Network effects on an agent-based market model with herding behavior

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Recent years have witnessed the appearance of a growing number of contributions based on heterogeneous interacting agents and interpreting the stylized facts of financial time series as the macroscopic outcome of the diversity among the economic actors and their connections. Most of these approaches put an emphasis on the processes of information transmission and social interaction among agents, processes which can be described within a network framework. In the context of these financial market models, it becomes crucial to understand the influence that the topology of interactions may have upon different market properties. It is the main purpose of this contribution to study such influence upon the macroscopic properties of an agent-based market model introduced by A. Kirman to model decision making among financial agents, and whose main ingredients are the inclusion of a herding behavior (a tendency to follow the crowd) and some idiosyncratic or noisy behavior.

Moving beyond the usual mean-field theories, we present an alternative approach based on the introduction of an annealed approximation for uncorrelated networks, allowing us to deal with the network structure as parametric heterogeneity [A. Carro, R. Toral and M. San Miguel, Scientific Reports **6**, 24775 (2016)]. By means of suitable approximations, we derive the dependence on the degree distribution of the underlying network of the average order parameter as well as the variance and autocorrelation of the global state variable. The approach is able to unfold the dependence of the model not only on the mean degree (the mean-field prediction) but also on more complex averages over the degree distribution. In particular, we find that the degree heterogeneity has a strong influence on the location of the critical point of a noise-induced, finite-size transition occurring in the model, on the local ordering of the system, and on the functional form of its temporal correlations.

This shift of the transition might have important practical implications, since it suggests that different behavioral regimes can be achieved by introducing changes in the network of interactions. Furthermore, we find that a larger degree heterogeneity leads to a higher average level of order in the steady state and that it plays a relevant role in determining the functional form of the temporal correlations of the system. Finally, we show how this latter effect can be used to infer the level of degree heterogeneity of the underlying network by studying only the aggregate behavior of the system as a whole, an issue of interest for systems where macroscopic, population level variables are easier to measure than their microscopic, individual level counterparts. Numerical simulations on different types of networks have been used to validate our analytical results. The generally good agreement found is all the more remarkable considering that, while the uncorrelated network assumption is essential for the proposed analytical method, we did not impose any particular structural constraint to avoid correlations in the networks used for the numerical simulations.