Applications of statistical physics to problems in economics

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Outline

Introduction

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Definitions

- Logarithmic Return
- Correlations
- Random Matrix Theory
- Distances
- Minimal Spanning Trees

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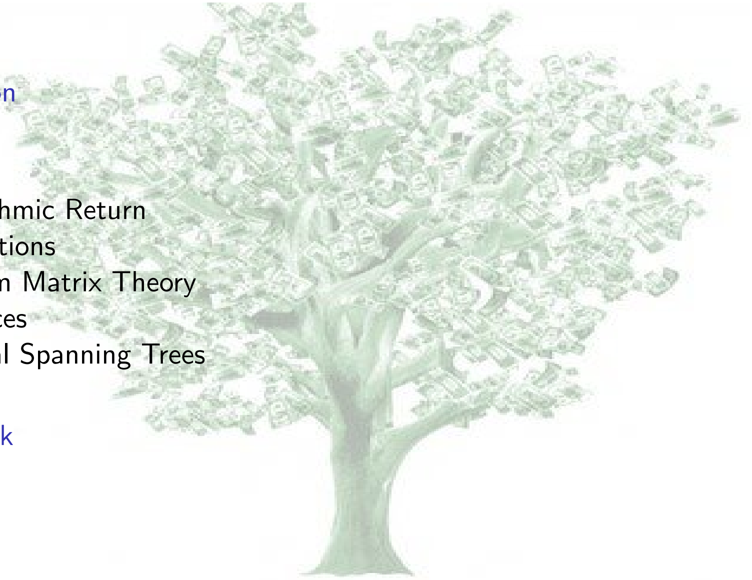

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Future work

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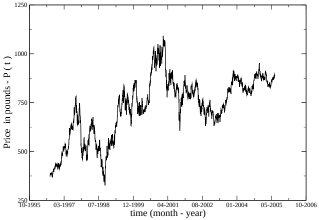
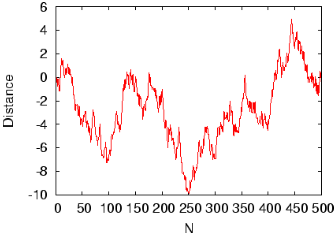
What is Econophysics?

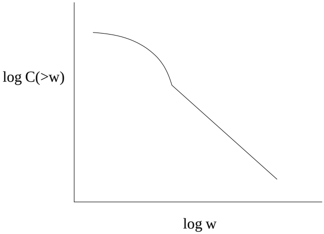
Two main areas:

- stock markets



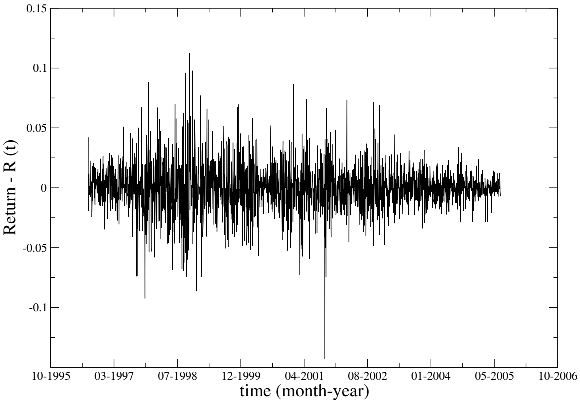


- distribution of wealth



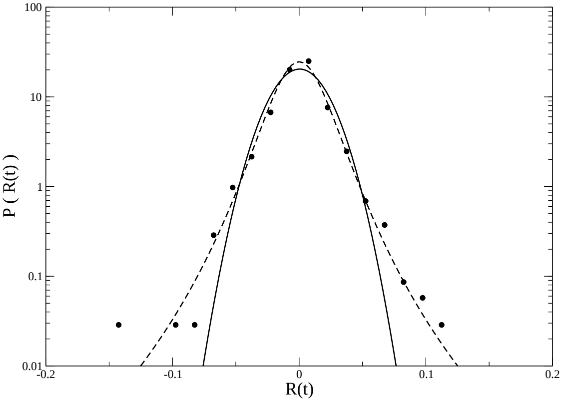
Log-return of stocks shows extreme events (e.g. HSBC)

