DEUTSCHE BUNDESBANK EUROSYSTEM

The Hierarchy of Critical Participants - A Clustering Approach utilizing Network Centrality Indicators

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THE HIERACHRY OF CRITICAL PARTICIPANTS
Co-Authors and Disclaimer

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CP IDENTIFICATION – NETWORK INDICATORS AND CLUSTERING
Agenda

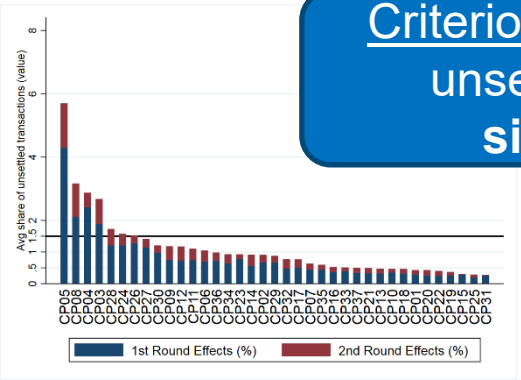
1) Introduction
2) Data sets
3) Clustering
4) Results
5) Conclusion
6) Discussion

INTRODUCTION
Current methodology for critical participant identification in TARGET2

Article 15 of SIPS regulation requires an operator **to identify critical participants** based on **payment volumes and values**, and their **potential impact on other participants and the system in the event of a significant operational problem**.

Criterion 1: Participant settles at least 1% of the total TARGET2 **turnover**

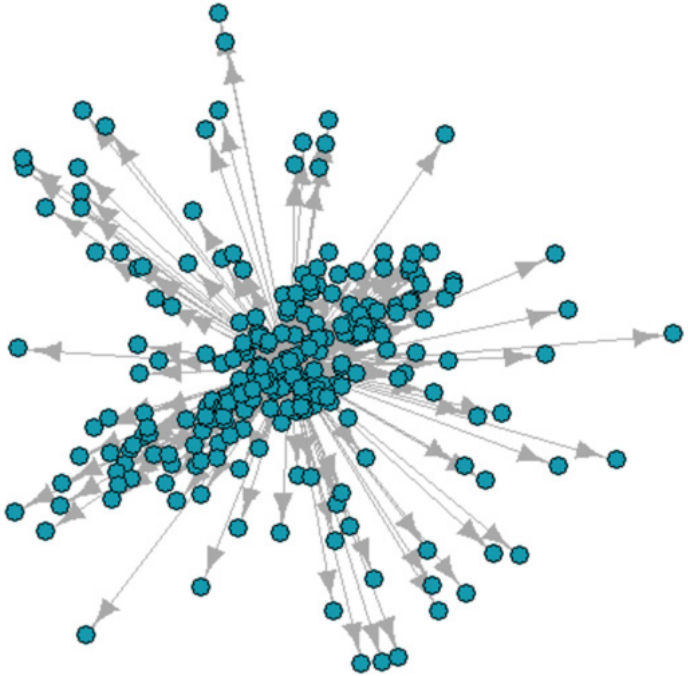
Criterion 2: Participant causes at least 1.5% of unsettled payments in value terms in the **simulation** of an operational failure



Participant is classified as critical if at least **one of the two criteria** is met with an additional element of **time dependency**.

Müller, A., Papsdorf, P. and Polo Friz, L. (2017). "Critical Participants in TARGET2", 15th Payment and Settlement System Simulation Seminar, Helsinki

INTRODUCTION
Motivation



Source: TARGET2 data, Authors' calculation.

