SUOMEN PANKKI EUROJÄRJESTELMÄ FINLANDS BANK EUROSYSTEMET

Instant payment liquidity risk

22nd BoF simulator seminar

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Outline

- Background, motivation and research questions
- Scenarios, parameters and the model approach
- (Initial) results
- Summary

Disclaimer:
The presented views are those of the author and are subject to change (work in progress).
They do not necessarily reflect the views of the Bank of Finland

Data and the background

- Starting point was the model used in Hellqvist-Korpinen (2021) on the analysis of **liquidity needs in instant payments**
  - Generation of artificial transaction data calibrated on real data: Poisson-lognormal stream of payment instructions
  - Statistic of Finnish SCT and SCT-Inst retail payments
- For the analysis of **liquidity risk**, extensions are needed
  - Constrained liquidity levels
  - Treatment of cases where payment fails due to (momentarily) insufficient funds
  - Topology of liquidity flows i.e. who pays to whom?
    How does that change in full migration to IP?

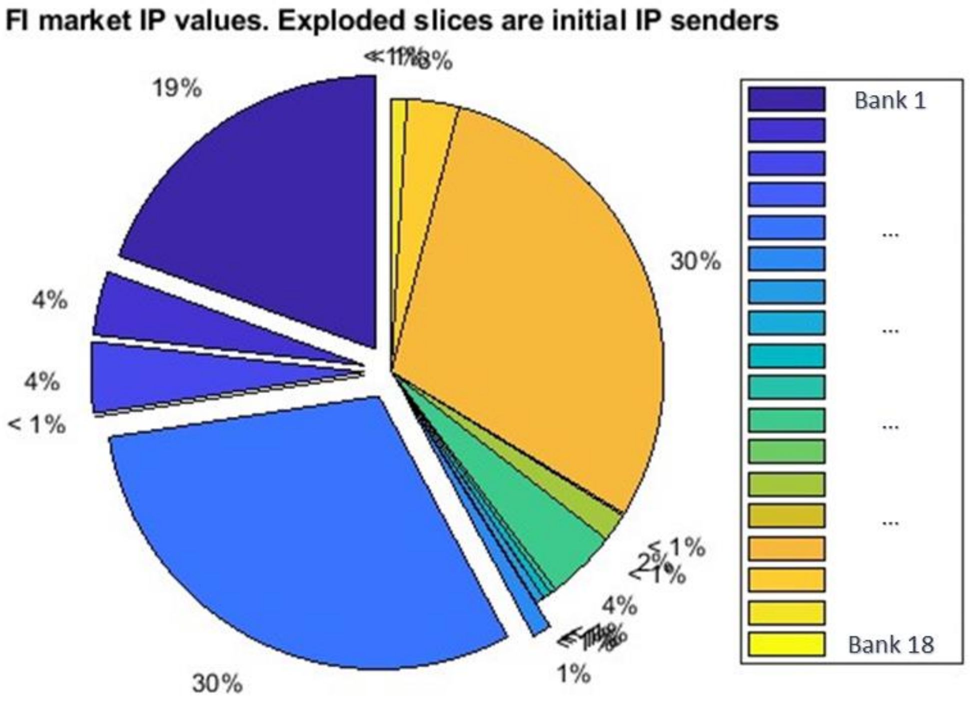
Research questions

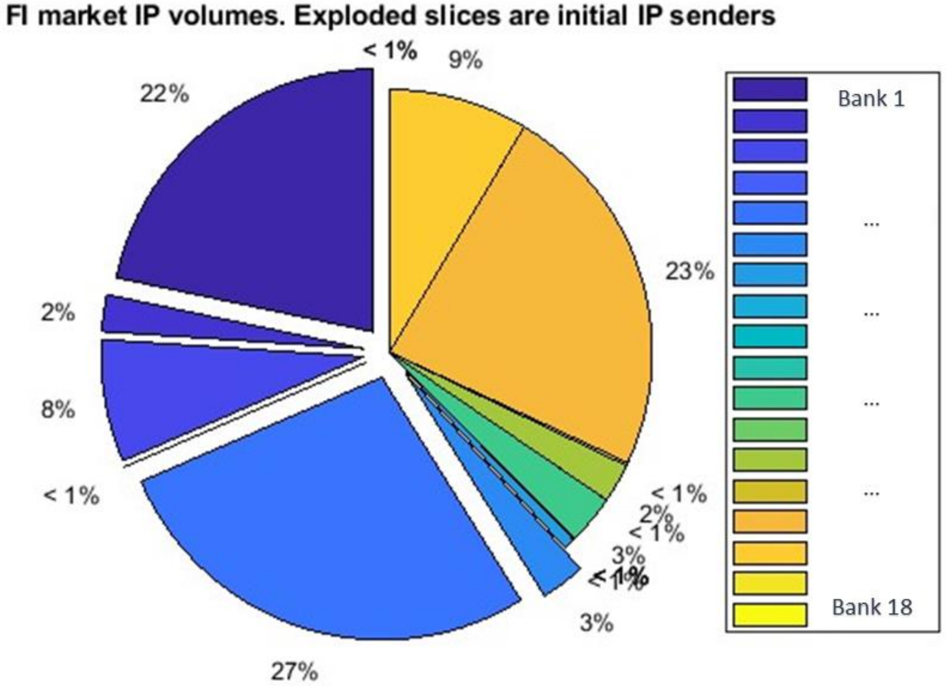
- What are the liquidity risks in processing of instant retail payments?
  - Risk of insufficient funds for individual participants caused by
    - Unexpected fluctuations in payment flow
    - Participant level outages
    - Contagion in system level
- How do these risks evolve during migration path into full adoption of instant payments?
- What is the impact of structure of payment flows
- … and what is the expected topology in the first place?

