

Complex network analysis of Jones stocks to identify extreme events such as financial crisis and covid-19

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Abstract : The present work investigates the time series of 28 stocks indexed in the Dow Jones Industrial Average(DJIA) from 2000 to 2021. DJIA is a stock market index consisting of 30 US based companies. Static networks and dynamic networks to extract out the information. In static periods main emphasis is given on the global financial crisis of 2008(GFC8) in three distinct periods; pre crisis, during crisis and post crisis. The threshold network analysis shows high correlation among the stocks during the period of crisis as comparison to crisis off periods. The rolling time window technique is applied for dynamic periods. The analysis in the moving time of one year identify some of dominant extreme events such as Dot-com bubble, GFC8, European sovereign debt crisis, Chinese stock market crisis and Covid-19. The outcomes of such studies are useful in the understanding and identification of such extreme events and has advantages in developing the probable indicators of risks.

Introduction:

The aim of present investigation is to investigate structure and dynamics of network of Dow Jones Industrial Average stocks.

The data is analyzed in two perspectives; Static analysis and dynamic analysis.

To study influence of global financial crisis of 2008 on the Dow Jones stocks period from 7/6/2006 to 30/11/2007 is taken as ‘pre-crisis’, period from 3/12/2007 to 30/6/2009 as ‘during crisis’ and period 1/1/2010 to 30/6/2011 as ‘post-crisis’.

Methodology:

Random Matrix Theory

Eigenvalues of cross correlation matrix (CCM) of DJIA stocks and Wishart matrix constructed from completely random time series are computed and compared.

Normalized Logarithmic returns $L_j(\tau)$ from daily closing prices of the stock stocks $P_j(\tau)$ is computed using following formula:

$$l_j(t) = \frac{L_j(\tau) - \langle L_j \rangle}{\sqrt{\langle L_j^2 \rangle - \langle L_j \rangle^2}} \text{ where } \langle \dots \rangle \text{ is the time average and}$$

$$L_j(\tau) \equiv \ln P_j(\tau) - \ln P_j(\tau - 1)$$

The CCM is computed from the normalized returns using following equation $C_{jk} \equiv \langle l_j(\tau) l_k(\tau) \rangle$

The values of $C_{jk} = 1, -1$ & 0 corresponds to perfect correlation, perfect anti-correlation and no correlation respectively.

