JUPITER ASSET MANAGEMENT

SYSTEMATIC INVESTING
NO FREE LUNCH: IS A SCIENCE OF THE STOCK MARKET POSSIBLE?

*Complex systems and econophysics are intriguing and expanding fields of research that in time may lead to new signals to be incorporated in our investment model, say **Amadeo Alentorn**, Lead Investment Manager, and **Matus Mrazik**, Investment Manager, overseeing the academic research programme, Jupiter Merian Global Equity Absolute Return strategy.*

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Authors:

Amadeo Alentorn
Lead Investment Manager

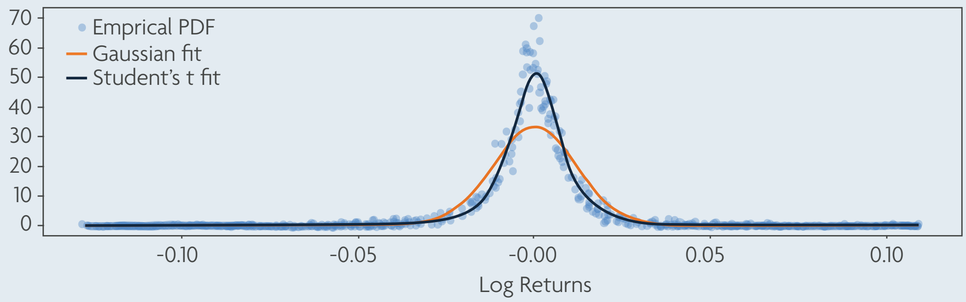
Matuz Mrazik
Investment Manager

'No free lunch' is a well-known saying in financial economics. The idea is that there is no easy way to make money in the stock market because any profitable opportunity will be quickly exploited by other investors and arbitrageurs, who will drive the price to its fair value. In other words, there is no such thing as a risk-free profit or a guaranteed return. The theory is that the stock market is efficient, reflecting all available information and expectations about the future performance of companies and the economy. This theory is often used as a justification for passive investing. The efficient market hypothesis (EMH) is often combined with the idea that stock prices follow a random walk, with a Gaussian probability distribution. A Gaussian process is a random process with a normal distribution, and is used for example to describe Brownian motion, the random buffeting of a small object such as a grain of pollen by air or water molecules. In the analogy, each stock in the market would be the grain of pollen.

But are real world stock markets efficient, and are they examples of a Gaussian process? If all information were reflected in prices, why do stock market bubbles and crashes occur? Arguably, the formation of any sizeable bubble would be impossible under the EMH, because the information that it was a bubble would immediately burst it. Empirical data shows that bubbles and crashes occur more frequently than a model based on a Gaussian probability distribution would predict. The distribution of real returns is not Gaussian but fat-tailed: extreme events have a higher probability than expected.

The graph below shows the probability density of the daily log returns of the S&P 500 index during nearly 30 years. The small circles represent the empirical data, and the continuous curves two theoretical distribution functions, the Gaussian (in orange) and a distribution with a higher kurtosis (in dark blue). The Gaussian kurtosis is visibly lower than the empirical data, which has fatter tails. This should lead us to suspect that the Gaussian model of markets, and perhaps also the Efficient Market Hypothesis, may be incorrect or incomplete.

Markets are not Gaussian
S&P500 Log Returns and Theoretical Distributions



Source: Bloomberg, Jupiter. S&P 500 log returns from 15.09.1994 to 2.04.2024. 'Student's' t is a probability distribution that has fatter tails than the Gaussian.

The new discipline of econophysics suggests that markets may be inherently unstable. Far from being in equilibrium, they are complex systems, prone to turbulence, herd behaviour, feedback loops and catastrophic events. Bubbles and crashes are to be expected from the nature of markets. This clearly has implications for our view of risk: if markets are prone to crashes, investors should make greater provision for risk.

What is econophysics?