Scenarios

- Market compositions of instant payments as the adoption progresses
  - **Initial status in data (6 sends/11 receives)** - Middle point (11s&r) – **Full adoption (18 s&r)**
  - Simulations or random migration paths (13 steps from 6 to 18)
  - Simulation of impact of transition between payment instruments (pending)
- **Operational failure scenarios**
  - No incident / One bank failure and recovery in 2 hours / 1 bank outage of one full day
- **End customer contingency measure**
  - Only identical payment resubmissions / End customers with an account in two separate banks

Basic statsistics for the assumed future market composition scenarios





- Daily value in totl €1.01 Billion, volume 863 thousand, Avg payment is thus 1165 €
- The assumed ends state: Current instant payments (RT1) + 50% of current credit transfers (STEP2)

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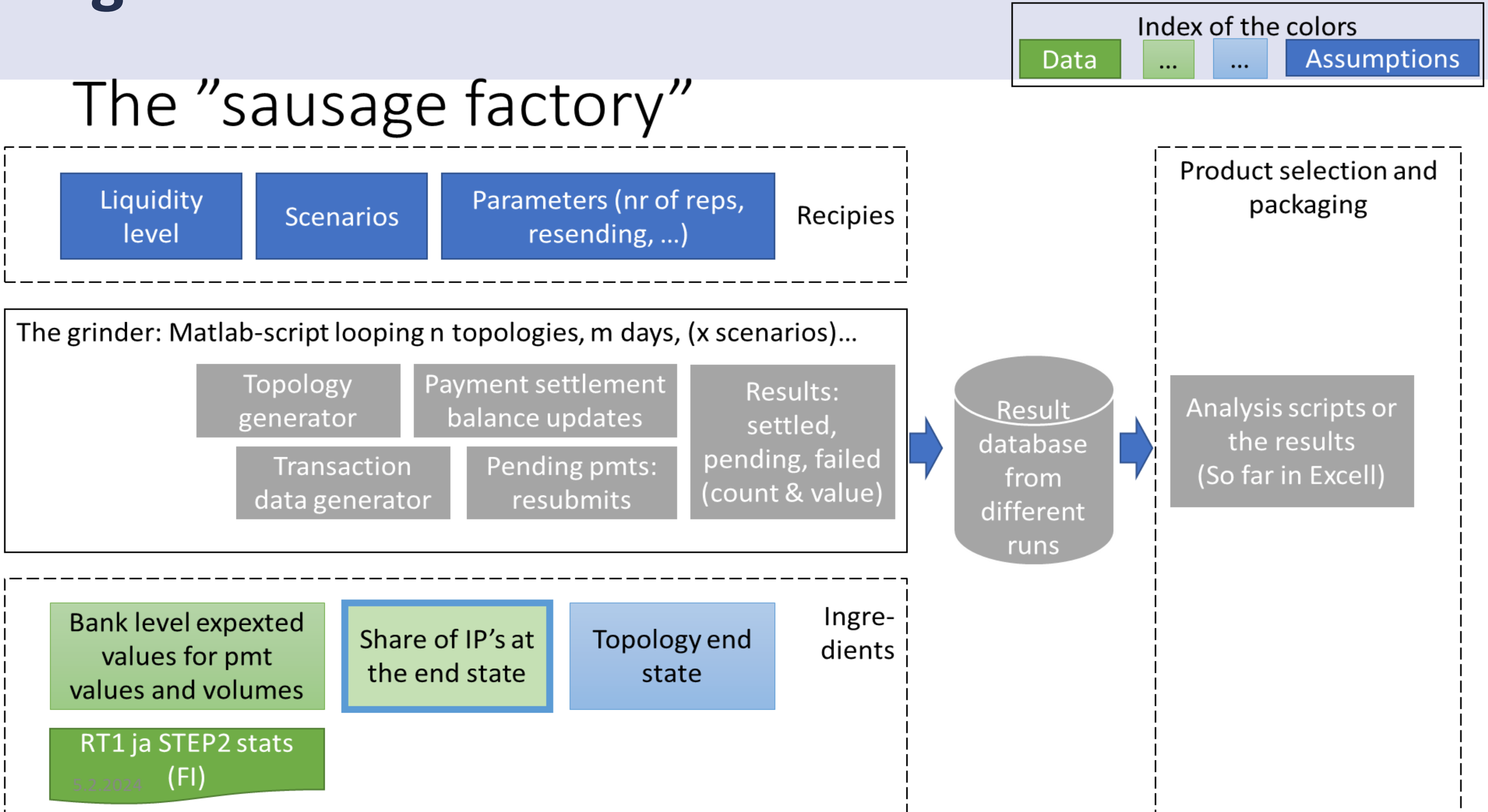
Scenarios and varied parameters

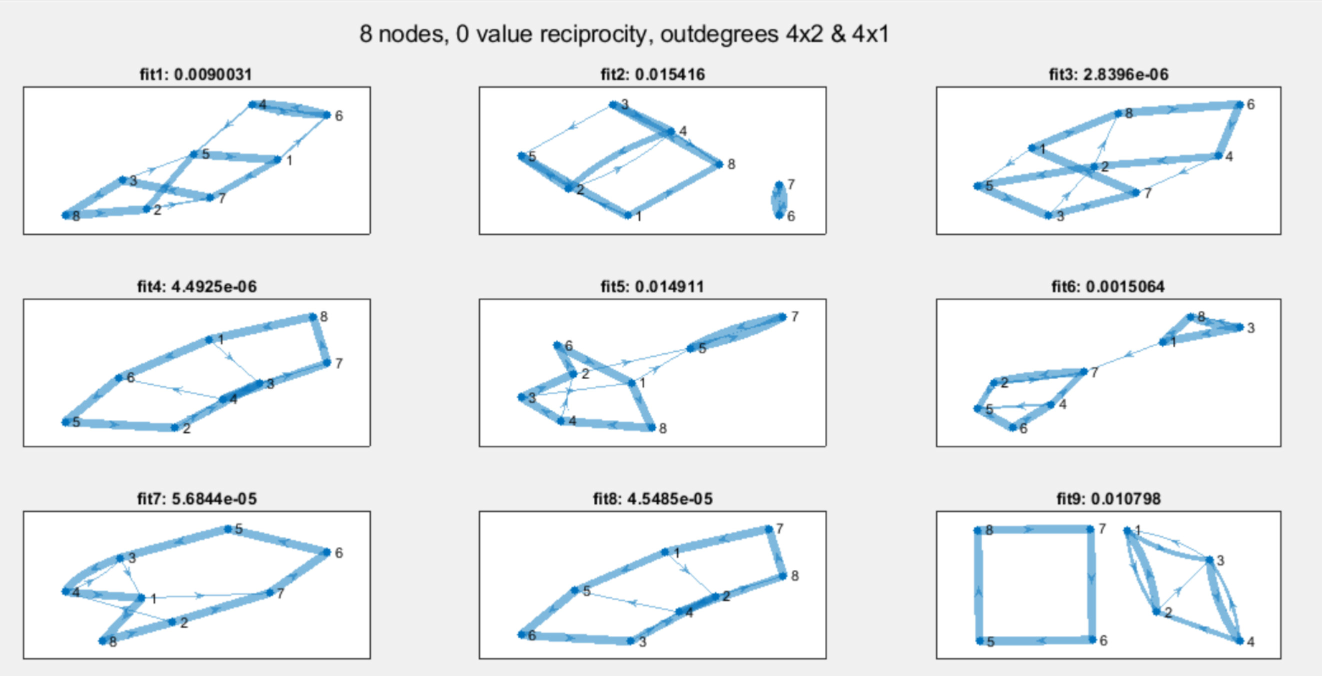
Dimensions of Monte Carlo simulation	**n**
Market compositions (Initial – middle – full)	3 (or 13)
Op. failure scenarios (No fail / 2h / full day)	3 x 6/11/18 = 18 … 54
End customer contingency scenarios (on / off)	2
Initial liquidity levels of banks - % of expected gross outflows (50%, 60%, … 120%) - % of expected net outflows	 6-8 (-)
Sample of topologies with fixed goal for aggregate network measures	5
Sampling of I.I.D days and payment submission & settlement trajectories	30
Total number of scenarios	97K … 1.7M

