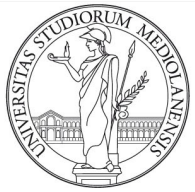

UNIVERSITÀ DEGLI STUDI DI MILANO

FACOLTÀ DI SCIENZE POLITICHE,
ECONOMICHE E SOCIALI

M.Sc. in Data Science and Economics

SOCIAL NETWORK ANALYSIS ON POST TRADE DATA: CENTRALITY, SCALE FREE BEHAVIOR AND RESILIENCY OF THE NETWORKS OVER TIME

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Objective

The aim of the study is the construction of **Social Networks** from post trade settlement instructions of Monte Titoli systems.

The study can be divided in two main networks constructions:

- **Monthly** cumulative and non-cumulative Networks:
  - Centrality analysis
  - Scale-free networks pattern detection
  - Networks resiliency analysis
- **Daily** Networks two case studies of disruptive events:
  - Impact of Covid19
  - Impact of BTP Italia and BTP Futura emissions

Technologies

PySpark
Extracting settlement instructions

Amazon Web Services (AWS)
Data storing, processing and analysis

Python
Programming Language

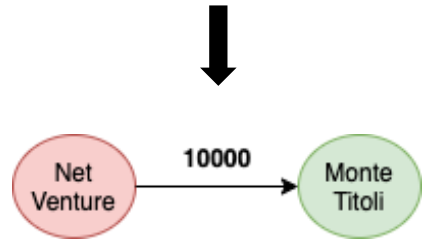
S3 buckets
Data storing

Sagemaker Notebooks
Data Analysis

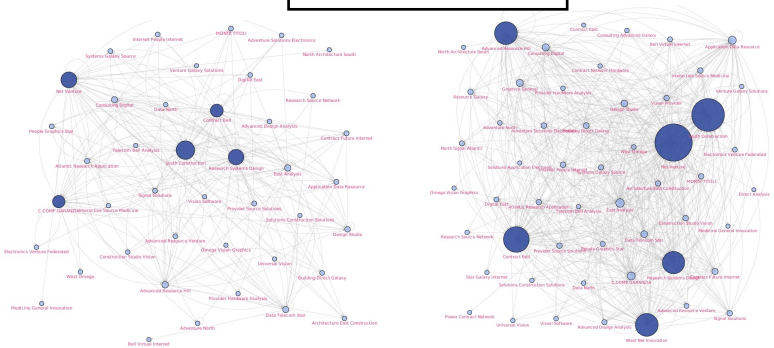
Networks construction

- Date range from **May 2018** to end of **July 2021**
- Companies' names have been anonymized except for Monte Titoli and CC&G

Deliverer	Receiver	Sett Status	financial instr type	ETF indicator	Amount
Net Venture	Monte Titoli	S	Corp. Bonds	0	10000



468 graphs

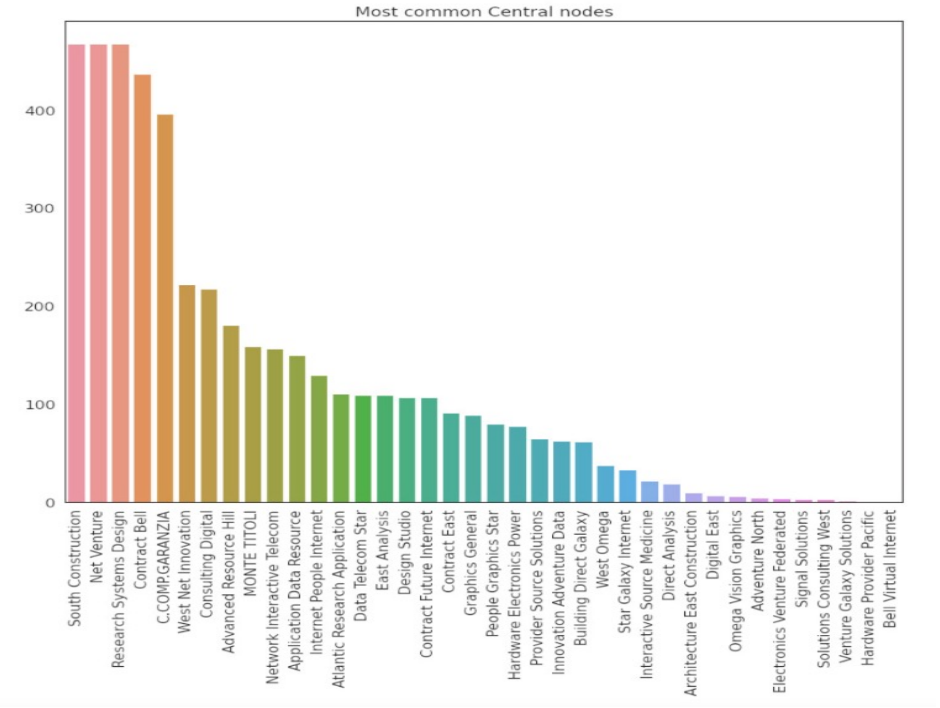


- Data are **aggregated** based on:
  - Company deliverer – receiver couple
  - Financial instrument type: Corporate Bonds, Government Bonds, Funds, Shares, ETF and others.
  - Settlement Status: settled (S) or failed (N)

