



EUROPEAN CENTRAL BANK

EUROSYSTEM

T2 analytics with simulations

Use cases in the T2-T2S consolidated platform

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Overview

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Disclaimer. The authors of this presentation are members of one of the user groups with access to TARGET data in accordance with Article 3 of the Decision (EU) 2023/549 of the European Central Bank of 6 March 2023 on access to and use of certain TARGET data and repealing Decision ECB/2010/9 (ECB/2023/3). The ECB and the MIB have checked the paper against the rules for guaranteeing the confidentiality of transaction-level data imposed by the MIB pursuant to Article 5 of the above-mentioned issue. The views expressed in the paper are solely those of the authors and do not necessarily represent the views of the Eurosystem.

1 Background



T2 is the RTGS system owned and operated by the Eurosystem, which replaced TARGET2 on 20 March 2023, as a result of the T2-T2S consolidation.



The Eurosystem performs **analytics on transactional data** for operational, oversight and research purposes.



Its **quantitative toolkit** ranges from individual statistical indicators to more complex methodologies, using advanced analytics and specific tools.



Although initially developed for regulatory compliance, many tools have become important instruments for **monitoring and understanding the system** over time.

2 Analytics in TARGET2



Until March 2023, a dedicated **secure environment** hosted the TARGET2 transactional data as well as statistical and econometric software tools.



One additionally available tool was the **TARGET2 simulator**, an adapted version of the Bank of Finland's Payment and Settlement System Simulator (BoF-PSS).



Simulations allowed studying TARGET2 and its participants in scenarios of e.g. **altered system features** or specific **operational or financial events**.



It was fed with real TARGET2 data, replicated the TARGET2 settlement logic, and allowed building **what-if scenarios** by changing system parameters/input data.

2 Simulations in TARGET2

Alteration of system features

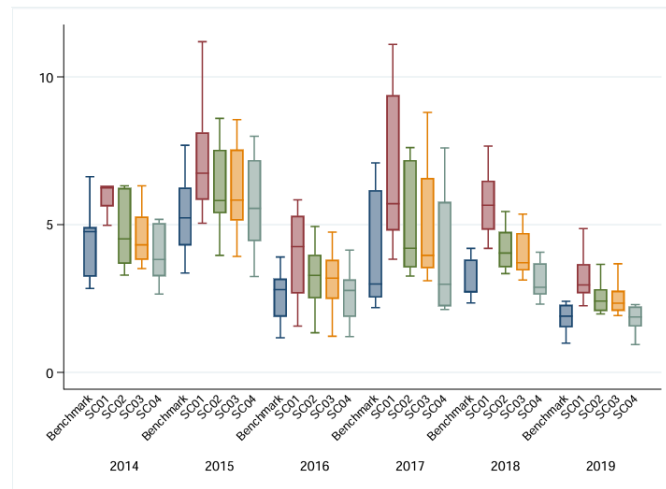
Progressive removal of liquidity saving mechanisms

Creation of a plain RTGS system with high volumes

Scenario	% unsettled payments	Change compared to baseline
Baseline	+10.23%	-
Double dataset	+11.29%	+1.06%
Quadruple dataset	+12.07%	+1.84%

Queuing time of payments across simulation results

(x-axis: simulated scenarios, y-axis: minutes)



Source: TARGET2, TAG calculations.

Notes: SC stands for scenario. The indicator takes into account all payments with all settlement statuses – directly settled, queued, and unsettled. Unsettled payments enter the calculation with a queue time until their respective cut-off time. The box displays the 25th, 50th and 75th percentiles, whereas the whiskers mark the minimum and maximum observations within the 25th/75th percentile ± 1.5 times the interquartile range. Outside values are excluded.

Sources: TARGET2, TAG calculations.