Building blocks of the model



On the sampling of topologies

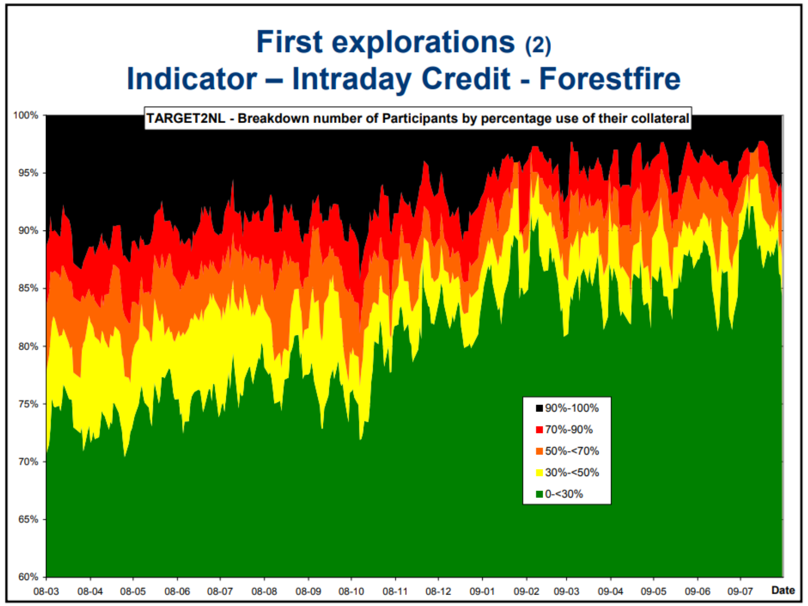
- Numerical optimization to find arbitrary network structure with matching aggregate network measures
- This opens many possibilities
  - Sensitivity analysis of payment topology
  - Scenarios of changing market structure
- In this study
  - Starting point estimated from FI instant payment daily level aggregate time series
  - End state:
    almost fully connected network as in
    Transfers processed by ACH Colombia: a network topology analysis, Ortega & Leon (2018)



Risk measures used here

- Transaction level Monte Carlo simulation of payment flows gives
  - Values and volumes of payments: Settled / postponed / failed
  - Remaining liquidity buffers on participant level: “forest fire” charts on system level

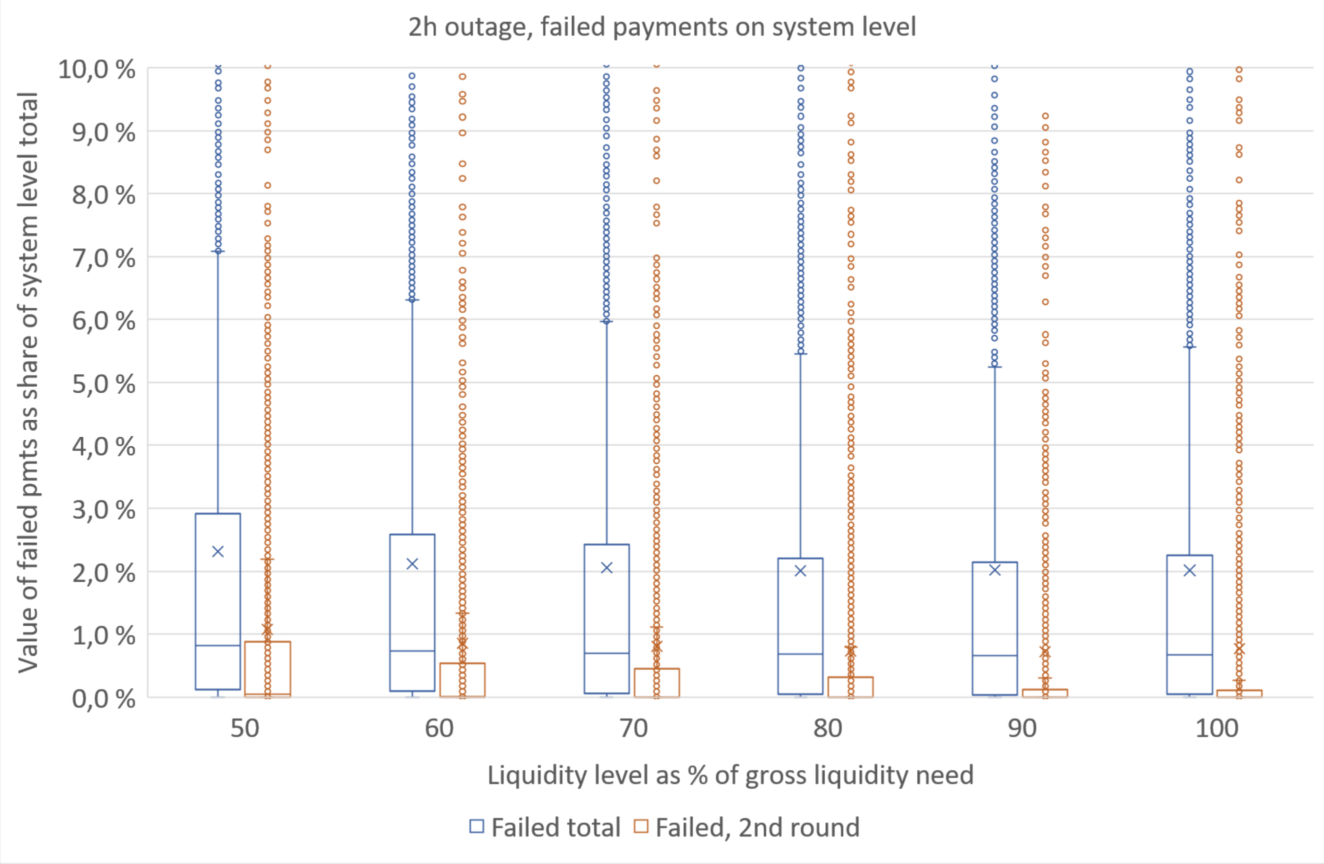
    from “Behaviour of banks during the financial crisis”, Chapel, Heuver & Heijmans, BoF Simulator seminar 2009