Definition of Criticality

- Definition ex-ante unclear
- Goal of the analysis is to assign each participant a binary label
- Assigned labels cannot be backtested

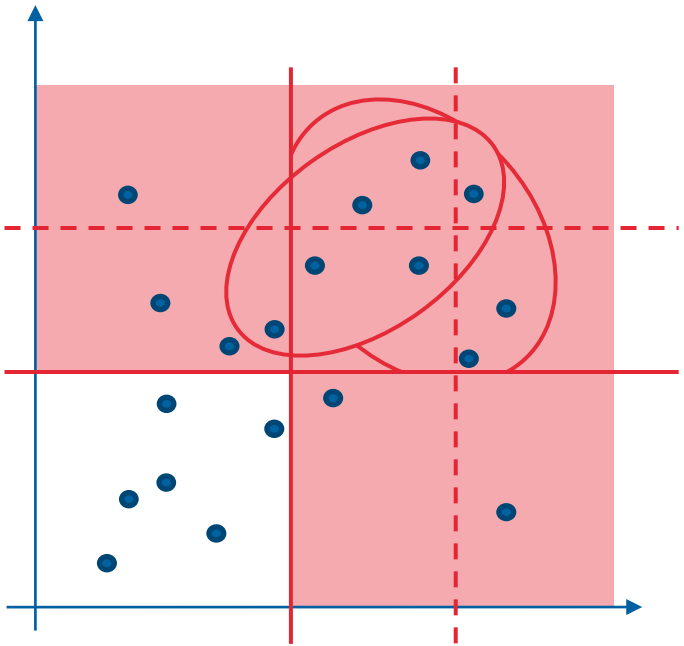
Additional indicators

- Centrality measures could put **interconnectedness** more into focus and enhance transparency of classification

Clustering

- Unsupervised machine learning for threshold calculation through **data-driven** clusters

INTRODUCTION
The challenge of combining multiple indicators

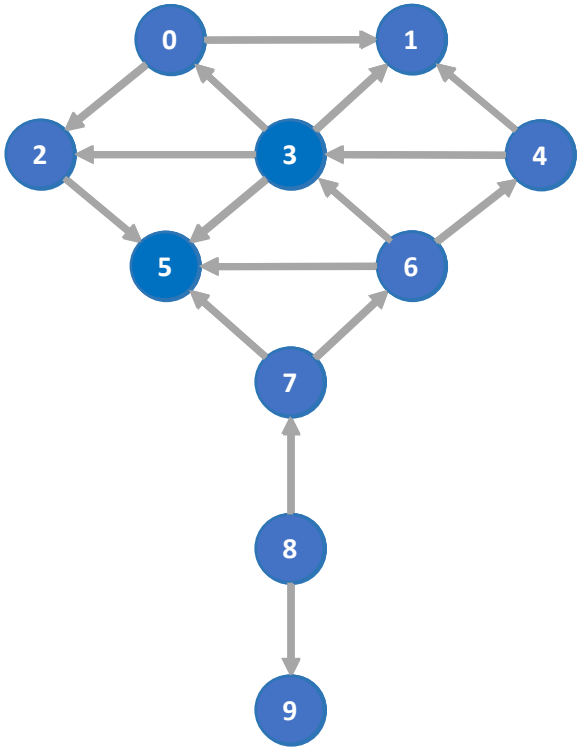


Pre-Condition: Indicators should not be (perfectly) correlated

Options for combining different thresholds

- Independent thresholds, condition on all / at least one / at least X indicators
- Combined thresholds, e.g. conditions with lower values for all indicators and conditions with higher values for single indicators
- Non-linear thresholds, e.g. results of a cluster analysis

DATA SET
Network centrality



Out-Degree centrality

- Measures for each node (participant) the number of links to other nodes
- 0: the participant *sends* no transaction to other participants
- 1: the participant *sends* at least one transaction to all other participants

