CAREC INSTITUTE RESEARCH CONFERENCE

4-5 March 2021

Session Three

Tourism Sector in Times of High Uncertainty

Speaker:
Dr. Tahir Mumtaz Awan & Mr. Mrestyal Khan

Department of Management Sciences, Comsats University, Pakistan

Network Analysis of Tourism Stocks During Pandemic times: An Evidence from CAREC Region

Faheem Aslam, Yasir Tariq Mohmand, Tahir Mumtaz Awan, & Mrestyal Khan

Department of Management Sciences, COMSATS University Islamabad, Pakistan

Background

- The pandemic (COVID-19) tracked back from December 2019, devastated every walk of life globally.
- High level of uncertainty and reduced income, businesses shutting down was noticed in past one year.
- COVID-19 is also labelled as black swan event (Renjen, 2020).
- Estimated losses in major economies range around 2.4 to 3.0 percent of the gross domestic product (GDP) in pandemic times (Azevêdo, 2020).
- More severe effect was noted in the tourism sector globally.
- According to World Travel and Tourism Council Report in 2019, predicted yearly growth of 1.8% in the next ten years, but the COVID-19 changed the whole situation.
- CAREC region is being recognized as significant to the whole world (Buyers, 2003).

Contribution of the Study

- Threefold contributions to the existing COVID-19 financial literature
  - Applies comprehensive network theory to analyze the dynamics of the COVID-19 on 55 tourism stocks registered in the CAREC region.
  - An estimate of changes regarding the networks of five different categories (hotel & catering, travel agencies, transportation, airlines, and cruise lines) of these tourism stocks.
  - Analyses of network changes with the evolution of COVID-19, by dividing the timeline into three sub-periods.

Data

- Daily closing prices of 55 tourism stocks of CAREC region.
- 5 different categories namely, hotel & catering, travel agencies, transportation, airlines, and cruise lines.
- Data range: 01-July-2019 to 10-November-2020.
- Study period is divided further into three sub-periods;
  - S1 (pre-pandemic times**)**
  - S2 (peak times of pandemic)
  - S3 (time when the pandemic came to an end and the spread was controlled)

Network Construction

- Long-run correlation coefficient proposed by (Andrews, 1991).
- For a given sample observations T, Andrews (1991) estimate takes the following form:
  - $\omega_T = \begin{bmatrix} w_{i,i} & w_{i,j} \\ w_{j,i} & w_{j,j} \end{bmatrix} = \sum_{m=-T+1}^{T-1} k\left(\frac{m}{B}\right) T(m)$

$$where$$

  - $T(m) = \begin{cases} T^{-1} \sum_{t=m+1}^{T-1} [Z_t Z_{t-m}], & m \geq 0 \\ T^{-1} \sum_{t=m+1}^{T} [Z_{t+m} Z_t], & m < 0 \end{cases}$
- Where $t = 1,2, \ldots, T$, $Z_t = [r_{i,t}, r_{j,t}]^T$ [], and $k\ (.)$ refers to the quadratic spectral kernel weighting function

Network Construction

- Furthermore, the mathematical expression for the quadratic spectral kernel function is as follows:

$$k\left(x=\frac{m}{B}\right)=\frac{25}{12\pi^2x^2}\left(\frac{\sin\left(\frac{6\pi x}{5}\right)}{\frac{6\pi x}{5}}-\cos\left(\frac{6\pi x}{5}\right)\right)$$

Additionally, the formula for long-run correlation $\rho_{i,j}$ is given below:

$$\rho_{i,j}=\frac{w_{i,j}}{\sqrt{w_{i,i}w_{j,i}}}$$

- Distance is calculated by using Mantegna (1999) and Stanley and Mantegna (2000) methodology as illustrated below:

$$D_{ij}=\sqrt{2\left(1-\rho_{ij}\right.}$$

- Matrices with 55 × 55 dimensions (considering all tourism stocks)

Minimum Spanning Tree

- Since stocks in the equity market are completely connected, they cannot be represented by complex networks, hence interconnections among the stocks can better be represented using a minimum spanning tree (MST).
- A minimum spanning tree is a sub-graph extracted from the network with all nodes but reduced edges.
- For MST extraction, this study used the Kruskal algorithm, which identifies most prominent and central nodes.
- Different centrality measures (degree, betweenness, and closeness centralities) were used.