2 Simulations in TARGET2

Replication of operational and financial events

Liquidity shortages due to sudden market-wide collateral deteriorations

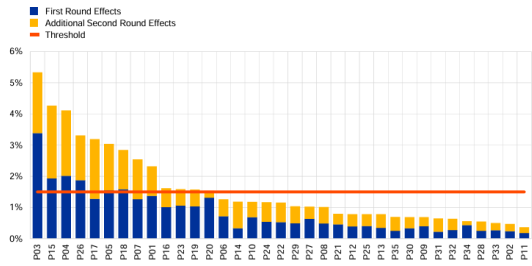
Operational failure of a participant



Simulations of the technical failure of participants in TARGET2

Criterion 2 (Simulations), first and second-round effects, sample year

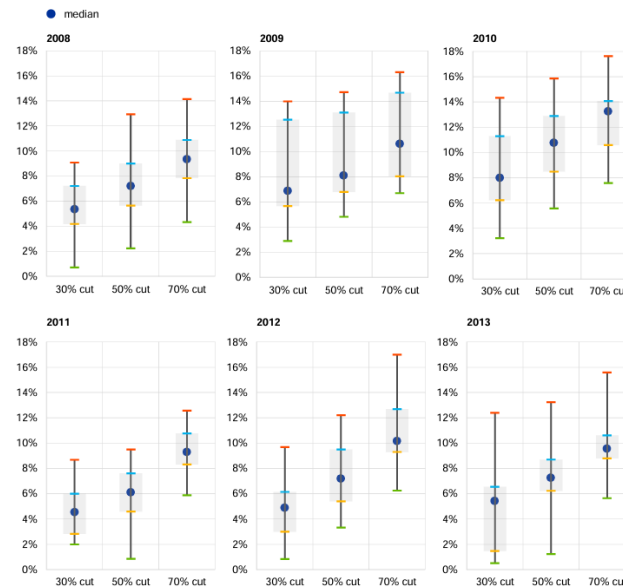
(x-axis: participant ID, y-axis: average share of unsettled transactions (value) in percent for each potential critical participant)



Sources: TARGET2, TAG calculations.

Unsettled payments in value

(x-axis: simulated scenarios; y-axis: percentage of total payments)

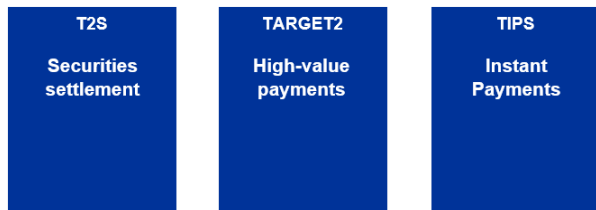


Source: TARGET2, Group on TARGET2 Stress Testing (GTST) calculations.

Note: The x-axis shows the simulated clean-cut scenarios, i.e. including both marketable and non-marketable assets.

3 The new T2 system

From a silo approach...



