

Information Dynamics and Structural Transitions in Nikkei 225 Correlation Networks

Keywords: Nikkei 225; correlation network; combinatorial information; market structure

Extended Abstract

Motivation. Financial markets exhibit time-varying dependence structures, especially during periods of stress, when cross-sectional synchronization tends to increase and sectoral distinctions may weaken. Understanding how the topology of stock correlation networks evolves over time is therefore important for studying market organization and systemic risk. This project investigates whether information-theoretic measures derived from filtered correlation networks can capture structural transitions in the Japanese equity market. Using Nikkei 225 constituent data, the study asks two main questions: first, how combinatorial information varies across time and filtering threshold; second, whether major market events are associated with visible reorganization in the mesoscopic structure of the network.

Approach and Methodology. The analysis is based on rolling-window correlation matrices constructed from Nikkei 225 stock returns. Pairwise correlations are converted into distances and then thresholded using a parameter ϵ to generate a family of evolving networks. To remove structurally unstable or bridge-like connections, Ollivier-Ricci curvature is computed on the thresholded networks, and edges with negative curvature are filtered out. On the remaining graph, connected components are identified and used to compute combinatorial information, which serves as a measure of structural heterogeneity in the network. By varying both time and ϵ , a two-dimensional heatmap is constructed to visualize how network information changes across market states.

Results. The results show that combinatorial information depends strongly on time, and clear temporal regime shifts are observed. During June–July 2019, the network remains in a relatively high-information state, indicating a more differentiated market structure. Information then declines during August–September 2019, consistent with trade-war-related market stress and stronger cross-sectional synchronization. From late October 2019 to late January 2020, the network returns to a broader high-information regime, suggesting a recovery of modular structure. In late January to February 2020, corresponding to the early COVID-19 shock window, the high-information region contracts again. This decline is associated with the emergence of larger connected clusters, implying that panic periods compress the market into a smaller number of dominant collective structures.

Conclusions and Outlook. Overall, the study suggests that combinatorial information is a useful indicator of time-varying market structure in the Nikkei 225 network. Declines in information tend to coincide with episodes of market stress, when synchronization increases and the network becomes dominated by larger clusters. Additional studies likely to be completed by the time of the conference include further investigation with a broader critical-

transition perspective into whether reductions in combinatorial information can act as early-warning signals of structural regime shifts, as well as analyses of transition abruptness, post-shock recovery patterns, and potential hysteresis in the market correlation network.

References

- [1] Onnela, J.-P., Chakraborti, A., Kaski, K., Kertesz, J. and Kanto, A. (2003) Dynamics of Market Correlations: Taxonomy and Portfolio Analysis. *Physical Review E*, 68, Article No. 056110.
- [2] Almog, A., & Shmueli, E.(2019).Structural Entropy: Monitoring Correlation-Based Networks Over Time With Application To Financial Markets. *Scientific Reports*,9(1),10832.<https://doi.org/10.1038/s41598-019-47210-8>
- [3] Ollivier, Y. (2009). Ricci curvature of Markov chains on metric spaces. *Journal of Functional Analysis*, 256(3), 810–864.

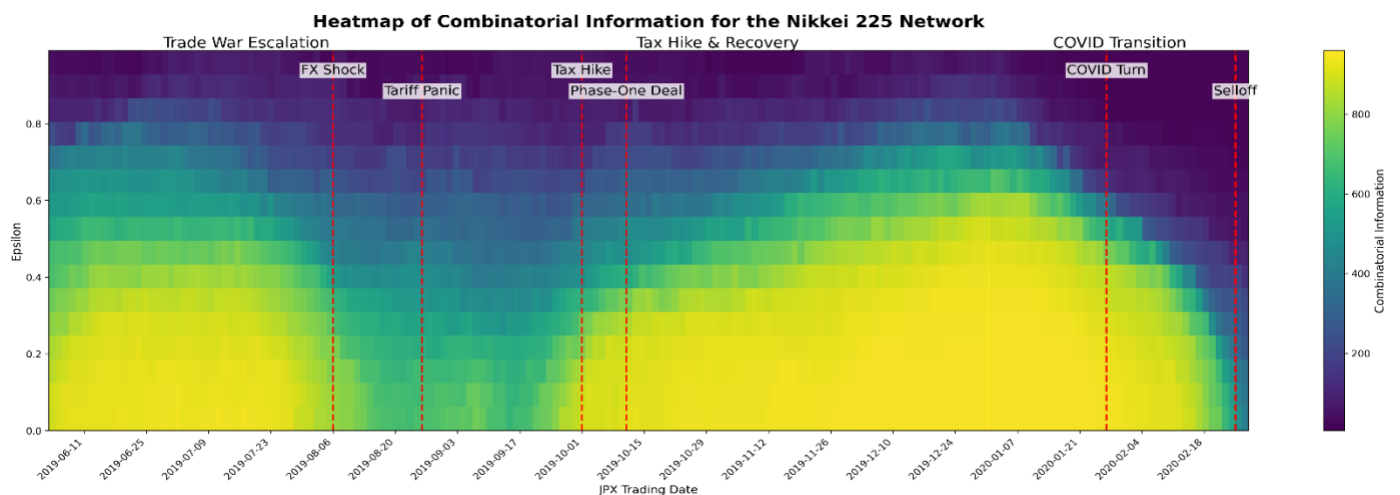


Figure 1. Heatmap of Combinatorial Information.

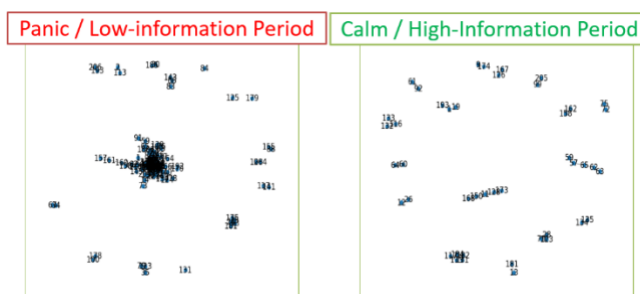


Figure 2. Example Network Plots.