OESTERREICHISCHE NATIONALBANK

Stabilität und Sicherheit.

Risk Concentration and Operational Risk in Payment Systems – A Simulation Approach

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Agenda

Motivation and Objectives

ARTIS – Liquidity and Concentration

Stress Testing ARTIS – A Simulation Approach

Results of the ARTIS Stress Tests

Key Findings and Conclusion

Motivation and Objectives

- **Motivation**
  - **OeNB in charge of payment system oversight**
  - **ESCB/OeNB objective: smooth functioning of the payments system**
- **Objectives**
  - **Better understanding of ARTIS**
    - **Statistical analysis (companion paper)**
  - **Analyse impact of operational risk of in payment systems**
    - **On aggregate level**
    - **On individual bank level**
  - **Policy implications?**

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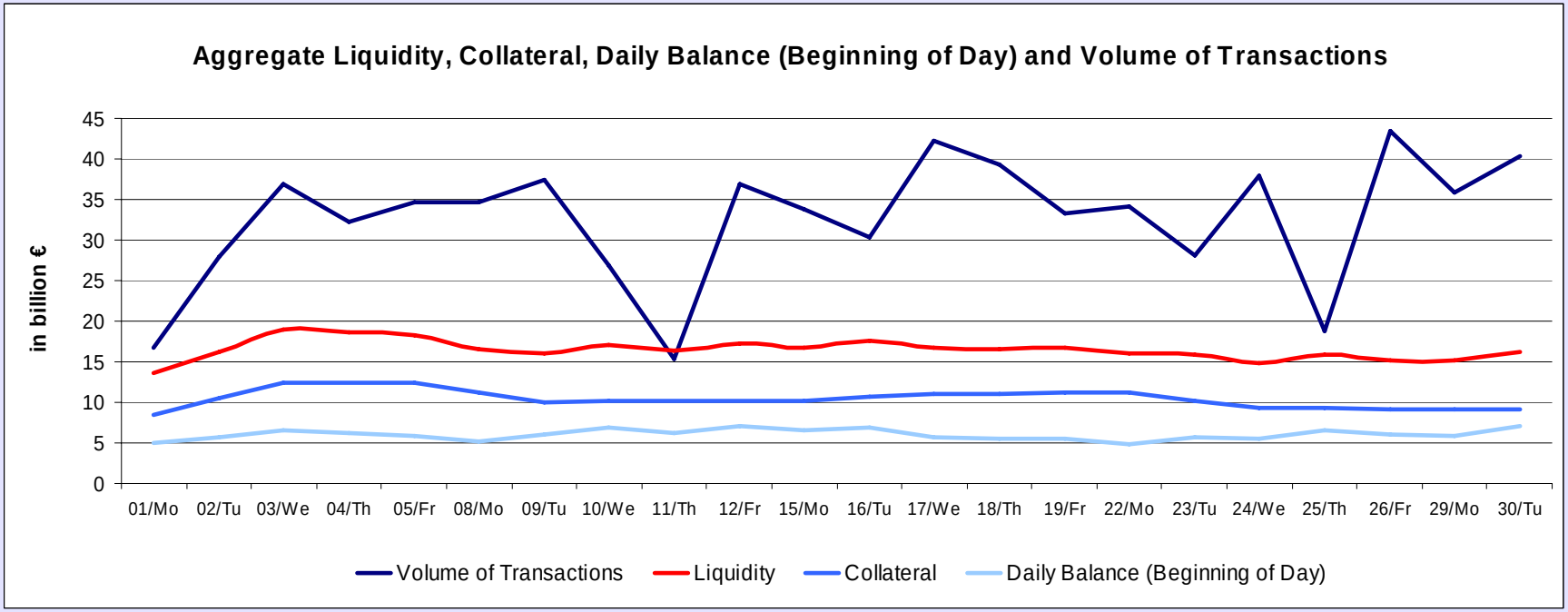
Aggregated liquidity in ARTIS

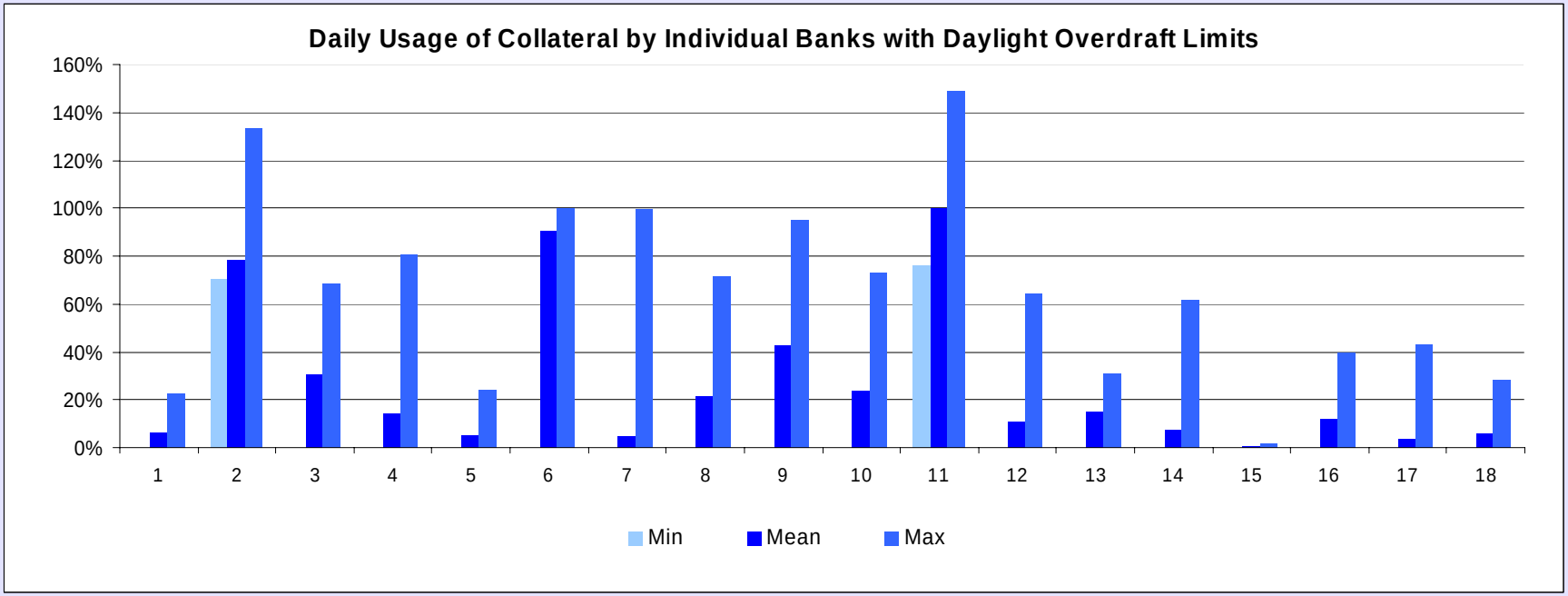
- **The average daily aggregate liquidity equalled 16.8 billion EUR**
  - **Liquidity in the system: beginning of day balances + collateral available**
- **The aggregate liquidity in the system exceeded the use of liquidity**
  - **No accounts experienced liquidity shortages that would have lead to unsettled transactions at closing time (6 pm)**
- **On average (across participants and across days):**
  - **about 1/3 of all transactions were covered by available liquidity reserves**
  - **about 2/3 were covered by liquidity from received payments**