Network Topology

- The mathematical illustration for betweenness centrality is given in equation below:

$$\boldsymbol{B_c(i) = \sum_{a,b \in N} \frac{\lambda(a,b|i)}{\lambda(a,b)}}$$

- Where N represents the node-set, $\lambda(a,b)$ shows the shortest paths whereas $\lambda(a,b|i)$ refers to the number of shortest paths passing i.
- Furthermore, equation 8 gives the mathematical expression for "closeness centrality".

$$\boldsymbol{C(V_i) = \frac{(N-1)}{\sum_{j=1}^{n} d(N_i N_j)}}$$

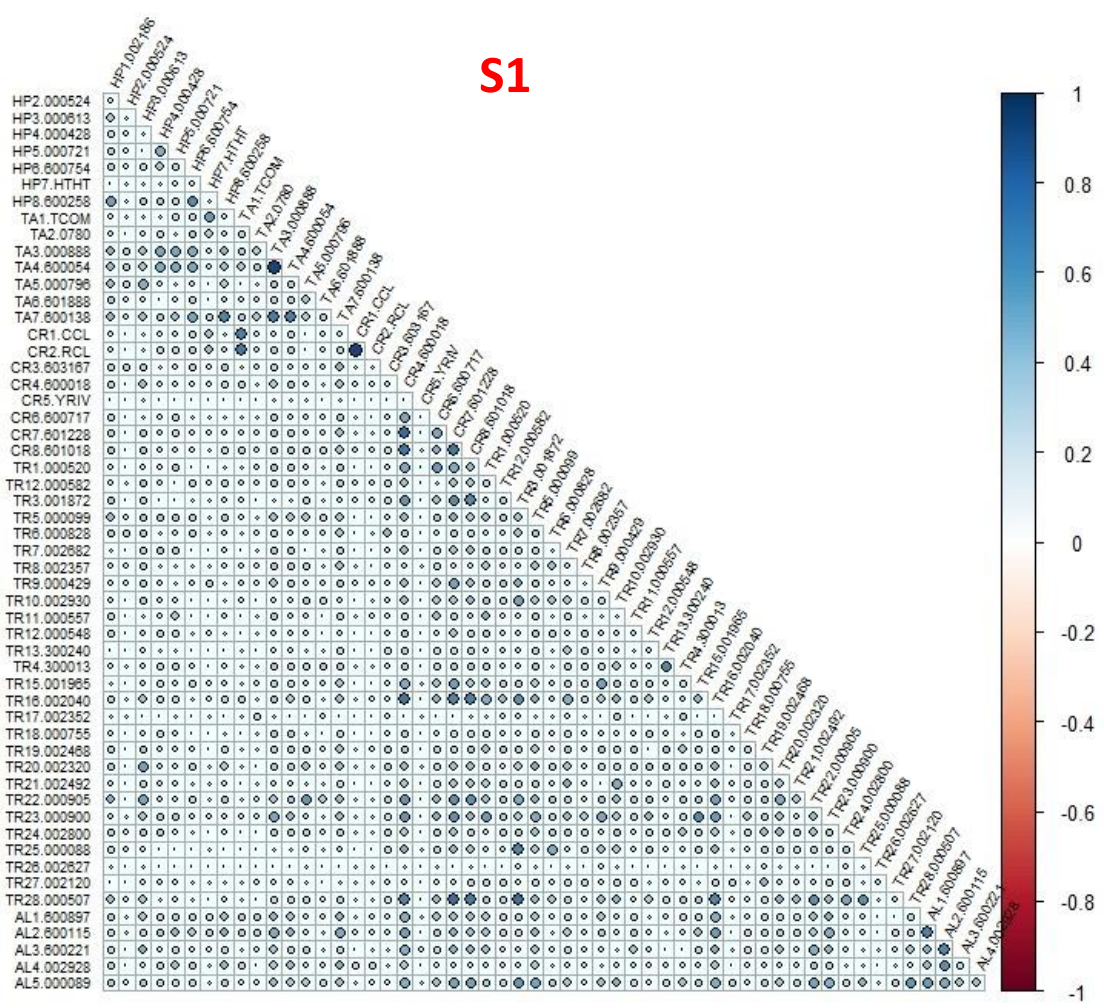
- Where $d(N_i N_j)$ shows the minimum distance from N_i to N_j whereas $(N-1)$ is used for normalization.
- Moreover, the averaged path is also considered which is illustrated below:

