Emergent Phenomena in Financial Markets

Simple Asset Trading Using the Genoa Agent-Based Model
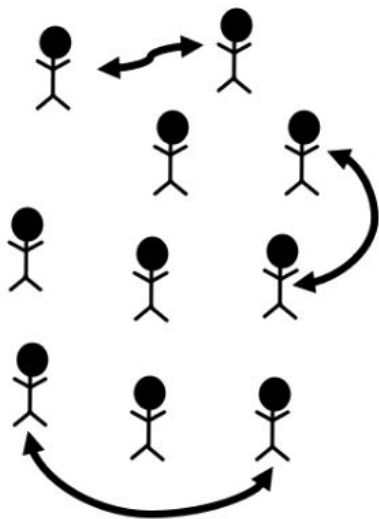
Group 14
Joos Akkerman
Oscar de Keijzer
Susy Maijer
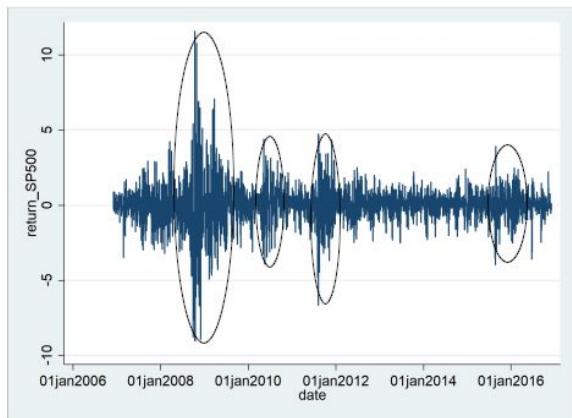Loek van Steijn

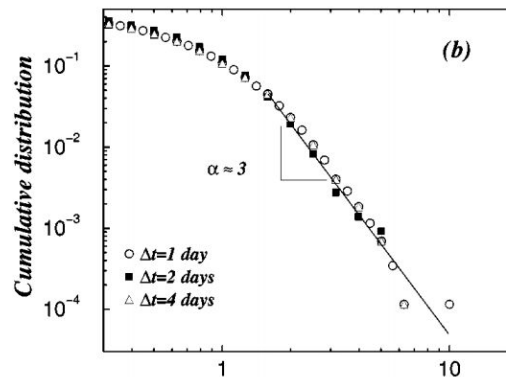Photo by M. B. M. on Unsplash

Introduction

- Financial Market is a very complex system with a lot of interacting heterogeneous elements

- Interactions generate various emergent phenomena

- Agent-Based Model (ABM) captures heterogeneity at micro level

- We use the Genoa ABM to analyse effect of cooperation on various emergent phenomena

Computational Science

Emergent Phenomena

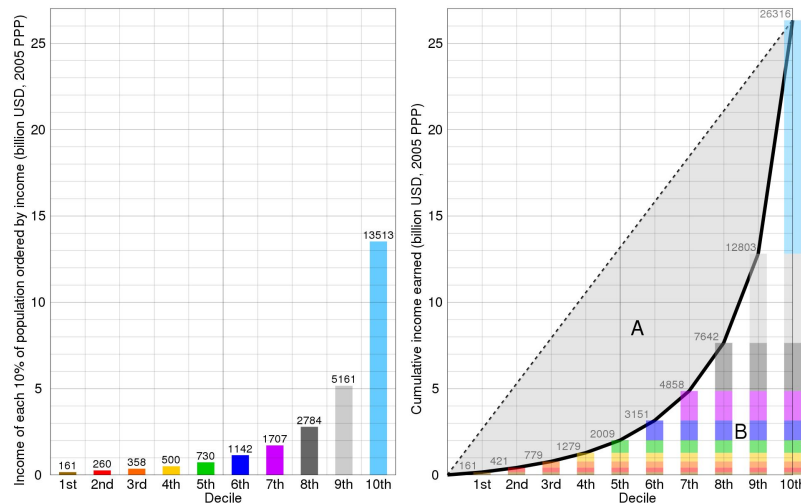Source: Gopikrishnan et al., Scaling of the distribution of fluctuations of financial market indices, 1999

