**: Transactions which were included in the settlement but remain unsettled.
  - **Settled**: Transactions that were settled in spite of the problems.
- Worst Case: After failure of one individual participant only 20% of the trades were settled. (not in the picture) Even failures of small participants can drop the settlement ratio down to 75%.
- Maximum value of failed transactions in the simulations was 2,5 billion euros per day.

EUROJÄRJESTELMÄ
EUROSYSTEMET

Empirical distribution for the multiplier effect, ratio of total value of unsettled vs. value rejected



EUROJÄRJESTELMÄ
EUROSYSTEMET

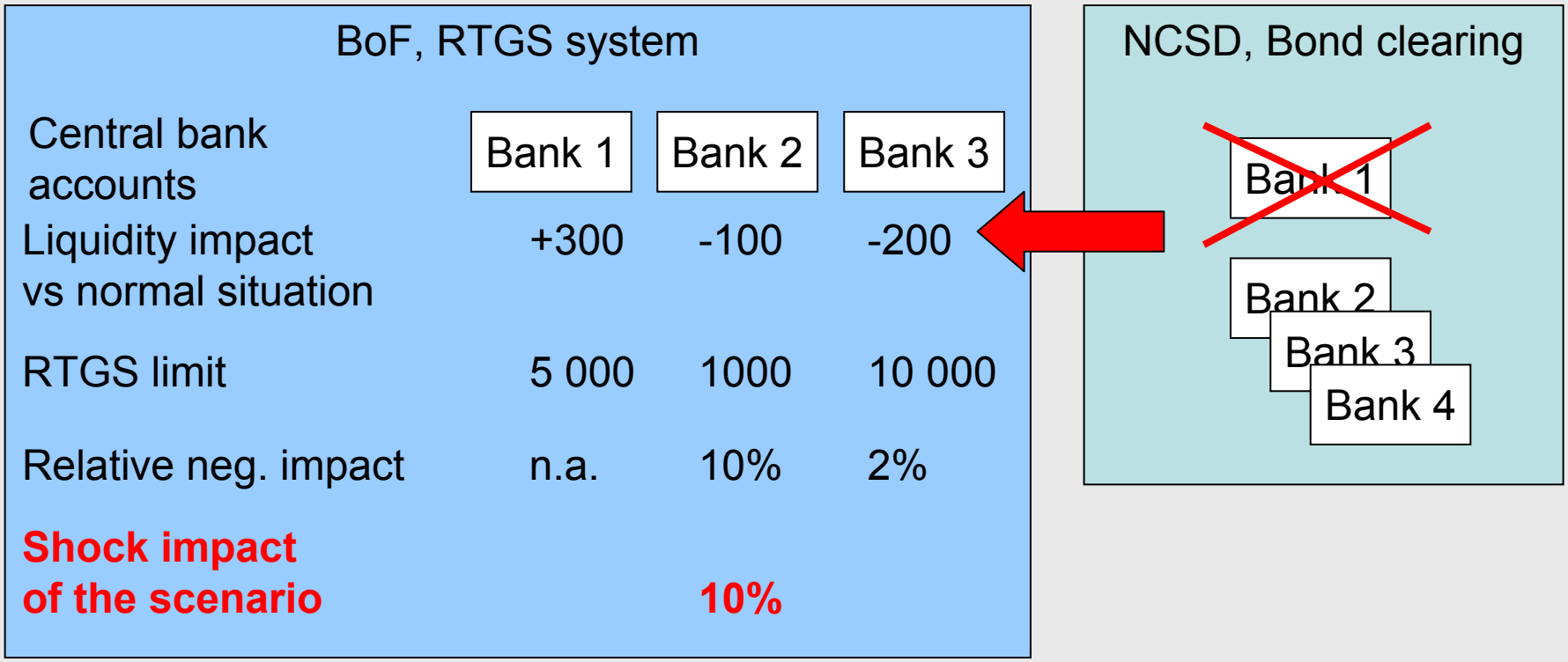
The multiplier effect on system level explained