$$\boldsymbol{a = \sum_{s,t \in V} \frac{d(s,t)}{n(n-1)}}$$

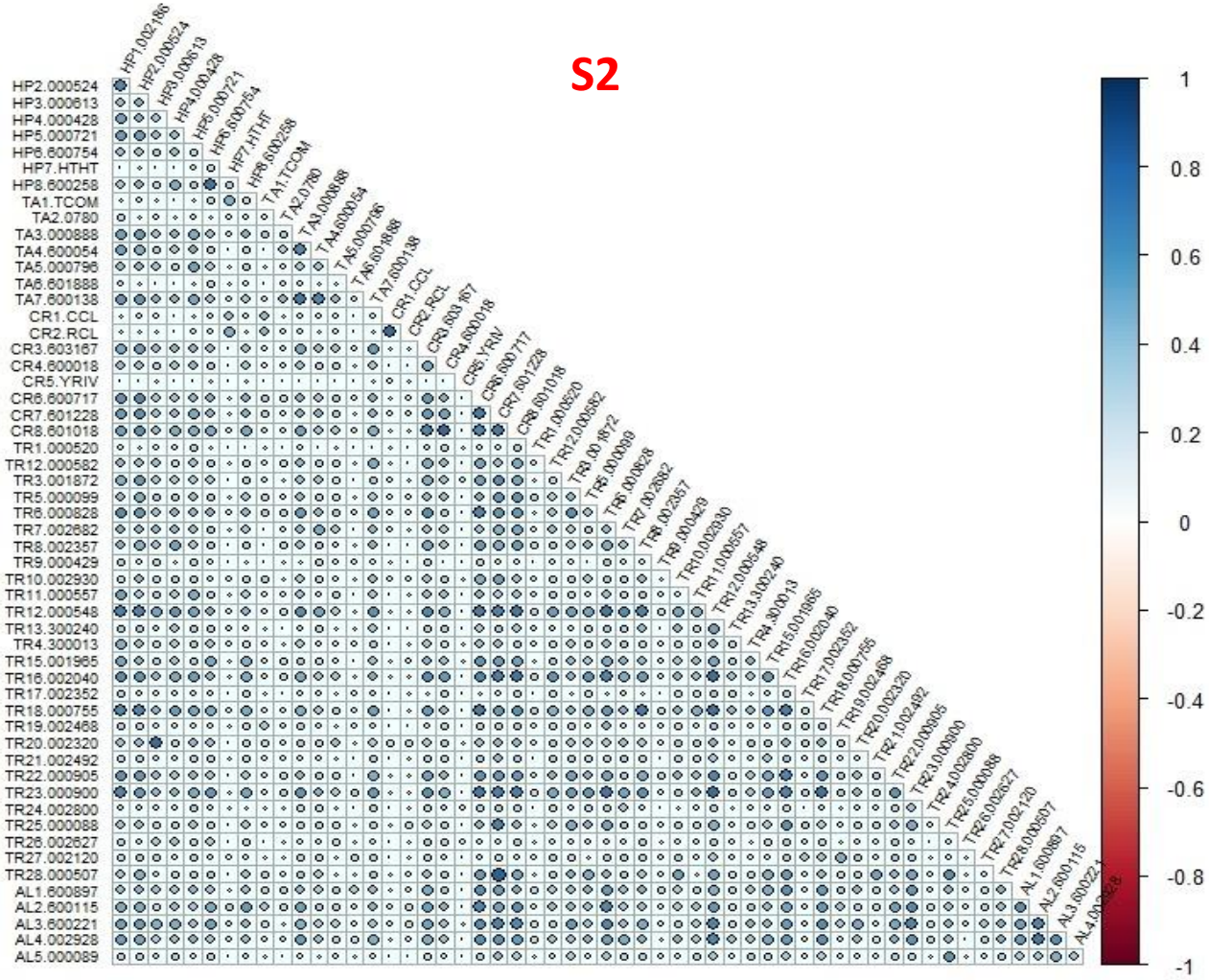
- Where n refers to the number of nodes, V represents the set of nodes, the shortest path from s to t is denoted by $d(s,t)$.

Increased Correlation Coefficients (with COVID Spread)

S1



S2



Increased Correlation Coefficients (with COVID Spread)