... to a modular approach

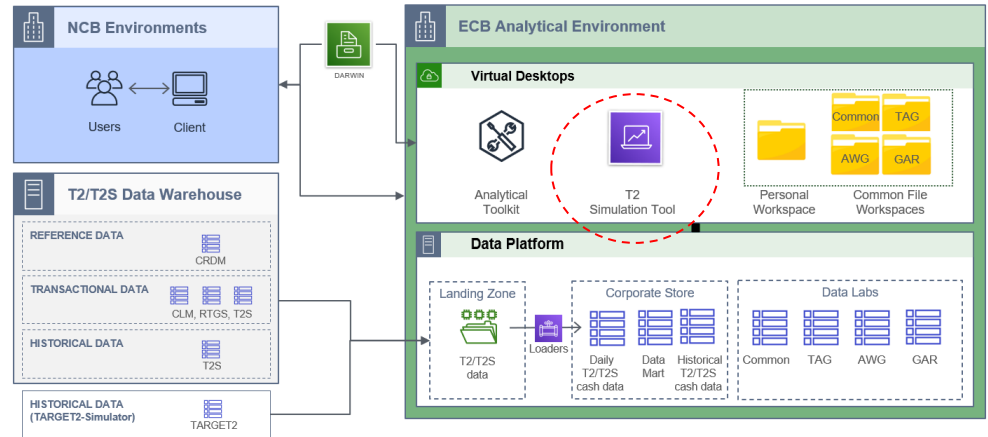


- T2 replaced TARGET2 in March 2023.
- T2 comprises a Central Liquidity Management (CLM) service and an RTGS service.
- Via the CLM participants also manage the liquidity that they hold in T2S and TIPS.
- Besides monetary policy, T2 is mainly used for interbank and customer payments and transactions related to other FMIs.
- Around 1,000 participants exchange more than 400,000 payments worth €2.2tn in T2 every day.

3 Analytics in T2

- At the same time, a new data analytics platform went live, the **TARGET Analytical Environment**.
- It allows **ex post analytics** and simulations on transactional data.
- Its users are bound to dedicated rules of **confidentiality**.
- The **BoF-PSS** had to be adapted to be able to simulate scenarios in the new T2 system.

Structure of the TARGET Analytical Environment



3 A new simulation tool for T2



The changes brought about by the T2-T2S consolidation required the **adaptation** of the BoF-PSS **to the new T2 system**.



On the one hand, the **settlement engine and algorithms** had to be adapted to work for CLM and RTGS and their interaction.



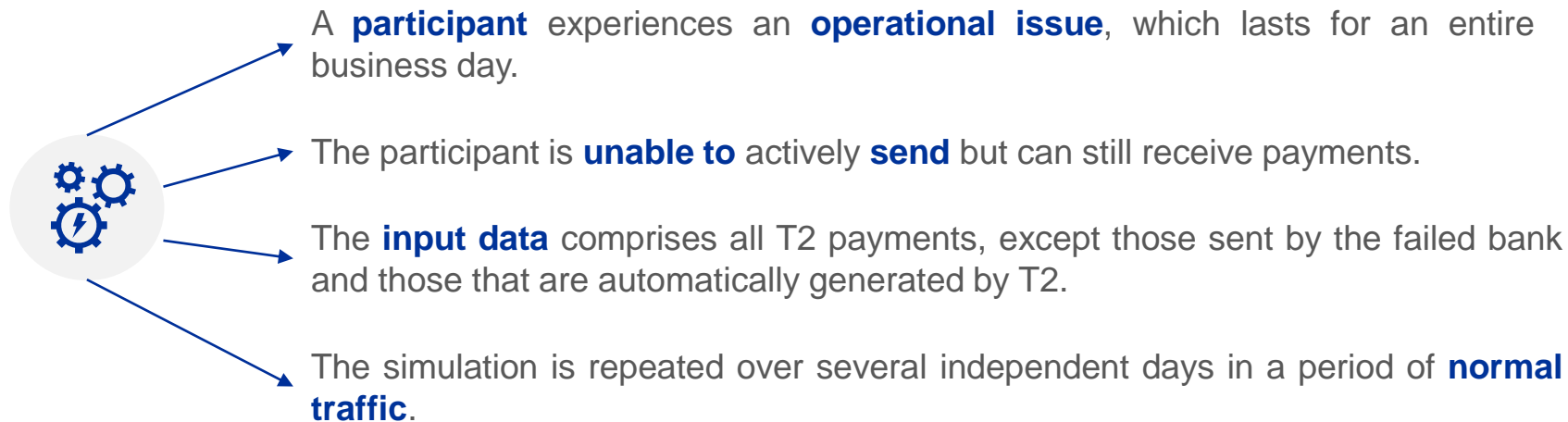
On the other hand, the **additional complex features** available in T2 (e.g., rule-based liquidity transfers) had to be developed and integrated in the tool.



The Eurosystem has been working with the Bank of Finland to adapt the tool to the new set-up and **test its functionalities** by running simulations (e.g., failures).