- The figure presents empirical distribution of

$$\textbf{multiplier} = \frac{\text{Total value of unsettled transactions}}{\text{Settlement obligations of failing participant}} = \frac{\text{total impact}}{\text{”the seed”}}$$

- Settlement system for bonds is under study
- 260 scenarios included: 20 days and 13 individual clearing participants
- The possibility of failure is assumed to be equal for all participants on all days and thus independent of the settlement activity.
  - Because of small number of trades, the sample also includes scenarios with participants failing with no trades at all.
- Descriptive statistics:
  - in 40,8% of cases the multiplier is less than or equal to 1 (in 15% it is zero)
  - in 46,2% of cases the multiplier is between 1 and 5
  - in 13,0% the multiplier is over 5.
  - Median value is 1,48.
- The biggest individual value was 451.

Contagion from bond settlement to RTGS, example

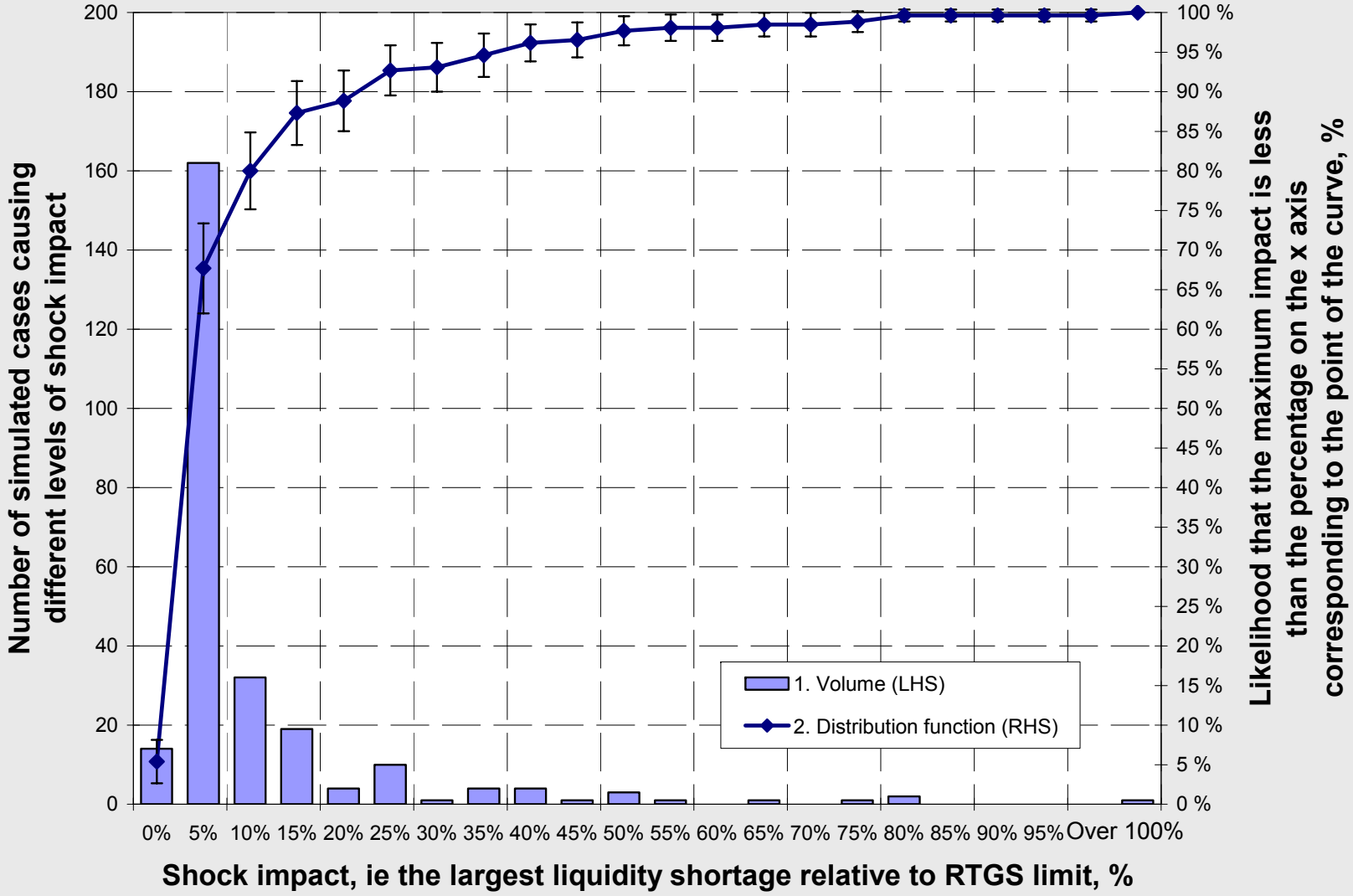


RTGS limit: Amount of intraday (or overnight) credit the banks can get from CB i.e. how much collateral have they pledged.

EUROJÄRJESTELMÄ
EUROSYSTEMET

Contagion from bond settlement to RTGS

Empirical distribution for liquidity impacts of operational failure on counterparties of monetary policy

