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Spectral signature of structural changes in financial networks

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Understanding economic and financial crises requires the analysis of the structure of the related networks of interacting agents. Of particular interest is establishing whether a real-world network is in a state of (quasi) stationary equilibrium. If this is the case, the system undergoes smooth, structural changes that are, then, predictable. If not, the system will likely be characterized by abrupt regime shifts, which makes controlling its behaviour unfeasible. Methods have been proposed to assess whether a real-world network is in a (quasi) stationary state by examining the coherence of its structural development with appropriate (quasi) equilibrium, maximum-entropy ensembles of graphs. These analyses have proven useful in identifying early-warning signals of upcoming critical events. However, they have primarily focused only on dyadic and triadic 'debt loops' with varying levels of reciprocity, thereby disregarding higher-order structures such as longer cycles. We aim to step forward by considering closed walks of any length. Therefore, we propose a heuristic approach to study the ensemble properties of the spectral radius of random network models. Although our assumptions may appear drastic, our approach works remarkably well for directed networks (binary or weighted). We analysed the Electronic Italian Interbank Money Market (e-MID), the Dutch Interbank Network (DIN), and the International Trade Network (ITN) across a time span, including 2008. Results suggest that the ITN is a perfect example of a (quasi) equilibrium network, while the DIN and e-MID are clearly out-of-equilibrium. In the latter cases, the entity of the deviations from (quasi) stationarity provided by spectral properties captures the topological changes characterising the build-up phase of the 2008 crisis, confirming that the spectral radius is a compact proxy of the resilience of economic and financial networks.

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