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Modeling Financial Markets by Self-Organized Criticality

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We present a self-organized criticality (SOC) model to study herding and avalanche dynamics in financial markets. We first consider a community of interacting investors, distributed in a small-world network, who bet on the bullish (increasing) or bearish (decreasing) behavior of an exogenous real market. Then we modify the model in order to generate endogenously a realistic price dynamics and to reproduce well-known stylized facts of financial markets. In both the models, we introduce in the community a variable number of random traders in order to study their possible beneficial role in stabilizing the market.

Summary

Financial markets are characterized by the interactions of many interconnected heterogeneous agents, who trade with each other and follow their own expectations with feedback mechanisms. The resulting aggregate behavior shows complex behavior, unpredictability and the occurrence of extreme events. Socio-economic systems can be studied as complex entities, by means of methods and concepts coming from statistical and theoretical physics. Such an approach helps studying financial markets exploiting the idea of behavioral heterogeneity, entailing a specific role for the interaction among market participants, in terms of imitation and individual psychology.

Building on similarities between earthquakes and extreme financial events, we present a self-organized criticality model to study herding and avalanche dynamics in financial markets. We first consider a community of interacting investors, distributed in a small-world network, who bet on the bullish (increasing) or bearish (decreasing) behavior of the market which has been specified according to the S&P 500 historical time series. Remarkably, we find that the size of herding-related avalanches in the community can be strongly reduced by the presence of a relatively small percentage of traders, randomly distributed inside the network, who adopt a random investment strategy. Our findings suggest a promising strategy to limit the size of financial bubbles and crashes. We also obtain that the resulting wealth distribution of all traders corresponds to the well-known Pareto power law, while that of random traders is exponential. In other words, for technical traders, the risk of losses is much greater than the probability of gains compared to those of random traders.

We also show that a modified version of our SOC model is able to generate endogenously a realistic price dynamics and to reproduce well-known stylized facts of financial markets. We consider a community of heterogeneous traders, composed by chartists and fundamentalists, and focus on the role of informative pressure on market participants, showing how the spreading of information, based on a realistic imitative behavior, drives contagion and causes market fragility. In this model imitation is not intended as a change in the agent' s group of origin, but is referred only to the price formation process. Finally, we introduce again in the community a variable number of random traders in order to study their possible beneficial role in stabilizing the market.

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