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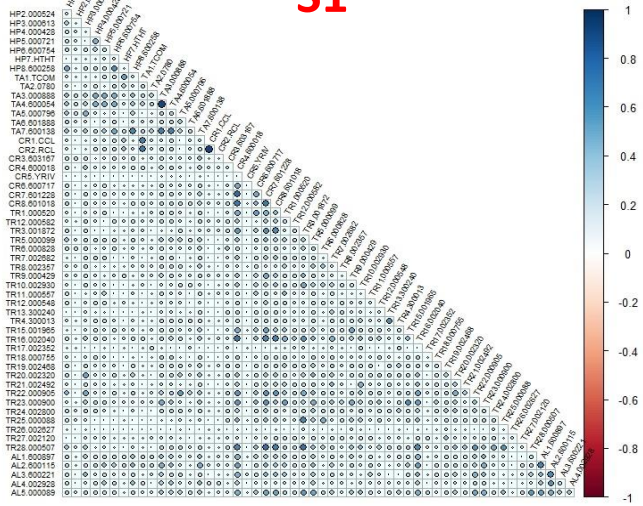
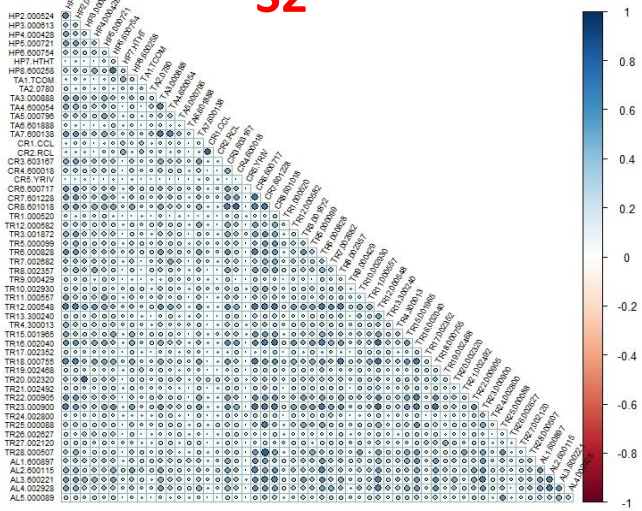
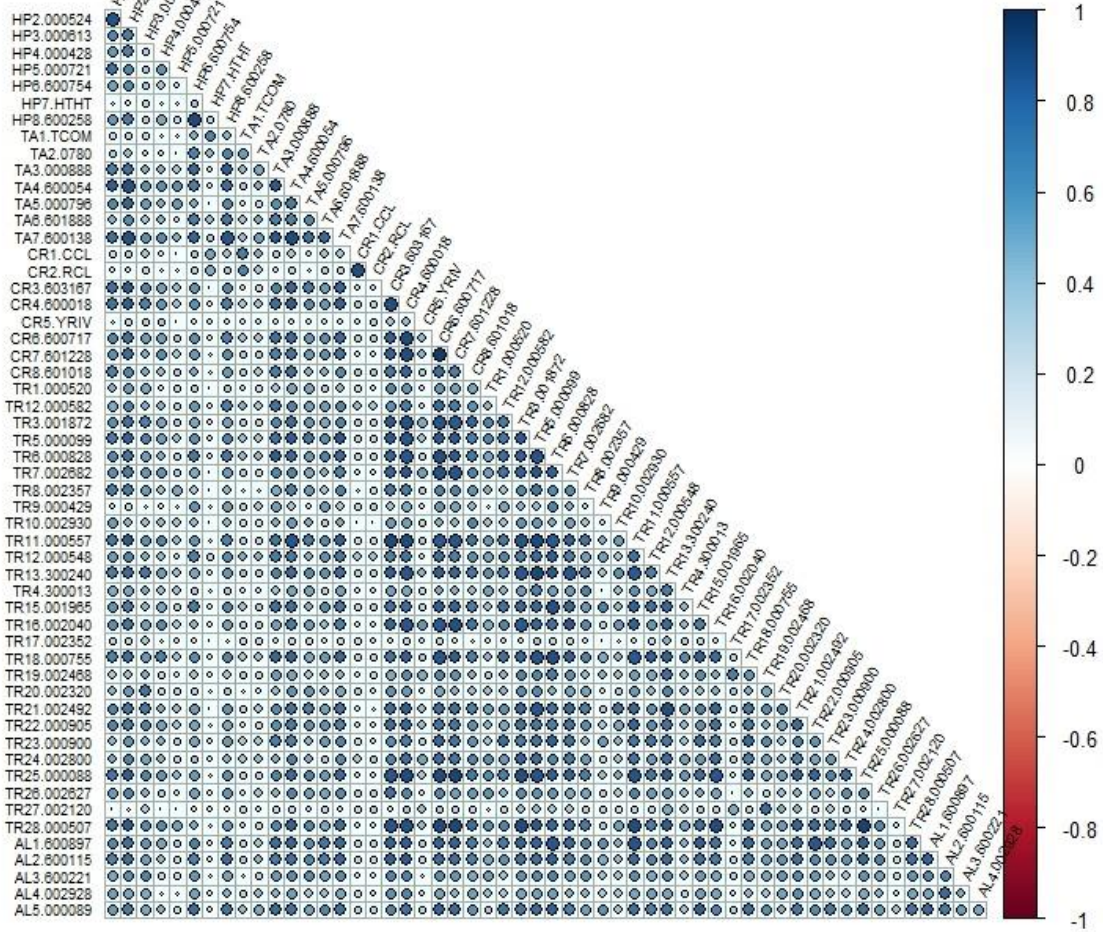