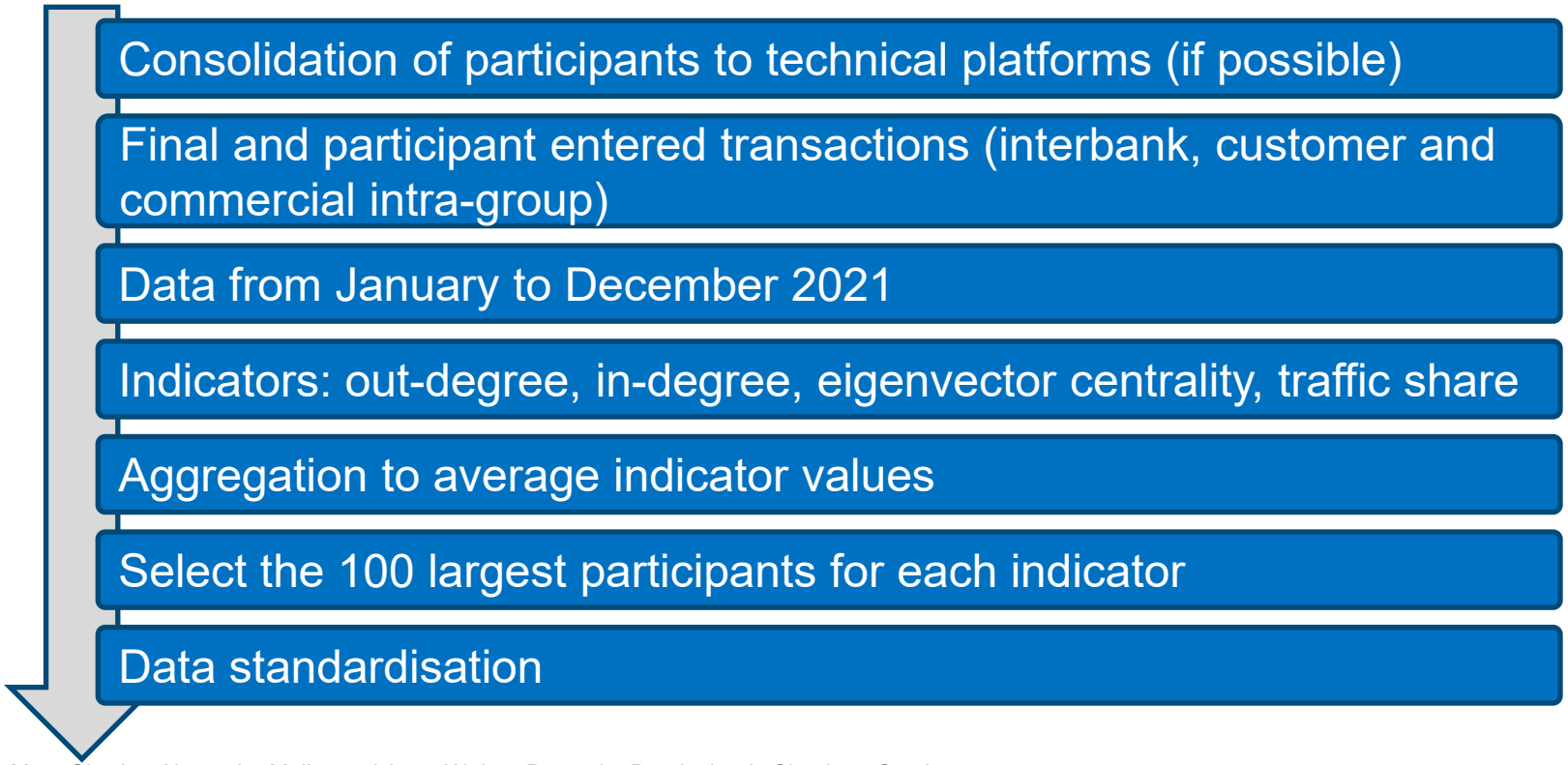
In-Degree centrality

- Measures for each node (participant) the number of links from other nodes
- 0: the participant *received* no transaction from other participants
- 1: the participant *received* at least one transaction from all other participants

