EUROPEAN CENTRAL BANK

EUROSYSTEM

# Payment System Participant Reactions Under Stressful Conditions: An Agent-Based Approach

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Disclaimer: *The presentation does not necessarily reflect the views of the ECB or the Bank of Finland*

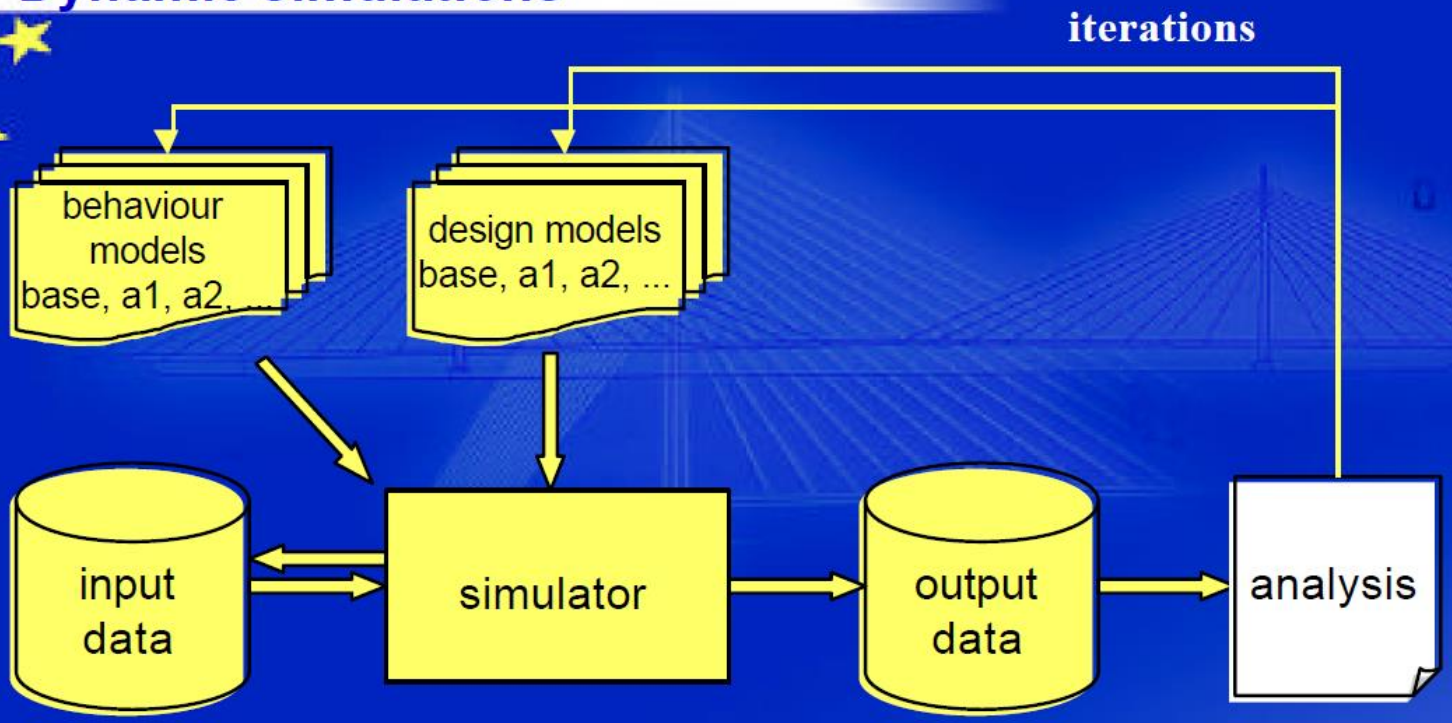
# Outline

- Project goal
- ABM approach
- Practical Implementation
- Some simple behaviours
- Simulation results
- Conclusions
- Future work

# Project goal

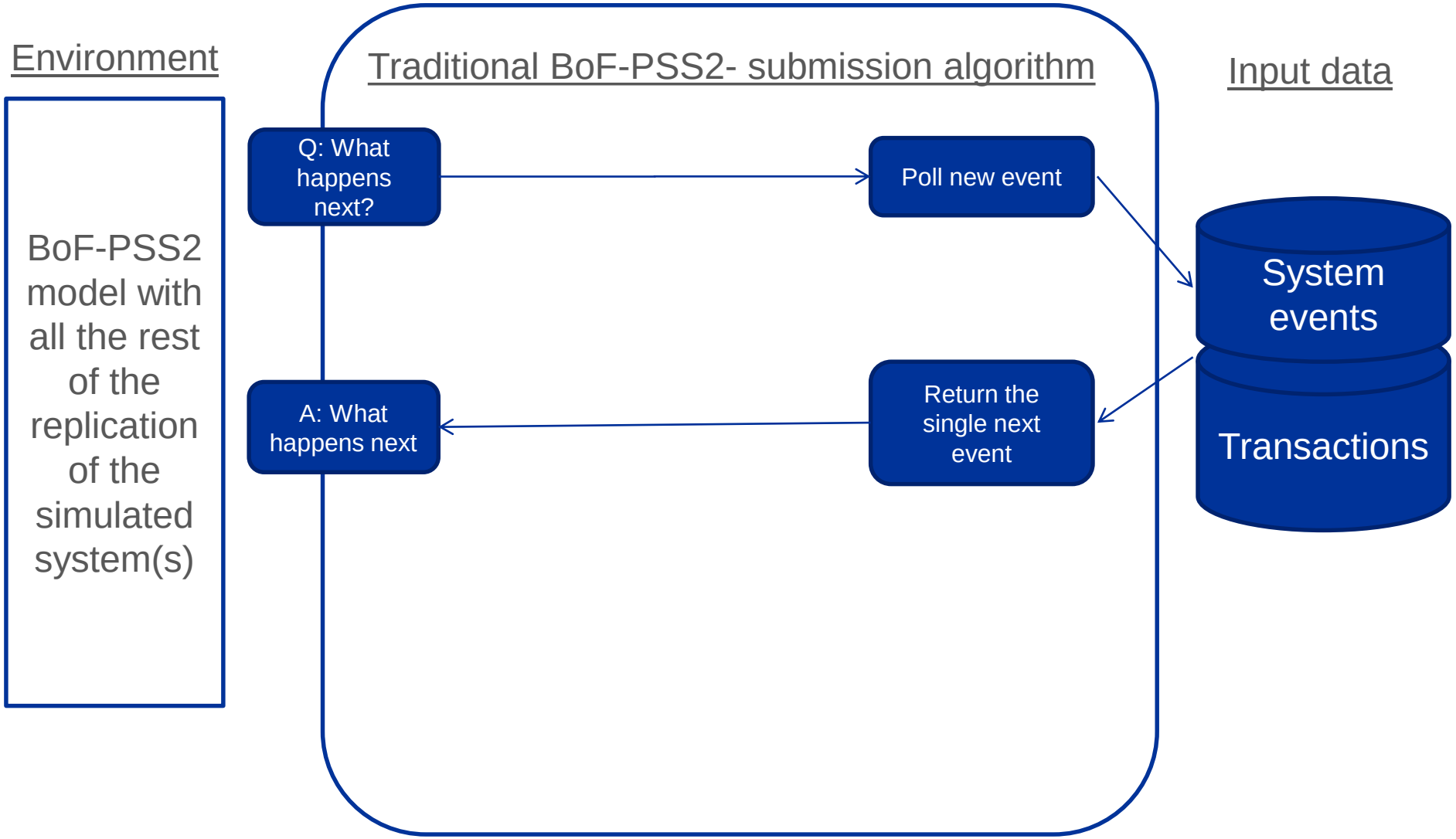
- To set up framework to combine (simple) ABM and LVPS settlement process within BoF-PSS2
- To implement a few plausible (simple) behaviours
- To see what impact they deliver on simulation results – preferably in stressed situation