S2

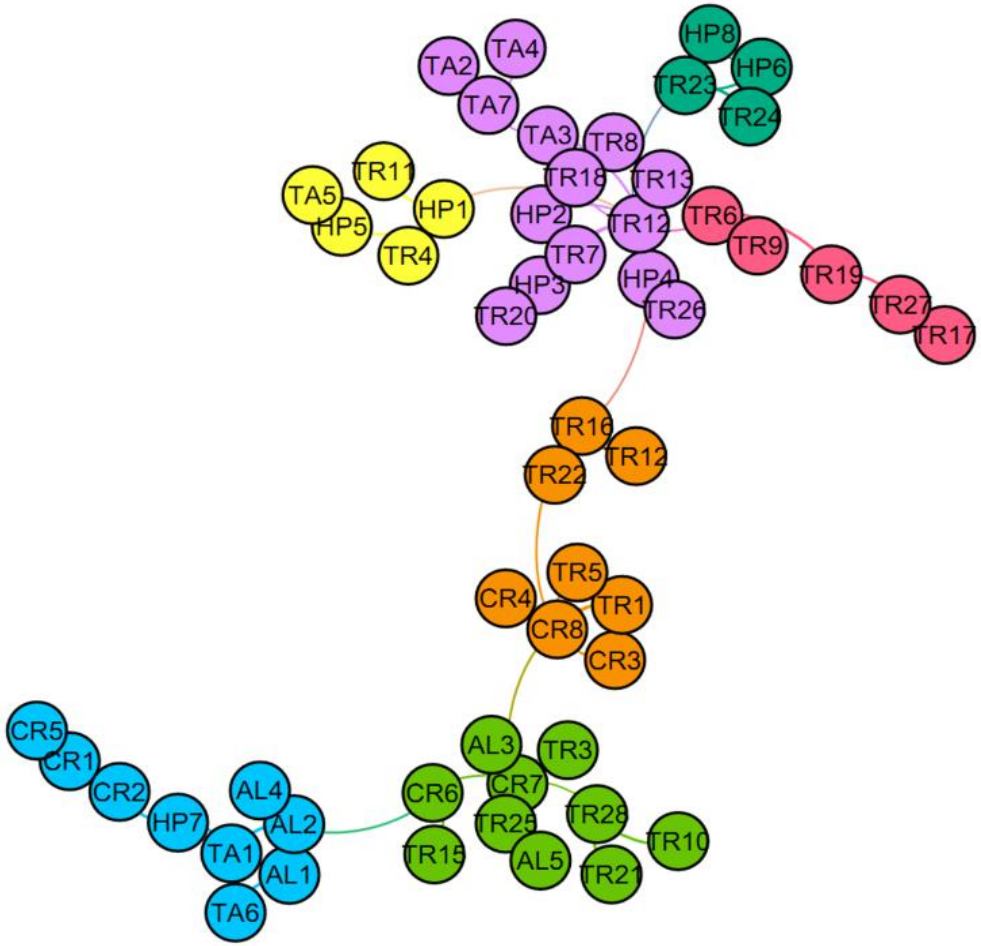


S3

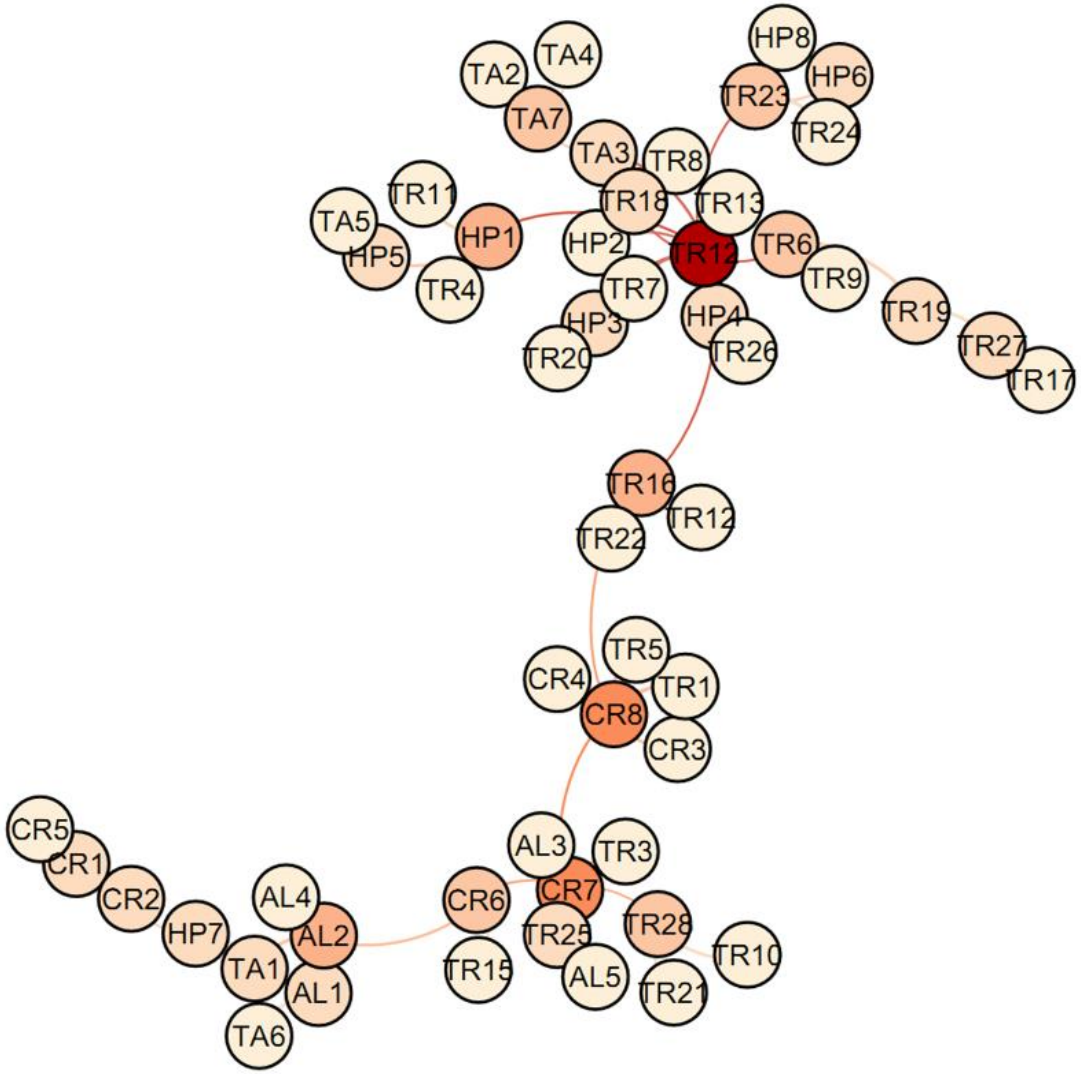


Financial Networks (S1)