- Additionally
  - Statistics on the impact of different model parameters or dimensions

Results, operational failure scenarios

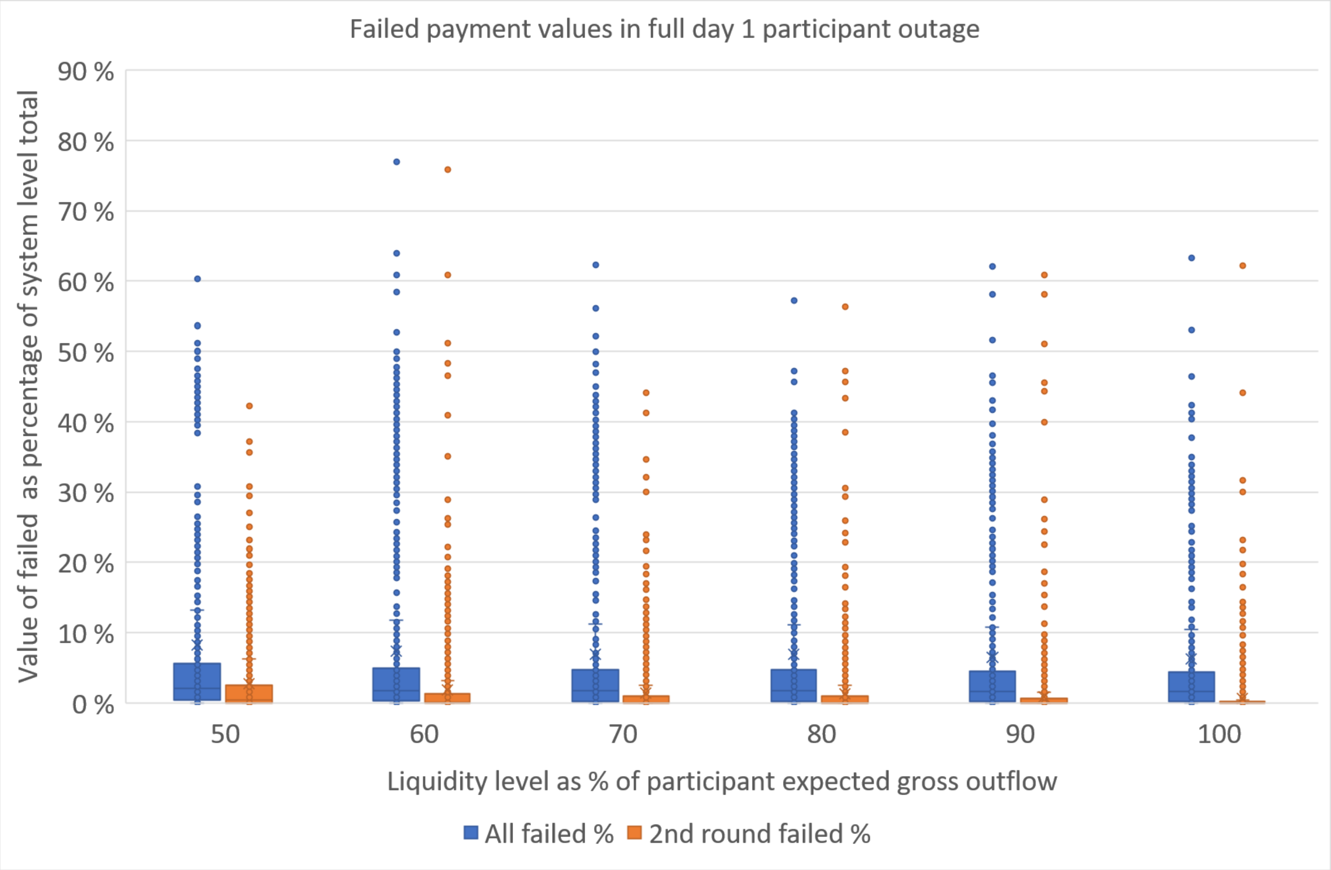
- System level view on 2-hour outage of one individual bank
- Value of unsettled payments varies (usually) in single digits range
- Number of 2nd round failed is miniature – mainly only largest payments are affected



Full day outage of 1 bank

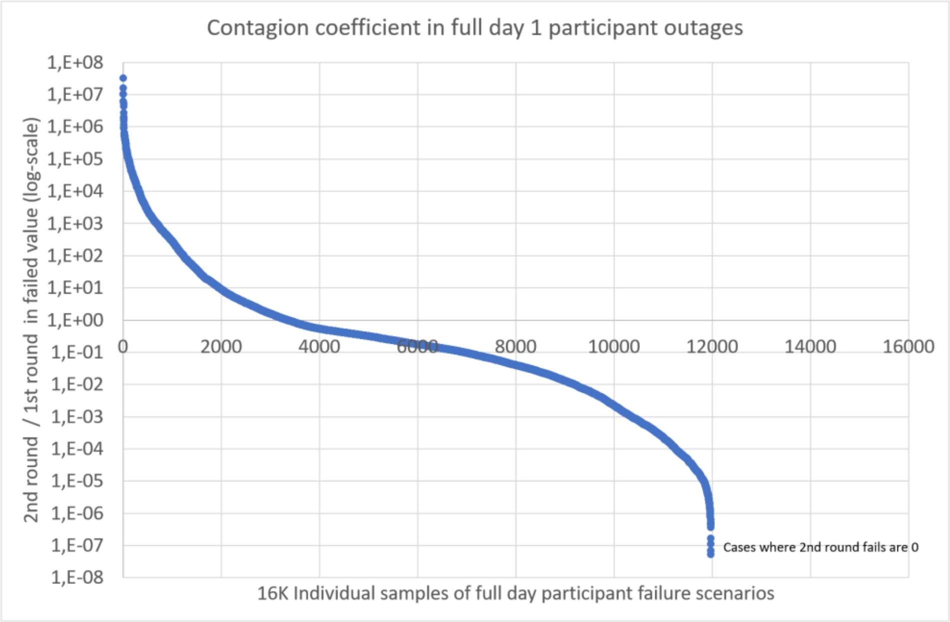
- System level view, full day outage of one bank at the time