# Dynamic simulations

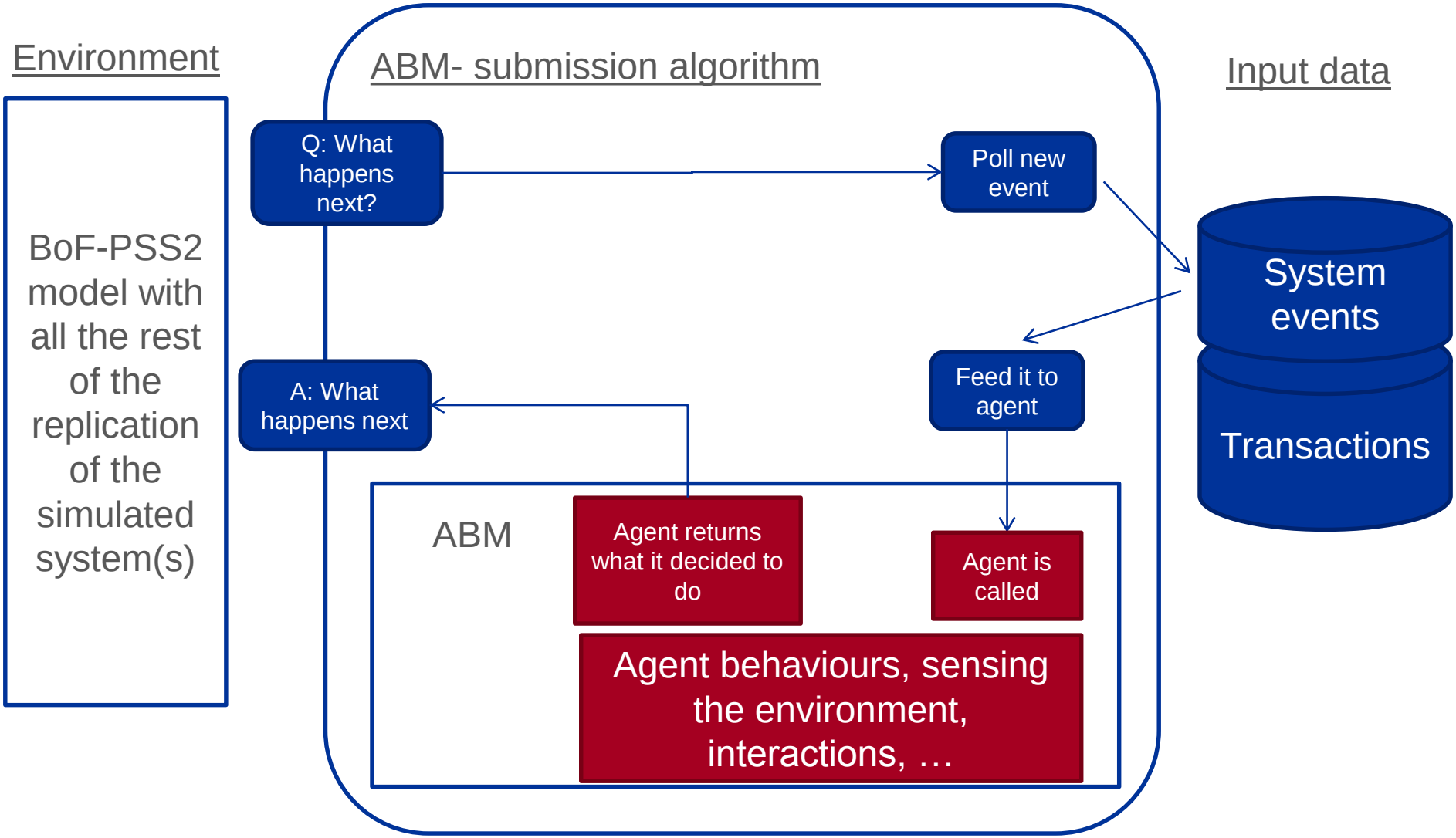


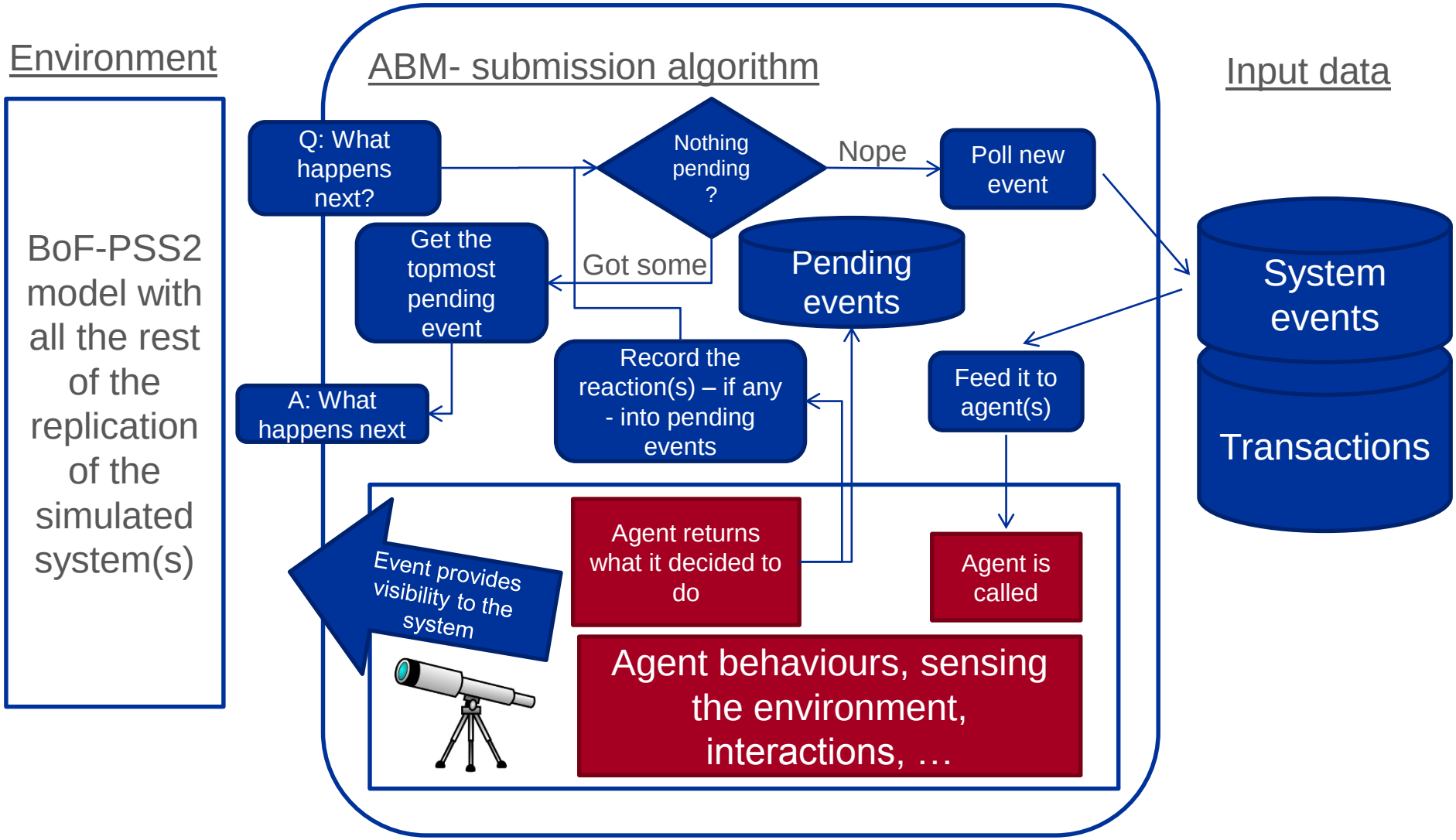

- extension to static simulations with an explicit model on how banks submit payments to the system
- can be used to study liquidity management by banks, or to model it

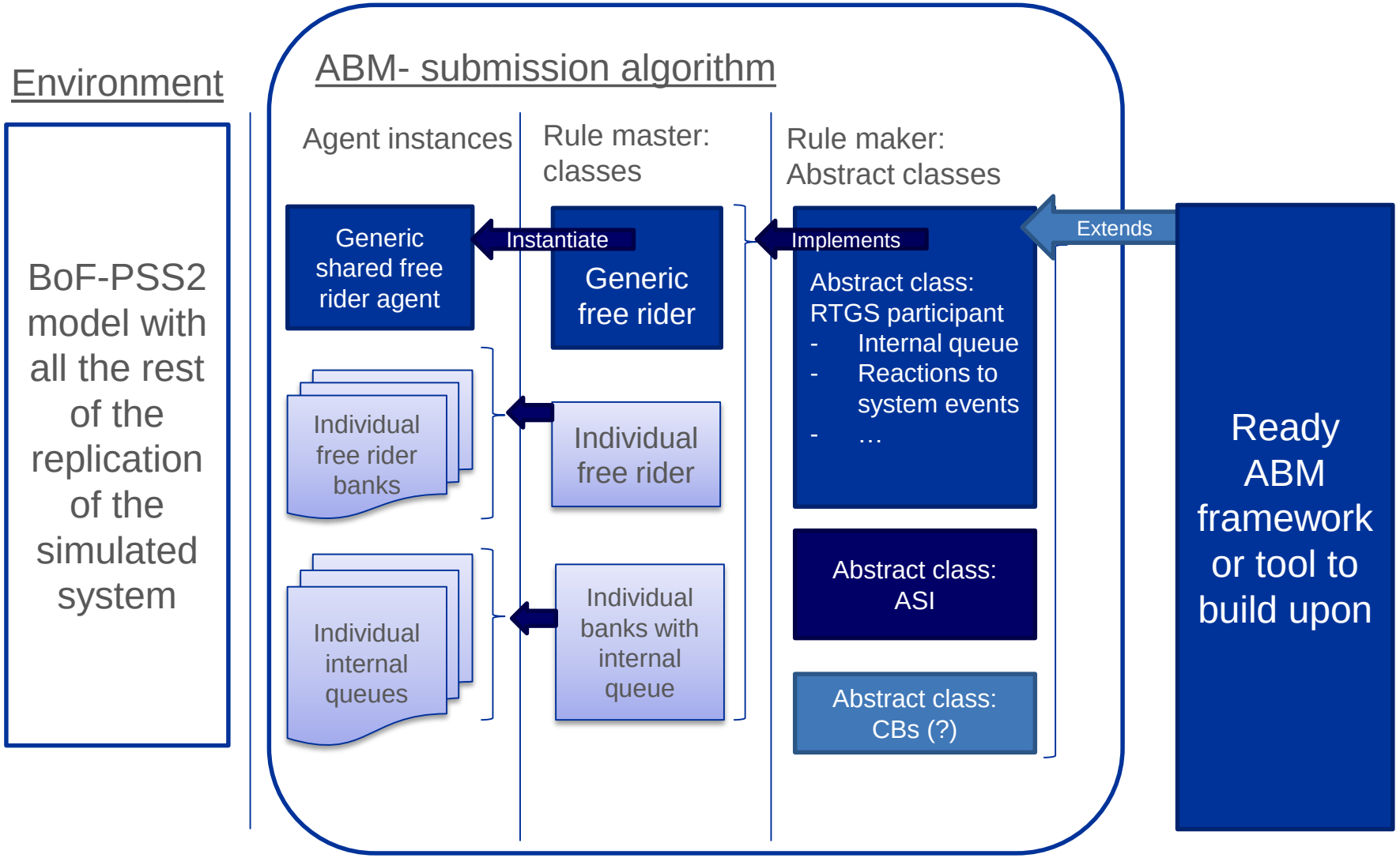
# ABM APPROACH - THEORY




Submission algorithm is available as open source code. It can be modified as a user module