Econophysics is a hybrid, and relatively new, field of academic research that has been developing over recent decades, combining physics with economic data. By applying methods and models from statistical mechanics, nonlinear dynamics, and complex systems theory, econophysicists aim to uncover the underlying mechanisms and regularities of economic phenomena.

Statistical mechanics is the branch of physics that describes collective behaviour in macroscopic bodies, whether solids, fluids or plasmas, and their properties, such as temperature, entropy and turbulence, without having to describe the motions of each individual particle.

EARTHQUAKES AND MARKET CRASHES

Professor Didier Sornette, a leading figure in econophysics, has developed a theory of critical phenomena that applies to various domains, including earthquakes, avalanches, and stock market crashes[1]. He argues that these events are not random and independent but result from the accumulation and release of stress in a system.

Positive feedback loops mean that small changes can trigger larger ones, creating a snowball effect

According to Sornette, critical phenomena are characterised by positive feedback loops, self-similarity, and power laws. Positive feedback loops mean that small changes can trigger larger ones, creating a snowball effect. Self-similarity means that the same patterns can be observed at different scales, such as the fractal structure of coastlines or clouds. Power laws mean that the probability of an event is inversely proportional to its size, so that large events are rare but not impossible. Sornette detects these features in the dynamics of stock market crashes and suggests they indicate the existence of a critical point or a phase transition in the system.

MAGNETISM AND SOCIAL CONFORMITY

Another analogy drawn by econophysicists between stock markets and physical systems is to model how investors' opinions change by using models developed for studying changes of magnetism in metals. The Ising model (named after the physicist Ernst Ising) is a mathematical framework for describing the behaviour of magnetic materials. Each atom in a metal lattice has a spin that can be either up (+1) or down (-1). The spin of each atom is influenced by the spins of its neighbouring atoms, as well as by an external magnetic field. The system tends to reach a state of minimum energy, where most of the spins are aligned with each other and with the external field. However, due to thermal fluctuations, some spins may randomly flip and create local regions of disorder. If the temperature is high enough, the system becomes disordered and loses its magnetization. This is known as the paramagnetic phase. On the other hand, if the temperature is low enough, the system becomes ordered and exhibits a spontaneous magnetization. This is known as the ferromagnetic phase. At a critical temperature, the system undergoes a phase transition from one state to another.

A similar process can be postulated for the dynamics of opinions in a social network, such as a stock market. Instead of atoms with spins, we have investors who hold either bullish (+1) or bearish (-1) opinions about the future prospects of an asset. The opinion of each market agent is affected by the opinions of his or her neighbours in the network, as well as by an external influence such as news. The system tends to reach a state of consensus, where most of the agents agree with each other and with the external influence. However, due to noise or uncertainty, some agents may change their opinions and create local regions of dissent. If the external influence is strong enough, the system becomes polarised and adopts a dominant opinion. This is analogous to the ferromagnetic phase. On the other hand, if the external influence is weak enough, the system becomes diverse and exhibits a variety of opinions. This is analogous to the paramagnetic phase.

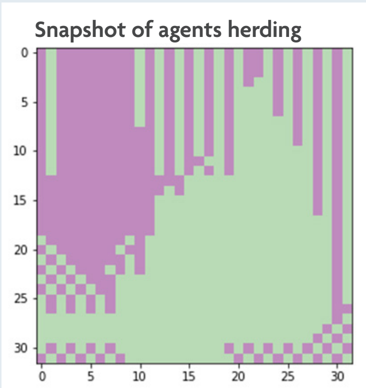
There are numerous ways to specify such social systems mathematically, but one, due to Stefan Bornholdt of Kiel University, calculates the probability of a +1 state in terms of the temperature and a local field that represents the tendency of an agent to confirm to his or her nearest neighbours, opposed by a tendency for agents resist conformity and form independent opinions. Bornholdt (2001) gives a formula[2] combining these parameters, and output from a computer program utilising it, adapted from code[3] by Carlo Requiao da Cunha (2022) is shown below. For an animation of the results see our website.