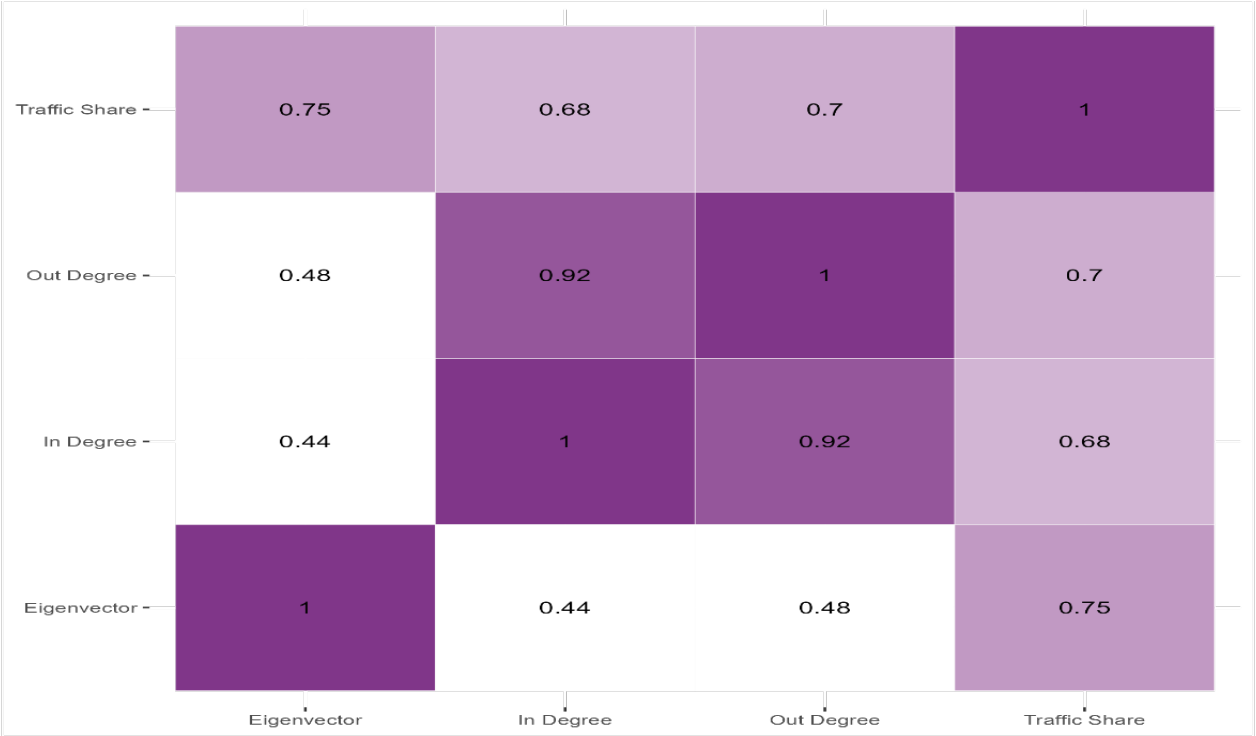
Eigenvector centrality

- Accounts for the inequality of nodes
- The centrality of one node (participant) is not necessarily depending on the number of links but also of the centrality of the connected nodes (participants)
- Combines Out- and In-Degree centrality and considers the weight of links
- High value: high influence of the participant and the participant is connected to many participants who themselves have high centrality

DATA SET
Data selection and preparation process



DATA SET
Correlation Heatmap



CLUSTERING
Background: Hierarchical clustering (agglomerative)