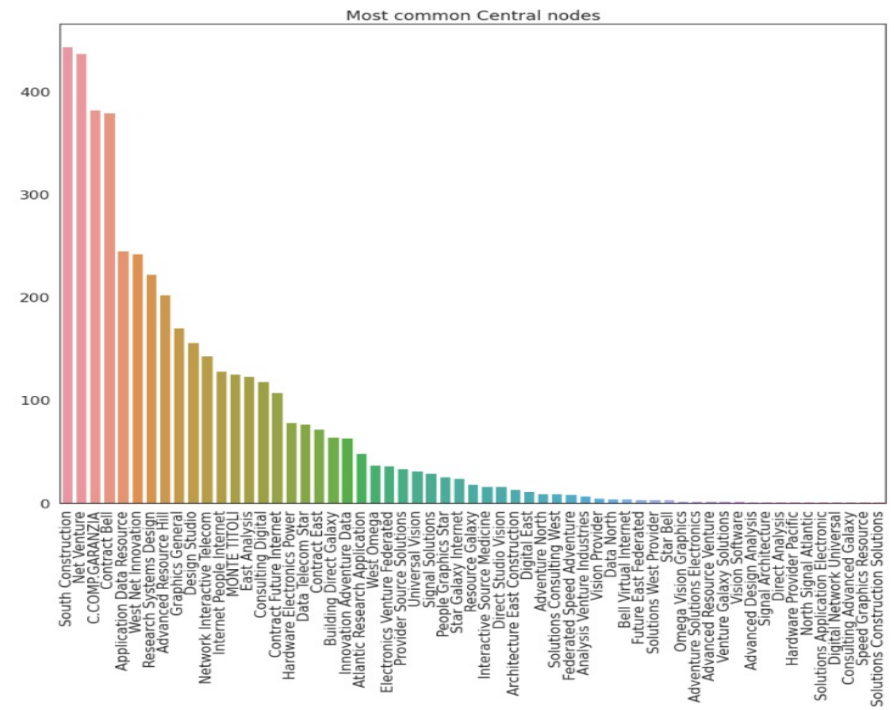
- Graph representation:
  - **Nodes**: companies
  - **Edges**:
    - Directed: from deliverer to reicever
    - Weighted: with cash flow

Central nodes - most frequent

Cumulative



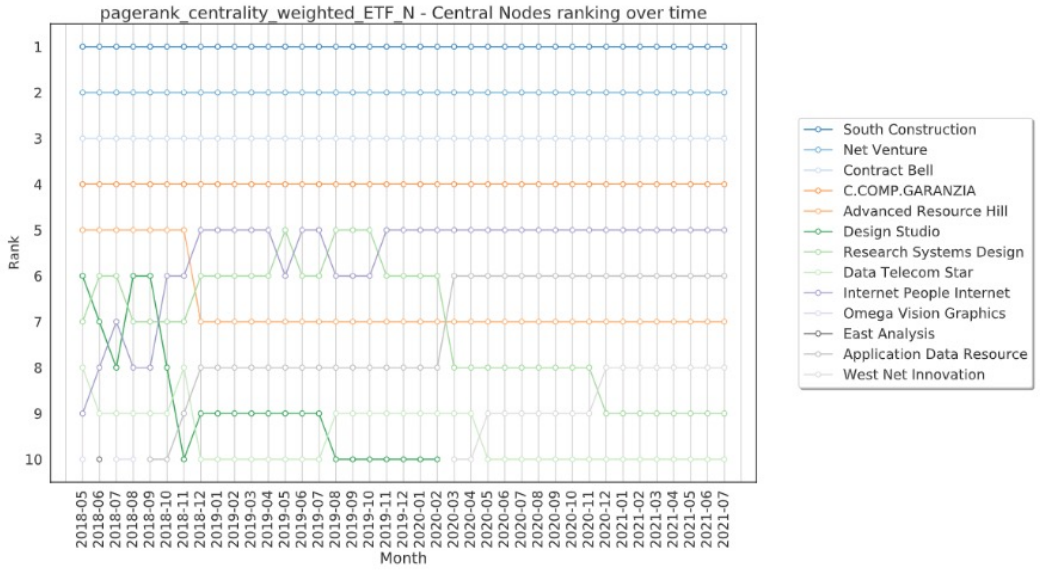
Non-Cumulative



- Cassa Compensazione e Garanzia (CC&G) protects contracting parties against default risk
- CC&G has a high centrality because is deputed to clearing and netting