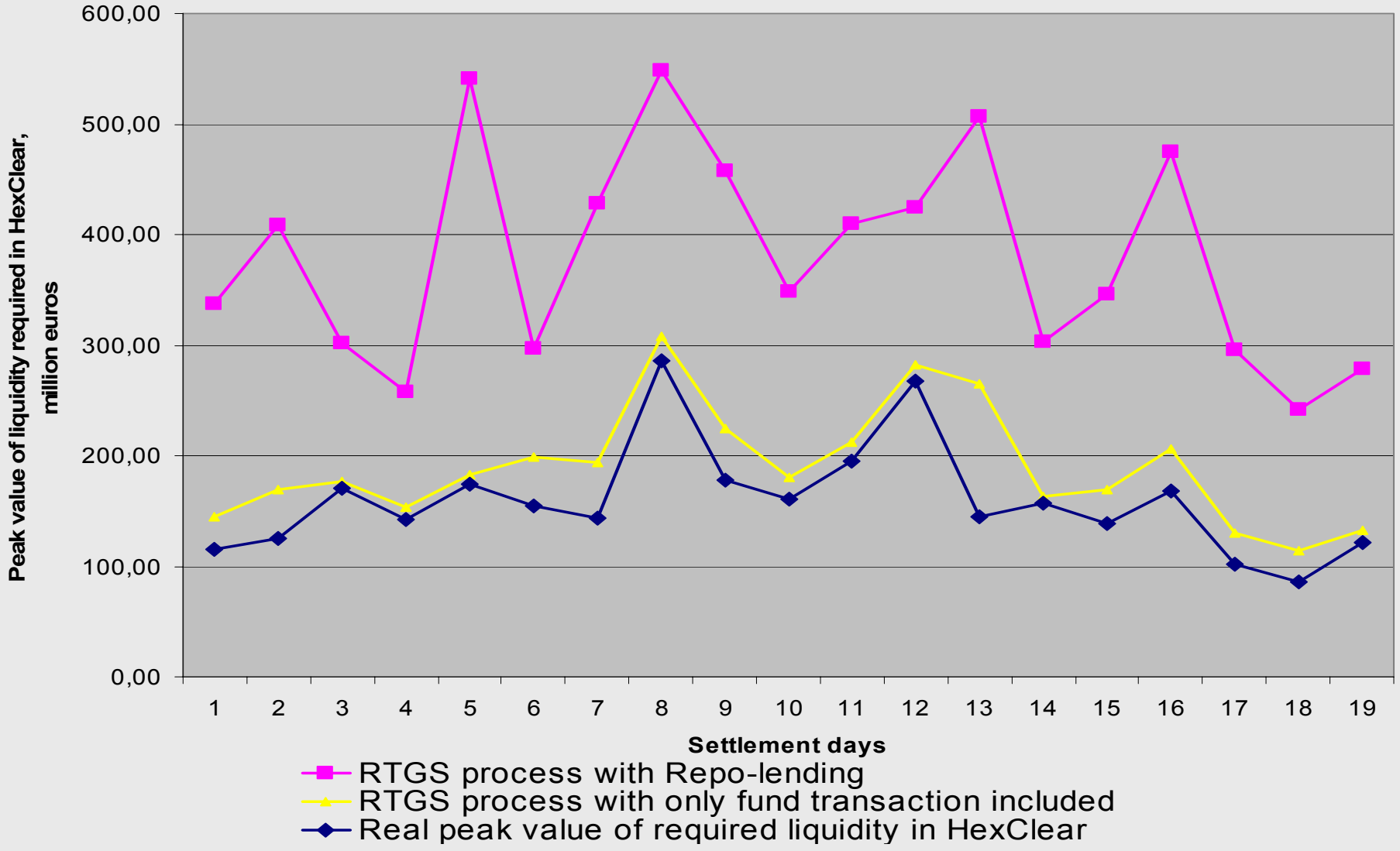


EUROJÄRJESTELMÄ
EUROSYSTEMET

Liquidity impact explained

- Liquidity shortages faced by each clearing participant are compared to RTGS limit of corresponding participant i.e. the amount of collateralized intraday credit available to the participant from Bank of Finland.
  - The RTGS limit values differ from bank to bank
  - RTGS limit is used as a proxy for liquid assets available for sure.
  - Not all the clearing participants have access to this intraday credit facility.
- Biggest liquidity shortage compared to RTGS limit faced by individual counterparty after an operational failure of one clearing participant is chosen as the measure of the impact of the scenario.
- The empirical distribution is concentrated on small values
  - Median value: 1,62%
  - in 75% of the cases the liquidity impact is less than 8,03% of RTGS limit
  - in 95% of the cases the liquidity impact is less than 35% of RTGS limit
  - One scenario among 260 with liquidity shortage bigger than RTGS limit of corresponding participant.
- The possibility of failure is assumed to be equal for all participants on all days and thus independent of the settlement activity.
  - Because of small number of trades, the sample also includes scenarios with participants failing with no trades at all.

The liquidity need in equities settlement when primary settlement algorithm is unavailable



The liquidity need of equities settlement explained