Daily values for aggregate liquidity



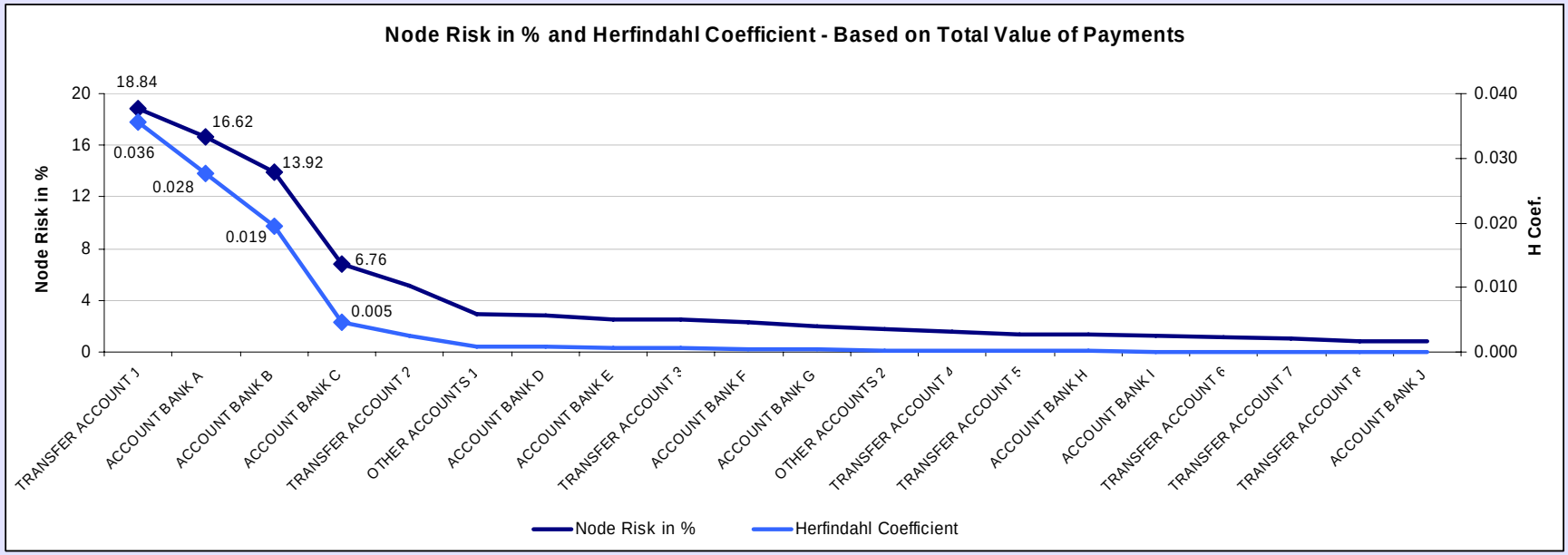
- **Despite sufficient aggregate liquidity, individual accounts were occasionally illiquid. Throughout an average day payments with a total value of 1.4 billion Euros were queued.**