Central nodes - ranking

Cumulative

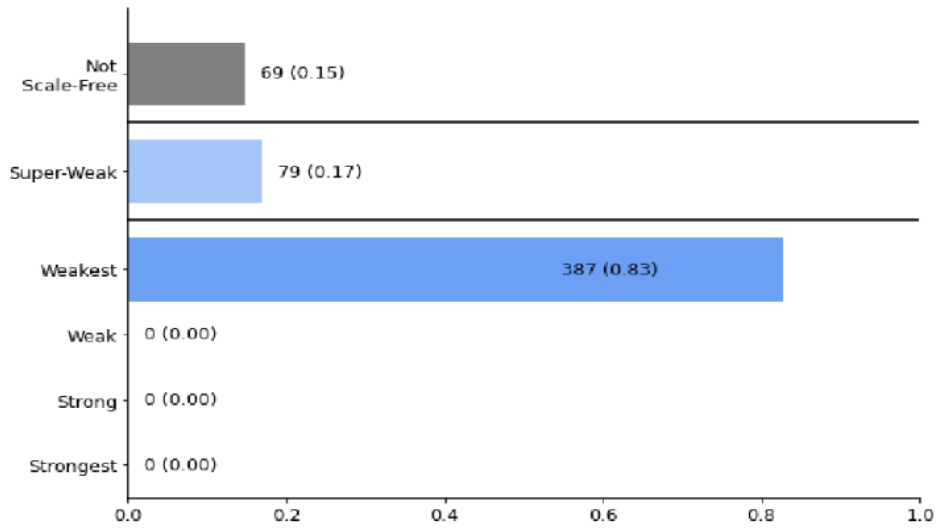


Non-Cumulative

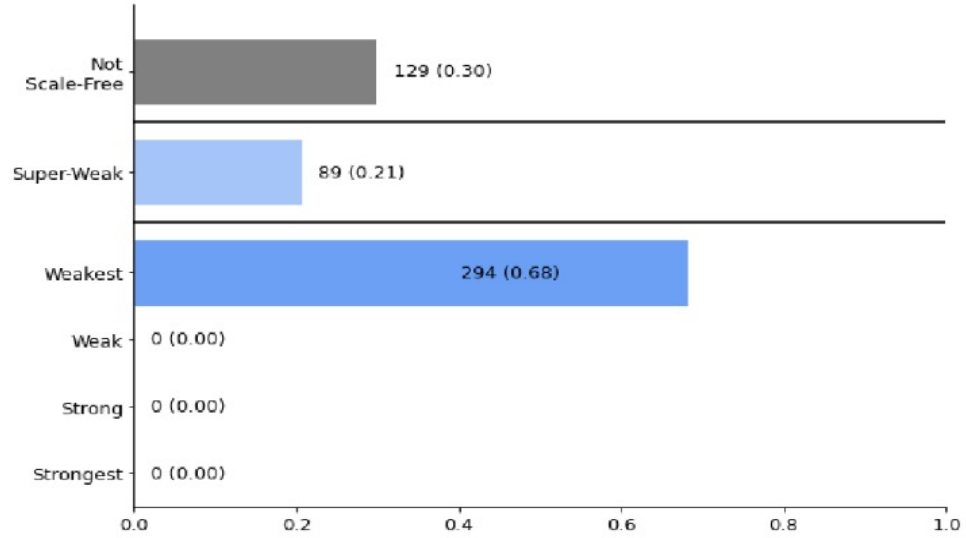
- Cumulative networks show a stable ranking over time
- Non-cumulative networks exhibit a non-stable pattern of firms' positions over time