Environment
BoF-PSS2 model with all the rest of the replication of the simulated system(s)
ABM- submission algorithm
Q: What happens next?
Poll new event
Input data
System events
Transactions
Feed it to agent
A: What happens next
ABM
Agent returns what it decided to do
Agent is called
Agent behaviours, sensing the environment, interactions, …


Environment
BoF-PSS2 model with all the rest of the replication of the simulated system(s)
ABM- submission algorithm
Input data
Q: What happens next?
Nothing pending ?
Nope
Poll new event
Got some
Get the topmost pending event
Pending events
System events
Transactions
A: What happens next
Record the reaction(s) – if any - into pending events
Feed it to agent(s)
Event provides visibility to the system
Agent returns what it decided to do
Agent is called
Agent behaviours, sensing the environment, interactions, …




The model is structured according to the ERA-scheme, Terna (2000)
http://web.econ.unito.it/terna/ct-era/ct-era.html

# PRACTICAL IMPLEMENTATION

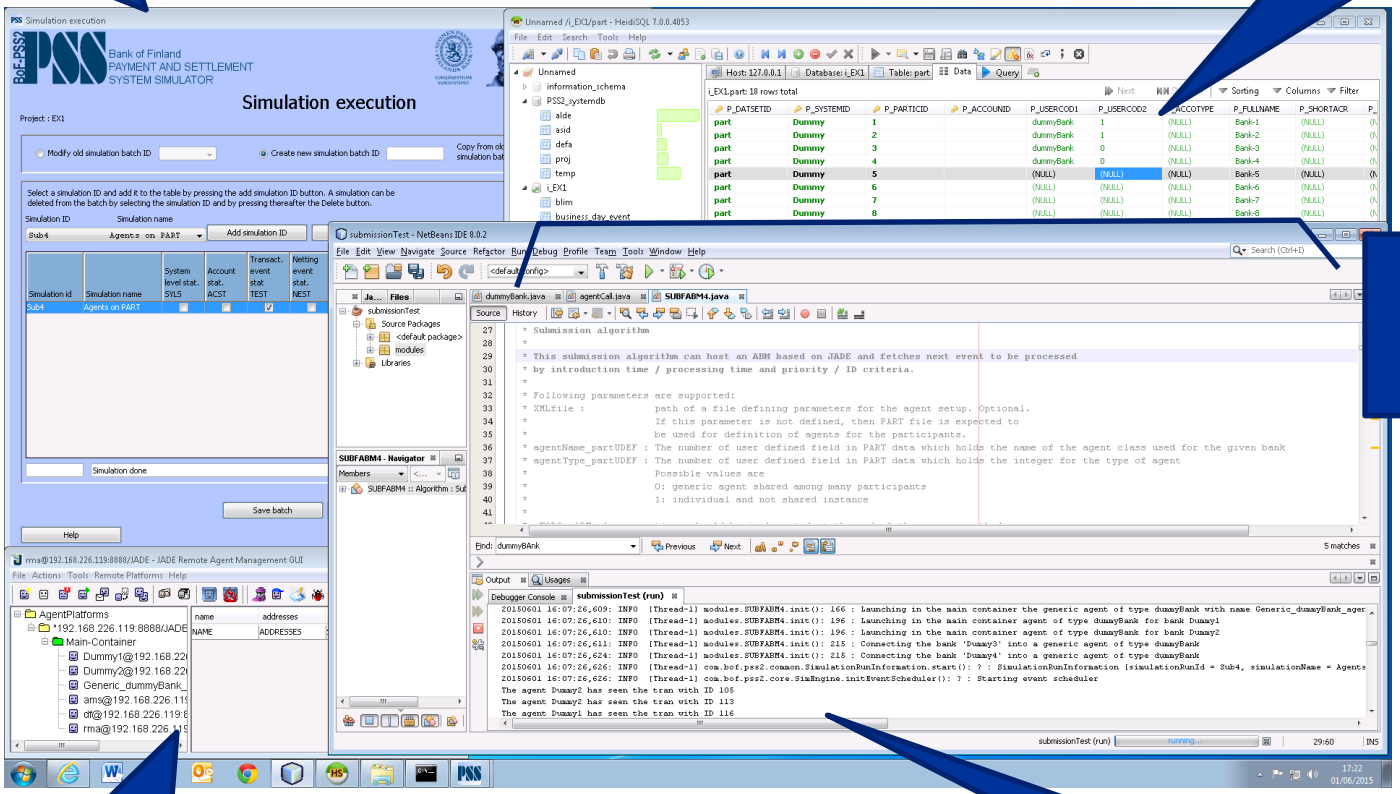
# Selected framework:

- JAVA Agent Development framework
  - Open source with LGPL licence
  - Hardware independent, scalable, parallelizable, embeddable
  - Standards for agent interaction (FIPA)
  - More a Multi-agent system (MAS) than ABM tool…
    - Linkages to AI libraries exist
  - http://jade.tilab.com/

# What do we have?

1. Modified submission algorithm that links to BoF-PSS2

2. Set up of agents based on PART input data



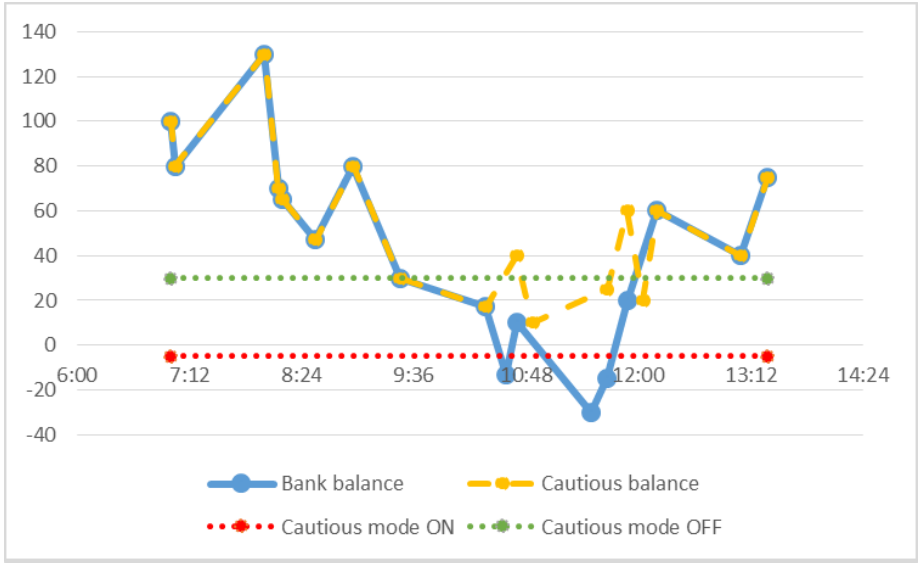

3. First agent logics implemented

4. JADE environment integrated and the agents are alive!

5. Events are passed to agents and their reactions integrate to the simulation

# Some Simple Behaviours

- Cautious Participants
  - Banks withhold payments in internal queues when liquidity is below some threshold value
  - Banks abandon cautious behaviour when liquidity is restored
  - Postponing can be focused on defined payment types




- Free-Riding Participants
  - Banks rely only on incoming liquidity for payments

# Some Simple Behaviours

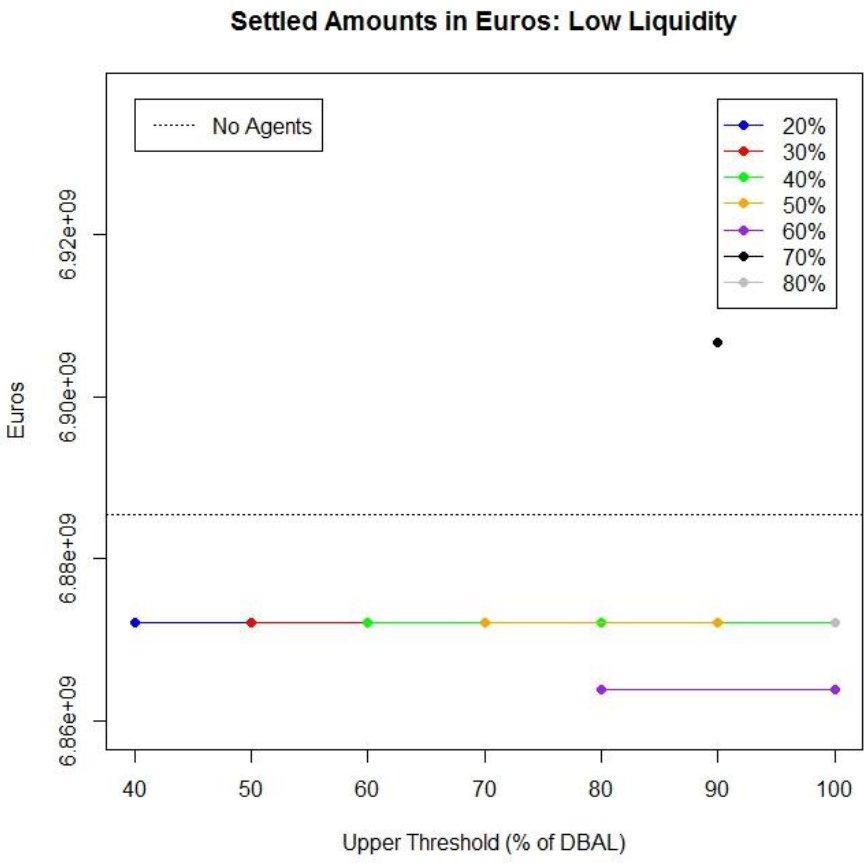
- ABM Simulations:
  - All banks exhibit same level of caution: Cautious behaviour turn-on/turn-off (by % initial liquidity)
    - 20%/{40%,60%,80%,100%}
    - 30%/{50%,70%,90%}
    - 40%/{60%,80%,100%}
    - 50%/{70%,90%}
    - 60%/{80%,100%}
    - 70%/90%
    - 80%/100%
  - Only largest one, two and three participants (by avg. tran. value) exhibit cautious behaviour:
    - 20%/40%; 30%/50%; 40%/60%; 50%/70%; 60%/80%; 70%/90%; 80%/100%
- Control Simulations:
  - Normal (i.e., non-agent-generating) simulations for setup above with two initial levels of liquidity (A and B)
  - Largest one, two and three participants have no initial liquidity