- Power law of stock returns, exponent ≈ 3 (Gopikrishnan et al., 1999)
- Wealth distribution (Pareto)
- Volatility clustering (Mandelbrot, 1963)

Source: Heng Sun and Bing Zhang, Volatility clustering in the S & P 500 index, 2017

Source: Lee, Derivation of the Lorenz Curve and Gini coefficient for global income, 2011

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Genoa Market Model

Agent-based simulation of a financial market

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09123 Cagliari, Italy

- Agent-based artificial financial market
- Heterogeneous agents trade a single asset
- Realistic price formation through trading mechanism
- Finite amounts of money and asset portfolios
- No money-creation process
- Clusters of similar trading strategies (cooperation)
- Reproduces the leptokurtic shape of the probability density of log price returns
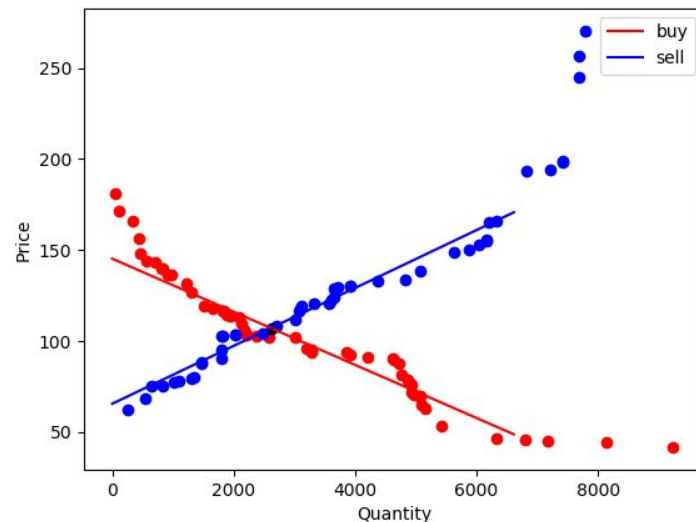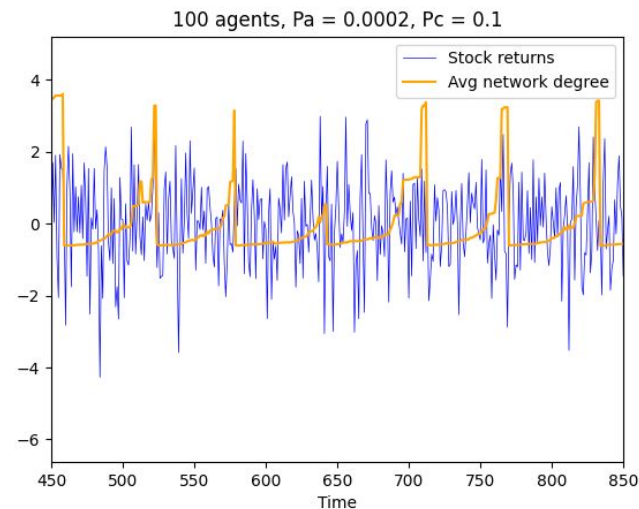- Reproduces volatility clustering


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Research Question & Experiments

What is the effect of changing the level of cooperation on the return distribution in the Genoa model?

We expect that without cooperation the price returns over time resemble Gaussian noise and no power law appears. As cooperation increases, we expect the power law to appear with the exponent value depending on the level of clustering.