Disaggregated analysis of collateral usage



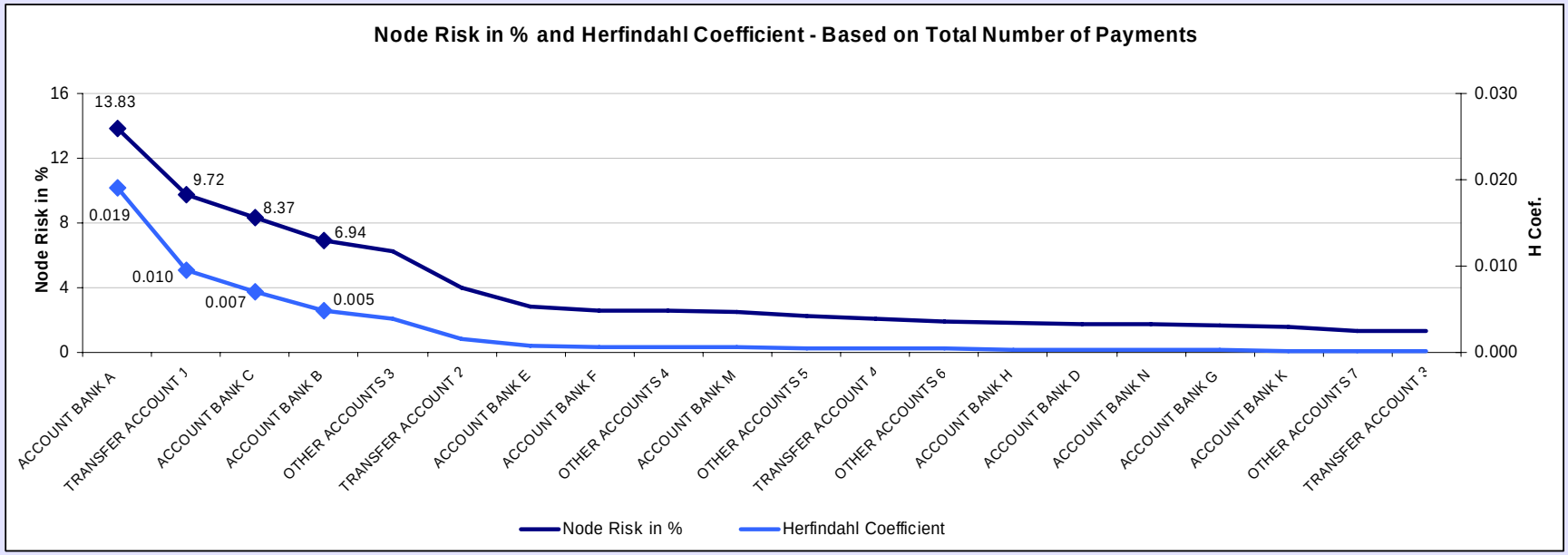
- **Sufficient aggregate liquidity does not imply sufficient individual liquidity**

Node risk based on the value of payments



- **The concentration of payment value is quite high in ARTIS:**
  - **CR3: 49.4 %** **(Node risk top 3 banks for the sample period)**
  - **CR5: 61.3 %** **(Node risk top 5 banks for the sample period)**
  - **HHI: 0.0955** **(Herfindahl Index for the sample period - uniformly distributed reference 1/56, 0.0017)**