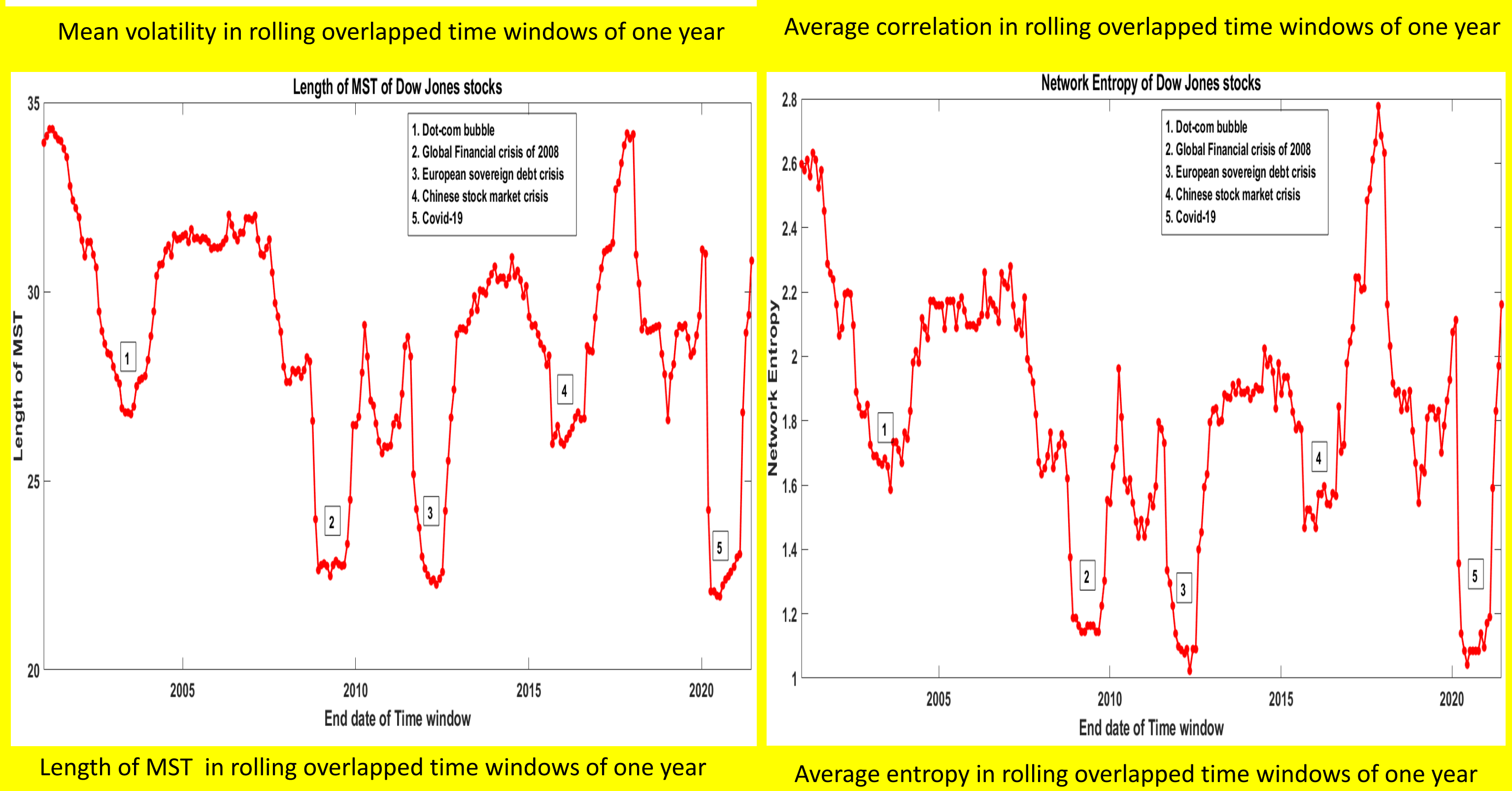
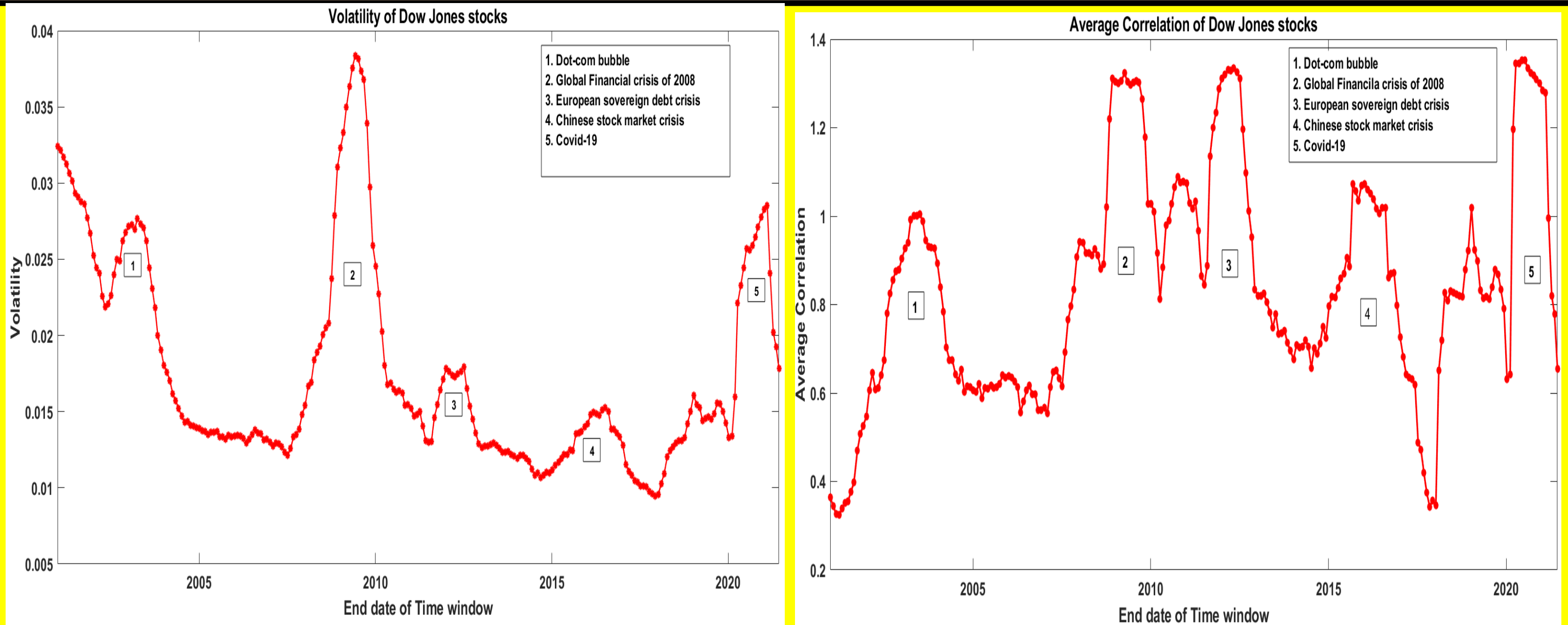
Complex Network Analysis

DJIA stocks act as the nodes of the network and correlation among them are the edges connecting them.