Herding leads to more volatile market conditions

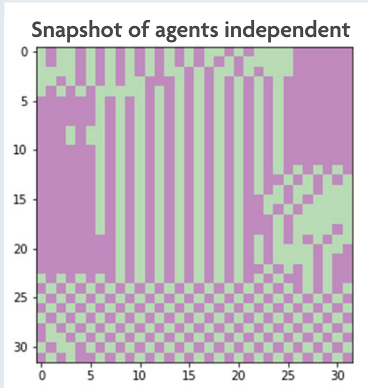
Interacting agents and simulated market returns

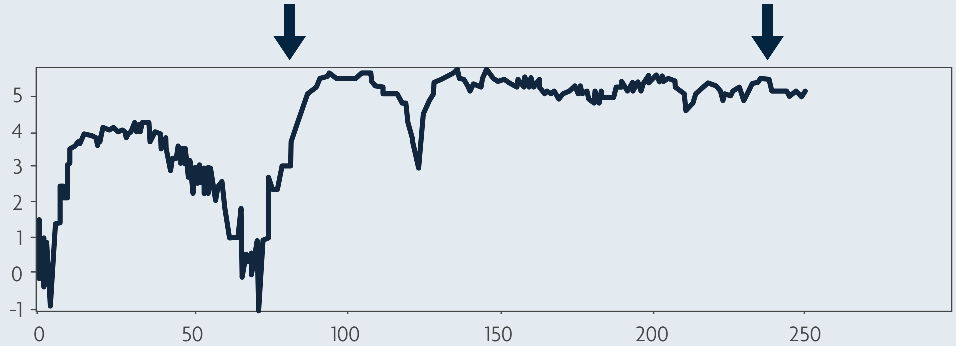
Each square of the grid in the upper box represents a market agent, and the iterations of their shifting +1 and -1 states result, over time, in the simulated market returns shown in the lower graph.

Herding behaviour (large colour block) leads to more volatile market conditions (sudden moves in the line chart below).

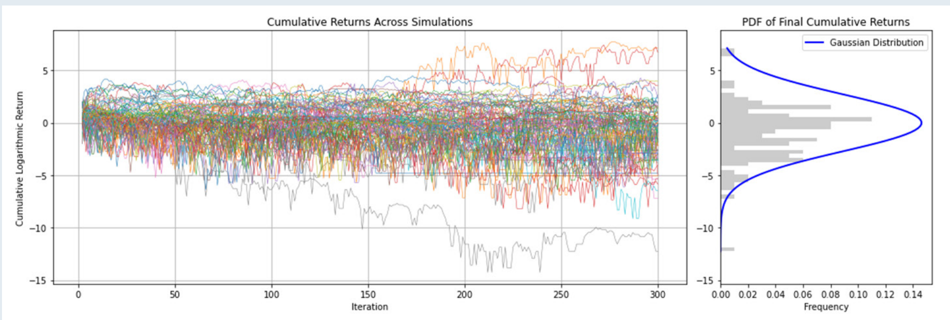


Lack of herding leads to less volatile market conditions.





Running the above simulation 100 times results in the plot below, with the probability distribution shown at the right.



Source: Jupiter. For illustrative purposes only.