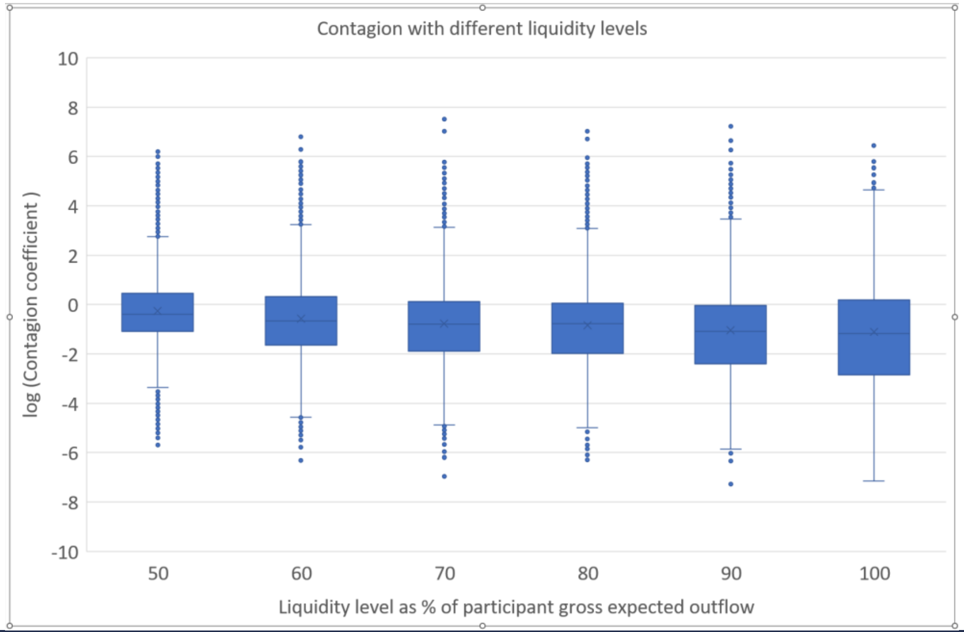
- (only) slightly higher levels
- The total impact (blue) in outliers seems to coincide with high 2nd round impact (orange)



Contagion coefficient

- 2^{nd} round / 1^{st} round in failed value
- In 21% of cases, 2^{nd} round is larger than initial impact, in 25% 2^{nd} round is zero
- Liquidity level has (only mild) impact on distribution of contagion effects