Scale free networks - degrees

Cumulative



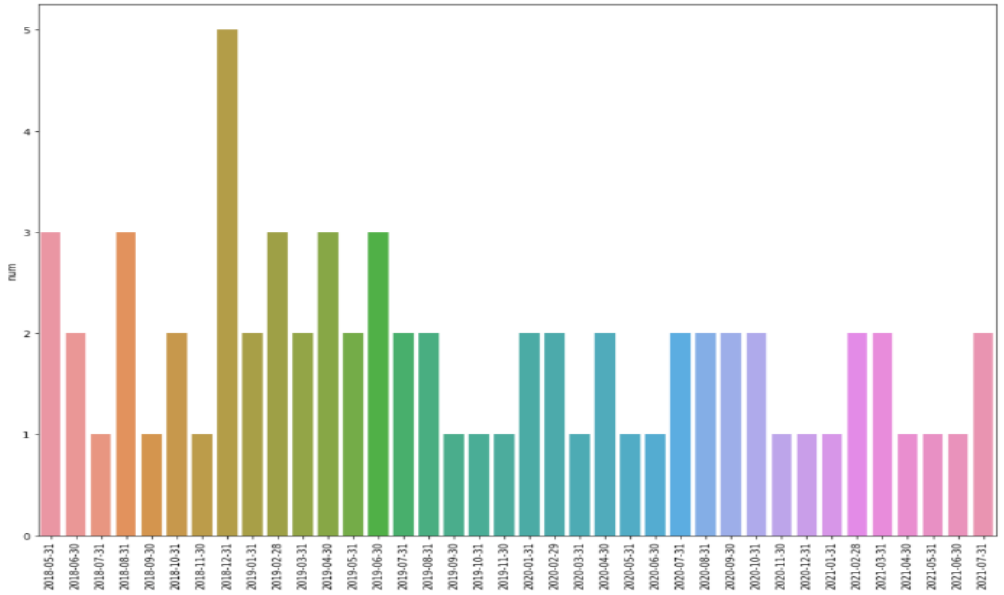
Non-Cumulative



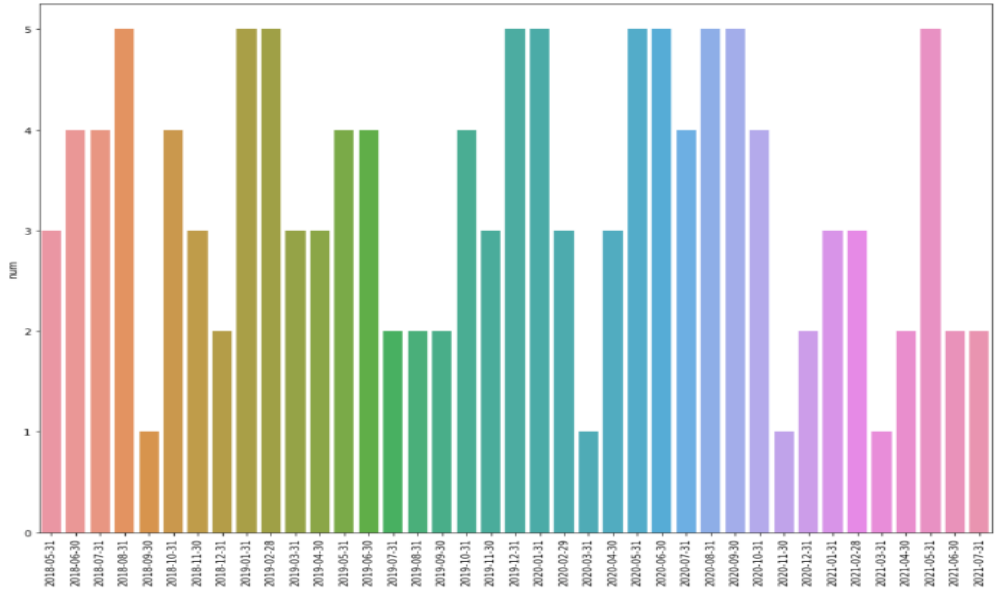
- Scale free networks follow Power law distribution.
- Cumulative networks are mostly scale-free.
- Non-cumulative are more non-scale-free with respect to cumulative.

Non-Scale free - over time

Cumulative



Non-Cumulative



- In cumulative networks as the number of nodes and links increases, the number of non-scale-free networks decreases.
- Non-cumulative networks does not show any pattern over time.

Node deletion

Different node deletion approaches are applied:

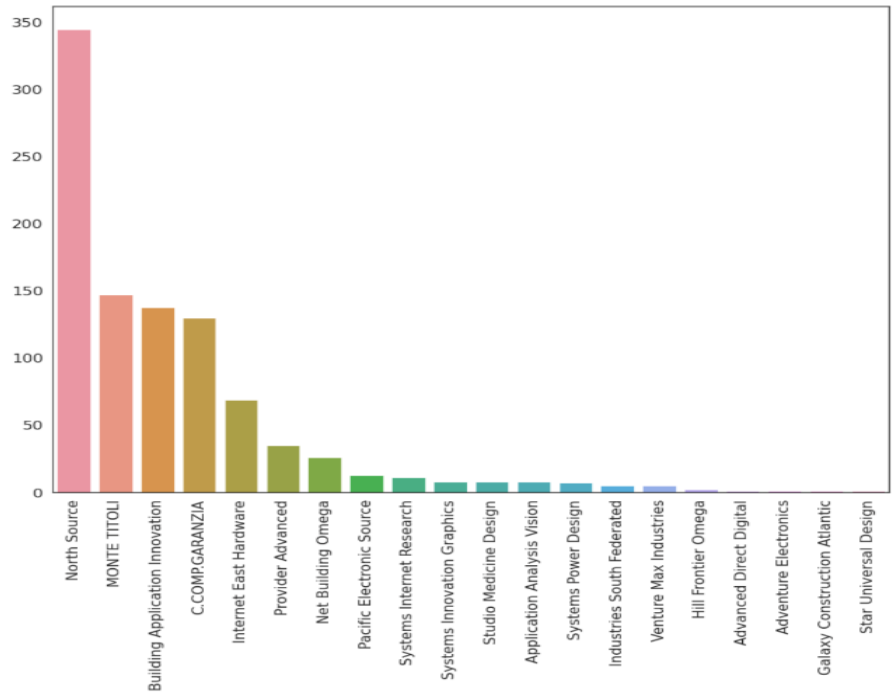
- **Random node deletion**: a node is deleted randomly from the network
- **Localized node deletion**: a deletion of a precisely selected node