4 Simulating participant failure

A scenario of failure of a participant can be built as follows:

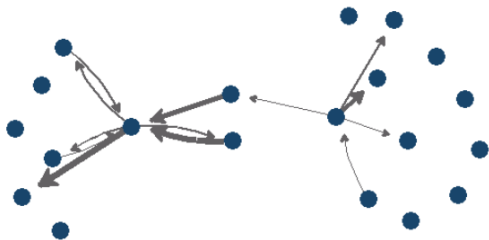


The analysis of the resulting unsettled traffic can help understand the new tool and assess its robustness.



4 Simulating participant failure

Two types of simulations were configured:

- A** Failure of an individual participant
- B** Failure of multiple participants (e.g., two, five and ten at the same time)



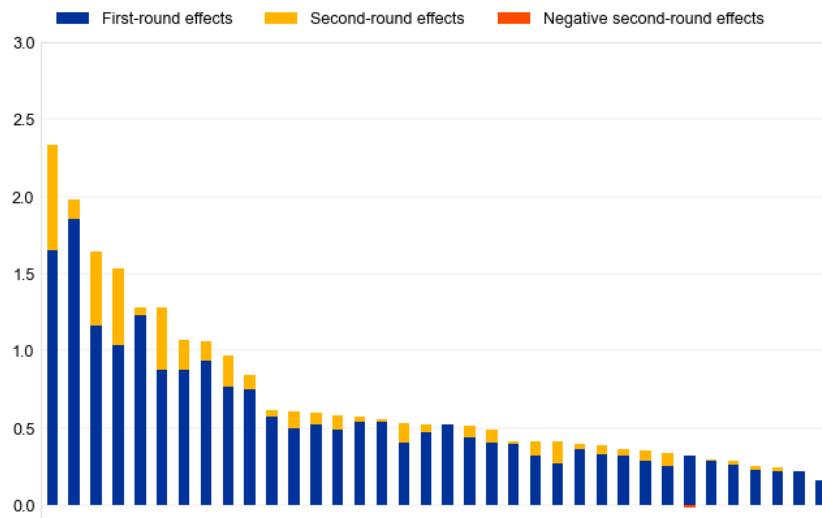
Unsettled traffic was decomposed into:

-  **First-round effects**
Payments sent by the participant that were unsettled due to its technical unavailability
-  **Second-round effects**
Payments sent by other participants that were unsettled due to the missing incoming liquidity from the failed participant

4a Failure of an individual participant

- Simulations were run for over 30 participants, chosen based on their contribution to T2 traffic.
- The failure of the largest participant did not cause, on average, more than 2.3% of unsettled traffic in a day.
- Overall, first-round effects tend to be consistently larger than second-round effects across participants.
- Exceptionally, few participants caused negative second-round effects.

Unsettled payments in T2 per failed participant (%)



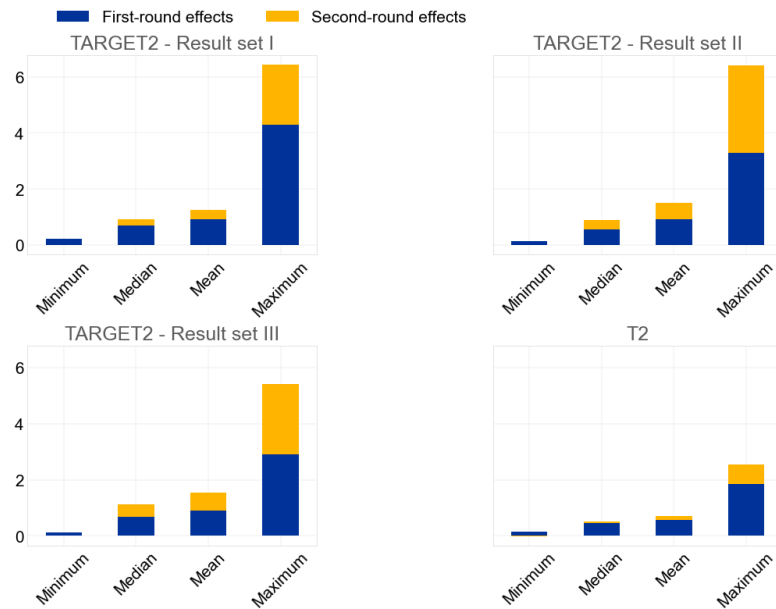
Source: ECB, T2.