Node risk based on the number of payments

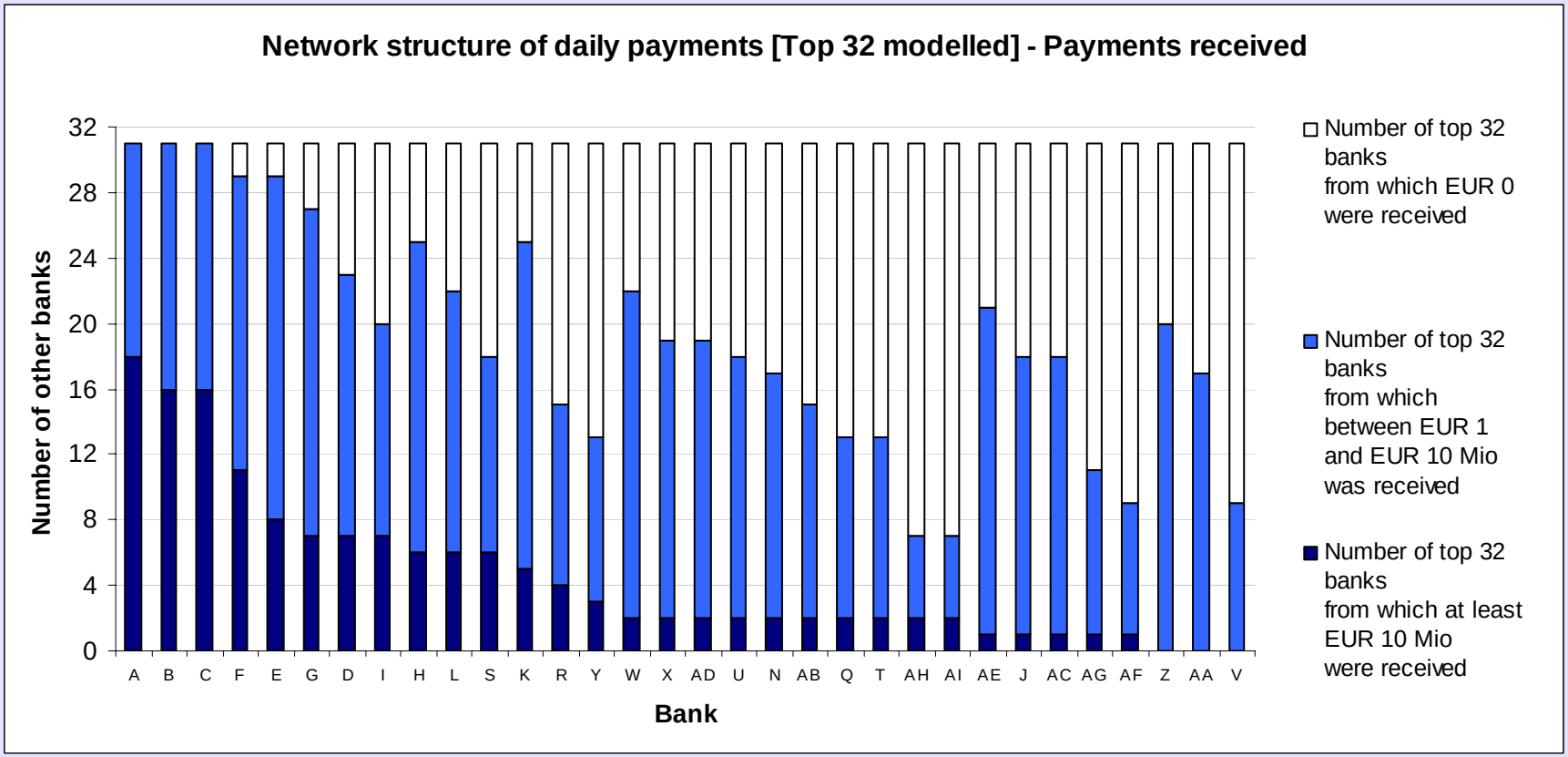


- **The concentration of the number of payments is much lower:**
  - **CR3: 31.9 %** **(Node risk top 3 banks for the sample period)**
  - **CR5: 45.1 %** **(Node risk top 5 banks for the sample period)**
  - **HHI: 0.0530** **(Herfindahl Index for the sample period - uniformly distributed reference 1/31, 0.0017)**

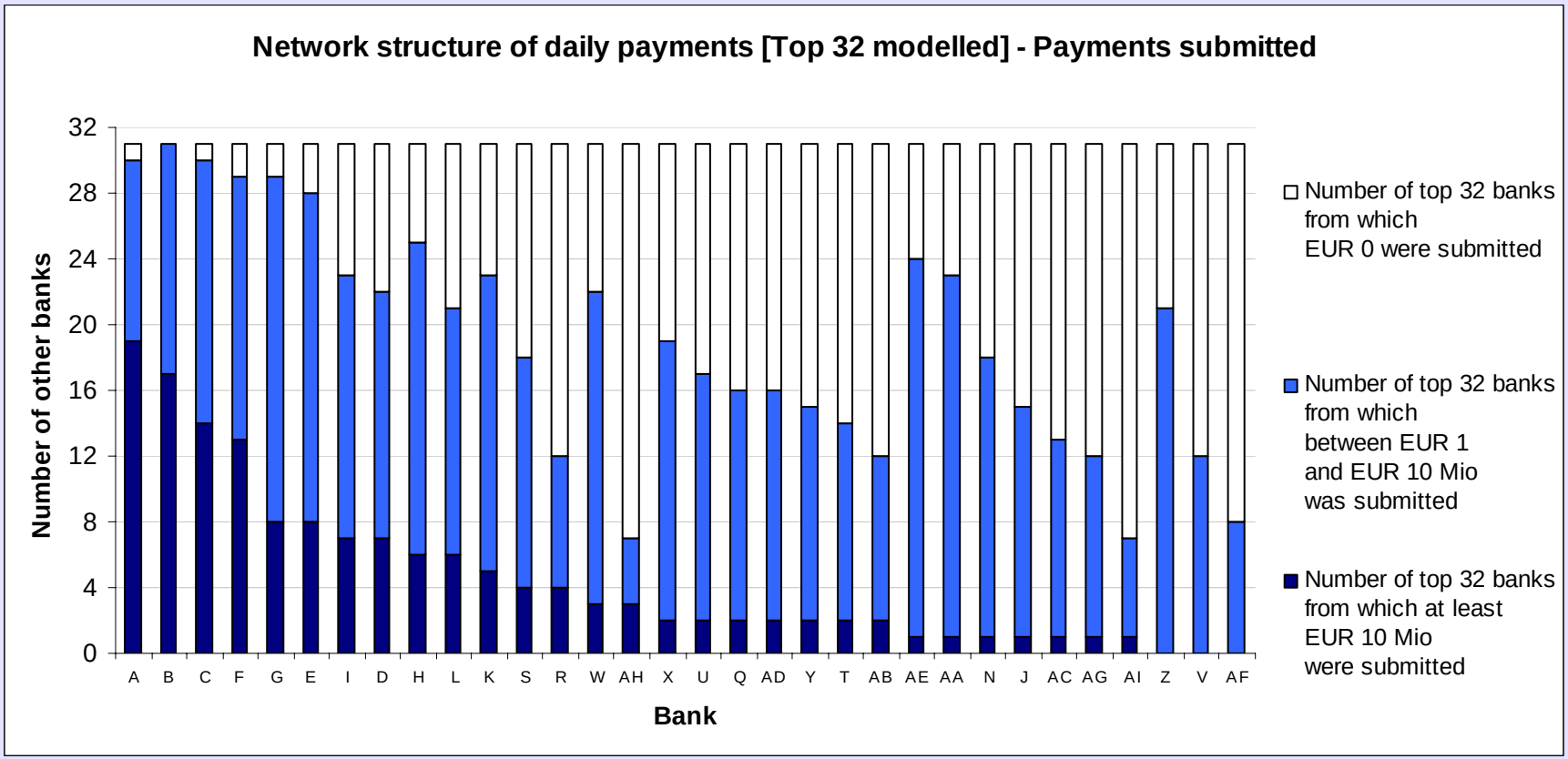
The network structure of ARTIS

- **Concentration ratios indicate that the most active banks also transfer higher value payments**
- **This conclusion is supported by the analysis of the network structure among the top 32 participating banks.**
- **Only the three most active accounts received payments from all other 31 banks among the top 32 on an average day.**
- **The other top 32 banks received payments from an average of 17.9 other banks.**
- **A similar picture was presented by the network analysis of the payments submitted.**

Network structure of daily payments received



Network structure of daily payments submitted



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Simulation fundamentals

- **The scenarios are designed according to an ex-ante estimation of potential risk concentrations.**
- **The objective of the simulations is to estimate the contagion effect within the system.**
- **The simulations utilise real data for the sample period November 2004 (a typical month of activity of ARTIS)**
  - **Daily simulations for 22 days**

