Trader Contagion: Agent-based Stochastic Model of Markets

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Overview

This project aims to implement a parallel version of the noise trader model described in "A Noise Trader Model as a Generator of Apparent Financial Power Laws and Long Memory". The model simulates a financial market with agents belonging to two groups, exhibiting heterogeneous behavior. The parallel implementation in Haskell will enhance the performance and efficiency of the simulation, enabling it to handle large-scale agent systems and perhaps more complex market dynamics.

Background

Financial markets are a classic example of complex systems, exhibiting dynamics that are both intricate and often unpredictable. Although working on a complex model that captures the dynamics, decision-making, and learning of agents in markets is interesting, the complexity often limits the model's analytical accessibility and practical insights. The noise trader model in "A Noise Trader Model as a Generator of Apparent Financial Power Laws and Long Memory", offers a simpler stochastic simulation framework to capture the collective behavior of traders and reproduce the key stylized facts in financial markets: unit roots, fat tails, and volatility clustering.

The model conceptualizes the market as consisting of two types of agents, A and B. The state of the market is quantified by a state variable x defined as the difference in the number of agents in groups A and B, normalized by the total number of agents given by equation (1). The evolution of the market is modeled through transition probabilities that embody the herding behavior, influenced by a herding parameter (v). The probabilities determine the likelihood of agents switching groups within a given time interval, detailed in equation(2) of the paper. The equilibrium distribution P_e is another key aspect of the model, as it represents the steady-state the market is expected to converge to from any initial state. Reflecting Boundary Conditions (RBCs) are applied to prevent the system from reaching extremes, maintaining the state variable within realistic limits.

The two-state model considers the behavior of fundamentalists, who are influenced by the deviation of price from its fundamental value, and noise traders, who respond to the herding impulse. Noise traders are further divided into optimists (buyers) or pessimistic (sellers).

The price dynamics are influenced by the proportion of optimists among the noise traders and a speed of price adjustment factor β. These elements are formalized in the model's equations, which also factor in a fixed transaction volume for each noise trader and the sensitivity of fundamentalists to price deviations.A discrete-time approximation of a continuous-time Langevin equation is used to describe the evolution of the opinion index and associated returns, introducing a random component that captures the stochastic nature of market changes.

The model's capability to reproduce stylized facts of financial markets, such as volatility clustering and leptokurtic distribution of returns, is analyzed through statistical methods. Monte Carlo simulations further enhance this analysis, allowing the exploration of the model's behavior under varied scenarios and parameter settings. This provides insights into the model's convergence, stability, and the distribution of outcomes and helps quantify the risk and uncertainty within the model, and identify parameter ranges that produce realistic market behaviors.

Proposal

Based on my initial review of the paper, the model seems highly parallelizable. Agent decision-making, state updates, simulations and analysis provide great opportunities for parallelization.The gains in efficiency will be quantified by comparing the performance of the parallel implementation against the sequential model on both single and multiple cores.

References

1. Simone Alfarano and Thomas Lux. 2007. A noise trader model as a generator of apparent financial power laws and long memory. Macroecon. Dyn. 11, S1 (2007), 80–101. DOI:https://doi.org/10.1017/s1365100506060299