Note: each bar represents the daily average share of unsettled payments in T2 generated by all the simulations of the failure of one participant.

4a Failure of an individual participant

- The overall impact of a participant's failure in T2 seems to be more limited than in TARGET2, as it decreased from an average of 1.4% to 0.7%.
- The drop is particularly pronounced for the participants with the largest impact (corresponding to the maximum value).
- Moreover, across both systems, first-round effects are consistently larger than second-round effects.

Unsettled payments in TARGET2 and T2 (%)

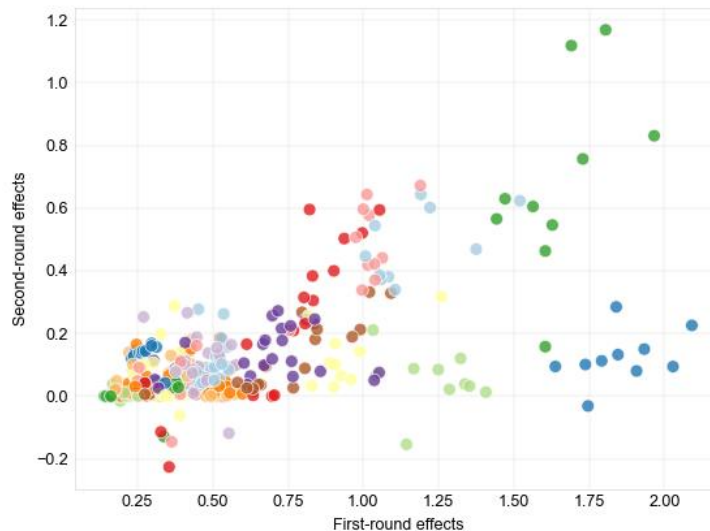


Source: ECB, TARGET2, T2.

4a Failure of an individual participant

- In general, there seems to be a positive relationship between first- and second-round effects.
- This suggests that larger participants (i.e., with larger first-round effects) tend to cause larger knock-on effects (i.e., larger second-round effects).
- Some participants experience very similar results across days, while others display more volatility.

Relationship between first- and second-round effects



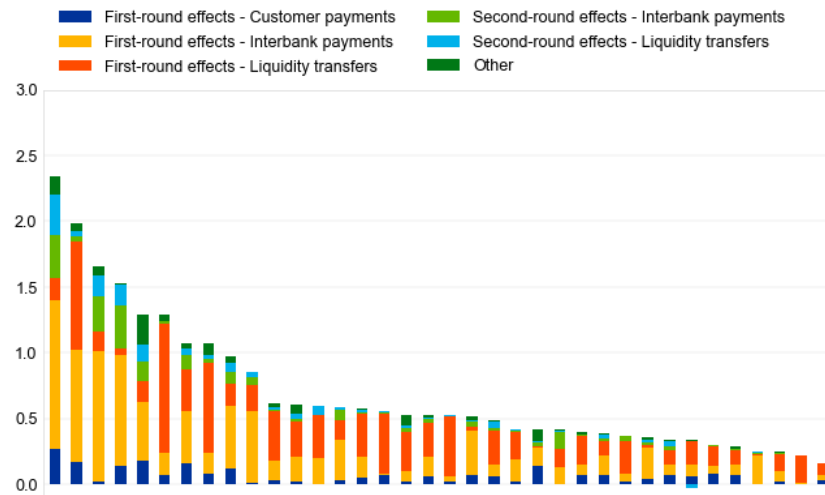
Source: ECB, T2.