Original features

- **We operate with real rather than simulated liquidity data**
- **Analysis of contagion based on the individual bank level in addition to aggregate level of unsettled payments**
- **Features of large value payment systems that have hitherto gone unstudied in the literature:**
  - **Stop sending rule**
  - **Debit authorisation**

Simulation scenarios

- First, we determined the nature of the operational incident
- Second, we determined the duration of the operational failure of a participant
  - One-day failure to submit payments; an exceptional but plausible shock
  - ARTIS provides business continuity arrangements
    - Re-run simulations under the assumption that back-up options would be employed effectively (a very restrictive assumption!)
- Third, selection of node(s) of the network, which is (are) affected by the operational failure based on
  - Value of liquidity concentrated (liquidity concentration channel)
  - Number and value of payments (payment concentration channel)
  - Herfindahl index of concentration of payment flows
  - Crude network analysis

Stricken accounts in the scenarios

- **The three scenarios with the highest expected impact and the highest expected contagion effects are accordingly:**
  - **the first scenario, which assumes that the most active transfer account cannot submit payments to the system**
  - **the second scenario, which assumes that the most active bank cannot submit payments to the system**
  - **the third scenario, which assumes that the three most active banks experience operational failure simultaneously and cannot submit payments to the system.**

Agenda

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The Austrian Large Value Payment System ARTIS

Stress Testing ARTIS – A Simulation Aproach

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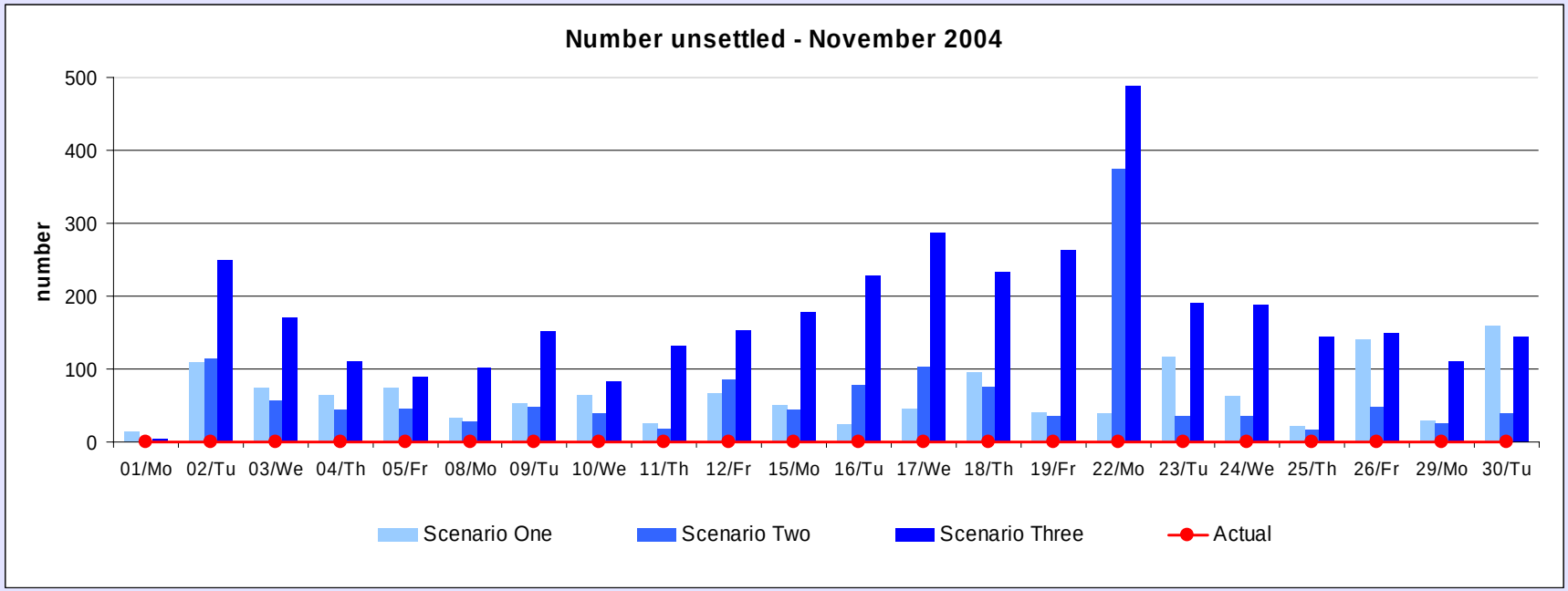
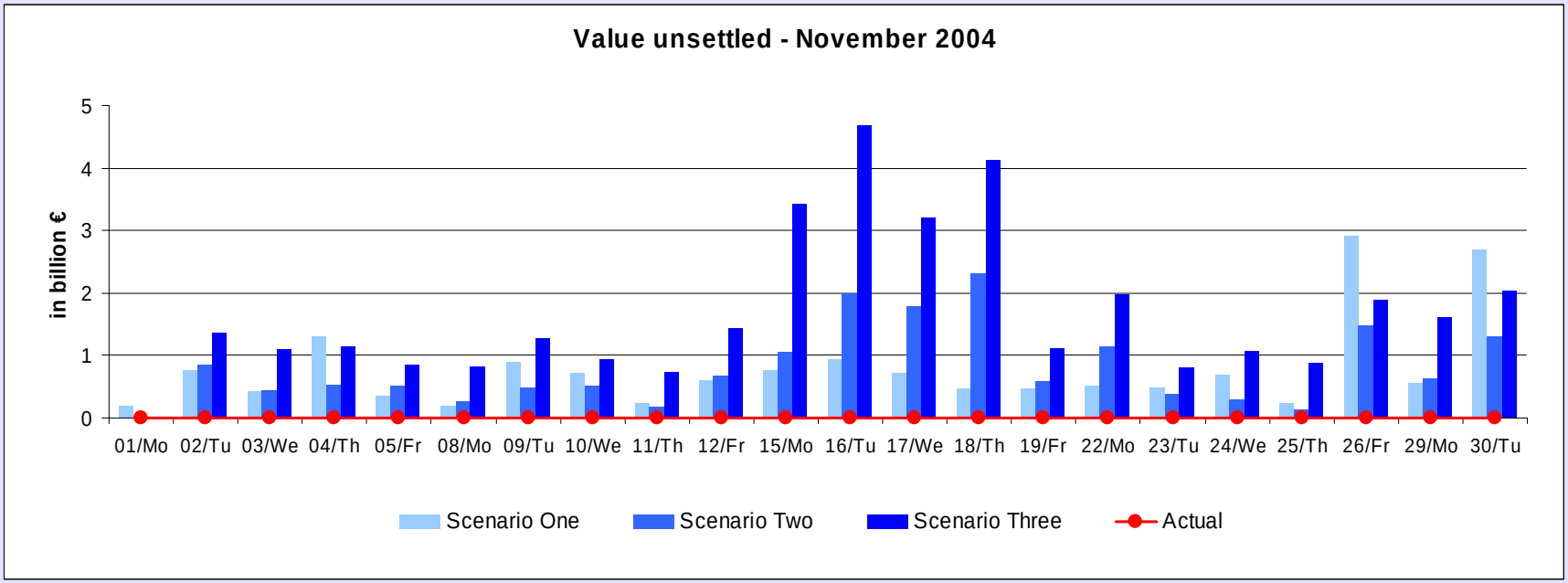
Unsettled payments in all three scenarios