- Study the progression in time of asset price returns, volatility, wealth distribution
- Vary the number of traders N, clustering probability P_a, cluster activation probability P_c, and number of timesteps per simulation

100 agents, Pa = 0.0002, Pc = 0.1

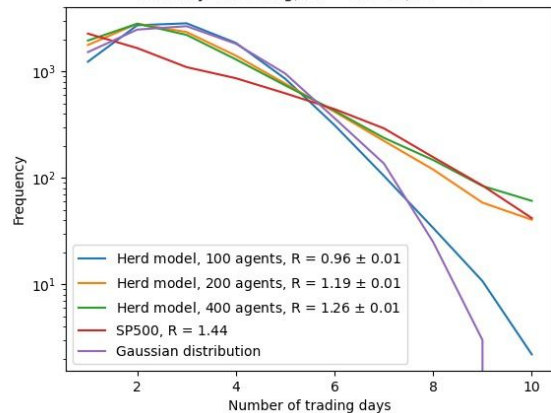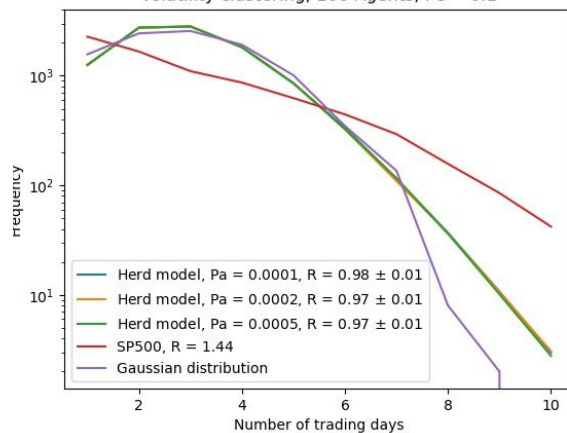# Result - Cubic law of stock returns
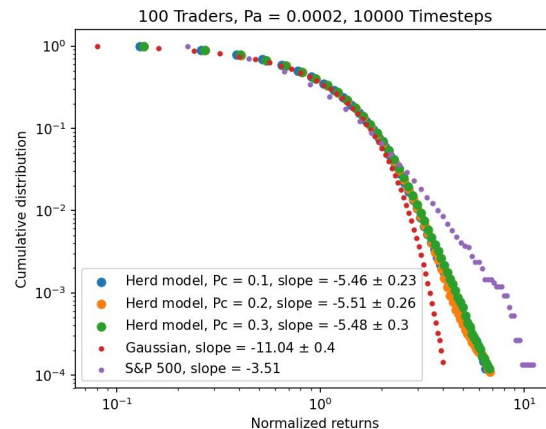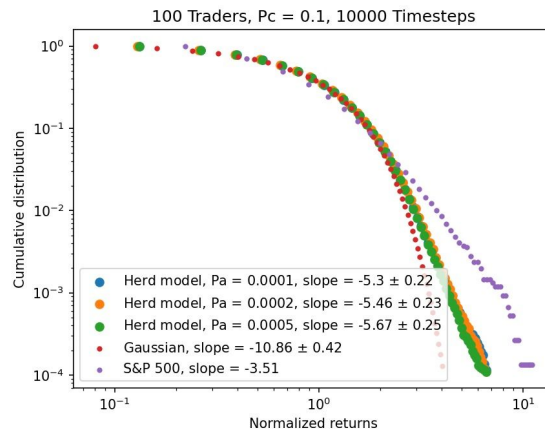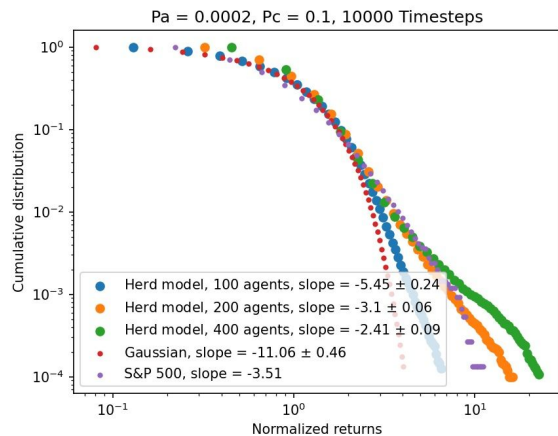
Result - Volatility Clustering