Note: each dot represents the simulation of one participant on a given day.

4a Failure of an individual participant

- Interbank payments and liquidity transfers are the types that fail most in value in the scenarios, especially in the first round.
- Customer payments represent a much smaller share of the failed payments in value.
- Negative second-round effects seem to represent an exception.

Unsettled payments by type in T2 per failed participant (%)



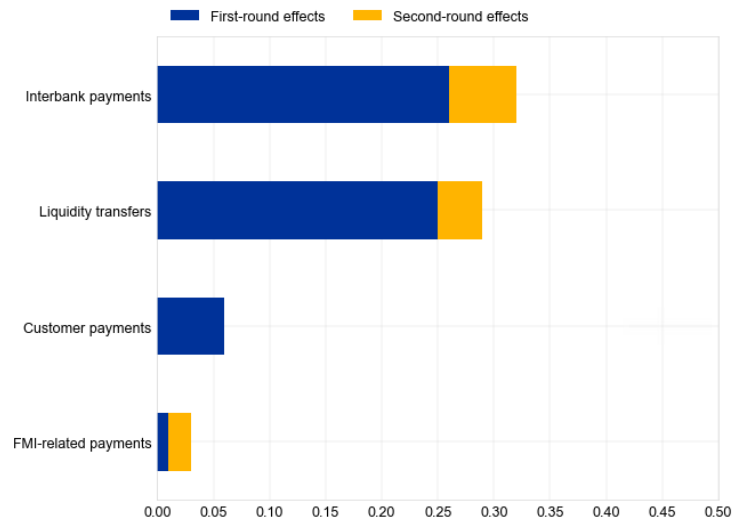
Source: ECB, T2.

Note: each bar represents the daily average share of unsettled payments in T2 generated by all the simulations of the failure of one participant.

4a Failure of an individual participant

- The indicator shows the share of each payment category out of the total unsettled payments in the simulations.
- On average, 0.7% of payments are unsettled in the simulations; 0.32% is represented by interbank payments and 0.28% by liquidity transfers.
- Around 85% of all failed interbank payments and liquidity transfers fail in the first round.

Average unsettled payments by type out of total (%)



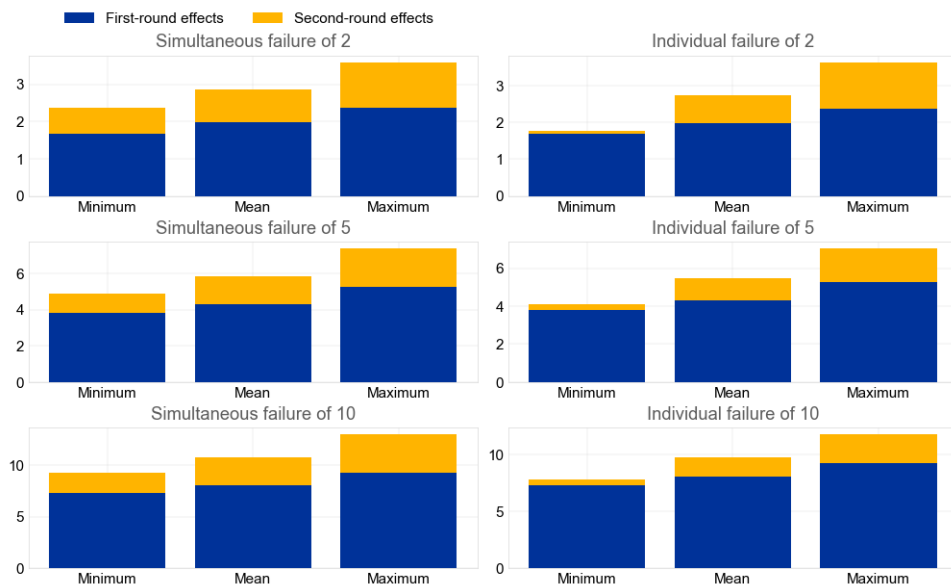
Source: ECB, T2.