We investigate if the structure of the network become divided into disconnected clusters after a node removal:

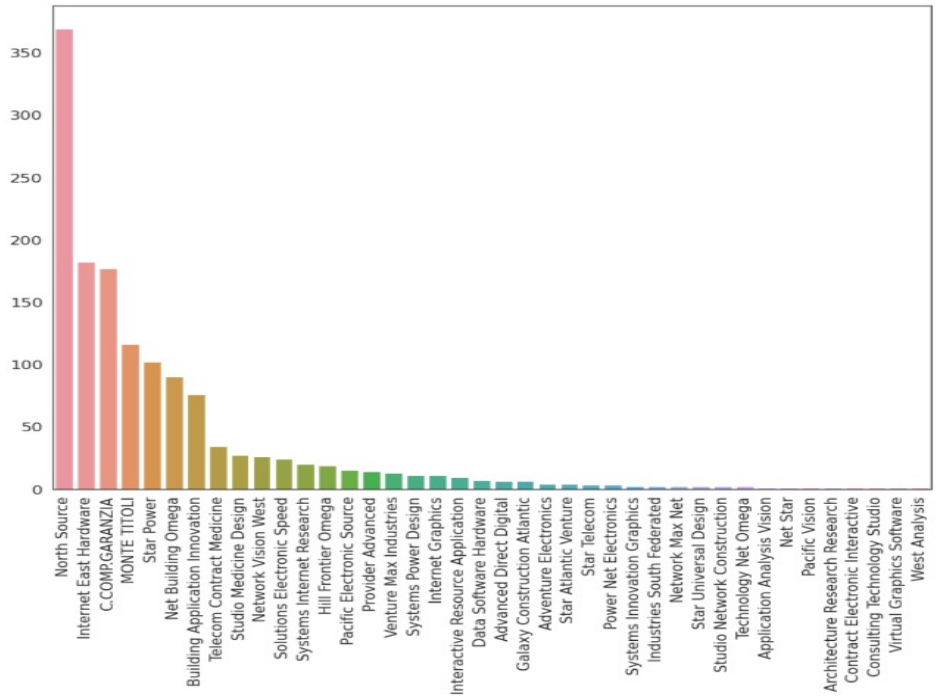
- Networks present only one main weakly connected component
- If after node deletion, the network results with more than one weakly connected components, then the network is considered altered.