Community Structure (S1)

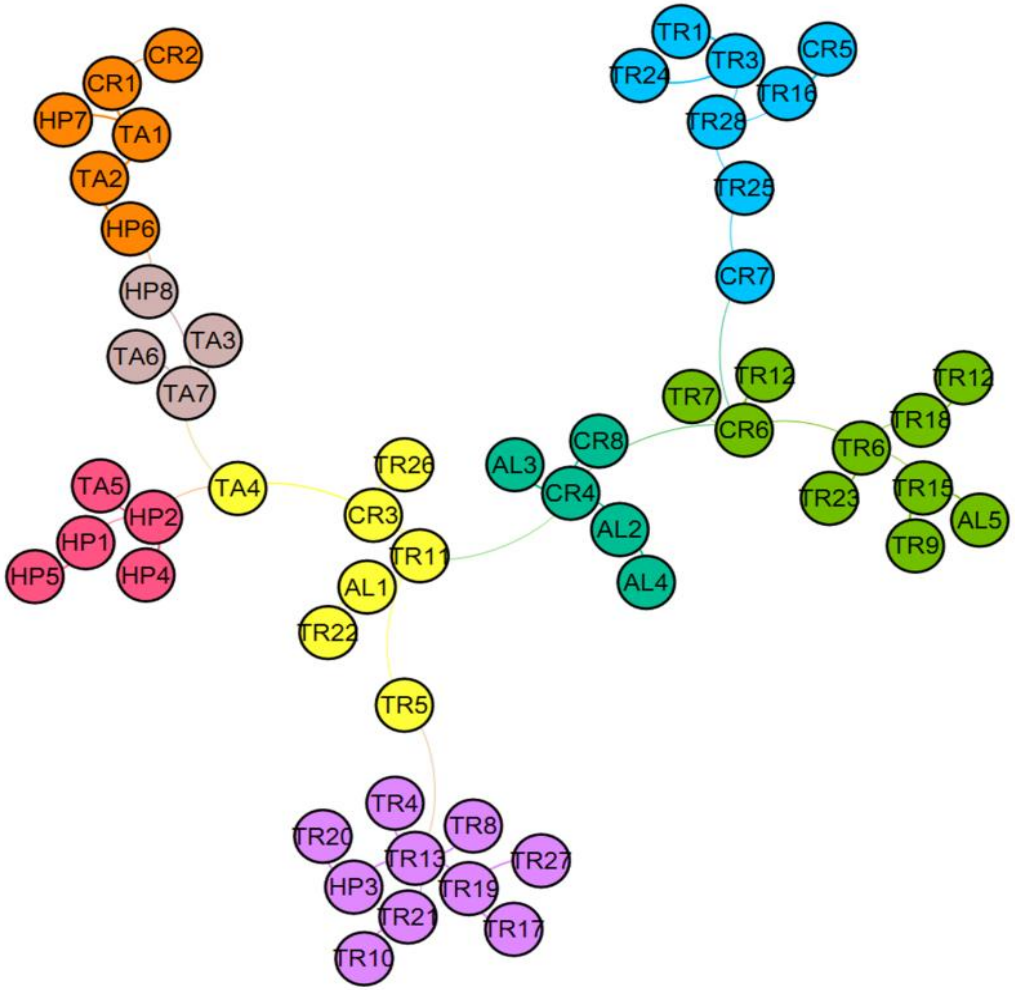


Degree Classification (S1)