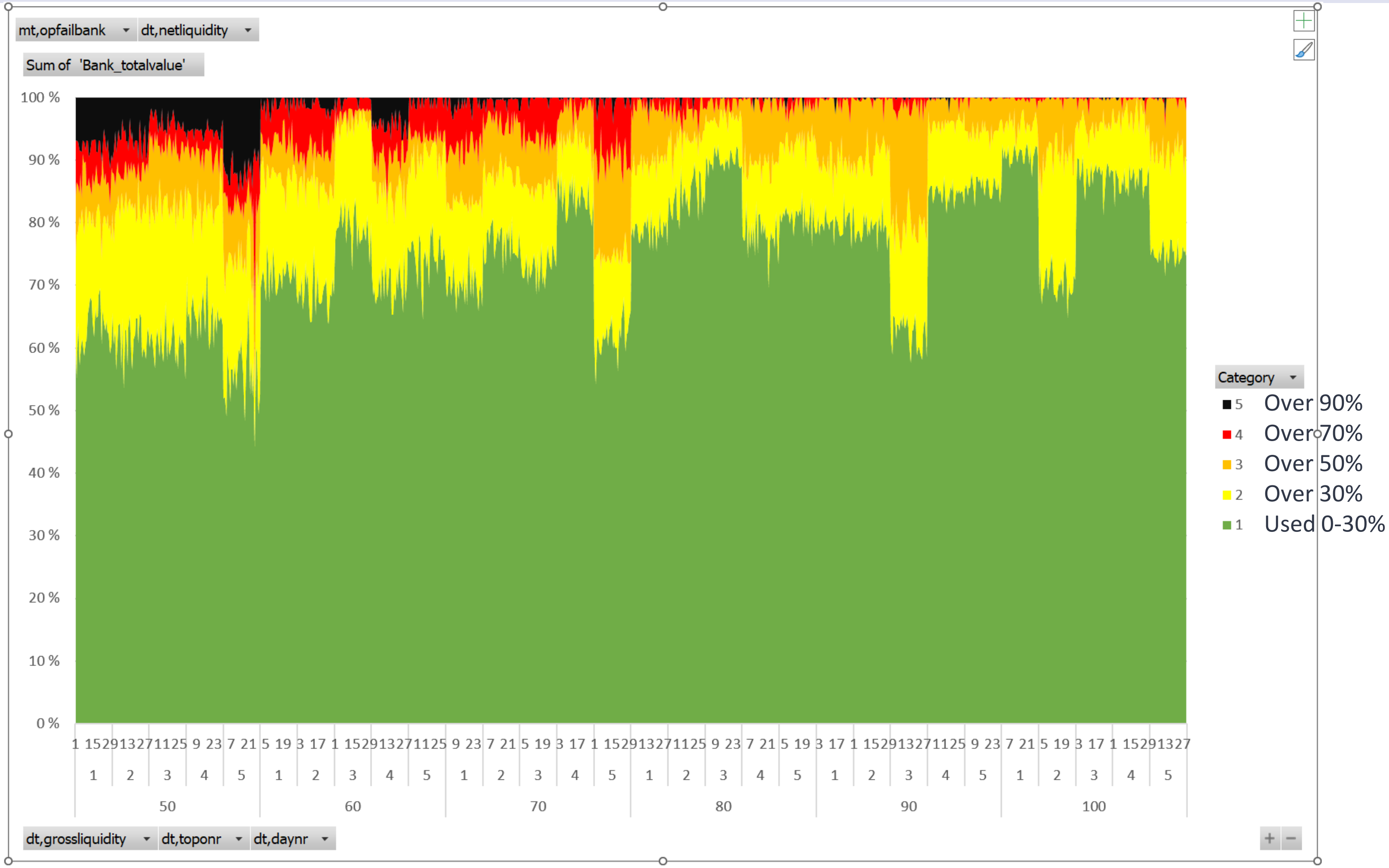




System level view on liquidity buffers

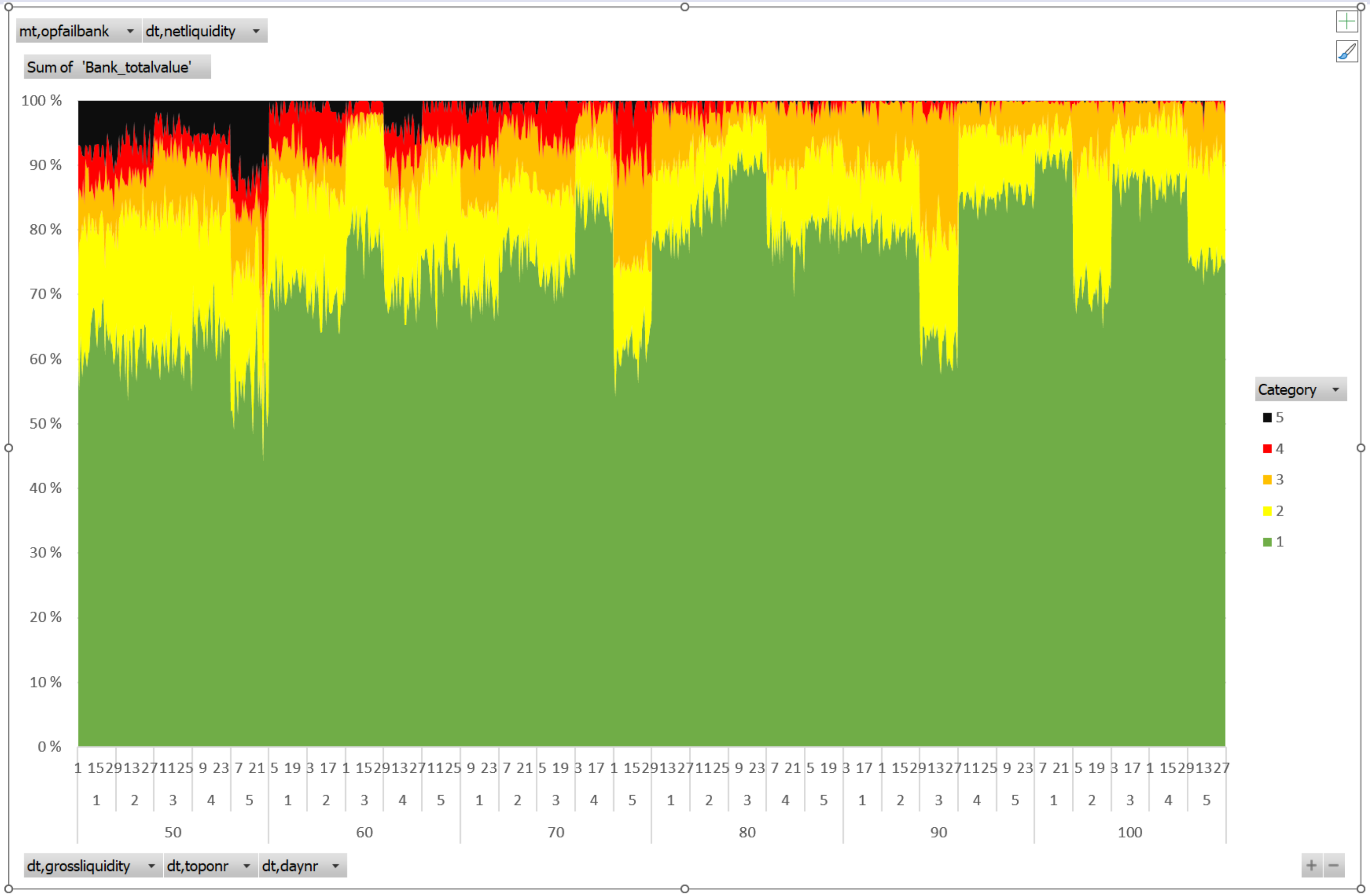
- “forest fire”: Chart colour based on how much participant liquidity buffers are “burned”
- 2 hour outage scenarios, fully IP migrated market
- Scaled with sender share of total outflow

Different scenarios and sampled days
Different sampled topologies
Aggregate liquidity levels



Forest fire observations

- Liquidity increase mitigates riks
- Differences between topologies are big
- Overall picture seems not alarming, but this is aggregated view



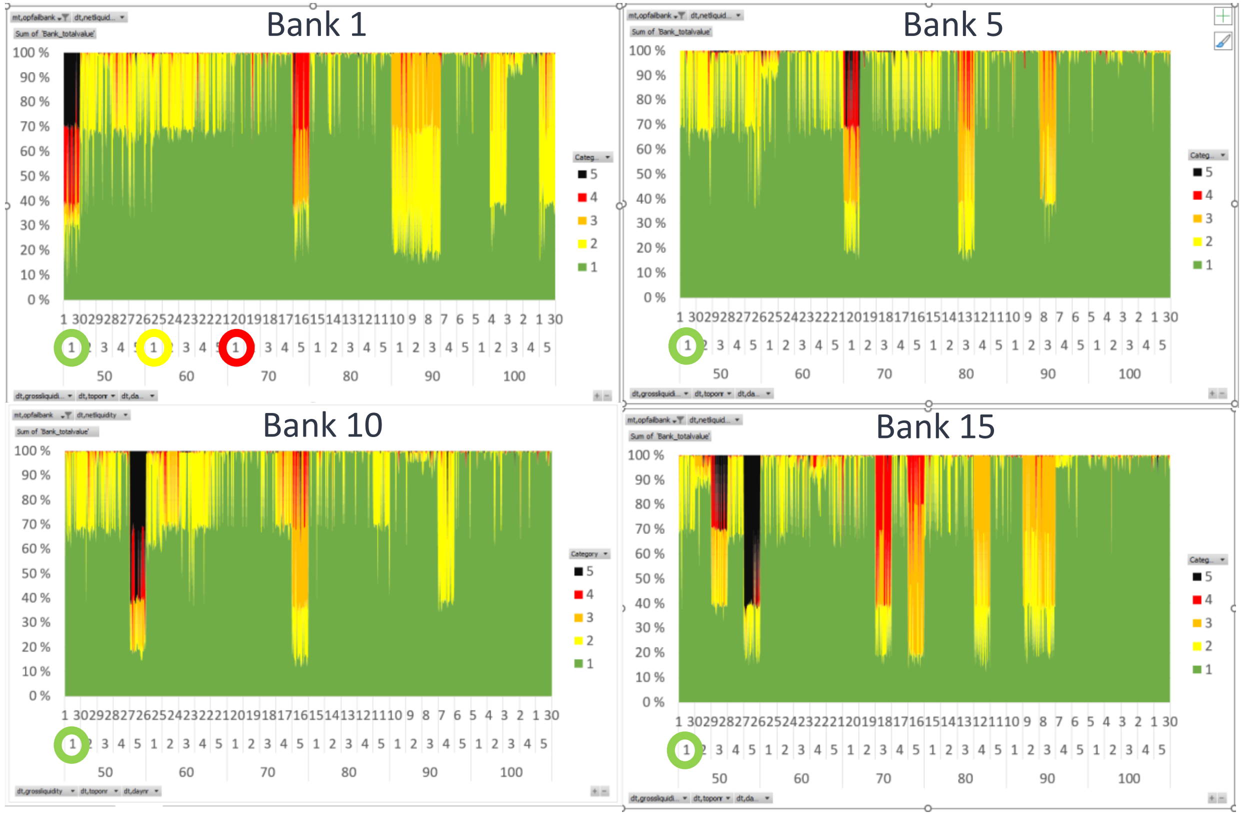
Over 90%
Over 70%
Over 50%
Over 30%
Used 0-30%