- **The average number of unsettled payments:**
  - **Scenario 1: 64.1**
  - **Scenario 2: 63.3**
  - **Scenario 3: 175.0**

The value of unsettled in all three scenarios



- **The average value of unsettled payments:**
  - **Scenario 1: 0.8 billion EUR (3.3 % of the value submitted)**
  - **Scenario 2: 0.8 billion EUR (2.7 % of the value submitted)**
  - **Scenario 3: 1.7 billion EUR (7.7 % of the value submitted)**

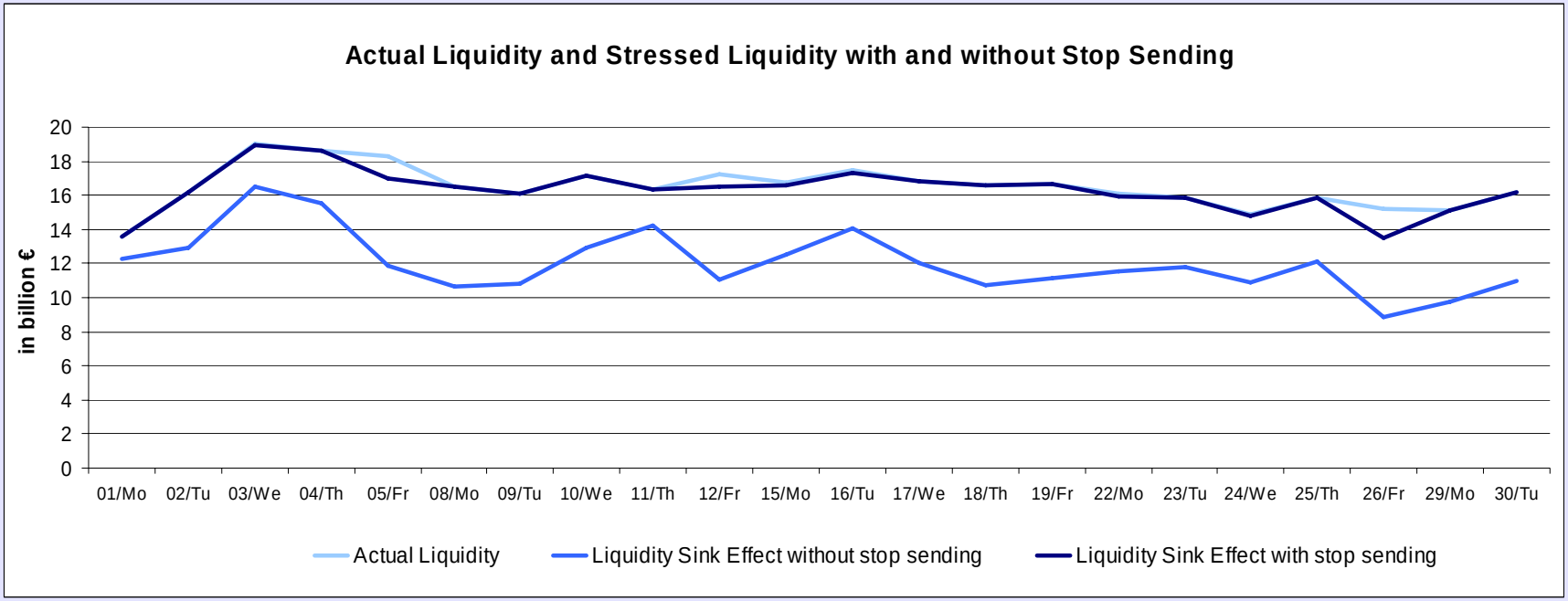
The number of banks with unsettled payments

Number of banks with unsettled payments	Actual	Scenario One	Scenario Two	Scenario Three
Daily average	0	12.14	8.73	22.77
Minimum	0	8.00	0.00	1.00
Maximum	0	18.00	12.00	30.00
Standard Deviation	0	2.42	2.81	5.87
Total	**0**	**36.00**	**38.00**	**56.00**