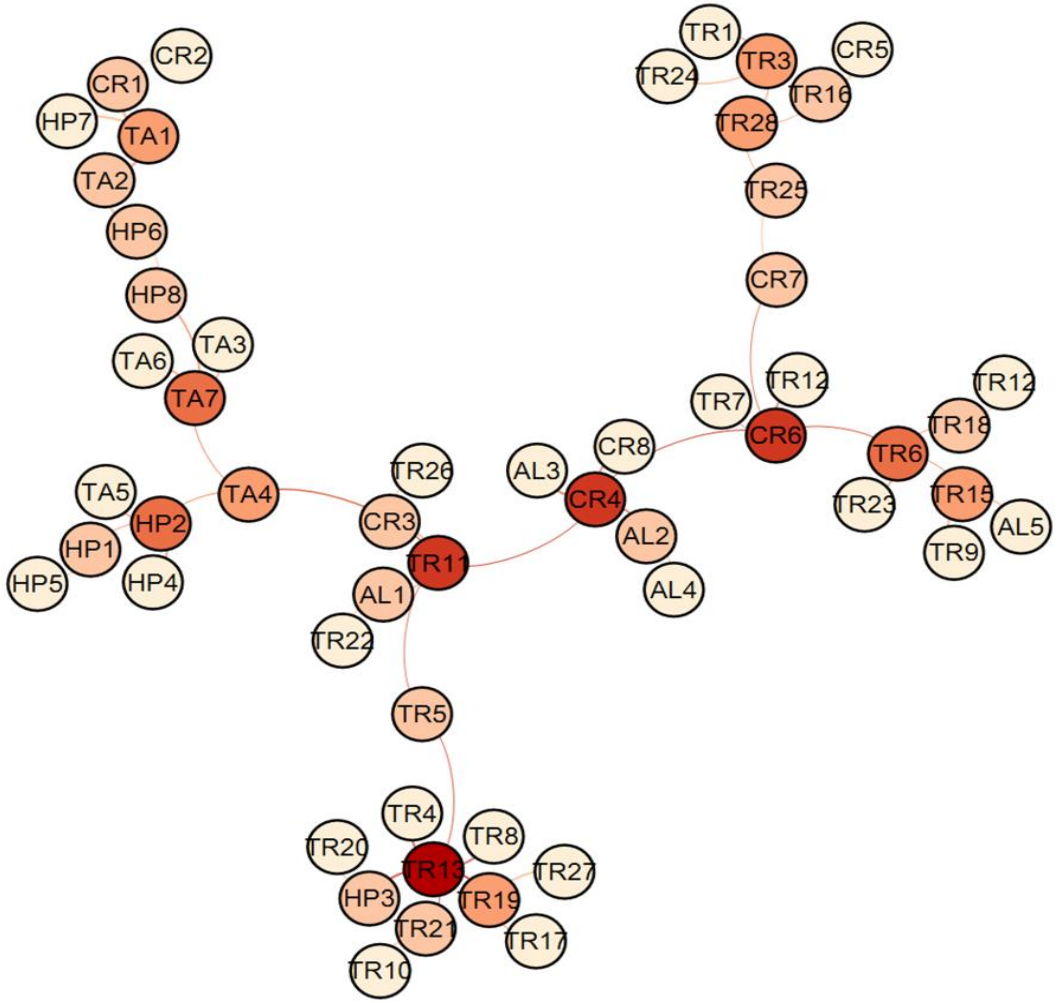


Financial Networks (S2)

Community Structure (S2)

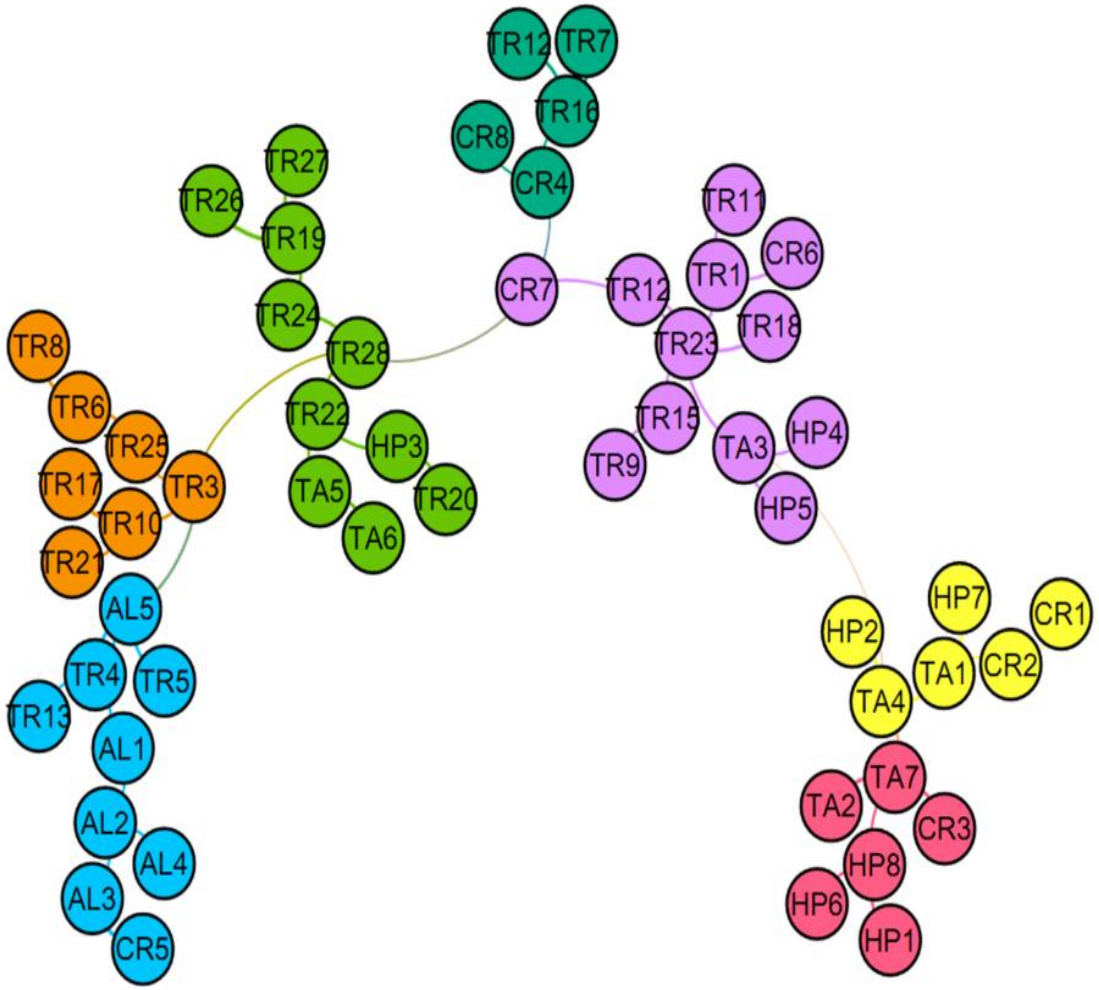


Degree Classification (S2)