Node deletion - frequency

Cumulative



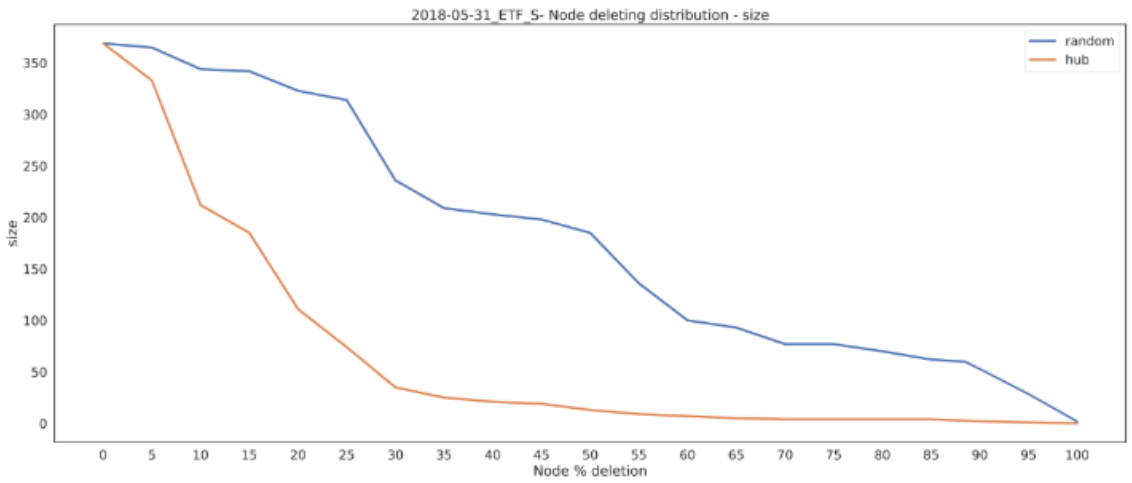
Non-Cumulative



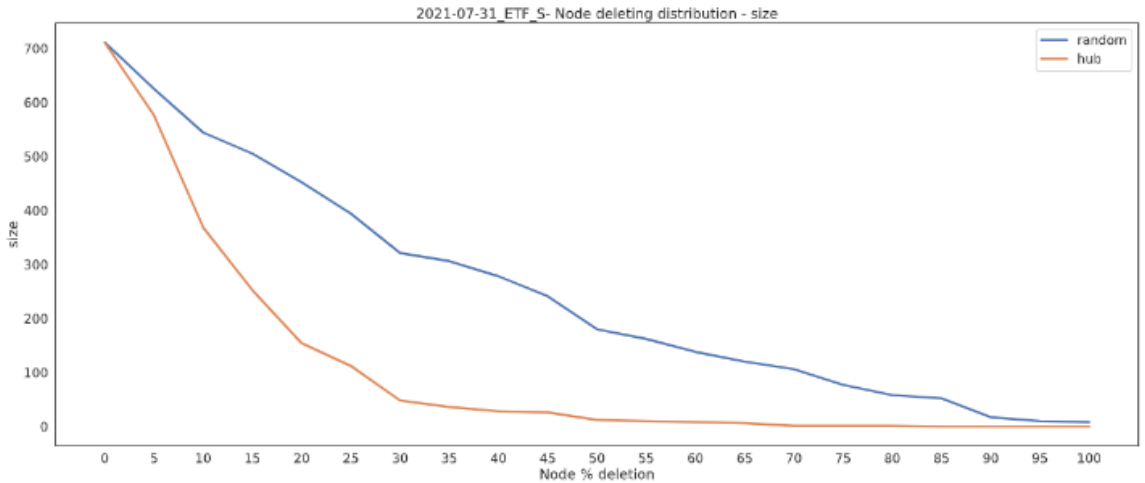
- Most frequent vulnerable nodes.
- CC&G and Monte Titoli exhibit a high vulnerability because of their centrality and importance in the system.

Node deletion - size

Cumulative May 2018



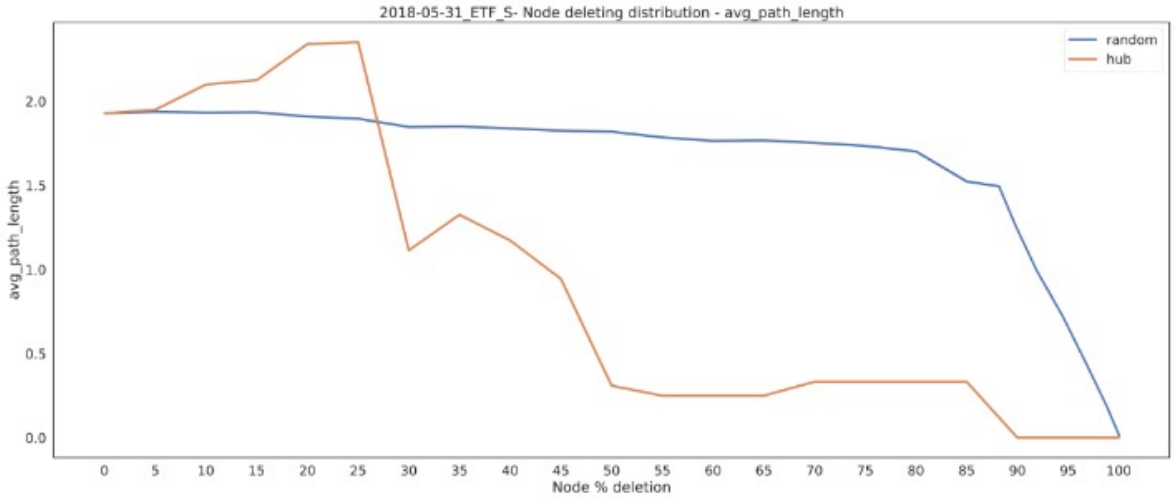
Cumulative July 2021



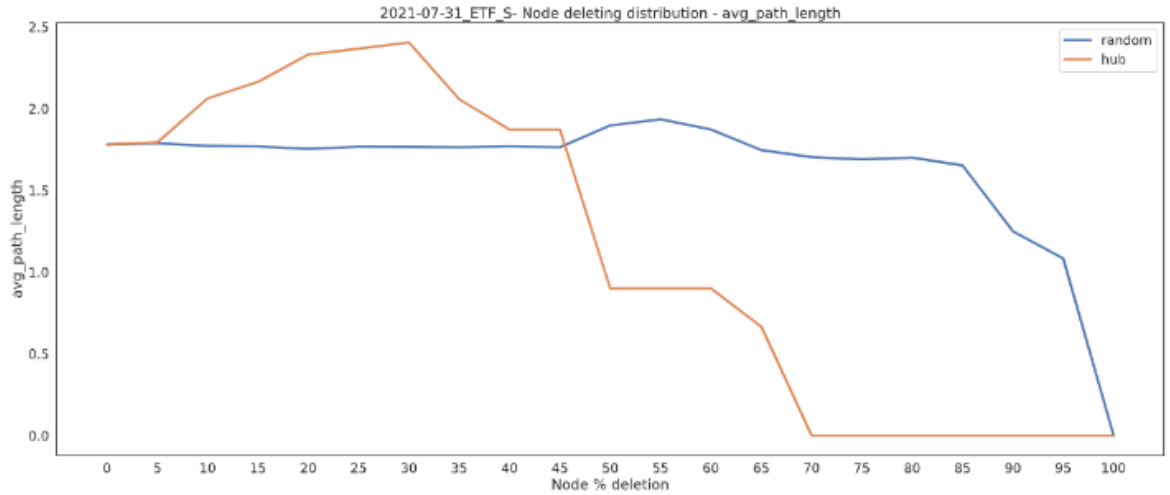
- After deleting 30% of the hub nodes, the size decreases rapidly to less than 50 links.
- Random node deletion results in a slower decrease in network size.
- In July 2021, the curve is smoother.