- Assume that the normal, more efficient settlement process with gridlock resolution is unavailable in equities settlement. How much more liquidity is needed in plain RTGS process to ensure smooth settlement without any delays?
  - Maximum value of momentary agregated liquidity need over the whole system is considered
- Scenarios
  1. Only the cash transfers of the settlement process and the liquidity requirement they create is measured.

     ⇒ In the average 21% increase in the liquidity nead, peak value +83%
  2. Lack of securities is included by converting the securities to cash with their average market value. In reality a very efficient and liquid Repo-marked would be needed for this.

     ⇒ In the average 146% increase in liquidity need, peak value +251%

EUROJÄRJESTELMÄ
EUROSYSTEMET

Structure of this presentation

- Concepts and framework
  - What forms of contagion are discussed?
- Simulation model of payment and settlement systems
  - Bank of Finland payment and settlement system simulator
- Results from two analysis of Finnish infrastructure
  - Stress testing securities settlement systems
- Conclusions

EUROJÄRJESTELMÄ
EUROSYSTEMET

Summary and conclusions

- Potential for direct contagion through payment systems can be quantified with scenario analysis
- Bank of Finland Simulator (BoF-PSS2) can replicate multitude of real processing patterns…
- …also in securities settlement systems!
- No systemic risk or remarkable possibility for contagion of liquidity risks were noticed in analysis of Finnish SSS infrstructure.

EUROJÄRJESTELMÄ
EUROSYSTEMET

- Thank you!