The stop sending rule

- **Operators in TARGET can apply a stop sending rule**
  - **Applies to CB components**
  - **If imposed, payments to the stricken account are not forwarded, but held in a queue and are available to cover other payments**
  - **The stop sending rule can therefore reduce the liquidity sink effect**
    - **Ongoing transactions before imposing the stop sending rule (but after operational problems occurred) reduce the available liquidity in the system accordingly**
  - **Implementation: map on input data**

Actual and stressed liquidity, Scenario 1



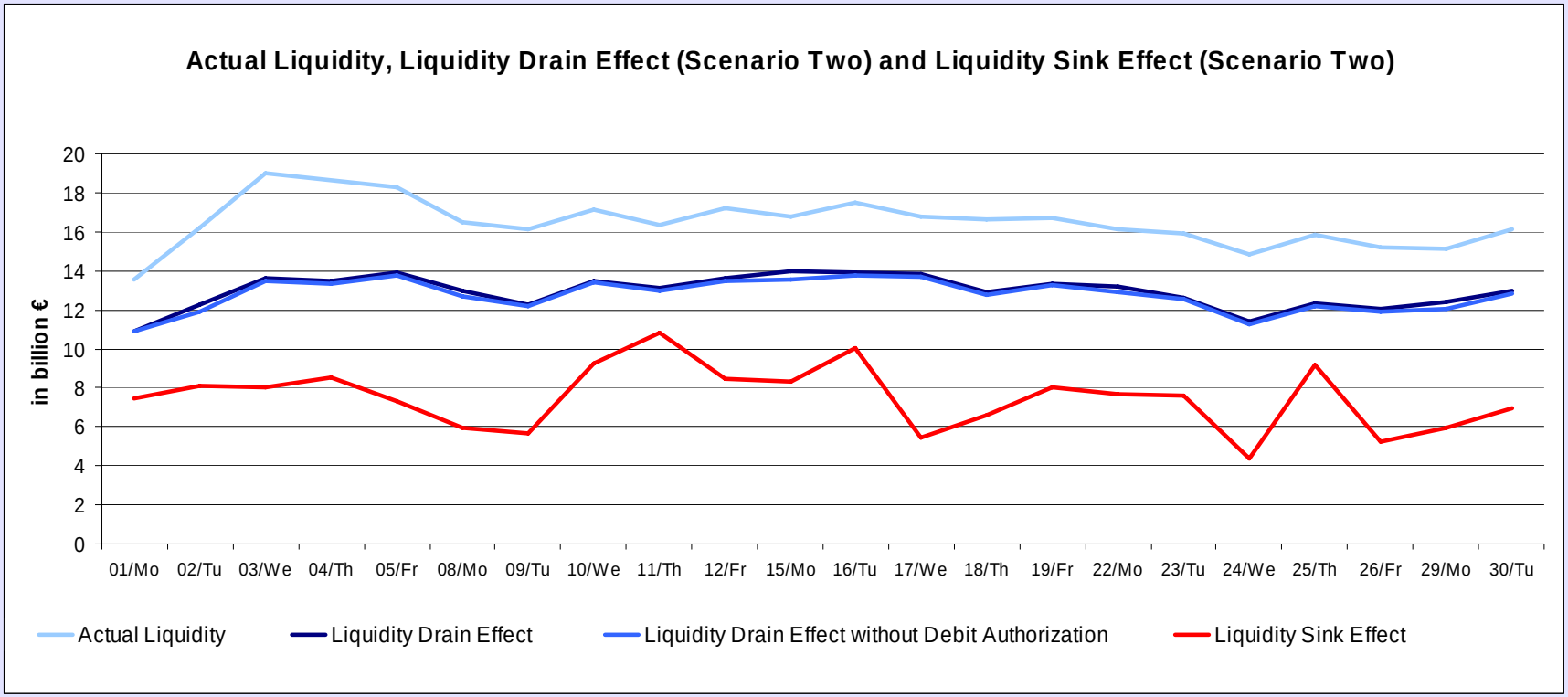
Impact of stop sending rule

Indicator	Scenario One with stop sending rule (1)	Scenario One without stop sending rule (2)	Difference (1) – (2)
Aggregate liquidity (in bill €)	16.28	12.05	**4.23 (25.98%)***
Liquidity reduction (in % of aggregate liquidity)	*1.19*	*26.91*	**-25.72***
Value submitted (in bill€)**	22.42	26.65	**-4.23 (-18.87%)**
Value unsettled (in bill €)***	0.78	1.34	**-0.56 (-71.79%)**

Debit authorization

- **Account holders can grant other account holders access to their account(s)**
  - **Used for some counter-parties with whom account holders interact very often**
  - **Cash supply, debit-card and e-money transactions**
  - **Reduces liquidity drain effect**
  - **Implementation: map on input data**
- **<u>Not</u> a crises mitigation instrument**