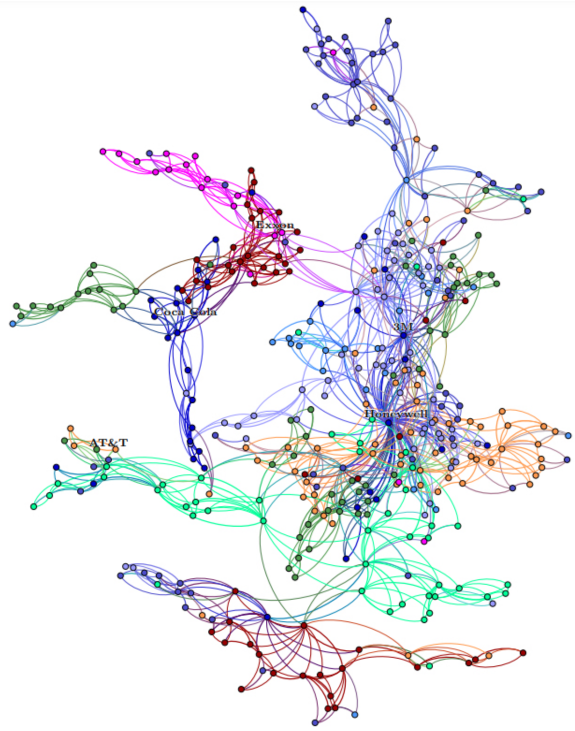
BUILDING OUR RESEARCH PROGRAM

We expect the field of econophysics to grow, as growing digitisation makes even larger amounts of data available. Those wishing to learn more about econophysics could consult a useful review of the academic literature by Ryszard Kutner, Marcel Ausloos, Dariusz Grech, T. Di Matteo, Christophe Schinckus, and H. Eugene Stanley[4].

Tiziana Di Matteo, a co-author of the above paper, is Professor of Econophysics at King's College London. Her research interests include econophysics, application of methods from statistical physics to finance, data analytics, complex systems, and the science of networks[5]. A recent paper by M. Raddant and Di Matteo[6] studies networks of stocks as defined by the correlations between their returns. The network graph below, reproduced with permission from their paper, represents stocks in the S&P 500, colour coded by sector. Pink is the energy sector, bright green is financials, for example.

The behavioural aspects of investors means that markets can be exploited

Interacting agents and resulting market returns



In this graph, stocks whose price movements behave similarly are shown as linked together. Stocks that behave differently are not connected. Sector classification of stocks is showed by colour.

Source: M. Raddant and Di Matteo (2023).[6]

Dr Tiziana Di Matteo is Professor of Econophysics at King's College London. Her areas of expertise include complex systems, complex networks and data science. She works in the Department of Mathematics at King's College London and is a member of the external faculty of the Complexity Science Hub in Vienna, a member of the UCL Centre for Blockchain Technologies, a member of the board of the Complex System Laboratory, and a member of the council and of the executive committee of the Complex Systems Society. She is also a member of the board of directors of the Museo Storico della Fisica e Centro Studi e Ricerche "E. Fermi". A trained physicist, she took her degree and PhD from the University of Salerno in Italy.

We are following with interest work by Professor Di Matteo, who is on our panel of academic advisors, and her graduate researchers, in applying methods from network analysis and graph theory to financial markets. The Systematic Equities team at Jupiter is currently sponsoring and co-supervising one of her PhD students. We hope this research may in due course lead to new ways of enhancing our industry momentum signal. Industry momentum relies on an MSCI classification of sectors. If we could specify more homogeneous groups instead of, or in addition to, the MSCI industries, our signal might benefit, as the momentum and autocorrelation properties would be stronger. Industry momentum is a key driver of our industry and sector positioning for all the strategies we manage.

This is just one part of our academic research programme, and we plan to share other aspects of it in future articles.

Our experience with managing money leads us to reject the Efficient Market Hypothesis: stock markets, in our view, are not efficient

Central to our philosophy as a team is a continuous and disciplined research effort to ensure that our investment process improves over time, and that we try to learn lessons from new market environments and more challenging performance periods. Over the past 15 years, this philosophy has resulted in a regular stream of evolutionary changes to our investment process, leading to improvements in our expected risk-adjusted returns over time. In addition to the research activity undertaken by our in-house research team, we continue to interact very productively with our team of researchers in our academic research programme, and with Jupiter's in-house Data Science Team.