Different scenarios and sampled days
Different sampled topologies
Aggregate liquidity levels

Forest fire – one bank 2h failure examples

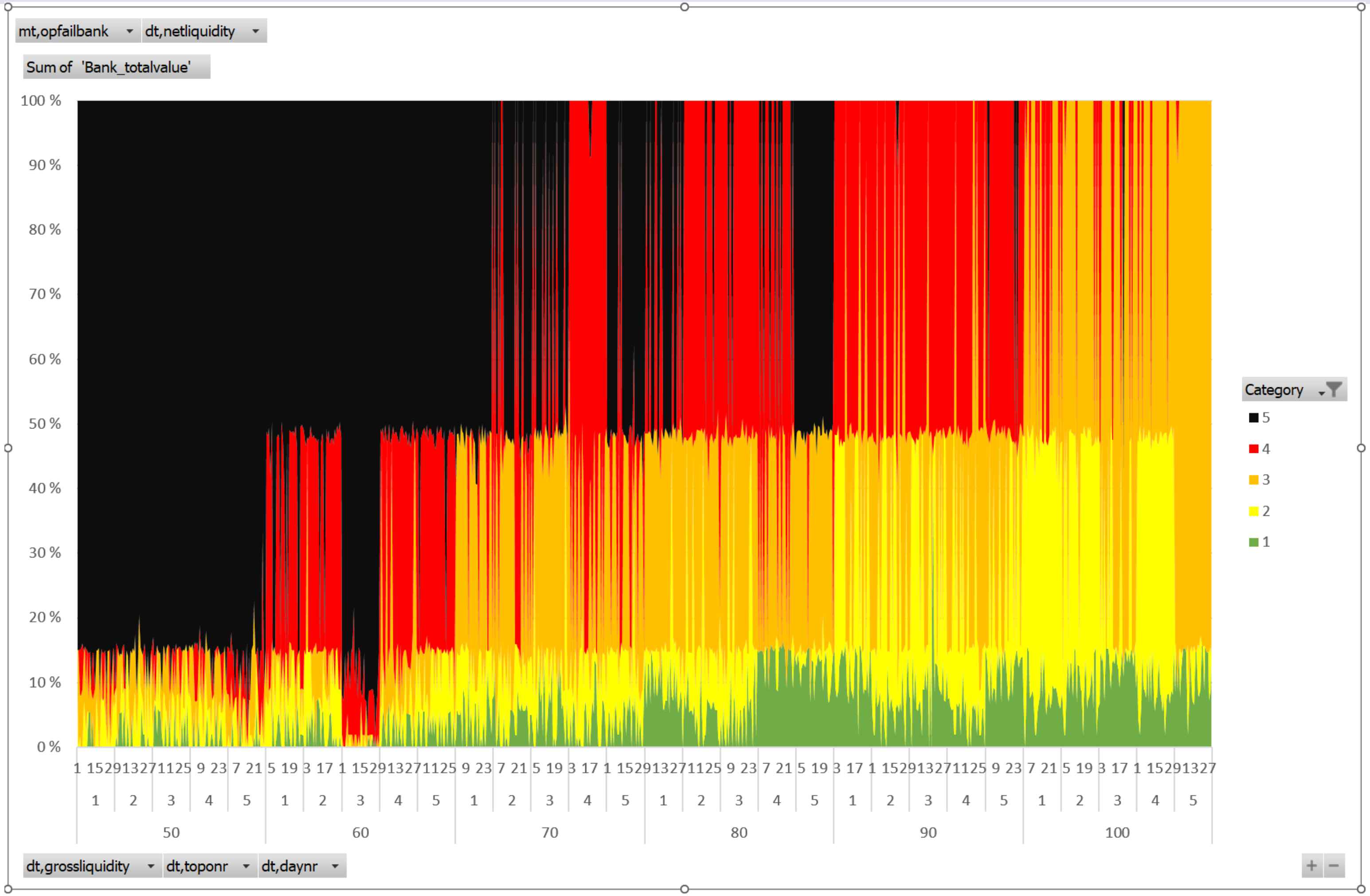
- Implications of topology sampling are very strong
- Topology variations trigger problems on different banks

- Clarification: topology labels are restarted after liquidity level change
    - E.g. the cases circled in green (Nr 1 on 50% liquidity) have the same topology
    - The ones with different colour are NOT with the same topology (nr 1 on different liquidity levels)



Forrest fire, initial market situation, no op. failures

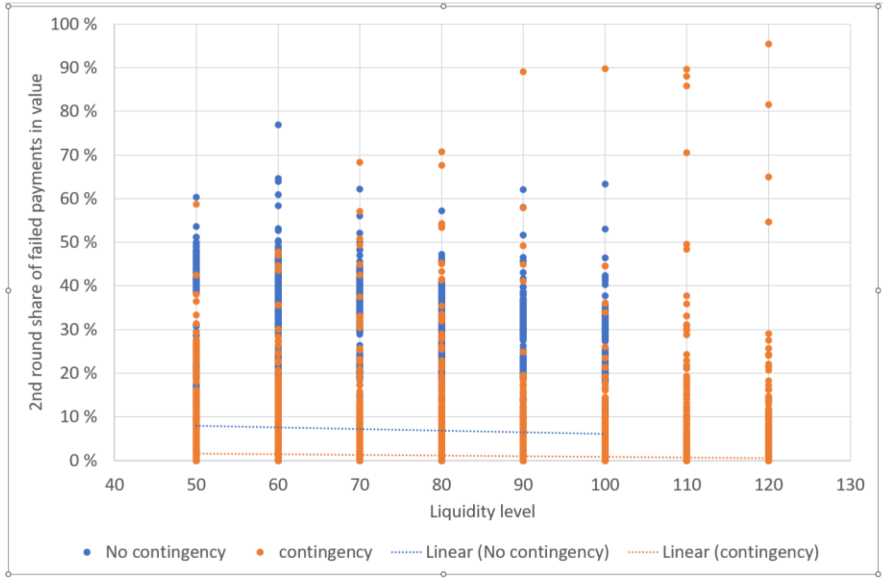
- Here only 5 banks send IP, while 11 receive
- A chronic liquidity sink
- “Unhappy merry-go-round”
  - Forrest fire pics the minimum liquidity position for each participant. These do not and cannot timely coincide in reality