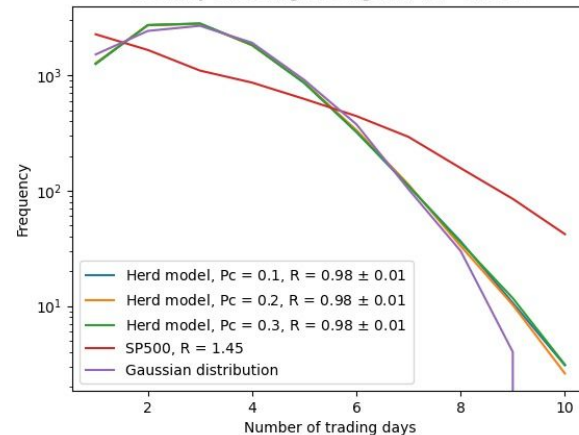Based on method by Tseng and Li. (Quantifying volatility clustering in financial time series, 2012)

Volatility clustering, Pa = 0.0002, Pc = 0.1
Herd model, 100 agents, R = 0.96 ± 0.01
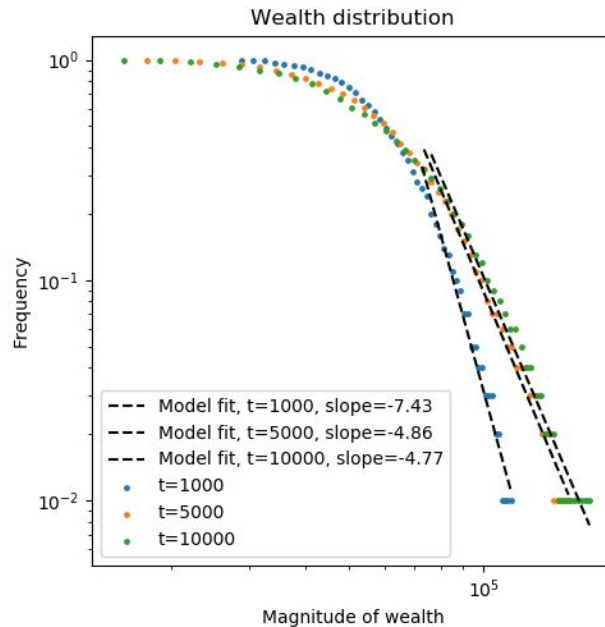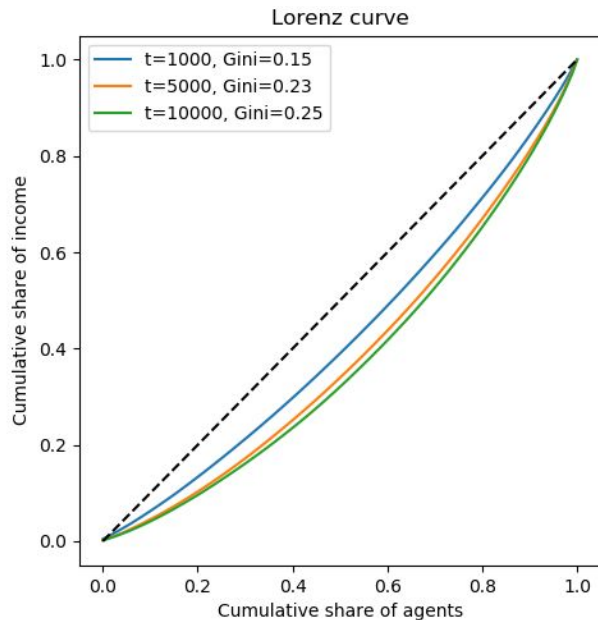Herd model, 200 agents, R = 1.19 ± 0.01
Herd model, 400 agents, R = 1.26 ± 0.01
SP500, R = 1.44
Gaussian distribution

Volatility clustering, 100 Agents, Pc = 0.1
Herd model, Pa = 0.0001, R = 0.98 ± 0.01
Herd model, Pa = 0.0002, R = 0.97 ± 0.01
Herd model, Pa = 0.0005, R = 0.97 ± 0.01
SP500, R = 1.44
Gaussian distribution