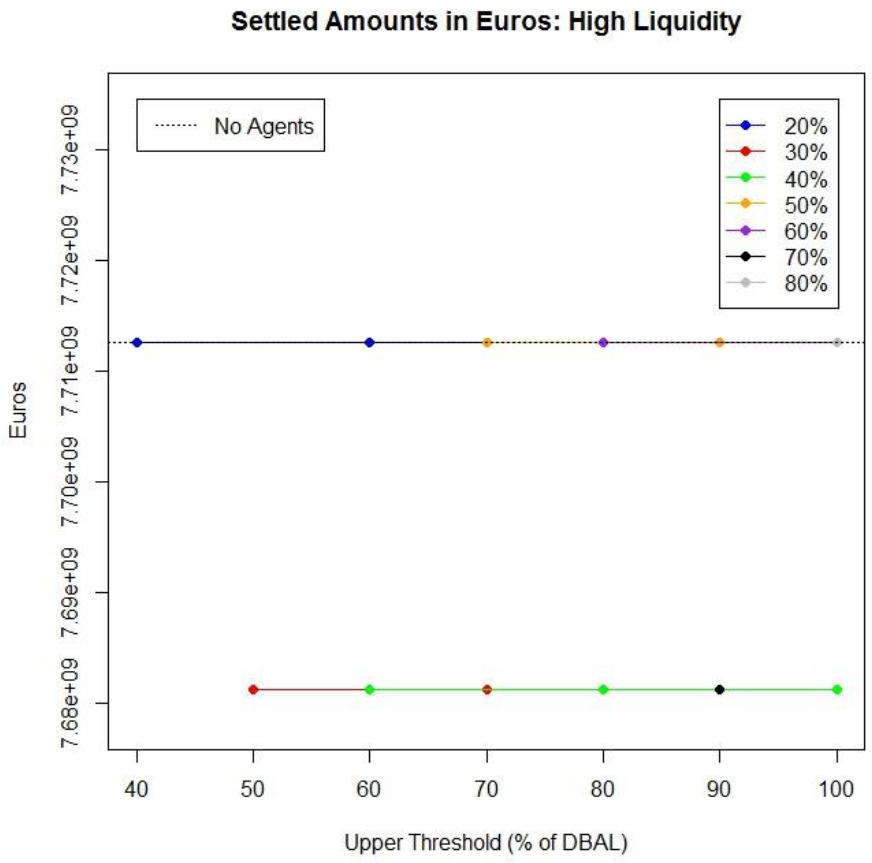
# Simulation Details

- All simulations were performed using dummy data provided by the BoF
  - 18 participants
  - 778 transactions
  - No credit, only initial liquidity levels
- Two levels of initial liquidity were used for all ABM and control runs
  - Lower and Upper bounds provided by BoF
- Simulation results were probed using the following indicators:
  - Total value settled
  - Number of transactions settled
  - Number of queued transactions
  - Total value of queued transactions
- Quick note: ABM simulations ran on average 80% more slowly, regardless number of created agents

# SIMULATION RESULTS

# All Participants Equally Cautious



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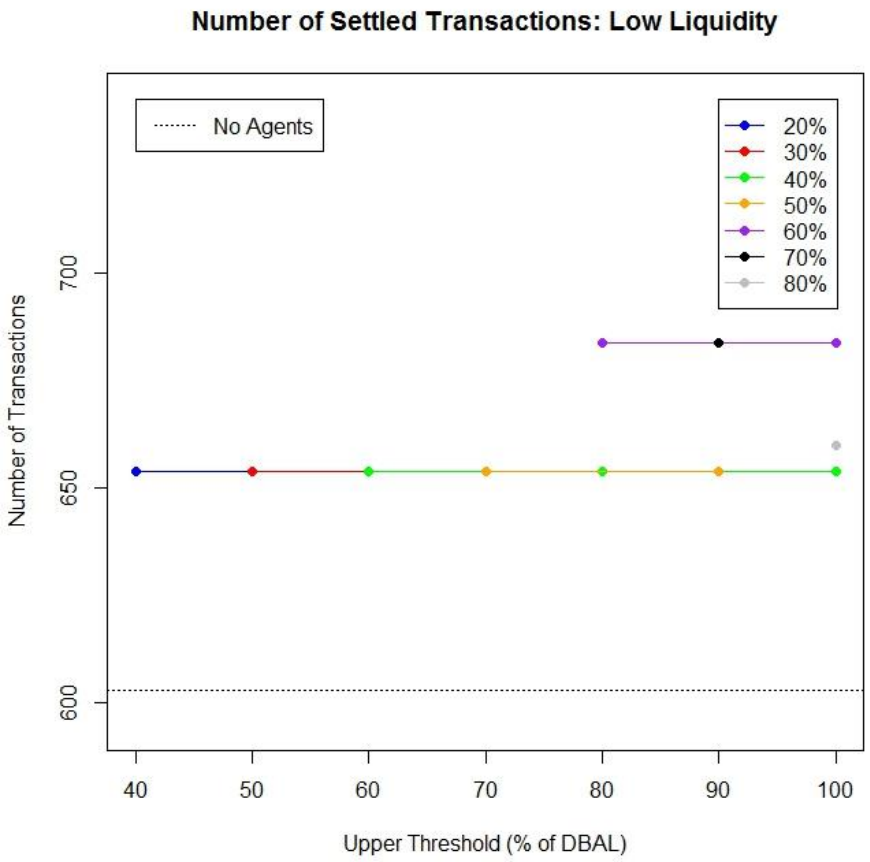


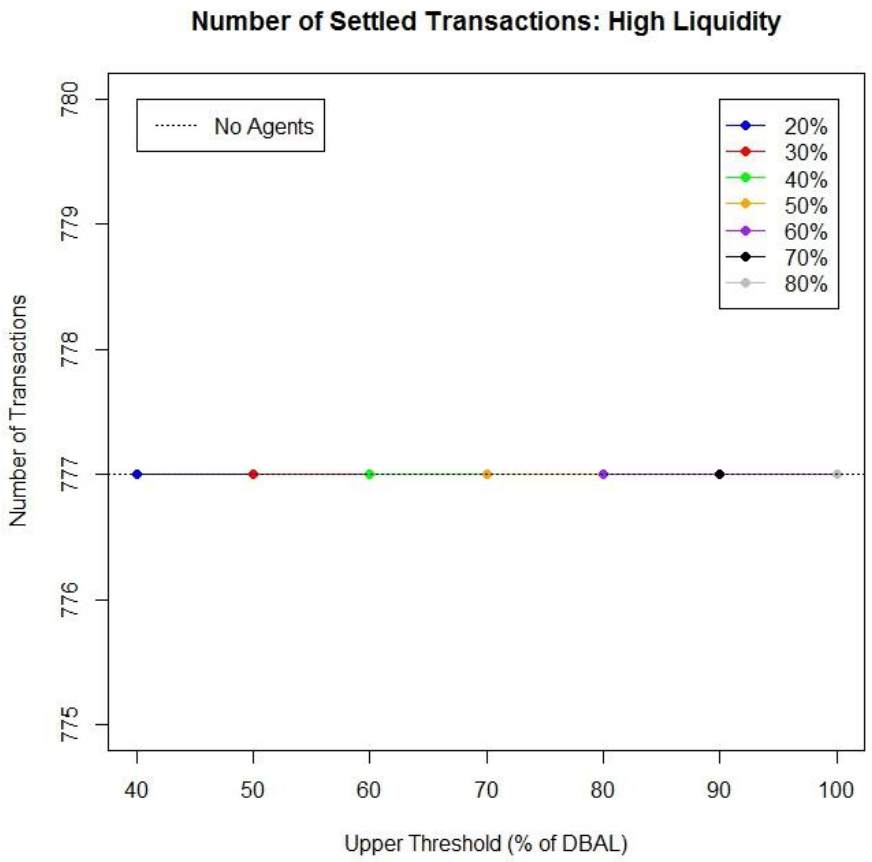

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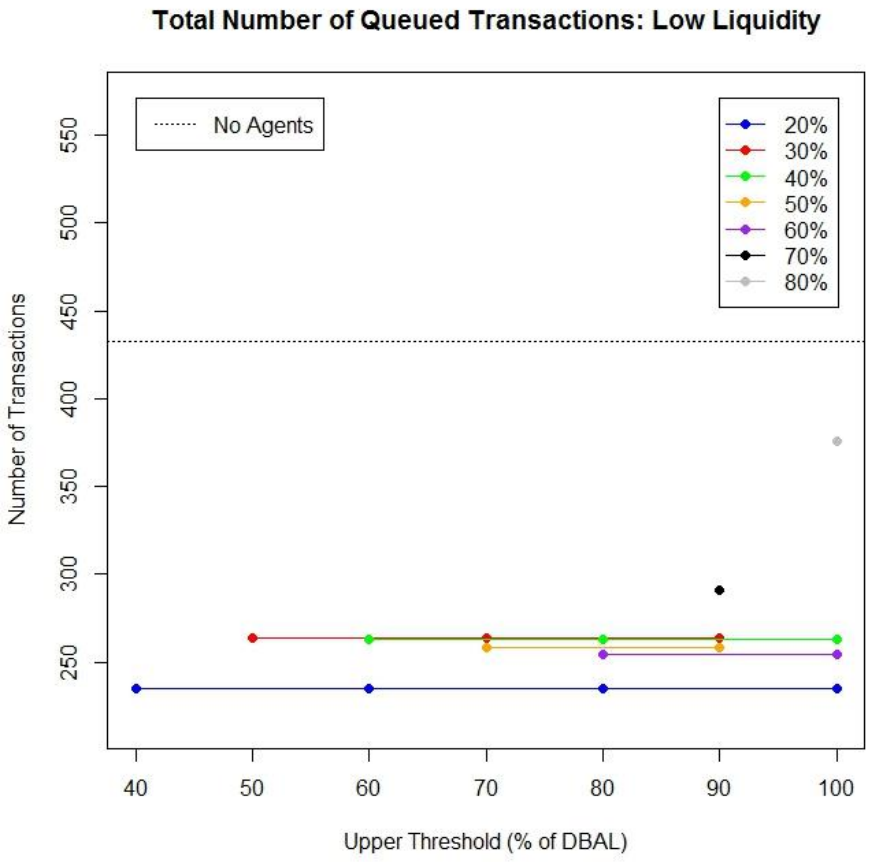