Impact of end customer contingency measures

- In all scenarios there is are two resubmission trials for failed payments after n seconds (n=15) => No significant impact in practice
- But assume some persons have another card or app in their wallet (here 50%)
  - Failing payment is resubmitted via another sender bank randomly based on market shares

  ⇒Shows a decrease in failed payments (visible with regression or trendlines) and strong visible change in “forest fire” charts



Todo and next steps

- What makes a high-risk topology or high-risk position of a bank?
- Potential for analysing other scenarios, e.g.
  - Finnish market and scenario of transitions between payment instruments – motivated by ongoing FI-Payments council and BoF project to establish a SCT-Inst based IP scheme
  - Calibration of the model on data from another market

- Interesting other use cases exist for the network sampling

Summary

- Study of artificial data for anticipated future scenarios of instant payments in the Finnish market shows
  - Relatively small risk of payment settlement failing, especially for smaller payments
  - Share of participants with potentially shallow liquidity positions and increased risk ,can be initially large but decreases with migration to instant payments
  - Significant variations are present in risk measures when topology is varied

- The possibility to do sensitivity analysis of topologies in FMI studies is methodologically promising

Thank you!

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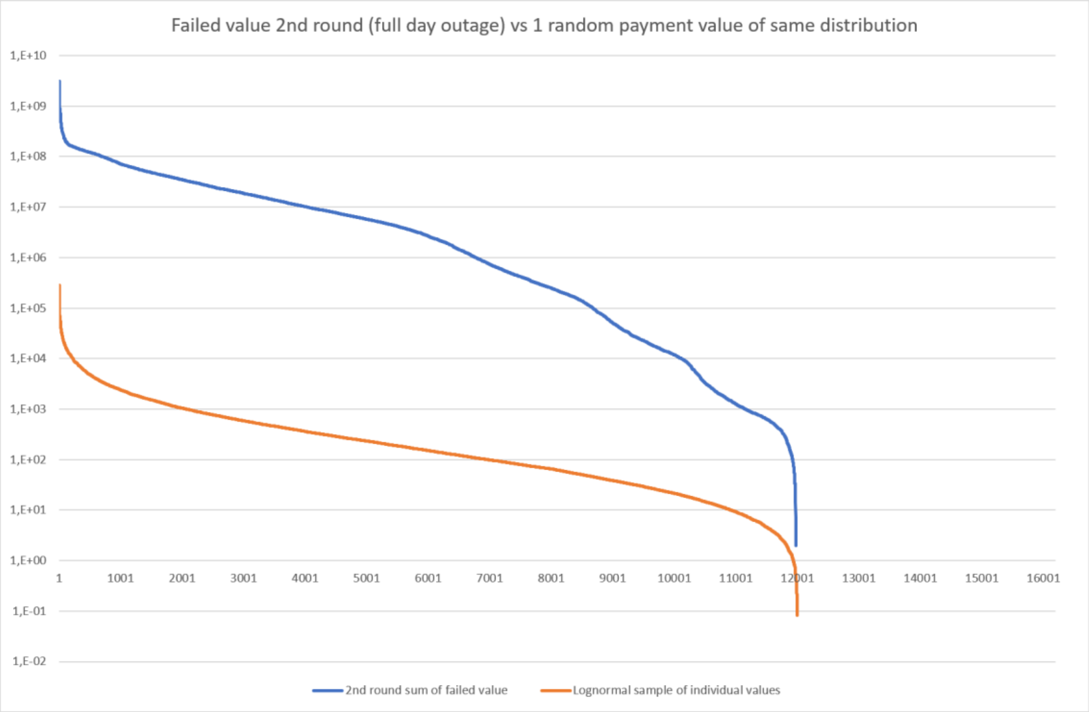
Extra slides

- Details on the network topology sampling to be added from the previous presentations

Value of 2nd round impacts vs log-normal sample



- Op failure continued: Comparison with 12k individual payment values of the same distribution
  - Values, not the relative “contagion coefficient”
- Similar shape, but difference grows @ higher value cases

Topology scenario path

- Point A / possible situation now
  - Daily statistics on IP's sent and received by FI banks in total
  - Inverse problem to find and fit a (static) topology on this data
  - 5 banks sending, 11 receiving

- Point B, possible final state
  - Values and volumes from Finnish retail payment statistics: 50% share in IP
  - Transfers processed by ACH Colombia: a network topology analysis, Ortega & Leon 2018 Lecturas de Economía, Universidad de Antioquia, Departamento de Economía, issue 88, pages 109-153, Enero – J
    - Only published network topology study of retail payment system (?)
    - 19 Banks (18 in FI) sending and receiving
    - Close to fully connected network unlike in many wholesale system topologies

Topology path from A2B

- First POC with real case
- *Point A:* Known FI banks are IP senders
  - Estimated based on aggregate IP statistics
- For each step and indicator set a new topology is calibrated
  - Random selection of IP-system entrant
  - Entrant makes a “big bang” start in IP
- Point B: all fully migrated

Steps	13				
Step	Senders	Receivers	Reciprocity	Avg degree	Avg path length
1	5	11	0.0383	1.727	1.250
2	6	11	0.1100	2.724	1.238
3	7	11	0.1816	3.720	1.225
4	8	11	0.2533	4.717	1.213
5	9	11	0.3250	5.714	1.201
6	10	11	0.3966	6.711	1.188
7	11	11	0.4683	7.707	1.176
8	12	12	0.5400	8.704	1.164
9	13	13	0.6117	9.701	1.152
10	14	14	0.6833	10.697	1.139
11	15	15	0.7550	11.694	1.127
12	16	16	0.8267	12.691	1.115
13	17	17	0.8983	13.688	1.102
14	18	18	0.9700	14.684	1.090

Topology generation demo: Finnish market from A 2 B