Actual and stressed liquidity, Scenario 2

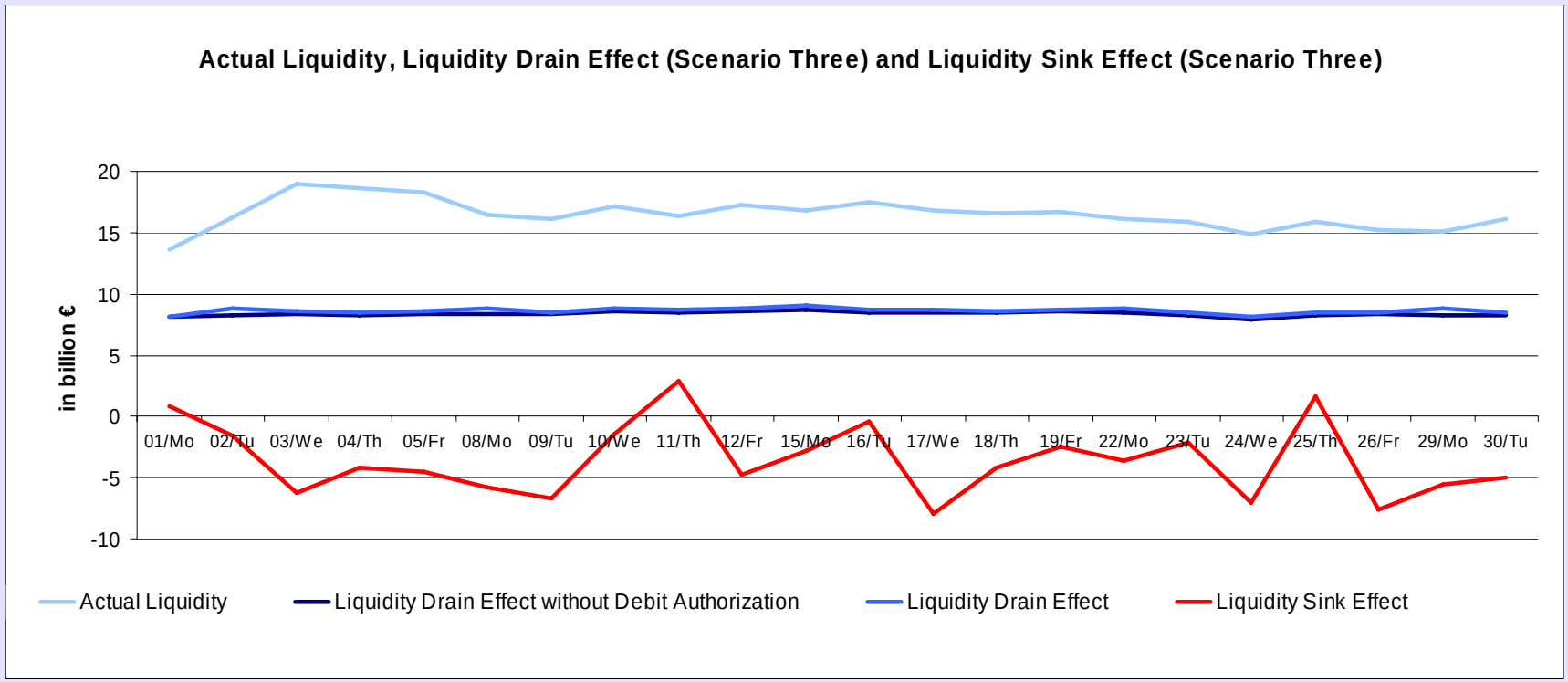


Impact of debit authorisation (Sc 2)

Indicator	Scenario Two with debit authorisation (1)	Scenario Two without debit authorisation (2)	Difference (1) – (2)
Liquidity reduction (in % of aggregate liquidity)	*21.4*	*22.5*	**-1.1%-points**
Value unsettled (in bill €)***	0.8	0.95	**-0.15 (-15.6%)**
∅# illiquid banks	8.7	10.3	**-1.6 (15.2%)**

- **Slightly attenuates contagion**
- **Shields accounts with debit authorisation from direct impact**

Actual and stressed liquidity, Scenario 3



Impact of debit authorisation (Sc 3)

Indicator	Scenario Three with debit authorisation (1)	Scenario Three without debit authorisation (2)	Difference (1) – (2)
Liquidity reduction (in % of aggregate liquidity)	*12.4*	*12.5.5*	**-1.5%points**
Value unsettled (in bill €)***	1.7	1.9	**-0.2 (-10.3%)**
∅# illiquid banks	22.8	24.6	**-1.8 (-7.3%)**

- **Slightly attenuates contagion**
- **Shields accounts with debit authorisation from direct impact**

Comparison across scenarios

Indicator		Actual	Scenario One	Scenario Two	Scenario Three
Aggregate liquidity (in bill €)		16.47	16.28	7.31	-3.81
Liquidity reduction (in % of aggregate liquidity)		*0.00*	*1.19*	*54.75*	*121.51*
of which	Liquidity drain (in %-points)	*0.00*	*0.00*	*21.58*	*47.43*
	Liquidity sink (in %-points)	*0.00*	*1.19**	*33.16*	*74.09*
Value submitted (in bill€)		32.61	22.42	27.38	20.72
Without business continuity arrangements					
Value unsettled (in bill €)		0.00	0.78	0.80	1.66
Value unsettled (in % of value submitted)		0.00	3.3	2.72	7.68
Number of payments unsettled		0.00	64.06	63.27	174.95
*With business continuity arrangements***					
Value unsettled (in bill €)		0.00	0.00	0.00	0.00
Value unsettled (in % of value submitted)		0.00	0.00	0.00	0.00
Number of payments unsettled		0.00	0.00	0.00	0.00

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- The Bank of Finland Payment System Simulator
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- **Key Findings and Conclusion**

Summary

- **Contagion effect on the smooth functioning of the payment system was substantial in all three scenarios**
  - **System functioned smoothly even under severe stress given the existing business continuity arrangements would prove effective.**
  - **This is unlikely – up to 4 000 payments need to be processed**
- **Stop sending rule**
  - **Substantially reduced the contagion effect**
- **Debit authorisation**
  - **Slightly attenuated contagion**
  - **Shielded accounts with debit authorisation from direct impact**
- **Policy implications**
  - **Quantify ELA**
  - **Propose new crisis mitigation instruments**
  - **Evaluate business continuity**

Further research

- **Stop sending had a substantial impact**
  - **Analyse policy option to extend stop sending to all accounts**
- **The impact of an operational incident differed widely**
  - **Across days**
  - **Across banks**
  - **Across scenarios**
  - **Further research focuses on determinants of differences**