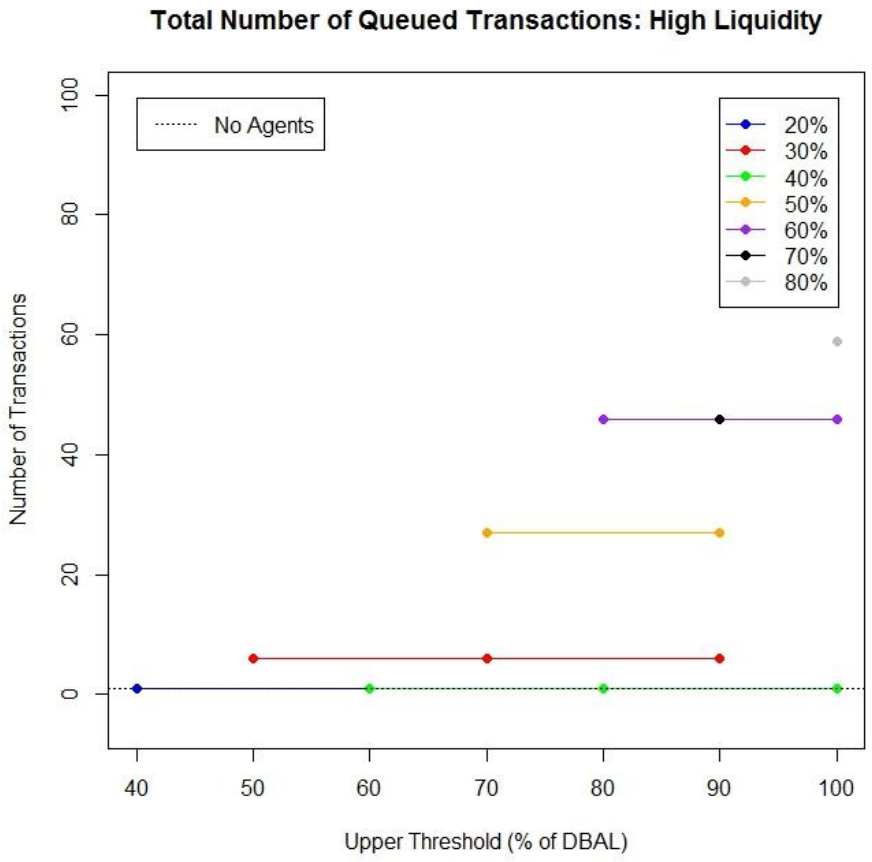

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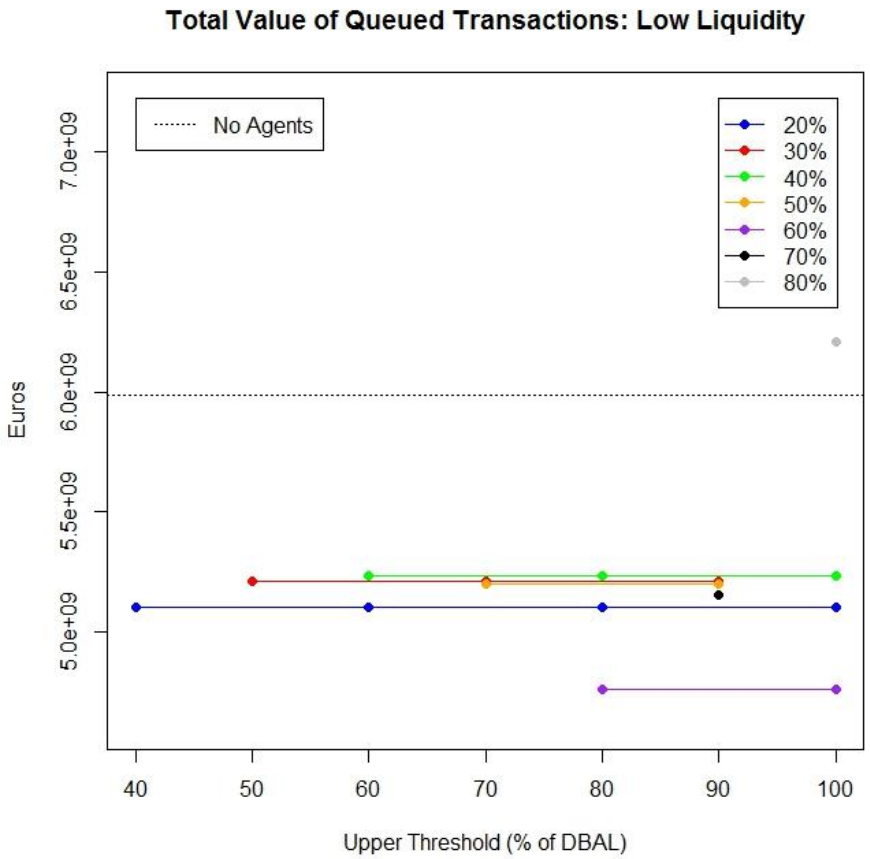
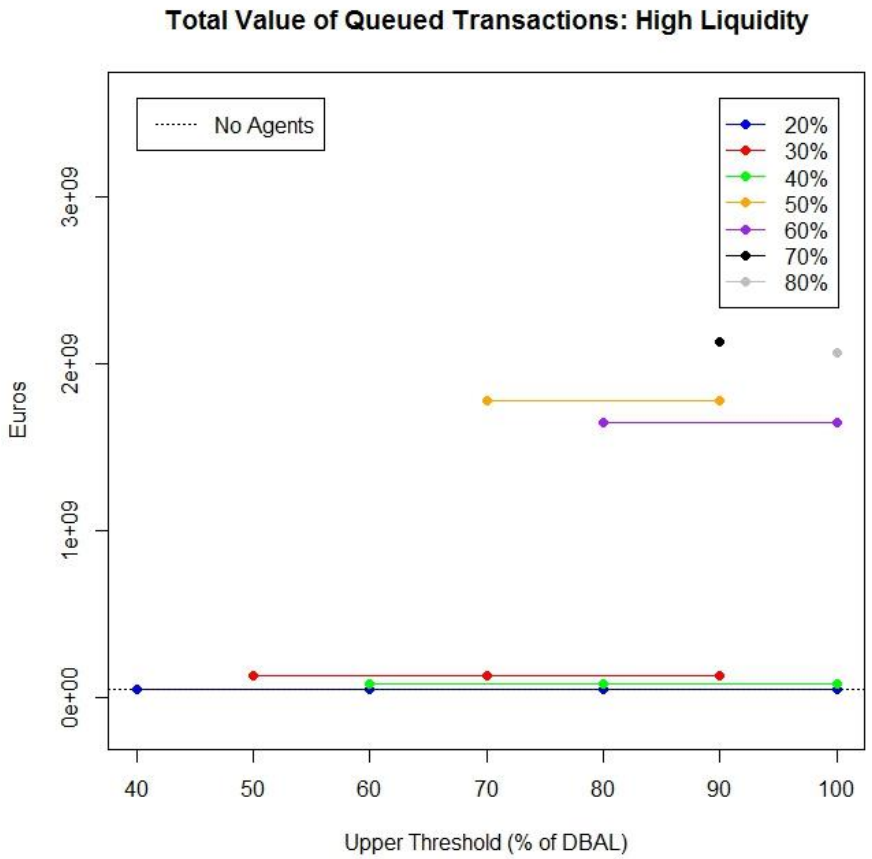
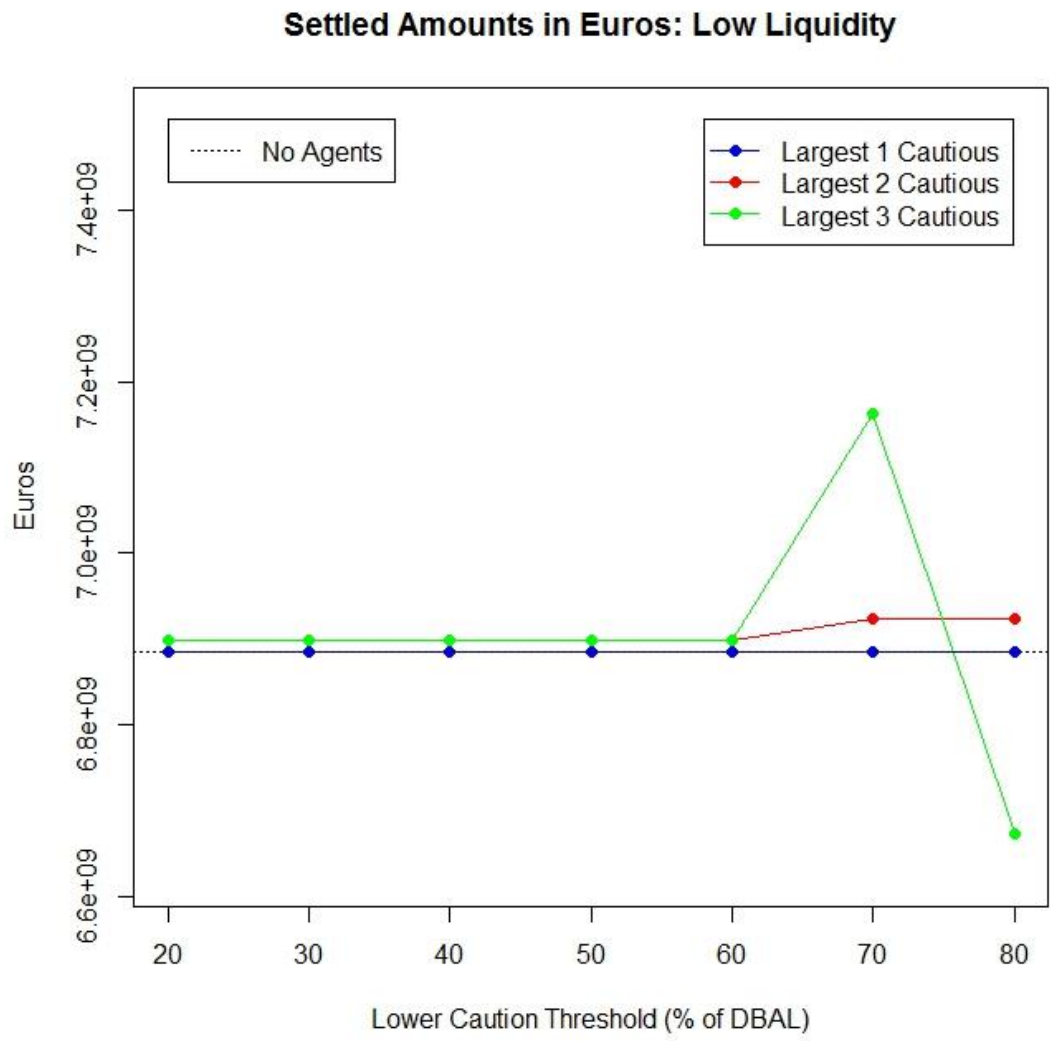