Node deletion - average shortest path

Cumulative May 2018



Cumulative July 2021



- The elimination of hub nodes results in increased distance
- After reaching 30% of hub node removal, the average shortest path length reduces significantly.
- Random removal presents a stable shortest path length.

Daily analysis

Disruptive events could irreversibly change topology and structure of the networks, such as the September 11th, 2001, terrorist attack.

Two different case-studies of disruptive events:

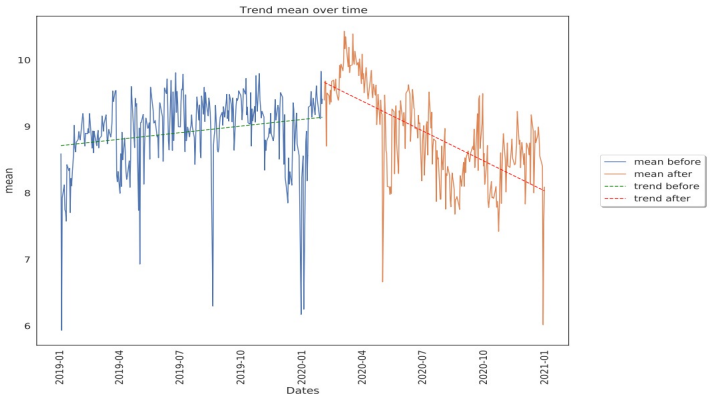
1. **The impact of Covid-19:**
   - Changes in networks topology
   - Period from January 2019 to December 2021

2. **The impact of large BTP emissions:**
   - Changes in networks topology
   - Emission of BTP Italia and BTP Futura

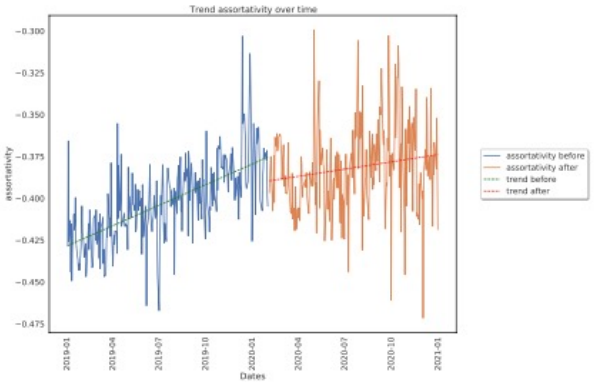
Impact of Covid19

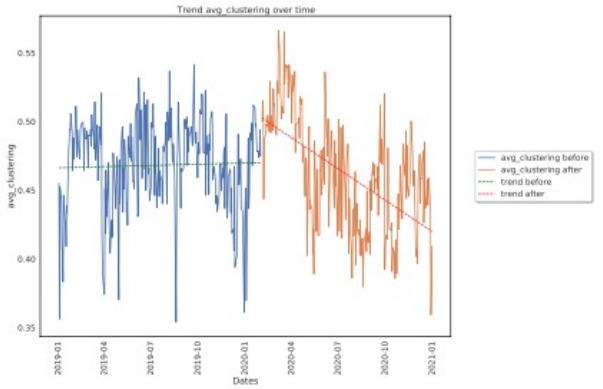
The Coronavirus pandemic has impacted the networks:

1. **Mean degree** decreases
2. **Assortativity** increases
3. **Average Clustering** decreases