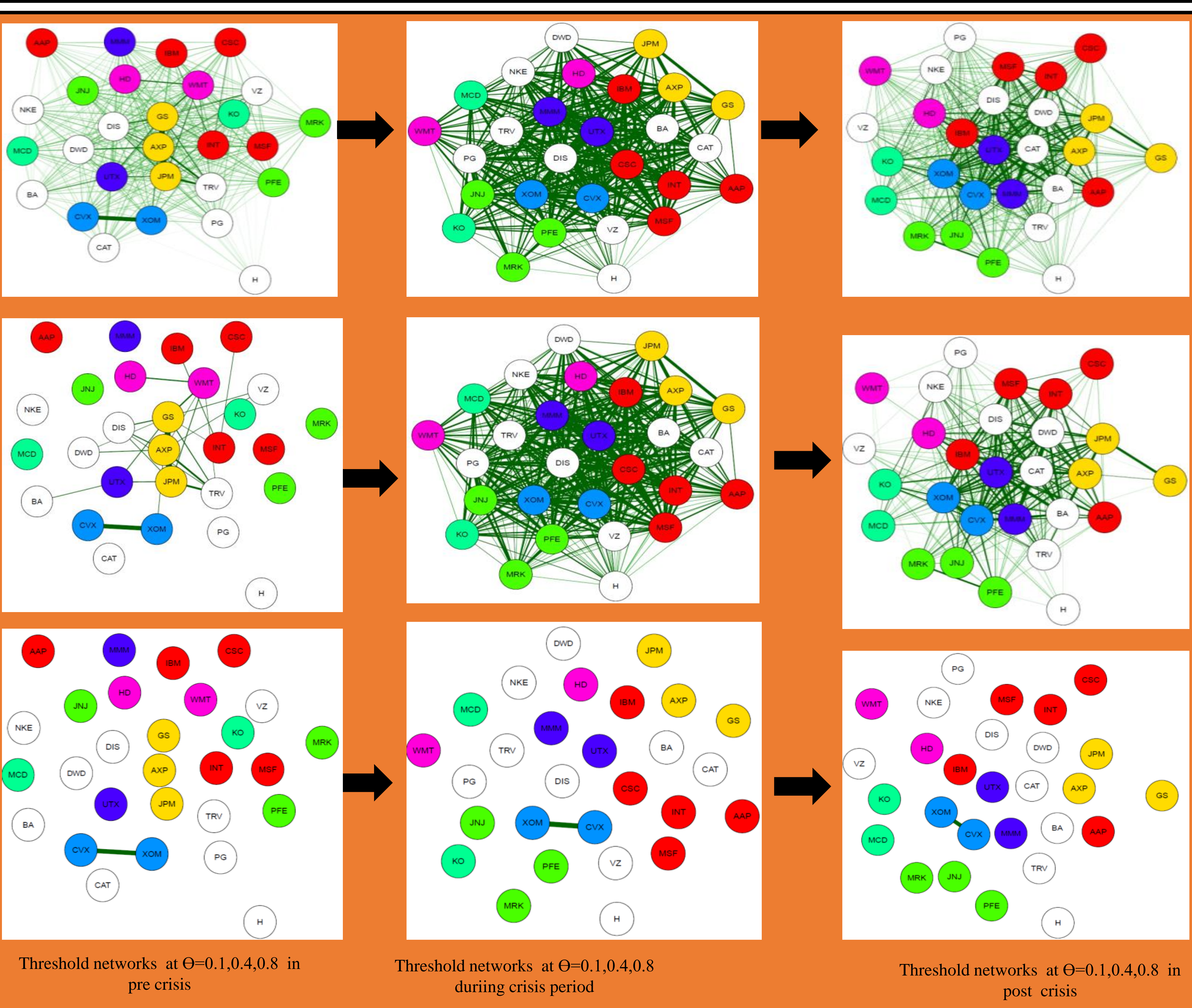
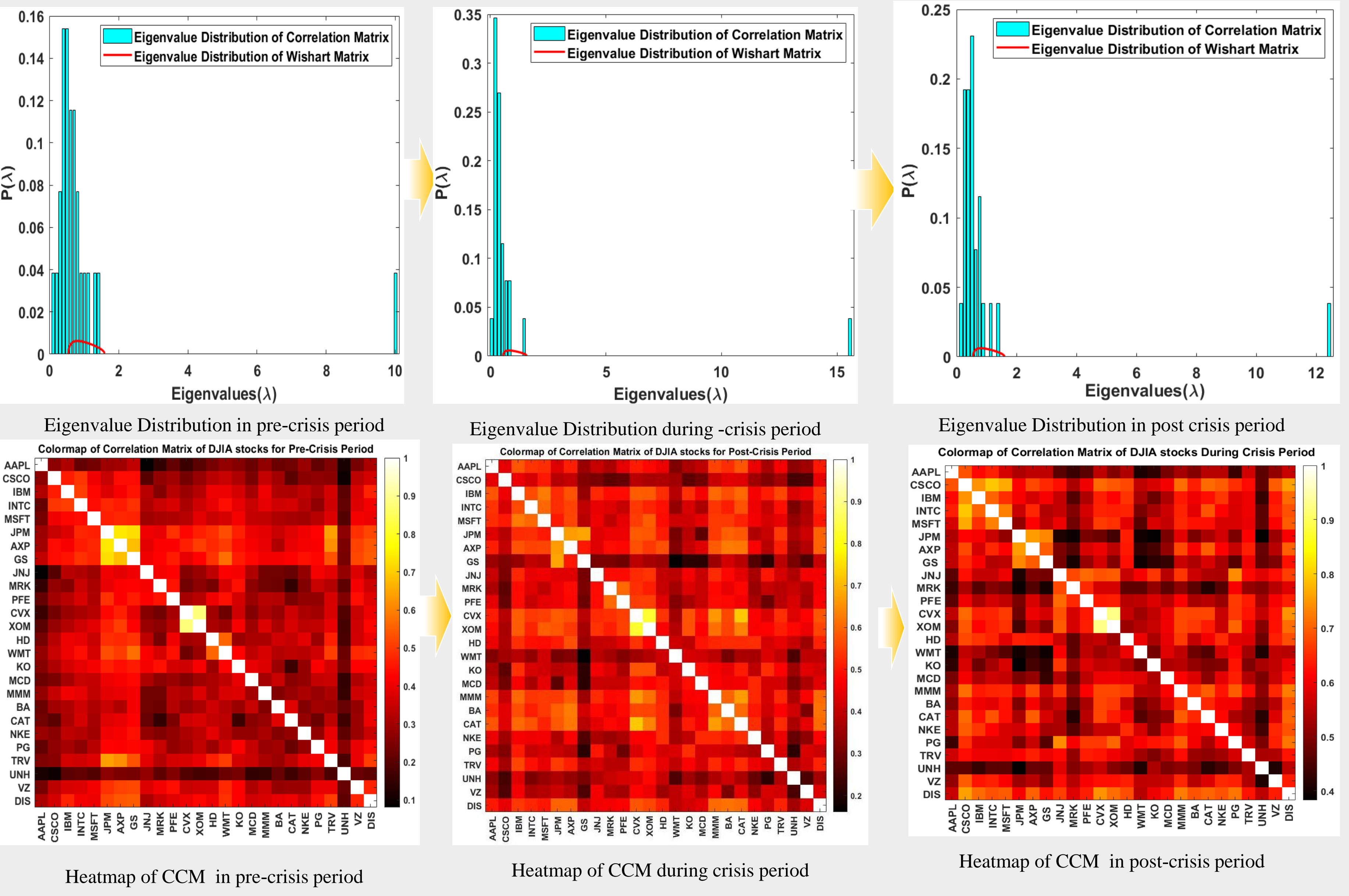
A threshold (θ) (at $\theta = 0$ all the nodes are connected) such that edges among the stocks (j, k) is disconnected if the correlation $C_{jk} < \theta$

Dynamic Period Analysis

In dynamic period analysis length of time series is divided into 143 rolling time windows, each of width one year. The distinct crests are detected corresponding to the occurrence of extreme events. The graph of Volatility, average correlation, network entropy and length of MST identifies Dot-com Bubble, GFC8, European sovereign debt crisis, Chinese Crisis and Covid-19.



Static Periods Analysis



Conclusions

The Largest Eigenvalue of cross correlation matrix are out of bound of RMT predictions in all period of crisis, which explored collective dynamics.

The threshold networks show the presence of high correlation among the DJIA stocks during the crisis period.

The Chevron and Exxon Mobil are observed to be highly correlated stocks and United Health Group (UNH or H) is weakly correlated stock in all periods of crisis.

The distinct crests corresponding Dot-com Bubble, GFC8, European sovereign debt crisis, Chinese crisis and Covid-19 are detected.

In nutshell, our investigation reveals the major changes in the structure and dynamics of Dow Jones stocks during period of crisis and are helpful in understanding of similar crisis in future/deciding the remedial actions