Volatility clustering, 100 Agents, Pa = 0.0002
Herd model, Pc = 0.1, R = 0.98 ± 0.01
Herd model, Pc = 0.2, R = 0.98 ± 0.01
Herd model, Pc = 0.3, R = 0.98 ± 0.01
SP500, R = 1.45
Gaussian distribution

Results - Wealth Distribution over time
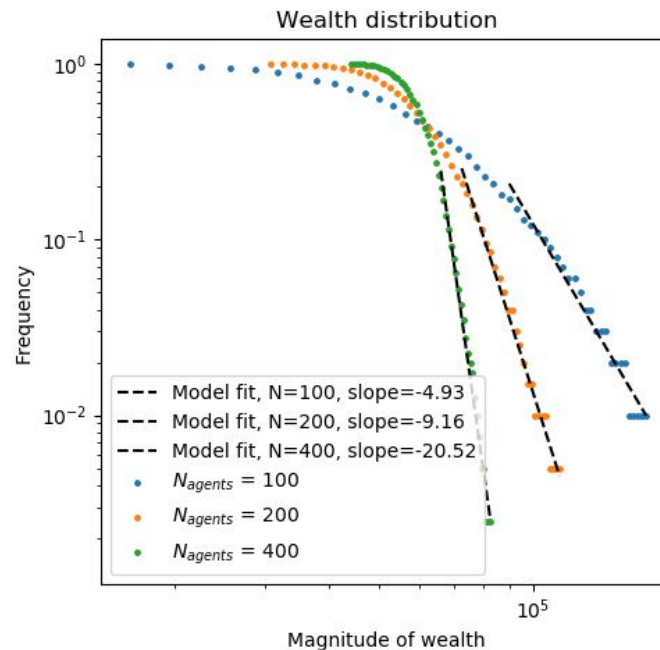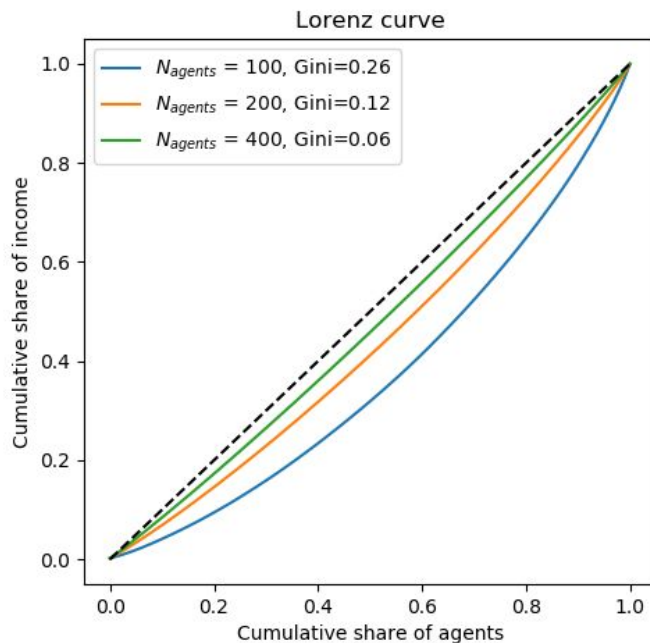
- Wealth inequality grows over time.

Results - Wealth Distribution for different amounts of traders.

- Wealth inequality decreases with more agents → What is the relation?

Conclusion

- Our implementation of the Genoa Model is only partially capable of simulating basic properties of financial time series.
  - Stock returns do not follow cubic law.
  - Volatility clustering only under certain conditions.
- Wealth distributions does not completely follow a Pareto distribution.
  - Consistent with empirical findings

Questions for further research

- What is the effect of more traders on the return distribution?
  - Is there a bi-modal distribution?
- What would be the effect of increasing cash amounts?
  - Relevant given recent increase in volatility.

Questions?