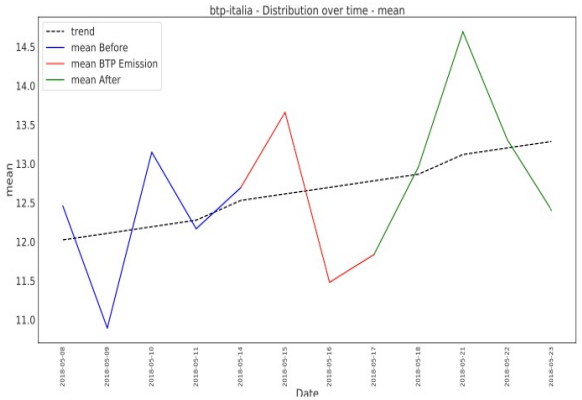
	Mean Degree			Assortativity			Average Clustering		
	before	during	Δ	before	during	Δ	before	during	Δ
ETF_N	9.803	9.629	-0.173	-0.428	-0.411	0.017	0.594	0.588	-0.006
ETF_S	15.974	15.284	-0.69	-0.502	-0.507	-0.005	0.703	0.665	-0.037
Government $Bonds_S$	22.217	22.138	-0.08	-0.555	-0.554	0.001	0.673	0.671	-0.003
Government $Bonds_N$	10.632	10.383	-0.249	-0.463	-0.402	0.061	0.605	0.575	-0.03
$Shares_S$	22.453	21.319	-1.134	-0.472	-0.49	-0.018	0.771	0.754	-0.016
$Shares_N$	12.711	12.843	0.131	-0.447	-0.435	0.013	0.607	0.588	-0.019
Corp. $Bonds_S$	8.098	7.784	-0.315	-0.61	-0.602	0.008	0.274	0.261	-0.013
Corp. $Bonds_N$	7.619	6.745	-0.874	-0.345	-0.291	0.054	0.484	0.432	-0.052
$Funds_S$	15.579	14.811	-0.768	-0.491	-0.491	0.0	0.673	0.633	-0.039
$Funds_N$	9.948	9.803	-0.145	-0.438	-0.412	0.026	0.613	0.601	-0.012
$Other_S$	4.515	6.511	1.996	-0.537	-0.479	0.058	0.188	0.294	0.105
$Other_N$	3.134	2.987	-0.147	-0.184	-0.129	0.055	0.105	0.065	-0.039

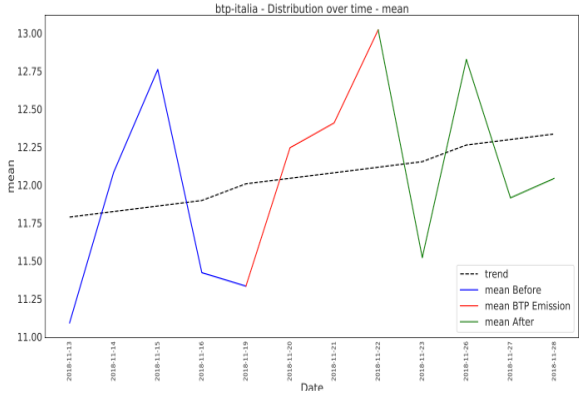




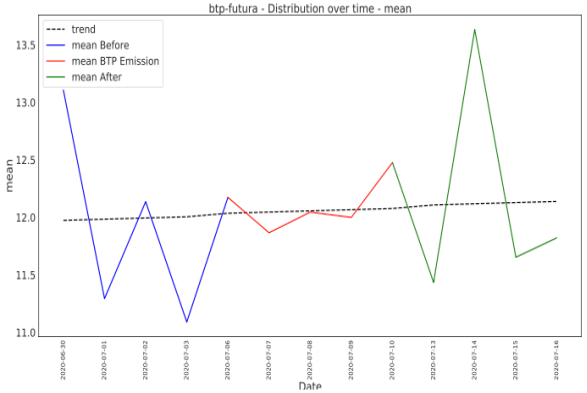
Impact of BTP emissions

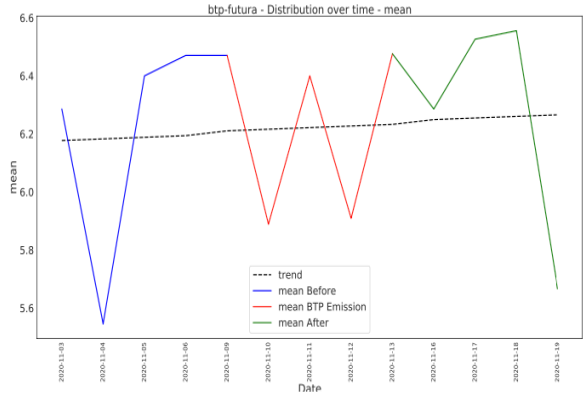
BTP Italia





BTP Futura





- Only Government Bonds networks are considered.
- There is no evidence that the emission of BTP Italia and Futura impacts the topology of the networks.

Conclusions

- **Monthly Networks**:
  - Centrality analysis: central nodes in cumulative networks show stable rank, non-cumulative networks do not exhibit any recognizable behavior.
  - Scale-free networks: cumulative networks show a predominance of scale-free behavior with respect to non-cumulative.
  - Networks resiliency: elimination of an important node has a greater impact on the network topology than randomly elimination.

- **Daily Networks**:
  - Covid19 had a negative impact on networks topology: decreased mean degree, disassortativity, clustering coefficient.
  - There is no evidence BTP Italia and BTP Futura emissions impact the networks topology.

Future works

For future works, there are several possibilities:

- Apply monthly networks analysis **also on daily networks** (centrality, scale-free, resiliency)
- Apply similar studies to **data from different contexts** and environments.
- Try **different types** of node elimination: almost-failures attack and efficient link attack.
- Try impact analysis on **settlement discipline** (penalty on instructions with long time failed status) that went live on 1st February 2022.

Thank you