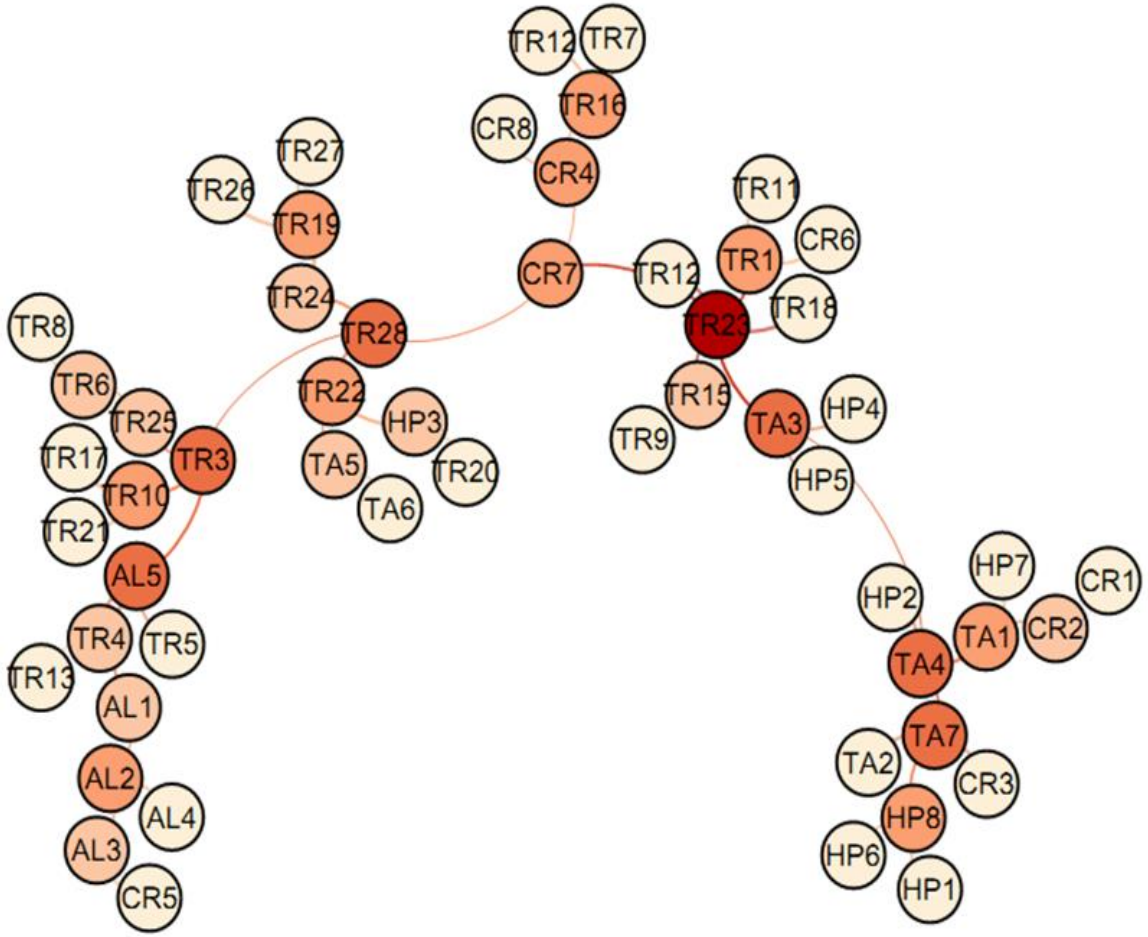


Financial Networks (S3)

Community Structure (S3)



Degree Classification (S3)



Topological Properties of the MST's

MST	Vertices	Links	Path length	Betweenness	Closeness
S1	55	54	5.146	0.078	0.203
S2	55	54	6.038	0.095	0.173
S3	55	54	5.717	0.089	0.181

Concluding remarks

- Estimated changes in financial networks 55 Tourism stocks by dividing the dataset into three sub periods (pre-pandemic, peak times, and post-pandemic).
- An increased association during the peak of virus spread and decreased afterwards.
- Important implications for both the domestic and foreign investors to construct optimal portfolios and to adopt risk mitigating strategies.
- The stock market regulators in the tourism industry must incorporate coordinated and combined policies to safe the whole industry.
- Investment managers can utilize the information regarding the tourism stocks in establishing pair trading strategies via observing the co-movement of selected categories.