Clustering process

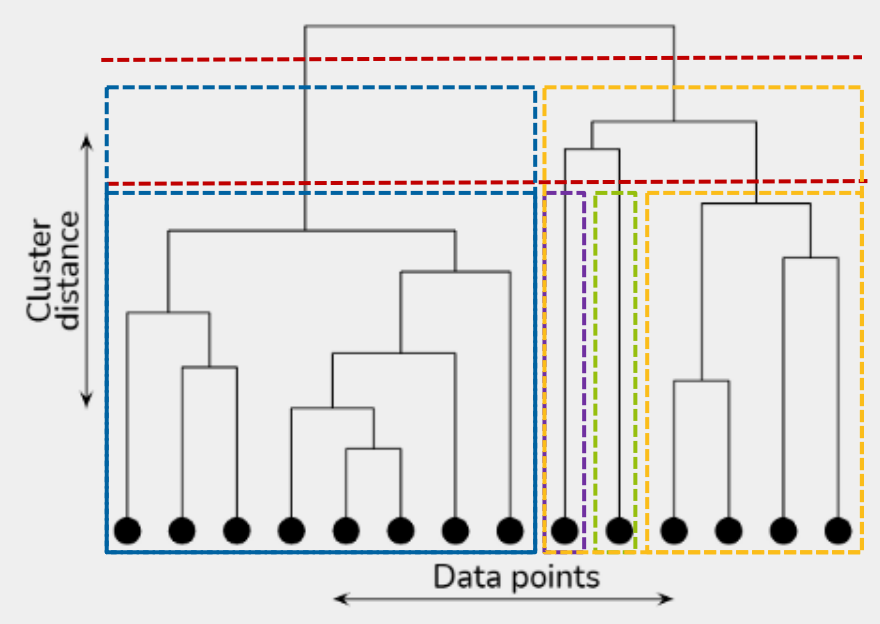
1. Starting from the finest partition, each object (participant) is treated as a separate cluster.
2. Calculate the pairwise distances between all grouped clusters.
3. Identify the two most similar clusters (with the smallest distances) and merge them into one new cluster
4. Repeat steps 2 and 3 until all objects (participants) are merged into one common cluster.

