Stochastic resonance and diversity in an agent-based herding model

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The mainstream approach to economics has traditionally neglected the study of two of the most relevant and universal features of the economic activity: the diversity among the economic actors, and the interplay and connections between them. Indeed, the overall systemic features of the present crisis could be understood as emergent phenomena arising from the micro-activity of strongly interacting economic units.

Recent years, however, have witnessed the appearance of a growing number of contributions, by heterodox economists and physicists, based on heterogeneous interacting agents. The fundamental attribute of these agent-based models is the behavioral heterogeneity among agents, i.e. their capability to choose from a set of different market strategies or trading rules. Furthermore, most of these models involve some interaction mechanism between market participants, whether direct or indirect, global or local. We will focus on a series of stochastic models of information transmission inspired by Kirman[1], and whose main ingredient is their emphasis on the processes of social interaction among agents, based on herding behavior or a tendency to follow the crowd.

Inspired by a series of entomological experiments with ant colonies, Kirman[1] proposed a stochastic herding formalism to model decision making among financial agents. In the experiments, entomologists observed asymmetric macroscopic patterns emerging from an apparently symmetric situation: when ants were faced with two identical food sources, a majority of the population tended to exploit only one of them at a given time, switching its foraging attention focus to the other source every once in a while. In order to explain this behavior, Kirman developed a stochastic model where the probability for an ant to change its foraging source is a combination of two terms, one related to pairwise herding interactions or recruitment probability, and the other as an autonomous switching tendency. This very simple model can also be interpreted in terms of market behavior by just replacing an ant's binary choice between food sources by a market agent's choice between trading strategies, particular rules for the formation of his expectations, or differences in access and interpretation of information.

A series of subsequent papers have focused on explaining some of the stylized facts observed in empirical data from financial markets[2],[3]. Those features are explained as the macroscopic outcome emerging from the internal dynamics of an ensemble of heterogeneous interacting agents. Some of the universal features of financial time series which have been reproduced in the framework of herding models of the Kirman type are: the non-Gaussian or leptokurtic character of the unconditional distribution of returns, the temporal bursting behavior of the volatility, and the positive autocorrelation of absolute and squared returns.

The main purpose of the present contribution is the study of some possible stochastic resonance effects in the framework of an agent-based herding model of the Kirman type. A stochastic resonance is basically a maximum in a suitably defined response of the system to an external forcing as a function of the intensity of some noise or fluctuations. It generally requires only a bistable system, an additive noise term and a sub-threshold periodic forcing[4]. The two former being already included in the original Kirman model, we just need to add an external periodic signal which will, at regular time intervals, induce a modification of the potential helping the transitions in one direction or the other alternatively. This external forcing can be interpreted, in terms of financial markets, as an advertising or a public perception in favor or against one of the two possible trading behaviors, thus periodically breaking the symmetry of the system. The conditions for the ensemble of agents to more accurately follow the periodicity of the signal are studied. In particular, we computed the response of the system as a function of the tendency of the agents to randomly change their behavior (switch the food source in the case of ants or the trading strategy in the case of financial markets), and also as a function of the diversity of the agents[5]. To this latter end, we introduced another source of heterogeneity in the model by allowing the agents to have different individual preferences for one or the other possible market strategies.

It is also worth mentioning that the method we used to solve the model is slightly different from those used in the previous literature. We applied a Gillespie algorithm in order to generate statistically correct trajectories of the stochastic equation.

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