$$R_i(t) = \ln P_i(t) - \ln P_i(t-1) \quad (1)$$



Distribution of the Log-return is non-Gaussian

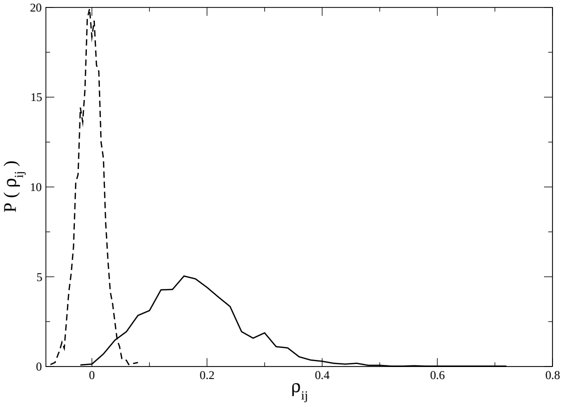
$k \sim 2.90$ and $q \sim 1.34$



Correlation between stocks i and j

$$\rho_{ij} = \frac{\langle \mathbf{R}_i \mathbf{R}_j \rangle - \langle \mathbf{R}_i \rangle \langle \mathbf{R}_j \rangle}{\sqrt{\left(\langle \mathbf{R}_i^2 \rangle - \langle \mathbf{R}_i \rangle^2\right)\left(\langle \mathbf{R}_j^2 \rangle - \langle \mathbf{R}_j \rangle^2\right)}} \quad (2)$$

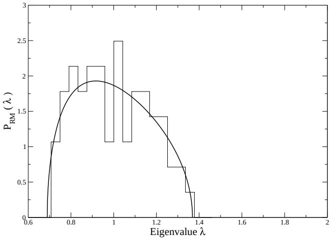
- ρ_{ij} form a symmetric $N \times N$ matrix; $-1 \leq \rho_{ij} \leq 1$; $\rho_{ii} = 1$.

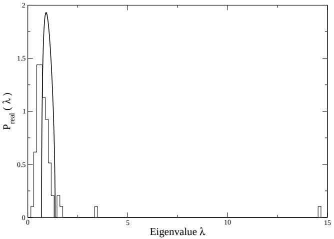


Matrix of correlations show non-randomness

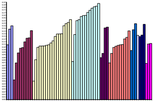
Random Matrix Theory for $N \to \infty$ and $T \to \infty$, where $Q = T/N$ is fixed and bigger than 1.

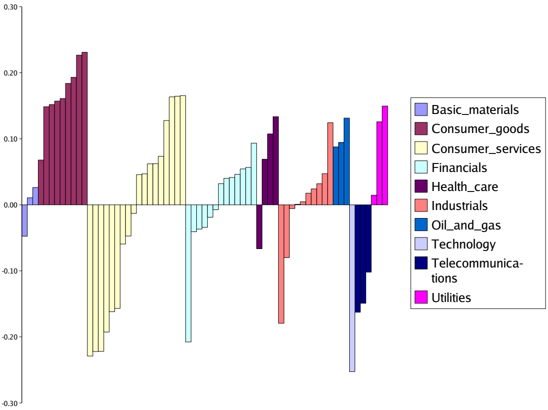
$$P_{RM}(\lambda) = \frac{Q}{2\pi} \frac{\sqrt{(\lambda_{max} - \lambda)(\lambda - \lambda_{min})}}{\lambda} \tag{3}$$





Highest eigenvector is equivalent to the market force

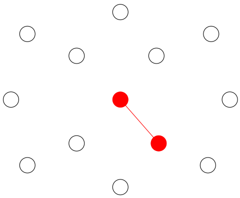




Distance between stocks *i* and *j*

$$d_{ij} = \sqrt{2(1 - \rho_{ij})} \quad (4)$$

- $0 \leq d_{ij} \leq 2$, small values imply strong correlations.
- From distances we construct the Minimal Spanning Tree (MST).
- Choose the minimum distance between 2 stocks - one link between these 2.



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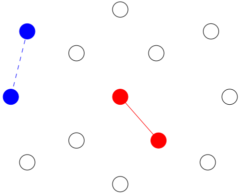

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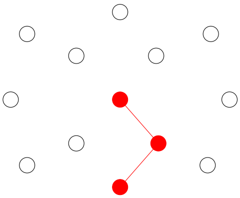

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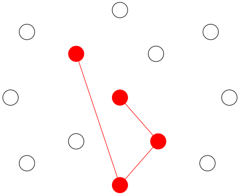

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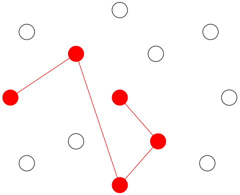

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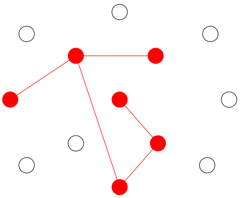

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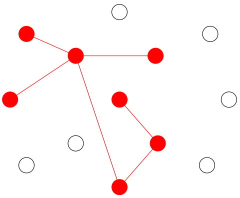

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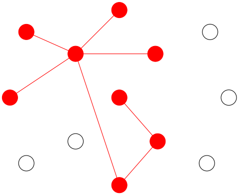