So, what is the answer to our original question: is there a free lunch? Our experience suggests that producing reliable investment signals is, in practice, highly time consuming in terms of researcher hours. Over the years we have introduced many new signals into our models, but each has typically been the result of many months of highly detailed empirical research and thorough testing. Our experience with managing money leads us to reject the Efficient Market Hypothesis: stock markets, in our view, are not efficient. The behavioural aspects of investors means that markets can be exploited. However, detecting market inefficacies in a reliable and repeatable way is no easy task, requiring considerable effort.

[1] Didier Sornette, Why Stock Markets Crash (Critical Events in Complex Financial Systems), Princeton University Press, 2003.

[2] Stefan Bornholdt Expectation bubbles in a spin model of markets: Intermittency from frustration across scales, Int. J. Mod. Phys. C 12 (2001), No 5. Available at https://arxiv.org/abs/cond-mat/0105224

[3] Carlo Requiao da Cunha, Introduction to Econophysics, CRC Press, 2022.

[4] R. Kutner, et al., Econophysics and sociophysics: Their milestones & challenges, Physica A (2018), https://doi.org/10.1016/j.physa.2018.10.019

[5] kcl.ac.uk/people/tiziana-di-matteo

[6] Di Matteo, T. (Accepted/In press). A Look at Financial Dependencies by Means of Econophysics and Financial Economics. Journal of Economic Interaction and Coordination. Available at https://kclpure.kcl.ac.uk/ws/portalfiles/portal/208080269/fin_dependencies10.pdf

The Jupiter Systematic Equities team

From left: **DR AMADEO ALENTORN, CFA** Lead Investment Manager; **TARUN INANI, CFA** Investment Analyst; **JAMES MURRAY, CFA** Investment Manager; **DR YUANGAO LIU, CFA** Investment Manager; **DR SEAN STOREY** Investment Manager; **MATUS MRAZIK** Investment Manager.

OUR SYSTEMATIC ACADEMIC PROGRAMME

We plan in future articles to bring you other aspects of our research and our collaboration with our external team of leading academic experts, who include those listed below.

Dr Jonathan N. Katz
Kay Sugahara Professor of Social Sciences and Statistics, California Institute of Technology

Research interest focuses on the development of statistical methods for the social sciences and their empirical applications. He is an elected fellow of the American Academy of Arts and Sciences.

Dr Sonia Konstantinidi
Senior lecturer in accounting, Bayes Business School, City, University of London

Research interests are in the areas of market efficiency, securities valuation and corporate finance.

Dr Dong Lou
Professor of Finance, LSE, Research Fellow, Centre for Economic Policy Research, Consultant to the Bank of England

Research Interests: Asset pricing, investment management, behavioral finance, and China's financial markets.

Dr Tiziana Di Matteo
Professor of Econophysics, King's College London

Research interests: Econophysics, Application of methods from Statistical Physics to Finance, Complex Systems, Science of Networks

Dr Alberto Moraglio
Senior Lecturer in Computer Science University of Exeter

Areas of expertise include theory and applications of Evolutionary Computation, Genetic Programming, Machine Learning, Heuristic and Mathematical Optimisation, and Optimisation on Quantum Computers.

Dr Peter Pope
Full professor of accounting, Bocconi University, Italy Professor of accounting Emeritus London School of Economics

Has researched and published extensively in the areas of capital markets, financial reporting and international equity valuation.

Dr Steve Satchell
Fellow of Trinity College, University of Cambridge

Focuses on both empirical and theoretical aspects of econometrics, finance, risk measurement and utility theory.

Dr Paolo Zaffaroni
Professor of financial econometrics, Imperial College London

Main research interests are financial econometrics and econometric theory as well as risk management and asset allocation.

__The value of active minds – independent thinking:__ A key feature of Jupiter's investment approach is that we eschew the adoption of a house view, instead preferring to allow our specialist fund managers to formulate their own opinions on their asset class. As a result, it should be noted that any views expressed – including on matters relating to environmental, social and governance considerations – are those of the author(s), and may differ from views held by other Jupiter investment professionals.