Algorithm parameter

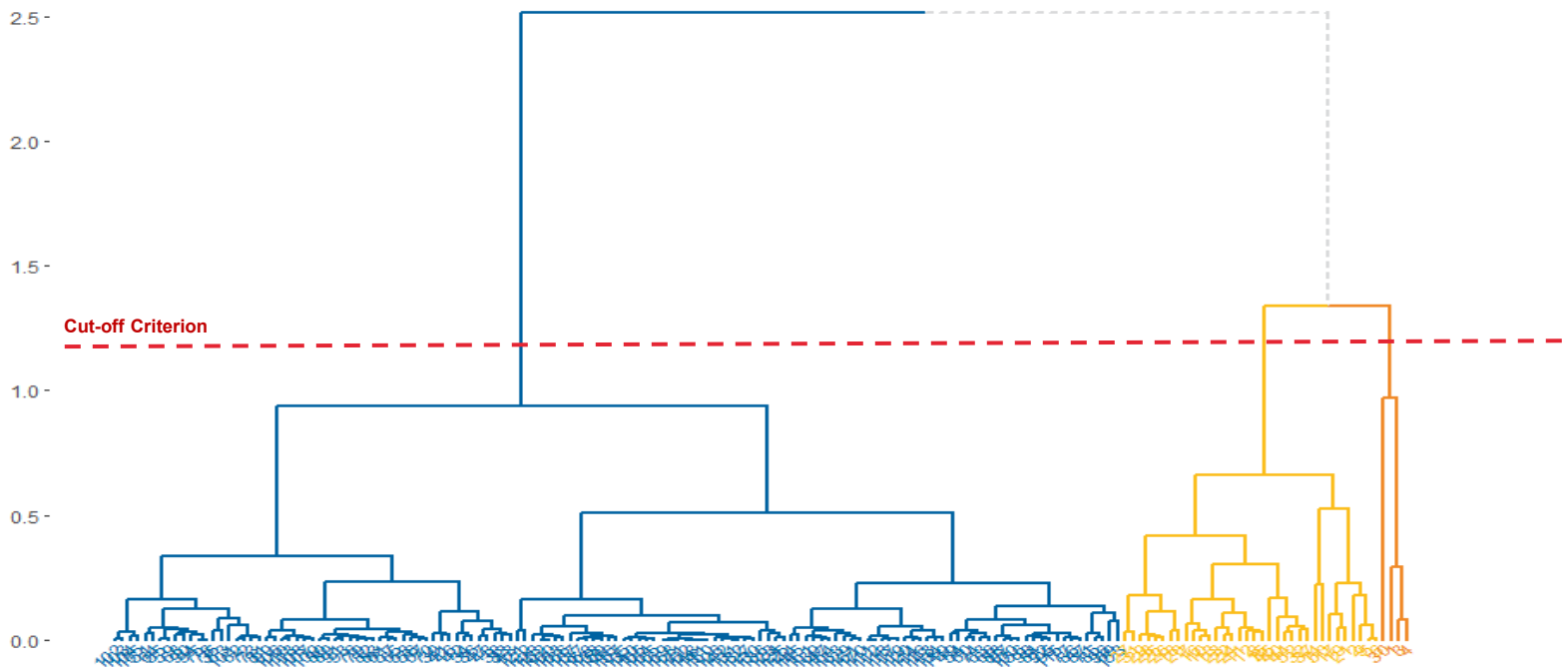
Distance metric: Euclidean Distance

Linkage criteria: Ward

Dendrogram

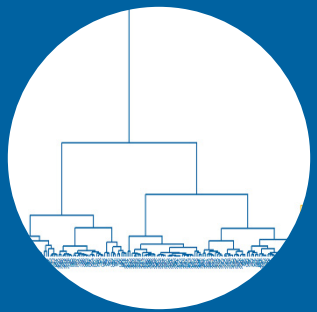


RESULTS
Dendrogram



Source: TARGET2 data, Authors' calculation.

RESULTS
Summary statistics of different Clusters



Not Critical

Number of Participants: 133

Out Degree:	In Degree:
Ø = 0,06	Ø = 0,07
Eigenvector:	**Traffic Share:**
Ø = 0,01	Ø = 0,01

Potentially Critical

Number of Participants: 34

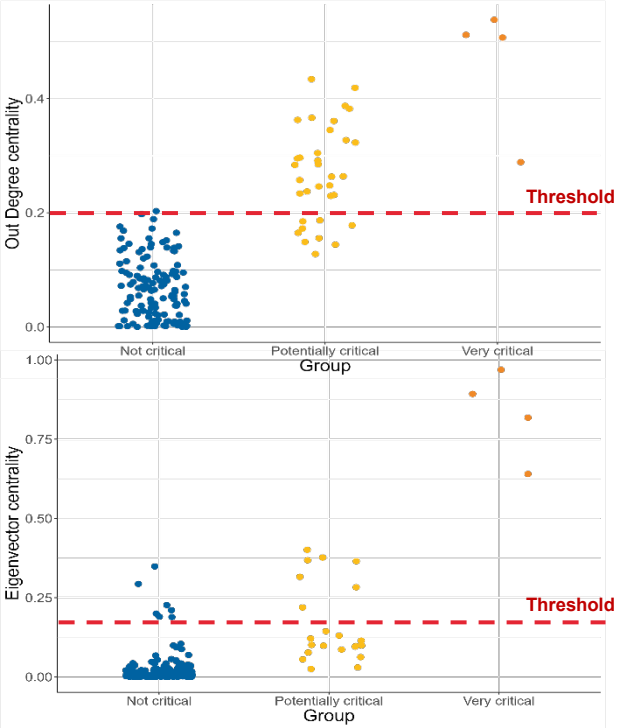
Out Degree:	In Degree:
Ø = 0,27	Ø = 0,21
Eigenvector:	**Traffic Share:**
Ø = 0,05	Ø = 0,05