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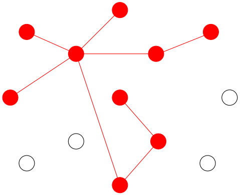

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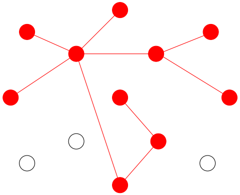

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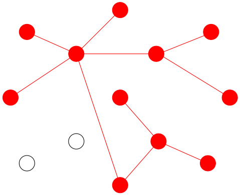

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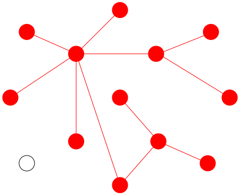

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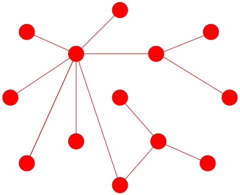
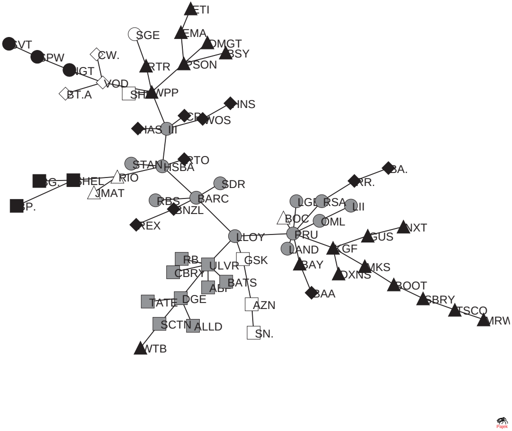


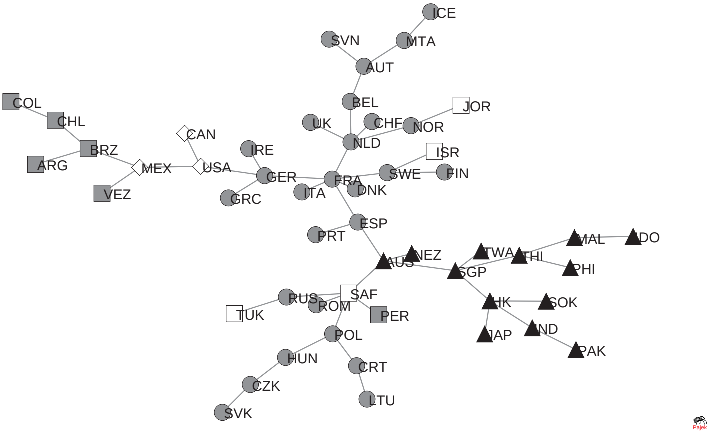
Stocks cluster in industrial sectors (ICB classification)

Full time series, $T = 2322$ days, for the FTSE100 stocks.



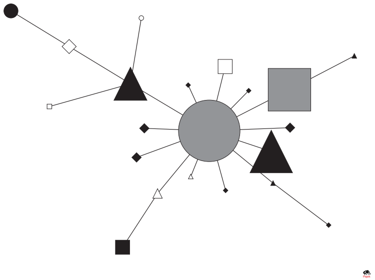
Markets organised by geographical location

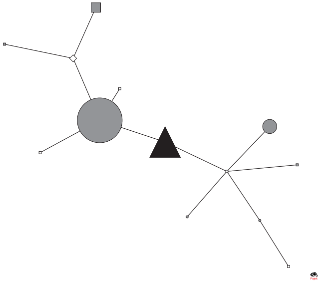
Full time series, $T = 475$ weeks, for the 53 World Indices.



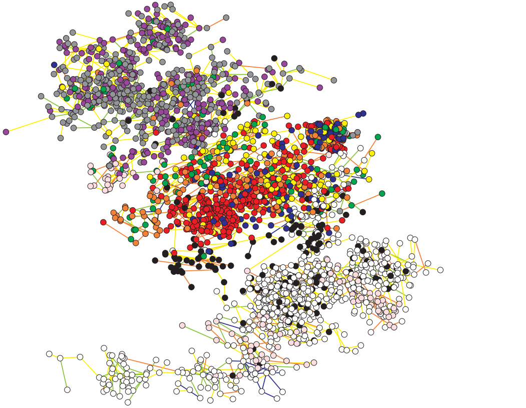
New visualisation of the previous clusters

Financial sector in one case and European markets in other are the center of these trees.





Future work ... (stocks from different countries)



Conclusions

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- Time series of returns have more information than just Gaussian noise.
- These time series can be filtered using Random Matrix Theory approach.
- Similar behaviour for both the FTSE100 stocks and the World Indices:
  - MST show different clusters (Industrial sectors / Geography)