Note: for each bar the numerator is the value of the failed payments in that category and the denominator is the total value of all payments submitted in the benchmark simulation. Only selected payment categories are shown.

4b Failure of multiple participants

- The simultaneous failure scenarios were run for 2, 5 and 10 participants; on average, 2.9%, 5.8% and 10.7% of payments failed, respectively.
- Compared to the sum of the individual failures, simultaneous failures created on average around a half percentage point more of unsettled payments.
- The first-round effects are unchanged due to the design of the scenarios; the stronger effects are due to larger second-round effects.

Unsettled payments in T2 (%)

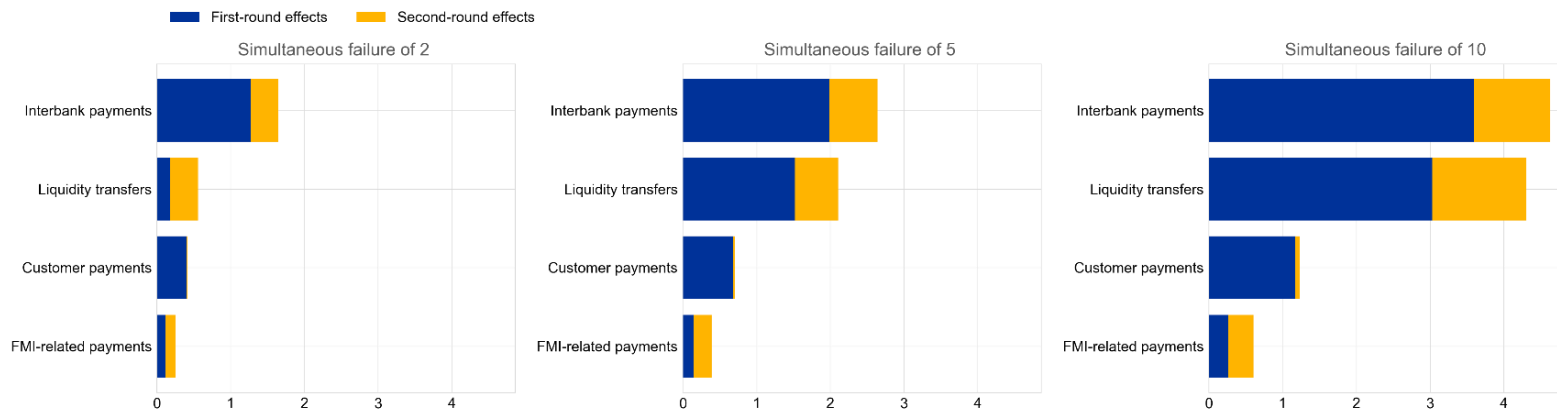


Source: ECB, T2.

Note: each bar represents the daily average share of unsettled payments in T2 generated by all the simulations of each scenario.

4b Failure of multiple participants

Unsettled payments by type out of total (%)



Source: ECB, T2.

Note: for each bar the numerator is the value of the failed payments in that category and the denominator is the total value of all payments submitted in the benchmark simulation. Only selected payment categories are shown.

- The contribution of the payment categories to failed payments in the first and second round is similar in both the individual failure scenarios and among the three cases shown above.

5 Conclusion



The **BoF-PSS** has become an important **component of the quantitative toolkit** for payment system analysis over the years.



The go-live of T2 required significant **adaptations in the Eurosystem's analytical capabilities**, including simulations.



An extensive Eurosystem **testing** campaign followed the deployment of the new BoF-PSS, and analyses aimed at **fine-tuning** the tool are now being run.



The results are promising so far and seem to point to an even stronger **resilience of the T2 system** to operational shocks compared to TARGET2.



At the same time, the results show that **further work is needed** to disentangle the underlying factors at work, discussing with the Bank of Finland as well.



Thank you for
your attention!