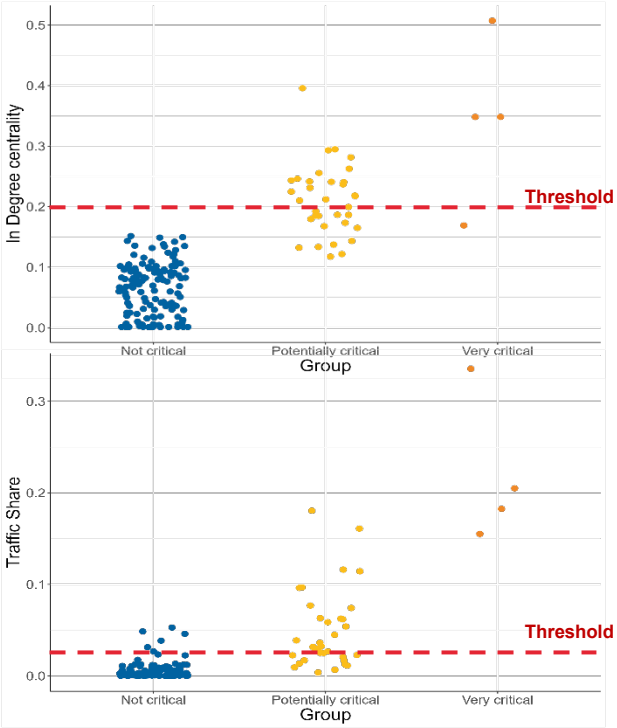
Critical

Number of Participants: 4

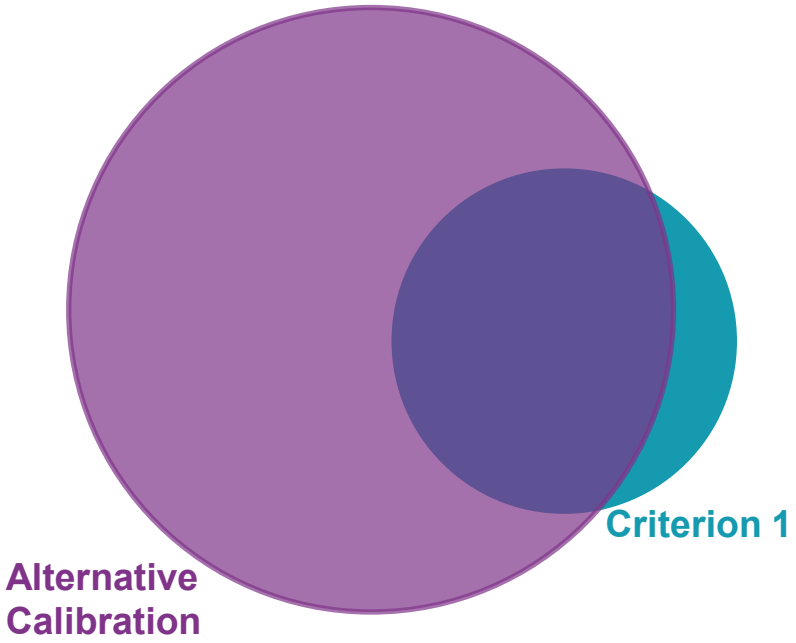
Out Degree:	In Degree:
Ø = 0,46	Ø = 0,21
Eigenvector:	**Traffic Share:**
Ø = 0,81	Ø = 0,21

RESULTS
Clustering with Out Degree, In Degree, Eigenvector centrality and Traffic Share





RESULTS
Comparision to the classification of critical participants through criterion 1



General observations

- 22 participants were classified as critical under **Criterion 1** in 2021.
- 44 participants fullfilled at least one of the **calibrated data-driven tresholds.** The number would significantly reduce when setting stricter criteria.
- The new method would classify additional participants, one participant would no longer be classified.
- Clustering results show that it is difficult to clearly delineate a group of critical participants with the same number of participants as with the current methodology.
- However, based on the clustering results it is **possible to define data-driven thresholds.**

CONCLUSION
New techniques brings new opportunities and challenges

- **Network centrality indicators**, especially eigenvector centrality, **add** an additional aspect of criticality **(interconnectedness)** to the **identification of critical participants**.
- The clustering **clearly identifies a group of very critical participants** with high indicator values.
- However, the algorithm has **difficulties to clearly divide** other groups of participants as the distances between them are rather small – similar to the thresholds today.
  - A potential reaction to the results and the inherent data structure could be to set **different requirements** to the group of very critical and potentially critical participants.
- Clustering could **combine different** indicators that are relevant for the criticality of a participant. The **list of indicators** could be further **expanded** to account for other dimensions of criticality.
- Based on the **cluster distributions, data-driven thresholds** could be **defined** to classify participants as critical.

THE HIERACHY OF CRITICAL PARTICIPANTS
Discussion and Questions

Thank you very much for your attention!

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