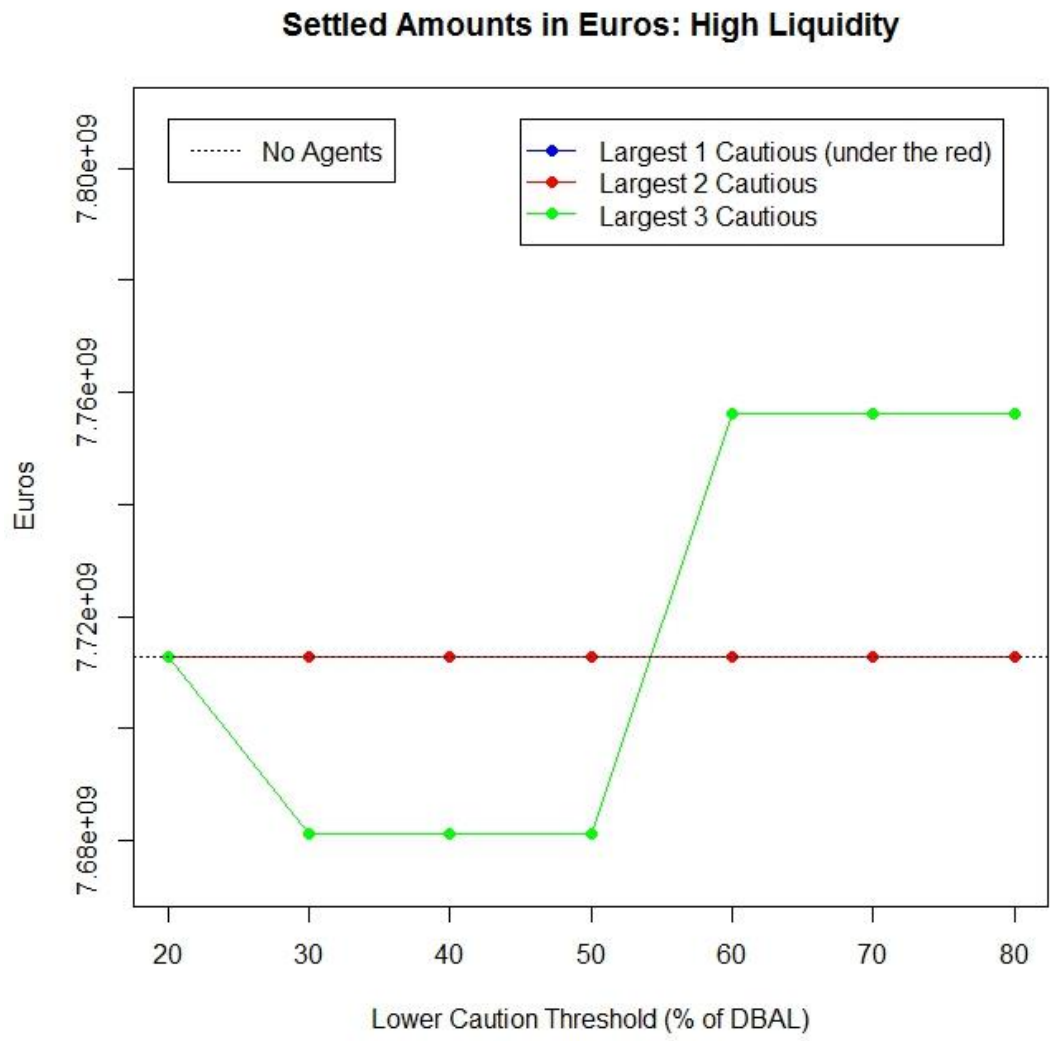
# Only Largest Participant(s) Cautious




Stressed Control Simulations:

No liquidity for:
Largest 1 – 5.57e+09
Largest 2 – 9.89e+08
Largest 3 – 1.66e+08

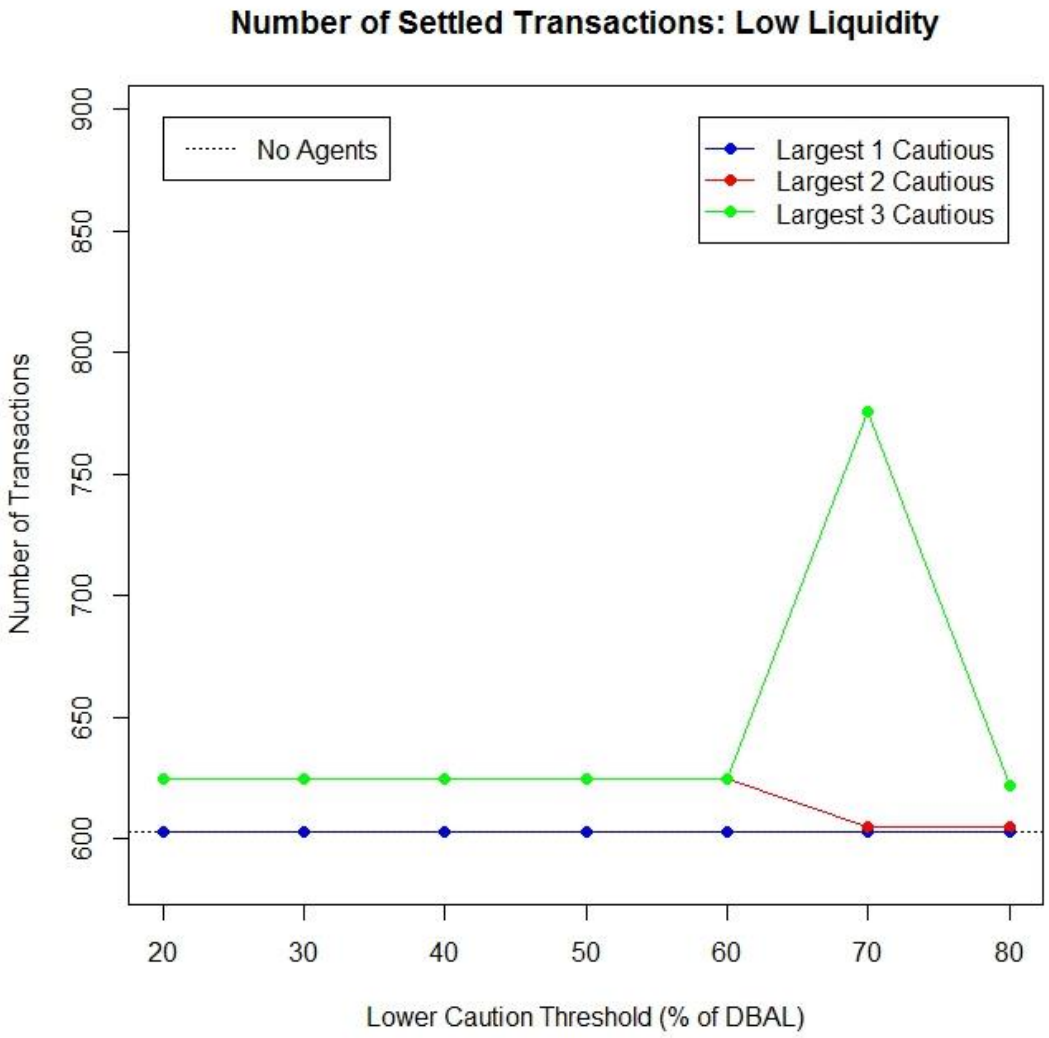
# Only Largest Participant(s) Cautious




Stressed Control Simulations:

No liquidity for:
Largest 1 – 6.64e+09
Largest 2 – 2.91e+09
Largest 3 – 2.45e+09

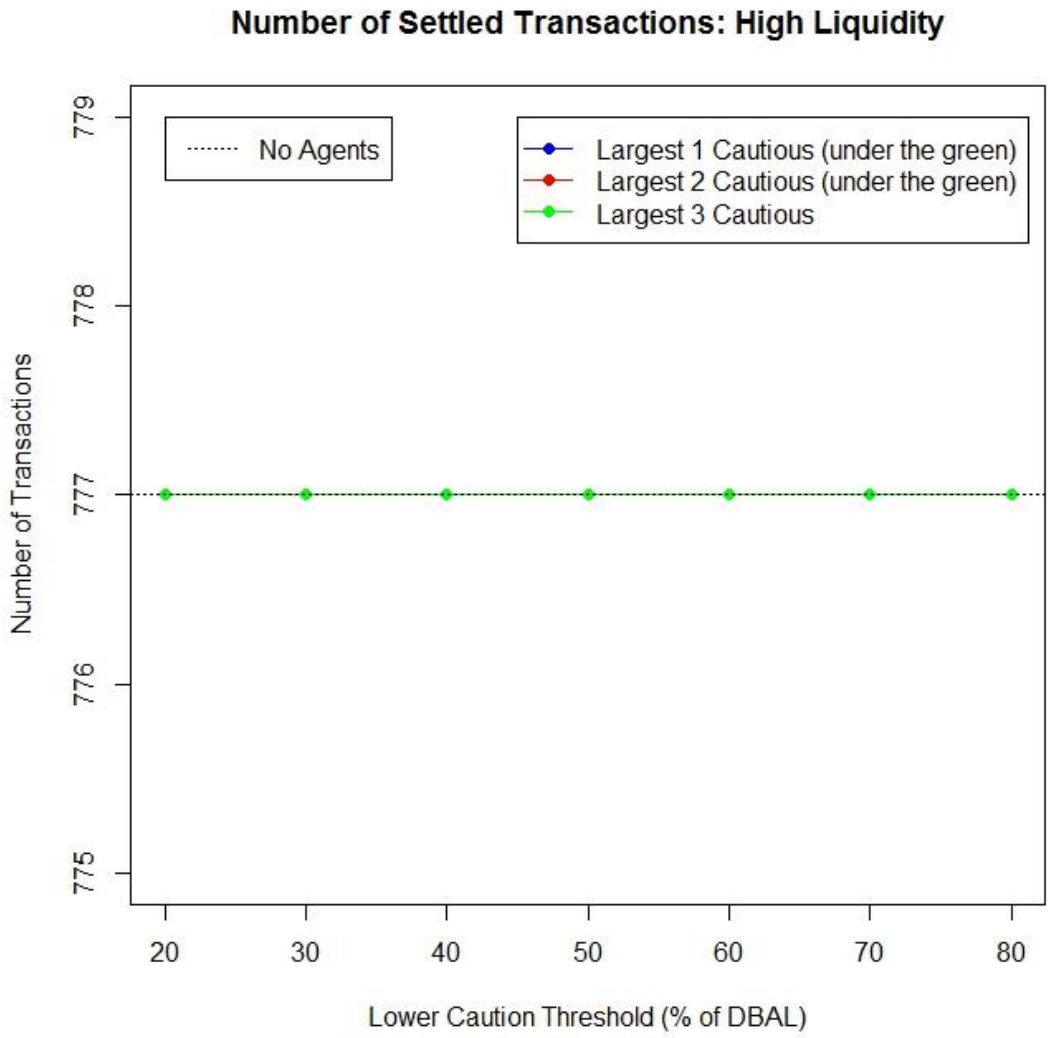
# Only Largest Participant(s) Cautious




Stressed Control Simulations:

No liquidity for:
Largest 1 – 521
Largest 2 – 293
Largest 3 – 99

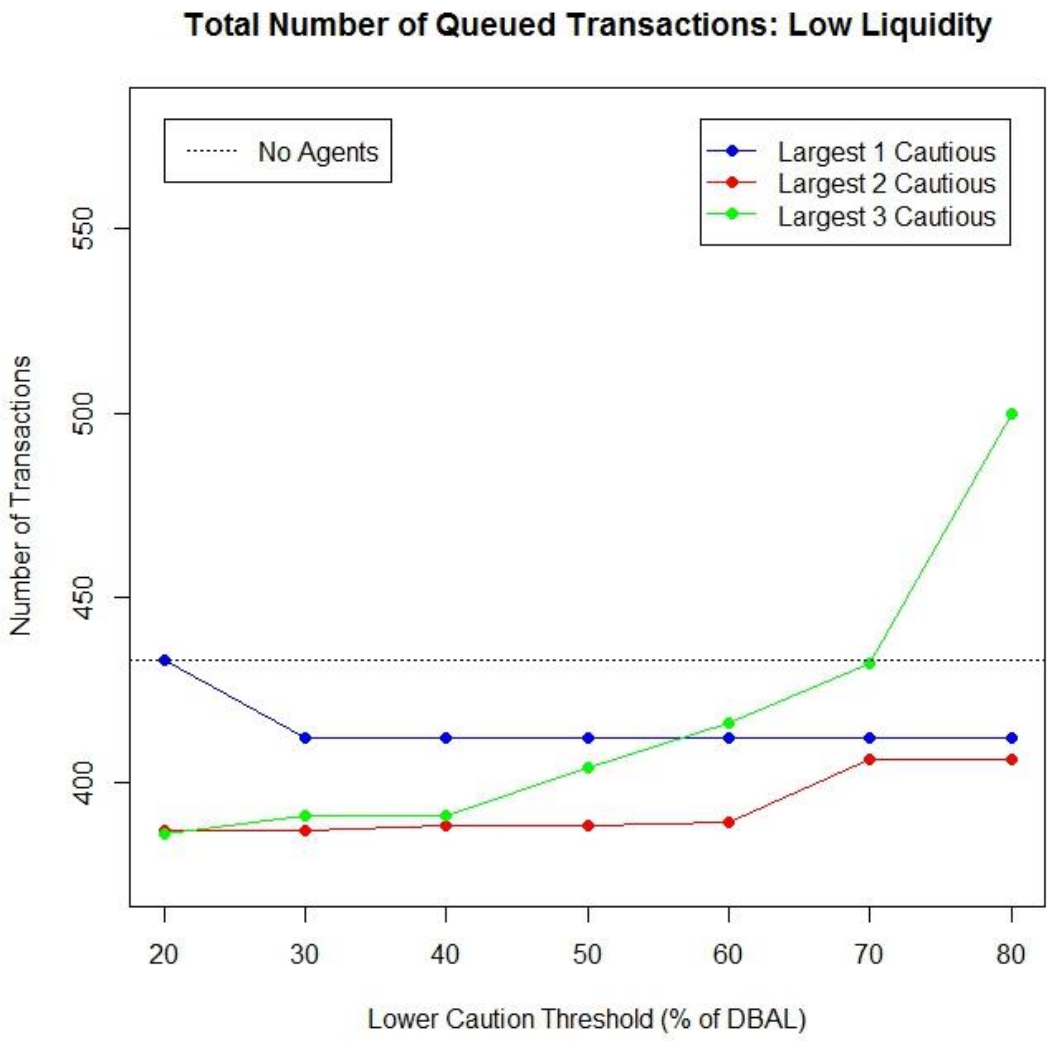
# Only Largest Participant(s) Cautious




Stressed Control Simulations:

No liquidity for:
Largest 1 – 771
Largest 2 – 649
Largest 3 – 603

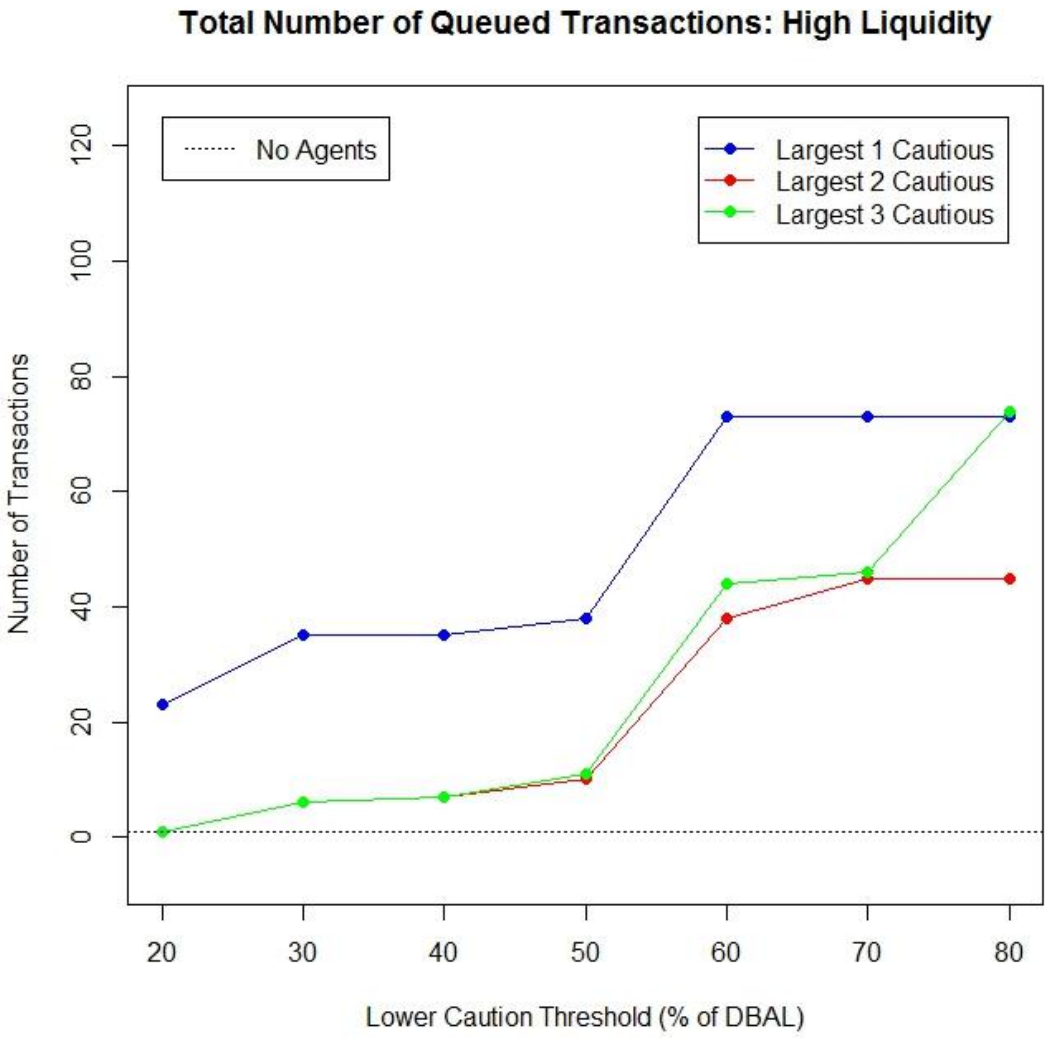
# Only Largest Participant(s) Cautious




Stressed Control Simulations:

No liquidity for:
Largest 1 – 489
Largest 2 – 598
Largest 3 – 717

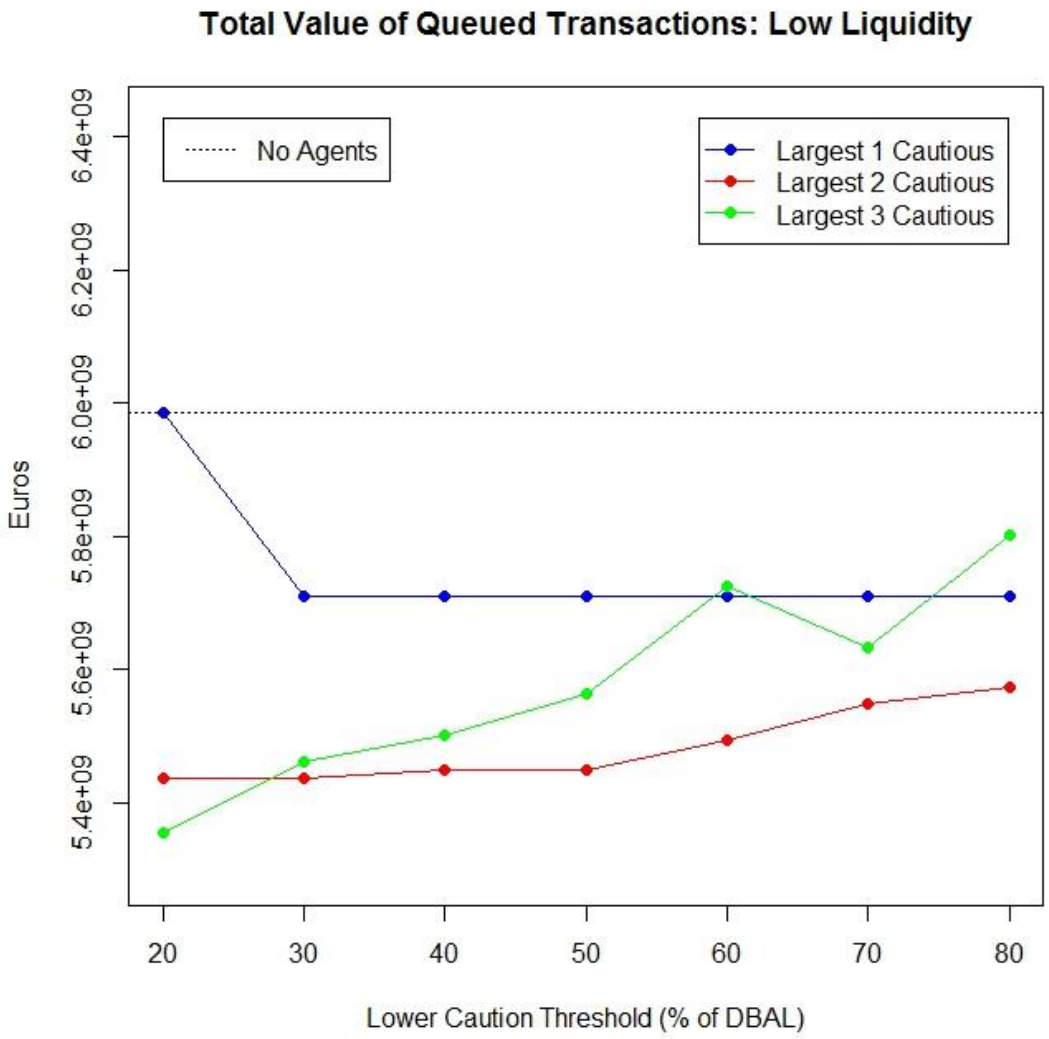
# Only Largest Participant(s) Cautious




Stressed Control Simulations:

No liquidity for:
Largest 1 – 119
Largest 2 – 229
Largest 3 – 303

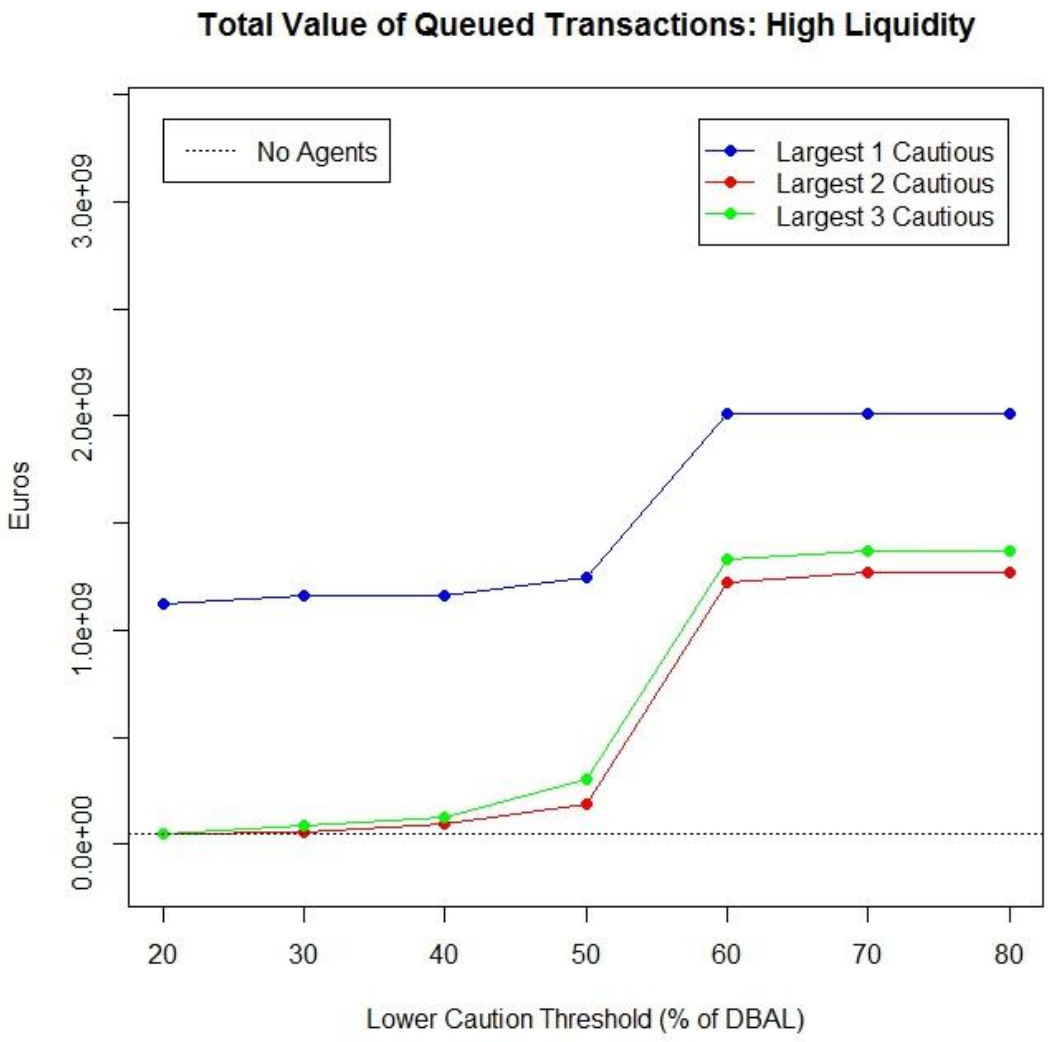
# Only Largest Participant(s) Cautious




Stressed Control Simulations:

No liquidity for:
Largest 1 – 6.59e+09
Largest 2 – 7.43e+09
Largest 3 – 7.70e+09

# Only Largest Participant(s) Cautious




Stessed Control Simulations:

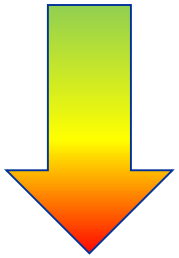
No liquidity for:
Largest 1 – 4.83e+09
Largest 2 – 5.48e+09
Largest 3 – 6.14e+09

# Conclusions

- Cautious behaviour on the part of participants relieves main system's queue and challenges banks' internal queues
- Too much caution on the part of participants, especially larger ones, can spell trouble for the system
- Behaviour matters little when the system is flooded with liquidity

# ABM method conclusions

- BoF-PSS2 architechture permits (only some) agent behaviours as user made modules
  - Reactions on/filtering of incoming events
  - Timed regular agent status reviews
  - Tailored ABM reactions initiated by distinct settlement events or logics…
  - …located in closed source parts of BoF-PSS2



Difficulty increases

- ERA scheme incompatible with JADE (?)
- JADE overhead is non-negligible but tolerable

# Future Work

- Make code more efficient to improve performance
- Apply ABM approach to real data
- Build in other realistic behaviours

# Extra slides